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VARIATION IN MORPHOMETRIC TRAITS OF FRUITS AND SEEDS OF *MORUS ALBA* L.

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ABSTRACT

The present study of variation in morphometric traits of fruits and seeds of *Morus alba* L. was initiated to identify potential germplasm for improving the species productivity. Significant variation was observed in different fruit and seed parameters. It was observed that various fruit parameters like fruit length, fruit width, stalk length and fruit weight significantly differed among the studied sources with the maximum average fruit length (3.98cm), fruit width (2.69cm), stalk length (4.58cm) and fruit weight (9.37g) were recorded from T2 (Khoverpora) source of Anantnag district. In addition to this, the same source recorded highest values for germination percentage (94%), mean daily germination (4.43), peak value (11.60), germination energy (85.50), germination value (51.45) and seed weight (2.52g). The data revealed that there exists significant positive genotypic correlation between various fruit as well as seed parameters. Selection of genetically diverse seed sources and evaluation of their potential could, therefore, be one of the futuristic strategies to identify superior source for improving the species productivity.
Keywords **:** *Morus alba,* morphometric traits, fruit and seed parameters, germination, variation.

Introduction

Mulberry is considered as a unique and remarkable plant across the globe because of its origin in the Himalayan foothills of India and China with wider geographical spread, growing fastly, deciduous woody tree species of the family Moraceae (Yuan and Zhao, 2017; Rohela *et al*., 2020). It is considered one of the most important plants with respect to the nutrition of *Bombyx mori* including its economic importance in the production of mori silk (*Bombyx mori*) larvae (Vijayan *et al*., 1998). Moreover, it is widely utilized for production of mulberry products which are a great source of employment generation. Mulberry is one of the great examples of sustainable development because it is used in plethora of sectors *viz* food, pharmaceutical and cosmetic in a way so as to provide sustainable benefits to present generation as well as needs and aspirations of the future generations. The fruits of *Morus alba* L. are eaten raw and are also used to make wine, when dried. The fruit has much significance in traditional Chinese medicine, where it is used to purify blood and treat diabetes. Many parts of white mulberry are used in ethno-medicine. The fruit contains essential fatty acids like palmitic, oleic and linoleic acids that are essential for cell membrane formation and functioning of nervous system by Ercisli and Orhan (2007).

Genetic diversity is a critical component in designing effective breeding programs for any crop. The success of hybridization and subsequent selection largely hinges on choosing parent plants with high genetic variability across various traits. Genetically diverse parents are more likely to yield heterotic effects and desirable segregates. Numerous studies have highlighted the importance of genetic divergence in identifying suitable parent plants (Archana *et al*., 2018). Genetic diversity serves as the foundation and its role in enhancing plant breeding through a diverse gene pool is indispensable (CGR, 2005). Furthermore, genetic diversity within and among populations is essential for conserving plant genetic resources, ensuring their availability for both current and future

needs (Quedraogo, 2001). It plays a crucial role in ensuring the prolonged survival of a species, fostering adaptability in the face of evolving environmental conditions. Source variation is an important consideration in tree improvement programs, particularly for species that exhibit high levels of genetic diversity. The selection of superior trees for seed collection and subsequent propagation can improve the performance of forest plantations and reforestation programmes. Genetic variation in provenances of tree species evolves either through local adaptation or genetic drift (Hamrick 1990), which provides evolutionary flexibility and enables a response to environmental change (Booth and Grime 2003). The natural variations in climate, ecology, and environment in different geographical regions induce genetic differences in morphology, physiology, and biochemistry of plant species (Jones *et al*., 2001). As a consequence, a plant species may respond differently in a new ecological region, compared to the original geographical location (Bower *et al*., 2014).

The benefits of using genetically diverse seed sources include improved growth and yield, increased resistance to pests and diseases, and enhanced adaptability to environmental stresses. In addition, the use of genetically diverse seed sources can help to maintain the genetic diversity of forest ecosystems, reducing the risk of genetic erosion and promoting long-term sustainability. Present study intends to discern the best source for propagation and screen out the best source for multiplication in the future, based on growth performance of the seedlings after germination from different sources.

Materials and Methods

Identification of mother trees as seed source:

The *Morus alba* trees were selected from ten sources (two sites representing two sources from each of the five districts *viz.*, Anantnag, Pulwama, Ganderbal, Kulgam and Shopian) on random basis subjected to the existence of naturally growing trees, in order to exploit greater genetic variability. At each selected site, two healthy trees of *Morus alba* L. were identified and tagged properly (Table 1).

Table 1 : Identified and evaluated seed sources of *Morus alba* L.

S. No.	District	Sources
1.	Anantnag	T_1 (Danter), T_2 (Khoverpora)
2.	Pulwama	T_3 (Nikas), T_4 (Pampore)
3.	Ganderbal	T_5 (Nunar), T_6 (Search)
4.	Kulgam	T_7 (Qaimoh), T_8 (Khudwani)
5.	Shopian	T_9 (Los Danev), T_{10} (Handev)

Fruit collection and seed extraction

Mature fruits were collected in the month of June from all the selected sources. The fruits were stored in an air tight room at ambient conditions for 3-4 days for easy kneading. Various parameters of the fruits collected from the selected trees/sources were also recorded during the investigation viz. fruit length, fruit width, stalk length and fruit weight. Colour, shape of fruits, presence of hair and fruit taste. Finally, seeds were extracted from the fruits and were shade-dried.

Seed germination studies

Seeds extracted from the fruits were kept in cold water for 24 hours. After that the seeds were placed in Petri plates and kept in seed germinator for 20 days. The germination studies were carried out in the laboratory of Faculty of Forestry. Observations were recorded for germination percentage, mean daily germination, peak value, germination value and germination energy.

Genetic Parameters

Phenotypic and genotypic coefficients of variance was calculated by using formula suggested by Burton and Devane (1953).

Statistical Analysis

The data obtained was statistically analysed using the CRD design through R studio version (4.2.2,2022).

Results and Discussion

Morphological parameters of mother trees

The result with respect to various morphological parameters of trees from which seeds were collected revealed considerable variation w.r.t. tree height, diameter at breast height (DBH), crown spread, average number of bunches in each bearing branch and average number of berries in each bunch. T2 (Khoverpora) of Anantnag district recorded maximum height (10 m), DBH (32 cm), crown spread (3.6 m), average number of bunches in each bearing branch (6.60) and average number of berries in each bunch (3.65) while as, minimum was recorded from and T4 (Pampore) of Pulwama district (Table 2).

Fruit characteristics of *Morus alba* L.

The results revealed that most of the fruit parameters like fruit length, fruit width, stalk length and fruit weight significantly differed among the sources. Among the seed sources, T2 (Khoverpora) of Anantnag district exhibited the maximum average fruit length (3.98cm), fruit width (2.69 cm), stalk length (4.58 cm) and fruit weight (9.37g). while as, the minimum average values for fruit length (1.75 cm),

fruit width (2.33 cm), stalk length (2.51 cm) and fruit weight (6.27 g) were recorded in T4 (Pampore) of Pulwama district (Table 3). Similar results were obtained by Hepsag, 2016 while working on different Morus spp. viz white (*Morus alba* L.), black (*M. nigra* L.) and urmu (*M. nigra* L.)

Amongst all mother tree sources, the colour of the fruit was observed to be white in the beginning of fruit development and then turned to pink in (T1, T3, T6, T7 and T9), purple in (T5) and at last turned to black in (T2, T4, T8 and T10) after complete maturation. Fully matured fruits from all mother tree sources were witnessed with presence of hair. Shape of the fruit was observed to be cylindrical among all the studied sources. Also, taste of fruit was observed to be sweet in all fruits (Table 4).

These results are in conformity with the findings of Hashemi and Khadivi (2020) and Anissa *et al*., 2009 who reported morphological and pomological variability of *Morus spp.* concluding that the morphological analysis constitutes a first approach of the genetic diversity assessment. Yilmaz *et al*. (2012) observed that fruit weight in *Morus alba* genotypes from Turkey ranged from 0.66 to 3.07 g. Similarly, Aljane and Sdiri (2016) reported an average fruit length of 21.38 mm, fruit width of 13.78 mm, fruit weight of 1.58 g, and fruit stalk length of 6.75 mm in *M. alba*. Additionally, Kalkisim (2013) documented a fruit length range of 22.27–30.32 mm, a fruit width range of 12.50–15.62 mm, and a fruit weight range of 2.02–2.73 g in *M. alba*. Among these traits, higher fruit weight is particularly valued as a key characteristic in mulberry breeding programs (Aljane and Sdiri, 2016).

Variability in seed germination parameters

The study of seed germination parameters as influenced by different seed sources indicated that seed sources significantly affected seed germination percentage, mean daily germination, peak value, germination energy, germination value as well as seed weight (Table. 5). The data revealed that the maximum germination of 94%, mean daily germination 4.43%, peak value (11.60), germination energy (85.50), germination value (51.45) and seed weight of 1000 seeds (2.52 g) were recorded in T2 (Khoverpora) of Anantnag district. While as, minimum values for seed germination (77 %), peak value (9.35), germination value (34.15) were recorded in T3 (Nikas) of Pulwama district as well as minimum mean daily germination (3.66), germination energy (32.75) and seed weight of 1000 seeds (2.20 g) in T4 (Pampore) of Pulwama district.

Since *Morus alba* L. has a wide distribution range, it is expected to have such variations. These results are supported by Rafeeq *et al.,* (2020) who reported high significant differences in germination percentage and survival percentage of *Morus alba* L in polyhouse and in field conditions.

Correlation studies

Genotypic and Phenotypic correlation

The knowledge of relationship of various characters among themselves is most important for any programme of tree improvement. The expression of a character is the sum total of so many other characters input and thus screening / selection should be performed on the basis of components that contribute to that character. The data revealed that there exists significant positive genotypic correlation between fruit length and fruit width (0.83) and fruit length and stalk length (0.84), fruit length and fruit weight (0.97). Fruit width also exhibited positive correlation with fruit length (0.60), stalk length (0.86) and fruit weight (0.91). A significant phenotypic correlation was also exhibited by stalk length with fruit length (0.79), fruit width (0.54) and fruit weight (0.95). Fruit weight also exhibited positive correlation with fruit length (0.91), fruit width (0.60) and stalk length (0.85). Studies by Bajpai *et al*., 2015; Hosseini *et al*., 2018; Farahani *et al*., 2019, Hashemi and Khadivi (2020) suggested that different fruit parameters were highly and positively correlated. It concludes that these variables can be exploited either by breeding programs and can facilitate in the identification of the reliable tree sources during field surveys.

Seed germination percent exhibited significant positive genotypic correlation with mean daily germination (0.99**), peak value (1.00**), germination energy (0.94**), germination value (1.00**) and seed weight (0.82**). Mean daily germination also showed significant positive genotypic correlation with peak value (1.00**), germination energy (0.94**), germination value (0.99**) and seed weight (0.80**). Peak value also exhibited positive phenotypic correlation with mean daily germination (0.60**), germination percentage (0.59**), germination energy (0.90**), germination value (1.00**) and seed weight (0.73**). Germination energy also showed positive phenotypic correlation with mean daily germination (0.88**), germination percentage (0.89**), peak value (0.53**), germination value (0.90**) and seed weight (0.91**). Germination value also exhibited positive phenotypic correlation with mean daily germination (0.81**), germination percentage (0.80**), peak value (0.94**), germination

energy (0.72**) and seed weight (0.77**). Similarly, a significant positive phenotypic correlation exists between seed weight and mean daily germination (0.76**), germination percentage (0.78**), peak value (0.42**), germination energy (0.88**) and germination value (0.61**).

Table 2 : Morphological parameters of selected mother trees of *Morus alba* L.

Mother tree source		Tree Height (m)	DBH (cm)	Crown spread (m)	Average no. of bunches in each bearing branch	Average no. of berries in each bunch
Anantnag	T1	7	25	2.5	3.35	2.10
	T2	10	32	3.6	6.60	3.65
Pulwama	T3	4.3	22	3.5	1.40	1.30
	T4	4	21	2.5	1.25	1.20
Ganderbal	T5	7.5	29	2.9	2.90	1.70
	T6	8	31	3.1	4.15	2.70
Kulgam	T7	5	25	3.0	1.70	1.80
	T8	9.3	27	3.2	6.05	3.30
Shopian	T9	9	31	2.5	4.80	3.00
	T10	7	29	3.2	1.75	1.70
	C.D.($p \leq 0.05$)	_	_	_	**0.65**	**0.44**

Note: Values sharing same letter are statistically non-significant at 5%

Table 3 : Morphological traits of fruits collected from different mother tree sources of *Morus alba* L.

Mother tree source		Fruit length (cm)	Fruit width (cm)	Stalk length (cm)	Fruit weight (gm)
Anantnag	T1	3.14	2.44	3.20	7.85
	T2	3.98	2.69	4.58	9.37
Pulwama	T3	2.30	2.37	3.06	6.90
	T4	1.75	2.33	2.51	6.27
Ganderbal	T5	3.28	2.45	3.10	8.07
	T6	3.36	2.52	3.71	8.60
Kulgam	T7	2.80	2.35	2.82	7.45
	T8	3.65	2.41	4.54	9.07
Shopian	T9	3.48	2.52	4.46	8.87
	T10	3.24	2.38	3.18	7.60
C.D ($p \leq 0.05$)		**0.22**	**0.15**	**0.52**	**0.48**

Note: Values sharing same letter are statistically non-significant at 5%

Table 4 : Morphological traits of fruits collected from different mother tree sources of *Morus alba* L.

Mother tree source		Fruit colour		Presence of hair in fruits	Fruit shape	Fruit taste
		Pre-ripe	Ripe			
Anantnag	T1	White	Pink	Present	Cylindrical	Sweet
	T2	White	Black	Present	Cylindrical	Sweet
Pulwama	T3	White	White pink	Present	Cylindrical	Sweet
	T4	White	Black	Present	Cylindrical	Sweet
Ganderbal	T5	White	Purple	Present	Cylindrical	Sweet
	T6	White	Pink	Present	Cylindrical	Sweet
Kulgam	T7	White	Pink	Present	Cylindrical	Sweet
	T8	White	Black	Present	Cylindrical	Sweet
Shopian	T9	White	Pink	Present	Cylindrical	Sweet
	T10	White	Black	Present	Cylindrical	Sweet

Note: Values sharing same letter are statistically non-significant at 5%

Table 5 : Effect of different mother tree sources on seed germination of *Morus alba* L.

Mother tree source		Seed germination percentage	Mean daily germination	Peak value	Germination energy	Germination value	1000 Seed weight (g)
Anantnag	T1	88.0	4.18	11.75	63.50	49.0	2.29
	T2	94.0	4.43	11.60	85.50	51.45	2.52
Pulwama	T3	77.0	3.80	9.35	41.75	34.15	2.25
	T4	80.0	3.66	9.98	32.75	37.87	2.20
Ganderbal	T5	90.75	4.31	11.40	57.00	48.80	2.31
	T6	91.0	4.32	11.02	64.25	46.60	2.32
Kulgam	T7	81.50	3.87	9.52	46.50	36.50	2.27
	T8	92.25	4.38	10.57	80.00	45.52	2.39
Shopian	T9	92.75	4.41	11.65	75.00	51.07	2.34
	T10	86.75	4.12	10.87	52.25	44.65	2.27
C.D.(p≤0.05)		**3.09**	**0.15**	**1.50**	**6.6**	**6.30**	**0.02**

Note: Values sharing same letter are statistically non-significant at 5%

Table 6 : Assessment of genotypic correlation (above diagonal) and phenotypic correlation (below diagonal) for fruit parameters of *Morus alba* L.

Fruit parameters	Fruit length	Fruit width	Stalk length	Fruit weight
Fruit length	-	0.83**	0.84**	0.97**
Fruit width	0.60**	-	0.86**	0.91**
Stalk length	0.79**	0.54**	-	0.95**
Fruit weight	0.91**	0.60**	0.85**	-

Note: ** significant at p ≤0.01; *significant at p≤0.05

Table 7 : Assessment of genotypic correlation (above diagonal) and phenotypic correlation (below diagonal) for seed germination parameters of *Morus alba* L.

Seed germination parameters	Mean daily germination	Seed germination percentage	Peak value	Germination energy	Germination value	1000 Seed weight
Mean daily germination	-	1.00**	1.00**	0.94**	0.99**	0.80**
Seed germination percentage	0.99**	-	1.00**	0.94**	1.00**	0.82**
Peak value	0.60**	0.59**	-	0..90**	1.00**	0.73*
Germination energy	0.88**	0.89**	0.53**	-	0.90**	0.91**
Germination value	0.81**	0.80**	0.94**	0.72**	-	0.77**
1000 Seed weight	0.76**	0.78**	0.42**	0.88**	0.61**	-

Note: ** significant at p ≤0.01; *significant at p≤0.05

Conclusion

The morphological analysis is considered as a first approach towards the assessment of genetic diversity in a plant species. Since all the *Morus alba* L. sources tested during the investigation showed significant difference in terms of fruit and seed parameters including seed germination which finally result in better seedlings, it indicates that there is room for improvement of this species in future. Given the exceptional performance demonstrated by the S2 (Khoverpora) source from Anantnag district, based on diverse seed morphological traits, it is recommended to prioritize this source of *Morus alba* L. for future improvement programs and large-scale multiplication to achieve immediate benefits.

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Conflict of interest

There is no conflict of interest among the authors

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