International Journal of Economic Plants 2023, 10(4): 302-307

Full Research

Doi: HTTPS://DOI.ORG/10.23910/2/2023.4444b

Growth Attributes and Economics of Brahmi (*Bacopa monnieri* L.) Cultivation Influenced by Organic Sources of Nutrients

Vikram N.[1], N. C. Sarkar[1*], R. Sridhar[1], B. Ghosh[2], M. K. Doon[1] and K. S. Bochalya[1]

[1]Dept. of Agronomy, Palli Siksha Bhavana, Visva-Bharati university, Sriniketan, West Bengal (731 236), India
[2]Dept. of Botany, Ramakrishna Mission Vivekananda Centenary College, Khardah, West Bengal (700 118), India

Corresponding Author

N. C. Sarkar
e-mail: narayanchandra.sarkar@visva-bharati.ac.in

Article History

Article ID: IJEP4444b
Received on 17th July, 2023
Received in revised form on 04th November, 2023
Accepted in final form on 25th November, 2023

Abstract

A field study was conducted at the Agricultural Farm of Visva-Bharati University, Sriniketan, West Bengal, during August, 2021 to January, 2022 and August, 2022 to January, 2023 to evaluate the effects of different nutrient sources on Brahmi's growth and profitability. Seven treatments were tested: T_1 (NPK @ 50:25:25), T_2 (farmyard manure @ FYM 10 t ha^{-1}), T_3 (vermicompost @ 5 t ha^{-1}), T_4 (FYM @ 10 t ha^{-1}+ seaweed extract @ 3 ml l^{-1}), T_5 (vermicompost @ 5 t ha^{-1}+seaweed extract @ 3 ml l^{-1}), T_6 (FYM @ 5 t ha^{-1}+vermicompost @ 2.5 t ha^{-1}), and T_7 (control with no amendments). Growth parameters such as Leaf area index (LAI), crop growth rate (CGR), and relative growth rate (RGR) were recorded. Pooled data revealed that T_6 (FYM+vermicompost) resulted in the highest LAI (1.536), CGR (1.462 g m^{-2} day^{-1}), and RGR (0.04338 g g^{-1} day^{-1}), indicating its superior performance in promoting Brahmi's growth. T_6 also achieved the highest economic returns, with gross returns of ₹ 2,36,728 ha^{-1} and a benefit-cost ratio of 2.88, making it the most profitable treatment. Treatments T_3 (vermicompost) and T_5 (vermicompost+seaweed extract) also performed well, particularly during early growth stages, though they were outperformed by T_6 over the entire growth cycle. T_1 (NPK) and T_2 (FYM) showed moderate growth and economic returns, while T_7 (control) recorded the lowest performance in both growth indices and profitability. These findings underscore the effectiveness of organic amendments, particularly the combination of FYM and vermicompost, in enhancing both the growth and economic viability of Brahmi cultivation.

Keywords: Brahmi, economics, FYM, growth, seaweed extract, vermicompost

1. Introduction

Bacopa monnieri (L.) Pennell, known as Brahmi, Jal Brahmi, water hyssop, herb of grace, and Indian pennywort, is a perennial, creeping, non-aromatic herb belonging to the Plantaginaceae family. It features succulent, oblanceolate leaves arranged oppositely on the stem, small actinomorphic flowers that are white or light blue with four to five petals, and a fibrous root system. The plant thrives in humid, muddy and flooded environments, such as wet and marshy areas and is highly tolerant of poor drainage conditions, performing best in alluvial marshy soil (Malik and Tlustos, 2023; Satyavati et al., 1976). Traditionally used in Ayurvedic medicine, Brahmi is recognized for its ability to enhance memory and cognitive function. Numerous studies have supported its therapeutic effects in treating neurological disorders and improving cognitive processes (Singh and Dhawan, 1997; Vohora et al., 2000; Das et al., 2002; Russo et al., 2003; Russo and Borrelli, 2005; Limpeanchob et al., 2008; Uabundit et al., 2010). Beyond its renowned cognitive benefits, Brahmi is also employed in treating respiratory, cardiac and neurological conditions, including depression, psychosis, insomnia, epilepsy and stress (Rajani, 2008). It's versatility makes it a valuable commodity in the herbal market, with significant trade volume and an estimated annual consumption of 140.62 metric tons (Goraya and Ved, 2017).

Traditionally, Brahmi is used to treat mild dysenteric bowel disorders in children, where a few leaves mixed with cumin and sugar are administered and pounded leaves are applied to the navel. The powdered form is also used to promote bowel and kidney functions, stimulate appetite, and alleviate digestive issues (Singh and Dhawan, 1982). Moreover, Brahmi is recognized for energizing the nervous system and the heart, aiding in treating conditions such as asthma, insanity and epilepsy (Mukherjee and Dey, 1966). In modern pharmacology, Brahmi contains bacosides, which enhance memory and cognitive functions. Products like Mentat, Memory plus and Megamind Plus utilize these compounds (Gupta and Patel, 2017).

Mineral fertilizers can increase biomass yield, but their use can harm soil health and the environment. For high-value medicinal plants like Brahmi, the focus should be on maintaining quality rather than maximizing yield, as the synthesis of secondary metabolites responsible for its medicinal properties is sensitive to growing conditions (Moniuszko and Wishniewski, 2001). The growing demand for organically cultivated products, which fetches a premium price in global markets, further underscores the importance of organic cultivation practices. However, India faces challenges in fully capitalizing on its export potential due to the fewer number of national certification schemes for authenticating organic produce (Nampoothiri, 2001). The rising costs of chemical fertilizers, energy crises and the limited purchasing power of farmers have spurred interest in alternatives like organic manure. Organic manures improves soil health by enhancing its physical, chemical, and microbial environment, which leads to increased crop yield, improved soil fertility, nutrient availability and moisture retention. Moreover, it offers a sustainable alternative to chemical fertilizers, whose long-term use has led to decline in soil fertility and nutritional quality, disruption of soil organisms and increased susceptibility of crops to pests and diseases. This overuse of nitrogenous fertilizers, such as urea, contributes to groundwater contamination, posing risks to human health (Moniuszko and Wishniewski, 2001). Given these factors, the present study was conducted at the agriculture farm PSB (Palli Siksha Bhavana), Visva-Bharati, Sriniketan, Bolpur, West Bengal, during the years 2021 and 2022. The study aims to examine the effects of organic and inorganic nutrients on Brahmi's growth indices, cultivation cost and profitability.

2. Materials and Methods

2.1. Field experiment

A field experiment was conducted to investigate the impact of organic manures on the growth and productivity of Brahmi during August, 2021 to January, 2022 and August, 2022 to January, 2023 growing seasons at the Agricultural Farm of the Institute of Agriculture (Palli Siksha Bhavana), Visva-Bharati University, Sriniketan, West Bengal, India. The study site is located at 23°40′11″ N latitude, 87°39′30′′ E longitude, with an average altitude of 58.90 meters above sea level in the sub-humid, semi-arid region of West Bengal. The soil characteristics of the experimental field were recorded with a pH of 5.80, nitrogen content (N) of 180 kg ha^{-1}, organic carbon content (OC) of 0.60%, phosphorus content (P) of 28 kg ha^{-1}, and potassium content (K) of 119 kg ha^{-1}.

Meteorological data over two years (2021–2022 and 2022–2023) was collected and analyzed to assess the climatic conditions during the Brahmi cropping period. In 2021–2022, the average maximum and minimum temperatures were 32.99°C and 25.16°C, respectively, with a total rainfall of 105.52 cm. The highest rainfall occurred in the 31st standard week of the year. The relative humidity averaged 84.73%, indicating a notably humid environment during the growing season, and the average sunshine duration was 4.74 hours per day. In 2022–2023, the meteorological data showed similar trends, with an average maximum temperature of 34.61°C, an average minimum temperature of 22.19°C, and a total rainfall of 95.06 cm. The relative humidity averaged 81.64% and the sunshine hours remained consistent at 4.74 hours per day. This data provides insights into the climatic conditions experienced during the Brahmi cultivation, which is crucial for research and agricultural planning.

2.2. Treatments and experimental details

The study employed seven different treatments to evaluate the effects of various nutrient sources on soil fertility and crop growth. The first treatment (T_1) involved the application of NPK fertilizer at a ratio of 50:25:25. The second treatment (T_2) used farmyard manure (FYM) at a rate of 10 tons per hectare. The third treatment (T_3) applied vermicompost at 5 tons per hectare. The fourth treatment (T_4) combined FYM at 10 tons per hectare with seaweed extract at a concentration of 3 ml per liter, which was applied 60 days after planting (DAP). The fifth treatment (T_5) consisted of vermicompost at 5 tons per hectare, also combined with seaweed extract at 3 ml l^{-1}, applied at 60 DAP. The sixth treatment (T_6) involved a mixture of FYM at 5 t ha^{-1} and vermicompost at 2.5 t ha^{-1}. The final treatment (T_7) served as the control group, with no amendments applied.

The farmyard manure used in the study contained 0.48% nitrogen (N), 0.28% phosphorus (P_2O_5) and 0.52% potassium (K_2O), while the vermicompost had 1.75% nitrogen (N), 0.75% phosphorus (P_2O_5) and 0.86% potassium (K_2O). The experiment followed a randomized block design with three replicates and each plot measured 4×3 m^2 (length×width). Planting material for the Brahmi variety 'CIM-Jagrithi' was sourced from the CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow, India. Approximately 40 kg of cuttings, each 15-20 cm long and containing 4–7 nodes, were sufficient for planting one hectare. These cuttings were planted manually at a depth of 5 cm, with a spacing of 50×50 cm^2 between rows and plants. Irrigation was provided immediately after planting to ensure proper establishment and reduce mortality.

2.3. Measurement of leaf area

The leaf area was measured using a leaf area meter. Thirty leaves of various sizes (large, medium, and small) were separated from the stems and measured. The average leaf area per leaf was calculated and multiplied by the total number of leaves to express the leaf area on an area basis (cm^2 m^{-2}). The leaf area index for each plant was then calculated using the formula provided by Radford (1967).

2.4. Crop growth rate (CGR)

The Crop Growth Rate (CGR) was calculated for four different intervals: 30 to 60, 60 to 90, 90 to 120 days after planting (DAP), and from 120 DAP to harvest (150 DAP). The CGR was determined using the following formula:

$$CGR=\frac{W_2-W_1}{t_2-t_1} \text{ g m}^{-2} \text{ day}^{-1}$$

Where,

W_1 and W_2 are dry matter production at times t_1 and t_2 respectively. It is expressed as g of dry matter produced per square meter per day (g m^{-2} day^{-1}) (Radford, 1967).

2.5. Relative growth rate (RGR)

The relative growth rate (RGR) was calculated using the formula:

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1} \text{ g g}^{-1} \text{ day}^{-1}$$

Where,

W_1 and W_2 are the dry weights of plant at times t_1 and t_2, respectively. It was expressed as gram of dry matter produced by a gram of existing dry matter in a day (g g^{-1} day^{-1}) (Radford, 1967).

2.6. Economics

2.6.1. Cost of cultivation

The cost of cultivation was calculated based on the prevailing local charges for various inputs, such as labor, equipment, planting material, fertilizers, chemicals and other expenses.

2.6.2. Gross returns

Gross returns were determined by multiplying the fresh herbage yield of Brahmi (in kg) by the prevailing market price.

2.6.3. Net returns

Net returns for each treatment were calculated by substracting the cost of cultivation from the gross returns.

2.6.4. Benefit-cost ratio

The benefit-cost ratio was calculated using the formula:

Benefit Cost ratio=Gross returns/Cost of cultivation

2.7. Statistical analysis

The data were pooled and statistically analyzed using the analysis of variance method (ANOVA) as described by Gomez and Gomez (1984) and Panse and Sukhatme (1978). The significance of different sources of variation was tested using Fisher-Snedecor's 'F' test at a probability level of 0.05. In the result tables, the standard error of the mean (SEm ±) and the critical difference (C.D.) are provided to compare the differences between means.

3. Results and Discussion

The results on leaf area index (LAI), crop growth rate, relative growth rate (RGR) had been explained in the following growth characters and on economics.

3.1. Leaf area index (LAI)

The pooled data (Table 1) revealed that treatment T_6 (FYM 5 t ha^{-1}+vermicompost 2.5 t ha^{-1}) exhibited the highest LAI across all growth stages, with a pooled mean LAI of 1.536 at harvest. This indicates that a balanced mix of FYM and vermicompost provides an optimal nutrient profile for leaf development. Treatments T_3 (vermicompost 5 t ha^{-1}) and T_5 (vermicompost 5 t ha^{-1}+seaweed extract) also showed relatively high pooled LAI values, especially at later growth stages, reinforcing the benefits of vermicompost, particularly when supplemented with seaweed extract. Conversely, T_1 (NPK 50:25:25) and T_2 (FYM 10 t ha^{-1}) resulted in moderate pooled LAI values, while the control group (T_7) consistently recorded the lowest LAI. The statistical analysis, with low SEM and significant CD values at the 5% level, confirmed the reliability of these results. Yashaswini et al. (2019) revealed that the treatments that included farmyard manure, vermicompost in combination with recommended nitrogen dose and biofertilizers recorded the highest leaf area index in medicinal plant Tulsi (*Ocimum sanctum* L.). Chandravanshi et al. (2021) reported that in Turmeric, leaf area index was significantly recorded higher values when the plants are treated with recommended dose of chemical fertilizer+VC (10 %) over the combined application of vermicompost and farm yard manure and in lettuce, highest leaf area index was found in case of vermicompost when compared with cow manure (Slamet et al., 2017).

Table 1: Leaf area index, relative growth rate as influenced by different nutrient sources

	Leaf area index					Relative growth rate (Pooled) (g g^{-1} day^{-1})			
	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	30–60 DAP	60–90 DAP	90–120 DAP	120 DAP–Harvest
T_1	0.033	0.423	0.593	0.703	0.829	0.03822	0.0172	0.00755	0.0054
T_2	0.03	0.356	0.613	0.902	0.961	0.03807	0.0231	0.00762	0.005
T_3	0.04	0.434	0.755	0.908	1.019	0.0395	0.022	0.00742	0.004
T_4	0.031	0.357	0.661	0.984	1.007	0.03737	0.0284	0.00554	0.0042
T_5	0.034	0.508	0.705	1.112	1.197	0.04033	0.0216	0.00718	0.0041
T_6	0.034	0.69	1.161	1.466	1.536	0.04338	0.0209	0.00607	0.0041
T_7	0.027	0.327	0.449	0.755	0.901	0.03467	0.022	0.00863	0.0031
SEm±	0.002	0.03	0.04	0.07	0.06	0.0013	0.0021	0.0007	0.0007
CD (p=0.05)	0.004	0.05	0.10	0.15	0.12	0.0029	0.0045	0.0014	0.0015

3.2. Crop growth rate (CGR)

The pooled CGR data (Figure 1) in across all growth periods revealed that T_6 significantly outperformed other treatments, with consistently high growth rates throughout the growth cycle. The pooled mean CGR values for T_6 (FYM 5 t ha^{-1}+ vermicompost 2.5 t ha^{-1}) were 1.462 g m^{-2} day^{-1} (30–60 DAP), 2.275 g m^{-2} day^{-1} (60–90 DAP), 1.209 g m^{-2} day^{-1} (90–120 DAP), and 1.232 g m^{-2} day^{-1} (120 DAP to harvest). Treatment T_5 (vermicompost+seaweed extract) showed strong performance in the early and mid-growth stages but saw a decline in later stages, with pooled mean CGR values decreasing toward harvest. Treatment T_3 (vermicompost alone) demonstrated moderate growth, while FYM alone (T_2) and NPK (T_1) exhibited relatively lower growth rates. The control group (T_7) consistently had the lowest CGR values across all stages. A greater leaf area index (LAI) may lead to increased light absorption, which in turn boosts crop growth rate (CGR) and ultimately results in higher yields (Mondal et al., 2017 and Datta et al., 2012). Anand (2004) reported that CGR was recorded highest for recommended NPK, FYM@ 20 t ha^{-1}, vermicompost @ 10 t ha^{-1}. The integrated use of vermicompost and Farm Yard Manure (FYM) significantly enhances Crop Growth Rate (CGR) in wheat by improving soil health and nutrient availability. Vermicompost provides essential nutrients like nitrogen, phosphorus, and potassium, along with beneficial microorganisms and enzymes that promote plant growth. When combined with FYM, these organic amendments improve soil structure, water retention, and aeration, fostering better root developmental and nutrient uptake. The approach of applying 50% of the recommended dose of fertilizers (RDF) along with 50% nitrogen through vermicompost ensures a balanced and sustained release of nutrients. This promotes consistent growth, leading to increased CGR, as plants are better able to absorb and utilize nutrients throughout their development stages, these results were revealed by Ahmed et al. (2022).

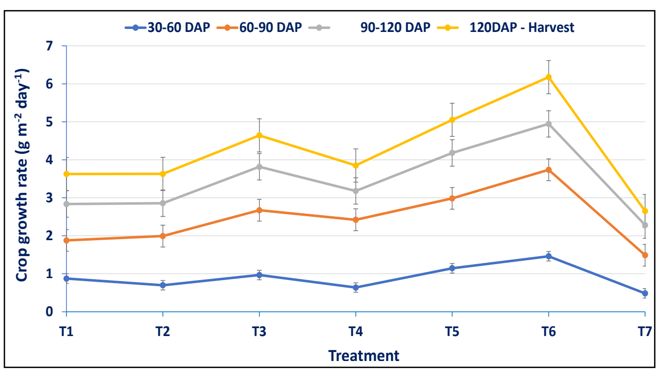

Figure 1: Effect of different sources of organic manures on the Crop growth rate (g m^{-2} day^{-1})

3.3. Relative growth rate (RGR)

Pooled RGR data (Table 1) across different growth periods further highlighted the superiority of T_6. During the early growth stage (30–60 DAP), T_6 showed the highest pooled mean RGR of 0.04338 g g^{-1} day^{-1}, with its effects remaining robust through the pre-harvest period (120 DAP to harvest), where the pooled mean RGR was 0.0041 g g^{-1} day^{-1}. Treatment T_4 (FYM+seaweed extract) demonstrated the highest pooled RGR during the mid-growth period (60-90 DAP) with a value of 0.0284 g g^{-1} day^{-1}, but it was outperformed by T_6 in the long term. Treatments involving vermicompost alone or in combination with seaweed extract (T_3, T_5) also demonstrated strong early growth, although their effects diminished in later stages. The control group (T_7) consistently recorded the lowest RGR across all periods, reinforcing the importance of nutrient amendments. These differences were confirmed to be statistically significant. Bijarnia et al. (2023) reported that the highest values for CGR (Crop growth rate), NAR (Net assimilation rate), and LAI (Leaf area index) at various growth stages were observed with the application of vermicompost at 5 t ha^{-1}, showing a significant increase compared to the control group. According to the study, the positive effect of vermicompost on several growth indices of cluster bean may be attributed to the enhancement of soil with balanced and sufficient quantities of primary, secondary, and micronutrients. This improvement likely facilitated better root development and proliferation, allowing for more efficient nutrient absorption from the soil.

3.4. Economic analysis

Pooled economics data (Table 2) across different growth periods further highlighted the superiority of T_6. The pooled economic analysis demonstrated substantial differences in profitability among treatments. Treatment T_6 achieved the highest gross returns (₹ 2,36,728 ha^{-1}) and net returns (₹ 1,54,238 ha^{-1}), with an impressive benefit-to-cost (B:C) ratio of 2.88, making it the most cost-effective treatment. Treatment T_5 followed closely with gross returns of ₹ 2,06,569 ha^{-1} and

Table 2: Economics of cultivation as influenced by different nutrient sources

	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1	64790	123696	58906	1.92
T_2	77490	139310	61820	1.8
T_3	87490	194750	107260	2.22
T_4	82973	157223	74250	1.91
T_5	92973	206569	113596	2.23
T_6	82490	236728	154238	2.88
T_7	62250	82012	19762	1.3
SEm±		9139.9	9139.9	0.12
CD (p=0.05)		19902.8	19902.8	0.26

1US$=INR 74.45 and 81.75 (Average during the harvesting month of January of 2022 and 2023) a net return of ₹ 1,13,596 ha^{-1}, accompanied by a B:C ratio of 2.23. In contrast, the control treatment (T_7) yielded the lowest gross and net returns, with values of ₹ 82,012 ha^{-1} and ₹ 19,762 ha^{-1}, respectively, and a B:C ratio of 1.3, underscoring the economic inefficiency of cultivation without amendments. The statistical analysis confirmed the significance of these economic differences, highlighting T_6 as the most economically viable option.

The pooled data across two years demonstrated that a combination of FYM and vermicompost (T_6) consistently resulted in the highest LAI, CGR, and RGR values, indicating superior plant growth and development. T_6 also proved to be the most economically advantageous treatment, offering the highest returns and the most favourable benefit-to-cost ratio. Treatments involving vermicompost alone (T_3) or combined with seaweed extract (T_5) also showed notable effectiveness, particularly in early growth stages, but were less consistent than T_6 over the full growth cycle. Traditional NPK fertilizer (T_1) and FYM alone (T_2) resulted in moderate growth and returns, while the control group (T_7) underperformed in all aspects. These findings highlight the significant potential of organic amendments, particularly FYM and vermicompost, for enhancing the growth and economic returns of Brahmi cultivation. The study underscores the value of integrated nutrient management strategies in optimizing crop performance, with T_6 emerging as the most effective and sustainable approach. Future research should explore the mechanisms behind the synergistic effects of these organic treatments and investigate their performance under different environmental conditions.

4. Conclusion

Organic nutrient management, particularly the combination of FYM (5 t ha^{-1}) and vermicompost (2.5 t ha^{-1}) in T_6, optimally enhanced Brahmi's growth indices, including LAI, CGR, and RGR, across all stages. T_6 also proved to be the most cost-effective, yielding the highest net returns and benefit-to-cost ratio. Vermicompost-based treatments (T_3, T_5) performed well but were less consistent. Overall, integrating organic amendments improves Brahmi crop growth and profitability, making T_6 the most sustainable option.

5. References

Ahmad, M., Tripathi, S.K., 2022. Effect of integrated use of vermicompost, FYM and chemical fertilizers on soil properties and productivity of wheat (*Triticum aestivum* L.) in Alluvial soil. Journal of Phyto Pharmacology 11(2), 101–106.

Anand, M. 2004. Effect of bio-organic sources of nutrition on growth, yield and quality of *Bacopa monnieri* L. and *Centella asiatica L.* [Doctoral thesis, G. B. Pant University of Agriculture and Technology, Uttrakhand].

Bijarnia, H.K., Arvind Verma, M.K., Kaushik, S.C., Meena, L.N., Mahaver, H.K., Jain., 2023. Effect of weed management and vermicompost on growth indices and yield of clusterbean under Udaipur Region. Biological Forum– An International Journal 15(3), 338–342.

Chandravanshi, K.C., Meena, K., Khan, A., Nitin Soni, D.K., Patidar. 2022. Responses of organic manures and inorganic fertilizers on growth, yield and economics of turmeric (*Curcuma longa* Linn.). Journal of Medicinal Plants Studies 9(3), 243–247.

Das, A., Shanker, G., Nath, C., Pal, R., Singh, S., Singh, H.K., 2002. A comparative study in rodents of standardized extracts of *Bacopa monniera* and *Ginkgo biloba*: anticholinesterase and cognitive enhancing activities. Pharmacology Biochemistry and Behavior 73(4), 893–900.

Datta, J.K., Ghosh, A., Banerjee, A., Mondal, N.K., 2012. Biochemical response of selected plant species under air pollution stress. Ecology Environment Conservation 18, 957–962.

Gomez, K.A., Gomez, A.A., 1984. Statistical procedures for agricultural research. 2nd Edition, John Wiley and Sons, New York. 680.

Goraya, G.S., Ved, D.K., 2017. Medicinal plants in India: an assessment of their demand and supply. National Medicinal Plants Board, Ministry of Ayush, Government of India, New Delhi and Indian Council of Forest Research and Education, Dehradun, 430.

Gupta, N.R., Patel, V.J., 2017. Interaction of two memory enhancing herbal drugs memory plus and mentat with morphine and imipramine in mice. International Journal of Basic & Clinical Pharmacology 6(2), 427–431.

Limpeanchob, N., Jaipan, S., Rattanakaruna, S., Phrompittayarat, W., Ingkaninan, K., 2008. Neuroprotective effect of *Bacopa monnieri* on beta-amyloid-induced cell death in primary cortical culture. Journal of Ethnopharmacology 120(1), 112–117.

Malik, M., Tlustos, P., 2023. Nootropic herbs, shrubs, and trees as potential cognitive enhancers. Plants 12(6), 1364.

Mondal, T., Datta, J.K., Mondal, N.K., 2017. Chemical fertilizer in conjunction with biofertilizer and vermicompost induced changes in morpho-physiological and bio-chemical traits of mustard crop. Journal of the Saudi Society of Agricultural Sciences.

Moniuszko, H., Wisniewski, J., 2001. Wplyw metody uprawyj i obsady roslin na plonowanie oraz sklad chemiczny kozlka lekarskiego (*Valeriana officinalis* L.). In Annales UMCS, 9, 107–112.

Mukherjee, G.D., Dey, C.D., 1966. Clinical trial on Brahmi. International Journal of Clinical and Experimental Medical Sciences 10(1), 5–11.

Nampoothiri, K.U.K., 2001. Organic farming-its relevance to plantation crops. Journal of Plantation Crops 29(1), 1–9.

Panse, V.G., Sukhatme, P.V., 1978. "Statistical methods for agricultural workers," 2nd Edition, Indian Council of Agricultural Research, New Delhi, 1967.

Radford, P.J., 1967. Growth analysis formulae: their use and abuse. Crop Science 7, 171–175.

Rajani, M., 2008. *Bacopa monnieri* a nootropic drug. Bioactive Molecules and Medicinal Plants 37, 175–195.

Russo, A., Borrelli, F., 2005. *Bacopa monniera*, a reputed nootropic plant: an overview. Phytomedicine 12(4), 305–317.

Russo, A., Borrelli, F., Campisi, A., Acquaviva, R., Raciti, G., Vanella, A., 2003. Nitric oxide-related toxicity in cultured astrocytes: effect of *Bacopa monniera*. Life Sciences 73(12), 1517–1526.

Satyavati, G.V., Raina, M.K., Sharma, M., 1976. Medicinal plants of India. ICRM: New Delhi, 118–122.

Singh, H.K., Dhawan, B.N., 1982. Effect of *Bacopa monniera* Linn. (Brahmi) extract on avoidance responses in rat. Journal of Ethnopharmacology 5(2), 205–214.

Singh, H.K., Dhawan, B.N., 1997. Neuropsycho pharmacological effects of the ayurvedic nootropic *Bacopa monniera* Linn. (Brahmi). Indian Journal of Pharmacology 29(5), 359.

Slamet, W., Endang, P.D., Adriani, D., Eny, F., 2017. Leaf area index, chlorophyll, photosynthesis rate of lettuce (*Lactuca sativa* L.) under N-organic fertilizer. Indian Journal of Agricultural Research 51(4), 365–369.

Uabundit, N., Wattanathorn, J., Mucimapura, S., Ingkaninan, K., 2010. Cognitive enhancement and neuroprotective effects of *Bacopa monnieri* in Alzheimer's disease model. Journal of Ethnopharmacology 127(1), 26–31.

Vohora, D., Pal, S.N., Pillai, K.K., 2000. Protection from phenytoin-induced cognitive deficit by *Bacopa monnieri,* a reputed Indian nootropic plant. Journal of Ethnopharmacology 71(3), 383–390.

Yashaswini, N.P., Vijaymahantesh, V.P., Singh, V.P., Kattimani, Rudresh, D.L., M.D., Jhalegar, J., 2019. Effect of integrated nutrient management on growth and yield of tulsi (*Ocimum sanctum* L.) in northern dry zone of Karnataka. International Journal of Chemical Studies 8(1), 1988–1991.

