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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON LEAF YIELD AND QUALITY OF BAY LEAF

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Abstract

Two field experiments were conducted during two successive years of 2019-20 and 2020-21, to study the response of integrated nutrient management (INM) on leaf quality and yield of bay leaf at experimental bay leaf garden of Regional Spices Research Centre, Bangladesh Agricultural Research Institute (BARI), Gazipur. The experiment comprised five nutrient management packages following the INM principle. They are T_1= 220-70-150-40-5-3 g tree^{-1} year^{-1} of N-P-K-S-Zn-B, T_2 = 165-70-150-40-5-3 g N-P-K-S-Zn-B + 7 kg cowdung tree^{-1} year^{-1} , T_3 = 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg vermicompost tree^{-1} year^{-1}, T_4 = 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1} and T_5 = Control (native fertility). The growth parameters of bay leaf were significantly affected by the different integrated nutrient management packages. The maximum annual increment of plant height (23.0 and 25.88 cm), the tallest plant (3.99 and 4.63 m), annual shoot growth (15.16 and 21.0 cm), leaf area (19.23 and 31.33 cm^2), number of leaves per feet of shoot (18.17 and 19.33), leaf dry weight (1.47 and 1.73 g) and leaf yield (7.70 and 8.53 kg tree^{-1}) in 2019-2020 and 2020-2021, respectively, were recorded from the application of nutrients @ 165-70-150-40-5-3g N-P-K-S-Zn-B with 4 kg mustard oil cake tree^{-1} year^{-1}. The application of nutrients @ 165-70-150-40-5-3g N-P-K-S-Zn-B with 4 kg mustard oil cake tree^{-1} year^{-1} might be recommended as the best suitable nutrient management packages for bay leaf cultivation in Grey Terrace Soil of Madhupur tract (AEZ-28).

Keywords: Bay leaf quality, organic manures, chemical fertilizers, integrated nutrient management, leaf yield

Introduction

Bay leaf (*Cinnamomum tamala* Nees and Eberm), a member of the Lauraceae family, is an evergreen perennial shrub originated in Bangladesh and south-east Asia and is widely distributed in the tropical and sub-tropical areas (Khanal, 2021; Kuna *et al*., 2020). Around 350 species of *Cinnamomum* are grown in worldwide. It is locally called *Tejpata,* commercially known as Indian cassia, an important cash crop in Bangladesh. Its leaves are used for flavoring and seasoning of foods as spices as fodder and leaves oils are used as medicine and perfumery over the

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world since ancient times (Raman *et al*., 2017; Parthasarathy *et al.*, 2008; Dighe *et al*., 2005). Some times its bark is also used as substitute for cinnamon (*Cinnamomum zeylenicum)* in many parts of the world (Jakhetia *et al***.,** 2010). In Bangladesh, bay leaf is grown on an area of 563.56 ha with annual production of 1814 metric tons with annual productivity of 3.22 t ha^{-1} (Anon., 2021). The annual increment of leaf production and use is increasing day by day due to changing food habits of peoples. The fresh and processing of this crop facilate opportunities for establishment of small industries at the local and regional levels. There are many production constraints for up scaling the leaf yield of bay leaf, viz. lack of modern cultivars, lack of processing technologies with value addition, lack of technical knowledge for spalling production, lack of improved production technologies, marketing facilities etc. Among the production technologies, nutrient management is one of the key yield limiting factors. Application of nutrient elements are ever ending input for growth and yield of crops. Continuous use of chemical fertilizers has degraded the soil health in terms of fertility and has also caused soil pollution. The reduction in the soil fertility has resulted in low productivity of the crop. Besides, the increasing cost of fertilizers and their negative effect on soil health has led to intensified attempts to the use of organic matter along with inorganic fertilizers. The supplying of NPK, farm yard manure improves the physical, chemical and biological status of soil; apart from this, it needs also to supply N, P, and K to soil. Due to these essential nutrients' deficiencies, bay leaf gardens are producing low- and poor-quality leaf. There are reports that lower yield and poor-quality leaves are associated with marco and micro-nutrients' unavailability from soils. Moreover, bay leaf is a nutrient loving plant, but growers of this region are not using balanced fertilizers that causes serious nutritional disorders in bay leaf. The investigation was conducted to develop a suitable nutrient management package for yield maximization of bay leaf.

Materials and Methods

The present investigation was carried out at the experimental bay leaf garden of Regional Spices Research Centre, Bangladesh agricultural Research Institute (BARI), Gazipur during 2019-20 and 2020-21. The geographic coordination of the experimental location was $24^{0}09^{/}$ North Latitude and $90^{0}26^{/}$ East Longitude with elevation of 8.2 m from mean sea level. The soil of the experimental site belongs to Chhiata Soil series and has been classified as Grey Terrace Soil, which falls under Inceptisol in Soil Taxonomy under the AEZ-28 (Madhupur Tract). The experimental field soil was sandy clay loam in texture, non-saline, low in organic carbon (0.88%), low in available nitrogen (0.009%), medium in available phosphorus (6.89 ppm) and low in available potassium (0.07 meq 100 g^{-1} soil). The experiment was laid out in randomized complete block design with three replications. The experiment comprised five treatment combinations which were: T_1= 220-70-150-40-5-3 g $tree^{-1}$ $year^{-1}$ of N-P-K-S-Zn-B, T_2 = 165-70-150-40-5-3 g N-P-K-S-Zn-B + 7 kg cowdung $tree^{-1}$ $year^{-1}$, T_3 = 165-70-150-40-5-3 g N-P-K-S-

Zn-B + 4 kg vermicompost tree^{-1} year^{-1}, T_4 = 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1} and T_5 = Control (native fertility). The chemical properties of the organic manures used in the experiment are stated in Table 1.

Table 1. Nutrient status of organic manure used in the experiment

Organic manure	pH	OC	N	K	P	S
		(%)				
Cowdung	7.3	10.6	1.1	0.6	0.5	0.06
Vermicompost	7.6	10.7	1.7	0.9	1.1	0.03
Mustard oil cake	6.6	35.6	4.3	1.3	1.9	0.41

The experiment consisted of uniformly grown ten trees of eight-year-old, spaced at 3 m were selected randomly where all the agronomic practices were carried out as per package of practices. The various growth parameters like, plant height, increase in plant height, annual shoots growth and leaf area was recorded by using standard methods. For annual shoot growth, ten annual shoots were randomly selected from all over the periphery of the tree and their length was measured with the measuring tape at the end of growing period and expressed in centimetre. The leaf area (cm^2) was recorded by randomly collecting twenty-five fully developed leaves from all directions of the tree periphery, measured with the help of Automatic Leaf Area Meter and expressed in square centimetre. The weight of ten leaves was recorded on electronic balance and the results were expressed in grams. The leaves of small branches were harvested on 01 October during both the years and dried in the shade for four days. The recorded data were statistically analyzed by using R version 3.5.0 software to find out the significance of variation between treatments. The difference between treatment means were judged by Least Significant Difference (LSD) test at 5% level of significance.

Results and Discussion

Effect of INM practices on growth parameters of bay leaf

Nutrient elements play an important role in plant growth and development, the excess and too low application may hinder growth and yield of bay leaf. So, by reducing the synthetic dose and applied in the form of organic and or integrated forms help to restore nutrient element and make it for available form. The Table 2 showed that the maximum plant height (3.9 m and 4.63 m in 2019-20 and 2020-21, respectively), annual increment of plant height (23.0 and 25.88 cm in 2019-20 and 2020-21, respectively) by the application of the treatment T_4 (165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1}) followed by T_3 with (19.67 and 21.7 cm in 2019-20 and 2020-21, respectively), and the minimum increment in plant height (12.0 and 12.66 cm in 2019-20 and 2020-21, respectively) were reported in treatment T_5 (Control). The maximum number of primary and secondary branches per plant (5.4 & 5.6 and 15.5 & 15.1 in 2019-20

and 2020-21, respectively) were recorded in T_4 treatment (165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1}) and the minimum (2.3 & 2.9 and 11.5 & 11.3 in 2019-20 and 2020-21, respectively) was noted in T_5 treatment (control). Hence, the present findings exposed that the integrated application of organic and chemical fertilizers was the best treatment for better tree growth. INM based nutrient management supplied all the essential nutrients and also improved soil physical, chemical and microbial properties of soil which enable the crop to utilize nutrients and water more efficiently. The application of recommended dose of N, P, K and S through chemical fertilizers enhanced the availability of nutrients, which resulted in increased photosynthetic activities and translocation of photosynthates from source to sink and resulted in increased plant growth.

Table 2. Effect of integrated nutrient management on vegetative growth parameters of bay leaf

Treatment	Plant height (m)		Annual Increment in plant height (cm)		No. of primary branches plant^{-1}		No. of secondary branches plant^{-1}	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	3.47a	4.23a	15.0cd	16.7bc	3.9ab	4.3ab	12.4b	12.9c
T_2	3.74a	4.17a	16.7bc	17.5cd	4.8ab	5.2ab	14.7a	14.3ab
T_3	3.67a	4.27a	19.7ab	21.7ab	4.7ab	5.0ab	13.3b	13.0bc
T_4	3.99a	4.63a	23.0a	25.88a	5.4a	5.6a	15.5a	15.1a
T_5	3.27b	3.37b	12.0d	12.66d	2.3b	2.9b	11.5c	11.3c
CV (%)	5.44	7.84	10.60	9.64	9.03	8.56	3.33	4.59

Treatment means followed by the same letter(s) do not differ significantly at 5% level of probability by LSD

T_1= 220-70-150-40-5-3 g N-P-K-S-Zn-B tree^{-1} year^{-1}

T_2= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 7 kg cowdung tree^{-1} year^{-1}

T_3= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg vermicompost tree^{-1} year^{-1}

T_4= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1}

T_5= Control

Effect integrated nutrient management on shoot growth, leaf size and leaf number

Annual increment of shoot, leaf size and number of leaves per feet of shoot were significantly differed by integrated nutrient management practices in bay leaf (Table 3). The maximum annual shoot growth (15.1 and 21.0 cm in 2019-20 and 2020-21, respectively), leaf area (19.23 and 31.33 cm^2 in 2019-20 and 2020-21, respectively) and number of leaves per feet of shoot (18.17 and 19.33 in in 2019-20 and 2020-21, respectively) were recorded T_4 treatment (165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1}) and the minimum annual shoot

growth (11.83 and 14.67 cm in 2019-20 and 2020-21, respectively), leaf area (15.87 and 22.83 cm^2 in 2019-20 and 2020-21, respectively) and number of leaves per feet of shoot (11.13 and 13.0 in 2019-20 and 2020-21, respectively) were obtained in T_5 (control). This increase in shoot growth, leaf size and number of leaves might be due to increase in uptake of nutrients and increased release of growth factors (*viz.,* auxins, gibberellins and cytokinins) and essential nutrient availability in root zone. Moreover, the release of nutrients might be considered with the physiological stage which resulted in proper root growth and enhanced nutrient uptake which was reflected in all growth parameters (Musmade *et al.,* 2010). This might be due to the increased photosynthetic rate and carbohydrate accumulation as a result of multifarious role of vermicompost and FYM to allow most favourable conditions of soil with increased availability of plant nutrients responsible for better plant growth (Dutta *et al.,* 2009). Application INM based fertilizer management packages had maintained the sustainable soil fertility in soil thus, improved in growth, leaf size and leaf number over control (Naik and Babu, 2007). The similar finding was also reported by Thakur and Thakur (2014).

Table 3. Effect integrated nutrient management on shoot growth, leaf size and leaf number of bay leaf

Treatment	Annual shoot growth (cm)		Leaf area (cm^2)		No. of leaves feet $shoot^{-1}$	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	13.50ab	18.33b	18.07a	28.67a	16.10a	19.33a
T_2	14.90a	18.0b	18.37a	29.0a	16.73a	17.0a
T_3	13.77a	18.67b	18.53a	29.67a	17.63a	18.33a
T_4	15.16a	21.0a	19.23a	31.33a	18.17a	19.33a
T_5	11.83b	14.67c	15.87b	22.33b	11.13b	13.0b
CV (%)	6.75	6.49	5.05	8.03	7.47	10.60

Treatment means followed by the same letter(s) do not differ significantly at 5% level of probability by LSD

T_1= 220-70-150-40-5-3 g N-P-K-S-Zn-B $tree^{-1}$ $year^{-1}$

T_2= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 7 kg cowdung $tree^{-1}$ $year^{-1}$

T_3= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg vermicompost $tree^{-1}$ $year^{-1}$

T_4= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake $tree^{-1}$ $year^{-1}$

T_5= Control

Effect of integrated nutrient management on leaf weight and leaf yield of bay leaf

The data presented in Table 4 reveled that integrated nutrient based nutrient management packages influenced the leaf weight and leaf yield of bay leaf. The highest leaf fresh weight (2.40 and 2.53 g in 2019-20 and 2020-21, respectively), leaf dry weight (1.47 and 1.73 g in 2019-20 and 2020-21, respectively) and leaf

yield per plant (7.70 and 8.53 kg in 2019-20 and 2020-21, respectively) were obtained by the application of 165-70-150-40-5-3 g N-PK-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1} while the lowest leaf fresh weight (1.73 and 1.83 g in 2019-20 and 2020-21, respectively), leaf dry weight (0.60 and 0.73 g in 2019-20 and 2020-21, respectively) and leaf yield per plant (5.87 and 6.53 kg in 2019-20 and 2020-21, respectively) were noted in the treatment T_5 (control). This might be attributed to enhancement of nutrient status of the tree. Yield is a complex character which involves the interaction of several intrinsic and external factors. It largely depends upon the production and mobilization of carbohydrates, uptake of nutrients and water from the soil and the hormonal balance, in addition to several environmental factors to which tree is exposed during the growing period. These findings are in accordance with the results of Soni *et al.* (2018). The effectiveness of chemical fertilizers was greatly enhanced, when it was applied along with organic fertilizer, this might have resulted due to better retention of N in root zone and better availability of potash and phosphate to the plants by applying organic matter.

Table 4. Effect of nutrient management on various leaf yield and yield contributing attributes in bay leaf

Treatment	Individual leaf fresh weight (g)		Individual leaf dry weight (g)		Leaf yield (kg plant^{-1})	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
T_1	2.23a	2.37a	1.43a	1.47a	7.00a	7.67ab
T_2	2.37a	2.30a	1.39a	1.66a	7.53a	8.33a
T_3	2.37a	2.50a	1.43a	1.62a	7.67a	8.37a
T_4	2.40a	2.53a	1.47a	1.73a	7.70a	8.53a
T_5	1.73b	1.83b	0.60b	0.73b	5.87b	6.53b
CV (%)	8.76	8.76	18.43	10.68	7.81	8.82

Treatment means followed by the same letter(s) do not differ significantly at 5% level of probability by LSD

T_1= 220-70-150-40-5-3 g N-P-K-S-Zn-B tree^{-1} year^{-1}

T_2= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 7 kg cowdung tree^{-1} year^{-1}

T_3= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg vermicompost tree^{-1} year^{-1}

T_4= 165-70-150-40-5-3 g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1}

T_5= Control

Conclusion

From this study it may be concluded that integrated nutrient management packages had beneficial effect in achieving higher leaf yield of bay leaf. The maximum leaf yield of bay leaf of 7.7 and 8.53 kg plant^{-1} in in 2019-20 and 2020-21, respectively was obtained from the fertilization @ 165-70-150-40-5-3g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1}. The overall results indicate that the fertilizer dose @ 165-70-150-40-5-3g N-P-K-S-Zn-B + 4 kg mustard oil cake tree^{-1} year^{-1} appears to

be the best suitable nutrient management package for achieving higher leaf yield of bay leaf in Grey Terrace Soil of Madhupur tract (AEZ-28).

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