Impact of bio-fertilizers on growth, yield and quality of Spinach (*Spinacia oleracea* L.) in Noida UP.

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ABSTRACT. A field trial was undertaken at Amity University Noida's experimental farm to investigate the effectiveness of microbial consortia on plant development and yield characteristics of spinach (Spinacia oleracea L.). Azotobacter, poultry manure, vermicompost, and FYM were used in various combinations throughout the treatments. The Desi (indigenous) variety was used in the field investigation. The use of biofertilizers is intended to increase crop yield and soil fertility while minimising environmental damage. The purpose of this study is to investigate the effects of various biofertilizers on the growth and yield of spinach (Spinacia oleracea L.) plants. These fertilisers include vermicompost, farmyard manure, Azotobacter, and poultry manure. The experiment was conducted out under closely monitored settings, with a randomised complete block design and three replications. Growth metrics were examined during the experiment to evaluate the vegetative growth of spinach plants, including plant height, leaf area, leaf length, and number of leaves per plant. The study's findings demonstrated that the various treatments that were applied had a discernible impact on the growth, production, and economics of spinach. According to early data, the usage of biofertilizers considerably affected the growth and yield of spinach plants when compared to the control group. In comparison to the control, which had plant height (26.4 cm), leaves number (14), length of the leaves (15cm), leaves width (8cm), area of leaf per plant (120 cm^2), and yield (4.5 Kg) the combined application of (Azotobacter + farmyard manure + poultry manure) demonstrated the highest performance on plant growth parameters such as height of the plants (35.4cm), leaves number per plant (16.7cm), leaves length (22cm), leaves width (12cm), and leaf area per plant (264 cm^2). Furthermore, as seen by higher nutrient levels and organic matter content, the application of biofertilizers significantly improved soil fertility. This research present to the growing body of valuable information on sustainable farming practices by elucidating the efficacy of biofertilizers in enhancing the spinach growth and yield. The findings highlight how important it is to incorporate biofertilizers into agricultural practices to enhance soil health, reduce adverse environmental effects, and ensure the production of food sustainably.

KEYWORDS: biofertilizers, farmyard manure, vermicompost, Azotobacter, poultry manure, spinach, growth, yield, sustainable agriculture.

1. Introduction

Spinacia oleracea L. also referred to as palak, is a popular leafy vegetable cultivated over the world, including in India. It is a member of the Chenopodiaceae family. Native to Central and Western Asia, spinach is a green-leaved plant (Spinacia oleracea). Because of its beautiful green colour, delicate texture, and nutritional value, it is frequently consumed [1]. We may plant spinach at any time of year. In the winter, between September and October, and in the spring, from mid-February to April, are the ideal times to plant seeds [2]. With the family name Chenopodiaceae and the subfamily Chenopodioideae, spinach belongs to the Caryophyllales order. With two pairs of chromosomes, spinach is thought to have come from ancient Persia about 2,000 years ago. In 647 AD, it was transported to India and ancient China via Nepal, whence it got its name "Persian vegetable" [3]. India's top-producing states like Gujarat, Karnataka, Maharashtra, West Bengal, Uttar Pradesh, Kerala, Tamil Nadu, and Andhra Pradesh are among the states that grow spinach [4]. A rosette made up of spinach's edible leaves gives rise to a seed stalk [5]. Simple leaves might be flat or puckered, and they can be ovate or triangular in shape. Little, dry fruits are produced by the barely perceptible blooms [3]. Chilly temperatures and rich, well-limed soil are necessary for spinach to grow quickly and have the largest possible leaf area [6]. Seeds can be sown every two weeks from early spring to late summer in rows spaced 30 cm (12 inches) apart, with the plantlets being trimmed as they grow. The final plantings result in

seedlings that give fruit in the autumn and survive the winter, perhaps even producing leaves through the whole winter if conditions are favourable [6]. It's used in frozen, canned, and fresh goods. When steamed or briefly boiled, it has a high antioxidant content, little calories, and excellent biological value. In addition to being high in calcium, iron, and vitamin A, spinach also contains small amounts of riboflavin, ascorbic acid, and thiamine. The glossy, meaty, bright green leaves are well-liked by many different kinds of people [2,5,6].

Over the past ten years, vegetable crop area and production have steadily expanded in India. As of right now, 10.2 million hectares are used for vegetable agriculture, producing 197.2 million tonnes year (Anon. 2021). The International Council on Medical Research (ICMR) states that an individual needs between 50 and 60 grammes of leafy vegetables per day. Our country produces about 19.7 tonnes per hectare, a significant decrease from other wealthy countries like Spain, whose production is 39.3 tonnes per hectare [7]. When growing baby spinach, organic fertilisers such farmyard manure, goat and chicken dung, and biofertilizers can take the place of chemical fertilisers[8]. "Growth and yield" are key ideas in a variety of disciplines, including agriculture, forestry, ecology, economics, and human development [9]. These concepts describe the dynamic processes by which organisms, systems, or economies evolve and create results throughout time. Understanding growth and yield is critical for increasing productivity, managing resources sustainably, and making sound decisions across multiple domains [10]. In agriculture and forestry, growth is defined as the increase in size, biomass, or volume of plants over time. It includes a variety of physiological activities as cell division, elongation, differentiation, and photosynthesis [11]. Understanding the elements that affect plant development, such as environmental circumstances, genetic features, and management approaches, is critical for improving crop yields, forest productivity, and overall ecosystem health [12]. Yield, on the other hand, refers to the amount or quality of the finished product gathered from a crop, forest stand, or economic activity [13]. It is the physical result of growth processes and displays how effectively resources are turned into usable products [14]. To maximise output, a comprehensive approach is required, taking into account plant genetics, soil fertility, water availability, pest and disease management, and socioeconomic considerations [15].

1.1 Objectives:

- To study the impact of bio-fertilizers on growth of spinach (FYM, Vermicompost, poultry manure, Azotobacter)
- Effect of different bio-fertilizers on yield of Spinach

2. Material and Methods

The current study, named **"Impact of bio-fertilizers on growth, yield and quality of Spinach (*Spinacia oleracea* L.) in Noida UP."** was carried out during the Rabi season of 2023. This chapter depicts the exploratory strategies used and approaches adopted during the investigation. Climatic and edaphic conditions prevailing during crop season, site identification, field cropping history, and other trail details have all been reported. The experimental trial was carried out at Amity University's research farm in the Rabi season of 2023–2024. Amity Institute of Organic Agriculture in Noida, Uttar Pradesh. Geographically, it is located at 77°19′51.64″E (77.331007) and 28°32′37.64″N (28.543793). And an altitude of 200 metres above sea level.

Table 1: Treatment details

Treatment No.	Treatment details
T1	FYM
T2	Azotobacter + FYM
T3	Azotobacter + poultry manure + FYM
T4	Vermicompost
T5	FYM + poultry manure
T6	control

3. Results

The data in table 2 shows plant height differed considerably between treatments throughout every observation phase. The plant height in all treatments ranged from (7.4-13.7)cm at 30 DAS, (14-23cm) at 45 DAS, and (26.4-35.4cm) at 60 DAS. T3 (Azotobacter + Poultry manure + FYM) showed the highest values at 30 DAS (13.7 cm), followed by T2 (Azotobacter + FYM) and T5 (Poultry manure + FYM) at 60 DAS (31.7 and 32.7 cm, respectively). The lowest values found at T6 are 7.4 cm, 14 cm, and 26.4 cm at (30,45,60) DAS respectively.

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	FYM	10	17.4	30
T2	Azotobacter +FYM	12	20.7	31.7
T3	Azotobacter+ Poultry manure +FYM	13.7	23	35.4
T4	Vermicompost	10.7	18	30.7
T5	Poultry manure +FYM	11.7	20	32.7
T6	control	7.4	14	26.4

Table 2 : Effect of bio-fertilizers on Plant height (cm)

C.D at 5%.		0.432 621	0.453 777	0.16271
SE±		0.194 174	0.203 67	0.07303

The standard length of the leaves was measured for all treatments, and the collected data was statistically evaluated. The data in table 3 show significant increases in spinach leaves following various biofertilizer applications. The combination of (Azotobacter + Poultry manure + FYM) T3 resulted in the largest leaf length (10, 16.4, and 22 cm). Separately applied biofertilizers reduced this metric even considerably. The control treatment produced the shortest leaf lengths (4.7, 9.7, and 15 cm) at (30,45,60) DAS respectively.

Table3 : Effect of bio-fertilizers on Length of leaves (cm)

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	FYM	6.7	11	18
T2	Azotobacter +FYM	7.4	14.4	19.7
T3	Azotobacter + Poultry manure +FYM	10	16.4	22
T4	Vermicompost	7	12	18.7
T5	Poultry manure +FYM	7.7	14	20.7
T6	control	4.7	9.7	15
CD at 5%		0.162 71	0.453 777	0.162 71
SE±		0.073 03	0.203 67	0.073 03

The data in table 4 analysis clearly demonstrated that the width of spinach plant leaves varied significantly as a result of various treatments. Leaves ranged in breadth from 3 cm to 7 cm at 30 DAS, 5 cm to 9.4 cm at 45 DAS, and 8 to 12 cm at 60 DAS. T3 (Azotobacter + Poultry dung + FYM) had the widest leaves (7, 9.4 and 12 cm). In each scenario, a mixture of biofertilizers is superior to a single application of biofertilizer. At 30, 45, and 60 DAS, the control treatment had significantly lower leaf widths (3, 5, and 8 cm) than the majority of the other treatments.

Table 4 : Effect of bio-fertilizers on leaves width (cm)

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	FYM	3.4	5.7	10
T2	Azotobacter +FYM	4.7	6.7	10.4
T3	Azotobacter + Poultry manure +FYM	7	9.4	12
T4	Vermicompost	4.4	5.7	9.7
T5	Poultry manure +FYM	5.4	6.7	11.4
T6	control	3	5	8
CD at 5%		0.263 621	0.263 621	0.263 621
SE ±		0.118 322	0.118 322	0.118 322

The data in table 5 shows the different biofertilizer combinations utilised increased the quantity of spinach leaves per plant significantly. The treatment T3 (Azotobacter + Poultry dung + FYM) produced the largest leaves number per plant (7, 10, and 16.7) at 30, 45, and 60 DAS, respectively. The control treatment produced least leaves (5, 7.8, and 14) at 30, 45, and 60 DAS.

Table 5: Effect of bio-fertilizers on leaves number per plant

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	FYM	6	8	15
T2	Azotobacter +FYM	6.7	9.4	15.7
T3	Azotobacter+ Poultry manure +FYM	7	10	16.7
T4	Vermicompost	6	8	15
T5	Poultry manure +FYM	6.7	9.4	15.7
T6	control	5	7.8	14

C.D at 5%		0.422298	0.453777	0.16271
SE±		0.189541	0.20367	0.07303

The data in table 6 shows the results pertaining to the average leaf area of cauliflower that were acquired through differential treatments . T3 with (Azotobacter+ Poultry manure + FYM) had the greatest leaf area per plant (70, 154.16, and 264 cm2), followed by T5 (41.58, 93.8, 235.98 cm2) and T2 (34.78, 96.48, and 204.88 cm2) at 30, 45, and 60 DAS: From the control treatment T6, the minimal leaf area (14.1, 48.5, and 120 cm2) was observed.

Table 6: Effect of bio-fertilizers on leaf area in (cm)

Tr. No.	Treatments	30 DAS	45 DAS	60 DAS
T1	FYM	22.78	62.7	180
T2	Azotobacter +FYM	34.78	96.48	204.88
T3	Azotobacter+ Poultry manure +FYM	70	154.16	264
T4	Vermicompost	30.8	68.4	181.39
T5	Poultry manure +FYM	41.58	93.8	235.98
T6	control	14.1	48.5	120
C.D at 5%		0.185835	0.353164	0.525467
SE±		0.083409	0.158512	0.235847

Effect of bio-fertilizers on yield

*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 hectare is 280q/ha in T3 (Azotobacter+ Poultry manure+ FYM) followed by T2 (Azotobacter +FYM) i.e. 250q/ha However, the control (T1) treatment produced the lowest yield per acre (49 q).

Table 7: Effect of bio-fertilizers on yield

Tr. No.	Treatments	Yield plot/kg	Yield q/ha
T1	FYM	5	166
T2	Azotobacter +FYM	7.5	250
T3	Azotobacter+ Poultry manure+ FYM	8.5	280
T4	Vermicompost	6	200
T5	Poultry manure+ FYM	6	200
T6	control	4.5	150
C.D at 5%		0.439368	0.542367
SE±		0.197203	0.542367

4. Conclusion:

The current study comes to the conclusion that among all the treatments, the combination of Azotobacter + Poultry manure + FYM in treatment T3 produced the best rate of seed germination. T2 including FYM + Azotobacter was the second most successful treatment. T5 with Poultry manure + FYM was the third-best treatment. Lower seed germination was observed with treatment T6 (control), closely followed by treatment T4 and treatment T1. In comparison to other treatments, treatment T3 (Azotobacter+ Poultry manure + FYM) produced considerably higher plant heights (13.7, 23 and 35.4) in spinach at the 30, 45, and 60 DAS stages. The treatment T6 (control) resulted in significantly lower plant height at various stages of growth. The treatment T3(Azotobacter + Poultry manure + FYM) had the most leaves per plant (7, 10, and 16.7). When employing different treatments containing Vermicompost, Azotobacter, FYM, Poultry manure, and each of their combinations, the length of spinach leaves per plant increased significantly. In comparison to the other treatments at 30, 45, and 60 DAS, the treatments T3 (Azotobacter + Poultry manure + FYM) had the longest leaves, measuring 10, 16.4, and 22 cm. Regarding spinach leaf width, the crop responded well to a range of treatments. Upon applying vermicompost, Azotobacter, FYM, and poultry manure individually as well as in combination with each other, the biofertilizers with the greatest leaf width were T3 (Azotobacter + Poultry manure + FYM), which measured 7 to 12 cm. T3 (Azotobacter + Poultry manure + FYM) also had the highest leaf area (70, 154.16, and 264cm2), followed by

T5 (41.58, 93.8, and 235.98cm2) and T2. The minimum leaf area (14.1, 48.5, and 120cm^2) was noted at 30, 45, and 60 DAS in the T6 control.

Different fertility treatments have a significant impact on yield due to factors such as yield plot (kilogrammes plot -1) and yield per hectare. The fertility treatment T3, which included biofertilizer sources, had a considerably higher maximum yield per hectare (280 q/ha) and plot (8.5 kilogrammes) when compared to the other treatments. The control treatment (T6) produced the lowest yield (150 q/ha and 4.5 kg/plot) followed by TI and T4 (166 to 200 q/ha, 5 to 6 kg/plot). The findings of this study unambiguously revealed that the use of combination bio-fertilizers produced significantly better results, encouraging its adoption for commercial farming techniques.

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