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# Seasonal variation in morphological characteristics of Brahmi (*Bacopa monnieri*) germplasm accessions in coastal regions of Andhra Pradesh

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**Abstract**
A field experiment was carried out during 2023-24 at Horticultural Research Station, Dr. YSR Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh to study the impact of different season on the morphological traits of Brahmi (*Bacopa monnieri*) germplasm accessions. The study employed a randomized block design with two replications evaluating morphological traits such as plant height, number of leaves, number of nodes, stem length, number of stolons and number of branches. Results revealed that kharif season consistently outperformed both Rabi and summer seasons, exhibiting significantly superior morphological characteristics across the evaluated variables. Maximum plant height obtained in APBm-10, APBm-1 and APBm-16 during kharif, Rabi and summer respectively. APBm-14 showed maximum number of leaves, stem length and number of branches during kharif and Rabi season. APBm-5 showed maximum number of leaves, branches and stem length in summer. APBm-10 recorded maximum for number of nodes during all seasons. For number of stolons APBm-1, APBm-21 and APBm-3 and APBm-4 showed maximum values in kharif, Rabi and summer respectively.

**Keywords:** Seasonal variation, morphological characters, accessions

## Introduction
Exploring the medicinal properties of plants has been a cornerstone of human healthcare for centuries. From ancient civilizations to the present day, humans relied on medicinal plants for their well-being. Among them, Brahmi (*Bacopa monnieri*) ranks second among the most indispensable Indian medicinal plants (Gupta *et al.*, 2017) [9] which belongs to Scrophulariaceae family. It is a creeping, succulent perennial herb with branches that grow in marshy and wet areas (Kumar, 2017) [12]. Brahmi is often recognized as Medhya Rasayana, a traditional Indian medication having beneficial effects in alleviating anxiety and necrosis as well as enhancing intelligence and memory function (Srivastava *et al.*, 2017) [17]. It is a primary component in various ayurvedic formulations including Brahmeegritham, Brahmi oil, Saraswatharishtam etc. (Beena *et al.*, 2018) [2]. Among various chemicals isolated from Brahmi, the active fractions includes Bacoside A and Bacoside B (Mathur *et al.*, 2016) [13], which is used to treat various disorders like Alzheimer's, Parkinson's, cancer, ulcer etc. (Sharma *et al.*, 2021) [16]. The demand for this crop has increased annually due to its potential use in the pharmaceutical industry and Ayurvedic medical system.
It is essential to record the diversity of a crop, which encompasses superior traits and active components across different seasons, in order to facilitate its profitable cultivation. Several studies have demonstrated the significant impact of different seasons on vegetative growth. Hence this study was conducted to access morphological characterization among different accessions across seasons.

## Materials and Methods
The present investigation was carried out during kharif (July-September), Rabi (October-February) and summer season (March-June) at Horticultural Research Station, Venkataramannagudem during 2023-2024. The experiment was laid out in randomized block design with two replications.

The study included 26 accessions of Brahmi *i.e.*, APBm-1, APBm-2, APBm-3, APBm-4, APBm-5, APBm-6, APBm-7, APBm-8, APBm-9, APBm-10, APBm-11, APBm-12, APBm-13, APBm-14, APBm-15, APBm-16, APBm-17, APBm-18, APBm-19, APBm-20, APBm-21, APBm-22, APBm-23, APBm-24, APBm-25 and APBm-26 which was collected from various regions of South India. The terminal cuttings were taken and planted in each plot under open field conditions. Intercultural operations and irrigations were carried out. Observations were made for five randomly selected plants in each replications and data was tabulated for each accessions in different seasons. The measured morphological parameters are plant height, number of leaves, number of nodes, stem length, number of stolons and branches.

**Minimum and maximum values of day and night temperature, relative humidity and seasonal rainfall were mentioned below**

| S. No | Season | Day temperature (°C) | | Night temperature (°C) | | Day R.H (%) | | Night R.H (%) | | Rainfall (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | |
| 1. | Kharif | 24.90 | 36.60 | 24.30 | 34.90 | 28.80 | 89.80 | 52.30 | 76.30 | 1.60-16.12 |
| 2. | Rabi | 19.80 | 23.90 | 29.60 | 33.90 | 34.50 | 42.70 | 80.60 | 92.50 | 2.80-2.30 |
| 3. | Summer | 26.20 | 39.43 | 28.98 | 36.54 | 26.70 | 39.40 | 74.40 | 87.10 | 0.50-2.20 |

## Results and Discussions

### Plant Height (cm)

Plant height was significantly higher during kharif season followed by Rabi and summer season. During kharif season the maximum plant height was obtained for APBm-7 (72.77 cm) and minimum for APBm-20 (55.78 cm). In Rabi season, APBm-1(64.89 cm) observed maximum plant height while minimum in APBm-4 (44.80 cm). Whereas in summer season, APBm-16 (57.04 cm) noticed highest plant height and APBm-26 (38.50 cm) lowest.

Plant height is a significant character, since whole herb is used therapeutically (Devendra *et al*., 2018) [5]. Favourable conditions in temperature, humidity and rainfall increased cell division and elongation contributing to enhanced plant height (Bhutia *et al*., 2018) during kharif season. The water stress and insufficient rainfall reduced plant height (Hatfield and Prueger, 2015) during summer. These findings are in agreements with those reported by Verma *et al.* (2011) [18] and Jessika *et al.* (2018) [11] in *Ocimum basilicum.*

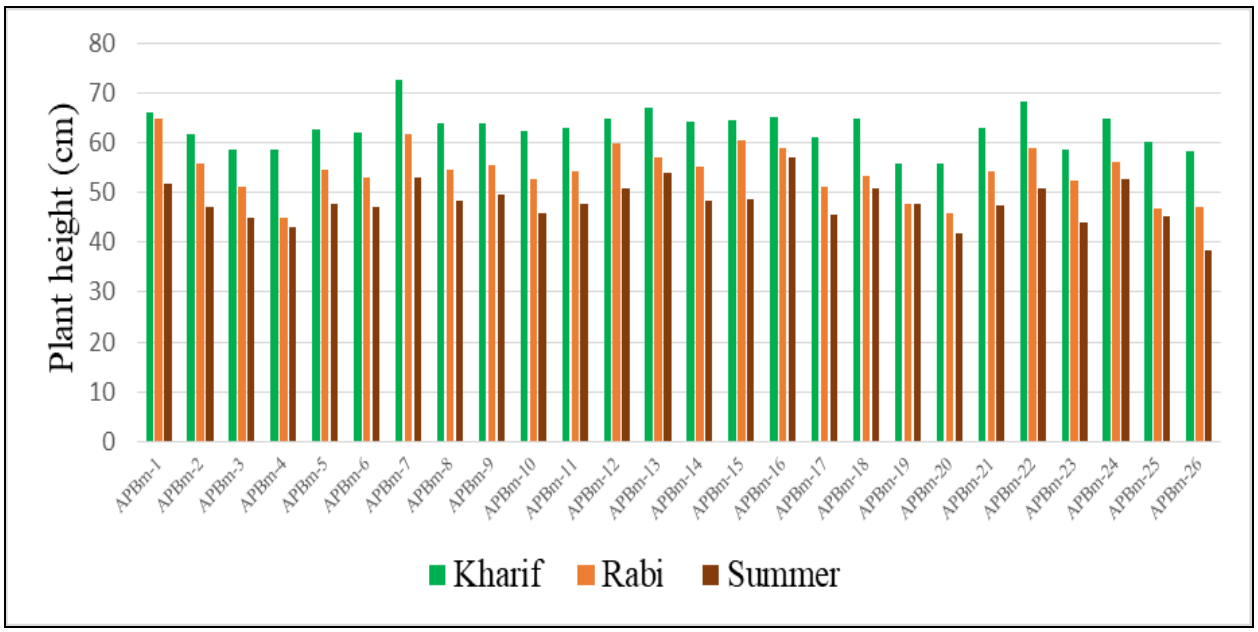


**Fig 1:** Plant height (cm) in *Bacopa monnieri* accessions under different seasons in coastal regions of Andhra Pradesh

### Number of leaves

Number of leaves was obtained highest during kharif season. APBm-14 (929.83) obtained more number of leaves while less in APBm-26 (622.50) during kharif season. Rabi season observed maximum number of leaves in APBm-14 (810.83) and minimum in APBm-26 (511.50). During summer season, APBm-5 (470.00) recorded maximum number of leaves and minimum in APBm-26 (395.67).

Plant height showed a significant positive correlation with number of leaves (Raja *et al*., 2020) [14]. These findings are in line with the results reported by Sakhubai *et al*. (2020) in *Plectranthus forskholii.*

### Number of nodes

The maximum number of nodes were noticed in kharif season followed by Rabi and summer. In kharif, Rabi and summer season, maximum number of nodes was observed in accession APBm-10 (22.16, 19.00 and 17.00) and minimum was recorded in APBm-12 (14.50, 13.84 and 9.83) in all the seasons respectively.

Brahmi grows faster in hot and humid climate and it proliferate at adequate rainfall (Zaidi, 2018) which increased number of nodes during kharif season. With a higher increase in temperature and light during summer caused a decrease in net photosynthetic rate caused lowest amount of number of nodes in plants compared to other seasons

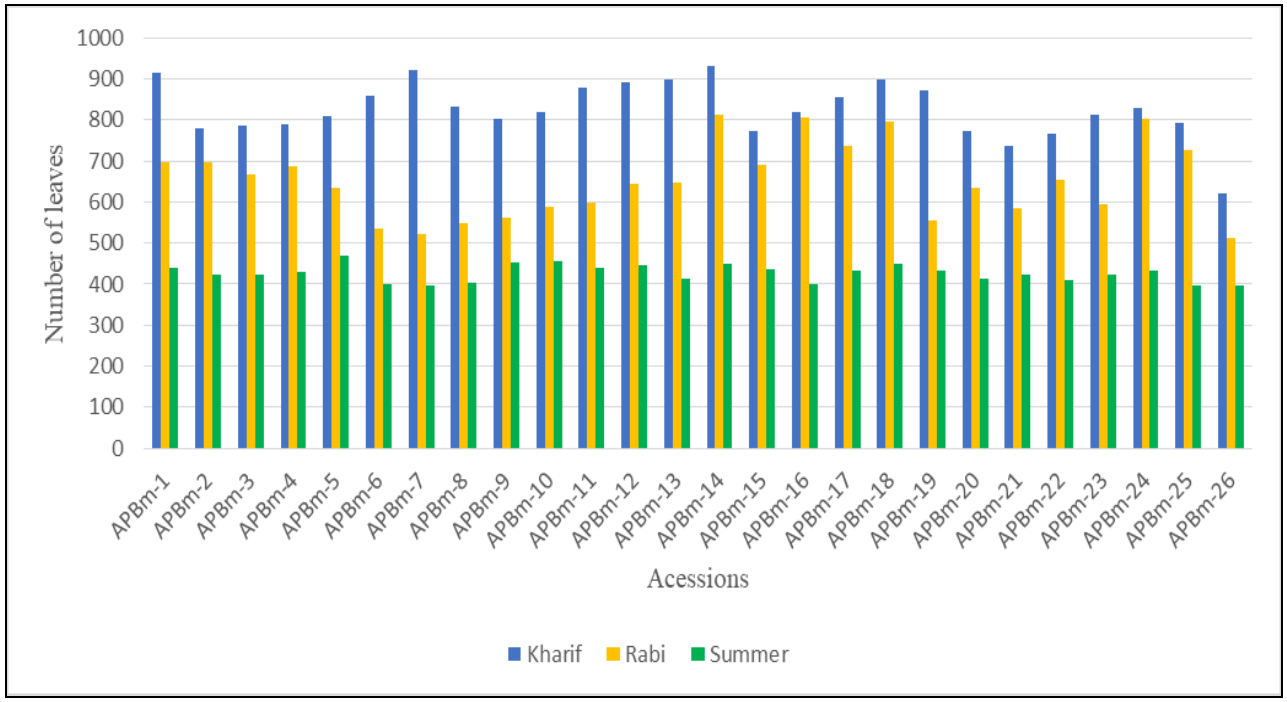


**Fig 2:** Number of leaves in *Bacopa monnieri* accessions under different seasons in coastal regions of Andhra Pradesh

**Stem length (cm)**

It was very evident that there is a significant difference among the accessions in stem length across the seasons. The maximum stem length was recorded in APBm-14 (37.65 cm) and minimum in APBm-26 (21.18 cm) during kharif season. In Rabi season, APBm-14 (22.68 cm) observed maximum stem length and minimum for APBm-26 (14.92 cm). During summer, APBm-5 (22.02 cm) observed maximum stem length while minimum in APBm-26 (13.03 cm).

During rainy season, plants show higher stem growth due to increased water availability, improved nutrient uptake, enhanced photosynthesis and favourable soil and temperature conditions. In winter, lower temperatures slow down plant metabolism and hinder growth. During the summer season, a deficit of water adversely impacted the cellular growth in the stem (Bistgani *et al.*, 2024), leading to a decrease in leaf production. Consequently, there was a reduction in the transportation of carbohydrates to the stem, contributing to diminished growth (Adachi *et al*., 2000) [1].

**Number of stolons**

From the results (Table 1) number of stolons were recorded significantly highest during kharif season and lowest in summer season. Maximum number of stolons were observed and recorded in APBm-1 (17.67) whereas minimum in APBm-25 (12.17) in kharif season. During Rabi, maximum number of stolons in APBm-21 (12.67) and minimum in APBm-24 (6.50). In summer, more number of stolons were obtained in APBm-3 and APBm-5 (9.50) and less in APBm-13 (6.82).

In kharif season, enhanced branching facilitated more number of stolons (Gibson and Hollowell, 1966) [7]. In the summer, the extended periods of daylight triggered a decrease in stolon production as reported by Eagles and Othman in 1986.

**Number of branches**

The data obtained by recording the number of branches were more in kharif season compared to Rabi and summer. During kharif maximum number of branches was noticed in APBm-14 (25.16) and minimum in (18.00). In Rabi season, APBm-14 (21.50) observed maximum and minimum in APBm-26 (11.50). In summer season, the maximum number of branches was obtained during APBm-5 (20.17) and least in APBm-26 (14.00). Gothandan *et al*. (2021) [8] reported that there is a positive correlation between plant height and number of branches.

**Table 1:** Seasonal influence of number of nodes, stem length (cm), number of stolons and number of branches in Brahmi (*Bacopa monnieri* L.) accessions

| Treatments | Number of nodes | | | Stem length (cm) | | | Number of stolons | | | Number of branches | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Kharif | Rabi | Summer | Kharif | Rabi | Summer | Kharif | Rabi | Summer | Kharif | Rabi | Summer |
| APBm-1 | 18.00 | 16.67 | 14.33 | 34.59 | 20.75 | 17.17 | 17.67 | 10.50 | 8.67 | 22.34 | 19.00 | 18.00 |
| APBm-2 | 21.00 | 17.85 | 14.67 | 35.10 | 16.27 | 19.00 | 15.17 | 9.89 | 8.50 | 22.17 | 15.17 | 16.67 |
| APBm-3 | 18.34 | 16.83 | 14.33 | 22.70 | 18.62 | 17.73 | 13.33 | 12.50 | 9.50 | 21.50 | 15.17 | 17.17 |
| APBm-4 | 21.17 | 17.50 | 15.00 | 26.09 | 17.33 | 21.12 | 15.83 | 10.50 | 9.35 | 21.83 | 15.84 | 17.33 |
| APBm-5 | 17.50 | 15.65 | 13.00 | 22.23 | 18.88 | 22.02 | 16.33 | 8.17 | 9.50 | 20.83 | 16.17 | 20.17 |
| APBm-6 | 21.50 | 17.62 | 16.00 | 26.39 | 15.77 | 15.85 | 13.33 | 9.33 | 7.48 | 20.00 | 18.00 | 15.50 |
| APBm-7 | 18.17 | 16.86 | 14.00 | 25.09 | 16.60 | 15.60 | 15.00 | 7.83 | 7.13 | 19.68 | 19.83 | 15.17 |
| APBm-8 | 16.17 | 14.68 | 12.00 | 29.78 | 22.00 | 15.58 | 13.33 | 8.34 | 7.17 | 20.00 | 17.50 | 15.50 |
| APBm-9 | 16.17 | 14.17 | 12.33 | 27.72 | 21.07 | 16.07 | 13.88 | 12.17 | 7.60 | 20.17 | 16.17 | 19.83 |
| APBm-10 | 22.16 | 19.00 | 17.00 | 30.00 | 16.80 | 16.92 | 17.16 | 9.17 | 8.50 | 20.33 | 16.50 | 20.00 |
| APBm-11 | 18.83 | 17.17 | 15.17 | 22.99 | 19.55 | 17.53 | 15.17 | 8.61 | 8.00 | 20.67 | 18.17 | 18.67 |
| APBm-12 | 14.50 | 13.84 | 9.83 | 26.35 | 15.18 | 16.32 | 14.16 | 8.50 | 7.84 | 21.00 | 18.50 | 19.00 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| APBm-13 | 16.33 | 14.67 | 12.83 | 26.24 | 18.82 | 15.97 | 13.50 | 7.70 | 6.82 | 21.17 | 18.67 | 15.83 |
| APBm-14 | 18.00 | 16.50 | 14.67 | 37.65 | 22.68 | 16.92 | 12.83 | 8.52 | 7.50 | 25.16 | 21.50 | 19.00 |
| APBm-15 | 17.93 | 15.84 | 13.83 | 25.12 | 15.78 | 16.53 | 14.33 | 8.62 | 7.17 | 21.83 | 14.50 | 18.00 |
| APBm-16 | 16.67 | 14.84 | 12.50 | 31.97 | 16.58 | 13.60 | 14.50 | 8.33 | 8.17 | 24.67 | 17.17 | 15.17 |
| APBm-17 | 17.67 | 15.50 | 13.67 | 27.49 | 15.84 | 14.23 | 14.16 | 9.67 | 7.84 | 23.17 | 17.84 | 17.50 |
| APBm-18 | 16.00 | 14.00 | 11.17 | 23.00 | 18.25 | 15.88 | 14.50 | 7.33 | 7.13 | 23.33 | 18.67 | 19.16 |
| APBm-19 | 17.67 | 15.83 | 13.50 | 22.57 | 21.13 | 14.13 | 12.50 | 8.01 | 7.67 | 20.17 | 18.00 | 17.83 |
| APBm-20 | 18.83 | 16.85 | 14.85 | 23.04 | 15.93 | 13.67 | 13.17 | 9.67 | 6.89 | 20.67 | 15.00 | 16.17 |
| APBm-21 | 16.00 | 14.50 | 12.17 | 24.82 | 18.40 | 14.95 | 14.50 | 12.67 | 8.17 | 20.33 | 14.50 | 17.17 |
| APBm-22 | 17.83 | 16.00 | 13.67 | 27.13 | 18.33 | 16.22 | 13.33 | 7.77 | 7.17 | 21.34 | 14.50 | 15.75 |
| APBm-23 | 17.83 | 15.84 | 13.83 | 23.84 | 15.15 | 17.03 | 15.83 | 9.88 | 8.17 | 20.50 | 16.17 | 16.67 |
| APBm-24 | 17.83 | 16.83 | 13.50 | 25.32 | 17.48 | 16.48 | 16.67 | 6.50 | 7.33 | 24.00 | 17.50 | 18.00 |
| APBm-25 | 18.00 | 16.84 | 16.83 | 25.53 | 16.12 | 15.78 | 12.17 | 7.67 | 6.84 | 22.84 | 16.00 | 14.33 |
| APBm-26 | 17.00 | 14.83 | 13.17 | 21.18 | 14.92 | 13.03 | 13.50 | 8.17 | 7.17 | 18.00 | 11.50 | 14.00 |
| Mean | 17.97 | 16.03 | 13.76 | 26.69 | 17.86 | 16.36 | 14.46 | 9.08 | 7.82 | 21.45 | 16.83 | 17.22 |
| S.EM | 1.12 | 0.61 | 0.92 | 2.169 | 1.292 | 1.287 | 1.021 | 0.808 | 0.384 | 0.688 | 0.686 | 1.218 |
| C.D. 5% | 3.27 | 1.77 | 2.69 | 6.32 | 3.76 | 3.75 | 2.97 | 2.35 | 1.12 | 2.00 | 2 | 3.55 |

## Conclusion

From this study it is concluded that there is a significant variations are shown in the morphological traits *i.e.*, plant height, number of leaves, number of branches, number of stolons, stem length and number of nodes are influenced by seasons. Kharif season showed more plant morphological characters compared to other seasons. APBm-10, APBm-1 and APBm-16 observed maximum plant height in kharif, Rabi and summer respectively. APBm-14 had the highest number of leaves, stem length and branches in kharif and Rabi. APBm-5 had the maximum number of leaves, branches and stem length in summer. APBm-10 consistently had the maximum number of nodes in all seasons. For the number of stolons, APBm-1, APBm-21, and APBm-3 had the highest values in kharif, Rabi and summer respectively.

## Future scope

These accessions can be utilised for studying optimal harvesting month to maximize fresh and dry herbage yield and bacoside content

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