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Original Research Paper

Effect of integrated nutrient management on dry herbage yield, nutrient uptake and profitability of French Basil (*Ocimum basilicum* L.)

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ABSTRACT

Field experiments were conducted at ICAR - Indian Institute of Horticultural Research, Bengaluru during *Kharif* season of 2015 and 2016 with nine treatments and three replications in a randomized block design to find out the effect of integrated nutrient management on dry herbage yield, nutrient uptake and economics of sweet basil (*Ocimum basilicum*). The results revealed that the conjunctive use of inorganic fertilizer along with FYM increased the dry herbage yield and nutrient uptake of sweet basil. Application of recommended FYM (10 t/ha) along with recommended NPK (160:80:80 kg/ha) registered the highest dry herbage yield (8.43 and 3.76 t ha^{-1}) in the main crop and ratoon, respectively and maximum uptake of nutrient in the main crop as N (155.67 and 113.19 kg/ha), P (43.80 and 32.43 kg/ha) and K (163.33 and 116.16 kg/ha) and in ratoon (56.43 and 26.65 kg ha^{-1}), (16.14 and 14.01 kg ha^{-1}) and (55.65 and 39.27 kg ha^{-1}) in 2015 and 2016 respectively. Highest B: C ratio (5.49) was obtained with application of full dose of recommended NPK fertilizer during 2015. While in 2016, the maximum B: C ratio (3.71) was recorded with application of recommended dose of NPK (160:80:80 kg/ha) + FYM (10 t/ha)

Keywords: Basil, fresh herbage, dry herbage, oil yield, economics, FYM, bio-fertilizer

INTRODUCTION

Basil (*Ocimum basilicum L.*) is an important essential oil bearing crop; grown worldwide as a medicinal and aromatic plant. Basil leaves and shoots are used fresh or dried in culinary applications, as an ingredient in Western and Mediterranean diets. The high economic value of basil oil is due to the presence of a complex mixture of volatile substances, monoterpenes, sesquiterpenes and their oxygenated analogs present at low concentrations in plants (Taie *et al.*, 2010). The oil yield may vary under different agro climates, soil conditions and nutrient application (Duhan and Gulati, 1977).

Basil is considered as a species which moderately needs for essential nutrients and fertilization, among the plant nutrients, nitrogen, phosphorus and potassium are the most important macro nutrient elements that decide the yield level.

The nature and the characteristics of nutrient release of chemical, organic and biofertilizers are different, and each type of fertilizer has its advantages and disadvantages in the context of nutrient supply, crop growth and environmental quality. The advantages need to be integrated in order to make optimum use of each type of fertilizer and achieve balanced nutrient management for crop growth. Applying of organic manures and biofertilizers such as cattle manure and nitrogen fixing bacteria has led to a decrease in the use of chemical fertilizers and has provided high quality products free of harmful agrochemicals for human safety (Mahfouz and Sharaf Eldin, 2007).

Cattle manure is the source of N and other nutrients for plants (such as phosphorus, potassium, calcium,, iron, zinc and copper) that can make valuable contributions to soil's organic matter, can improve physical fertility, and is a center for biological activities of soil and mineral element absorption (Salem and Awad, 2005), caused more biomass production (Darzi, 2012; Najm *et al*., 2012). *Azotobacter*, were found to have not only the ability to fix nitrogen but also the ability to release phytohormones similar to Gibberellic acid and Indole Acetic acid, which could stimulate plant growth, absorption of nutrients, and photosynthesis (Mady and Youssef, 2014).The effect of organic and bio-fertilizer on root morphology and development, uptake of nitrogen, phosphorous and other minerals and hormone supply to plants have been suggested as factors influencing growth responses (Abou El-Ghait *et al*., 2012; Gendy *et al*., 2013); But, considering economics and also physiological potential of varieties, entire dependence on organic sources of nutrients may not be adequate to attain the most productivity (Anwar *et al*., 2005). However, in many situations, the high cost of nutrient sources and the difficulty to supply the necessary amount of organic manure makes conventional management of the nutrient as the best strategy to produce herbs. Several studies have reported that cattle manure can increase the yield of some medicinal plants such as sage (Kaplan *et al.,* 2009); basil (Biasi *et al*., 2009); geranium (Araya *et al*., 2006) and lemon balm (Santos *et al*., 2009). Some other studies have reported that nitrogen fixing bacteria such as *Azotobacter chroococcum* and *Azospirillum lipoferum* could cause increased yield in a few medicinal plants such as fennel (Azzaz *et al*., 2009) and davana (Kumar *et al*., 2009).

The rigorous management of fertilization must try to ensure both an improved and safeguarded environment; so, a balanced fertilization strategy that combines the use of chemical, organic or biofertilizers must be developed and evaluated. In this context, the present study aimed to show the effect of integrated nutrient management on dry herbage yield, nutrient uptake and profitability of French Basil (*Ocimum basilicum* L.)

MATERIAL AND METHODS

Field experiments were conducted in a randomized complete block design with three replications in the experimental field of ICAR-Indian Institute of Horticultural Research (IIHR), Bangalore during the *kharif* season of 2015 and 2016. The experimental station is located at an altitude of 890 m above mean sea level and $13^{0}58"$ North latitude and 77┐ 29" East longitudes. The nine treatments of experiment contain T_1 (FYM (10 t/ha) +100% recommended N through FYM), T_2 (FYM (10 t/ha) + 100% recommended N through FYM + bio-fertilizer), T_3 (FYM (10 t/ha) +75% recommended N through FYM), T_4 (FYM (10 t/ha) + 75% recommended N through FYM + bio-fertilizer), T_5 (FYM (10 t/ha) + 50% recommended N through FYM), T_6 (FYM (10 t/ha) + 50% recommended N through FYM + biofertilizer), T_7 (recommended FYM (10 t/ha) only), T_8 (recommended NPK (160:80:80 kg/ha) only), and T_9 (recommended FYM (10 t/ha) + recommended NPK (160:80:80 kg/ha). Initial experimental soil samples (0-30 cm depth) were taken for the nutrient analysis prior to land preparation and analyzed using standard procedures (Piper, 1966; Jackson, 1973; Subbaiah and Asija, 1956). Physical and chemical properties of the initial experimental soil are presented in **Table 1**. The nutrients were supplied in the form of straight fertilizers like urea (160 kg/ha), single super phosphate (80 kg/ha) and muriate of potash (80 kg/ha). Fifty per cent of nitrogen and full dose of phosphorus and potash were applied as basal and the remaining fifty per cent of N was applied after 45 days of transplanting in T_8 and T_9 treatments. For bio-fertilizers, Arka Microbial Consortium (AMC) developed by ICAR-IIHR was used in the experiment and it contains N fixing, P and Zn solubilizing and plant growth promoting microbes in a single carrier. After 15 days of transplanting, recommended dose of AMC @ 5 kg/ha was applied at 2 cm deep to individual plants and immediately covered by soil. Similar method of application was followed for ratoon crop after harvest of main crop in T_2, T_4, and T_6 treatments. Quantities of added fertilizers are mentioned in **Table 2.**

The land was brought to a fine tilth by ploughing and harrowing. The experimental site was divided into plots having dimensions of 4.8 m long and 4.0 m wide with the spacing of 40 cm between the plants and 60 cm between the rows. There was a space of 0.5 meter between plots and 0.5 meter between replications. Basil seeds were sown in two nursery beds of 6.0 m in length with 0.1 m in width and 10 cm height. Forty days old (40) healthy and uniformly rooted seedlings of sweet basil were transplanted to the field. Weeding was done manually and drip irrigation was given daily

Table 1. Physical and chemical proprieties of initial experimental soil

Physical properties	
Bulk density (Mg m^{-3})	1.32
Particle Density (Mg m^{-3})	2.65
Pore space (%)	42
Chemical properties	
pH (1:2.5)	7.75
Electrical Conductivity (dSm^{-1})	0.36
Organic Carbon (g kg^{-1})	5.0
Available N (kg ha^{-1})	185
Available P (kg ha^{-1})	28
Available K (kg ha^{-1})	200
Exchangeable Ca (cmol(p^+)kg^{-1})	5.25
Exchangeable Mg (cmol(p^+)kg^{-1})	0.84
DTPA Fe (mg kg^{-1})	7.5
DTPA Mn (mg kg^{-1})	5.8
DTPA Cu (mg kg^{-1})	1.33
DTPA Zn (mg kg^{-1})	1.22

Table 2. Treatment wise applied quantities of FYM, inorganic fertilizer and bio-fertilizers

	Quantity of inputs			Total nutrient supplied		
Treatments	**FYM t ha^{-1}**	**NPK kg ha^{-1}**	**BF* kg ha^{-1}**	**N kg ha^{-1}**	**P kg ha^{-1}**	**K kg ha^{-1}**
T_1:FYM (10 t ha^{-1}) +100% Rec. N through FYM	31.5	39.2	224	-	0	35
T_2:FYM (10 t ha^{-1}) +100% Rec. N through FYM + BF	31.5	39.2	224	5	0	35
T_3:FYM (10 t ha^{-1}) +75% Rec. N through FYM	25.9	32.2	184	-	0	28.75
T_4:FYM (10 t ha^{-1}) +75% Rec. N through FYM + BF	25.9	32.2	184	5	0	28.75
T_5:FYM (10 t ha^{-1}) +50% Rec. N through FYM	20.3	25.2	144	-	0	22.5
T_6:FYM (10 t ha^{-1}) +50% Rec. N through FYM+BF	20.3	25.2	144	5	0	22.5
T_7:Rec. FYM (10 t ha^{-1}) only	9	11.2	64	-	0	10
T_8:Rec.NPK (160:80:80 kg ha^{-1})	80	80	160	-	Rec	0
T_9:Rec.NPK (160:80:80 kg ha^{-1}) + Rec. FYM (10 t ha^{-1})	89	91.2	224	-	Rec	10

FYM - Farm Yard Manure, Rec. – Recommended and *BF - Bio-fertilizer for half an hour during the early stages of the crop and subsequently irrigation was given depending on the soil moisture condition. Five plants were randomly selected from each plot and the observations were recorded as pooled data of two years in the main crop and ratoon at harvest time. Fresh and dry weight from each plot was converted to per hectare and it was expressed in tones (t). Dried plant samples were ground to a fine powder and analyzed for determination of total nutrients content by adopting standard methods. The total nitrogen (%) was determined by Micro- kjeldhal method as outlined by Piper (1966), total phosphorus was estimated from di-acid extract by Vanadomolybdate phosphoric acid yellow colour method (Kitson and Mellon, 1944) using spectrophotometer. Total potassium was estimated from di-acid extract by using flame photometer (Piper, 1966).

Total plant nutrient uptake was calculated by following the equation:

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Dry matter yield (kg/ha)} \times \text{nutrient content (\%)}}{100}$$

Gross income, net income, returns to cost ratio were also calculated as per the formulas given below.

Gross income

Gross income was calculated based on the prevailing market price of the produce.

Net income

The net income per hectare was calculated on the basis of gross income and cost of cultivation per hectare as follows:

Net income = Gross income - Cost of cultivation

Benefit: Cost ratio

The benefit: cost ratio was worked out using the following formula:

$$\text{Benefit: Cost ratio} = \frac{\text{Gross income (Rs/ha)}}{\text{Total costs of cultivation (Rs/ha)}}$$

Statistical Analysis

The data generated from the experiment were analyzed using SAS 9.3 version of the statistical package (SAS Institute Inc, 2011). Analysis of variance (ANOVA) was performed using SAS PROC ANOVA procedure. Means were separated using Fisher's protected least significant difference (LSD) test at a probability level of $p<0.01$.

RESULTS AND DISCUSSION

Dry herbage yield (t/ha)

The data on dry herbage yield (t/ha) of basil as influenced by different levels of N through FYM with and without bio-fertilizers and inorganic fertilizer is given in **Table 3**. Application of recommended NPK (160:80:80 kg /ha) along with recommended FYM (10 t/ha *i.e.*,T_9 registered the highest dry herbage yield (8.43, 3.76 and 12.19 t/ha) whereas the lowest dry herbage yield was observed with recommended FYM (10 t/ha) *i.e.*, T_7 (4.80, 2.08 and 6.88 t/ha) of main crop, ratoon and cumulative data respectively. Among the biofertilizer treatments, application of FYM (10 t/ ha) + 100% recommended N through FYM + bio-fertilizer *i.e.*, T_2 recorded maximum dry herbage yield (6.97, 3.05 and 10.02 t/ha) in the main crop, ratoon and cumulative data, respectively. More suitable surrounding environment is created by organic manure that enhance root growth and nutrient availability, which lead to increased plant growth and dry matter (Scheffer and Koehler, 1993). The plants treated by bio-fertilizer can absorb nutrients from soil easily resulting in accumulation of more N, P and K in the leaves (Rai, 2006) that lead to increase the yield. These results are on line with the findings of Khaliq and Janardhanan (1997) in mint, Kapoor *et al*. (2004) in fennel and Joshee *et al*. (2007) in *Scutellaria integrifolia*.

Available macro nutrient in the soil

The results of the study presented in **Table 4** revealed that highest available nitrogen and potassium in the soil after cropping was recorded with application of FYM (10 t/ha) +100% Rec. N through FYM + BF *i.e,* T_2 (227 and 236.33 kg/ha) and (296.80 and 340.60 kg/ha) during 2015 and, 2016, respectively. While, application of (160:80:80 kg /ha) + FYM (10 t/ha) *i.e.*, T_9 recorded the highest available phosphorus (42.31 and 58.15 kg/ha) during 2015 and, 2016, respectively.

Table 3: Effect of integrated nutrient management on dry herb yield (t ha^{-1}) of basil (*Ocimum basilicum*)

Treatments	Dry herb yield (t ha^{-1})							
	First year (2015)			Second year (2016)			Pooled	
	Main crop	Ratoon	Total yield	Main crop	Ratoon	Total yield	Main crop	Ratoon
T_1	6.67^{D}	3.15^{D}	9.82^{E}	5.50^{CD}	2.30^{CD}	7.8^{CD}	6.09^{D}	2.73^{D}
T_2	7.71^{BC}	3.66^{C}	11.37^{C}	6.24^{C}	2.45^{C}	8.69^{C}	6.97^{C}	3.05^{C}
T_3	6.38^{DE}	2.89^{E}	9.27^{E}	4.73^{DEF}	2.07^{FG}	6.8^{DEF}	5.56^{EF}	2.48^{E}
T_4	7.33^{C}	3.32^{D}	10.65^{D}	4.96^{DE}	2.25^{DE}	7.21^{DE}	6.14^{D}	2.79^{D}
T_5	5.98^{EF}	2.65^{F}	8.63^{F}	4.51^{EF}	1.91^{GH}	6.42^{EF}	5.25^{F}	2.28^{F}
T_6	6.71^{D}	2.87^{EF}	9.58^{E}	4.74^{DEF}	2.11^{EF}	6.85^{DEF}	5.72^{DE}	2.49^{E}
T_7	5.54^{F}	2.34^{G}	7.88^{G}	4.05^{F}	1.82^{H}	5.87^{F}	4.80^{G}	2.08^{G}
T_8	8.00^{B}	3.95^{B}	11.95^{B}	7.28^{B}	2.76^{B}	10.04^{B}	7.64^{B}	3.36^{B}
T_9	8.71^{A}	4.31^{A}	13.02^{A}	8.16^{A}	3.21^{A}	11.37^{A}	8.43^{A}	3.76^{A}
Mean	7.00	3.24	10.24	5.58	2.32	7.89	6.29	2.78
CV%	4.09	4.15	2.91	8.79	4.26	6.63	3.98	3.32
$LSD_{5\%}$	0.49	0.23	0.51	0.84	0.17	0.90	0.43	0.15

T_1: FYM (10 t/ha) +100% Rec. N through FYM; T_2: FYM (10 t/ha) +100%Rec. N through FYM + BF; T_3: FYM (10 t/ha) +75% Rec. N through FYM; T_4: FYM (10 t/ha)+75% Rec. N through FYM + BF T_5: FYM (10 t/ha)+50% Rec. N through FYM; T_6: FYM (10t/ha)+ 50% Rec. N through FYM+BF; T_7: Rec. FYM (10t/ha) only; T_8: Rec. NPK (160:80:80 Kg /ha); T_9: Rec. NPK (160:80:80 Kg /ha)+(10t/ha).

Table 4. Influence of integrated nutrients practices on macro nutrient availability in the soil (kg/ha)

Treatments	N		P		K	
	2015	2016	2015	2016	2015	2016
T_1	220.15^{AB}	262.10	36.91^{ABC}	46.37^{ABC}	268.80^{ABC}	281.66^{ABC}
T_2	227.40^{A}	277.00	42.10^{A}	47.98^{ABC}	296.80^{ABC}	340.60^{A}
T_3	211.68^{ABC}	246.00	33.33^{ABC}	45.58^{ABC}	242.67^{ABC}	275.67^{ABC}
T_4	222.57^{AB}	266.70	38.74^{AB}	46.25^{ABC}	265.07^{ABC}	315.86^{AB}
T_5	203.21^{ABC}	228.00	30.33^{BC}	39.29^{BC}	250.13^{BC}	261.00^{BC}
T_6	211.68^{ABC}	246.40	36.41^{ABC}	43.25^{ABC}	259.47^{ABC}	324.53^{AB}
T_7	189.91^{C}	201.40	27.33^{C}	34.17^{C}	212.80^{C}	234.90^{C}
T_8	195.96^{BC}	214.20	40.40^{AB}	53.26^{AB}	229.60^{AB}	323.22^{AB}
T_9	199.58^{ABC}	222.00	42.31^{A}	58.15^{A}	235.20^{A}	333.33^{A}
Mean	209.13	240.42	36.42	46.03	251.17	298.97
CV%	5.09	5.20	11.54	11.08	8.49	8.46
$LSD_{5\%}$	10.46	20.04	4.19	13.91	36.92	43.94

T_1: FYM (10 t/ha) +100% Rec. N through FYM; T_2: FYM (10 t/ha) +100%Rec. N through FYM + BF; T_3: FYM (10 t/ha) +75% Rec. N through FYM; T_4: FYM (10 t/ha) +75% Rec. N through FYM + BF T_5: FYM (10 t/ha) +50% Rec. N through

FYM; T_6: FYM (10 t/ha) +50% Rec. N through FYM+BF; T_7: Rec. FYM (10 t/ha) only; T_8: Rec. NPK (160:80:80 Kg /ha); T_9: Rec. NPK (160:80:80 Kg /ha) + (10 t/ha)

The treatment T_7 recorded lowest available nitrogen (189.91 and 201.23 kg/ha), phosphorus (27.33 and 34.17 kg/ha) and potassium (212.8 and 234.90 kg /ha) during 2015 and, 2016, respectively. In general, increasing the level of N application through FYM leads to increase in the availability of major nutrient.

Organic acids produced during decomposition of FYM had solubilizing action that lead to create good balance between nutrients in the soil solution and improvement of nutrient exchange between soil and plant (Bhandari *et al*. 1992). Bio-fertilizer enhances nutrients mobilizing microorganism which helps in increase the levels of extracted minerals and made it more available (Sharma, (2002); Murugan *et al.* (2011) and Gichangi and Mnkeni, (2009).

Table 5. Influence of integrated nutrient practices on macro nutrient uptake of basil (*Ocimum basilicum* L.) during first year of 2015

Treatments	N		P		K	
	Ratoon	**Main crop**	**Ratoon**	**Main crop**	**Ratoon**	**Main crop**
T_1	82.63 ^{CD}	27.06^{D}	29.85^{BC}	12.87^{B}	99.16^{CD}	33.80^{DE}
T_2	112.69^{B}	40.24^{C}	36.76^{AB}	14.53^{B}	124.97^{B}	44.05^{BC}
T_3	82.88^{CD}	26.96^{D}	27.21^{BC}	10.47^{C}	108.55^{BC}	33.65^{DE}
T_4	95.72^{C}	32.92^{D}	32.49^{ABC}	13.67^{B}	122.89^{B}	38.94^{CD}
T_5	68.50^{DE}	20.84^{D}	22.16^{C}	8.77^{D}	87.02^{DE}	27.56^{E}
T_6	82.23 ^{CD}	25.96^{D}	28.36^{BC}	8.14^{D}	115.35^{BC}	30.14^{DE}
T_7	55.92^{E}	15.95^{D}	20.54^{C}	6.97^{D}	79.55^{E}	24.67^{E}
T_8	123.52^{B}	41.95^{B}	35.47^{AB}	12.58^{B}	125.19^{B}	49.15^{AB}
T_9	155.67^{A}	56.43^{A}	43.80^{A}	16.14^{A}	163.33^{A}	55.56^{A}
Mean	83.07	32.04	29.00	11.57	114.00	37.50
CV%	9.15	12.32	16.05	7.63	7.31	10.43
$LSD_{5\%}$	15.13	6.83	8.54	1.52	14.43	4.03

T_1: FYM (10 t/ha) +100% Rec. N through FYM; T_2: FYM (10 t/ha) +100%Rec. N through FYM + BF; T_3: FYM (10 t/ha) +75% Rec. N through FYM; T_4: FYM (10 t/ha) +75% Rec. N through FYM + BF T_5: FYM (10 t/ha) +50% Rec. N through FYM; T_6: FYM (10 t/ha) +50% Rec. N through FYM+BF; T_7: Rec. FYM (10 t/ha) only; T_8: Rec. NPK (160:80:80 Kg /ha); T_9: Rec. NPK (160:80:80 Kg /ha) + (10 t/h

Table 6. Influence of integrated nutrient practices on macro nutrient uptake of basil (*Ocimum basilicum* L.) during second year of 2016

Treatments	N		P		K	
	Ratoon	**Main crop**	**Ratoon**	**Main crop**	**Ratoon**	**Main crop**
T_1	69.66 ^{CD}	17.33^{D}	24.07^{BC}	8.65^{BC}	77.64^{CD}	24.88^{CDE}
T_2	84.80^{B}	19.44^{C}	27.17^{AB}	12.54^{B}	85.23^{C}	29.44^{BC}
T_3	64.04 ^{CD}	15.29^{E}	17.74^{CD}	7.60^{CD}	62.31 ^{DE}	22.07^{DE}
T_4	68.15^{C}	17.57^{D}	19.95^{D}	7.79^{B}	68.69^{CDE}	26.63^{BCD}
T_5	61.36^{DE}	13.80^{F}	15.63^{D}	5.09^{CD}	57.20^{E}	20.02^{DE}
T_6	63.83 ^{CD}	15.80^{E}	17.27^{D}	9.41^{CD}	63.03 ^{DE}	23.40^{CDE}
T_7	53.81^{E}	13.16^{F}	14.22^{D}	5.28^{D}	51.92^{E}	19.10^{E}
T_8	97.35^{B}	21.69^{B}	25.36^{ABC}	10.27^{B}	99.33^{B}	31.37^{B}
T_9	113.19^{A}	26.65^{A}	32.43^{A}	14.01^{A}	116.16^{A}	39.27^{A}
Mean	75.13	17.86	21.32	8.96	75.72	26.24
CV%	8.15	3.74	12.14	12.29	10.56	10.53
$LSD_{5\%}$	10.6	1.15	4.47	1.66	13.84	4.03

T_1: FYM (10 t/ha) +100% Rec. N through FYM; T_2: FYM (10 t/ha) +100%Rec. N through FYM + BF; T_3: FYM (10 t/ha) +75% Rec. N through FYM; T_4: FYM (10 t/ha) +75% Rec. N through FYM + BF T_5: FYM (10 t/ha) +50% Rec. N through FYM; T_6: FYM (10 t/ha) +50% Rec. N through FYM+BF; T_7: Rec. FYM (10 t/ha) only; T_8: Rec. NPK (160:80:80 Kg /ha); T_9: Rec. NPK (160:80:80 Kg /ha) + (10 t/h

Nutrient uptake by plant

The data on nutrient uptake by the plants presented in **Tables 5** and **6**. Total uptake of nutrients was significantly influenced by different treatments. Among the treatments**,** T_9 with application of NPK (160:80:80 kg /ha) + FYM (10 t/ha) recorded maximum uptake of nitrogen (155.67 and 113.19 kg/ha), phosphorus (43.80 and 32.43 kg/ha) and potassium (163.33 and 116.16 kg/ha) in the main crop during 2015 and 2016, respectively. Similar trend was also observed in ratoon crop that different treatments varied significantly with respect to nutrient uptake and T_9 resulted in the highest uptake of N (56.43 and 26.65 kg/ha), P (16.14 and 14.01 kg/ha) and K (55.56 and 39.27 kg/ha) in 2015 and 2016, respectively. Whereas, application of recommended FYM (10 t/ha) *i.e.,* T_7 recorded lowest uptake of nutrient in the main crop i.e., N (55.92 and 53.81 kg/ha), P (20.54 and 14.22 kg/ha) and K (79.55 and 51.92 kg/ha). Similarly, in ratoon lowest uptake of N (15.95 and 13.16 kg/ha), P (6.97 and 5.28 kg/ha) and K (24.67 and 19.10 kg/ha) was registered in 2015 and 2016 respectively.

The gradual mineralization process lead to improvement in nutrient uptake by the plant with application of organic manures, beside to the chelating effect on nutrients thereby continued nutrient availability through the growing period (Preetha *et al.* 2005). Similar results were also reported by Attia and Saad (2001) in periwinkle, EL-Khashlan (2001) in roselle plants and El-Latif (2006) in *Salvia officinalis.*

Table 7. Cost of cultivation, gross income, net income and B/C ratio as influenced by integrated nutrient management in basil

	Total cost of Cultivation (Rs/ha)		Cumulative oil yield (l/ha)		Gross income (Rs./ha)		Net income (Rs./ha)		B/C ratio	
T No.	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
T_1	55,015	54,526	238.37	141.26	143022.0	84756	88,007	29,741	2.60	1.54
T_2	55,515	55,026	294	179.2	176400.0	107520	120,885	52,005	3.18	1.94
T_3	51,265	50,776	172.76	103.84	103656.0	62304	52,391	11,039	2.02	1.22
T_4	51,765	51,276	232.21	116.82	139326.0	70092	87,561	18,327	2.69	1.35
T_5	47,515	47,026	157.58	94.38	94548.0	56628	47,033	9,113	1.99	1.19
T_6	48,015	47,526	172.91	100.11	103746.0	60066	55,731	12,051	2.16	1.25
T_7	40,015	39,526	133.65	67.76	80190.0	40656	40,175	641	2.00	1.02
T_8	35,790	35,790	327.51	220.47	196506.0	132282	160,716	96,492	5.49	3.70
T_9	41,790	41,301	356.3	258.27	213780.0	154962	171,990	113,172	5.12	3.71

T_1: FYM (10 t/ha) +100% Rec. N through FYM; T_2: FYM (10 t/ha) +100%Rec. N through FYM + BF; T_3: FYM (10 t/ha) +75% Rec. N through FYM; T_4: FYM (10 t/ha) +75% Rec. N through FYM + BF T_5: FYM (10 t/ha) +50% Rec. N through FYM; T_6: FYM (10 t/ha) +50% Rec. N through FYM+BF; T_7: Rec. FYM (10 t/ha) only; T_8: Rec. NPK (160:80:80 Kg /ha); T_9: Rec. NPK (160:80:80 Kg /ha) + (10 t/ha)

Economic studies

The economics has been worked out by comparing costs and returns as influenced by different levels of organic manures along with and without bio-fertilizers and inorganic fertilization in basil and given in **Table 7**. Cost of cultivation under each treatment was estimated by summing the cost of agro inputs, manpower needed for one hectare area, oil extraction, overhead costs and interest per capital. The cost of cultivation for basil crop was maximum with the treatment T_2 *i.e.* FYM (10 t/ha) +100% recommended N through FYM + bio-fertilizers, which amounted Rs. 55,026 and 55,515 /ha in 2015 and 2016, respectively, whereas the application of 100% recommended NPK alone (T_8) required an investment of only Rs 35,790 / ha in each year. The high cost of organic nutrient sources may form an impediment for integrated nutrient management and makes the conventional management "the best" strategy to produce basil herbs.

Gross income was minimum in treatment T_7 *i.e.* recommended FYM (10 t/ha) as it attained Rs 80190 and 40656 /ha in 2015 and 2016, respectively, whereas, T_9 with application of NPK (160:80:80 kg /ha) + recommended FYM (10 t/ha) recorded the maximum gross income of Rs 2, 13,780 and 1, 54,962 /ha in first and second year, respectively. Net returns from the data reveals that an application of recommended doses of NPK (160:80:80 kg /ha) + recommended FYM (10 t/ha) *i.e.* (T_9) fetched maximum net income of Rs 171,990 and 113,172 /ha, whereas the minimum net income of Rs 40,175 and 641 per ha was recorded in treatment T_7 (recommended FYM (10 t/ha) during 2015 and 2016, respectively.

Benefit cost ratio ranged from 1.99 in T_5 *i.e.* the application of FYM (10 t/ha) + 50% recommended N through FYM to 5.49 in T_8 *i.e.* the application of 100% recommended dose of NPK fertilizer in 2015. While in 2016, the maximum value of B:C (3.71) was realized by the application of recommended dose of NPK (160:80:80 kg/ha) + recommended FYM (10 t/ ha), *i.e.* T_9. Application of nutrients through organic manure along with inorganic fertilizer improved the production of oil yield as well as soil fertility (Alizadeh *et al*., 2010) which lead to increased returns. Adoption of a balanced fertilization is the way of enhancing productivity and economic profitability of basil. These finding were supported by Sudhakara *et al*. (2010) and Vennila (2014) in coleus and Patil (2014) in ashwaganda.

CONCLUSION

The outcome of the present investigation revealed that the highest dry herbage yield, nutrient uptake, and maximum B: C ratio was obtained with application of recommended FYM (10 t/ha) + recommended NPK (160:80:80 kg/ha) for both main as well as in ratoon basil crop. Hence, the incorporation of full dose of recommended FYM along with 50 percent of recommended N through inorganic fertilizer as basal and the remaining fifty per cent as top dressing at 45 days after transplanting may be recommended for basil crop to realize maximum dry herbage, nutrient uptake and profitability.

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