Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2018; SP1: 3067-3070

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# Study on seed and seedling characteristics of different populations of Teak in Karnataka

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**Abstract**
In the present study fruits were collected from the seven natural populations of teak from Ponnampet, Mudigere, Shivamogga, Sirsi, Kiravathi, Dandeli and Bidar. Nursery experiment was carried out during April 2004 to June 2005 at Agriculture Research Station (Paddy), College of Forestry Campus, Sirsi. Teak populations have showed the significant variations among different locations for various fruit and seed characteristics. For seed length and seed breadth highest was found in the Ponnampet population 5.57 mm and 3.96 mm respectively and least was observed in the Bidar population 5.31 mm and 3.63 mm respectively. Shivamogga population has showed highest for the seed thickness with 2.51 mm, followed by Dandeli and Mudigere 2.42. Whereas least was found in the Bidar population (2.33 mm). The germination per cent of teak in different location was poor (<14%) may be due to poor seed filling which is a major problem in teak. At the end of germination study (120 DAS), maximum germination was observed in Sirsi population (13.1%), followed by Kiravathi (11.10%). Both Shivamogga and Ponnampet recorded low germination (6.3%). Highest total biomass was observed in Kiravathi (86.4 g) followed by Dandeli (80.8 g) and lowest was observed in Ponnampet (38.0 g). The results revealed a significant positive association of collar diameter with shoot biomass (r=0.952) and number of lateral roots (r=0.863). Similarly, seed breadth showed significant positive association with 100 fruit weight (r=0.549) and fruit diameter (r=0.544).

**Keywords:** Seed characteristics, seedling characteristics, Teak, germination percent, population

## Introduction
Teak is a large, deciduous tree growing over 30 to 35 m height and 150 to 220 cm GBH in favourable conditions. The crown is open with many small branches, the bole is often buttressed, fluted at the base and pale brown and grey in colour. Teak tree sheds its leaves from November to January (in India) and remain leafless for a long period of 3 to 4 months (Palanisamy *et al.*, 2009a). Teak flowers are small, 6 to 8 mm in size, white or rarely purplish pink colour occur in large inflorescences or panicles (20 to 90 cm) which initiate from terminal buds of stem and branch shoots. The total number of flowers in each panicle varies from 1,200 to 3,700 (Bryndum and Hedegart, 1969). The fruit is a drupe with four chambers, round, hard and woody enclosed in an inflated, bladder-like covering, pale green at early stage of growth and turns brown at maturity. Each fruit may contain 1 to 4 seeds and one kilogram contains 1000 to 3500 fruits.

Natural teak forests exist between 9º to 26º N latitude and 73º to 104º E longitude, 0 to 1200 m altitude, with temperature ranges from 14 to 36 ºC and rainfall 800-2500 mm (Palanisamy, 2009b). Teak thrives well in deep, well-drained, fertile alluvial soil with a pH of 6.5 to 7.5 and a relatively high calcium and phosphorus content (Kulkarni, 1951; Tewari, 1992). The quality of growth, however, depends on the depth, drainage, moisture status and the fertility of the soil. Teak does not tolerate water logging and clayey soils. The demand for quality timber has made teak the most widely planted hardwood species even in areas outside its natural distribution (Kumar *et al.*, 1997). In India, Teak occurs naturally in Kerala, Tamil Nadu, Andhra Pradesh, Karnataka, Orissa, Madhya Pradesh and Maharashtra. Teak from the Western Ghats region in Kerala and Karnataka is preferred for structural needs like shipbuilding and construction, as these regions receive high rainfall (2000-3000 mm) and the teak attains huge sizes suitable for the shipbuilding (Somaiya, 2005).

The Karnataka state is having natural teak forests, plantations, clonal seed orchards and seed production orchards (Katwal, 2005). In Karnataka, the teak from Kiravathi and Dandeli (Uttar Kannada district) of Western Ghat area are superior in quality, fetches highest price and has great market demand. Similarly, in Kerala the teak from Nilambur region was found to be

superior. Genetic factors have a significant contribution to the quality of wood and many traits contributing to the wood quality are genetically controlled (Bhat, 1999). The forest genetic resources are facing severe threats from both the biotic and abiotic stresses resulting the loss of valuable resources. Therefore, it is imperative to study the variability of the natural populations and select the populations for *in situ* conservation and further genetic improvement.

**Material and methods**

In the present study fruits were collected from the seven natural populations of teak from Ponnampet, Mudigere, Shivamogga, Sirsi, Kiravathi, Dandeli (they are located between $12^0$ 20' N to $15^0$ 15' N latitude and $74^0$ 38' E to $75^0$ 56' E longitude and altitude ranges from 540 m to 982 m MSL in Western Ghats) and Bidar (located at $17^0$ 55 ' N latitude, $77^0$ 32 ' longitude with an elevation of 560 m MSL which is 500 KM away from the Western Ghats towards East).

Seeds were extracted from 10 fruits from each tree and seed traits like, seed length, seed breadth and seed thickness were measured using a digital calliper and expressed in millimetres (average value of ten seeds was considered for statistical analysis).

The fruits from all the seven experimental sites were collected treated with alternate soaking and shade dried with cow dung slurry for a week to soften the hard fruit coat (Osmaston, 1908; Gamble, 1921; Chacko *et al*., 1997). After the treatment, mesocarp was removed by thrashing and then soaked in water for overnight. The pre-treated seeds were sown separately on standard raised bed and the mulched beds were watered regularly. Nursery experiment was carried during April 2004 to June 2005 at Agriculture Research Station (Paddy), College of Forestry Campus, Sirsi.

**Results and discussion**

Teak populations have showed the significant variations among different locations for various fruit and seed characteristics (Table 1).

Dandeli showed comparatively a higher fruit weight (75.51 g) and fruit diameter (1.62 cm), followed by Ponnampet population 74.86 g and 1.61 cm respectively. Whereas as least was observed in the Bidar population 53.41 g and 1.42 cm respectively. For seed length and seed breadth highest was found in the Ponnampet population 5.57 mm and 3.96 mm respectively and least was observed in the Bidar population 5.31 mm and 3.63 mm respectively. Shivamogga population has showed highest for the seed thickness with 2.51 mm, followed by Dandeli and Mudigere 2.42. Where as least was found in the Bidar population (2.33 mm). These variations may be due to the fact that, this species grows over a wide range of climatic conditions as well as soil types and altitudes. Similar findings were revealed by Palupi and Owens, 1998 in Thailand for the teak.

The germination per cent of teak in different location was poor (<14%) may be due to poor seed filling which is a major problem in teak. ANOVA results indicated a significant difference among the populations in all the four treatments from 30 DAS to 120 DAS (Table 2). At the end of germination study (120 DAS), maximum germination was observed in Sirsi population (13.1%). Both Shivamogga and Ponnampet recorded low germination (6.3%). The mean germination per cent increased gradually from 2.8 in 30 DAS to 9.3 in 120 DAS. Germination studies revealed that the percentage of germination in Western Ghats region was 6.3 to 13.1 per cent, which was very low for any commercial nursery practices, and so enhancing of the germination percentage is one of the prime requirements for teak improvement apart from the wood quantity improvement. However, Palupi and Owens (1998) reported that percentage of teak germination was 40 to 50% in seed production areas and 10 to 20% in clonal seed orchards, indicating that germination in natural population was poor than seed production areas may be due to less stand density in natural populations. Pitcher (1982) stated that even phenotypically superior teak trees failed to produce better progenies. Indira and Basha (1999) reported that germination varies among different seed sources of teak.

Analysis of variance (ANOVA) revealed that the results were statistically significant for all the seedling attributes (Table 2 & 3). The seedling parameters such as shoot height, collar diameter, taproot length and biomass characters were also evaluated for different locations. For most of the seedling traits, the location Dandeli registered a highest value (shoot height 10.74 cm, collar diameter 5.69 mm and number of lateral roots 13.70) followed by Kiravathi and lowest in Bidar. In general, it is suggested that seed and seedling related parameters vary considerably across populations. The observed patterns of variation on seed and seedling characteristics will have implications for genetic resource conservation and long-term tree improvement programme.

Seedlings of different populations showed significant variation with respect to stem, leaf, root, shoot and total biomass (Table 4). For all parameters seedlings of the Dandeli, Kiravathi and Bidar populations showed highest value, which was found to be superior to others, while that of Ponnampet population recorded the least.

Significant variation was found for the mean value of shoot biomass with a moderate CV of 14.86 per cent. The Dandeli attained significantly highest mean value (54.8 g) for shoot biomass followed by Kiravathi (41.8 g), Bidar (33.8 g), Shivamogga (26.2 g), Sirsi (25.2 g), Mudigere (22.2 g) and least value was noticed in Ponnampet (18.2 g) population. The results showed significant variations with regard to total dry weight of seedlings of different locations (CV of 15.71%). Highest total biomass was observed in Kiravathi (86.4 g) followed by Dandeli (80.8 g) and lowest was observed in Ponnampet (38.0 g).

Association was carried out among various seed and seedling characteristics to understand the influence of seed parameters with seedling parameters (Table 5). The results revealed a significant positive association of collar diameter with shoot biomass (r=0.952), number of lateral roots (r=0.863), shoot length (r=0.751), diameter of tap root (r=0.711), fruit diameter (r=0.485) and 100 fruit weight (r=0.440). Seed length showed significant positive association with fruit diameter (r=0.536), shoot length (r=0.388), 100 fruit weight (r=0.360) and collar diameter (r=0.342). Similarly, seed breadth showed significant positive association with 100 fruit weight (r=0.549) and fruit diameter (r=0.544).

Correlated quantitative traits are of major interest in any tree improvement programme, as the improvement of one character may have bearing on the other character. Genetic control of seed morphometric traits had been indicated for several tree species, including teak (Jayasankar *et al.*, 1999 and Gera *et al.*, 2001).

**Table 1:** Fruit and Seed characteristics of seven different teak populations in Karnataka State

| Location | 100 Fruit weight (g) | Fruit diameter (cm) | Seed length (mm) | Seed breadth (mm) | Seed thickness (mm) |
|---|---|---|---|---|---|
| Dandeli | 75.51 | 1.62 | 5.52 | 3.83 | 2.42 |
| Kiravathi | 68.39 | 1.60 | 5.50 | 3.84 | 2.36 |
| Sirsi | 66.70 | 1.58 | 5.42 | 3.80 | 2.39 |
| Shivamogga | 64.38 | 1.58 | 5.35 | 3.93 | 2.51 |
| Mudigere | 65.78 | 1.56 | 5.44 | 3.82 | 2.42 |
| Ponnampet | 74.86 | 1.61 | 5.57 | 3.96 | 2.36 |
| Bidar | 53.41 | 1.42 | 5.31 | 3.63 | 2.33 |
| Mean | 66.29 | 1.57 | 5.44 | 3.83 | 2.40 |
| CV% | 0.400 | 0.110 | 0.380 | 0.340 | 0.370 |
| SEm ± | 0.188 | 0.001 | 0.014 | 0.009 | 0.006 |
| C.D.(0.05) | 0.388 | 0.002 | 0.029 | 0.019 | 0.012 |
| C.D.(0.01) | 0.526 | 0.003 | 0.039 | 0.025 | 0.017 |

**Table 2:** Germination (%), shoot height (cm) and collar diameter (mm) of teak populations from different locations in Karnataka State

| Location | Germination (%) | | | | Shoot height (cm) | | | | Collar diameter (mm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 120 DAS | 30 DAG | 60 DAG | 90 DAG | 120 DAG | 30 DAG | 60 DAG | 90 DAG | 120 DAG |
| Dandeli | 3.9 | 6.0 | 8.2 | 10.4 | 7.64 | 8.67 | 9.71 | 10.74 | 3.44 | 4.19 | 4.95 | 5.69 |
| Kiravathi | 2.0 | 5.1 | 8.1 | 11.1 | 7.48 | 8.02 | 8.57 | 9.12 | 2.71 | 3.32 | 3.93 | 4.56 |
| Sirsi | 2.0 | 5.7 | 9.4 | 13.1 | 5.33 | 6.43 | 7.54 | 8.64 | 2.38 | 2.98 | 3.59 | 4.19 |
| Shivamogga | 4.7 | 5.2 | 5.8 | 6.3 | 5.18 | 6.16 | 7.12 | 8.09 | 2.50 | 2.97 | 3.46 | 3.95 |
| Mudigere | 2.4 | 4.1 | 5.9 | 7.6 | 5.99 | 7.16 | 8.33 | 9.50 | 2.63 | 3.06 | 3.51 | 3.95 |
| Ponnampet | 3.1 | 4.2 | 5.3 | 6.3 | 6.45 | 7.09 | 7.72 | 8.34 | 2.59 | 3.04 | 3.48 | 3.93 |
| Bidar | 1.5 | 4.4 | 7.3 | 10.2 | 5.43 | 6.24 | 7.03 | 7.82 | 2.72 | 3.28 | 3.84 | 4.40 |
| Mean | 2.8 | 5.0 | 7.1 | 9.3 | 6.21 | 7.11 | 8.00 | 8.89 | 2.71 | 3.27 | 3.82 | 4.38 |
| C.V. (%) | 15.27 | 5.75 | 8.00 | 10.27 | 6.01 | 4.92 | 4.35 | 4.15 | 4.70 | 4.88 | 5.13 | 5.29 |
| SEm ± | 0.302 | 0.202 | 0.403 | 0.675 | 0.264 | 0.247 | 0.246 | 0.261 | 0.090 | 0.113 | 0.138 | 0.164 |
| C.D.(0.05) | 0.623 | 0.417 | 0.832 | 1.393 | 0.545 | 0.510 | 0.508 | 0.539 | 0.186 | 0.233 | 0.285 | 0.338 |
| C.D.(0.01) | 0.845 | 0.565 | 1.127 | 1.888 | 0.738 | 0.691 | 0.688 | 0.730 | 0.252 | 0.316 | 0.386 | 0.459 |

DAS = Days after sowing DAG = Days after germination

**Table 3:** Taproot length, diameter of taproot, number of lateral roots and length of three largest lateral roots of different teak populations in Karnataka State (120 days after germination)

| Location | Tap root length (cm) | Maximum diameter of tap root (mm) | Number of lateral roots | length of three largest lateral roots | | |
|---|---|---|---|---|---|---|
| | | | | First | Second | Third |
| Dandeli | 24.7 | 18.2 | 13.7 | 17.5 | 14.7 | 10.9 |
| Kiravathi | 26.4 | 19.4 | 10.9 | 19.2 | 15.9 | 12.5 |
| Sirsi | 24.9 | 14.4 | 06.5 | 17.0 | 13.1 | 09.8 |
| Shivamogga | 22.9 | 14.6 | 08.7 | 16.6 | 13.4 | 10.0 |
| Mudigere | 24.7 | 15.0 | 08.7 | 17.5 | 13.6 | 09.4 |
| Ponnampet | 22.0 | 13.3 | 06.1 | 14.9 | 12.1 | 08.6 |
| Bidar | 25.6 | 17.3 | 10.2 | 19.0 | 15.0 | 11.5 |
| Mean | 24.5 | 16.0 | 09.2 | 17.4 | 13.9 | 10.4 |
| C.V. | 2.28 | 5.24 | 10.61 | 3.14 | 3.45 | 04.71 |
| SEm ± | 0.394 | 0.594 | 0.693 | 0.386 | 0.340 | 0.346 |
| C.D.(0.05) | 0.813 | 1.226 | 1.43 | 0.797 | 0.702 | 0.714 |
| C.D.(0.01) | 1.102 | 1.661 | 1.938 | 1.08 | 0.951 | 0.968 |

**Table 4:** Stem weight, leaf weight, root weight, shoot biomass and total biomass of teak populations from different locations in Karnataka State (120 days after germination)

| Location | Stem weight (g) | Leaf weight (g) | Root weight (g) | Shoot biomass (g) | Total biomass (g) |
|---|---|---|---|---|---|
| Dandeli | 17.3 | 37.5 | 31.6 | 54.8 | 86.4 |
| Kiravathi | 13.2 | 28.6 | 39.0 | 41.8 | 80.8 |
| Sirsi | 06.8 | 18.8 | 24.0 | 25.2 | 49.2 |
| Shivamogga | 06.9 | 19.5 | 24.0 | 26.2 | 50.3 |
| Mudigere | 08.5 | 15.3 | 23.0 | 22.2 | 45.8 |
| Ponnampet | 05.7 | 12.5 | 19.8 | 18.2 | 38.0 |
| Bidar | 10.6 | 23.3 | 31.1 | 33.8 | 64.9 |
| Mean | 9.8 | 22.2 | 27.5 | 30.3 | 57.9 |
| C.V. | 15.65 | 14.15 | 16.93 | 14.86 | 15.71 |
| SEm ± | 1.089 | 2.223 | 3.807 | 3.335 | 7.061 |
| C.D.(0.05) | 2.248 | 4.588 | 7.858 | 6.883 | 14.574 |
| C.D.(0.01) | 3.046 | 6.218 | 10.648 | 9.328 | 19.75 |

**Table 5:** Association of seed, fruit and seedling traits among teak populations (Pearson's correlation coefficient values)

| Correlation | Seed Breadth (mm) | Seed Thickness (mm) | 100 Fruit Weight (g) | Fruit Diameter (cm) | germination % | shoot length (cm) | Collar diameter (mm) | Tap root length (cm) | Max. diameter of tap root (mm) | No. of lateral roots | Shoot biomass |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Seed Length (mm) | 0.275 | -0.451** | 0.360* | 0.536** | -0.305 | 0.388* | 0.342* | -0.14 | 0.261 | 0.31 | 0.278 |
| Seed Breadth (mm) | | 0.063 | 0.549** | 0.544** | -0.288 | 0.105 | -0.234 | -0.721** | -0.461** | -0.319 | -0.285 |
| Seed Thickness (mm) | | | 0.221 | 0.045 | -0.554** | -0.279 | 0.099 | -0.266 | -0.029 | 0.180 | 0.168 |
| 100 Fruit Weight (g) | | | | 0.955** | -0.437** | 0.248 | 0.440** | -0.251 | 0.132 | 0.149 | 0.390* |
| Fruit Diameter (cm) | | | | | -0.337* | 0.363* | 0.485** | -0.327 | 0.061 | 0.139 | 0.363* |
| germination% | | | | | | -0.316 | -0.499** | 0.047 | -0.499** | -0.703** | -0.62** |
| shoot length (cm) | | | | | | | 0.751** | 0.248 | 0.425* | 0.640** | 0.657** |
| Collar diameter (mm) | | | | | | | | 0.403* | 0.711** | 0.863** | 0.952** |
| Tap root length (cm) | | | | | | | | | 0.802** | 0.521** | 0.553** |
| Max. diameter of tap root (mm) | | | | | | | | | | 0.863** | 0.871** |
| No. of lateral roots | | | | | | | | | | | 0.939** |

Critical 'r' value = 0.334 / 0.430 * indicates significance at P =< 0.05 level ** indicates significance at P =< 0.01 level

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