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# Nutrient Management of Brahmi (*Bacopa monnieri* L.) Cultivars in Soil and Comparison with Hydroponically Grown Plants for Better Herbage Yield

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**ABSTRACT**

A field experiment was conducted during *kharif* season of 2019-20 at Department of Agriculture, Khalsa College, Amritsar. It consisted of 10 treatment combinations which included two cultivars (CIM-Jagriti and Subodhak) and five nutrient management, viz. Vermicompost 10 t $ha^{-1}$, FYM 20 t $ha^{-1}$, Vermicompost 5 t $ha^{-1}$ + FYM 10 t $ha^{-1}$, Recommended dose of NPK fertilizers 100: 60: 50 kg $ha^{-1}$ and Hydroponics (half-strength Hoagland solution). The results revealed that cv. Subodhak had produced more yield than cv. CIM-Jagriti but bacoside-A content was higher in the latter (16 percent higher). Among nutrient management, brahmi grown in hydroponics (half-strength Hoagland solution) had significantly higher growth and yield attributes (viz. main shoot length, number of shoots, number of leaves, leaf area, fresh and dry weight) while FYM 20 t $ha^{-1}$ recorded lowest growth and yield. Additionally, hydroponically grown brahmi had 7.5 percent more bacoside-A content than soil grown brahmi.

***Key words**: Brahmi, Hydroponics, Vermicompost, Nutrient management*

## Introduction

*Bacopa monnieri* (L.) typically named as brahmi or water hyssop is one of the powerful medicinal plant belonging to family Scrophulariaceae. It is a semi-aquatic, succulent, glaborous, perennial creeping herb with bitter taste. It is propagated mainly through shoot cuttings of 5-10 cm length with internodes and rootlets. It necessitates 30-40 $^{o}$C temperature and 65-80% relative humidity with plenty of sunshine and copious rainfall for its ideal growth. It is frequent in moist habitat and water edges throughout tropical and sub-tropical regions.It is found in India, Sri Lanka, China, Nepal, Taiwan, Vietnam and United States (Rai *et al.,* 2017).

Brahmi is a crucial ayurvedic medicine for the improvement of intelligence and memory. It is beneficialfor the management of anxiety, poor cognition and lack of concentration (Mukherjee and Dey, 1966). The plant has been used considerably as a nootropic, digestive aid and to enhance respiratory functions. It has also been described to heal the effects of inflammatory diseases like asthma, bronchitis and rheumatism (Channa *et al.,* 2006). Brahmi extract is also known to have anti-cancer and antioxidant properties (Elangovan *et al.,* 1995, Tripathi *et al.,* 1996). Bacoside A has been recognized as the chief component responsible for its therapeutic effects (Rai *et al.,* 2017).

The whole plant of brahmi is used medicinally. Many products of brahmi like powder, tablets, capsules, oil etc are in huge demand due to its utilization in defeating some of the very common health disorders. To satisfy this high commercial demand, brahmi is mostly collected from wild/natural resources because farm cultivated brahmi is generally rejected by pharmacies as it is suspected of being contaminated with chemicals, which are applied indiscriminately under conventional farming system. So,to avoid the depletion of natural resources, there is a need to adopt good cultivation practices with the use of organic sources of nutrients. Further, bioaccumulation of heavy metals such as Al, As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb and Zn was found in the samples of brahmi plants cultivated in the soils / wetlands contaminated with these heavy metals (Hussain *et al.,* 2010). Thus, the brahmi grown in soils contaminated with heavy metals and other harmful chemicals fail to obtain quality clearance as per raw herb purity guidelines of WHO because it may lead to human health hazards as it is an important ingredient of many Ayurvedic medicines and nutraceutical products. To deal with this problem, hydroponic production technology can be used.

Hydroponics is a method for growing plant material without soil using mineral nutrients dissolved in water.Various results from different countries have proved it to be thoroughly practical and have advantages over conventional methods (Barman *et al.,* 2016). Thus, the advantages of hydroponics can be utilized to increase the production of brahmi. The major advantages are all year-round production, greater yield than soil culture with high quality (free from heavy metals and chemicals) and less insect and pathogen infection, thus free from pesticides (Maneeply *et al.,* 2018). Therefore, keeping these facts in view, the objectives of this study was to determine the effect of different nutrient management practices on the herbage yield of brahmi cultivars and to compare the yield and quality of soil grown brahmi with hydroponically grown brahmi.

## Materials and Methods

The experiment was conducted at the Students' Research Farm, Khalsa College, Amritsar during *kharif* season of 2019-20. The soil had sandy loam texture and it was low in N (164 kg ha$^{-1}$), medium in $P_2O_5$ (12.5 kg ha$^{-1}$), $K_2O$ (315 kg ha$^{-1}$) and organic carbon (0.66 %) with normal pH.The experiment was laid out in factorial randomized block design with three replications. It consisted of 10 treatment combinations which included two cultivars i.e. $C_1$: CIM-Jagriti and $C_2$: Subodhak and five nutrient management treatments i.e. $N_1$: Vermicompost 10 t ha$^{-1}$; $N_2$: FYM 20 t ha$^{-1}$; $N_3$: Vermicompost 5 t ha$^{-1}$ + FYM 10 t ha$^{-1}$; $N_4$: Recommended dose of NPK fertilizers 100: 60: 50 kg ha$^{-1}$ and $N_5$: Hydroponics (using half-strength Hoagland solution).

### Soil cultivation

The total soil area used for the experiment was 147.2 m$^2$. Well decomposed FYM and vermicompost were incorporated into the soil before seven days of planting. On an average, vermicompost consists of 0.5-1.5 % N, 0.1-0.70 % $P_2O_5$ and 0.15-0.60 % $K_2O$ and FYM consists of 0.3-0.5 % N, 0.2 % $P_2O_5$ and 0.3-0.5 % $K_2O$. A recommended dose of NPK fertilizers (100: 60: 40) in form of urea, DAP and MOP was mixed in the soil. Half N along with full phosphorus and potash was applied as basal dose and remaining N was applied in three split doses at 30, 45 and 60 days after planting. The cuttings of about 5-10 cm long, containing 2-3 nodes were planted at 5 cm depth at a row to row spacing of 20 cm and plant to plant spacing of 10 cm. The first irrigation was provided immediately after planting and subsequent irrigations were given when the soil showed dryness. Weeding was done manually to check the weed population.

### Hydroponic cultivation

The hydroponic system was established using Nutrient Film Technique (NFT) in an area of 14 m$^2$ which was 10.5 times lesser than soil area. The nutrient solution used was half-strength Hoagland's solution (Hoagland and Arnon, 1950). The system was made up of PVC pipes of 2 inch diameter. The holes were drilled in pipes of the size of net pots (plant holder) at a spacing of 5 cm. Cocopeat was used as a growing media in net pots to hold the plant cuttings. These pipes with net pots were placed on A-shaped iron frames with 6' height and it had 12 pipes placed vertically on each side with one cultivar on one side and second cultivar on the other side of the frame. The flow rate of solution was controlled by a timer. A shallow depth of nutrient solution was continuously cycled through the pipes for 20 minutes, followed by 10 minutes off. Fresh solutions were added in to the main tank whenever the TDS value drops below 750 ppm and pH value rise above the 6.5. The pH value was maintained in the optimum range by adding phosphoric acid or sulphuric acid. If TDS value rise above the optimum range then dilution of the solution was required.

**Analysis of bacoside A content**

For the determination of bacoside-A content, samples of both the cultivars of brahmi grown in hydroponics and soil (composite sample of all soil treatments) were sent to Khalsa College of Pharmacy, Amritsar. The quantification was done by drying the extract and the dried extract containing bacoside-A was hydrolyzed to release the aglycon which was then quantified using UV spectrophotometer at 278 nm. (Pal and Sarin, 1992) and results were expressed on percent basis.

**Statistical analysis**

Observations on growth parameters were recorded at 30 days interval till harvest (mean of three plants from each replication and each treatment). The statistical analysis was done using CPCS 1 software developed by Punjab Agricultural University, Ludhiana. The comparisons were made at 5% level of significance.

## Results and Discussion

The results obtained in the investigationfor growth parameters (Table 1) and fresh and dry yield of brahmi (Table 2) indicated that there was no significant difference between both the cultivars of brahmi but in nutrient management, there was significant difference due to different treatments. Brahmi plants cultivated in hydroponics ($N_5$) exhibited significant increase in all the growth parameters, i.e. main shoot length, no. of shoots, no. of leaves, leaf area and fresh and dry herb yield than all other treatments in soil. In soil, vermicompost 10 t $ha^1$ ($N_1$) gave maximum results for growth and yield but they were statistically at par with recommended dose of NPK fertilizers ($N_4$) and FYM 20 t $ha^{-1}$ ($N_2$) gave minimum results. It was observed that brahmi grown in hydroponics ($N_5$) produced 108.63, 154.0, 131.91 and 113.06 percent more fresh yield than treatments $N_1$, $N_2$, $N_3$ and $N_4$, respectively and 76.82, 141.07, 117.07 and 87.47 percent more dry yield than treatments $N_1$, $N_2$, $N_3$ and $N_4$, respectively.

Brahmi grown in hydroponics ($N_5$) resulted in more number of shoots, number of leaves, main shoot length, leaf area and yield which might be due to reason that water and nutrients are better available to the plant roots and in hydroponics, plants are grown vertically which are able to absorb sunlight better than soil grown plants. All essential nutrients needed by plants are given in the form of solution with optimum pH level for nutrient availability (Raviv and Lieth, 2008). The optimum nutrient solution pH ranges between 5.5 – 6.5, a range in which maximum number of elements are at their highest availability for plants. Further, nutrient solution flows continuously throughout the crop and oxygen is easily available to the plant roots. Thus, brahmi plants grown in hydroponics can uptake nutrients more efficiently than plants grown in soil. Since, the plants received the desired nutrients in the desired quantities at all growth stages, plant yield attribut-

**Table 1.** Growth parameters of brahmi cultivars as influenced by nutrient management during kharif 2019-20 (pooled data).

| Treatments | Main shoot length (cm) | No. of shoots (per plant) | No. of leaves (per plant) | Leaf area (per plant) |
|---|---|---|---|---|
| *Cultivars* | | | | |
| $C_1$: CIM-Jagriti | 99.40 | 47.80 | 401.73 | 353.43 |
| $C_2$: Subodhak | 100.2 | 49.27 | 411.93 | 360.41 |
| SE ± | 0.40 | 0.74 | 5.10 | 3.49 |
| CD (P=0.05) | NS | NS | NS | NS |
| *Nutrient management* | | | | |
| $N_1$: Vermicompost 10 t $ha^{-1}$ | 107.85 | 44.50 | 442.50 | 383.09 |
| $N_2$: FYM 20 t $ha^{-1}$ | 80.15 | 34.50 | 271.67 | 244.74 |
| $N_3$: Vermicompost 5 t $ha^{-1}$ + FYM 10 t $ha^{-1}$ | 93.32 | 37.67 | 342.50 | 305.81 |
| $N_4$: NPK 100: 60: 50 kg $ha^1$ | 104.24 | 43.00 | 405.83 | 362.35 |
| $N_5$: Hydroponics (half-strength Hoagland solution) | 113.46 | 83.00 | 571.67 | 488.60 |
| SE ± | 5.91 | 8.80 | 50.42 | 40.77 |
| CD (P=0.05) | 9.79 | 4.61 | 49.84 | 44.07 |
| Interaction | NS | NS | NS | NS |

**Table 2.** Fresh and dry yield of brahmi cultivars as influenced by nutrient management during kharif 2019-20 (pooled data).

| Treatments | Fresh weight (gplant$^{1}$) | Dry weight (gplant$^{-1}$) |
|---|---|---|
| Cultivars | | |
| $C_1$: CIM-Jagriti | 46.21 | 7.69 |
| $C_2$: Subodhak | 48.19 | 7.96 |
| SE ± | 0.99 | 0.14 |
| CD (P=0.05) | NS | NS |
| Nutrient management | | |
| $N_1$: Vermicompost 10 t ha$^{-1}$ | 40.67 | 7.24 |
| $N_2$: FYM 20 t ha$^{-1}$ | 33.55 | 5.66 |
| $N_3$: Vermicompost 5 t ha$^{-1}$ + FYM 10 t ha$^{-1}$ | 36.59 | 6.11 |
| $N_4$: NPK 100: 60: 50 kg ha$^{1}$ | 40.16 | 6.57 |
| $N_5$: Hydroponics (half-strength Hoagland solution) | 84.83 | 13.55 |
| SE ± | 9.51 | 1.45 |
| CD (P=0.05) | 4.57 | 0.84 |
| Interaction | NS | NS |

ing characters such as shoot length, number of leaves, number of shoots and leaf area will increase. The similar results were also reported by Maneeply *et al.* (2018) in *Bacopa monnieri*, Surendran *et al.* (2017) in *Mentha spicata* and Aliniaeifard *et al.*(2010) in lemon verbena.

Vermicompost ($N_1$) caused comparable but higher results than recommended dose of NPK ($N_4$). This might be due to the fact that earthworms may stimulate microbial activities and also influence microbial populations. As a result, more available nutrients and microbial metabolites are released into the soil (Tomati *et al.*, 1988). Moreover, in terms of plant growth and soil health, vermicompost plays an important role in improving soil structure, aeration, and reduces soil compaction thus it enhances water and nutrient holding capacity of soil. It also acts as chelating agent thus maintains the availability of essential nutrients throughout the growth period leading to higher yield attributing characters. The results are supported with the findings of Kashem *et al.* (2015) in tomato crop, Joshi and Vig (2010) in tomato crop and Tomati *et al.*(1990) in radish and lettuce seedlings. Further, vermicompost ($N_1$) exhibited significant effect on growth of brahmi over FYM ($N_2$) and vermicompost + FYM ($N_3$). Although vermicompost and FYM both are organic manures but vermicompost performed better than FYM. Vermicompost contains high levels of macronutrients such as N, P, K, Ca and Mg and micronutrients such as Fe, Zn, Cu and Mn than other organic fertilizers. It contains nutrients in a form that is relatively easy for plants to absorb because the earthworms grind and uniformly mix minerals in simple forms, thus plants need only minimum effort to obtain them. The worms' digestive systems create en-

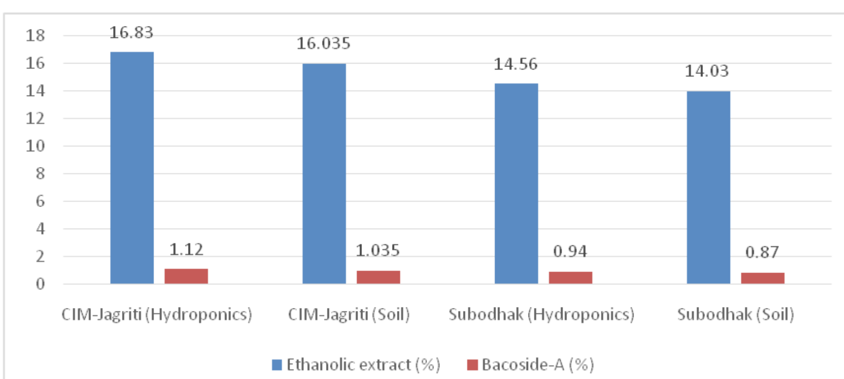


**Fig. 1.** Ethanolic extract (%) and bacoside-A content (%) of brahmi cultivars grown in hydroponics and soil.

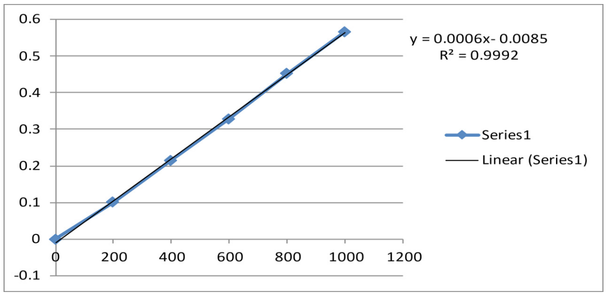


**Fig. 2.** Calibration curve of standard bacoside-A.

vironment that allow certain species of microbes to thrive and help to create a living soil environment for plants which converts nutrients already present in the soil into plant available forms. Unlike FYM, worm castings also contain worm mucus which helps to prevent nutrient from washing away. This might be responsible for better growth and productivity of brahmi using vermicompost ($N_1$) than $N_2$, $N_3$, and $N_4$.

While considering bacoside-A and total ethanolic extract obtained, the difference in their percent content was found between both the cultivars grown in hydroponics and soil. Total ethanolic extract and bacoside-A content obtained in two cultivars of brahmi grown in hydroponics and soil (composite sample of all soil treatments) is presented in Fig. 1. The calibration curve of the standard bacoside-A is prepared in concentration ranging from 200- 1000 µg/ml and is presented in Fig. 2.

The results revealed that ethanolic extract and bacoside-A content was higher in cv. CIM-Jagriti than cv. Subodhak. Further, it was observed that brahmi cultivars grown in hydroponics had more yield of total ethanolic extract and bacoside-A content than soil grown brahmi cultivars. It was observed that hydroponically grown and soil grown CIM-Jagriti had 16.1 and 15.9 percent, respectively, more bacoside-A than hydroponically grown and soil grown Subodhak. Additionally, cultivars CIM-Jagriti and Subodhak when grown under hydroponics had 7.59 and 7.44 percent, respectively, more bacoside-A when compared to soil grown cultivars. Similar results of enhancement of bioactive compounds in plants grown under hydroponics has been reported by Lu *et al.* (2018) in *Salvia miltiorrhiza*, Surendran *et al.* (2017) in *Mentha spicata*, and Pedneault *et al.* (2002) in *Achillea millefolium*. The reason for the increment of bioactive compounds under hydroponics is - control over the whole process of cultivation, especially the amount, constitution and pH of nutrient solution and environmental conditions such as temperature, humidity and light.

## Conclusion

It was concluded from this study that Subodhak produced more herb yield than CIM-Jagriti but bacoside-A content was higher in CIM-Jagriti. Among the nutrient management treatments, hydroponically grown brahmi gave better herb yield and quality. Thus, the results of study showed that hydroponic system can be promoted for large scale biomass production of this medicinally important plantand cultivar CIM-Jagriti can avail higher profits in terms of quality (bacoside-A content).

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