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SEASONAL VARIATION IN BIOCHEMICAL 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 biochemical characteristics of Brahmi (*Bacopa monnieri*) germplasm accessions. The study employed a randomized block design with two replications evaluating biochemical parameters such as carbohydrates, proteins, tannins, phenols, flavonoids and bacoside content. Carbohydrate content was highest in APBm-22 and lowest in APBm-11 during kharif season. APBm-20 showed highest and APBm-15 showed lowest during rabi season. APBm-25 showed highest and APBm-19 showed lowest in summer season. Protein showed highest and lowest in APBm-1 and APBm-10 in kharif season respectively. During rabi season it was maximum in APBm-20 and minimum in APBm-9. APBm-6 and APBm-5 showed higher and lower protein content in summer season respectively. APBm-1 and APBm-22 showed highest and lowest during kharif season and APBm-2 and APBm-20 showed maximum and minimum in rabi season for tannin content respectively. Higher content of tannin was showed in APBm-21 and lower in APBm-14 during summer season. APBm-4 and APBm-15 showed maximum and minimum phenol content in kharif season. APBm-11 and APBm-20 showed highest and lowest during rabi and APBm-12 and APBm-14 showed minimum and maximum during summer season. Flavonoid content was higher in APBm-13 and lower in APbm-3 during kharif season. APBm-1 and APBm-23 showed maximum and minimum during rabi and APBm-11 and APBm-18 showed highest and lowest during summer season respectively.

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

Introduction

Medicinal herbs have been the cornerstone of traditional medicine for centuries, offering a vast array of bioactive compounds with profound therapeutic potential. Among these, *Bacopa monnieri* stands out as a paradigm of nature's pharmacy, boasting a rich phytochemical profile and a multitude of health benefits that have been revered in traditional Ayurvedic medicine for millennia. *Bacopa monnieri* belongs to Scrophulariacea family and is a creeping and branched succulent perennial herb (Kumar, 2017). In India, it grows naturally in wet soil, shallow water and marshy areas showing rooting at nodes. The herb

can be found at elevations from sea level to an altitude of 4,400 feet and is easily cultivated if adequate water is available. This plant possesses antioxidant property and is used as a cardiotonic in India and Pakistan (Tanveer *et al.,* 2010). Brahmi is used for improving intellect and memory and also against inflammatory diseases. It contains several biologically active compounds including alkaloids, bacosides, flavonoids, glycosides, triterpenoids and saponins (Maneeply *et al*., 2018).

The therapeutic effects of *Bacopa monnieri* are attributed to triterpenoid saponins called bacosides. The bacosides promote the repair of damaged neurons by upregulating neuronal synthesis, kinase activity and restoration of synaptic activity which leads to nerve impulse transmission (Mathur *et al*., 2016). At present, Brahmi can be found as an ingredient in food supplements, teas and cosmetic products. The raw materials of Brahmi are in high demand by these industries (Phrompittayarat *et al*., 2011). Due to these reasons, *Bacopa monnieri* has been designated as the second most important medicinal plant in a prioritization list, and it is one of 32 medicinal plant species identified for conservation and cultivation efforts (Bansal et al., 2016). The study was conducted to understand the best suitable seasons for growing Brahmi and find superior accessions from them during each season which giver higher biochemical compounds.

Material and Methods

The experiment 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.

Carbohydrate and protein content was analysed using the method by Patel *et al.* (2022) and phenol content was estimated by the procedure by Gurumoorthi *et al.* (2003). Tannin content was analyzed using Tambe and Bhambar (2014) method. Flavonoid content was obtained using Chang *et al.* (2002) procedure.

Result and Discussions

Carbohydrates

Maximum carbohydrate content was obtained during kharif season in APBm-22 (238.11 mg $100g^{-1}$) while APBm-11 registered lowest carbohydrates (74.4 mg 100 g^{-1}) content. In rabi season, APBm-20 recorded the highest carbohydrates content (139.4 mg 100 g^{-1}) whereas APBm-15 registered lowest carbohydrates (63.83 mg 100 g^{-1}) content. During summer season, APBm-25 recorded the highest carbohydrates content (179.4 mg 100 g^{-1}) and APBm-19 registered lowest carbohydrates (65.11 mg 100 g^{-1}) content.

Carbohydrate levels in Brahmi were highest during the rainy season followed by summer and lowest in winter. The abundance of carbohydrates during the rainy season can be attributed to the role of sugars in providing the carbon and energy required for plant growth and development. The lower carbohydrate levels in winter may be due to reduced photosynthetic activity under cooler temperatures, resulting in less sugar production. These results are in line with El-lamey and El-Maboud in Capparis spinosa (2022) and Wahba *et al.* (2017) in *Cynara cardunculus* L.

Proteins

In kharif season, APBm-1 recorded the highest protein (33.34 mg 100 g^{-1}) and APBm-10 registered lowest protein (2.36 mg 100 g^{-1}). In rabi season, APBm-20 recorded the highest protein (29.27 mg 100 g^{-1}) while APBm-9 registered lowest protein (7.6 mg 100 g^{-1}). In summer season, APBm-6 recorded the highest protein (35.86 mg 100 g^{-1}) and APBm-5 (29.48 mg 100 g^{-1}) registered lowest protein (11.09 mg 100 g^{-1}).

Protein content in Brahmi was highest during the summer season, followed by the rainy season while the lowest levels were observed in winter. These results are in agreement with Gehlot and Kasera, 2013 in *Phyllanthus amarus* and Uddin and Alam, 2022 in *Centella asiatica.*

Tannins

In kharif season, APBm-1 recorded the highest tannins content (29.13 mg g^{-1}) whereas APBm-22 registered the lowest tannins (0.53 mg g^{-1}) content. In rabi season, APBm-2 recorded the highest tannins (11.81 mg g^{-1}) while APBm-20 registered lowest tannins (4.43 mg g^{-1}) content. In summer season, APBm-21 recorded the highest tannins (19.02 mg g^{-1}) followed by APBm-1 (16.56 mg g^{-1}) and APBm-19 (16.31 mg g^{-1}). APBm-14 registered lowest tannins content (1.97 mg g^{-1}).

From the results tannin was highest during rainy season followed by summer and winter. In kharif season the high content of tannin is due to greater photosynthetic activity and greater herbivore pressure (Monteiro *et al*., 2006). These findings are in line with Gololo *et al*., 2016 in *Barleria dinteri* and *Grewia flava* which shows rainy season have more tannin content than summer.

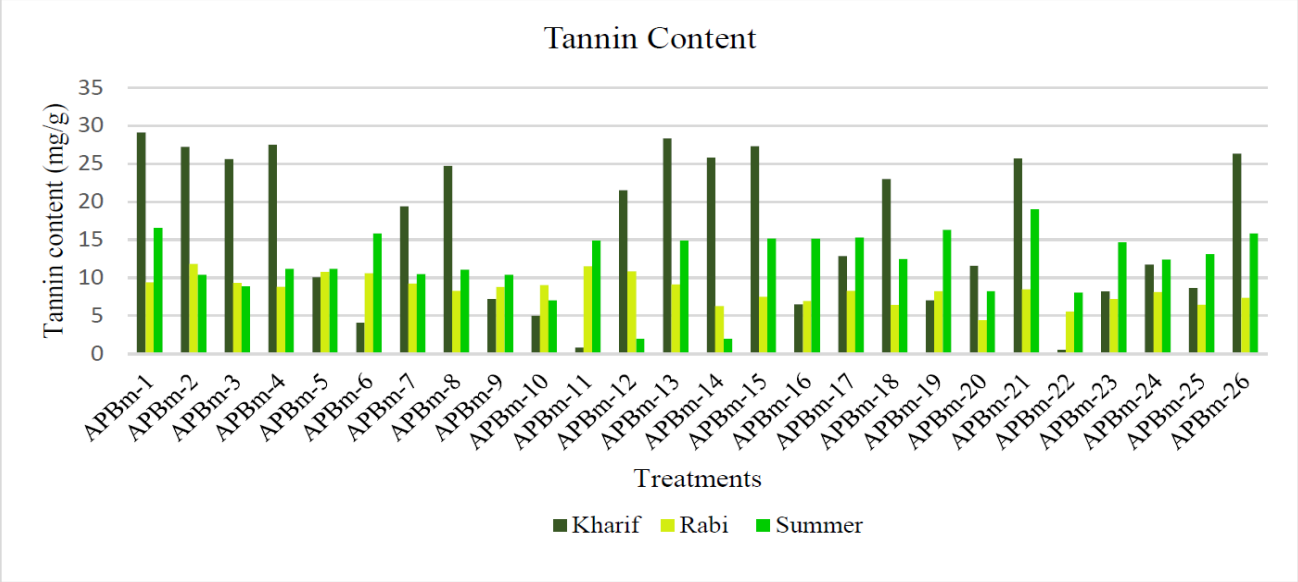

Fig. 1: Seasonal variation of tannin content in *Bacopa monnieri* germplasm accessions.

Phenols

In kharif season, the average phenol content was 8.84 mg g^{-1} with a range of 2.30 mg g^{-1} to 19.80 mg g^{-1}. APBm-4 recorded the highest phenols (19.80 mg g^{-1}) whereas APBm-15 registered lowest phenol (2.3 mg g^{-1}) content. In rabi season, APBm-11 recorded the highest phenol (22.77 mg g^{-1}) while APBm-20 registered lowest phenol (2.61 mg g^{-1}) content. In summer season, the average phenol was 25.69 mg g^{-1} with a range of 11.10 mgg^{-1} to 37.56 mg g^{-1}. APBm-12 recorded the highest phenol (37.56 mg g^{-1}) and APBm-14 registered lowest phenol (11.10 mg/g) content.

Phenolic content in Brahmi was highest during summer followed by winter with the lowest levels were recorded during the rainy season. The observed increase in phenolic content during summer represents an adaptive response that protects the plants from UV-B penetration in leaf tissues, acting as a natural screen and an antioxidant to protect cells from reactive oxygen species (Kumari *et al*., 2009). The higher phenol concentration in winter compared to the rainy season may be attributed to low temperature stress (Soni *et al*., 2015). These results and findings are in consistent with Verma and Kasera (2007) in *Sida cordifolia* and Gololo *et al*. (2016) in *Barleria dinteri*.

Flavonoids

In kharif season, APBm-13 recorded the highest flavonoid (12.16 mg g^{-1}) while APBm-3 registered lowest flavonoid (6.04 mg g^{-1}) content. In rabi season, APBm-1 recorded the highest flavonoid (10.77 mg g^{-1}) while APBm-23 registered the lowest flavonoid content (3.89 mg g^{-1}). In summer season, APBm-11 recorded the highest flavonoid (7.95 mg g^{-1}) and APBm-18 registered the lowest flavonoid (2.56 mg g^{-1}) content.

Flavonoid content in Brahmi was highest during the rainy season, followed by winter and lowest levels observed in summer. High temperatures (30°C – 40°C) during the summer can inhibit flavonoid synthesis by suppressing gene expression and enzyme activity, while cooler temperatures in winter can induce flavonoid biosynthesis (Prinsloo and Nogemane, 2018). These findings are in line with Soni *et al*. (2015) in *Chelidonium majus*.

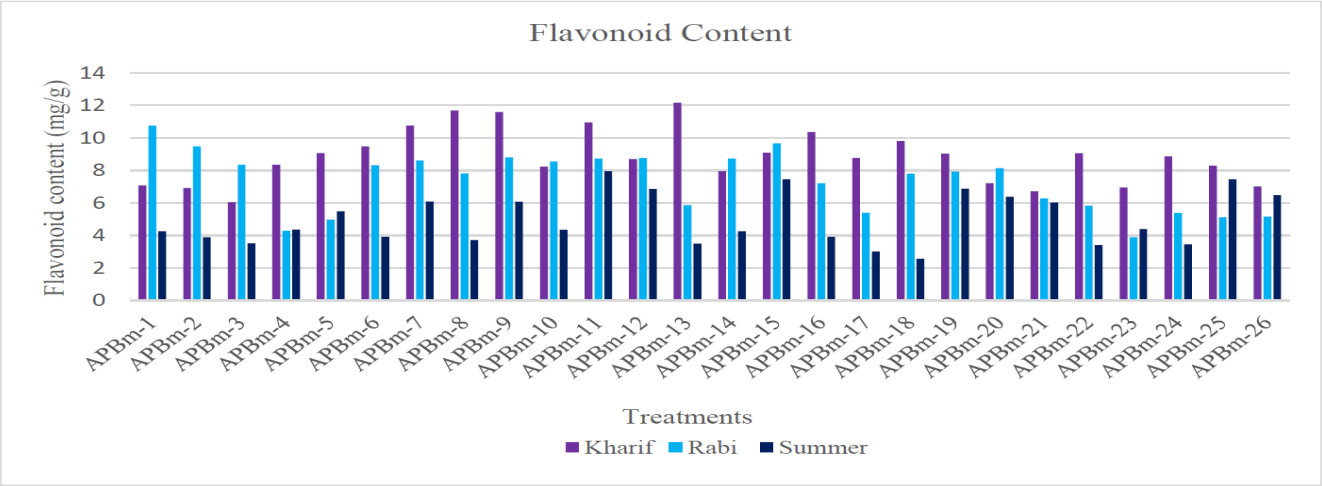

Fig. 2 : Seasonal variation of flavonoid content in Bacopa monnieri germplasm accessions

Conclusion

From this study, found out that highest carbohydrate was obtained during rainy season followed by summer and lowest in winter. Protein content in Brahmi was highest during the summer season, followed by the rainy season and winter. Tannin was highest during rainy season followed by summer and winter. Phenolic content in Brahmi was highest during summer followed by winter and rainy season. Flavonoid content in Brahmi was highest during the rainy season, followed by winter and summer.

Table 1 : Seasonal variation of Bacopa monnieri germplasm accessions in carbohydrate, protein and phenol content.

Treatments	Carbohydrate (mg/100g)			Protein (mg/100g)			Phenol (mg/g)		
	Kharif	Rabi	Summer	Kharif	Rabi	Summer	Kharif	Rabi	Summer
APBm-1	197.68	128.69	110.69	33.34	26.14	19.62	13.98	18.23	31.84
APBm-2	136.25	114.40	91.83	30.67	22.16	22.34	4.34	19.29	28.64
APBm-3	76.68	92.40	79.40	22.64	9.14	17.86	2.90	13.43	18.54
APBm-4	102.97	97.26	96.54	28.18	22.62	19.83	19.80	18.91	21.92
APBm-5	92.54	125.83	139.26	15.39	18.25	29.48	13.64	9.11	27.74
APBm-6	103.97	113.69	126.54	16.78	11.3	35.86	3.70	17.89	27.74
APBm-7	79.11	115.98	107.97	20.73	13.76	20.30	2.62	5.31	31.34
APBm-8	174.82	125.98	120.69	5.57	15.07	17.60	9.60	17.35	35.74
APBm-9	112.40	133.40	119.26	10.50	7.6	17.39	9.50	18.63	27.12
APBm-10	118.68	114.40	122.11	2.36	11.53	16.18	6.98	20.31	27.48
APBm-11	74.40	135.98	103.26	3.17	10.18	22.14	7.20	22.77	16.24
APBm-12	90.11	85.83	96.69	17.15	13.62	21.79	13.18	10.33	37.56
APBm-13	125.82	95.98	135.11	10.48	13.16	19.95	17.20	10.21	28.48
APBm-14	111.54	121.98	106.69	15.13	15.18	19.67	18.98	4.33	11.10
APBm-15	174.82	63.83	120.83	2.97	18.2	18.23	2.30	8.33	21.66
APBm-16	136.25	114.40	112.26	5.04	13.88	16.20	2.70	8.75	31.04
APBm-17	187.68	76.69	95.26	27.06	22.93	17.86	7.60	5.29	27.80
APBm-18	94.83	80.69	108.26	24.43	22.23	17.07	7.20	6.61	24.08
APBm-19	76.83	111.12	65.11	23.29	23.18	22.72	11.34	2.61	34.66
APBm-20	125.83	139.40	139.54	25.48	29.27	33.27	14.84	6.29	35.74
APBm-21	192.11	128.69	113.97	23.73	22.16	11.09	13.06	9.15	27.12
APBm-22	238.11	134.69	138.26	25.61	21.9	15.27	4.46	8.33	18.34
APBm-23	158.83	129.26	139.69	25.64	10.58	22.90	2.66	6.33	20.22
APBm-24	94.82	91.69	126.54	24.26	18.16	13.16	7.20	6.71	23.18
APBm-25	112.40	104.83	179.40	13.66	19.58	20.41	10.38	13.39	12.32
APBm-26	118.69	74.40	120.83	22.57	13.41	15.67	2.60	9.43	20.20
Mean	**127.24**	**109.67**	**116.00**	**18.30**	**17.12**	**20.15**	**8.84**	**11.44**	**25.69**
S.EM	**3.067**	**2.197**	**1.396**	**0.734**	**0.774**	**0.757**	**1.013**	**0.922**	**1.128**
C.D. 5%	**8.93**	**6.40**	**4.07**	**2.14**	**2.25**	**2.21**	**2.95**	**2.68**	**3.29**

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