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CONTENTS

Effect of FYM and nitrogen levels on growth, dry matter accumulation, yield and nutrient uptake of brahmi (*Bacopa monnieri L.*)

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ABSTRACT: A field experiment was conducted during *kharif* season to evaluate the efficacy of FYM and inorganic nitrogen levels on growth, dry matter accumulation, yield and nutrient uptake of Brahmi crop. Crop was treated with N:P:K (100:50:50 kg/ha), FYM (5, 10, 15 and 20 t/ha), N+ FYM (75 kg + 5 t/ha, 50 kg + 10 t/ha and 25 kg + 15 t/ha) and control. The study revealed that growth characters *viz.*, upright shoot length, number of shoots and number of leaves, dry matter accumulation, yield and nutrient uptake increased with increasing the fertility levels. Maximum dry biomass yield 7.8 t/ha was recorded with an integrated package of N @ 75 kg + FYM @ 5 t/ha treatment which was at par with N:P:K @ 100:50:50 kg/ha and FYM @ 20 t/ha. Highest value of dry matter accumulation (808.5 g/m^2) and nitrogen uptake (106.3 kg/ha) was also recorded due to N @ 75 kg + FYM @ 5 t/ha treatment however phosphorus and potassium uptake by plant was maximum with N:P:K @ 100:50:50 kg/ha.

Key words: *Bacopa monnieri,* Brahmi, FYM, medicinal plant, nitrogen, nutrient content, nutrient uptake

Bacopa monnieri, popularly known as Brahmi, is commercially grown in India. In ayurvedic medicine, it is considered as astringent, bitter and cooling herb and is known to improve the intellect. Also it has been used for the treatment of asthma, insanity and epilepsy. It has been used by Ayurvedic medical practitioners in India for almost 3000 years and is classified as amedhyarasayana, brahmighritam and brahmirasayanam, a drug used to improve memory and intellect (medhya). The earliest chronicled mention in several ancient Ayurvedic treatises including the Charak Samhita (6th century A.D.), in which it was recommended in formulations for the management of a range of mental conditions including anxiety, poor, cognition and lack of concentration (Russo and Borrelli, 2005). Brahmi is currently recognized as being effective in the treatment of mental illness and epilepsy and also a major component of modern medicine such as Memory Plus and Mega Mind Plus (Tiwari *et al*., 2001). Besides, its renowned status as memory vitalizer, it is used to treat respiratory, cardiac and neuro pharmacological disorders like depression, psychosis, insanity, insomnia, epilepsy and stress (Rajani, 2008).

Soil receiving plant nutrients only through chemical fertilizers are showing declining productivity even though sufficient nutrients are being provided. This decline in productivity could be attributed to the appearance of secondary and micronutrients as well as to the deteriorating the soil physical condition caused due to long term use of chemical fertilizers. Contrary to chemical fertilizers, organic manures by creating and maintaining better physical and chemical environment enhance the crop yield and sustainability. But at present, the utilization of organic manure is not adequate to meet the crops nutritional requirement. Therefore, application of organic manure in conjunction with inorganic fertilizer is an integrated manner appears to be the best alternative.

Integrated nutrient management (INM) has assumed great importance firstly, because of the present nutrient balance and secondly, neither the chemical fertilizer alone nor the organic source exclusively can achieve the crop production and sustainability of soil as well as crops, under highly intensive cropping systems. Integrating chemical fertilizers with organic manures has been found to be quite promising not only in maintaining higher productivity but also in providing great stability in crop production (Nambiar and Abrol, 1989).

Nitrogen is one of the very important plant nutrients as it is integral part of the plant tissues and has direct and positive effects on the crop growth and performance which directly affect the plant growth and development. It is constituent of nucleic acid, protoplasm, amino acid and might have increased carbohydrates synthesis which is used for synthesis of phyto-harmones like auxins, gibberellins and cytokinins resulting better plant growth (Haque and Haque, 2016). Nitrogen enhances the vegetative growth and assists the plant to mobilize the photosynthates.

Farmyard manure being used as a major source of organic manures and when integrated with reduced of inorganic fertilizers resulted in improved soil fertility, growth and yield of plant.

Proper manuring and fertilization is very important for better growth and development of the crop plants. Consequently, nitrogenous fertilizers are among the most used fertilizers in the world. Nevertheless, its deficiency causes several abnormalities like over growth and less flowering (Verma *et al*., 2019) and excessive use of N can have negative economic and the environmental implications. Intensive N fertilization can lead to toxic N levels in plant tissues and herbivores.

Both organic and inorganic N fertilizers have advantages and disadvantages. Inorganic fertilizers provide readily available nitrogen; however, they are easily lost by leaching, denitrification, volatilization and run-off. Furthermore, inorganic fertilizers have been frequently linked to cases of environmental contamination, soil acidification and salinity. On the other hand, organic fertilizers released N to plant tends to be slower and depends on the mineralization rates. Nevertheless, organic fertilizers improve the soil physical and chemical properties.

But very little work has been done on nutrient requirement by Brahmi crop therefore; there is an urgent need to find out appropriate amount of nitrogen and FYM for medicinal herb Brahmi. Hence, this present investigation was conducted to standardize amount of nitrogen and FYM requirements of *Brahmi* for sustaining higher productivity.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season of the year 2003 at Medicinal Plants Research and Development Centre, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The soil of experimental field was sandy loam in texture with high organic carbon (0.82%), low available nitrogen (205.50 kg/ha) and medium phosphorus and potassium (23.70 and 202.30 kg/ha, respectively) with soil pH of 6.7.
Nine nutrient management treatments *i.e.,* Control (T_1), N:P:K (100: 50:50 kg/ha) (T_2), FYM 5 t /ha (T_3), FYM 10 t /ha (T_4), FYM 15 t /ha (T_5), FYM 20 t/ha (T_6), 75 kg N/ha +FYM 5 t/ha (T_7), 50 kg N/ha +FYM 10 t/ha (T_8), 25 kg N/ha +FYM 15 t/ha (T_9) were tested with 3 replications arranged in randomized block design of gross plot size 4 m × 3.8 m and net plot size 3 m × 2.8 m.

The field was ploughed followed by two cross harrowing and leveling. The experimental area was divided into 3 blocks, leaving 1.5 meter wide channels between each block. Each block was divided into nine plots leaving 1.3 meter wide channel between each plot within the block. The experimental plots were uniformly fertilized as per treatments using urea (46% N), singe super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). Organic manure was applied through FYM containing 0.5% N, 0.15% P_2O_5, 0.5% K_2O on fresh weight basis. Before planting, well decomposed FYM and half dose the total nitrogen, full phosphorus and potassium according to the treatments were uniformly broadcasted and incorporated into top 15 cm layer of soil. The remaining half quantity of nitrogen was top dressed 45 days after planting.

About 5-10 cm long cutting containing few leaves and nodes of *Bacopa monnieri* planted in 5 cm deep furrows opened at 30 cm distance by end to end method with The irrigation was given immediately after planting in all brahmi sown plots then subsequent irrigations were provided as per requirement of the crop. First weeding was done at 30 days after planting and later on when required to keep the field weed free. Weeding operations were performed manually. The crop was harvested at 135 days after planting. Harvesting was done manually by uprooting the crop with the help of *khurpi*.

Observation on shoot length, number of shoots, number of leaves, dry matter accumulation and yield were recorded replication wise according to fertility treatments. Sticks were fixed at 5 plants in net plot area for recording upright shoot length, number of shoots, number of leaves. Fresh weight (g/m^2) and dry matter accumulation (g/m^2) observations were recorded by taking out the plant samples out of net plot area. The crop was grown to maturity and harvested after following the required crop measures. Yield (fresh as well as dry herbage yield) was recorded by harvesting the total biomass from net plot area. Fresh biomass was weighed and fresh herbage yield was recorded. For dry herbage yield, plant material was kept for sun drying for 2-3 days, after sun drying, the plant samples were again dried for 48 hours in hot air oven at 65±5^{0}C temperature and then weighed. These dried samples were ground to fine powder and pass through 0.5 mm mesh sieve. Then processed plant samples were analysed for determination of nitrogen, phosphorus and potassium concentration as described by Jackson (1973). To quantify the nutrients (N, P and K) uptake by *Bacopa monnieri* plant, calculation was done using the following formula:

Nutrient uptake = [Nutrient content (%) in sample x yield (kg/ha)/100

The collected experimental data were statistically analyzed for each character by following the procedure of Snedecor and Cochran (1967) by using statistical software programme, STPR-3 (Developed by Department of Mathematics & Statistics, CBSH, GBPUA&T, Pantnagar). The critical difference for comparing the treatment means at 5% level of probability was computed wherever the F-test was significant.

RESULTS AND DISCUSSION

Effect of FYM and nitrogen on growth and yield

An integrated package of N @ 75 kg/ha + FYM @ 5 t/ha treatment had highest upright shoot length but effect was non-significant. However, 75 N kg/ha + FYM @ 5 t/ha treatment caused significantly more number of shoots over control/ha (Table 1).

In case of number of leaves, fresh weight (g/m^2) and dry matter accumulation (g/m^2), 75 kg N /ha + FYM 5 t/ha treatment caused significant higher number of leaves, fresh weight and dry matter accumulation than all other treatments except N: P: K 100: 50:50 kg/ha and FYM @ 20 t/ha treatments. The data clearly indicated that good plant growth response

Table 1: Effect of different treatments on growth parameters of *Bacopa monnieri* at harvesting stage (135 days after sowing)

S. No.	Treatments	Upright shoot length (cm)	Number of shoots per m^2	Number of leaves per m^2	Fresh weigh (g/m^2)	Dry matter accumulation (g/m^2)	Fresh biomass yield (t/ha)	Dry biomass yield (t/ha)
1	Control	13.2	1536	1440	1560.0	409.4	18.06	4.97
2	N:P:K @ 100: 50: 50 kg/ha	16.9	2672	3573	2763.5	779.8	26.43	7.50
3	FYM @ 5 t/ha	14.1	2308	2901	1946.7	522.8	21.53	5.85
4	FYM @ 10 t/ha	14.3	2388	2965	2007.9	539.0	21.85	5.92
5	FYM @ 15 t/ha	15.0	2512	3232	2150.7	585.6	23.23	6.49
6	FYM @ 20 t/ha	16.9	2608	3515	2555.8	699.0	25.63	7.03
7	N @ 75 kg/ha + FYM @ 5 t/ha	17.4	2752	3691	2821.2	808.5	27.18	7.79
8	N @ 50 kg/ha + FYM @ 10 t/ha	16.5	2512	3397	2380.4	670.1	23.92	6.77
9	N @ 25 kg/ha + FYM @ 15 t/ha	15.9	2544	3327	2288.0	629.3	23.20	6.62
	SEm±	1.1	122	82	128.0	37.7	1.06	0.26
	C.D. at 5%	NS	365	246	383.8	113.0	3.18	0.77

was recorded with N @ 75 kg/ha + FYM @ 5 t/ha which might be due to improved root health and growth of plants due to incorporation of FYM. Similar results were reported by Singh *et al*. (2017), Bhilare *et al*. (2002) and Prabhu *et al*. (2003).

Integrated application of nitrogen and FYM increased fresh and dry biomass yield. Plots treated with 75 kg N /ha through inorganic fertilizer alongwith FYM 5 t/ha recorded significantly higher crop yield over all the treatments except the plots which were treated with N: P: K 100: 50:50 kg/ha and 20 t FYM /ha (Table 1).

Greenland (1971) explained the inorganic nitrogen substituted with FYM may lead to sustained production due to improvement in various soil properties. The reason for increasing the yield when part of nitrogen was substituted by FYM may be due to increase in number of favourable microorganisms such as bacteria, fungi and *actinomycetes* which may help in solubilization of nutrients present in unavailable form in the soil.

FYM is a balanced nutrient provider which resulted in optimum growth and development of crop, resulting in higher seed yield of *Anethum graveolens* (Vineeta *et al*., 2013). FYM contains good amount of nutrients which makes temporary linkage with inorganic nutrients, hence losses of nutrients decreases and these nutrients are made slowly available to crop plants. Due to less loss and more amount of nutrients availability, the soil fertility get enhanced. FYM also help to improve soil physical conditions which make the plant roots to proliferate for better utilisation of nutrients to boost up the yield

Table 2: Nitrogen, Phosphorus and potassium content (%) in plant and uptake (kg/ha) by *Bacopa monnieri* plant as influenced by different treatments

Treatments	Content (%)			Uptake (kg/ha)		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Control	0.75	0.19	1.22	38.78	9.81	63.00
N:P:K @ 100: 50: 50 kg/ha	1.17	0.37	1.50	83.79	27.2	112.54
FYM @ 5 t/ha	0.82	0.24	1.31	47.93	14.03	76.65
FYM @ 10 t/ha	0.89	0.28	1.34	52.79	16.58	79.34
FYM @ 15 t/ha	0.94	0.30	1.40	61.21	19.47	90.86
FYM @ 20 t/ha	1.00	0.33	1.44	70.69	23.28	101.69
N @ 75 kg/ha + FYM @ 5 t/ha	1.36	0.27	1.33	106.3	21.05	103.72
N @ 50 kg/ha + FYM @ 10 t/ha	1.30	0.29	1.36	87.57	19.64	92.40
N @ 25 kg/ha + FYM @ 15 t/ha	1.23	0.31	1.42	82.42	21.38	95.14
SEm±	0.03	0.02	0.03	3.76	1.53	3.79
C.D. at 5%	0.10	0.07	0.09	11.27	4.59	11.39

Table 3: Organic carbon (%), available nitrogen, phosphorus and potassium (kg/ha) in soil after harvesting of *Bacopa monnieri* crop as influenced by different treatments

Treatments	Organic carbon (%)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
Control	0.60	185.5	14.1	186.6
N:P:K @ 100: 50: 50 kg/ha	1.05	215.4	25.9	203.4
FYM @ 5 t/ha	0.74	201.0	19.9	190.2
FYM @ 10 t/ha	0.95	202.3	20.7	192.3
FYM @ 15 t/ha	1.12	203.8	21.3	195.2
FYM @ 20 t/ha	1.26	205.9	23.0	199.2
N @ 75 kg/ha + FYM @ 5 t/ha	1.08	222.7	20.1	192.3
N @ 50 kg/ha + FYM @ 10 t/ha	1.19	218.1	21.2	193.6
N @ 25 kg/ha + FYM @ 15 t/ha	1.30	211.1	22.1	196.8
SEm±	0.10	6.73	1.98	14.7
C.D. at 5%	0.30	20.2	5.9	NS

of crop due to more availability of macro and micronutrients.

Effect of FYM and nitrogen on nutrient content and uptake

From the data presented in Table 3, it is clear that N content as well as uptake was higher due to application of 75 kg N /ha + FYM @ 5 t /ha. This might be due to increased supply of nutrients directly through organic (FYM) and inorganic source to the crop as well as directly to checking the loss of nutrients from the soil solution as FYM makes temporary linkage with nutrients and makes the availability of nutrients to crop plants for longer periods (Greenland, 1971), which resulted better growth, higher dry matter accumulation and higher yield because due to the integrated nutrition, the crop enjoyed a better nutritional environment and resulted more nutrient concentration and more nutrient uptake (Devi *et al*., 2018). Increase in uptake of nitrogen might be due to application of FYM have been also reported by Meshram and Shande (1982) and Kamlakumari and Singram (1996) while increase in nitrogen concentration in plants and uptake by Brahmi crop due to increasing nitrogen level was reported by Kumar (2002) and Singh (2002).

Higher P concentration in plants and uptake by crop was recorded in N:P:K @ 100: 50: 50 kg/ha treatment in comparison to all the treatments except P uptake by Brahmi plant in FYM 20 t/ha. Higher concentration and uptake of phosphorus and potassium was because of higher nitrogen, phosphorus and potassium content in plant due to this treatment.

Potassium concentration and uptake by Brahmi plants was recorded in N:P:K @ 100: 50: 50 kg/ha treatment which was statistically at par with FYM 20 t/ha and also 25 kg N/ha + 15 t FYM/ha in case of K concentration and also 75 kg N/ha + 5 t FYM/ha in case of potassium uptake by crop plant comparison to all other treatments.

Higher concentration and uptake of phosphorus and potassium was because of higher nitrogen, phosphorus and potassium content in plant due to N:P:K @ 100: 50: 50 kg/ha treatment.
The higher uptake of phosphorus and potassium due to nitrogen application had also been reported by Krishnamoorthy *et al*., 1977 and Ram *et al*., 2003. The higher uptake of nutrients due to nitrogen application might be due to more proliferation of foliage, which extract more nutrients from soil and finally increase the crop yield (Singh *et al*., 2002; Biswas, 1977 and Kothari *et al*., 1987).

Nitrogen-treated plants had higher N content in the leaves compared to low N-exposed plants suggesting that the treatment with an increased level of N could have induced high uptake of nitrogen (Felix *et al*., 2018). According to Masclaux and his co worker (2010) nitrate uptake is followed by reduction to nitrite, which is then transported to the chloroplast wherein it is reduced to ammonium and is mostly assimilated in the plastid/chloroplast and finally undergoes nitrogen remobilization, whereby leaf proteins and especially photosynthetic proteins of plastids are extensively degraded during senescence, providing an enormous source of nitrogen that plants can tap to supplement the nutrition of growing organs such as new leaves and seeds.

FYM also helps to increase phosphorus and potassium content and uptake in plants due to improved availability by better mineralization and release of phosphorus and potassium from organic sources (Smitha *et al*., 2020). FYM solubilizes organic and inorganic bounded nutrients and improves better nutrient use efficiency (Khiriya and Singh, 2003).

Data on effect of FYM with or without inorganic nitrogen on soil fertility status are presented in Table 3. Organic carbon content in soil was recorded higher due to 25 kg N/ha + FYM @ 15 t/ha which was statistically at par with all the treatments except control, FYM 5 t/ha and FYM 10 t/ha. Singh, during 2002 suggested that FYM is best source for relatively more accumulation of Organic carbon in soil. Saha *et al*. (2010) also reported that FYM is used abundantly in India and is effective to raising the

SOC content and aiding the buildup of soil fertility. The combination of FYM with NPK significantly increased the soil C content. This result is in agreement with the results published by Du *et al*., 2020. Available nitrogen and phosphorus content in soil was recorded higher due to 75 kg N/ha + FYM @ 5 t/ha which was significantly over control, FYM 5 t/ha and also FYM 10 t/ha in case of available nitrogen but statistically at par with all the treatments. Effect of different fertility levels on available potassium content in soil was found non-significant though maximum value was recorded in N:P: K 100 : 50: 50 kg/ha treatment. In this present study it was observed that plots treated with inorganic fertilizer along with organic manures showed higher availability of available nitrogen and phosphorus compared to plots received only inorganic fertilizer. This is supported by the study of Parasuranam *et al*., 2000 and Thomas *et al*., 2019.

CONCLUSION

On the basis of experiment findings, it can be concluded that application of chemical fertilizer (N:P:K 100: 50: 50 kg/ha) recorded higher growth, yield nitrogen uptake by crop. However, application of 75 kg N /ha + 5 t FYM /ha recorded highest growth parameters, yield and nutrient uptake of Brahmi. On the other hand, organic manures contain organic matter that directly affects the physiological, chemical, and biological properties of the soil. From this point of view, the combined application of FYM and mineral fertilizers results in maintaining soil fertility

So integrated use of organic manure along with inorganic fertilizers is beneficial to improve the yield of *Bacopa monnieri* and uptake by crop plant also sustains the soil fertility.

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