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# Morphometric assessment of *Butea monosperma* for tree improvement in Balaghat

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**Abstract**

This study assessed the morphometric traits of *Butea monosperma* in Balaghat district, Madhya Pradesh, based on ten mature phenotypically superior trees. Mean values for tree height (12.2 m), GBH (99.8 cm), crown spread (8.36 m), flowering intensity (2.6), and fruit yield (24.5 kg/tree) were the lowest among the evaluated regions. Reproductive traits exhibited higher coefficients of variation than structural traits, indicating substantial within-population variability and the presence of potentially valuable genotypes. Conservation and utilization strategies targeting this genetic diversity are recommended to support future breeding efforts and ensure long-term ecological sustainability.

**Keywords:** *Butea monosperma*, Balaghat, morphometric traits, tree selection, variability

## Introduction

*Butea monosperma* (Lam.) Taub., commonly known as Palash or Flame of the Forest, is a medium-sized deciduous tree species native to the Indian subcontinent. It is recognized for its ecological, medicinal, and economic importance, and is widely distributed across India, particularly in tropical and subtropical regions (Gupta *et al.*, 2010) [3]. *B. monosperma* is known for its striking orange-red flowers, drought tolerance, and its utility in traditional agroforestry systems. The tree's ability to thrive in arid conditions makes it valuable in sustaining soil fertility and providing shade in agroforestry landscapes (Rai *et al.*, 2021) [7]. Additionally, parts of the tree, including its flowers, leaves, and bark, are used in various medicinal applications, from treating respiratory issues to skin diseases, making it a crucial species in ethno medicine (Mishra and Mukherjee, 2023) [5].

Despite its wide distribution, *B. monosperma* has not been adequately utilized in formal tree improvement programs. The natural populations of this species often face significant pressures due to deforestation, over-exploitation, and land-use changes, leading to fragmentation and a subsequent loss of genetic diversity (Khan *et al.*, 2014) [4]. Conservation efforts are critical to preserving the species' genetic resources, especially as it is a keystone species in many dryland ecosystems. Fragmented natural stands, combined with anthropogenic influences, contribute to a reduction in the quality and sustainability of *B. monosperma* populations Dhyani *et al.*, 2015) [2]. Given these challenges, it is essential to explore conservation strategies that focus on in situ and ex situ methods while enhancing the genetic potential of the species.

One approach to improving *B. monosperma* is genetic enhancement through phenotypic selection, which involves identifying superior trees based on desirable traits. This method has been successfully used for other tree species to improve both growth and reproductive performance (Zobel and Talbert, 1984) [10]. Phenotypic selection allows for the identification of trees that exhibit superior traits, such as increased height, greater crown spread, or higher reproductive output. These trees can serve as the basis for breeding programs aimed at improving productivity and resilience. Understanding the phenotypic variability within populations is, therefore, a crucial first step in developing tree improvement programs for *B. monosperma*.

Previous studies have documented considerable variation in morphological and reproductive traits of *B. monosperma* across different agro climatic regions. Vashishtha *et al.* (2013) [9] highlighted differences in tree height, crown spread, and fruit yield among populations in northern and central India. These variations are likely influenced by both genetic factors and environmental conditions, underscoring the importance of region-specific assessments for tree improvement programs. However, studies focusing on the specific traits of *B. monosperma* populations in Madhya Pradesh, particularly in districts like Balaghat, remain sparse. As a result, the genetic potential of these populations has not been fully explored or utilized for breeding purposes.

Balaghat, located in the central part of Madhya Pradesh, is an ecologically rich region that offers a unique environment for *B. monosperma*. The district's diverse landscapes and relatively undisturbed natural forests provide an ideal setting for the growth of this species. The indigenous management practices in Balaghat have helped maintain a healthy population of *B. monosperma*, which could harbor significant genetic diversity. Documenting the phenotypic variability within the Balaghat population will contribute to identifying superior trees that can be used for breeding programs aimed at improving the species' productivity and

resilience to environmental stresses.

This study aims to assess the key morphological and reproductive traits of *B. monosperma* in Balaghat, focusing on tree height, girth at breast height (GBH), crown spread, flowering intensity, and fruit yield. By quantifying trait variability and linking it to environmental factors, this research will contribute to a better understanding of the species' phenotypic plasticity and adaptive potential. Identifying elite individuals will lay the groundwork for the development of tree improvement programs in the region, ensuring the sustainable management and conservation of *B. monosperma* in Balaghat and surrounding areas. Moreover, this study aims to contribute to broader conservation efforts, providing valuable data for the establishment of in situ and ex situ conservation strategies for this important species.

## Methodology

### Study Area

The study was conducted in the natural forests of Madhya Pradesh, focusing on Balaghat district located in the central part of Madhya Pradesh and are known for their rich forest biodiversity, including significant populations of *Butea monosperma* (Flame of the Forest). The forests in these areas provide an ideal environment for the growth of this species, characterized by a tropical and subtropical climate that supports robust tree growth and reproductive potential.

### Sampling and Tree Selection

In total, 10 *Butea monosperma* trees were randomly selected from the natural forests of Balaghat, district. The trees were chosen using the Individual Tree Selection (ITS) method, which is a common practice in forest tree improvement. This method involves selecting individual trees based on superior phenotypic traits that reflect the genetic potential of the species. The selected trees were mature, aged over 20 years, and displayed phenotypic traits that indicated high productivity and vitality.

### Selection Criteria

The selection of superior trees was based on the following phenotypic traits, which are critical for evaluating the overall fitness and potential of the trees:

1. **Tree Height:** The height of each tree was measured to assess its growth potential. Taller trees are typically indicative of better overall health and vigor.
2. **Girth at Breast Height (GBH):** The circumference at 1.3 meters above ground level was recorded for each tree to measure its stem diameter. Larger girth values are associated with better growth and reproductive capacity.
3. **Crown Spread:** The horizontal spread of the tree's crown was measured along both the north-south and east-west axes. A broader crown spread suggests a higher level of canopy development, which is important for photosynthesis and overall tree productivity.
4. **Flowering Intensity:** The flowering intensity was visually assessed on a scale of 1 to 5, with 1 representing minimal flowering and 5 representing abundant flowering. Strong flowering intensity is crucial for seed production and reproductive success.
5. **Fruit Yield:** The quantity and weight of fruit produced by each tree were recorded. Higher fruit yield is indicative of the tree's reproductive fitness and potential for seed collection.

### Data Collection

Data was collected during the flowering and fruiting seasons to capture the full spectrum of phenotypic traits. The following methods were employed to measure the traits (Chaturvedi and Khanna, 1994) [1].

1. **Tree Height Measurement:** The height of each selected tree was measured using a Ravi multimeter to ensure accurate measurements
2. **GBH Measurement:** The girth at breast height was measured using a standard measuring tape at 1.37 meters from the ground.
3. **Crown Spread Measurement:** The crown spread was measured by calculating the distance between the furthest branches along the north-south and east-west axe.
4. **Flowering Intensity Rating:** Flowering intensity was rated on a scale of 1 to 5 based on visual observation, with higher scores assigned to trees with more abundant and vibrant flowers Olubode *et al.* (2015) [6].
5. **Fruit Yield Estimation:** The number of pods and the total weight of fruits from each tree were recorded during the peak fruiting season to estimate the overall fruit yield (Shukla *et.al*. 2014) [8]

### Statistical Analysis

The collected data was analyzed using descriptive statistics and trees exhibiting superior phenotypic traits, such as taller height, larger GBH, more extensive crown spread, stronger flowering intensity, and higher fruit yield, were identified as candidates for future breeding programs. These superior trees will be used for seed collection and genetic improvement efforts aimed at enhancing the productivity and resilience of *Butea monosperma* in the region.

## Results

The descriptive statistics of the measured traits are summarized in Table 1. The results are as follows:

**Table 1:** Descriptive Statistics of Morphological and Reproductive Traits in *Butea monosperma* Trees from Balaghat

| | Tree Height (m) | GBH (cm) | Crown Spread (m) | Flowering Intensity (1-5) | Fruit Yield (kg/tree) |
|---|---|---|---|---|---|
| N | 10 | 10 | 10 | 10 | 10 |
| Min | 11 | 95 | 8 | 2 | 20 |
| Max | 13 | 105 | 8.8 | 3 | 29 |
| Sum | 122 | 998 | 83.6 | 26 | 245 |
| Mean | 12.2 | 99.8 | 8.36 | 2.6 | 24.5 |
| Std. error | 0.2043961 | 1.083205 | 0.09092121 | 0.1632993 | 0.9574271 |
| Variance | 0.4177778 | 11.73333 | 0.08266667 | 0.2666667 | 9.166667 |
| Stand. dev | 0.6463573 | 3.425395 | 0.2875181 | 0.5163978 | 3.02765 |
| Median | 12.25 | 99.5 | 8.35 | 3 | 24.5 |
| 25 prcntil | 11.725 | 96.75 | 8.075 | 2 | 21.75 |

| | | | | | |
|---|---|---|---|---|---|
| 75 prcntil | 12.775 | 103.25 | 8.625 | 3 | 27.25 |
| Skewness | -0.4968515 | 0.1915837 | 0.1514631 | -0.4841229 | 0 |
| Kurtosis | -0.299284 | -1.230469 | -1.356985 | -2.276786 | -1.2 |
| Geom. mean | 12.18434 | 99.74724 | 8.35556 | 2.550849 | 24.33013 |
| Coeff. var | 5.298011 | 3.43226 | 3.439212 | 19.86145 | 12.35776 |

Tree height ranged from 11.0 to 13.0 m (mean = 12.2 m, CV = 5.30%), while GBH varied from 95 to 105 cm (mean = 99.8 cm, CV = 3.43%). These low coefficients of variation indicate considerable structural uniformity within the population, likely arising from similar site conditions, shared management history, or limited genetic heterogeneity patterns also noted in other semi-natural tree populations (Khan *et al.*, 2014) [4]. Due to their stability and ease of measurement, such primary growth traits are valuable for the preliminary selection of elite genotypes in tree improvement programs (Zobel and Talbert, 1984) [10].

Crown spread averaged 8.36 m (range 8.0-8.8 m; CV = 3.44%), indicating low variability. Crown architecture strongly influences photosynthetic efficiency, biomass production, and ecological services, including shade provision and habitat creation (Rai *et al.*, 2021) [7]. While variation here was limited, selecting genotypes with wider, well-structured crowns could enhance both productivity and ecological functions in agroforestry systems. Flowering intensity showed the highest variability among all traits, ranging from 2 to 3 on a five-point scale (mean = 2.6, CV = 19.86%). Such variability in reproductive traits is typical of cross-pollinated tree species and can be influenced by genetic diversity, age, vigor, and micro environmental factors (Vashishtha *et al.*, 2013) [9]. Given the role of prolific flowering in seed production and regeneration, high-flowering individuals should be prioritized in restoration programs, particularly in fragmented landscapes (Dhyani *et al.*, 2015) [2]. Fruit yield ranged from 20 to 29 kg/tree (mean = 24.5 kg, CV = 12.36%), representing moderate variability. Yield is an important indicator of reproductive capacity and a determinant of the species' value for seed harvesting and medicinal use (Mishra and Mukherjee, 2023) [5]. Selecting and propagating high-yielding trees could strengthen germplasm collections and community forestry initiatives.

These results align with earlier studies documenting intra-population diversity in *B. monosperma* morphological and reproductive traits across central India (Vashishtha *et al.*, 2013) [9]. The observed pattern low variation in structural traits and moderate to high variation in reproductive traits suggests that multi-trait selection strategies should combine both growth and reproductive parameters. Integrating these phenotypic findings into selection protocols will enhance *B. monosperma* improvement programs. Establishing clonal trials and germplasm banks from high-performing individuals can ensure both genetic conservation and productivity gains. Future work should include wood quality assessments, drought resistance evaluation, and molecular characterization to confirm trait heritability and genetic distinctiveness (Khan *et al.*, 2014) [4]. Incorporating ecological and socio-economic considerations will further support sustainable and locally adapted breeding strategies.

## Conclusion

The Balaghat population of *Butea monosperma* exhibited relatively uniform structural traits, with low variability in tree height, GBH, and crown spread, suggesting a stable growth form possibly shaped by similar site conditions and limited genetic diversity. In contrast, reproductive traits particularly flowering intensity and fruit yield showed moderate to high variability, indicating scope for improvement through targeted selection. While overall growth and reproductive performance were lower than other evaluated regions, the presence of high-performing individuals within this population offers potential for seed-based propagation and genetic enhancement. Conservation of this germplasm is equally important, as it may harbor unique adaptive traits suited to local environmental conditions. Integrating these findings into breeding, conservation, and restoration programs will help maintain genetic diversity while improving productivity in *B. monosperma.*

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