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Research Article

Effect of Nutrient Integrated Management on Oil Yield, Nitrogen Balance and Economics of Basil (*Ocimum basilicum*) Cultivation

[1]Baraa AL-Mansour, [2]D. Kalaivanan and [3]G. Basavaraj

[1]Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, UHS Campus, Bengaluru, India
[2]Division of Soil Science and Agricultural Chemistry, ICAR-Indian Institute of Horticultural Research, Bengaluru, India
[3]Regional Horticultural Research and Extension Centre-UHS Campus, GKVK Post, Bengaluru, India

Abstract

Background and Objective: Intensive cropping systems with chemical fertilizer often lead to non-sustainability in production and also pose a serious threat to soil health. The research evaluated the effects of integrated nutrient management on oil productivity, nitrogen balance and economics of basil to find out the an adequate combination of inorganic and organic nitrogen sources and biofertilizer. **Materials and Methods:** Field experiments were conducted at ICAR-Indian Institute of Horticultural Research, Bengaluru during Kharif season of 2015 and 2016 with 9 treatments and 3 replications in a randomized block design to find out the effects of integrated nutrient management on oil yield and economy of basil cultivation and the soil was analyzed to determine the nitrogen sheet balance. **Results:** The treatment T_2 applied with FYM (10 t ha^{-1})+100% Rec. N through FYM+BF recorded the highest value in the main crop (182.04, 123.13 and 152.6 L ha^{-1}) and ratoon (111.96, 56.07 and 84.02 L ha^{-1}) during kharif 2015, 2016 and pooled data, respectively. Also, T_2 recorded the maximum gain of available nitrogen in soil (42.4 kg ha^{-1}) in 2015. While, maximum net income of 171,990 and 113,172 Rs. ha^{-1} recorded with application of NPK (160:80:80 kg ha^{-1}) along with FYM (10 t ha^{-1}) in (T_9). **Conclusion:** It could be concluded that integration of nutrient sources could increase oil yield, nitrogen balance and economic of basil cultivation.

Key words: Integrated nutrient management, balance, productivity, biofertilizer

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Corresponding Author: Baraa AL-Mansour, Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, UHS Campus, Bengaluru, India

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sweet basil was cultivated as aromatic plant for its essential oil, which is extensively used in perfumery, pharmaceutical industries, confectionery as well as in food, flavor, dental, oral products. Ocimum leaves which is produced in small scale used as culinary herb and considered one of the major source of income for farmers[1].

Growth and yielding of basil, like other cultivated plants, depend upon the availability of all nutrients in the nutritional environment, closely connected with macro and micro-elements taken up[2-4]. Nitrogen is one of the basic nutrients used by plants to build many organic compounds, such as amino-acids, peptides, proteins, enzymes or nucleic acids[5-7].

However, long-term applications of inorganic fertilizers have caused a noticeable decrease in crop productivity and an increase in pollution around its surrounding environment[8]. Intensive cropping systems with fertilizer responsive crops that rely on high input of inorganic fertilizers often lead to non-sustainability in production and also pose a serious threat to soil health[9]. Reduction and elimination of the adverse effects of synthetic fertilizers on human health and the environment is a strong indicator that organic agriculture is gaining worldwide attention[10,11].

Organic fertilizers are environmentally friendly, since they are from organic sources[12,13] claimed that substituting chemical fertilizers by biofertilizers, ecosystem health and quality of life will increase which it is the most important goals of sustainable developments. Planting of medicinal herbs under integrated management with organic and inorganic fertilizers is the best current strategy that can be employed to improve yield and the active compounds of these plants[14].

However, in many situations, the high cost of nutrient sources and the difficulty to supply the necessary amount of organic manure makes the nutrient conventional management the best strategy to produce herbs[15].

Considering a number of studies concerning integrated management of nitrogen fertilizer in Basil farming, the one could conclude that neither inorganic nitrogen fertilizer nor the organic one are rational option in basil cultivation, therefore the actual study aimed to find out the an adequate combination of inorganic and organic nitrogen sources and biofertilizer, so that, would raise oil yield, nitrogen soil content and obtain rational cost ratio of basil cultivation at the same time.

MATERIALS AND METHODS

Experimental site: Field experiments were conducted in a randomized complete block design with three replications in an 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°58" North latitude and 77°29" East longitudes.

Treatments of the experiment: The T_1 (FYM (10 t ha^{-1})+100% recommended N through FYM), T_2 (FYM (10 t ha^{-1})+100% recommended N through FYM+biofertilizer), T_3 (FYM (10 t ha^{-1})+75% recommended N through FYM), T_4 (FYM (10 t ha^{-1})+75% recommended N through FYM+biofertilizer), T_5 (FYM (10 t ha^{-1})+50% recommended N through FYM), T_6 (FYM (10 t ha^{-1})+50% recommended N through FYM+biofertilizer), T_7 (recommended FYM (10 t ha^{-1}) only), T_8 (recommended NPK (160:80:80 kg ha^{-1}) only) and T_9 (recommended FYM (10 t ha^{-1})+recommended NPK (160:80:80 kg ha^{-1}).

Data collection: Initial experimental soil samples (0-30 cm depth) were taken for the nutrient analysis prior to land preparation and analyzed using standard procedures[16-18]. Since that, available N was determined by titrating against standard 0.01 (N) H_2SO_4, available phosphorus by spectrophotometer (ECIL, made in India) and available K by using flame photometer (Elico, made in India). Physical and chemical properties of the initial experimental soil are presented in Table 1. The nutrients were supplied in the

Table 1: Physical and chemical properties of initial experimental soil

Parameters	Values
Physical properties	
Bulk density (Mg m^{-3})	1.32
Particle density (Mg m^{-3})	2.65
Pore space (%)	42.00
Chemical properties	
pH (1:2:5)	7.75
Electrical conductivity (dSm^{-1})	0.36
Organic carbon (g kg^{-1})	5.00
Available N (kg ha^{-1})	185.00
Available P (kg ha^{-1})	28.00
Available K (kg ha^{-1})	200.00
Exchangeable Ca (cmol (p$^+$)kg^{-1})	5.25
Exchangeable Mg (cmol (p$^+$)kg^{-1})	0.84
DTPA Fe (mg kg^{-1})	7.50
DTPA Mn (mg kg^{-1})	5.80
DTPA Cu (mg kg^{-1})	1.33
DTPA Zn (mg kg^{-1})	1.22

Table 2: Different treatment combinations and applied nutrient levels under different treatments

Treatments	Inputs quantities		Total applied nutrients			
	FYM (kg 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	35.00	0	-	224	39.2	31.5
T_2: FYM (10 t ha^{-1})+100% Rec. N through FYM+BF	35.00	0	5	224	39.2	31.5
T_3: FYM (10 t ha^{-1})+75% Rec. N through FYM	28.75	0	-	184	32.2	25.9
T_4: FYM (10 t ha^{-1})+75% Rec. N through FYM+BF	28.75	0	5	184	32.2	25.9
T_5: FYM (10 t ha^{-1})+50% Rec. N through FYM	22.50	0	-	144	25.2	20.3
T_6: FYM (10 t ha^{-1})+50% Rec. N through FYM+BF	22.50	0	5	144	25.2	20.3
T_7: Rec. FYM (10 t ha^{-1}) only	10.00	0	-	64	11.2	9.0
T_8: Rec. NPK(160:80:80 kg ha^{-1})	0.00	Rec	-	160	80.0	80.0
T_9: Rec. NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1})	10.00	Rec	-	224	91.2	89.0

FYM: Farm yard manure, Rec: Recommended, BF: Biofertilizer

form of straight fertilizers like urea (160 kg ha^{-1} N), single super phosphate (80 kg ha^{-1} P_2O_5) and muriate of potash (80 kg ha^{-1} K_2O). About 50% of nitrogen and full dose of phosphorus and potash were applied as basal and the remaining 50% of N was applied after 45 days of transplanting in T_8 and T_9 treatments. For biofertilizers, 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 at 5 kg ha^{-1} 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.

Land preparation: 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 m between plots and 0.5 m between replications. Basil seeds were sown in two nursery beds of 6.0 m in length with 1.0 m in width and 10 cm height. Forty days old healthy and uniformly rooted seedlings of sweet basil were transplanted to the field. Weeding was done manually and drip irrigation was given daily for half an hour during the early stages of the crop and subsequently irrigation was given depending on the soil moisture condition.

Determination of the essential oil yield (L ha^{-1}): About 100 g of harvested fresh herbage and flower top from each plots of the experiment were distilled in the steam distillation unit. The duration of the each distillation was 3 h. Oil volume was recorded and oil yield was calculated as the volume (L) of oil per weight (t) of fresh herbage yield[19].

Determine the available nitrogen and N sheet balance: Soil samples from 0-30 cm depth were collected soon after harvest of first and second ratoon crop and analyzed for N availability following standard procedures. Samples were digested in sulphuric acid and estimated by alkaline potassium permanganate method[18]. To work out the N balance sheet, initial status of soil available nutrients, nutrients added through organic manures and inorganic fertilizer, plant uptake and available soil N after Basil cultivation was taken in to the account.

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

$$\text{Benefit: Cost ratio} = \frac{\text{Gross income (Rs ha}^{-1}\text{)}}{\text{Total costs of cultivation (Rs ha}^{-1}\text{)}}$$

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:

$$\text{Net income} = \text{Gross income-Cost of cultivation}$$

Statistical analysis: The data generated from the experiment were analyzed using SAS 9.3 version of the statistical package. 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

Oil production: Oil production is the most important parameter in basil farming, on which depends all economic indicators (gross income, net income and benefit cost ratio).

Table 3: Effect of different level of N supplied through FYM, inorganic fertilizer and biofertilizers on oil yield (L ha^{-1}) of basil (*Ocimum basilicum* L.)

	Yield/ha (2015)			Yield/ha (2016)			Pooled	
Treatments	Main crop	Ratoon	Cumulative yield	Main crop	Ratoon	Cumulative yield	Main crop	Ratoon
T_1	151.96^{D}	86.41^{C}	238.37^{C}	105.50^{D}	35.79^{C}	141.26^{D}	128.70^{D}	61.10^{D}
T_2	182.04^{B}	111.96^{B}	294.00^{B}	123.10^{C}	56.07^{B}	179.20^{C}	152.60^{C}	84.02^{C}
T_3	115.81^{E}	56.95^{DE}	172.76^{D}	78.99^{EF}	24.85^{E}	103.84^{EF}	97.40^{E}	40.90^{EF}
T_4	166.42^{C}	65.79^{CD}	232.21^{C}	86.05^{E}	30.77^{D}	116.82^{E}	126.20^{D}	48.28^{E}
T_5	106.44^{EF}	51.14^{DE}	157.58^{D}	73.90^{F}	20.48^{F}	94.38^{F}	90.20^{E}	35.81^{FG}
T_6	116.50^{E}	56.41^{DE}	172.91^{D}	78.70^{EF}	21.41^{EF}	100.11^{F}	97.60^{E}	38.91^{EF}
T_7	95.13^{F}	38.52^{E}	133.65^{D}	52.40^{G}	15.36^{G}	67.76^{G}	73.80^{F}	26.94^{G}
T_8	194.06^{B}	133.50^{AB}	327.51^{A}	161.70^{B}	58.81^{B}	220.47^{B}	177.90^{B}	96.13^{B}
T_9	211.94^{A}	144.36^{A}	356.30^{A}	187.40^{A}	70.81^{A}	258.27^{A}	199.70^{A}	107.58^{A}
Mean	148.92	82.77	231.96	105.31	37.15	142.45	127.10	59.96
CV%	4.83	15.62	7.38	6.35	5.51	7.38	3.81	10.17
$LSD_{5\%}$	12.45	22.38	29.61	11.56	3.54	29.61	8.39	10.55

FYM: Farm yard manure, T_1: FYM (10 t ha^{-1})+100% Rec. N through FYM, T_2: FYM (10 t ha^{-1})+100% Rec. N through FYM+BF, T_3: FYM (10 t ha^{-1})+75% Rec. N through FYM, T_4: FYM (10 t ha^{-1})+75% Rec. N through FYM+BF T_5: FYM (10 t ha^{-1})+50% Rec. N through FYM, T_6: FYM (10 t ha^{-1})+50% Rec. N through FYM+BF, T_7: Rec. FYM (10 t ha^{-1}) only, T_8: Rec. NPK (160:80:80 kg ha^{-1}), T_9: Rec. NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1})

Table 4: Impacts of different level of FYM, biofertilizers and inorganic fertilizer on Nitrogen balance during 2015

		N added (kg ha^{-1})								
Treatments	Initial fertility (kg ha^{-1}) (A)	Mineral fertilizer	Rec. FYM	Rec. N through FYM	Total (B)	Nutrient uptake (kg ha^{-1}) (C)	Expected balance D=B-C	Actual fertility after harvest (E)	Apparent gain/losses (kg ha^{-1}) F=E-D	Actual gain/losses (kg ha^{-1}) G=E-A
T_1	185	0	64	160	409	117.84	291.16	220.15	-71.01	35.15
T_2	185	0	64	160	409	150.62	258.38	227.40	-30.97	42.40
T_3	185	0	64	120	369	107.51	261.49	211.68	-49.81	26.68
T_4	185	0	64	120	369	134.02	234.98	222.57	-12.42	37.57
T_5	185	0	64	80	329	89.10	239.90	203.21	-36.69	18.21
T_6	185	0	64	80	329	105.95	223.05	211.68	-11.37	26.68
T_7	185	0	64	0	249	78.04	170.96	189.91	18.95	4.91
T_8	185	160	0	0	345	169.93	175.07	195.96	20.89	10.96
T_9	185	160	64	0	409	208.20	200.80	199.58	-1.21	14.58

FYM: Farm yard manure, Rec: Recommended, BF: Bio-fertilizer, T_1: FYM (10 t ha^{-1})+100% Rec. N through FYM, T_2: FYM (10 t ha^{-1})+100% Rec. N through FYM+BF, T_3: FYM (10 t ha^{-1})+75% Rec. N through FYM, T_4: FYM (10 t ha^{-1})+75% Rec. N through FYM+BF T_5: FYM (10 t ha^{-1})+50% Rec. N through FYM, T_6: FYM (10 t ha^{-1})+50% Rec. N through FYM+BF, T_7: Rec. FYM (10 t ha^{-1}) only, T_8: Rec. NPK (160:80:80 kg ha^{-1}), T_9: Rec. NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1})

Moreover, it plays a key factor in selecting the "adequate" combination of fertilizers. In Table 3, oil yield per hectare increased with the increase of FYM doses, while, T_9 applied with NPK (160:80:80 kg ha^{-1})+FYM (10 t ha^{-1}) recorded highest oil yield in the main crop (211.94, 187.46 and 199.7 L ha^{-1}) and in ratoon (144.36, 70.81 and 107.58 L ha^{-1}) during 2015, 2016 and pooled data respectively, Whereas, the lowest oil yield per hectare was recorded with recommended dose of FYM alone in T_7 in the main crop (95.13 and 52.40 L ha^{-1}) in ratoon (38.52 and 15.36 L ha^{-1}) during 2015 and 2016, respectively and in the pooled data (73.8 and 26.94 L h^{-1}) increase in oil production could attribute to the increase of nitrogen doses either throughout organic or inorganic form. For cumulative oil yield, application of NPK (160:80:80 kg ha^{-1})+FYM (10 t ha^{-1}) i.e., T_9 recorded significantly the highest value (356.3 and 258.27 L ha^{-1}) while, the minimum value (133.65 and 67.76 L ha^{-1}) was recorded in T_7 during 2015 and 2016, respectively.

Nitrogen balance: The results in Table 4 of the soil after harvest showed that the application of FYM (10 t ha^{-1})+100% Rec. N through FYM+BF (T_2) gave the maximum nitrogen actual gain (42.40 kg ha^{-1}) in 2015, whereas, T_7 applied with FYM (10 t ha^{-1}) recorded the minimum actual gain of nitrogen in soil (4.91 kg ha^{-1}). The maximum uptake was (208.20 kg ha^{-1}) in T_9 while, the minimum nitrogen uptake was (78.04 kg ha^{-1}) in T_7 (FYM (10 t ha^{-1}).

The final status of available N in soil after harvest of basil was considerably increased from 185-227.4 kg ha^{-1} in T_2 while, in T_7 it increased to only 189.58 over initial status.

The data in Table 5 indicates that the initial level of available N in soil in 2016 ranged from189.91-227.40 kg ha^{-1} in T_7 and T_8, respectively. The maximum nitrogen uptake (134.31 kg ha^{-1}) and the highest nitrogen gain (20.58 kg ha^{-1}) after the harvest of basil was observed in treatment T_9 while, the lowest balance (12.10 kg ha^{-1}) was observed in treatment T_2. The final status of available N in soil after harvest of basil was considerably increased from 185-227.4 kg ha^{-1} in T_2, while it increased from 185-190.82 kg ha^{-1} in T_7.

Table 5: Impacts of different level of FYM, biofertilizers and inorganic fertilizer on Nitrogen balance during 2016

Treatments	Initial fertility ($kg\ ha^{-1}$) (A)	N added ($kg\ ha^{-1}$) Mineral fertilizer	Rec. FYM	Rec. N through FYM	Total (B)	Nutrient uptake ($kg\ ha^{-1}$) (C)	Expected balance D=B-C	Actual fertility after harvest (E)	Apparent gain/losses ($kg\ ha^{-1}$) F=E-D	Actual gain/losses ($kg\ ha^{-1}$) G=E-A
T_1	220.15	0	64	160	444.14	82.17	361.97	234.66	-127.31	14.52
T_2	227.40	0	64	160	451.40	100.40	351.16	239.50	-111.66	12.10
T_3	211.68	0	64	120	395.68	74.85	320.83	226.20	-94.63	14.52
T_4	222.57	0	64	120	406.56	81.07	325.50	237.08	-88.42	14.52
T_5	203.21	0	64	80	347.21	70.61	276.60	217.73	-58.87	14.52
T_6	211.68	0	64	80	355.68	75.19	280.49	231.03	-49.46	19.35
T_7	189.91	0	64	0	253.90	63.09	190.82	208.05	17.23	18.14
T_8	195.96	160	0	0	355.95	115.99	239.96	211.87	-28.10	15.91
T_9	199.58	160	64	0	423.58	134.31	289.28	220.17	-69.11	20.58

FYM: Farm yard manure, Rec: Recommended, BF: Biofertilizer, T_1: FYM (10 t ha^{-1})+100% Rec. N through FYM, T_2: FYM (10 t ha^{-1})+100% Rec. N through FYM+BF, T_3: FYM (10 t ha^{-1})+75% Rec. N through FYM, T_4: FYM (10 t ha^{-1})+75% Rec. N through FYM+BF T_5: FYM (10 t ha^{-1})+50% Rec. N through FYM, T_6: FYM (10 t ha^{-1})+50% Rec. N through FYM+BF, T_7: Rec. FYM (10 t ha^{-1}) only, T_8: Rec. NPK (160:80:80 kg ha^{-1}), T_9: Rec. NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1})

Table 6: Pooled data of Nitrogen balance for trials of the two years

Treatments	Nitrogen balance 2015	2016	Pooled data	Gain/losses (%) Compared with T_8*	Compared with T_7**
T_1: FYM (10 t ha^{-1})+100% Rec. N through FYM	42.4	12.1	27.3	202.8	236.4
T_2: FYM (10 t ha^{-1})+100% Rec. N through FYM+BF	37.6	14.5	26.0	193.9	226.0
T_3: FYM (10 t ha^{-1})+75% Rec. N through FYM	35.2	14.5	24.8	184.9	215.5
T_4: FYM (10 t ha^{-1})+75% Rec. N through FYM+BF	26.7	19.4	23.0	171.3	199.7
T_5: FYM (10 t ha^{-1})+50% Rec. N through FYM	26.7	14.5	20.6	153.3	178.7
T_6: FYM (10 t ha^{-1})+50% Rec. N through FYM+BF	14.6	20.6	17.6	130.9	152.5
T_7: Rec. FYM (10 t ha^{-1}) only	18.2	14.5	16.4	121.8	142.0
T_8: Rec. NPK (160:80:80 kg ha^{-1})	11.0	15.9	13.4	100.0	116.6
T_9: Rec. NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1})	4.9	18.1	11.5	85.8	100.0

FYM: Farm yard manure, Rec: Recommended, BF: Biofertilizer, T8 and T7 was considered a baseline (100 gain/losses), Then compared with the other treatments, *: Significant and **: More significant

Nitrogen gain in pooled data: Pooled data Table 6 showed a maximum nitrogen gain of 27.4 kg ha^{-1} in T_1, whereas, the addition of nitrogen through the combination of Rec. The NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1}) i.e., T_9, recorded the minimum nitrogen gain (11.5 kg ha^{-1}).

To compare the effect of T_8 with the other combination, it was considered as a baseline (100%), so the gain of available nitrogen after harvest was higher than T_8 in all treatment, except T_9 which recorded a decrease by 14.2% in available nitrogen after harvest as compared with T_8, whereas, T_1 increased the available nitrogen gain by nearly two folds (202.8%). This result may indicated that the Rec. mineral doses alone couldn't be considered an adequate option for sustainable agriculture. However, when T_7 was compared with other treatments, T_1 recorded the maximum increase of gained nitrogen in soil by 236.4%, while T8 fetched the minimum one 116.6%. All treatments recorded a better gain of nitrogen in soil, therefore, neither Rec. The FYM alone nor the Rec. mineral doses alone could be an adequate option for sustainable agriculture.

Economic studies: Cost of cultivation under each treatment Table 7 was estimated by summing the cost of agro inputs, cost of 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, which amounted 55,026 and 55,515 R. ha^{-1} in 2015 and 2016 respectively, whereas, the application of 100% recommended dose of NPK alone (T_8) required an investment of only 35,790 Rs. ha^{-1} in each year. The high cost of inorganic nutrient sources may form an impediment for integrated management of nutrient and makes the conventional management "the best" strategy to produce basil herbs, but environmental pollution and the soil health may be enforce the integrated management of nutrients.

Net monetary returns from the data reveals that an application of Rec. doses of NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1}) i.e., (T_9) fetched maximum net income of 171,990 and 113,172 Rs. ha^{-1}, whereas, the minimum net income were 40,175 and 641 Rs ha^{-1} was recorded in treatment T_7 (Rec. FYM (10 t ha^{-1}), in 2015 and 2016, respectively.

Benefit cost ratio, ranged from 1.99 in T_5 to 5.49 in T_8 in 2015. It could be attributed to the high cost of FYM on one hand and to the decrease in oil production on the other hand.

Table 7: Economic of organic, biofertilizer and inorganic practices in basil

	Total cost of cultivation (Rs. ha^{-1})		Cumulative oil yield (L ha^{-1})		Gross income (oil yield) (Rs. ha^{-1})		Net income (Rs. ha^{-1})		B/C ratio	
Treatments	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	294.00	179.20	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	356.30	258.27	213780.0	154962	171,990	113,172	5.12	3.71

T_1: FYM (10 t ha^{-1})+100% Rec. N through FYM, T_2: FYM (10 t ha^{-1})+100% Rec. N through FYM+BF, T_3: FYM (10 t ha^{-1})+75% Rec. N through FYM, T_4: FYM (10 t ha^{-1})+75% Rec. N through FYM+BF, T_5: FYM (10 t ha^{-1})+50% Rec. N through FYM, T_6: FYM (10 t ha^{-1})+50% Rec. N through FYM+BF, T_7: Rec. FYM (10 t ha^{-1}) only, T_8: Rec. NPK (160:80:80 kg ha^{-1}), T_9: Rec. NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1}). 1 L oil = 600 Rs. B/C ratio was calculated taking into account the cost of cultivation and gross returns obtained over 2 years of the experiment Data statically not analyzed

While in 2016 the minimum value (1.02) was recorded with application recommended dose of FYM in T_7 and the maximum value of B:C (3.71) was fetched by the application of the Rec. doses of NPK (160:80:80 kg ha^{-1})+Rec. FYM (10 t ha^{-1}), i.e., T_9.

DISCUSSION

Essential oil is synthesized from products of photosynthesis through enzymatic actions. Organic fertilizers enhance the content of macro and micro-elements in the soil, play an essential role in the plant growth and development and the amount of essential oil[20]. Similarly, application of biofertilizer lead to improvement of nitrogen uptake and eventually increase of biomass[21], that has a positive effect on essential oil content.

In general, combined applications of organic manure and inorganic fertilizers improve soil properties and make suitable plant growth conditions that lead to increase oil yield[22]. These findings are in accordance with the observations of Shalan[23] and Harshavardhan *et al.*[24]. Also application of FYM cause slow release of available nitrogen, explaining the higher value of available N over the initial value. The pooled data of the two years of trials showed a clear effect of biofertilizes as it increased the nitrogen gain in soil. This result could be attributed to the fact that, biofertilizers generates plant nutrients like nitrogen through their activities in the soil or rhizosphere and makes them available to the plants on the soil[25], help better sink source relations to allocate more nutrients, mobilize the availability of nutrients by their biological activity in particular and help in building up the micro/flora and in turn the soil health in general and may explain the increasing level of actual gain in the N soil content[26].

Basil plant has vast potential for cultivation as a short duration economically-viable aromatic crop. Farmers should be made aware about this fact. However, application of organic manure along with inorganic manure suitable cropping pattern that increase the overall oil by considering its return per unit area could make the cultivation basil a preferred option without affecting the soil properties. Adoption of a balanced fertilizer management approach will safeguard the higher productivity and returns from money spent, not only on nutrients but also on relay cropping enterprise. Application of nutrients through organic manure along with inorganic fertilizer improved the production of oil yield as well as soil fertility[27] which lead to increased returns from money spent. Adoption of a balanced fertilization is the way of enhancing productivity and economic profitability of basil.

CONCLUSION

The outcome of the present investigation revealed that for highest oil yield we could adapt application of recommended FYM (10 t ha^{-1}) along with recommended NPK (160:80:80 kg ha^{-1}) for both main as well as in ratoon basil crop. While, adequate option for basil fertilizing could be by application of FYM (10 t ha^{-1})+100% Rec. N through FYM+biofertilizer, as it gave a high net income per hectare on one hand and raised nitrogen in soil on the other hand.

SIGNIFICANCE STATEMENT

This study revealed the large benefits of integrated nutrient management , which indicate that using organic and biofertilizer along with chemical fertilizer could increase nitrogen soil content and oil yield without threading the soil health. The research studied nitrogen sheet balance which is the important principle of sustainability. This give the current research huge applicability on the actual cultivation with noticing that it reflect positively on economic profitability of basil. This research will also help the researchers and farmers to adopt balanced fertilization as the way of enhancing productivity and replace the concept that application of chemical fertilizer is the only way to increase the yield. Thus, integrated nutrient approach lead to increase productivity side by side protection of soil health.

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