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Effect of vermicompost and microbial inoculants on growth parameters of chia crop under Hill zone of Karnataka

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Abstract
Field experiment was carried out to study the "Effect of vermicompost and microbial inoculants on growth parameters of chia (*Salvia hispanica* L.) crop" under hill zone of Karnataka at Agricultural and Horticultural Research Station, Thirthahalli during 2020-21. The experiment comprised of eleven treatments and three replications and it was laid out in randomized complete block design (RCBD). The study revealed that among different treatments, plants treated with vermicompost @ 10 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria (T_{11}) recorded higher plant height (93.03 cm), number of branches (23.13), number of leaves (110.30), total fresh weight of plant (424.53 g/plant), total dry weight of plant (135.90 g/plant), leaf area per plant (4407.59 cm^2/plant) and leaf area index (1.63). The same treatment (T_{11}) also recorded maximum total chlorophyll (2.42 mg/g of fresh weight). The study indicated that application of vermicompost @ 10 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria was found optimum for realizing higher growth parameters in chia, followed by vermicompost @ 10 t/ha + *Azotobacter* (T_7) and vermicompost @ 10 t/ha + Phosphate solubilizing bacteria (T_8) under hill zone of Karnataka. On the base of research results, vermicompost and microbial inoculants application can be used in improvement of growth of chia crop.

Keywords: chia, vermicompost, *Azotobacter*, phosphate solubilizing bacteria, potassium solubilizing bacteria

Introduction

There has been an increasing demand for functional foods with numerous health benefits due to intensified consumer awareness leading to a major shift in the consumption patterns of food. This has largely been attributed to increased lifestyle diseases across different populations. The use of food with nutraceutical and functional properties for management of lifestyle diseases like diabetes, obesity and cardiovascular problems is now gaining momentum among the public. Consequently, the consumption of chia seeds (*Salvia hispanica* L.) has increased in recent years particularly due to its high content of omega-3 fatty acids and dietary fiber.

Chia seed is composed of protein (15-25 %), fats (30-33 %), carbohydrates (26-41 %), dietary fibre (18-30 %), ash (4-5 %), minerals, vitamins and dry matter (90-93 %) (Ali *et al*., 2012). To add on that, niacin, vitamin C and A can be found substantially in chia seeds. Owing to the rich nutritional profile, chia seeds provide numerous health benefits such as; cardiac protective and hepatic protective effects, anti-aging and anti-carcinogenic properties. The high amounts of dietary fibres present in the seeds also confer benefits by preserving good glycaemic control thus helps in controlling diabetes mellitus. Modern agricultural farming practices, along with irrational use of chemical inputs over the past four decades have resulted in not only loss of natural habitat balance and soil health but have also caused many hazards like soil erosion, decreased groundwater level, soil salinization, pollution due to fertilizers and pesticides, ill effects on environment, reduced food quality and increased cost of cultivation, rendering the farmer poorer year by year.

Vermicompost is finely-divided mature peat-like materials with a high porosity, aeration, drainage and water-holding capacity and microbial activity which are stabilized by interactions between earthworms and microorganisms in a non-thermophilic process. Vermicompost contains most nutrients in plant available form such as nitrates, phosphates and exchangeable calcium and soluble potassium (Orozco *et al*., 1996). Microbial inoculants, a sustainable eco-friendly agricultural approach to crop improvement is used to supplement chemical fertilizers mainly to maintain soil fertility. Continuous application of expensive chemical fertilizers causes reduction of organic matter content in soil and also microbial activity drastically. These microbial inoculants are organic and bio-degradable.

The organic fertilization is not only a cost effective and eco-friendly, but also improves soil environment, yield of medicinal and aromatic plants. Therefore, the present field experiment was carried out to find out the effect of vermicompost and microbial inoculants on growth parameters of chia (*Salvia hispanica* L.) crop under hill zone of Karnataka at Agricultural and Horticultural Research Station, Seebinakere Farm, Thirthahalli, Shivamogga District, during 2020-21.

Material and methods

The experiment comprised of eleven treatments and three replications and it was laid out in randomized complete block design (RCBD). The treatments consist of T_1 – Control (RDF- 90:60:75 kg/ha), T_2 – Vermicompost (VC) @5 t/ha, T_3 – VC @10 t/ha, T_4 – VC @5 t/ha + *Azotobacter* (AZT), T_5 – VC @5 t/ha + Phosphate solubilizing bacteria (PSB), T_6 – VC @5 t/ha + Potassium solubilizing bacteria (KSB), T_7 – VC @10 t/ha + AZT, T_8 – VC @10 t/ha + PSB, T_9 – VC @10 t/ha + KSB, T_{10} –VC @5 t/ha + AZT + PSB + KSB, T_{11} – VC @10 t/ha + AZT + PSB + KSB.

Note: Microbial inoculants used were Azotobacter: *Azotobacter chroococcum*, Phosphate solubilizing bacteria: *Bacillus megaterium*, Potassium solubilizing bacteria: *Frateuria aurantia*. The roots of planting material were thoroughly dipped into the prepared solution of microbial inoculants before planting for 30 minutes.

Application of manures and microbial inoculants

The experimental plots were uniformly manured as per treatments using vermicompost, containing N (2.5 %), P_2O_5 (1.8 %) and K_2O (2 %).

The inorganic fertilizers were not used in the experimental plots except control (According to KSNUAHS Shivamogga RDF: N: P_2O_5:K_2O 90:60:75 Kg/ha) treatment. Before transplanting, *Azotobacter* inoculum mixed with the jaggery solution. Phosphate solubilizing bacteria and potassium solubilising bacteria were used as the solution (1l/5 litre of water) for inoculation and then the roots of planting material were thoroughly dipped into the prepared solution of microbial inoculants for 30 minutes. The two doses of vermicompost i.e., 5 t/ha and 10 t/ha and three microbial inoculants *i.e.*, Azotobacter (*Azotobacter chroococcum*), Phosphate solubilizing bacteria (*Bacillus megaterium*) and Potassium solubilising bacteria (*Frateuria aurantia*) were used in different combinations.

Observations recorded

For recording growth parameters, destructive method of sampling procedure was followed where, five healthy plants were selected randomly from each treatment of three replications. plant height, number of branches, number of leaves, total fresh weight of plant, total dry weight of plant, leaf area per plant, leaf area index and total chlorophyll was recorded.

Results and discussion

The experimental results presented in the preceding chapter gave a detailed account of the effect of vermicompost and microbial inoculants on growth and yield of chia (*Salvia hispanica* L.) crop.

The study revealed that among different treatments, plants treated with vermicompost @ 10 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria (T_{11}) recorded higher plant height (93.03 cm), number of branches (23.13), number of leaves (110.30), total fresh weight of plant (424.53 g/plant), total dry weight of plant (135.90 g/plant), leaf area per plant (4407.59 cm^2/plant), leaf area index (1.63). The same treatment (T_{11}) also recorded maximum total chlorophyll (2.42 mg/g of fresh weight).

The use of organic fertiliser boosted vegetative growth (plant height, number of leaves, branches, fresh and dry weight of plant organs, leaf area, leaf area index and total chlorophyl). Increasing production and enhancing crop quality is dependent on boosting plant vegetative development. Zarrabi *et al.* (2017) [13] in *Melissa officinalis* and Asheghi *et al.* (2018) [2] in green basil.

The increase in plant height could be attributable to the inoculation of nitrogen fixers, which results in the creation of more chlorophyll. Salman *et al.* (2019) in chia (*Salvia hispanica*) and Smitha *et al.* (2019) [9] in sacred basil. The better plant development could be related to improved soil health, since the physico-chemical properties of the soil were improved, resulting in an increase in microbial activity as well as macro and micro nutrients. Sharafi *et al*. (2019) [11] in *Thymus vulgaris* L. and Khalediyan *et al.* (2021) [6] in *Ocimum basilicum* and *Satureja hortensis.*

The increased leaf area could be due to increased nitrogen availability, which was influenced by a higher percentage of nitrogen through nitrogen fixing culture, as documented by Bambal *et al.* (1998) [3] or the production of growth regulators by *Azotobacter* in the root zone, which is absorbed by the plant roots, as reported by Rana and Chandel (2003) [9]. Govahi *et al*. (2015) [5] in sage. Higher chlorophyll may be related to increased biological nitro-fixation, improved organic nitrogen use, improved root system development and probable synthesis of plant growth regulators such as IAA, GA_3 and cytokinin. Befrozfar *et al.* (2013) [4] in basil, Larimi *et al.* (2014) [7] in sweet basil

Conclusion

From the results obtained during the present investigation with different treatment combinations of vermicompost and microbial inoculants on growth parameters of chia, it is concluded that plants treated with vermicompost @ 10 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria, vermicompost @ 10 t/ha + Azotobacter and vermicompost @ 10 t/ha + Phosphate solubilizing bacteria have shown the better results.

Therefore, organic chia (*Salvia hispanica* L.) may be grown successfully with combined application of vermicompost and microbial inoculants for growth parameters under hill zone of Karnataka.

Table 1: Effect of vermicompost and microbial inoculants on growth parameters of chia

Treatments	Plant height (cm)	Number of branches per plant	Number of leaves per plant	Total fresh weight of plant (g/plant)
T_1. Control (RDF)	80.03	17.70	74.13	318.00
T_2. Vermicompost @ 5 t/ha	81.30	18.30	77.63	332.52
T_3. Vermicompost @ 10 t/ha	86.26	20.01	95.10	395.13
T_4. Vermicompost @ 5 t/ha + *Azotobacter*	83.20	19.54	86.14	370.46
T_5. Vermicompost @ 5 t/ha + Phosphate solubilizing bacteria	82.56	19.17	85.08	361.10
T_6. Vermicompost @ 5 t/ha + Potassium solubilizing bacteria	82.13	18.95	80.90	340.53
T_7. Vermicompost @ 10 t/ha + *Azotobacter*	91.96	22.16	106.01	417.86
T_8. Vermicompost @ 10 t/ha + Phosphate solubilizing bacteria	89.23	20.43	101.56	410.63
T_9. Vermicompost @ 10 t/ha + Potassium solubilizing bacteria	87.36	20.11	97.67	393.56
T_{10}.Vermicompost @ 5 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria	84.30	19.92	93.41	353.66
T_{11}.Vermicompost @ 10 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria	93.03	23.13	110.30	424.53
S. Em ±	1.39	0.82	1.68	9.48
CD @ 5%	4.14	2.43	5.04	28.15

Table 2: Effect of vermicompost and microbial inoculants on total dry matter of plant, leaf area, leaf area index of chi crop

Treatments	Total dry weight of plant (g/plant)	Leaf area per plant (cm^2/plant)	Leaf area index
T_1. Control (RDF)	76.90	2641.99	0.98
T_2. Vermicompost @ 5 t/ha	83.66	2766.73	1.03
T_3. Vermicompost @ 10 t/ha	114.66	3695.34	1.37
T_4. Vermicompost @ 5 t/ha + *Azotobacter*	101.49	3161.29	1.17
T_5. Vermicompost @ 5 t/ha + Phosphate solubilizing bacteria	96.56	3122.39	1.16
T_6. Vermicompost @ 5 t/ha + Potassium solubilizing bacteria	92.00	2968.76	1.10
T_7. Vermicompost @ 10 t/ha + *Azotobacter*	129.26	4236.29	1.57
T_8. Vermicompost @ 10 t/ha + Phosphate solubilizing bacteria	123.53	4058.60	1.50
T_9. Vermicompost @ 10 t/ha + Potassium solubilizing bacteria	119.14	3902.89	1.45
T_{10}.Vermicompost @ 5 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria	104.63	3428.07	1.27
T_{11}.Vermicompost @ 10 t/ha + *Azotobacter* + Phosphate solubilizing bacteria + Potassium solubilizing bacteria	135.90	4407.59	1.63
S. Em±	2.78	65.13	0.024
CD @ 5%	8.25	193.49	0.072

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