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BASIL (*OCIMUM BASILICUM* L.): GROWTH, YIELD, QUALITY AND ECONOMICS INFLUENCED WITH ORGANIC MANURES AND BIO-FERTILIZERS

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ABSTRACT

The present field investigation was carried out at department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, R.V.S.K.V.V., Mandsaur (M.P.) during the year 2021-2022 in RBD Design with three replications. The plots of individual treatments were applied different levels of FYM, vermicompost, bio-fertilizers (PSB, *Azotobactor* and *Azospirillum*) and control plots. Result revealed that T_8 - FYM@20 tonha^{-1} + bio-fertilizers@3 kg ha^{-1}had highest plant height (41.90, 67.23, 80.91, 81.81 and 81.81 cm plant^{-1}), number of branches (8.67, 28.17, 23.33, 24.00 and 24.00 plant^{-1}),number of inflorescence (5.40, 49.67, 68.87, 69.87 and 69.87 plant^{-1}), length of inflorescence (7.20, 19.93, 20.97, 21.05 and 21.05 cm plant^{-1}), fresh weight (108.33, 243.02, 368.00, 259.80 and 236.10 g plant^{-1}) and dry weight (4.26, 9.05, 42.83, 112.40 and 135.86 g plant^{-1}), leaf area index (0.30, 0.97, 2.07 and 2.83), leaf area duration (244.27, 789.03, 1677.94 and 2291.38 cm^2 day^{-1}), crop growth rate (0.61, 0.14, 0.19 and 0.05 g cm^{-2}day^{-1}) and relative growth rate (0.13, 0.08, 0.09 and 0.04 g g^{-1} day^{-1}) at different intervals. Dry herb yield (49.47 q plant^{-1}), Seed yield (10.75 q ha^{-1}) essential oil content (0.77% at 70 DAT and 0.86% at 110 DAT) also gross return (263425 Rs. ha^{-1}), net return (187322.27 Rs. ha^{-1}) and benefit: cost ratio (2.5) in T_8 - FYM@20 ton ha^{-1} + bio-fertilizers @ 3 kg ha^{-1}.

Key words : Organic Manures, Bio-fertilizers, Yield, Quality, Economics and Basil.

Introduction

Basil (*Ocimum basilicum* L.) is belonging to the family Lamiaceae and also includes about 50-150 species of herbs and shrubs coming from the tropical regions of Asia, Africa and Central and South America (Malav *et al.*, 2015).It is a wide, herbaceous, erect, strongly aromatic annual herb, its leaves opposite, ovate-lanceolate and slightly hairy; flora developed in racemose inflorescences, flowers are prominent, seeds black and ellipsoid which turn mucilaginous on wetting. It is the "King of the herbs" and generally utilized for its commercial, culinary, industrial, cosmetic and medicinal value (Meena *et al.*, 2013). Being an economically beneficial herb of polymorphic group, it forms a good source of many naturally occurring essential oils and aroma chemicals (Khosla *et al.*, 2000). It's also essential for the pharmaceutical industry and it's quite utilized in folk medicines in several parts of the world. Its essential oil contains biologically active compounds such as Eugenol (71%), Eugenol methyl ether (20%), Methychavicol (3%), Camphor and Methyl cinnamates and lesser amounts of Nerol, Caryophyllene, Selinene, Camphor, Cineole and Linalool etc (Ram *et al.*, 2019). Organic manures and bio-fertilizers are providing N, P, K and micronutrients such as Fe, S, Mo and Zn etc. in

available forms to the through biological decomposition and get better physio-chemical properties of soil such as aggregation, aeration, permeability, water holding capacity, slow release of nutrients and enhance in cation exchange capacity and stimulation of soil as flora and fauna. Vermicompost increase the root elongation and development of lateral roots in plants. It is also increasing the nutrient uptake by the plants through enhancing the permeability of root cell membrane, stimulating root growth and enhancing proliferation of root hairs (Ram *et al.*, 2019).

Materials and Methods

The experiment was laid out at department Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, under Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Mandsaur (M.P.) during the year 2021-2022. The site of experiment is situated in western part of Madhya Pradesh lies between the parallels of latitude 23° 45' North to 24° 13' North and between the meridians of longitude 74° 44' East and 75° 18' East. The district is situated at an altitude of 435.02 meters from the mean sea level. This region falls under agro climatic zone number 10 of the state. The study was conducted with eight treatments in simple Randomized Block Design and replicated three times.

The treatments are accompanied with different doses of vermicompost, FYM and three bio-fertilizers (PSB, *Azotobactor* and *Azospirillum*.The applied treatments detail are T_1: Control, T_2: Vermicompost @4 T ha^{-1} + Bio-fertilizers @5 kg each ha^{-1}, T_3: Vermicompost @6 T ha^{-1}+ Bio-fertilizers @ 4 kg each ha^{-1}, T_4: Vermicompost @8 T ha^{-1}+ Bio-fertilizers @3 kg eachha^{-1}, T_5: Vermicompost @10 T ha^{-1}+ Bio-fertilizers @ 2 kg each ha^{-1}, T_6: FYM @ 10 T ha^{-1}+ Bio-fertilizers @5 kg each ha^{-1}, T_7: FYM @15 T ha^{-1}+ Bio-fertilizers @4 kg each ha^{-1}, T_8: FYM @20 T ha^{-1}+ Bio-fertilizers @3 kg each ha^{-1}. All the parameters were recorded at 30, 60, 90, 120 days after transplanting and at harvest. The statistical analysis of variance for the applied design (RBD) was analysed using Genstat software (2005 Edition). The F-test was measured at the $P<0.05$ level of significance.

The morphological parameters such as plant height, number of primary branches, number of leaves, fresh weight and dry weight of plant at 30, 60, 90 DAT and at harvest were taken.

Plant height (cm plant^{-1}) : The plant height was measured in centimeters from the base of stem at ground level to the tip of inflorescence.

Number of leaves (plant^{-1}) : The leaves from five randomly selected plants from each plot were counted. The mean was computed and expressed as number of leaves per plant.

Number of inflorescence (plant^{-1}) : The five randomly plants were selected from each row and number of inflorescences were counted and average was calculated and expressed as number of inflorescences per plant.

Length of inflorescence (cm) : The length of inflorescence was measured in centimeters from the base of inflorescence to the tip of inflorescence. The five randomly inflorescence were selected from each row and length of inflorescence were counted and average was calculated and expressed as number of inflorescences per plant.

Fresh weight (g plant^{-1}) : The five randomly selected plants were uprooted away from border rows of a plot, cleaned and then were weighed and mean was calculated as gram per plant.

Dry weight (g plant^{-1}) : After taking fresh weight plants were kept in the oven at 60-62^{0}C for drying about 60 hours. Then were weighed at 30, 60, 90, 120 DAT and at harvest and mean was calculated as gram per plant.

The growth parameters were calculated by standard methods mentioned below.

Leaf area index : It is expresses the ratio of leaf surface (one side only) to the ground area occupied by the plant or crop stand Gardner *et al.* (1985).

$$LAI = \frac{(LA_2 + LA_1)}{2\ P}$$

Where, the LA_1 and LA_2 represent the leaf area of two consecutive intervals and 'P' stands for ground area (Watson, 1974).

Leaf area duration (cm^2 day^{-1}) : It is expresses the magnitude and persistence of leaf area of leafiness during the period of crop growth. It reflects the extent or seasonal integral of light interception and correlates with yield (Watson, 1952).

$$LAD = \frac{(LA_2 + LA_1)}{2} \times (t_2 - t_1)$$

Where, the LA_1 and LA_2 represent the leaf area of two consecutive time intervals (t_1 & t_2) (Watson, 1952).

Crop Growth Rate (g cm^{-2} day^{-1}) : The gain in weight of a community of plants on a unit of land in a unit of time is termed to as crop growth rate (Gardner *et al.*, 1985). It is estimated by calculating the average daily

increment of plant biomass (W_1 and W_2) per unit ground area (P) per unit time interval (t_1 and t_2).

$$CGR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P}$$

Relative Growth Rate (g g^{-1} day^{-1}) : It expresses the dry weight increase in a time interval in relation to the initial weight. The mean relative growth rate is calculated from measurements taken at time t_1 and t_2 (Beadle, 1985).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

The yield parameters were calculated by methods mentioned below

Dry Herb yield (g $plant^{-1}$) : After harvesting, the five plants were selected from each plot, cleaned and then were weighed and mean was calculated as gram per plant

Dry Herb yield (q ha^{-1}) : Dry herb yield per hectare were calculated by multiplying dry herb yield per plant with number of plants per hectare.

Seed yield (g $plant^{-1}$) : Five tagged plants of each plot were harvested, dried under shade and threshed. The average weight of seeds from five plants was recorded and expressed as seed yield per plant in grams.

Seed yield (q ha^{-1}) : Seed yield per hectare were calculated by multiplying seed yield per plant with number of plants per hectare. After threshing and winnowing clean seeds obtained from each plot were weighed and the weight was recorded in gram per plot. This can be converted in to quintal per hectare by using the formula given below.

$$\text{Seed yield (q/ha)} = \frac{\text{Seed yield (g) / plot (sq. m)} \times 10000}{\text{Size of plot (sq. m)} \times 1000 \times 100}$$

Essential oil content was recorded at 70 and 110 DAT by methods mentioned below:

Essential Oil Content (%)

Percentage of essential oil in fresh leaves, inflorescence and tender part of plant was estimated using Clevenger's apparatus as per standard procedure taking 100 gm fresh herb in vegetative stage at 70 DAT and reproductive stage at 110 DAT of each treatment from each replication. Weight difference of conical flask was recorded and percentage oil from fresh herb was calculated using the formula,

$$\text{Percent oil from fresh herb} = \frac{\text{Weight of flask (B)(g)} - \text{Weight of flask (A)(g)}}{\text{Weight of fresh sample taken (g)}} \times 100$$

Results and Discussion

Morphological parameters

The results manifested that, treatment T_8 - FYM@20 ton ha^{-1} + bio-fertilizers @ 3 kg ha^{-1} had maximum plant height (41.90, 67.23, 80.91, 81.81 and 81.81 cm $plant^{-1}$), number of branches (11.60, 25.53, 26.57, 28.53 and 28.53 $plant^{-1}$), number of inflorescence (5.40, 49.67, 68.87, 69.87 and 69.87 $plant^{-1}$), length of inflorescence (7.20, 19.93, 20.97, 21.05 and 21.05 cm $plant^{-1}$), total fresh weight (108.33, 243.02, 368.00, 368.80 and 236.10 g $plant^{-1}$) and dry weight (24.55, 74.45, 85.55, 85.55 and 104.68 g $plant^{-1}$)which was at par with T_7 - FYM@15 $tonha^{-1}$ + bio-fertilizers@4 kg ha^{-1}; while, minimum in T_1 - control at 30, 60, 90, 120 and at harvest, respectively (Tables 1, 2 and 3). It might be due to organic manure and bio-fertilizers had articulated influence on growth characters of Indian basil crop. Based on present research, it was accounted that the spread in vegetative growth parameters may be because of the generation of high chlorophyll content with inoculation of nitrogen fixers. The other logical clarification behind increased vegetative growth might be the formation of plant growth regulators by microorganism in rhizosphere, the application of organic manures might have supply adequate quantity of micro and macro nutrients, which arise higher metabolic rate and auxin activities in the plant, resulting in better growth attributes which are absorbed by the roots, Ram *et al.* (2019). Similar result was observed by Arafa *et al.* (2017), Harish Kumar *et al.* (2019), Darzi *et al.* (2013) and Mansour *et al.* (2017). FYM contains good C/N ratio and soil gets easily mineralized into available forms which ultimately leads to increased nutrient uptake. The enhancement in soil conditions might have increased the sweet basil plant ability to extract more nutrients from soil. Organic manures like FYM when mixed to the soil, with the action of microorganisms, complex nitrogenous compounds were steadily broke down and its availableness in the form of nitrate N is stable through crop growth (Anuja and Jayasri, 2011).

Growth parameters

It is confirmation that, treatment T_8 - FYM @ 20 $tonha^{-1}$ + bio-fertilizers @ 3 kg $ha^{-1}$was denoted highest leaf area index (0.30, 0.97, 2.07 and 2.83), leaf area duration (244.27, 789.03, 1677.94 and2291.38 cm^2 day^{-1}), crop growth rate (0.61, 0.14, 0.19 and 0.05 g cm^{-2} day^{-1}) and relative growth rate (0.13, 0.08, 0.09 and 0.04 g g^{-1} day^{-1}) and was at par with T_7 - FYM@15 ton ha^{-1} + bio-fertilizers @ 4 kg ha^{-1}. However, the lowest value of these parameters were found in T_1 - control at 30-60, 60-90, 90-120 and 120-at harvest, respectively (Figs. 1a,

Table 1 : Response of Organic manures and bio-fertilizers on growth and oil yield of Basil (*Ocimum basilicum* L.).

	Treatments	Plant height (cm plant^{-1})					Number of branches (plant^{-1})				
		30 DAT	60 DAT	90 DAT	120 DAT	At harvest	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
T_1	Control	37.87	58.50	70.88	71.95	71.95	8.67	23.00	23.33	24.00	24.00
T_2	VC@4ton/ha+BF@5 kg each/ha	39.27	63.44	71.89	73.73	73.73	9.87	23.83	24.73	27.20	27.20
T_3	VC@6ton/ha+BF@4 kg each/ha	38.07	62.82	71.33	72.87	72.87	9.33	23.80	24.47	24.80	24.80
T_4	VC@8ton/ha+BF@3 kg each/ha	39.50	63.91	75.29	75.78	75.78	10.00	23.87	24.90	27.23	27.23
T_5	VC@10ton/ha+BF@2 kg each/ha	40.35	66.43	75.64	80.20	80.20	11.00	23.97	24.97	27.90	27.90
T_6	FYM@10ton/ha+BF@5 kg each/ha	40.17	65.57	75.47	75.86	75.86	10.93	23.93	24.93	27.43	27.43
T_7	FYM@15ton/ha+BF@4 kg each/ha	41.17	66.55	80.04	80.32	80.32	11.20	24.13	25.27	28.27	28.27
T_8	FYM@20ton/ha+BF@3 kg each/ha	41.90	67.23	80.91	81.81	81.81	11.60	25.53	26.57	28.53	28.53
SE m (±)		**0.82**	**1.63**	**2.23**	**0.79**	**0.79**	**0.59**	**0.40**	**0.43**	**0.82**	**0.82**
CD @ 5 %		**2.49**	**4.95**	**6.78**	**2.40**	**2.40**	**1.78**	**1.20**	**1.29**	**2.49**	**2.49**

Table 2 : Response of Organic manures and bio-fertilizers on growth and oil yield of Basil (*Ocimum basilicum* L.).

	Treatments	Number of inflorescence (plant^{-1})					Length of inflorescence (cm plant^{-1})				
		30 DAT	60 DAT	90 DAT	120 DAT	At harvest	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
T_1	Control	3.00	33.13	52.80	55.47	55.47	5.43	14.90	15.98	16.33	16.24
T_2	VC@4ton/ha+BF@5 kg each/ha	3.20	40.20	53.80	60.47	60.47	5.87	15.63	17.52	18.11	18.11
T_3	VC@6ton/ha+BF@4 kg each/ha	3.13	38.20	53.20	55.73	55.73	5.53	15.70	17.03	18.01	18.01
T_4	VC@8ton/ha+BF@3 kg each/ha	3.27	42.53	59.00	60.53	60.53	5.87	15.63	18.19	18.55	18.25
T_5	VC@10ton/ha+BF@2 kg each/ha	4.23	46.17	60.53	62.47	62.47	6.97	16.80	18.92	19.15	19.15
T_6	FYM@10ton/ha+BF@5 kg each/ha	3.80	45.67	59.87	61.53	61.53	6.93	16.73	18.73	18.95	18.95
T_7	FYM@15ton/ha+BF@4 kg each/ha	4.40	49.07	61.47	64.27	64.27	7.03	17.18	19.16	19.55	19.55
T_8	FYM@20ton/ha+BF@3 kg each/ha	5.40	49.67	68.87	69.87	69.87	7.20	19.93	20.97	21.05	21.05
SE m (±)		**0.45**	**1.96**	**2.70**	**2.68**	**2.68**	**0.42**	**0.93**	**0.77**	**0.73**	**0.83**
CD @ 5 %		**1.36**	**5.96**	**8.19**	**8.13**	**8.13**	**1.26**	**2.82**	**2.34**	**2.21**	**2.52**

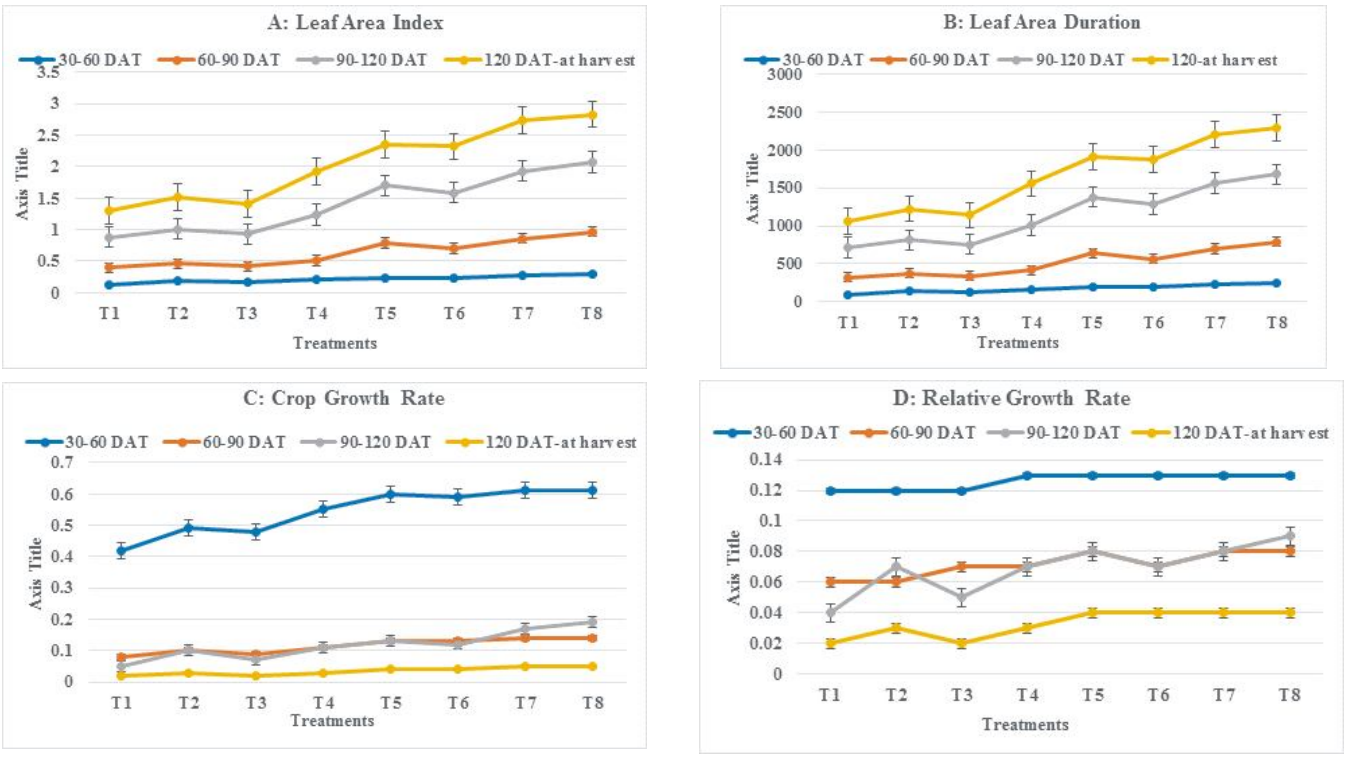

Fig. 1 : Response of organic manures and bio-fertilizers on leaf area index, leaf area duration (cm^2 $days^{-1}$), crop growth rate (g cm^{-2} day^{-1}) and relative growth rate (g g^{-1} day^{-1}) of Basil (*Ocimum basilicum* L.).

b, c and d). Leaf area increased with application of organic manure along with bio-fertilizer could be related to more nutrition that assigned to leaf development, because of nutrient release by microorganisms in the soil and followed by increased plant growth, that will be as a result of production of more assimilate and increased cell division and cells size (Sellosse *et al.*, 2004). This finding is similar to the results of Jayasri (2010), Harishkumar *et al*. (2019) and Ram *et al.* (2019). Due to use of organic fertilizer enhance the physical, chemical and biological properties of soil; that is seems to enhanced by rising soil organic matter, cation exchange capacity, water holding capacity and availability of mineral nutrients and, this in turn, enhance plant growth parameters (Ram *et al.*, 2019).

Yield parameters

The maximum dry herb yield (49.47 q ha^{-1}) and seed yield (10.75 q ha^{-1}) were found in T_8- FYM @ 20 ton ha^{-1} + bio-fertilizers @ 3 kg ha^{-1} and the minimum dry herb yield (35.76 q ha^{-1}) and seed yield (6.84 q ha^{-1}) in T_1 - control at harvest (Table 4). Organic manures and biofertilizers had articulated impact on yield and yield parameters of Indian basil. The evolution in vegetative growth parameters may be because of the generation of high chlorophyll content with inoculation of nitrogen fixers. The other logical clarification behind increased vegetative growths might be the formation of plant growth regulators by microorganism in rhizosphere, which are absorbed by the roots (Meena *et al.*, 2022). Similar result was seen in Darzi (2012), Arafa *et al.* (2017), Mansour *et al.* (2017) and Ram *et al.* (2019).

Quality parameters

The present investigation indicated that, the maximum essential oil content recorded in treatment T_8 - FYM @ 20 $tonha^{-1}$ + bio-fertilizers @ 3 kg ha^{-1} (0.77 and 0.86%) while, minimum under T_1 - control (0.29 and 0.42%) at vegetative and reproductive phases, respectively (Table 4). It is clear that using organic manures with biofertilizers, in most treatments produced higher oil percentage than using organic manures alone. This is due to not only the positive effect of organic manures, but also the beneficial effect of the used biofertilizer, which increasing the growth of plants, the production of dry matter and mineral content, and increasing volatile oil in herb tissues, or might be increasing the number of oil glands in leaves. These results reported that, FYM with biofertilizers enhanced volatile oil percentage of marjoram plants over the control (Al-Fraihat *et al.*, 2011). Similar results was seen by Arafa *et al.* (2017).

Economics of the treatments

The present research manifested that, the maximum cost of cultivation (95802.73 Rs. ha^{-1}) was observed in treatment T_5 - vermicompost @ 10 $tonha^{-1}$ + bio-

Table 3 : Response of Organic manures and bio-fertilizers on growth and oil yield of Basil (*Ocimum basilicum* L.).

	Treatments	Fresh weight(g plant^{-1})					Dry weight (g plant^{-1})				
		30 DAT	60 DAT	90 DAT	120 DAT	At harvest	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
T_1	Control	56.17	155.17	250.32	250.32	147.10	14.03	48.32	54.60	54.60	60.52
T_2	VC@4ton/ha+BF@5 kg each/ha	84.63	184.10	278.87	278.87	175.15	17.37	57.20	65.27	65.27	75.43
T_3	VC@6ton/ha+BF@4 kg each/ha	77.60	170.54	261.68	261.68	164.60	15.40	54.60	61.87	61.87	69.23
T_4	VC@8ton/ha+BF@3 kg each/ha	97.57	184.37	291.05	291.05	195.32	17.37	62.07	71.33	71.33	82.58
T_5	VC@10ton/ha+BF@2 kg each/ha	106.17	202.02	299.67	299.67	212.70	19.40	68.22	78.86	78.86	92.59
T_6	FYM@10ton/ha+BF@5 kg each/ha	104.83	189.55	293.15	293.15	195.55	17.53	65.10	75.57	75.57	88.10
T_7	FYM@15ton/ha+BF@4 kg each/ha	107.83	210.72	337.33	337.33	223.23	20.53	70.02	81.29	81.29	98.83
T_8	FYM@20ton/ha+BF@3 kg each/ha	108.33	243.02	368.00	368.00	236.10	24.55	74.15	85.55	85.55	104.68
SE m (±)		**5.55**	**13.77**	**15.95**	**5.84**	**4.53**	**2.00**	**2.50**	**2.66**	**2.39**	**2.38**
CD @ 5 %		**16.83**	**41.78**	**48.39**	**17.71**	**13.73**	**6.05**	**7.60**	**8.07**	**7.24**	**7.23**

Table 4 : Response of Organic manures and bio-fertilizers on growth and oil yield of Basil (*Ocimum basilicum* L.).

	Treatments	Dry herb yield (q ha^{-1})	Seed yield (q ha^{-1})	Essential oil (%)		Economics			
				70 DAT	110 DAT	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C Ratio
T_1	Control	35.76	6.84	0.29	0.42	53904.72	178320.00	124415.28	2.31
T_2	VC@4ton/ha+BF@5 kg each/ha	39.77	7.60	0.33	0.54	72702.73	198100.00	125397.27	1.72
T_3	VC@6ton/ha+BF@4 kg each/ha	37.92	7.48	0.35	0.51	80402.73	192115.00	111712.27	1.39
T_4	VC@8ton/ha+BF@3 kg each/ha	42.91	7.68	0.49	0.62	88102.73	207315.00	119212.27	1.35
T_5	VC@10ton/ha+BF@2 kg each/ha	44.24	9.27	0.55	0.71	95802.73	231110.00	135307.27	1.41
T_6	FYM@10ton/ha+BF@5 kg each/ha	43.74	8.35	0.49	0.64	66702.73	217900.00	151197.27	2.27
T_7	FYM@15ton/ha+BF@4 kg each/ha	47.10	9.89	0.71	0.81	71402.73	246320.00	174917.27	2.45
T_8	FYM@20ton/ha+BF@3 kg each/ha	49.47	10.75	0.77	0.86	76102.73	263425.00	187322.27	2.46
SE m (±)		**0.61**	**0.38**	**0.03**	**0.02**	—	—	—	—
CD @ 5 %		**1.86**	**1.16**	**0.10**	**0.07**	—	—	—	—

fertilizers@2 kg ha^{-1},while highest gross return (263425 Rs. ha^{-1}), net return (187322.27 Rs. ha^{-1}) and benefit: cost ratio (2.5) were noted in treatment T_8 - FYM @ 20 ton ha^{-1} + bio-fertilizers @ 3 kg ha^{-1}. Hence, FYM@20 ton ha^{-1} + bio-fertilizers @ 3 kg ha^{-1} is best for the cultivation of basil (Table 4). Use of organic manure with bio-fertilizer increased the production of oil yield along with soil fertility, which lead to enhanced net returns. Implementation of a balanced fertilization is the way of increasing productivity and economic profitability of basil according to Mansour *et al.*(2017). Similar results were observed by Sahu *et al.* (2020) in fenugreek and Meena *et al.* (2022) in Ocimum.

Conclusion

On the basis of present study, it could be concluded that, out of 8 treatment combinations, T_8 - FYM @ 20 ton ha^{-1} + bio-fertilizers @ 3 kg ha^{-1} is superior for obtaining the maximum growth, quality and higher oil and seed yield in basil.

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