Journal of Advances in Biology & Biotechnology

Volume 27, Issue 11, Page 1-9, 2024; Article no.JABB.124957
ISSN: 2394-1081

Synergistic Effect of Organic Inputs on the Morphophysiological Traits of Sweet Basil (*Ocimum basilicum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/jabb/2024/v27i111578

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/124957

Original Research Article

Received: 20/08/2024
Accepted: 22/10/2024
Published: 26/10/2024

ABSTRACT

The present investigation was conducted from 2023 in Chengam, Tiruvannamalai district. The objective was to evaluate the impact of various organic treatments on the growth and yield characteristics of sweet basil (*Ocimum basilicum* L.). The experiment was carried out is Randomized Block Design with ten treatments and replication thrice. Among the ten different treatments applied, the combination of FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Seaweed extract @ 2% (T_9) consistently outperformed other treatments. This treatment significantly enhanced growth characteristics *viz*., plant height (35.01, 60.33, 86.71 and 110.34 cm), number of leaves $plant^{-1}$(291.34, 540.56, 850.41 and 1010.66), leaf area (482.33, 1673.20, 3581.23 and 4468.67 cm^2) and leaf area index (0.65, 1.33, 2.32 and 3.23), number of primary branches $plant^{-1}$ (21.45, 25.37, 32.17 and 39.46) and secondary branches $plant^{-1}$ (64.72, 76.45, 96.56 and 109.34), plant spread (north - south) (25.32, 33.39, 40.26 and 50.38 cm), plant spread (East- west) (40.56, 55.89, 65.47 and

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***Cite as:** Muruganandam, C., and Dharanidharan S. 2024. "Synergistic Effect of Organic Inputs on the Morphophysiological Traits of Sweet Basil (Ocimum Basilicum L.)". Journal of Advances in Biology & Biotechnology 27 (11):1-9. https://doi.org/10.9734/jabb/2024/v27i111578.*

71.45 cm), at 30, 60, 90 and 120 DAT. The findings indicate that the integration of organic inputs of treatment, T_9 (FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Seaweed extract @ 2%) is highly effective in optimizing the growth of sweet basil.

Keywords: Sweet basil; organic farming; FYM; Vermicompost; seaweed extract.

1. INTRODUCTION

Sweet Basil (*Ocimum basilicum L.*), a widely cultivated aromatic herb, is known for its flavorful foliage (Davis, 1995). it belongs to the Lamiaceae family, comprising 50-150 species of herbs and shrubs native to tropical regions of Asia, Africa and the Americas (Malav *et al*., 2015). Sweet basil is tetraploid, with a chromosome number of 2n=48 (Farooqi & Sreeramu, 2005). Known as the "King of herbs," basil holds commercial, culinary, cosmetic and medicinal value (Meena *et al*., 2013). Overuse of chemical fertilizers depletes soil, while organic fertilizers restore nutrients and enhance soil health. Organic farming of sweet basil boosts pharmaceutical demand for its chemical-free properties, improving oil quality and medicinal value. Organic systems enhance morpho-physiological traits, yield and soil health by increasing organic carbon, phosphorus and microbial activity, ensuring long-term productivity. The overuse of chemical fertilizers has degraded soil health and reduced the quality of medicinal and aromatic plants (MAPs), which are increasingly needed for chemical-free products in the pharmaceutical industry. Organic farming offers a solution by restoring soil fertility, improving crop growth and enhancing essential oil quality. This sustainable approach boosts yields, enhances soil health and meets the demand for high-quality, organically grown MAPs like sweet basil.

2. MATERIALS AND METHODS

The present investigation was conducted from February to May 2023 in Chengam, Tiruvannamalai district. The experiment focused on Sweet Basil (*Ocimum basilicum* L.), utilizing a local cultivar. It was conducted using a Randomized Block Design (RBD) with a total of 10 treatments and 3 replications. The plants were spaced 60 cm apart in rows and 40 cm between plants, resulting in a plot size of 2.40 m², accommodating 30 plants per plot. The duration of the study was set at 120 days. Source of seedling .The seeds of sweet basil (*Ocimum basilicum* L.) were sown in lines on a nursery bed of well pulverized soil. After sowing of seeds, the light irrigation was applied and covered the nursery with paddy straw. After 10-15 days of sowing, covered material was removed out from the nursery carefully. One month old healthy seedlings (10-15 cm tall, 4-5 leaf stage) were used for transplanting purpose. The seedlings were uprooted, washed and were transplanted in to main experimental plot with 50 cm row to row and 30 cm plant to plant distance.Five randomly selected plants in each replication were tagged, labelled and used for observation of different growth parameters. The mean of five plants was taken for analysis. The data recorded were subjected to statistical analysis by adopting the standard procedure of Panse and Sukhatme (1985). The critical differences were arrived at 5 per cent probability significance. Analysis of variance (one-way classified data) for each characteristic was performed using 'WASP 1.0' software.

3. RESULTS AND DISCUSSION

The data in Table 1 showed significant differences among treatments, with T_9 (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Seaweed extract @ 2%) recording the highest plant height (35.01, 60.33, 86.71, 110.34 cm) and number of leaves $plant^{-1}$ (291.34, 540.56, 850.41, 1010.66) followed by T_{10} (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Jeevamrutham @ 3%) with plant height of 33.74, 58.05, 83.77, 106.22 cm and number of leaves $plant^{-1}$ of 269.69, 510.22, 821.64, 969.12 while the lowest values were observed in the control (T_1) with plant heights of 23.62, 39.81, 60.34 and 73.62 cm and number of leaves $plant^{-1}$ of 96.49, 267.50, 591.48 and 636.80 at 30, 60, 90 and 120 DAT.

Farmyard manure (FYM) promotes microbial growth, accumulates humus and provides phytohormones that aid plant growth, even with reduced chemical fertilizers (Gupta *et al*., 1983). The basal application of vermicompost (VC) enhances plant height by promoting cell division and enlargement. The combination of organic manures like FYM and VC ensures balanced nutrient supply, increasing the number of nodes and internodal length, thus boosting plant height. Similar results were observed by Malav *et al*. (2015), Baraa *et al*. (2017), Jalil Dehghan Saman *et al*. (2017) and Rajit Ram et al. (2019) in Ocimum Spp.

Table 1. Effect of organic inputs on plant height (cm) and Number of leaves plant^{-1} in sweet basil (*Ocimum basilicum* L.)

Treatments	Plant height (cm)				Number of leaves plant^{-1}			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_1 – Control	23.62	39.81	60.34	73.62	96.49	267.50	591.48	636.80
T_2 - FYM @ 25t ha^{-1}	24.88	42.09	63.26	77.38	118.14	297.83	620.25	678.34
T_3 - VC @ 5 t ha^{-1}	26.15	44.37	66.20	81.50	139.09	328.18	649.02	719.88
T_4 - FYM @ 25t ha^{-1} + VC @ 2.5 t ha^{-1}	29.59	51.21	74.99	93.86	204.74	419.20	735.32	844.50
T_5 - FYM @ 25 t ha^{-1} + Seaweed extract @ 2%	28.68	48.93	72.06	89.74	183.09	388.86	706.56	802.96
T_6 - FYM @ 25 t ha^{-1} + Jeevamrutham @ 3%	27.42	46.65	69.13	85.62	161.44	358.51	677.79	761.42
T_7 - VC @ 5 t ha^{-1} + Seaweed extract @ 2%	32.48	55.77	80.85	102.10	248.04	479.88	792.87	927.58
T_8 - VC @ 5 t ha^{-1} + Jeevamrutham @ 3%	31.21	53.49	77.92	97.98	226.39	449.54	764.10	886.04
T_9 - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Seaweed extract @ 2%	35.01	60.33	86.71	110.34	291.34	540.56	850.41	1010.66
T_{10} - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutham @ 3%	33.74	58.05	83.77	106.22	269.69	510.22	821.64	969.12
S.ED	**0.57**	**0.98**	**1.43**	**1.80**	**4.13**	**8.19**	**14.1**	**16.2**
CD (P = 0.05)	**1.15**	**1.97**	**2.89**	**3.62**	**8.38**	**16.47**	**28.36**	**32.67**

Table 2. Effect of organic inputs on leaf area (cm^2) and leaf area index in sweet basil (*Ocimum basilicum* L.)

Treatments	Leaf area (cm^2)				Leaf area index			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_1 – Control	331.85	967.69	2026.57	2447.81	0.38	0.79	1.33	2.15
T_2 - FYM @ 25t ha^{-1}	348.57	1046.08	2199.31	2672.35	0.41	0.84	1.44	2.26
T_3 - VC @ 5 t ha^{-1}	365.29	1124.46	2372.05	2896.89	0.43	0.91	1.55	2.38
T_4 - FYM @ 25t ha^{-1} + VC @ 2.5 t ha^{-1}	415.44	1359.64	2890.26	3570.51	0.53	1.09	1.88	2.75
T_5 - FYM @ 25 t ha^{-1} + Seaweed extract @ 2%	398.73	1281.25	2717.53	3345.97	0.50	1.03	1.77	2.63
T_6 - FYM @ 25 t ha^{-1} + Jeevamrutham @ 3%	382.01	1202.86	2544.79	3121.43	0.47	0.97	1.66	2.50
T_7 - VC @ 5 t ha^{-1} + Seaweed extract @ 2%	448.89	1516.42	3235.75	4019.59	0.59	1.21	2.10	2.99
T_8 - VC @ 5 t ha^{-1} + Jeevamrutham @ 3%	432.17	1438.03	3063.01	3795.05	0.56	1.15	1.99	2.87
T_9 - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Seaweed extract @ 2%	482.33	1673.20	3581.23	4468.67	0.65	1.33	2.32	3.23
T_{10} - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutham @ 3%	465.61	1597.80	3408.49	4244.13	0.62	1.27	2.21	3.11
S.ED	**7.97**	**26.2**	**55.9**	**69.2**	**0.01**	**0.20**	**0.36**	**0.52**
CD (P = 0.05)	**16.02**	**502.82**	**112.44**	**139.20**	**0.021**	**0.042**	**0.074**	**0.106**

Note: FYM – farm yard manure, VC- vermicompost

Table 3. Effect of organic inputs on plant spread North – South (cm) and Plant spread East - West (cm) in sweet basil (*Ocimum basilicum* L.)

Treatments	plant spread North – South (cm)				Plant spread East - West(cm)			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_1 – Control	16.68	23.13	24.33	35.16	26.79	32.49	39.37	46.07
T_2 - FYM @ 25t ha^{-1}	17.64	24.26	26.10	36.85	28.32	35.09	42.26	48.88
T_3 - VC @ 5 t ha^{-1}	18.60	25.40	27.87	38.55	29.85	37.69	45.17	51.71
T_4 - FYM @ 25t ha^{-1} + VC @ 2.5 t ha^{-1}	21.47	28.83	33.18	43.62	34.43	45.48	53.87	60.17
T_5 - FYM @ 25 t ha^{-1} + Seaweed extract @ 2%	20.50	27.69	31.41	41.93	32.91	42.89	50.97	57.35
T_6 - FYM @ 25 t ha^{-1} + Jeevamrutham @ 3%	19.55	26.54	29.64	40.24	31.38	40.29	48.07	54.52
T_7 - VC @ 5 t ha^{-1} + Seaweed extract @ 2%	23.40	31.11	36.72	47.00	37.50	50.68	59.66	65.81
T_8 - VC @ 5 t ha^{-1} + Jeevamrutham @ 3%	22.44	29.97	34.95	45.30	35.97	48.09	56.77	62.99
T_9 - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Seaweed extract @ 2%	25.32	33.39	40.26	50.38	40.56	55.89	65.47	71.45
T_{10} - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutham @ 3%	24.36	32.25	38.49	48.69	39.03	53.29	62.57	68.63
S.ED	**0.40**	**0.55**	**0.63**	**0.83**	**0.66**	**0.87**	**1.03**	**1.15**
CD (P = 0.05)	**0.82**	**1.11**	**1.28**	**1.68**	**1.33**	**1.76**	**2.08**	**2.32**

Table 4. Effect of organic inputs on number of primary and secondary branches plant $^{-1}$ in sweet basil (*Ocimum basilicum* L.)

Treatments	Number of primary branches plant $^{-1}$				Number of secondary branches plant $^{-1}$			
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**
T_1 – Control	12.27	14.48	18.76	23.89	27.46	40.27	45.89	58.58
T_2 - FYM @ 25t ha^{-1}	13.28	15.69	20.25	25.62	31.60	44.28	51.52	64.22
T_3 - VC @ 5 t ha^{-1}	14.31	16.90	21.74	27.35	35.74	48.31	57.14	69.86
T_4 - FYM @ 25t ha^{-1} + VC @ 2.5 t ha^{-1}	17.36	20.53	26.21	32.54	48.16	60.36	74.04	86.78
T_5 - FYM @ 25 t ha^{-1} + Seaweed extract @ 2%	16.35	19.32	24.72	30.81	44.02	56.35	68.41	81.14
T_6 - FYM @ 25 t ha^{-1} + Jeevamrutham @ 3%	15.33	18.11	23.23	29.08	39.88	52.33	62.78	75.50
T_7 - VC @ 5 t ha^{-1} + Seaweed extract @ 2%	19.41	22.95	29.19	36.00	56.44	68.41	85.30	98.06
T_8 - VC @ 5 t ha^{-1} + Jeevamrutham @ 3%	18.39	21.74	27.70	34.27	52.30	64.39	79.67	92.42
T_9 - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Seaweed extract @ 2%	21.45	25.37	32.17	39.46	64.72	76.45	96.56	109.34
T_{10} - FYM @ 25 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutham @ 3%	20.43	24.16	30.68	37.73	60.58	72.43	90.93	103.70
S.ED	**0.33**	**0.39**	**0.50**	**0.62**	**0.95**	**1.17**	**1.42**	**1.68**
CD (P = 0.05)	**0.67**	**0.80**	**1.01**	**1.26**	**1.92**	**2.36**	**2.92**	**3.38**

Note: FYM – farm yard manure, VC- vermicompost

Seaweed extracts improve plant growth due to growth-promoting hormones (IAA, IBA, cytokinins), trace elements (Fe, Cu, Zn, Co, Mo, Mn, Ni), vitamins and amino acids, as noted by Katarzyna Chojnacka *et al*. (2012), Wajahatullah Khan *et al*. (2009) and Craige (2011). Organic manures enhance leaf production due to the optimal C:N ratio in FYM, which releases nitrogen (ammonium and nitrate) during decomposition. Increased nitrogen levels stimulate leaf production, larger leaf areas and greater plant spread, as nitrogen is vital for amino acids and co-enzymes Umesha *et al*. (2011). Similar findings were reported by Ashashri Shinde *et al*. (2013) in ashwagandha, Mansour *et al*. (2017) in sweet basil, Patke *et al*. (2018), Ram *et al*. (2019b) in Indian basil (*Ocimum sanctum* L. cvs. Cim-Ayu and Cim-Angana), Aloe vera and Gunda *et al*. (2022) in sweet basil. Nitrogen in vermicompost also boosts leaf production, supported by findings from Suresh and Senthilnathan (2018). This is consistent with studies by Padmapriya *et al*. (2010) in gymnema, Tiwari and Roy (2014) in gloriosa, Khanzadeh and Naderi (2015) in periwinkle, Hidangmayum and Sharma *et al*. (2017) and Suresh *et al*. (2018) in Japanese mint. Seaweed extracts, containing growth substances, further enhance vegetative growth and yield by influencing cellular metabolism (El-Miniawy *et al*., 2014).

The data in Table 2 revealed significant differences among treatments in leaf area (cm^2) and leaf area index. T_9 (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Seaweed extract @ 2%) recorded the highest leaf area (482.33, 1673.20, 3581.23 and 4468.67 cm^2) and leaf area index (0.65, 1.33, 2.32 and 3.23). This was followed by T_{10} (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Jeevamrutham @ 3%) with leaf area of 456.61, 1597.80, 3408.49 and 4244.13 cm^2 and leaf area index of 0.62, 1.27, 2.21 and 3.11. The lowest values were recorded in T_1 (Control), with leaf area of 331.85, 967.69, 2026.57 and 2447.81 cm^2 and leaf area index of 0.38, 0.79, 1.33 and 2.15 at 30, 60, 90 and 120 DAT.

The increase in leaf area and leaf area index with the application of organic manure could be related to better nutrition allocated to leaf development, due to nutrient release by microorganisms in the soil, which in turn increased plant growth as a result of the production of more assimilates and increased cell division and cell size (Selosse *et al*., 2004). This finding is similar to the results of Jayasri (2010), Harishkumar *et al*. (2019) and Ram *et al*. (2019a). Meanwhile, the foliar spraying of seaweed extract (*Ascophyllum nodosum*) influenced the vegetative growth of the plant (Gheorghe Cristian Popescu and Monica Popescu, 2014). Increased vegetative growth might have been due to the presence of nutrients and hormonal levels in brown seaweed. These results are in close agreement with Salama and Raina (2015) and Veeranan Uthirapandi *et al*. (2018) in sacred basil.

The data in Table 3 showed significant differences among treatments, with T_9 (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Seaweed extract @ 2%) recording the highest number of primary branches plant-1 (21.45, 25.37, 32.17, 39.46) and secondary branches plant-1 (64.72, 76.45, 96.56, 109.34), followed by T_{10} (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Jeevamrutham @ 3%) with primary branch counts of 20.43, 24.16, 30.68, 37.73 and secondary branch counts of 60.58, 72.43, 90.93, 103.70. The lowest number of primary and secondary branches was observed in the control (T_1) with 12.27, 14.48, 18.76, 23.89 for primary branches and 27.46, 40.27, 45.89, 58.58 for secondary branches at 30, 60, 90 and 120 DAT.

The increased number of branches as a result of higher nitrogen content from FYM was attributed to the involvement of nitrogen in the physiological processes of the plant, which stimulated growth and, thus, the increased number of branches per plant at higher nitrogen levels were observed. Almost identical results have been reported by Kandil *et al*. (2009) in Holy Basil, Asgharipour (2011), Rahman *et al*. (2014) in Holy Basil and Naggar *et al*. (2015) and EL-Sayed *et al*. (2015) in basil. The basal application of vermicompost stimulated bacterial activity in the soil, nitrogen accumulation and nutrient availability in the plant, resulting in enhanced plant growth (Mohammad Reza Befrozfar *et al*., 2013). Similar results were obtained by Soheila Shahriari *et al*. (2015) in basil and Chandana *et al*. (2018) in kalmegh and Mohit Lal *et al*. (2018) in sacred basil. According to Dhriti Battacharyya *et al*. (2015), seaweeds affected plant growth due to the effects of oligosaccharides, hormone-like elicitors, betaines and minerals that promoted cell division, protein synthesis and improved stress tolerance.

The data in Table 4 showed significant differences among treatments, with T_9 (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} +

Seaweed extract @ 2%) recording the highest plant spread North-South (25.32, 33.39, 40.26, 50.38 cm) and East-West (40.56, 55.89, 65.47, 71.45 cm), followed by T_{10} (FYM @ 25 t ha^{-1} + Vermicompost @ 2.5 t ha^{-1} + Jeevamrutham @ 3%) with plant spread North-South of 24.36, 32.25, 38.49, 48.69 cm and East-West of 39.03, 53.29, 62.57, 68.63 cm. The lowest plant spread was observed in the control (T_1), with North-South measurements of 16.68, 23.13, 24.33, 35.16 cm and East-West measurements of 26.79, 32.49, 39.37, 46.07 cm at 30, 60, 90 and 120 DAT.

The superior performance for branches per plant might have been due to the higher availability of nutrients from planting to harvest. The results are in line with those of Munnu Singh (2011) in geranium and Singh and Wasnik (2013) in rosemary Mansour *et al*. (2017) and Netam *et al*. (2020) in basil.

4. CONCLUSION

Synergistic Effect of Organic Inputs on the Morphophysiological Traits of Sweet Basil (*Ocimum basilicum* L.) Based on the findings of the present study, it can be concluded that the synergistic application of farmyard manure (FYM) at a rate of 25 tons per hectare, vermicompost at 2.5 tons per hectare, and a 2% seaweed extract significantly enhances the growth and physiological characteristics of sweet basil (*Ocimum basilicum* L.). This combination of organic inputs not only promotes substantial increases in plant height and leaf area but also enhances overall biomass accumulation.The interaction among these organic amendments appears to optimize various morphophysiological traits, facilitating improved nutrient availability, enhanced soil structure, and increased microbial activity. Such improvements contribute to more vigorous vegetative growth and better physiological function, ultimately leading to higher productivity levels in basil cultivation.This integrated approach represents a highly effective strategy for boosting basil yield within sustainable agricultural systems. By leveraging the complementary benefits of these organic inputs, farmers can achieve significant improvements in crop performance while promoting ecological sustainability. Further investigations into the mechanisms underlying these enhancements could provide deeper insights into the benefits of organic farming practices and their long-term effects on soil health and crop resilience.

ACKNOWLEDGEMENT

This work was part of a master's degree research conducted at Chengam, Tiruvannamalai district. We also extend our gratitude to the Chairman for their logistical assistance in implementing the research in designated conservation areas.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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Details of the AI usage are given below:

1. chatGpT
2. Grammerly

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/124957