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SEASONAL VARIATION IN YIELD CHARACTERISTICS OF BRAHMI (*BACOPA MONNIERI*) GERMPLASM ACCESSIONS IN COASTAL REGIONS OF ANDHRA PRADESH, INDIA

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ABSTRACT

A field experiment was carried out during 2023-24 at Horticultural Research Station, Dr. Y.S.R. Horticultural University, Venkataramannagudem, West Godavari District, Andhra Pradesh to study the impact of different seasons on the yield characteristics of Brahmi (*Bacopa monnieri*) germplasm accessions. The study employed a randomized block design with two replications evaluating yield traits such as leaf area, basal leaf area, fresh weight of leaves, dry weight of leaves, fresh herbage yield and dry herbage yield. APBm-6 showed highest basal leaf area during kharif season and APBm-10 showed highest during rabi and APBm-22 showed highest during summer season. APBm-14 showed highest leaf area, fresh weight of leaves, dry weight of leaves, fresh herbage yield and dry herbage yield during kharif and rabi season. APBm-5 showed highest leaf area, fresh weight of leaves, dry weight of leaves, fresh herbage yield and dry herbage yield during summer. Results revealed that kharif season consistently outperformed both rabi and summer seasons exhibiting significantly superior yield characteristics across the evaluated variables.

Keywords **:** Seasonal variation, yield characters, accessions.

Introduction

In the realm of healthcare, medicinal plants have always stood as nature's pharmacy to cure ailments, soothe injuries and promote overall wellness. India has always been a rich repository of medicinal plants having 7500 species showcasing the country's long-lasting commitment to harnessing the therapeutic potential of its indigenous flora for promoting health and wellness (Kala, 2006). Among them, *Bacopa monnieri* ranks the second most indispensable medicinal plant (Gupta *et al*., 2017) which belonging to Scrophularaciae family (Choudary *et al.,* 2021). It is an annual creeping herb that mainly grows in wet, damp and marshy areas throughout India (Christopher *et al.,* 2017). This plant grows rapidly and recognized as "Medhya-rasayana" in Ayurveda due to its properties that enhance cognitive function (Singh *et al.,* 2021). The key bioactive constituents responsible for its cognitive-enhancing effects are attributed to the presence of two saponin compounds, specifically bacoside A and bacoside B (Naik *et al.,* 2012).

Brahmi is a versatile ingredient that is extensively utilized across various industries including the food and beverage sector and it is incorporated as a nutritional enhancer in drink formulations and as an herbal component in culinary products. Brahmi is commonly formulated into tablets and tonics within the health supplement market. The powdered form of

Brahmi can be directly consumed by individuals or used as a value-added ingredient in the production of various nutritional products (Smitha *et al.,* 2021).

In order to determine the superior genotypes against different seasons and to understand which season is more suitable for growing the crops were studied in this investigation.

Materials and Methods

The research was conducted at the Horticultural Research Station in Venkataramannagudem, West Godavari, Andhra Pradesh. The experiment was conducted in three seasons (kharif, rabi and summer season) in 2023-2024. In this experiment, 26 genotypic accessions of Brahmi were used in randomized block design with two replications. The 26 genotypic accessions are 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.

Cuttings were planted in a plot of 1m x 1m with a spacing of 10 cm between plants. Irrigation and fertilizers were applied. Leaf area and basal leaf area were measured using leaf area meter. Fresh weight of leaves, dry weight of leaves, fresh herbage yield and dry herbage yield were measured using weighing balance.

Table 1: 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

Result and Discussions

Leaf area

Leaf area was higher during kharif compared to winter and summer season. APBm-14 was highest during kharif and rabi season (4.32 cm^2 and 4.27 cm^2) respectively. APBm-5 showed highest during summer season (2.23 cm^2) whereas APBm-26 showed least during every season (2.61 cm^2, 2.39 cm^2 and 2.23 cm^2).

The abundant rainfall during the rainy season leads to an increase in soil moisture, promoting greater leaf area compared to winter and summer (Pandey *et al.*, 2019) season. In contrast, the summer season experiences the least leaf area due to reduced rainfall and decreased soil moisture, which limits nutrient availability and leads to drought stress. Winter falls in the middle, as cooler temperatures slow down metabolic processes, but the available moisture is still greater than in summer, allowing for moderate leaf growth.

Table 2: Leaf area (cm^2) during different seasons of *Bacopa monnieri* germplasm accessions

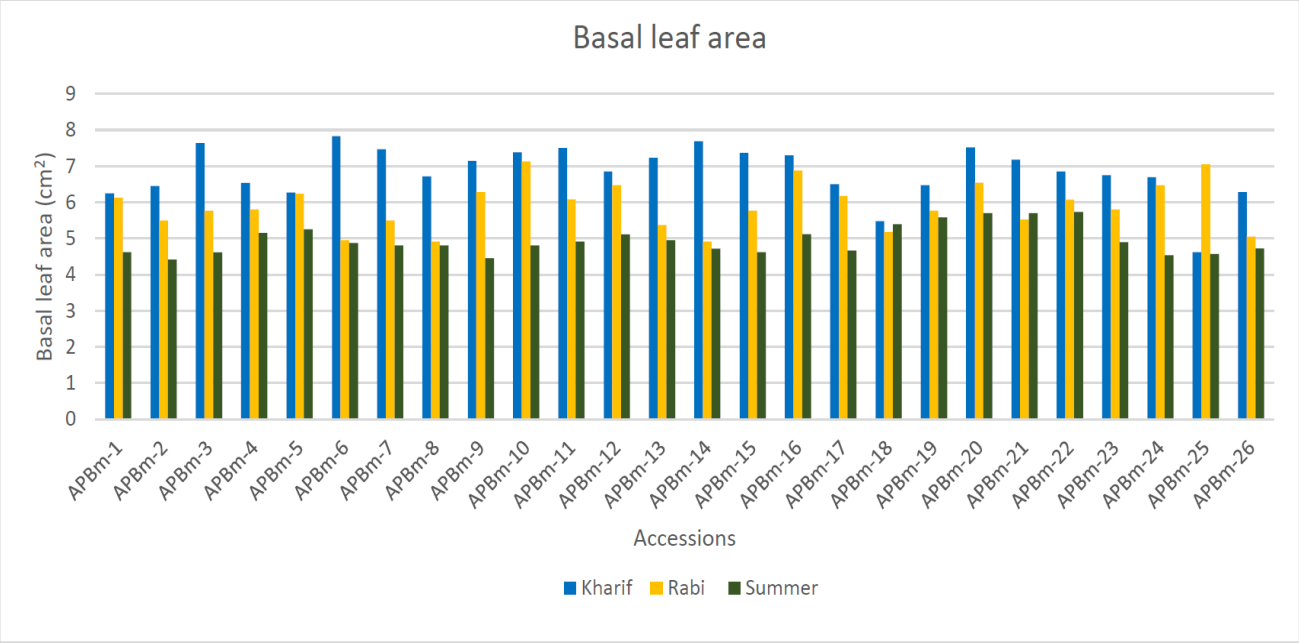
Treatment	Leaf area (cm2)		
	Kharif	Rabi	Summer
APBm-1	4.05	3.59	3.20
APBm-2	2.93	3.50	2.71
APBm-3	3.05	3.45	2.81
APBm-4	3.15	3.45	2.84
APBm-5	3.35	3.27	3.84
APBm-6	3.67	2.52	2.46
APBm-7	4.22	2.48	2.38
APBm-8	3.63	2.57	2.52
APBm-9	3.30	2.69	3.42
APBm-10	3.42	2.82	3.54
APBm-11	3.72	3.08	3.23
APBm-12	3.73	3.32	3.26

APBm-13	3.83	3.32	2.61
APBm-14	4.32	4.27	3.28
APBm-15	2.77	3.49	3.15
APBm-16	3.50	3.89	2.41
APBm-17	3.63	3.68	2.93
APBm-18	3.92	3.72	3.28
APBm-19	3.68	2.66	3.03
APBm-20	2.92	3.12	2.64
APBm-21	2.72	2.78	2.75
APBm-22	2.73	3.43	2.57
APBm-23	3.37	2.96	2.69
APBm-24	3.50	3.76	3.14
APBm-25	3.20	3.63	2.26
APBm-26	2.61	2.39	2.23
Mean	3.42	3.22	2.89
S.EM	0.111	0.136	0.081
C.D. 5%	0.32	0.40	0.23

Basal leaf area

Basal leaf area was highest during kharif followed by rabi and summer season. In kharif season maximum was obtained for APBm-6 (7.83 cm^2) and minimum obtained for APBm-25 (4.62 cm^2). In rabi season maximum and minimum obtained for APBm-10 and APBm-14 (7.13 cm^2, 4.62 cm^2) respectively. Meanwhile APBm-22 showed highest basal leaf area (5.73 cm^2) and lowest for APBm-2 in summer season (4.42 cm^2).

Increase in water content can increase the basal leaf area and it can be decreased with aggravated water stress (Ke *et al.*, 2022). Elevated temperature and reduced precipitation during summer, have an impact on basal leaf area, serving as an adaptive mechanism to limit transpiration, in order to conserve soil moisture around plant roots to increase the chance of survival of plant. This cause the reduction in cell size thus a decrease in basal leaf area (Boutraa *et al.*, 2010).



Graph 1: Basal leaf area (cm2) of Bacopa monnieri germplasm accessions in different seasons

Fresh weight of leaves

The fresh weight of leaves was highest in APBm-14 during kharif and rabi season and during summer (5.63 g and 5.45 g) respectively. APBm-5 was highest during summer season on 4.03 g. And APBm-26 was found lowest during kharif, rabi and summer season (3.73 g, 3.61 g and 3.29 g) respectively. Fresh weight of leaves was found to be higher during kharif and least during winter.

In drought-stressed conditions, the reduction in lower photosynthetic rates, attributed to biochemical limitations and water scarcity, leading to a decrease in the photosynthetic pigments. This decline in pigments resulted in reduced biomass, ultimately contributing to a decrease in the fresh weight of leaves (Shu-han *et al*., 2018) during summer.

Dry weight of leaves

The dry weight of leaves was highest in APBm-14 during kharif and rabi season and during summer (1.11 g and 1.01 g) respectively. APBm-5 was highest during summer season (0.58 g) And APBm-26 was found lowest during kharif, rabi and summer season (0.58 g, 0.62 g and 0.37 g) respectively.

Dry weight of leaves was obtained more in kharif season compared to winter and summer across all accessions. During the kharif season, an increased number of leaves resulted in higher dry weight of leaves. Conversely in summer, reduced leaf production due to water stress led to decrease in the dry weight of leaves. These results are in agreement with Santos *et al*. (2012) in *Mentha* spp.

Table 3: Fresh weight of leaves (g) and dry weight of leaves (g) of Bacopa monnieri germplasm accessions during different seasons.

Treatment	Fresh weight of leaves (g)			Dry weight of leaves (g)		
	Kharif	Rabi	Summer	Kharif	Rabi	Summer
APBm-1	5.50	4.64	3.74	0.90	0.87	0.42
APBm-2	4.24	4.63	3.61	0.89	0.70	0.39
APBm-3	4.56	4.58	3.64	0.87	0.71	0.40
APBm-4	4.66	4.59	3.67	0.88	0.72	0.41
APBm-5	4.71	4.38	4.03	0.74	0.75	0.58
APBm-6	5.07	3.83	3.45	0.64	0.80	0.38
APBm-7	5.62	3.76	3.41	0.64	0.89	0.38
APBm-8	5.06	3.97	3.49	0.64	0.79	0.39
APBm-9	4.69	4.17	3.89	0.70	0.75	0.43
APBm-10	4.75	4.29	3.91	0.71	0.76	0.44
APBm-11	5.12	4.30	3.74	0.74	0.85	0.42
APBm-12	5.18	4.40	3.78	0.76	0.85	0.42
APBm-13	5.19	4.40	3.56	0.78	0.87	0.39
APBm-14	5.63	5.45	3.82	1.11	1.01	0.43
APBm-15	4.21	4.60	3.72	0.88	0.69	0.42
APBm-16	4.79	5.20	3.44	1.04	0.77	0.38
APBm-17	5.07	4.80	3.68	0.94	0.80	0.41
APBm-18	5.45	4.96	3.87	0.95	0.87	0.43
APBm-19	5.08	4.06	3.71	0.68	0.83	0.41
APBm-20	4.24	4.36	3.58	0.74	0.70	0.39
APBm-21	4.18	4.18	3.63	0.71	0.67	0.40
APBm-22	4.18	4.56	3.53	0.78	0.68	0.39
APBm-23	4.72	4.30	3.59	0.73	0.76	0.39
APBm-24	5.01	5.05	3.71	0.99	0.78	0.41
APBm-25	4.67	4.72	3.35	0.92	0.73	0.37
APBm-26	3.73	3.61	3.29	0.58	0.62	0.37
Mean	4.82	4.45	3.65	0.81	0.78	0.41
S.EM	0.349	0.309	0.129	0.055	0.045	0.020
C.D. 5%	1.02	0.90	0.37	0.16	0.13	0.06

Fresh herbage yield (kg m^{-2})

The fresh herbage yield per plot was highest in APBm-14 during kharif and rabi season and during summer (8.176 kg m^{-2} and 4.349 kg m^{-2}) respectively. APBm-5 was highest during summer season (0.980 kg m^{-2}). And APBm-26 was found lowest during kharif, rabi and summer season (2.188 kg m^{-2}, 1.33 kg m^{-2} and 0.033 kg m^{-2}) respectively. Fresh herbage yield was higher during kharif season and least during summer.

During winter season, the humidity levels are high compared to summer season despite lower temperatures contribute to improved growth performance and higher herbage yield (Chia and Lim, 2022) than summer season. Furthermore, the rainy season is favoured for the growth of Brahmi due to the combination of moderate humidity, elevated temperatures and availability of adequate water during this period (Wate *et al*., 2021).

These results are consistent with Rahajanirina *et al*. (2012) in *Centella asiatica*.

Dry herbage yield (kg m^{-2})

The dry herbage yield per plot was highest in APBm-14 during kharif and rabi season and during summer (1.322 kg m^{-2} and 0.893 kg m^{-2}) respectively. APBm-5 was highest during summer season (0.289 kg m^{-2}). And APBm-26 was found lowest during kharif, rabi and summer season (0.385 kg m^{-2}, 0.194 kg m^{-2} and 0.014kg m^{-2}) respectively. Higher dry herbage yield was obtained during kharif followed by winter and summer season.

During kharif season plants cultivated under favourable weather conditions experienced an extended vegetative growth period characterized by increased plant height, spread and number of branches. This abundance contributed to a larger leaf area enhancing photosynthesis efficiency and resulting in significant increase in total dry matter accumulation, as observed in mint (Desai *et al*., 2019). However, the low precipitation rates during the summer season led to reduced plant growth compared to the winter season.

These results are in line with Santos *et al*. (2012) in *Mentha* spp.

Conclusion

From this study it is concluded that there is significant difference in yield characteristics during each season and also among the accessions. APBm-14 showed superior yield traits such as leaf area, fresh weight of leaves, dry weight of leaves, fresh herbage yield and dry herbage yield during kharif and rabi season. APbm-5 showed higher leaf area, fresh weight of leaves, dry weight of leaves, fresh herbage yield and dry herbage yield during summer season compared to other accessions.

Table 4: Fresh herbage yield (kg/m2) and dry herbage yield (kg/m2) of Bacopa monnieri germplasm accessions during different seasons.

Treatment	Fresh herbage yield (kg/m^2)			Dry herbage yield (kg/m^2)		
	Kharif	Rabi	Summer	Kharif	Rabi	Summer
APBm-1	5.787	2.869	0.809	1.189	0.673	0.189
APBm-2	3.326	2.822	0.572	0.618	0.624	0.174
APBm-3	3.442	2.540	0.650	0.630	0.370	0.176
APBm-4	3.516	2.597	0.662	0.655	0.371	0.177
APBm-5	3.670	2.411	0.980	0.748	0.273	0.289
APBm-6	4.429	1.727	0.439	0.902	0.223	0.117
APBm-7	6.317	1.615	0.339	1.322	0.222	0.116
APBm-8	4.107	1.840	0.448	0.846	0.226	0.119
APBm-9	3.639	1.906	0.883	0.710	0.253	0.219
APBm-10	4.020	1.980	0.952	0.788	0.259	0.245
APBm-11	4.494	2.318	0.839	0.965	0.272	0.194
APBm-12	4.710	2.522	0.869	0.972	0.304	0.194
APBm-13	4.726	2.525	0.540	1.022	0.310	0.149
APBm-14	8.176	4.349	0.872	1.566	0.893	0.199
APBm-15	3.131	2.804	0.791	0.528	0.492	0.187
APBm-16	4.035	3.851	0.369	0.789	0.788	0.117
APBm-17	4.164	3.097	0.759	0.850	0.725	0.182
APBm-18	5.046	3.122	0.879	1.029	0.730	0.207

APBm-19	4.493	1.905	0.768	0.943	0.252	0.183
APBm-20	3.211	2.332	0.544	0.602	0.273	0.169
APBm-21	2.231	1.959	0.622	0.459	0.254	0.175
APBm-22	2.763	2.526	0.502	0.471	0.367	0.146
APBm-23	3.684	2.210	0.562	0.778	0.264	0.173
APBm-24	4.105	3.126	0.789	0.835	0.773	0.185
APBm-25	3.637	3.081	0.130	0.689	0.678	0.113
APBm-26	2.188	1.330	0.033	0.385	0.194	0.014
Mean	4.12	2.51	0.64	0.82	0.43	0.17
S.EM	0.022	0.041	0.006	0.016	0.001	0.006
C.D. 5%	0.064	0.119	0.017	0.047	0.004	0.016

References

Boutraa, T., Akhkha, A., Al-Shoaibi, A.A. and Alhejeli, A.M. (2010). Effect of water stress on growth and water use efficiency (WUE) of some wheat cultivars (*Triticum durum*) grown in Saudi Arabia. *Journal of Taibah University for Science*. ***3***(1): 39-48.

Chia, S.Y. and Lim, M.W. (2022). A critical review on the influence of humidity for plant growth forecasting. *IOP Conference Series: Materials Science and Engineering*. **1257**: 012001.

Choudhary, S., Kumari, I., Thakur, S., Kaurav, H. and Chaudhary, G. (2021). Brahmi (*Bacopa monnieri*)- a potential ayurvedic cognitive enhancer and neuroprotective herb. *International Journal of Ayurveda and Pharma Research*, **9**(5): 41-49.

Christopher, C., Johnson, A.J., Mathew, P.J. and Baby, S. (2017). Elite genotypes of *Bacopa monnieri*, with high contents of Bacoside A and Bacopaside I, from southern Western Ghats in India. *Industrial Crops and Product*s, **98**: 76-81.

Desai, S., Pushpa, T.N., Srikantaprasad, D., Kantharaju, V., Biradar, I.B. and Hiremath, J.S. (2019). Influence of different planting dates on growth, yield and quality of menthol mint (*Mentha arvensis* L.) cultivars during kharif season. *International Journal of Current Microbiology and Applied Sciences*, **8**: 468-478.

Gupta, R., Singh, A., Srivastava, M., Singh, V., Gupta, M.M. and Pandey, R. (2017). Microbial modulation of bacoside A biosynthetic pathway and systemic defense mechanism in *Bacopa monnieri* under *Meloidogyne incognita* stress. *Scientific Reports*, **7**(1): 41867.

Kala, C.P, Dhyani, P.P. and Sajwan, B.S. (2006). Developing the medicinal plants sector in northern India: challenges and opportunities. *Journal of Ethnobiology and Ethnomedicine*, 2:32.

Ke, M., Wang, W., Zhou, Q., Wang, Y., Liu, Y., Yu, Y., Chen, Y., Peng, Z. and Mo, Q. (2022). Response of leaf functional traits to precipitation change: A case study from tropical woody tree. *Global Ecology and Conservation,* **37**: e02152.

Naik, P.M., Manohar, S.H., Praveen, N., Upadhya, V. and Murthy, H.N. (2012). Evaluation of Bacoside A Content in Different Accessions and Various Organs of *Bacopa monnieri* (L.) Wettst. *Journal of Herbs, Spices & Medicinal Plants,* **18**(4): 387-395.

Pandey, V., Bhatt, I.D. and Nandi, S.K. (2019). Environmental stresses in Himalayan medicinal plants: research needs and future priorities. *Biodiversity and Conservation*, **28**: 2431-2455.

Rahajanirina, V., Raoseta, R.S.N.O, Roger, E., Razafindrazaka, H., Pirotais, S., Boucher, M. and Danthu, P. (2012). The Influence of Certain Taxonomic and Environmental Parameters on Biomass Production and Triterpenoid Content in the Leaves of *Centella asiatica* (L.) Urb. from Madagascar. C*hemistry and Biodiversity*, ***9***(2): 298-308.

Santos, V.M.C.S., Pinto, M.A.S., Bizzo, H.R. and Deschamps, C. (2012). Seasonal variation of vegetative growth, essential oil yield and composition of menthol mint genotypes at southern Brazil. *Bioscience Journal,* **28**(5): 790–798.

Shu-han, Z., Xue-feng, X., Ye-min, S., Jun-lian, Z. and Chao-zhou, L. (2018). Influence of drought hardening on the resistance physiology of potato seedlings under drought stress. *Journal of Integrative Agriculture,* **17**(2): 336–347.

Singh, V., Jain, N. and Shri, R. (2021). Effect of abiotic factors on bacoside A content, acetylcholinesterase inhibitory and antioxidant activities of *Bacopa monnieri* (L.) Wettst. *Journal of Applied Pharmaceutical Science*, **11**(1): 063-070.

Smitha, G.R., Kalaivanan, D. and Sujatha, S. (2021). Influence of shade and organic nutrition on growth, yield and quality of memory enhancing herb, Brahmi (*Bacopa monnieri* L.). *Medicinal Plants*, **13**(1): 72-90.

Wate, P., Khobragade, P. and Pargaonkar, A. (2021). Chromatographic evaluation of optimization and seasonal variation of bacoside a content from wild and cultivated brahmi (*Bacopa monnieri* Linn.) plant. *International Journal of Pharmaceutical Sciences and Research,* **12**(6): 3481-3489.