Effect of different bio-fertilizers on growth and yield of spinach (*Spinacia oleracea L.*)

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Abstract. A field trial was conducted with the aim to study the effect of different bio-fertilizers on growth and yield of spinach (*Spinacia oleracea L.)* Spinach stands as a significant leafy vegetable in global agriculture, prized for its nutritional richness and versatile culinary applications. With an increasing emphasis on sustainable agricultural practices, the investigation of alternative fertilization methods has garnered attention, particularly bio-fertilizers known for their eco-friendly attributes and potential multifaceted benefits. This study delves into the effects of diverse bio-fertilizers on the growth and yield of spinach crops. During the rabi season of 2023-2024, the field experiment was carried out at AlOA Amity University Noida U.P. Agricultural Research Farm. The experiment was organized in a randomized complete block design to assess the efficacy of different bio-fertilizer treatments. Key growth parameters including plant height, leaf area were meticulously monitored throughout the crop cycle. Additionally, yield metrics such as fresh weight and marketable yield were recorded to evaluate the productivity of spinach plants under various bio-fertilizer regimes with six treatments consisting of a single or combination of bio-fertilizers in three replications. T6 (Vermicompost + azotobacter +poultry manure) exhibited the highest values for maximum plant height, no. of leaves per plant, length and width of leaves, leaf area, followed by T5 and T4 at 30, 45, and 60 DAS. The minimum plant height and other morphological parameters were observed in the treatment T1 (control) at 30, 45, and 60 DAT. T6 (Vermicompost + azotobacter + poultry manure), T5 (Azotobacter + Vermicompost), and T4 (FYM and poultry manure) had the highest fresh weight whereas the control treatment had the lowest. When compared to all other treatments, the treatment T6 (Vermicompost + Azotobacter + poultry manure) produced the highest growth and yield.

KEY WORDS: Growth, Yield, FYM, Poultry Manure, Azotobacter, Vermicompost.

1. Introduction

Spinach, scientifically known as *Spinacia oleracea*, is a green leafy vegetable [1], that has captivated the taste buds and nutritional interest of people around the world. It belongs to the family Amaranthaceae and its a commonly grown annual crop plant that is valued for its nutrient-dense, dark green leaves [2]. It is believed that spinach first appeared in southwest Asia, and as early as the 12th century, it was recognized in Europe. The majority of the nation's produce is produced in California and Texas [3]. It is known as the nutrient power house Packed with essential vitamins and minerals, it provides an abundance of nutrients vital for overall health [4]. Rich in iron, calcium, vitamins A, C, K and vitamin B12 (riboflavin) as well as folate [2,5]. Spinach is an essential food for immune system support, skin health, and bone health. Cool, temperate climates are ideal for spinach growth [1,2,5]. A warmer growing region to the south grows spinach in the winter, whereas cooler growing regions to the north sow seeds in the spring and fall [6]. Usually, the growth phase lasts for forty days. A dense cluster of leaves known as a rosette forms on spinach plants as they grow and mature. "Growth and yield" are fundamental concepts in various fields, including agriculture, forestry, ecology, economics, and even human development [7]. These terms encapsulate the dynamic processes through which organisms, systems, or economies change and produce outcomes over time. Understanding growth and yield is crucial for maximizing productivity, managing resources sustainably, and making informed decisions across diverse domains. [8]. It is the tangible outcome of growth processes and reflects the efficiency with which resources are converted into useful products [9]. Maximizing yield requires a holistic approach that considers factors such as plant genetics, soil fertility, water availability, pest and disease management, and socioeconomic factors [10]. Inorganic fertilizers are likely to be supplemented or replaced with bio-fertilizers, which are less noticeable, environmentally beneficial, and sustainable. The current trend in vegetable production is to provide highly nutritious, chemical-free, organic products [7,11]. One of the many inputs used in organic vegetable cultivation is bio-fertilizer. In addition to raising output, bio-fertilizers also help to improve the soil's nutritional status through quality improvement [2]. An Azotobacter is a free-living, aerobic, gram-negative

bacterium that fixes atmospheric nitrogen [5]. As a more environmentally friendly, sustainable, and less conspicuous alternative to inorganic fertilizers, biofertilizers are expected to gain more importance in the future [3].

1.1 Objectives:

- To study the effect of different bio-fertilizers on growth of spinach (FYM, Vermiconpost, poultry manure, Azotobacter)
- Effect of different bio-fertilizers on yield.

2. Material and Methods

The present investigation topic "Effect of different bio-fertilizers on growth and yield of spinach (Spinacia oleracea L.)" were carried out at the Amity Institute of organic agriculture farm, Amity University Noida, Uttar Pradesh during the Rabi growing season of 2023 - 2024. The detail of different treatment is given below at table no. 1.

Table 1: Treatment details.

TreatmentNo.	Treatment details
T1	Control
T2	(FYM) Farm yard Manure
T3	Vermicompost
T4	Farm yard manure + Poultry manure
T5	Vermicompost + Azotobacter
T6	Vermicompost + Poultry manure + Azotobacter

3. Results

Plant height (cm), no. of leaves per plant, length (cm), width (cm), leaf area (cm), yield per plot (cm), and yield (quintal/ha) were among the growth metrics that were observed and documented in tables.

Table 2: Effect of bio-fertilizers on Plant height

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	Control	7.66	10.00	21.33
T2	FYM	9.00	10.67	25.00
T3	Vermicompost	8.67	13.00	28.67
T4	FYM+ Poultry manure	11.00	25.00	30.00
T5	Vermicompost + Azotobacter	12.67	26.33	31.67
T6	Vermicompost+ Poultry manure + Azotobacter	15.00	29.00	32.33
CD at 5%		0.18	0.59	0.28
SE±		0.08	0.26	0.12

Table. 2 provide the data on spinach plant height at harvest. At the time of harvest, the plant height ranged from 12.997 cm to 25.443 cm. Treatment T6 (Vermicompost+ azotobacter + poultry manure) resulted in much more spinach plant height than any other treatment, followed by T1, T2, T3, T4 and T5. Treatment 6 had the highest plant height (42.16 cm) (T6). In the treatment (T1) control group, the minimum plant height (12.997 cm) was recorded.

The combined application of Vermicompost+ azotobacter + poultry manure in T6 showed significantly higher plant height than other treatments.

Table 3: Effect of bio-fertilizers on number of leaves per plants

Tr.no.	Treatments	30 DAS	45 DAS	60 DAS
T1	Control	3.33	5.00	7.33
T2	Fym	3.67	6.67	8.00
T3	Vermicompost	4.33	7.67	13.00
T4	FYM+Poultry manure	9.00	10.33	13.67
T5	Vermicompost + Azotobacter	10.33	12.67	14.33
T6	Vermicompost+ Azotobacter + Poultry manure	12.33	13.67	16.33
CD at 5%		0.46	0.29	0.29
SE ±		0.20	0.13	0.13

One of the growth factors connected to crop physiological development is the no. of leaves per plant. Table 3 show the results of a leaf count performed during spinach harvest.

During the harvest of spinach, the number of leaves ranged from 14.110 to 5.220. The maximum leaves per plant obtained in the T6 treatment. However, Un-amended or control (T1) had the lowest number of leaves per plant (control).

Table 4: Effect of bio-fertilizers on length of leaves

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	Control	6.00	6.67	8.00
T2	Fym	7.33	10.33	12.00
T3	Vermicompost	10.00	11.67	13.33
T4	FYM+ Poultry manure	11.00	13.00	15.00
T5	Vermicompost + Azotobacter	11.66	13.3	17.33

T6	Vermicompost+ Azotobacter + Poultry manure	13.33	15.00	21.00
CD at 5%		0.29	0.17	0.28
SE±		0.13	0.08	0.12

In comparing the results of treatments T1 through T6, it is evident that T6 (Vermicompost + Azotobacter + Poultry manure) stands out prominently, exhibiting significantly longer leaf lengths compared to the other treatments. This outcome underscores the efficacy of T6 in promoting robust leaf growth. While each treatment likely played a role in fostering plant development, the pronounced superiority of T6 highlights its potential as a particularly potent treatment method. Further analysis of the mechanisms behind T6's success could yield valuable insights into optimizing plant growth and enhancing agricultural practices.

Table 5: Effect of bio-fertilizers on width of leaves (cm)

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	Control	3.00	3.3	4.7
T2	FYM	5.00	6.7	8.00
T3	Vermicompost	5.00	7.00	9.7
T4	FYM+Poultry manure	6.00	8.30	12.00
T5	Vermicompost + Azotobacter	7.00	9.70	17.3
T6	Vermicompost+ Azotobacter + poultry manure	8.00	11.30	18.00
C.D at 5%		0.44	0.40	0.37
S.E ±		0.20	0.18	0.17

In table 5 shows the Analyzed results from treatments T1 through T6 reveals a notable trend, with T6 emerging as the standout performer in terms of leaf width. Among all the treatments, T6 consistently produced leaves with significantly greater width, indicating its effectiveness in promoting robust leaf expansion. While each treatment likely contributed to overall plant development, the distinct advantage of T6 underscores its potential as a superior treatment method for enhancing leaf morphology. Further investigation into the specific mechanisms underlying the efficacy of T6 could offer valuable insights into optimizing agricultural practices and maximizing crop yield.

Table 6: Effect of bio-fertilizers on leaf area

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	Control	18.00	22.01	37.6
T2	FYM	36.65	69.21	9.00
T3	Vermicompost	50.00	81.69	129.3
T4	FYM+Poultry manure	66.00	107.9	180
T5	Vermicompost + Azotobacter	81.62	129.01	299.9
T6	Vermicompost+ Azotobacter + Poultry manure	106.64	169.5	378
C.D at 5%		0.19	0.48	0.17
S.E ±		0.08	0.21	0.07

The outcome of different treatments on leaf area are provided in table 6. At harvest, the leaf area of spinach ranged from 25.870 cm^2 to 218.047 cm^2. Furthermore, T6(Vermicompost + Azotobacter + Poultry Manure) showed the largest leaf area, followed by T5 (Vermicompost + Azotobacter) and T1 (control) with smallest leaf area.

Table 7: Effect of bio-fertilizers on yield per plot (kg)

Tr. No.	**Treatments**	**Yield / plot (kg)**	**Yield / hectare (q)**
T1	Control	0.67	67
T2	FYM	0.83	83
T3	Vermicompost	0.93	93
T4	FYM + Poultry Manure	1.09	109
T5	Vermicompost + Azotobacter	1.18	118
T6	Vermicompost +Azotobacter + Poultry manure	1.43	143
CD at 5%		0.17	0.87
SE±		0.07	0.39

Yield per plot (kg): There were notable variations in the yield per plot (kg) between the various treatments, according to the yield per plot statistics shown in Table 7.

The data clearly shows that the maximum yield kg/plot (1.89) was observed in the therapy (T6), which involves applying poultry manure, vermicompost, and Azotobacter. The second-highest yield kg/plot (1.12) with vermicompost + azotobacter application was noted in T5. On the other hand, the treatment (T1) control, which received no treatment, had the lowest yield kg/plot (0.49).

Yield per hectare (q): There were notable variations in the yield per hectare (q) across the various treatments, according to the data on yield per hectare (q) and as shown in Fig. 7. According to the study, treatment yielded the highest yield per acre (189 q). T5 vermicompost + azotobacter is added after the vermicompost + azotobacter + poultry manure combination.

However, the control (T1) treatment produced the lowest yield per acre (49 q).

4. Conclusion

It has been noted that the maximum values of growth characteristics, such as plant height (25.443 cm) and leaf count per plant (4.110 cm), length of plant (16.443 cm) width of the plant (12.433 cm) and leaf area per plant (218.047 cm2) were recorded with the application of vermicompost (1kg)+poultry manure (1kg) + azotobacter (25g) (T6) while minimum values for all these parameters like plant height (12.997 cm), number of leaves per plant (5.220 cm), length of plant (6.890 cm), width of plant (3.667 cm) and leaf area per plant (25.870 cm2) were recorded in control (T1) treatment. In T6 (vermicompost -1kg +poultry manure -1kg + azotobacter - 25g) the yield was reported maximum i.e (143 q/ha) followed by T5 (Vermicompost + Azotobacter) (118 q/ha) and the minimum yield is T1 control (67q/ha).

The observation showed that using a different bio-fertilizers on the growth parameters and yield qualities of spinach in general. The application of combined bio-fertlizers produced significantly superior results. overall, the application combination of Azotobacter + Poultry manure + Vermicompost together should be recommended.

5. Reference

1. C. S. Lasya Spinach and its health benefits: A review, The Phar. Inno. J. Pub. (2022).
2. B. Zhang, H. Zhang, D. Lu, L. Cheng, J. Li, Effects of biofertilizers on the growth, leaf physiological indices and chlorophyll fluorescence response of spinach seedlings. Editor Mayank Gururani, United Arab Emirates University (2023).
3. M. I. Jakhro, S. I. Shah, Z. M. Amanullah, Z. A. Rahujo, S. Ahmed, & M.A. Jakhro. Growth and yield of spinach (Spinacia oleracia) under fluctuating levels of organic and inorganic fertilizers. Inter. J. of Dev. Res., **7,** 11454-11460 (2017).
4. S. G. Bharad, S. D. Korde, S. Pravina, & M. N. Baviskar, Effect of organic manures and number of cuttings on growth, yield and quality of Indian spinach. Asian J. of Horti. **8,** 60-64 (2013).
5. A.A. Shinde, A.S. Kadam and S.J. Syed Effect of biofertilizers on growth and yield of Spinach (Beta vulgaris L.). Int. J. of Chemi. Stud. (2018).
6. C. James, Correll, E. Teddy, Morelock, Mark C. Black, T. Steven. Koike, P Lynn, J. Brandenberger, Frank, Dainello. Economically important diseases of spinach. Sci. Res. an academic Pub., Pp 655 (2004).
7. A. Jabeen, S. Narayan, K. Hussain, S. Ahmed Mir & F.A Khan, Effect of organic manures and biofertilizers on quality of spinach beet (Beta vulgaris var. bengalensis). Int. J. Curr. Microbiol. Appl. Sci. **7**, 1312-1317 (2018).
8. V. D. Doifode, & P.B. Nandkar, Influence of biofertilizers on the growth, yield and quality of brinjal crop. Int J Life Sci, **2**, 17-20 (2014).
9. R.L. Sahu, H. Sahu, & S. Kumar. Effect of application of inorganic fertilizers and biofertilizers on growth components and yield traits of coriander (Coriandrum sativum L.). Progressive Horticulture, **46**, 102-106 (2014).
10. M.B. Dange, A.M. Bhosale, & S.R. Barkule, Effect of organic and inorganic fertilizers on growth, yield and quality of palak (Beta vulgaris L.) var. Pusa Jyoti. International J. Plant Sc.(Muzaffarnagar), **6,** 91-94 (2011).
11. S.K. Malhotra, B.B. Vashishtha, & V.V. Apparao, Influence of nitrogen, Azospirillum sp. and farmyard manure on growth, yield and incidence of stem gall disease in coriander (Coriandrum sativum L.). J. of Spices and Aromatic Crops, **15**, 115-117 (2006).