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**Modi JS**

Department of Silviculture and Agroforestry, ASPEE College of Horticulture and Forestry, Navsari Agricultural University Navsari, Gujarat, India

**Tandel MB**

Department of Silviculture and Agroforestry, ASPEE College of Horticulture and Forestry, Navsari Agricultural University Navsari, Gujarat, India

**Prajapati VM**

Department of Silviculture and Agroforestry, ASPEE College of Horticulture and Forestry, Navsari Agricultural University Navsari, Gujarat, India

**Ahir BR**

Department of Silviculture and Agroforestry, ASPEE College of Horticulture and Forestry, Navsari Agricultural University Navsari, Gujarat, India

## Morphological variations in teak (*Tectona grandis* L. f.) clones

Modi JS, Tandel MB, Prajapati VM and Ahir BR

**Abstract**

The investigation on "Morphological variations in Teak (*Tectona grandis* L. f.) clones" was carried out at Rajpipla Silviculture Forest Division, Rajpipla, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari (Gujarat). The experiment comprised of 15 clones viz., C<sub>1</sub>-Bandhpada (North Dangs), C<sub>2</sub>-Chikhli (South Dangs), C<sub>3</sub>-Nilambo (Dungarda), C<sub>4</sub>-African (Dungarda), C<sub>5</sub>-Satkhasi (Vyara), C<sub>6</sub>-Khalta (Bariya), C<sub>7</sub>-Achhala (Godhra), C<sub>8</sub>-Kevadi (Chotaudepur), C<sub>9</sub>-Raighadh (Sabarkantha North), C<sub>10</sub>-Danta (Banaskantha), C<sub>11</sub>-Vanaj (South Sabarkantha), C<sub>12</sub>-Dankiwadu (Gir West), C<sub>13</sub>-Bhavnath (Junagadh), C<sub>14</sub>-Develvel (Gir East) and C<sub>15</sub>-Khatam (Rajpipla East). This experiment was laid out in Randomized Block Design (RBD) comprising of fifteen clones and three replications. Significantly maximum plant height, diameter at breast height and 100 seed weight was noted in clone C<sub>7</sub> - Achhala (Godhra); leaf length in the clone C<sub>8</sub> - Kevadi (Chotaudepur); leaf width in the clone C<sub>13</sub> - Bhavnath (Junagadh); leaf area in the clone C<sub>14</sub> - Develvel (Gir East); petiole length in the clone C<sub>15</sub> - Khatam (Rajpipla East) and seed yield per plant C<sub>13</sub> - Bhavnath (Junagadh). The genotypic correlation coefficients were in general, higher than the corresponding phenotypic and environmental indicating strong inherent association between the characters. Seed yield had highly significant positive correlation with leaf width ( $r_g = 0.3315$ ). Whereas, seed yield had highly significant negative correlation with petiole length ( $r_g = -0.4024$ ) and diameter at breast height ( $r_g = -0.3078$ ). The rest of the traits showed non-significant positive or negative correlation. Path coefficient analysis indicated that the direct effect of diameter at breast height and petiole length on seed yield was of very high magnitude followed by leaf width.

**Keywords:** Teak, clone, morphological parameters, correlation co-efficient matrix

**Introduction**

The forests of India are ancient in nature with high diversity. They are not only rich in tree species composition but also provide shelter to a wide range of fauna, avian-fauna and insects. The teak tree is native to South-East Asia, more specifically to India, Myanmar, Thailand and Laos. Over the past 150 years, it has been planted extensively both within its native range and in other tropical and sub-tropical region of Asia, Africa and America. It is naturalized in the Indonesian island of Java and some of the smaller islands east of Java, where it is believed to have been introduced some 400-600 years ago.

Teak (*Tectona grandis*) is a tall and handsome deciduous tree representing Lamiaceae family in plant kingdom. Locally, it is also known as sagon, saigon, saj, taku, kayum, etc. in various Indian languages. Teak tree has an erect trunk, a cylindrical bole and an umbrella like beautiful crown. It tends to be fluted at the base. Its bark is thin, fibrous and light brown or grey in color which can be peeled off into long thin strips. Leaves are simple, opposite, large i.e. 30 to 50 cm x 25 cm, round, broad, pointed and thick in structure. New leaves emerge during May-June, whereas its flowers emerge in July-August. Its branches show 50 to 100 cm long whitish cymes. Individual florets are small and round with a diameter of about 4 mm. The fruits appear in August-September and ripe between November and January. Its seeds are small and require considerable time to germinate.

Teak genetic improvement was started in India in the year 1954. Teak improvement was limited to establishing seed production areas (SPAs) and clonal seed orchards (CSO). CSOs are established with grafted plants of superior phenotypes (plus trees) selected from natural forests and plantations. These "plus trees" were chosen at a very high intensity (often one in several hectares of forests) with rigorous selection criteria (Emmanuel and Bagchi, 1988 and Kumar *et al.* 1998) [3, 9].

More than 1,000 ha of CSOs have been established in India with 450 ha in Maharashtra, 240 ha in Madhya Pradesh, 120 ha in Karnataka, 92 ha in Andhra Pradesh, 35 ha in Kerala, 30 ha in Orissa and Tamil Nadu, and 25 ha in Arunachal Pradesh (Katwal, 2005). CSOs are the main focus of genetic improvement of teak in India; but the output from these orchards has been far

**Correspondence****Modi JS**

Department of Silviculture and Agroforestry, ASPEE College of Horticulture and Forestry, Navsari Agricultural University Navsari, Gujarat, India

from satisfactory. Poor flowering, asynchrony in flowering phenology, low fruit and seed set were the major problems faced by various scientists.

## Materials and Methods

The investigation on "Morphological variations in Teak (*Tectona grandis* L. f.) clones" was carried out at Rajjipla Silviculture Forest Division, Rajjipla, Gujarat. Clonal Teak Seed Orchard, Rajjipla (TSO) was established in 2000-2001 at Rajjipla in Narmada District for getting good quality seed material. For this purpose, planting materials from different forest ranges were collected and planted in nursery by cutting and thereafter, they were transplanted in the field. Totally, 15 plants from each of the 15 clones were planted at 4 X 4 m spacing. Clonal seed orchard, Rajjipla is located at 21° 53' N Latitude, 73° 31' E Longitude at 45 meters above the mean sea level in Narmada district of South Gujarat in India. The climate of Rajjipla is tropical characterized by fairly hot weather, moderately cold winter with humid and warm monsoon coupled with moderately heavy rainfall. The monsoon commenced from second week of June and lasts up to first week of October. Most of the precipitation received from the South-West monsoon during July and August. This experiment was laid out in Randomized Block Design (RBD) comprising of fifteen clones viz., C<sub>1</sub>-Bandhpada (North Dangs), C<sub>2</sub>-Chikhli (South Dangs), C<sub>3</sub>-Nilambo (Dungarda), C<sub>4</sub>-African (Dungarda), C<sub>5</sub>-Satkhasi (Vyara), C<sub>6</sub>-Khalta (Bariya), C<sub>7</sub>-Achhala (Godhra), C<sub>8</sub>-Kevadi (Chotaudepur), C<sub>9</sub>-Raighadh (Sabarkantha North), C<sub>10</sub>-Danta (Banaskantha), C<sub>11</sub>-Vanaj (South Sabarkantha), C<sub>12</sub>-Dankiwadu (Gir West), C<sub>13</sub>-Bhavnath (Junagadh), C<sub>14</sub>-Develvel (Gir East) and C<sub>15</sub>-Khatam (Rajjipla East) and three replications. The observations on various morphological parameters were recorded and analyzed as per methods prescribed by Panse and Sukhatme (1967) [11]. Karl Pearson's correlation coefficients of the geographical factors of seed origin with seed physical traits, seedling traits and early field growth traits were worked as per Panse and Sukhatme (1967) [11]. Phenotypic, genotypic and environmental correlation coefficients were estimated as per Searle (1961) [14] for morphological traits of Teak clones.

## Result and Discussion

### A. Morphological Parameters

#### 1. Plant height (m)

The mean data pertaining to morphological parameter presented in Table-1. It is evident from data that among various clones of Teak, there is significant amount of variation for plant height. Significantly higher plant height was found in the C<sub>7</sub>-Achhala (13.08 m) which was statistically at par with C<sub>11</sub>-Vanaj, C<sub>10</sub>-Danta and C<sub>12</sub>-Dankiwadu (12.08, 11.92 and 11.92 m, respectively). Whereas, lowest plant height was found in C<sub>3</sub>-Nilambo (10.42 m).

#### 2. Diameter at breast height (cm)

The data presented in Table- 1 revealed that diameter at breast height was registered significantly higher in clone C<sub>7</sub>- Achhala (18.50 cm) which was on same bar with C<sub>11</sub>- Vanaj (17.97 cm), C<sub>10</sub>- Danta (16.80 cm), C<sub>5</sub>-Satkhasi (16.40cm), C<sub>12</sub>-Dankiwadu (16.40 cm), C<sub>1</sub>-Bandhpada (16.30 cm) and C<sub>4</sub> - African (15.60 cm).

#### 3. Leaf attributes

It is evident from the data shown in Table-1 that significant variation in various leaves attributes (leaf length, leaf width, leaf area and petiole length) of various Teak clones.

Maximum leaf length, leaf width, leaf area and petiole length were noted in the clone C<sub>8</sub>- Kevadi (50.73 cm), C<sub>13</sub>-Bhavnath (33.67cm), C<sub>14</sub> – Develvel (307.00 cm<sup>2</sup>) and C<sub>15</sub>-Khatam (5.86 cm), respectively. Whereas Minimum leaf length, leaf width, leaf area and petiole length were noted in the clone C<sub>4</sub>- African and C<sub>9</sub>-Raighadh (36.00 cm), C<sub>2</sub>-Chikhli (21.40 cm), C<sub>3</sub>-Nilambo (190.00 cm<sup>2</sup>) and C<sub>3</sub>-Nilambo (1.14 cm), respectively.

#### 4. 100 seed weight (g)

The statistical analysis showed significant effect of different clones on 100 seed weight among different clones of *Tectona grandis* L. f. The 100 seed weight of Teak varied from 79.71 to 96.16 g (Table - 1). Among fifteen clones, the 100 seed weight (96.16 g) of *Tectona grandis* L. f. was recorded significantly higher in the clone C<sub>7</sub>-Achhala (Godhra) which was at par with C<sub>2</sub>-Chikhli (South Dangs, 95.17 g), C<sub>4</sub>-African (Dungarda, 94.70 g), C<sub>1</sub>- Bandhpada (North Dangs, 94.42 g), C<sub>10</sub>-Danta (Banaskantha, 93.36 g), C<sub>9</sub>-Raighadh (Sabarkantha North, 93.24 g), C<sub>14</sub>-Develvel (Gir East, 93.11 g), C<sub>11</sub>-Vanaj (South Sabarkantha, 91.49 g), C<sub>12</sub>-Dankiwadu (Gir West, 91.29 g), C<sub>3</sub>-Nilambo (Dungarda, 90.12 g), C<sub>5</sub>-Satkhasi (Vyara, 89.45 g) and C<sub>8</sub>-Kevadi (Chotaudepur, 88.20 g), The significantly lowest 100 seed weight was found in the clone of C<sub>13</sub>-Bhavnath (Junagadh, 79.71 g).

#### 5. Seed yield per plant (kg/plant)

From Table - 1, it is evident that during observation, the clone C<sub>13</sub>-Bhavnath (Junagadh) noted significantly higher seed yield per plant (1.53 kg) which was followed by C<sub>14</sub>-Develvel (Gir East, 1.27 kg). The significantly lowest seed yield per plant was found in the clone of C<sub>15</sub>-Khatam (Rajjipla East, 0.88 kg).

## Discussion

Variation in various morphological parameters might be due to the geographical variation or due to genetical constituent or better environment of the particular place. This variability might be substantially influenced by parental as well as environmental conditions. Similar variability was earlier reported by Bayramzadeh *et al.* (2012) [1] in Beech populations, Hidayat (2010) [5] in Surain tree, Dubey *et al.* (2006) [2] in *Jatropha curcas*. It has also been reported in this direction by Kumar *et al.* (2006a) [8] in *Pinus roxburghii*, Kumar *et al.* (2006b) [7] in *Jatropha curcas*, Ginwal *et al.* (2004) [4] in *Jatropha curcas*, Mohanty and Khurana (2003) [10] in clones of *Populus ciliate* x *Populus maximowiczii*, Raebild *et al.* (2003) [13] in *Prosopis cineraria*, Pathak (1998) [12] and Shivkumar and Banerjee (1986) [15] in *Acacia nilotica*.

## B Correlation coefficient matrix

### 1. Correlation matrix

The data on correlation matrix between seed yield and various morphological attributes in different clones of *Tectona grandis* L. f. are presented in Table - 2. The seed yield is significantly and positively correlated with diameter at breast height (0.4249) and 100 seed weight (0.2632).

### 2. Environmental, genotypic and phenotypic correlation coefficient analysis

The correlation coefficient between seed yield and other morphological traits were estimated at environmental, phenotypic and genotypic levels. The environmental ( $r_e$ ), genotypic ( $r_g$ ) and phenotypic ( $r_p$ ) correlation coefficient of

seven characters were studied and data are presented in Table - 3, 4 and 5.

It was observed from these correlations that genotypic correlations were higher in magnitude than their corresponding phenotypic and environmental correlations in most of the cases. From Table – 3, it is evident that seed yield had highly significant negative correlation with leaf area ( $r_c = -0.4859$ ). While, rest of the traits showed non-significant positive or negative correlation.

However in case of genotypic correlation matrix, seed yield had highly significant positive correlation with leaf width ( $r_g = 0.3315$ ). Whereas, seed yield had highly significant negative correlation with petiole length ( $r_g = -0.4024$ ) and diameter at breast height ( $r_g = -0.3078$ ). The rest of the traits showed non-significant positive or negative correlation.

In case of phenotypic correlation matrix, seed yield had highly significant negative correlation with petiole length ( $r_p = -0.3152$ ). While, rest of the traits showed non-significant positive or negative correlation.

**Table 1:** Variations of morphological attributes in different clones of *Tectona grandis* L. f.

Clones	Plant height (m)	Diameter at breast height (cm)	Leaf length (cm)	Leaf width (cm)	Leaf area (cm <sup>2</sup> )	100 Seed weight (g)	Seed yield (kg/plant)	Petiole length (cm)
C <sub>1</sub> -Bandhpada (North Dangs)	10.92	16.30	45.50	29.83	209.00	94.42	0.93	2.28
C <sub>2</sub> -Chikhli (South Dangs)	11.75	13.67	39.50	21.40	202.00	95.17	1.17	3.54
C <sub>3</sub> -Nilambo (Dungarda)	10.42	12.47	41.83	24.00	190.00	90.12	0.90	1.14
C <sub>4</sub> -African (Dungarda)	11.25	15.60	36.00	21.63	268.00	94.70	1.09	1.54
C <sub>5</sub> -Satkhasi (Vyara)	11.42	16.40	50.00	26.67	226.00	89.45	0.89	3.28
C <sub>6</sub> -Khalta (Bariya)	11.75	15.47	41.40	25.83	215.00	85.31	0.93	3.37
C <sub>7</sub> -Achhala (Godhra)	13.08	18.50	44.83	26.33	269.00	96.16	1.23	2.80
C <sub>8</sub> -Kevadi (Chotaudepur)	11.58	13.87	50.73	27.83	205.00	88.20	1.13	2.74
C <sub>9</sub> -Raighadh (Sabarkantha North)	11.00	15.00	36.00	22.83	299.00	93.24	1.06	2.77
C <sub>10</sub> -Danta (Banaskantha)	11.92	16.80	47.33	27.33	271.00	93.36	0.92	2.87
C <sub>11</sub> -Vanaj (South Sabarkantha)	12.08	17.97	38.67	25.83	244.00	91.49	0.89	4.25
C <sub>12</sub> -Dankiwadu (Gir West)	11.92	16.40	39.67	26.53	281.33	91.29	1.15	2.88
C <sub>13</sub> -Bhavnath (Junagadh)	10.58	13.60	43.83	33.67	200.00	79.71	1.53	1.90
C <sub>14</sub> -Develvel (Gir East)	11.42	15.03	41.33	25.80	307.00	93.11	1.27	2.42
C <sub>15</sub> -Khatam (Rajpipla East)	11.33	14.53	48.83	29.00	235.00	80.65	0.88	5.86
S. Em.±	0.451	1.000	2.494	1.615	11.012	3.223	0.073	0.193
C. D. at 5%	1.31	2.90	7.22	4.68	31.91	9.34	0.21	0.56
C. V.%	6.80	11.22	10.04	10.63	7.90	6.17	11.87	11.49

**Table 2:** Correlation matrix between seed yield and various morphological attributes in different clones of *Tectona grandis* L. f.

	Leaf area	Diameter at Breast Height	Plant Height	Petiole Length	Leaf Length	Leaf Width	100 Seed Weight	Seed Yield
<b>Leaf area</b>	1							
Diameter at Breast Height	0.4872	1						
Plant Height	0.3629	0.7415	1					
Petiole Length	0.0318	0.2417	0.3822	1				
Leaf length	-0.3750	-0.0044	0.0692	0.2709	1			
Leaf width	-0.2864	0.0272	-0.1632	0.1067	0.6089	1		
100 seed weight	0.4290	-0.2042	0.3837	-0.3274	-0.3744	-0.6368	1	
Seed Yield	0.1144	0.4249**	-0.0039	-0.3672	-0.1633	-0.1097	0.2632*	1
Significance Levels	0.05	0.01						
If Correlation r=>	0.2539	0.3801						

**Table 3:** Environmental correlation matrix between seed yield and various morphological attributes in different clones of *Tectona grandis* L. f.

	100 Seed weight (g)	Leaf area (cm <sup>2</sup> )	Plant height (m)	Petiole length (cm)	Leaf length (cm)	Leaf width (cm)	Diameter at breast height (cm)
100 Seed weight (g)	1	0.0340	0.3214*	0.2313	0.1824	-0.3322*	0.0769
Leaf area (cm <sup>2</sup> )		1	0.0134	0.1032	0.0820	0.1983	-0.3199*
Plant height (m)			1	0.1937	-0.0949	-0.4205**	0.4408**
Petiole length (cm)				1	0.1987	-0.1818	0.0611
Leaf length (cm)					1	0.4584**	0.2109
Leaf width (cm)						1	0.0312
Diameter at breast height (cm)							1
Seed yield (kg) r (e)	-0.1989	-0.4859***	-0.0253	-0.0260	-0.0275	0.0013	0.0992
Significance Levels	0.05	0.01					
If Correlation r=>	0.2939	0.3801					

**Table 4:** Genotypic correlation matrix between seed yield and various morphological attributes in different clones of *Tectona grandis* L. f.

	100 Seed weight (g)	Leaf area (cm <sup>2</sup> )	Plant height (m)	Petiole length (cm)	Leaf length (cm)	Leaf width (cm)	Diameter at breast height (cm)
<b>100 Seed weight (g)</b>	<b>1</b>	0.5727***	0.4341***	-0.4645***	-0.6626***	-0.7975***	0.6403***
Leaf area (cm <sup>2</sup> )		<b>1</b>	0.5178***	0.0289	-0.4741***	-0.3819**	0.7051***
Plant height (m)			<b>1</b>	0.5022***	0.1670	-0.0260	0.9624***
Petiole length (cm)				<b>1</b>	0.3011*	0.1446	0.2981*
Leaf length (cm)					<b>1</b>	0.6634***	-0.1028
Leaf width (cm)						<b>1</b>	0.0257
Diameter at breast height (cm)							<b>1</b>
Seed yield (kg) r (g)	-0.0849	0.1910	0.0042	-0.4024**	-0.2009	0.3315*	-0.3078*
Significance Levels	0.05	0.01					
If Correlation r=>	0.2939	0.3801					

**Table 5:** Phenotypic correlation matrix between seed yield and various morphological attributes in different clones of *Tectona grandis* L. f.

	100 Seed weight (g)	Leaf area (cm <sup>2</sup> )	Plant height (m)	Petiole length (cm)	Leaf length (cm)	Leaf width (cm)	Diameter at breast height (cm)
<b>100 Seed weight (g)</b>	<b>1</b>	0.3040*	0.3543*	-0.2002	-0.1510	-0.5139***	0.2743
Leaf area (cm <sup>2</sup> )		<b>1</b>	0.2448	0.0382	-0.2614	-0.1724	0.2678
Plant height (m)			<b>1</b>	0.2979*	0.0006	-0.2660	0.6044***
Petiole length (cm)				<b>1</b>	0.2392	0.0597	0.1888
Leaf length (cm)					<b>1</b>	0.5566***	0.0782
Leaf width (cm)						<b>1</b>	0.0286
Diameter at breast height (cm)							<b>1</b>
seed yield (kg) r (p)	-0.1357	0.0049	-0.0110	-0.3152*	-0.1229	0.1875	-0.1056
Significance Levels	0.05	0.01					
If correlation r=>	0.2939	0.3801					

## Conclusion

From this morphological variation study it is concluded that significant variations were observed in morphological parameters. Significantly maximum plant height and diameter at breast height were noted in clone C<sub>7</sub> - Achhala (Godhra); leaf length in the clone C<sub>8</sub> - Kevadi (Chotaudepur); leaf width in the clone C<sub>13</sub> - Bhavnath (Junagadh); leaf area in the clone C<sub>14</sub> - Develvel (Gir East) and petiole length in the clone C<sub>15</sub> - Khatam (Rajpipla East). However, the genotypic correlation coefficients were in general and higher than the corresponding phenotypic and environmental indicating strong inherent association between the characters. Seed yield had highly significant positive correlation with leaf width ( $r_g = 0.3315$ ). Whereas, seed yield had highly significant negative correlation with petiole length ( $r_g = -0.4024$ ) and diameter at breast height ( $r_g = -0.3078$ ). The rest of the traits showed non-significant positive or negative correlation.

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