

ESTIMATION OF FIELD ENVIRONMENT VARIABILITY FOR GERMINATION AND SEEDLING TRAITS IN *MADHUCA INDICA* GMEL.

Mohd. Saleem Wani and Latief Ahmad*

School of Forestry and Environment,
Allahabad Agricultural Institute, Deemed-University, Allahabad, India
*Division of Agronomy SKUAST-Kashmir

aas_srinagar@rediffmail.com

ABSTRACT

The study was conducted under field environment in the nursery of the School of Forestry and Environment, Allahabad Agricultural Institute, Deemed-University, Allahabad, situated at 25.28°N latitude and 81.55°E longitude, twenty (20) genotypes of *Madhuca indica* Geml scattered over district Allahabad and adjoining areas in Uttar Pradesh in their natural range were studied for the pattern of genetic variation. Higher values for phenotype coefficient of variation as compared to genotypic coefficient of variation in germination and seedling growth traits indicating that they are greatly influenced by the environment. The heritability and expected genetic gain were also observed to be high to moderate for these traits. There is wide scope for early screening of the genotypes because of the positive and significant correlation at 5% level of significance among germination traits with each other except for few traits times with each other such as internodal length with number of leaves per seedling, number of leaves with dry weight of shoot, fresh weight of root and total biomass of seedling etc. The respective genotypes S₂₀, S₁₂, S₉ and S₁₉ showed comparatively good performance and are recommended for further genetic improvement programme in this species.

Key words: variability, environment and germination

INTRODUCTION

Madhuca indica Gmel commonly known as Mahua belongs to family “Sapotaceae”. It is a deciduous, medium sized tree, attaining a height of 12-18 m, usually with a short bole and a girth of 2-4 m (Troup, 1921). The tree is essentially found in the dry tropical and sub-tropical climate, where the absolute maximum shade temperature varies from 28.5⁰C to 48.5⁰C and the absolute minimum varies from 1.7⁰C to 11.7⁰C. The normal rainfall in its natural habitat varies from 750 to 2000 mm or more. Mahua occurs below 800 m amsl as the attitudinal range above sea level. It is widely grown in large parts of India from Indo-gangetic plains in the North to Tamil Nadu in South (Troup, 1921).

Madhuca indica is economically important because of its multifarious uses. Almost all parts roots, bark, latex- juice, seed and oil are known to possess medicinal properties, (Chopra and Nagar, 1956). The leaves are astringent; bark is used for rheumatism, ulcers and diabetics mellitus (Ayurvedamfitham, 2007). Flowers are used in cough, cold and bronchitis. Mahua seed oil possesses biodiesel properties (Ghadge and Raheman, 2005). Madhua wood is durable and lasts well under water. The timber can be put to a variety of uses. Virtually being the lifeline of tribal belt in Central India. The tree is culturally most identified with Indian life in plains. The tree wins in fame due to liquor distilled from the flowers which are used to make vinegar (Troup, 1921).

In spite of multifarious and diversified uses of Mahua, the species is not getting due consideration from silvicultural and management point of view for the reason of other commercial crops, due to which the genetic resources of the species are depleting hard and fast. The species, therefore, is urgently required to be conserved. In addition large-scale artificial regeneration and tree improvement of the species is urgently required to augment the economy. To begin with, it is important to study the variability existing in the species and to select superior genotypes for adoptability, fast growth, oil content and disease resistance. It is desirable to screen the naturally available genetic

variation so as to ensure that only the best material is utilized for maximum productivity and for further breeding work (Shiva Kumar and Banergjee, 1986).

In this research paper a successful attempt was made to find out the variation in germination, morphological and biomass traits of twenty (20) genotypes collected from different geographical locations in Uttar Pradesh.

MATERIALS AND METHODS

The study was conducted in the Forest Nursery of Allahabad Agricultural Institute-Deemed University, Allahabad, situated at 25.28°N latitude and 81.55°E longitude. The area is located at an altitude of 98 m above average mean sea level, and enjoys sub-tropical type of climate. Candidate plus trees of *Madhuca indica* were marked using the following criteria; Height (m), Diameter at breast height (m), Seed length (cm), Seed diameter (cm), free from disease and insect-pests and straight, non-forked cylindrical bole. Following the above criteria, fresh and fully ripened open pollinated seeds of 20 plus trees were collected from different geographical locations in district Allahabad and adjoining areas in Uttar Pradesh during July, 2010 (Table 1).

Four seed samples were randomly collected from each select plus tree from 20 different sites or locations for the measurement of seed parameters. The seed length and seed diameter were measured by using vernier caliper for four replications, 100 seed weight was also recorded for four replications of 100 seeds each randomly selected from seed samples collected. Germination tests were conducted under field (open) environment between 30-35°C. Three replications of 40 seeds each were used for the test. 120 seeds of each plus tree were simultaneously sown under field environment in nursery, in polythene bags at a depth of 1.0 cm containing potted mixture of soil, sand and farm yard manure (1:1:1) in three replicates used Randomized Block Design (RBD) during last week of July, 2010. Plant to plant distance was kept at 15 cm and row to row distance at 30 cm. A uniform pre-treatment was given to the seeds by soaking in warm water, allowed to cool and kept soaked for 24 hours. Watering was done daily and polythene bags were placed on raised beds to avoid water logging, regular weeding was done as per requirement.

104 The germination count was recorded on every alternate day for 30 days. Various
105 germination indices viz., germination percentage (GP), germination energy index (GEI),
106 mean daily germination (MDG), peak value (PV), germination value (GV) and
107 germination speed (GS) were calculated following Czabator (1962). Observations on
108 seedling height, seedling collar diameter, internodal length, number of leaves per
109 seedling, leaf area, shoot fresh and dry weight, root fresh and dry weight, shoot/root ratio
110 and total biomass of seedlings were taken after one growing season. 15 seedlings per
111 replication i.e. 45 seedlings per plus tree progeny/ family, randomly selected were taken
112 for the purpose of observations.

113 The recorded observations were subjected to analysis of variance (ANOVA) to
114 understand the significance of differences among 20 plus tree progenies. Least significant
115 difference (LSD) was calculated and plus tree progenies were ranked for the variables
116 studied using a computer software program "SPSS". Coefficient of variance (CV %) and
117 linear correlation coefficients among studied traits were calculated as described by
118 Snedecor and Cochran (1967). Various genetic parameters like genotypic coefficient of
119 variance (GCV), phenotypic coefficient of variance (PCV), broad sense heritability,
120 estimated genetic advance and genetic gain were determined following Johnson *et al.*
121 (1955).

122

123 **RESULTS AND DISCUSSION**

124 **Germination and seedling growth:**

125 An appraisal of the data presented in Table 2 pertains to germination traits of 20
126 different genotypes of *Madhuca indica* under field environment. Analysis of variance
127 indicated highly significant differences ($P < 0.05$) among the 20 genotypes for all the
128 traits studied. The maximum value for germination per cent (90.00) was recorded for S₂₀
129 which was followed by S₁₉ (71.67). The maximum value for germination energy index
130 (37.50) per cent was recorded for S₂₀ which was followed by S₉ (29.86) per cent. The
131 maximum value (3.21) for mean daily germination was exhibited by S₂₀ which was
132 followed by S₉ (2.56). The maximum value (4.67) for peak value was revealed by S₂₀
133 followed by S₉ (3.67). The maximum value for germination value was recorded for S₂₀

134 (15.00) followed by S₉ (9.35). The maximum value for germination speed (1.37) was
135 recorded for S₂₀ followed by S₉ (1.06).

136 The differences among 20 genotypes of plus tree progenies were noticed to the
137 significant ($P < 0.05$) for germination, morphological and biomass traits (Table 2 and 3).
138 The maximum seedling height (24.02 cm) was recorded for S₈ followed by S₁₃ (22.88
139 cm). The maximum collar diameter (6.73 mm) was revealed for S₂₀ followed by S₁₉ (6.33
140 mm). The maximum value for internodal length (3.25 cm) was observed for S₇ followed
141 by S₈ (2.83 cm). Maximum number of leaves per seedling (9.73) was noticed in S₁₅
142 proceeded by S₁₃ (9.63). The maximum leaf area (43.20 cm²) was recorded for S₂₀ which
143 was followed by S₁₉ and S₁₀ (40.00 cm²). The maximum shoot fresh weight (8.77 g) was
144 revealed for S₂₀ followed by S₉ (8.04 g). The maximum shoot dry weight (2.14 g) was
145 noticed for S₂₀, statistically at par with S₂, S₈ and S₁₃ (1.77). The maximum root fresh and
146 dry weight (15.23 g) and (3.93 g) both were recorded for S₁₂. The highest value (0.80) for
147 shoot/root ratio was recorded for S₁₀, followed by S₁₇ (0.64). The maximum value (23.00
148 g) registered for total biomass of seedling was revealed for S₁₂ followed by S₁₉ and S₅
149 (22.50 g).

150 Variations refer to the observable differences in individual for a particular trait.
151 These differences may partly due to genetic factors and partly due to environmental
152 effect. The observed value of a trait is the phenotypic value of that individual. The related
153 magnitude of these components determines the genetic properties of any particular
154 species (Jain, 1982). The extent of variation observed in germination value (CV–
155 54.79%), germination speed (CV–43.39%) and germination per cent (CV–27.50%)
156 (Table 2) was found to be high as compared to other germination traits studied. Whereas,
157 the extent of variation observed in internodal length (CV–18.89%), root fresh weight
158 (CV–18.59%) and seedling height (CV–18.51%) was found to be high as compared to
159 other morphological and biomass traits studied (Table 3). The variation noticed among
160 the 20 plus tree progenies/genotypes might have arisen due to the fact that such
161 genotypes grew in different edaphic and micro-climatic (locality) conditions and must
162 have experienced varying pressures of natural selection. The differences observed in
163 morphological and biomass traits may be attributed to genetic in nature as a result of
164 adaptation to diverse environmental conditions (Mathur *et al.*, 1984). Similar significant
165 variation in germination, morphological and biomass traits has earlier been reported in

166 *Acacia mangium* (Salazer, 1989), *A. nilotical* (Sneizko and Stewart, 1989), *Albizia*
167 *chinensis* (Dhanai *et al.*, 2003), *Cassia ariculata* (Sekaran *et al.*, 1997), *Dalbergia sessoo*
168 (Singh and Pokhriyal, 2001), *Tecomella undulate* (Arya *et al.*, 1993).

169 The extent of variability is also assessed by genotypic and phenotypic variances
170 and genotypic and phenotypic coefficient of variation (Subramanian *et al.*, 1995). All the
171 germination traits viz., germination per cent, germination energy index, mean daily
172 germination peak value, germination value and germination speed, and morphological
173 and biomass traits studied viz., seedling height, seedling collar diameter, internodal
174 length, number of leaves per seedling, leaf area, fresh and dry shoot weight, fresh and
175 dry root weight, shoot/root ratio and total biomass of seedling under field environment
176 showed higher values for phenotypic coefficient of variation as compared to their
177 corresponding genotypic coefficient of variation (Table 4). This indicated that all these
178 traits are greatly influenced by environment. Similar findings were reported by
179 Whitemore (1971) for seedling height, diameter and number of branches in *Cedrela*
180 species and Khosla *et al.*, (1985) in *Pinus roxburghii* stands.

181 The heritability was maximum for leaf area (99.39%) respectively followed by
182 germination speed (84.56%), germination per cent (77.90%), mean daily germination
183 (76.70%), seedling height (73.89%) and internodal length (72.59%). The heritability
184 values were ranging from very high to moderately high for almost all the traits study. The
185 top ranking value was exhibited by leaf area (99.39%) and the bottom ranking value was
186 recorded for peak value (34.34%). Although heritability in broad sense may give useful
187 indication about the relative value of selection in the material at hand; to arrive at a more
188 reliable conclusion, heritability and associated genetic gain should be considered jointly
189 (Johnson *et al.*, 1995). The expected genetic gain was ranging from quite high (85.59%)
190 for germination value to moderate (12.67%) for seedling collar diameter. The traits
191 germination value (85.59%), germination speed (79.80%), germination per cent
192 (47.80%), mean daily germination (46.79%), germination energy index (46.26%), leaf
193 area (42.60%), seedling height (30.40%) and fresh weight of shoot (27.25%) were found
194 to be associated with higher amount of genetic gains indicating a wide scope of genetic
195 improvement (Table 4). These findings are in line with those of Ramachandra (1996) in
196 *Acacia catechu*, Deragiri *et al.*, (1997) in *Heracleum candicans* and Subramanian *et al.*,
197 (1995) in *Euclyptus grandis*.

198 The correlation coefficient among the germination, morphological and biomass
199 traits studied is presented in Table 5 and 6. A perusal of data in Table 5 revealed that
200 correlations between all the germination traits with each other showed positive and
201 significant correlation at 5% level of significance. Scrutiny of data in Table 6 revealed
202 that all the morphological and biomass traits with each other except for internodal length
203 times with number of leaves per seedling, number of leaves per seedling times with dry
204 weight of shoot, root fresh weight and total biomass of seedling showed positively non-
205 significant correlation at 5% level of significance. shoot/root ratio with all traits and
206 shoot/root ratio with total biomass of seedling showed negatively non-significant
207 correlation with each other at 5% level of significant. Langdom (1958), Williams (1967)
208 and Kandya (1978) have earlier reported similar results in *pinus elliottii*, *pinus oocarpa*
209 and *pinus dasycarpa*. It can therefore be inferred that the positive correlation among all
210 the germination, morphological and biomass traits can be used for early screening of the
211 genotypes. The results are also useful for the further improvement of the species.

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213 **CONCLUSION**

214 On the basis of mean performance of 20 genotypes of *Madhuca indica*, from the
215 present study it is clear that considerable genetic differences exist in all the important
216 traits of germination and seedling growth among the genotypes. Overall, the plus tree
217 progenies of S₂₀, S₁₂, S₉ and S₁₉ accordingly have shown better germination and seedling
218 growth performance for majority of the traits as compared to the rest of the genotypes as
219 discussed above. They are also expected to do well in greenhouse environment as
220 positive correlation between greenhouse and field performance in a number of tree
221 species has been reported by many researchers viz; Gupta *et al.* (1991) and Ginwal and
222 Gera (2000) in *Dalbergia sissoo*. Therefore, we recommend the genotypes S₂₀, S₁₂, S₉
223 and S₁₉ for further genetic improvement programme.

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316 **Table 1. Passport details and Morphological observations of twenty (20) plus trees**
 317 **(S₁-S₂₀) of *Madhuca indica* Gmel.**

Notation	PT/Site (Name)	Latitude	Longitude	Height (m)	Dbh(m)	Seed length (cm)	Seed diameter (cm)
S ₁	Hanumanganj	25° 42' N	82° 04' E	14.5	2.8	3.5	1.7
S ₂	Ghoorpur (Mankawar)	25° 18' N	81° 48' E	14.8	3.2	3.4	1.5
S ₃	Phulpur (Munshikapur)	26° 08' N	82° 86' E	16.2	2.5	3.4	1.6
S ₄	Jhansi (Sarianayat)	25° 25' N	81° 54' E	13.7	3.5	3.7	1.4
S ₅	Naini (Kharkawni)	25° 21' N	81° 51' E	17.1	2.9	3.5	1.7
S ₆	Naini (Chakka)	25° 27' N	81° 51' E	13.5	2.8	3.2	1.5
S ₇	Sahsoo (Badrahikapur)	25° 29' N	81° 58' E	12.3	3.9	3.8	1.6
S ₈	Dandi (Muhabatgaj)	25° 24' N	81° 50' E	17.5	2.3	3.1	1.5
S ₉	Jhalwa (Peepal)	25° 25' N	82° 46' E	14.2	3.6	3.4	1.8
S ₁₀	Mahewa (Agri-field)	25° 24' N	81° 51' E	15.6	3.2	3.9	1.7
S ₁₁	Gousi (Aravikalla)	25° 26' N	82° 05' E	12.3	4.1	3.2	1.6
S ₁₂	Phulpur (Malaka)	25° 33' N	81° 92' E	18.3	2.7	3.3	1.7
S ₁₃	Sarila	25 °46' N	79° 43' E	13.9	3.7	3.0	1.6
S ₁₄	Jalalpur (Khurd)	25° 36' N	81° 27' E	14.8	3.2	3.4	1.8

S ₁₅	Dandi (Muradpur)	25 °22' N	81° 51' E	17.3	3.6	3.2	1.8
S ₁₆	Naini (Tilakwar)	25 °19' N	81° 52' E	12.7	3.5	3.3	1.4
S ₁₇	Gauhania (Govti)	25° 14' N	81° 41' E	16.8	2.9	3.1	1.5
S ₁₈	Nawabganj	26 °56' N	82 °12' E	16.5	4.2	3.9	1.9
S ₁₉	Naini (Madhupur)	25 ⁰ 43' N	82 ⁰ 16' E	15.9	3.4	3.3	1.5
S ₂₀	Karhedahm (The.)	25 ⁰ 26' N	81 ⁰ 50' E	18.2	3.7	3.6	1.8

318 **Table 2. Mean performance of 20 plus trees of *Madhuca indica* for germination**
319 **traits under field environment during 2010.**

Sites		Germination (%)	Germination Energy Index	Mean daily Germination	Peak value	Germination value	Germination speed
S ₁		48.33	20.25	1.73	2.00	3.45	0.50
S ₂		35.00	14.58	1.25	2.33	2.98	0.38
S ₃		45.00	18.75	1.61	2.33	3.93	0.44
S ₄		68.33	26.25	2.32	2.67	6.25	1.00
S ₅		58.33	24.31	2.08	2.00	4.17	0.88
S ₆		51.00	20.14	1.65	3.00	5.18	0.45
S ₇		42.00	16.67	1.48	2.67	3.95	0.52
S ₈		41.33	15.97	1.37	2.33	3.15	0.36
S ₉		71.67	29.86	2.56	3.67	9.35	1.06
S ₁₀		60.33	24.46	2.08	3.33	7.02	0.86
S ₁₁		38.33	15.97	1.32	2.00	2.64	0.39
S ₁₂		40.00	16.67	1.43	2.33	3.33	0.46
S ₁₃		51.67	21.53	1.85	3.33	6.25	0.58
S ₁₄		70.00	29.17	2.50	2.33	5.77	0.89
S ₁₅		39.67	17.84	1.49	2.00	2.66	0.48
S ₁₆		65.00	27.08	2.12	2.67	6.65	0.89
S ₁₇		53.33	22.22	1.90	3.33	6.43	0.55
S ₁₈		66.67	27.78	2.38	3.00	7.14	0.90
S ₁₉		37.00	17.58	1.49	2.00	2.71	0.36
S ₂₀		90.00	37.50	3.21	4.67	15.00	1.37
Mean		53.65	22.23	1.89	2.70	5.35	0.67
Range	Min	35.00	14.58	1.25	2.00	2.64	0.36
	Max	90.00	37.50	3.21	4.67	15.00	1.37
Coefficient of Variance (CV)		27.50	26.91	27.15	25.93	54.79	43.39
F – test		S	S	S	S	S	S
S. Ed. (±)		6.13	2.57	0.22	0.62	1.56	0.10
C.D. at (5%)		12.42	5.19	0.44	1.25	3.16	0.20

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Table 3. Mean performance of 20 sites for morphological and biomass characters of *Madhuca indica* in open condition during 2010.

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Sites	Seedling height (cm)	Collar diameter (mm)	Internodal length (cm)	No. of leaves per seedling	Leaf area (cm ²)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Dry weight of root (g)	Shoot/Root ratio	Total biomass of seedling (g)
S ₁	13.35	4.27	1.93	7.33	31.30	5.37	1.46	7.60	1.92	0.80	12.97
S ₂	14.63	6.31	1.85	8.40	27.90	6.77	1.73	10.80	2.90	0.60	17.57
S ₃	13.00	5.05	2.15	6.33	22.40	7.57	2.00	14.37	3.76	0.54	21.93
S ₄	13.98	5.27	1.50	9.34	32.50	5.82	1.48	9.76	2.66	0.55	15.58
S ₅	17.85	4.93	2.50	8.87	28.50	7.90	2.04	14.60	3.85	0.53	22.50
S ₆	22.15	5.53	2.47	9.13	26.80	5.68	1.38	9.80	2.65	0.52	15.48
S ₇	18.18	5.90	3.25	6.00	20.70	6.27	1.52	13.28	3.59	0.42	19.55
S ₈	24.02	5.60	2.83	8.73	33.40	7.28	1.77	12.60	3.38	0.52	19.88
S ₉	17.07	5.48	1.95	9.00	28.40	8.04	1.98	11.97	3.18	0.62	20.01
S ₁₀	18.50	6.03	2.10	9.03	40.00	7.23	1.70	12.42	3.22	0.53	19.66
S ₁₁	18.83	6.17	2.29	9.20	27.00	5.41	1.39	10.77	3.01	0.46	16.18
S ₁₂	19.75	5.33	2.57	8.00	26.50	7.77	1.91	15.23	3.92	0.49	23.00
S ₁₃	22.88	6.27	2.34	9.63	31.60	7.44	1.77	13.00	3.48	0.51	20.44
S ₁₄	13.14	4.93	1.48	9.10	25.30	5.43	1.32	8.53	2.33	0.57	13.97
S ₁₅	21.11	6.00	2.12	9.73	25.20	7.00	1.55	11.83	3.12	0.50	18.83
S ₁₆	18.31	4.73	2.44	8.80	38.30	5.74	1.39	11.44	3.13	0.45	17.18
S ₁₇	14.27	4.48	1.93	7.73	24.50	5.95	1.44	8.67	2.24	0.64	14.62
S ₁₈	19.00	5.13	2.23	8.47	36.70	7.16	1.74	12.73	3.39	0.51	19.90
S ₁₉	20.10	6.33	2.27	9.27	40.00	7.60	1.81	14.90	3.77	0.48	22.50
S ₂₀	18.73	6.73	1.94	9.53	43.20	8.77	2.14	13.60	3.56	0.60	22.37
Mean	17.94	5.54	2.21	8.58	30.51	6.81	1.68	11.90	3.15	0.54	18.70
Range	Min.	13.00	4.27	1.48	6.00	20.70	5.37	1.32	7.60	1.92	12.97
	Max.	24.02	6.73	3.25	9.73	43.20	8.77	2.14	15.23	3.92	23.00
Coefficient of variance (CV)	18.51	11.81	18.89	12.03	12.03	15.05	15.03	18.59	17.84	15.54	16.57
F-test	S	S	S	S	S	S	S	S	S	S	S
S.Ed. (±)	1.59	0.53	0.20	0.62	0.40	0.70	0.19	1.30	0.34	0.05	1.92
C.D. at 5%	3.23	1.08	0.40	1.25	0.82	1.42	0.39	2.64	0.69	0.10	3.90

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Table 4. Estimation of components of variance for germination, morphological and biomass traits of twenty (20) plus tree progenies of *Madhuca indica* in open condition during 2010.

Traits	Mean	(PCV)	(GCV)	Heritability (h ²) (%)	Genetic advance (GA)	Genetic gain (%)
Germination (%)	53.65	29.78	19.29	77.90	25.64	47.80
Germination energy index	22.23	29.28	25.64	76.70	10.28	46.26
Mean daily	1.89	29.51	25.89	76.98	0.88	46.79
Peak value	2.70	34.58	20.26	34.34	0.66	24.46
Germination value	5.35	62.05	50.78	66.96	4.58	85.59
Germination speed	0.69	45.81	42.12	84.56	0.53	79.80
Seedling height (cm)	17.94	20.53	17.41	73.89	5.45	30.40
Collar diameter (mm)	5.54	15.22	9.67	40.42	0.70	12.67
Internodal length (cm)	2.21	20.90	17.80	72.59	0.69	31.25
No. of leaves per seedling	8.58	14.00	10.91	60.70	1.50	17.51
Leaf area (cm ²)	30.51	20.84	20.78	99.39	13.02	42.68

Fresh weight of shoot (g)	6.81	18.22	13.91	52.40	1.34	19.67
Dry weight of shoot (g)	1.68	18.93	12.64	44.60	0.29	17.39
Fresh weight of root (g)	11.90	21.59	16.90	61.28	3.24	27.25
Dry weight of root (g)	3.15	20.89	16.10	59.38	0.81	25.55
Shoot/Root ratio	0.54	17.792	14.283	64.44	0.12	23.620
Total biomass of seedling (g)	18.70	19.50	14.88	58.28	4.38	23.41

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350 **Table 5. Correlation coefficient between different germination traits of *Madhuca***
351 ***indica* in open condition during 2010.**

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Traits	Germination (%)	Germination energy index	Mean daily germination	Peak value	Germination value	Germination speed
Germination (%)	1.000	0.999*	0.988*	0.716*	0.893*	0.966*
Germination Energy Index	-	1.000	0.994*	0.702*	0.893*	0.960*
Mean Daily Germination	-	-	1.000	0.708*	0.900*	0.964*
Peak Value	-	-	-	1.000	0.929*	0.666*
Germination Value	-	-	-	-	1.000	0.860*
Germination Speed	-	-	-	-	-	1.000

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Table 6. Correlation coefficient between different morphological and biomass traits of *Madhuca indica* in open condition during 2010.

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Traits	Seedling height (cm)	Collar diameter (mm)	Internodal length (cm)	No. of leaves per seedling	Leaf area (cm ²)	Fresh weight of shoot (g)	Dry weight of shoot (g)	Fresh weight of root (g)	Dry weight of root (g)	Shoot/Root ratio	Total biomass of seedling (g)
Seedling height (cm)	1.000	0.527*	0.769*	0.538	0.376*	0.459*	0.282	0.574*	0.601	-0.562	0.560*
Collar diameter (mm)	-	1.000	0.135*	0.614	0.330*	0.559	0.457*	0.503*	0.523	-0.379	0.542*
Internodal length (cm)	-	-	1.000	-0.065	0.173*	0.324*	0.276	0.596*	0.608*	-0.485	0.530
No. of leaves per seedling	-	-	-	1.000	0.424*	0.112	-0.099	0.059*	0.109	-0.391	0.079*
Leaf area (cm ²)	-	-	-	-	1.000	0.309*	0.238*	0.228	0.274*	-0.132	0.307
Fresh weight of shoot (g)	-	-	-	-	-	1.000	0.955*	0.821	0.790	-0.171	0.914*
Dry weight of shoot (g)	-	-	-	-	-	-	1.000	0.776*	0.744*	-0.031	0.867
Fresh weight of root (g)	-	-	-	-	-	-	-	1.000	0.990*	-0.594	0.982*
Dry weight of root (g)	-	-	-	-	-	-	-	-	1.000	-0.663	0.965*
Shoot/Root ratio	-	-	-	-	-	-	-	-	-	1.000	-0.478
Total biomass of seedling (g)	-	-	-	-	-	-	-	-	-	-	1.000

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