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Effect of organic manures and bioformulations on growth, herb yield, quality and economics of Japanese mint (*Mentha arvensis* L.) VAR. Kosi

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Abstract
The present investigation "Effect of organic manures and bioformulations on growth, herb yield, quality and economics of Japanese mint (*Mentha arvensis* L.) var. Kosi". was conducted during two seasons *ie.,* during February-May of 2022 and August-November of 2022 at College of Horticulture, Rajendranagar, Sri Konda Laxman Telangana State Horticulture University. The experiment was devised in randomized block design with 10 treatments and 3 replications. Among the different treatments, the results reported that T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) recorded significantly maximum plant height (58.70 cm and 54.70 cm), plant spread N-S (45.77 cm and 44.10 cm), plant spread E-W (48.30 cm and 47.30 cm), number of primary branches (30.45 and 27.11), number of secondary branches (10.23 and 9.95), number of leaves (1012.37 and 977.37), leaf area (18.77 cm^2 and 17.77 cm^2), at harvest compared to other treatments which was statistically on par with T_9 (50% FYM (16 t/ha) + 25% VC (1.3 t/ha) + 25% NC (0.8 t/ha) + jeevamruth spray (10%)) during Feb-May and Aug-Nov respectively. Significantly maximum fresh herb yield per ha (237.04 q and 235.63 q), dry herb yield per ha (64.25 kg and 62.71 kg), oil yield per ha (232.45 kg and 208.30 kg) and essential oil content (0.98% and 0.88%) were recorded in T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) compared to the other treatments which was statistically on par with T_9 (50% FYM (16 t/ha) + 25% VC (1.3 t/ha) + 25% NC (0.8 t/ha) + jeevamruth spray (10%)) but a non-significant difference was observed in menthol content (77.30% and 75.97%) during Feb-May and Aug-Nov respectively. The benefit cost ratio (1.48 and 1.27) was highest in the treatment T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) compared to the other treatments.

Keywords: Panchagavya, jeevamruth, Japanese mint, menthol mint, vermicompost, neem cake

1. Introduction
"Mint is the common name of *Mentha arvensis* L. having approximately 25 species of the genus *Mentha* belonging to family Lamiaceae. The mint species *Mentha arvensis*, termed as Japanese mint have 80-85% menthol contents". "Kosi is a new released, early variety of menthol mint (90-100 days) and produces higher oil content (0.3-1.2%) containing 81- 83% menthol". "The crop is commercially cultivated as spring season crop (January-February to April-May) in Tarai and the central part of Uttar Pradesh and Uttarakhand, Punjab, Bihar and Haryana". Mint, either as herb or its essential oil form is used for flavoring, perfume production and medicinal purposes. "Mint is valued for its multipurpose uses in the field of pharmaceuticals, cosmetics as well as for flavoring foods, beverages and tobacco" (Ohloff, 1994). "Essential oil and their valuable chemical constituents obtained from menthol mint have great export potential. The area under menthol mint cultivation in India is estimated to be 0.15 million hectares with annual production of 20,000 metric tons of essential oil.
Now a days, chemical fertilizers are indiscriminately used to boost up the agricultural production. This has drained the soil and a gradual loss of soil productivity while organic manures paved the way to replenish the essential nutrients for improving soil health and crop productivity. Nutrient management through organic manures make a hygienic and beneficial way of disposal and utilization of waste and residues. Use of farmyard manure (FYM), poultry

manure, vermicompost, biofertilizers, neem cake, etc., has become imperative in medicinal and aromatic plants to meet the nutritional and health demand of the crop. Mint oil is used as an environment friendly insecticide. Such essential oil has a variety of industrial applications such as therapeutic and cosmetic industries. To retain this environment friendly property of Japanese mint oil, organic production must be encouraged. Organic fertilizers are low cost and eco-friendly inputs which have tremendous potential for supplying nutrients and which can reduce the over dependence on chemical fertilizers. Therefore, a trend of cultivation of medicinal and aromatic plants with the use of organic manures is increasing at a rapid pace, as they maintain the health of soil and form essential part of the sustainable farming.

2. Materials and Methods

Experimental site

The present investigation was conducted at College of Horticulture, Rajendranagar during Feb-May 2022 (season 1) and Aug-Nov 2022 (season 2). The experimental site is situated at a latitude of 17º.32' North, longitude of 78º.40' East and altitude of 542.3 m above mean sea level.

The experiment treatments consisted of ten different combination of organic manures and bioformulations *viz*., T_1: 100% FYM (32 t/ha); T_2: 100% FYM (32 t/ha) + panchagavya spray (3%); T_3: 100% FYM (32 t/ha) + jeevamruth spray (10%); T_4: 75% FYM (24 t/ha) + 25% VC (1.3 t/ha) + panchagavya spray (3%); T_5: 75% FYM (24 t/ha) + 25% VC (1.3 t/ha) + jeevamruth spray (10%); T_6: 75% FYM (24 t/ha) + 25% NC (0.8 t/ha) + panchagavya spray (3%); T_7: 75% FYM (24 t/ha) + 25% NC (0.8 t/ha) + jeevamruth spray (10%); T_8: 50% FYM (16 t/ha) + 25% VC (1.3 t/ha) + 25% NC (0.8 t/ha + panchagavya spray (3%); T_9: 50% FYM (16 t/ha) + 25% VC (1.3 t/ha) + 25% NC (0.8 t/ha) + jeevamruth spray (10%); T_{10}: control. The experiment was laid down on the Randomized Block Design (RDB) with commercially cultivated cultivar Kosi, with three replications.

Raising of the crop

Organic fertilizer was applied by broadcasting uniformly in rows to individual plots as per the treatment before 15 days of planting and spraying of panchagavya (3%) and jeevamruth (10%) as recommended to their treatment plots was done at 15 days interval. Each experimental plot size was 3 m long and 2 m wide with a spacing of 30 cm between the plants and 45 cm between the rows. There was a space of 30 cm between the plots and 60 cm between replications. Suckers of 7-10 cm length with 3-5 nodes were taken from two-year-old mint plants (kosi variety) which were procured from experimental farm of CSIR-CIMAP, Lucknow and are planted at a depth of 5 cm placing horizontally end to end and covered with the soil. Weeding was done manually at 20 days interval and subsequently drip irrigation was given depending on the soil moisture condition. Fresh herbage weight from each plot was converted to per hectare and it was expressed in quintals (q). Fresh shoots and leaves of Japanese mint are cut into pieces within half day after collection. The oil is distilled using Clevenger apparatus. The mint oil was subjected to Gas chromatography using Flame Ionization detector fitted with electronic integrator using a 25 mm BP-20 fused silica column. The Gas chromatography capillary column (30 m × 0.25 mm, 0.25 µm) programmed with temperature from 60 to 230oC at 3ºC/min and then at 70 to 230ºC at 4ºC/min. Hydrogen gas was the carrier gas with injection volume 0.02 µl. Identification was based on retention time of standard compounds. The relative number of individual components were calculated based on percent pack area relative to total peak area from the GC/FID analyses without using correction factor. Menthol content was expressed in percentage (%).

3. Results and Discussion

3.1 Growth Parameters

3.1.1 Plant height

The data revealed that during season 1 and season 2 among the treatments, highest plant height at harvest (58.70 cm and 54.70 respectively) was observed with T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) which was statistically at par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (57.77 cm and 53.77 respectively). The lowest plant height (33.90 cm and 29.90 cm respectively) was recorded in T_{10} control. Increase in plant height might be attributed to the effect of organic fertilizer that improves physical, chemical, and biological properties of soil that is, increasing soil organic matter, cation exchange capacity, and water holding capacity and availability of mineral nutrients which in turn, increase plant height. Panchagavya contains macro nutrients, essential micro nutrients, many vitamins, essential amino acids, growth promoting factors like IAA, GA and beneficial microorganisms (Natarajan, 2007; Sreenivasa *et al*., 2010) [6, 13].

3.1.2 Plant spread

During season 1 and season 2, among the treatments T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) recorded maximum plant spread (E - W) (48.30 cm and 47.30 cm respectively at harvest), (N - S) (45.77 cm and 44.10 respectively) and was found to be on par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%) plant spread (E-W) (46.30 cm and 45.30 respectively at harvest), plant spread (N-S) (45.77 and 43.83 cm). While the minimum plant spread (E - W) (20.90 cm and 19.90 respectively at harvest) and (N-S) (19.57 and 18.57) was recorded in T_{10} control. The combined application of organic manures and bioformulations favored the growth parameter by making available more nutrients during crop growth period and the available soil organic matter might have created environment which is congenial for better plant growth and development. Similar findings on increase in the plant spread due to application of panchagavya has been reported by, Sridhar (2003) [14] in black nightshade, Selvaraj *et al*. (2003) [12] in thyme and rosemary.

Table 1: Effect of organic manures and bioformulations on plant height (cm), plant spread (cm), number of primary branches, number of secondary branches of Japanese mint (*Mentha arvensis* L.) var. Kosi during Feb-May and Aug-Nov 2022

Treatments	Plant height		Plant spread (E-W)		Plant spread (N-S)	
	Feb-May	Aug-Nov	Feb-May	Aug-Nov	Feb-May	Aug-Nov
T_1: 100% FYM	50.47	49.80	35.67	34.67	34.00	32.33
T_2: 100% FYM + panchagavya spray (3%)	53.83	49.83	38.67	37.67	36.94	35.27
T_3: 100% FYM + jeevamruth spray (10%)	52.50	48.50	38.61	37.61	36.30	34.63
T_4: 75% FYM + 25% vermicompost + panchagavya spray (3%)	56.40	52.40	42.57	41.57	43.15	40.81
T_5: 75% FYM + 25% vermicompost + jeevamruth spray (10%)	55.67	51.87	41.73	40.73	40.40	38.73
T_6: 75% FYM + 25% neem cake + panchagavya spray (3%)	55.75	51.75	38.90	37.90	38.50	36.83
T_7: 75% FYM + 25% neem cake + jeevamruth spray (10%)	55.87	51.67	38.80	37.80	37.33	35.67
T_8: 50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)	58.70	54.70	48.30	47.30	45.77	44.10
T_9: 50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)	57.77	53.77	46.30	45.30	45.17	43.83
T_{10}: control	33.90	29.90	20.90	19.90	19.57	18.57
SEm±	0.73	0.74	0.88	0.85	0.69	0.30
CD @ 5%	2.14	2.17	2.56	2.47	2.01	0.89

Number of primary branches per plant

Number of primary branches per plant during season 1 and season 2 indicated that significantly maximum number of branches (30.45 and 27.11 at harvest respectively) was observed with the application of T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) and was at par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (29.10 and 26.43 at harvest respectively) followed by T_4 (75% FYM + 25% vermicompost + panchagavya spray(3%)) (28.57 and 25.12 at harvest respectively). The minimum number of branches per plant (10.90 and 10.23 at harvest respectively) was recorded with T_{10} (Control).The main reason is organic manure improves the soil physical conditions and promotes microbial and soil organic matter, which, in turn, produces organic acids, which inhibits particularly IAA oxidase enzyme, resulting in enhancing the promotive effect of auxin-IAA, which has direct effect on plant growth. Increase in number of primary branches per plant due to nutrient delivery via foliar application of panchagavya, which increased the plants growth rate because it contains beneficial macro and micronutrients, growth promoting hormones like IAA, GA_3 and cytokinin, and biofertilizers in liquid formulation. These results were in conformity with Aswani *et al.* (2020) [1] in Japanese mint, Pavithra *et al.* (2021) [8] in Japanese mint, and Sai rohit *et al.* in chilli.

3.1.3 Number of Secondary branches per plant

Number of secondary branches per plant during season 1 and season 2 indicated that significantly maximum number of secondary branches (10.23 and 9.95 at harvest respectively) was observed with the application of T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) and was at par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (8.27 and 9.45 at harvest respectively), followed by T_4 (75% FYM + 25% vermicompost + panchagavya spray(3%)) (9.37 and 9.21 at harvest respectively). The minimum number of secondary branches per plant (2.30 and 1.92 at harvest respectively) at was recorded with T_{10} (Control).

3.1.4 Number of leaves per plant

The data revealed that during season 1 and season 2 maximum number of leaves per plant (1012.37 and 977.37 at harvest respectively) were observed with T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)), and was at par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (1001.37 and 963.03 at harvest respectively), followed by T_4 (75% FYM + 25% vermicompost + panchagavya spray (3%)) (988.57 and 883.55 at harvest respectively). The minimum number of leaves per plant (289.57 and 271.57 at harvest respectively) was recorded with T_{10} (Control). These results may be attributed to the effect of organic manures in increasing levels of endogenous hormones in treated plants which could be interpreted by cell division and cell elongation which finally resulted in increase in number of branches, which ultimately increase the leaves. In addition to the basal application of nutrients, foliar spray of panchagavya at 3 per cent enhanced the growth rate of plant since it contains the favourable micro and macro nutrients, growth hormones and biofertilizers in the liquid formulation. These results were in conformity with the findings of Chitra *et al.* (2021) [5] in curry leaf.

3.1.5 Leaf Area (cm^2)

All treatments showed significant difference with respect to leaf area at all growth stages during season 1 and season 2. Significantly maximum leaf area (18.77 cm^2 and 17.77 cm^2 at harvest respectively) was recorded in T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) which were on par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (17.83 cm^2 and 16.83 cm^2 at harvest respectively) followed by T_4 (75% FYM + 25% vermicompost + panchagavya spray (3%)) (17.45 cm^2 and 16.45 cm^2 at harvest respectively) while it was minimum in T_{10} (Control) (11.23 cm^2 and 12.23 cm^2 at harvest respectively).This might be due to the physiological roles of vitamins and amino acids in the effect of organic treatments which increased role of the metabolic processes and levels of indigenous hormones, i.e., IAA and GA_3. Leaves are the main organs in plants which absorb the nutrients quickly when given in the form of foliar spray which results in the increase in the leaf area (Bishal Chakraborty and Indrajit Sarkar, 2019) [3]. These results were in conformity with the findings of Prabha *et al.* (2010) [9] in *Cassia angustifolia* and Prabhu and Armurgam (2013) [10] in *Mentha arvensis* L.

Table 2: Effect of organic manures and bioformulations on number of primary branches, number of secondary branches, number of leaves and leaf area of Japanese mint (*Mentha arvensis* L.) var. Kosi during Feb-May and Aug-Nov 2022.

Treatments	No. of primary branches		No. of secondary branches		Number of leaves		Leaf area (cm^2)	
	Feb-May	Aug-Nov	Feb-May	Aug-Nov	Feb-May	Aug-Nov	Feb-May	Aug-Nov
T_1: 100% FYM	25.20	20.53	5.60	5.35	822.55	717.56	14.73	13.73
T_2: 100% FYM + panchagavya spray (3%)	26.55	23.89	6.71	6.31	969.17	864.16	15.63	14.63
T_3: 100% FYM + jeevamruth spray (10%)	26.77	22.77	6.30	5.81	950.63	845.62	15.83	14.83
T_4: 75% FYM + 25% vermicompost + panchagavya spray(3%)	28.57	25.70	9.37	9.21	988.57	883.55	17.45	16.45
T_5: 75% FYM + 25% vermicompost + jeevamruth spray (10%)	28.33	25.12	9.07	8.67	983.07	878.01	17.07	16.07
T_6: 75% FYM + 25% neem cake + panchagavya spray (3%)	27.70	25.03	8.57	8.23	978.83	873.82	16.48	15.48
T_7: 75% FYM + 25% neem cake + jeevamruth spray (10%)	27.79	24.99	8.27	8.15	972.00	867.08	16.77	15.77
T_8: 50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)	30.45	27.11	10.23	9.95	1012.37	977.31	18.77	17.77
T_9: 50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)	29.10	26.43	9.70	9.45	1001.37	963.01	17.83	16.83
T_{10}: control	10.90	10.23	2.30	1.92	289.57	271.59	11.23	12.23
SEm±	0.60	0.36	0.25	0.19	5.92	6.13	0.43	0.36
CD @ 5%	1.74	1.06	0.73	0.56	17.29	17.89	1.25	1.06

3.2 Yield parameters

3.2.1 Fresh herb yield per hectare (q)

During season 1 and season 2 significantly maximum fresh herb yield per hectare (237.04 q and 235.63 q respectively) at harvest was recorded in T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) was statistically on par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (234.96 q and 232.96 q respectively) followed by T_4 (75% FYM + 25% vermicompost + panchagavya spray (3%)) (214.52 q and 210.74 q respectively) While it was minimum in T_{10} Control (86.07 q and 83.90 q respectively). The combined application of organic manures and panchagavya as foliar spray impoved the plant height, plant spread, number of branches, number of leaves, leaf area which in turn are corelated with the fresh herb yield of plant which resulted in higher whole biomass of the plant. These results are in accordance with that of Prabhu *et al.* (2013) [10] in *Mentha arvensis* L., Sai rohit *et al.* (2021) in chilli, Chitra *et al.* (2021) [5] in curry leaf.

3.2.2 Dry herb yield per hectare (q)

From the data it is clear that there was significant difference observed among the treatments during season 1 and season 2. Among all the treatments, the maximum dry herb yield (64.25 q and 62.71q) was observed in T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) which was statistically on par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (63.52 q and 61.32 q) while, the minimum dry yield per hectare (25.10 q and 22.45 q) was recorded in T_{10} control. Maximum dry herb yield per hectare was recorded in T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)), which might be due to the same treatment registered higher fresh herb yield per hectare over the other treatments due to better vegetative growth.

3.2.3 Essential oil yield (kg/ha)

The results indicated that in season 1 and season 2, application of organic manures and bioformulations had significant influence on essential oil yield. Among the treatments, T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) recorded significantly maximum essential oil yield (232.45 kg/ha and 208.30 kg/ha respectively), which was statistically on par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%) (225.56 kg/ha and 204.77 kg/ha respectively) while minimum value (56.69 kg/ha and 51.68 kg/ha) was recorded in T_{10} (Control).

Essential oil content (%)

The results indicated that in season 1 and season 2, application of organic manures and bioformulations had significant influence on essential oil content. Among the treatments, T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) recorded significantly maximum essential oil content (0.98% and 0.88%), which was statistically on par with T_9 (50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)) (0.96% and 0.88%) while minimum value (0.66% and 0.62%)) was recorded in T_{10} (Control). Higher oil recovery had resulted in the increase in number of leaves as well as number of inflorescences. A positive correlation between increased leaf yield and oil content was reported by Arularasu and Sambandamurthi (1999) in tulsi. The soil with its content in macro and micro elements, enhanced by the use of organic fertilizers, plays an essential role in the plant growth and development and also it can be noted that the vegetative mass is rich and the amount of essential oil is high when using organic manures as in support of studies by Aswani *et al.* (2020) [1] in Japanese mint, Pavithra *et al.* (2021) [8] in Japanese mint.

Table 3: Effect of organic manures and bioformulations on fresh herb yield (q/ha) and dry herb yield (kg/ha) and oil yield (kg/ha) of Japanese mint (*Mentha arvensis* L.) var. Kosi during Feb-May and Aug-Nov 2022.

Treatments	Fresh herb yield per hectare (q)		Dry herb yield per hectare (kg)		Oil yield per hectare (kg)	
	Feb-May	Aug-Nov	Feb-May	Aug-Nov	Feb-May	Aug-Nov
	200.72	**193.97**	**53.99**	**51.39**	**163.92**	**140.82**
T_2: 100% FYM + panchagavya spray (3%)	207.70	203.93	56.69	55.28	180.01	159.06
T_3: 100% FYM + jeevamruth spray (10%)	207.78	203.56	57.86	56.00	179.80	157.35
T_4: 75% FYM + 25% vermicompost + panchagavya spray(3%)	214.52	210.74	60.17	58.57	197.93	172.60
T_5: 75% FYM + 25% vermicompost + jeevamruth spray (10%)	213.46	209.18	59.53	57.86	194.96	169.86
T_6: 75% FYM + 25% neem cake + panchagavya spray (3%)	212.15	210.37	59.19	57.87	191.64	167.03
T_7: 75% FYM + 25% neem cake + jeevamruth spray (10%)	210.67	208.93	58.47	56.87	188.20	164.22
T_8: 50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)	237.04	235.63	64.25	62.71	232.45	208.30
T_9: 50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)	234.96	232.96	63.52	61.32	225.56	204.77
T_{10}: control	86.07	83.90	25.10	22.45	56.69	51.68
SEm±	2.60	2.58	0.87	0.66	2.79	2.56
CD (P=0.05)	7.59	7.54	2.55	1.92	8.14	7.47

3.2.4 Menthol content (%)

Non-significant differences were observed among the treatments in menthol content. How ever significant difference was observed over the control. Maximum menthol content was observed in T_8 and minimum was noticed in T_{10} Control.

3.2.5 Benefit cost ratio of oil yield

Table 4: Effect of organic manures and bioformulations on oil yield (kg/ha) and essential oil content (%) of Japanese mint (*Mentha arvensis* L.) var. Kosi during Feb-May and Aug-Nov 2022

Treatments	Essential oil content (%)		Menthol content (%)		B:C ratio	
	Feb-May	Aug-Nov	Feb-May	Aug-Nov	Feb-May	Aug-Nov
T_1: 100% FYM	0.82	0.73	76.20	74.87	1.41	1.33
T_2: 100% FYM + panchagavya spray (3%)	0.87	0.78	75.83	75.17	1.41	1.37
T_3: 100% FYM + jeevamruth spray (10%)	0.87	0.77	75.97	74.97	1.25	1.21
T_4: 75% FYM + 25% vermicompost + panchagavya spray(3%)	0.92	0.82	76.17	74.83	1.47	1.43
T_5: 75% FYM + 25% vermicompost + jeevamruth spray (10%)	0.91	0.81	76.00	75.00	1.30	1.25
T_6: 75% FYM + 25% neem cake + panchagavya spray (3%)	0.90	0.79	76.90	75.90	1.28	1.26
T_7: 75% FYM + 25% neem cake + jeevamruth spray (10%	0.89	0.79	76.00	75.33	1.12	1.10
T_8: 50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)	0.98	0.88	77.30	75.97	1.53	1.51
T_9: 50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)	0.96	0.88	76.37	75.70	1.35	1.33
T_{10}: control	0.66	0.62	73.03	73.37	0.99	0.94
SEm±	0.02	0.02	0.51	0.58	_	_
CD (P=0.05)	0.07	0.07	1.50	1.69	_	_

The economics on oil yield as influenced by the effect of organic manures and bioformulations has been calculated and presented in Table 4.36. Among the treatments during season 1 the highest gross returns (₹ 2,90,563), net returns (₹ 1,73,615) and benefit-cost ratio (1.48) was recorded with T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)), whereas T_{10} control recorded lowest gross returns (₹ 70,858), net returns (₹ 25,875) and benefit cost ratio (0.58). Among the treatments during season 2 the highest gross returns (₹ 2,60,375), net returns (₹ 1,45,842), benefit-cost ratio (1.27) was recorded with T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)), whereas T_{10} control recorded lowest gross returns (₹ 64,600), net returns (₹ 20,117) and benefit cost ratio (0.45).

Treatments	Essential oil content (%)		Menthol content (%)		B:C ratio	
	Feb-May	Aug-Nov	Feb-May	Aug-Nov	Feb-May	Aug-Nov
T_1: 100% FYM	0.82	0.73	76.20	74.87	1.41	1.33
T_2: 100% FYM + panchagavya spray (3%)	0.87	0.78	75.83	75.17	1.41	1.37
T_3: 100% FYM + jeevamruth spray (10%)	0.87	0.77	75.97	74.97	1.25	1.21
T_4: 75% FYM + 25% vermicompost + panchagavya spray(3%)	0.92	0.82	76.17	74.83	1.47	1.43
T_5: 75% FYM + 25% vermicompost + jeevamruth spray (10%)	0.91	0.81	76.00	75.00	1.30	1.25
T_6: 75% FYM + 25% neem cake + panchagavya spray (3%)	0.90	0.79	76.90	75.90	1.28	1.26
T_7: 75% FYM + 25% neem cake + jeevamruth spray (10%	0.89	0.79	76.00	75.33	1.12	1.10
T_8: 50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)	0.98	0.88	77.30	75.97	1.53	1.51
T_9: 50% FYM + 25% vermicompost + 25% neem cake + jeevamruth spray (10%)	0.96	0.88	76.37	75.70	1.35	1.33
T_{10}: control	0.66	0.62	73.03	73.37	0.99	0.94
SEm±	0.02	0.02	0.51	0.58	_	_
CD (P=0.05)	0.07	0.07	1.50	1.69	_	_

4. Conclusion

From the study it is concluded that different treatments have positive effect on growth and yield of Japanese mint. Treatment T_8 (50% FYM + 25% vermicompost + 25% neem cake + panchagavya spray (3%)) has shown best results compared to other treatments and proved to be the best treatment in Japanese mint and T_8 was statistically on par with treatment T_9. Different combination of organic manures not only supply major nutrients but also sufficient quantity of required micronutrients such as Zn, B, Fe, Cu, Mn *etc.* Panchagavya contains macronutrients, micronutrients and phytoharmones. Panchagavya in the form of foliar spray increased the absorption of the nutrients quickly through leaves and thereby increase in the herb yield and oil yield.

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