Growth and Yield Performance of Radish (*Raphanus Sativus L.*) Fertilized with Biofertilizer

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Abstract

The study was conducted to evaluate to effectiveness of Bio fertilizer and combined inorganic fertilizer on growth and yield of radish (Raphanus sativus L). This study was designed with five treatments having ten replicates. Treatments are T_1-(Control); Recommended amount of chemical fertilizer by Department of Agriculture (RDOA), T2-1/2 RDOA of urea +Recommended amount of Triple super phosphate and Muriate of potash +250ml/ha Bio fertilizer, T3-1/2 RDOA of urea + TSP&MOP +500ml/ha Bio fertilizer, T_4-1/2 RDOA of urea + TSP & MOP + 750ml/ha Bio fertilizer, T_5 -1l/ha Bio fertilizer alone. All other agronomic practices were followed based on DOA recommendation. Plant height, number of leaves, leaf area were measured by in weekly interval. Fresh weight of and, dry weight of leave, storage root length and diameter, fresh weight and dry weight of storage root were measured at the time of harvesting (6^{th} week after planting). Analysis of variance was performed to determine significant difference among treatment ($p<0.05$). The results revealed that treatments combining inorganic fertilizers with biofertilizer (T_3 and T_4) significantly enhanced plant growth and tuber yield compared to inorganic fertilizers alone (T_1) as well as biofertilizers alone (T_5). The highest tuber yield was observed in T_4, demonstrating the effectiveness of biofertilizers in improving nutrient uptake, root elongation, and soil microbial activity. These findings suggest that integrating biofertilizers with inorganic fertilizers can enhance radish productivity while reducing the environmental impact of excessive chemical fertilizer use.

Keywords: Bio fertilizer, Chemical fertilizer, Radish

I. INTRODUCTION

In today's world, with pollution and environmental degradation posing significant challenges, adopting sustainable practices across all sectors, including agriculture, has become essential. Conventional farming techniques, which often depend heavily on synthetic fertilizers and pesticides, not only pollute the environment but also disturb the soil natural nutrient balance (Pradhan *et al.*,2023).

Fertilizers can have both positive and negative effects on soil health. On the positive side, they supply essential nutrients that promote plant growth and improve soil fertility. However, excessive or improper use of fertilizers can have detrimental effects. Over relying on inorganic fertilizers can disrupt the soil's natural nutrient balance, leading to imbalances that reduce soil quality. This can result in the loss of organic matter, decreased fertility, and greater vulnerability to erosion (Johnson, 2023). Particularly nitrogen fertilizers can have several negative effects, including reduced crop quality, soil acidification, and pollution from heavy metals, soil compaction, and alterations to the soil micro biome (Lin *et al.*, 2019). The sustainability of agricultural systems is a critical global concern, leading to a greater emphasis on the potential benefits of organic fertilizer use. Organic fertilizers can enhance soil microbial activity, which in turn promotes improved crop growth and helps control pests and diseases (Lin *et al.*, 2019). Organic farming relies on the use of biological fertilizers, pest control, compost, and sustainable practices such as intercropping, mulching, and crop rotation. This method strictly limits the use of chemical fertilizer, growth regulators, pesticides, herbicides, and other synthetic inputs. (Soni *et al.*, 2022).

Radish *(Raphanus Sativus* L.) is an important vegetable crop (Pathak *et al.,* 2017). Radishes

ISBN 978-955-627-161-4

thrive as a cool weather crop and are best direct sown in early spring or late summer. While they prefer full sun, they can tolerate partial shade, though less than 6 hours of sunlight daily may slow their growth (Rakib *et al.*, 2013). For radishes, balanced fertilization plays a crucial role in promoting growth. The application of nitrogen in varying doses has been shown to enhance plant growth and increase radish yield (Kumar et al., 2022). Bio fertilizers improve agricultural yield and soil fertility, providing substantial advantages over traditional chemical fertilizers (Taha et al., 2010).

Biofilms are intricate communities composed of multiple microbial species, naturally attached to surfaces or physical interfaces. These biofilms can also be artificially developed in vitro using beneficial microbes to create Biofilm Biofertilizers (BFBFs). When applied to agricultural systems, BFBFs introduce sub-network components that integrate with the broader soil-plant-microbe network. (Premarathna et al., 2021). Biofilm biofertilizers are composed of beneficial microbial communities encapsulated within extracellular polymeric substances (EPS). This encapsulation helps stabilize soil structure, enhance nutrient solubilization, and improve water retention. When applied to soil, these bio fertilizers significantly enhance fertility by increasing the organic matter content, facilitating nutrient cycling, and boosting microbial activity. These changes create a more supportive environment for plant growth. As a result, biofilm bio fertilizers contribute to better root development, faster plant growth rates, and higher crop yields, making them an effective tool for sustainable agricultural practices (Salsabila *et al.,* 2024).

The combined application of fertilizers is a strategy aimed at boosting agricultural production while ensuring environmental sustainability for future generations. This approach integrates the use of both organic and inorganic plant nutrients to enhance crop productivity, prevent soil degradation, and meet future food supply demands. Notably, the residual effects are more significant when fertilizer is used in conjunction with organic manures, emphasizing the benefits of this integrated method (Ali *et al*., 2023).

II. METHODOLOGY

The radish seeds were collected from Agriculture seeds sales center, Eravur. This study was carried out to determine the appropriate application rate of this bio fertilizer for radish among the tested combination of inorganic fertilizer and bio fertilizer. The study used a completely randomized design (CRD), with ten each of the five treatments having 10 replicates each.

Table 01: Treatments used in the study

Treatment	Description
T_1	Recommended amount of chemical fertilizer by Department of Agriculture (RDOA)
T_2	1/2 RDOA of urea +Recommended amount of Triple super phosphate & Muriate of potash +250ml/ha Bio fertilizer
T_3	1/2 RDOA of urea + TSP&MOP +500ml/ha Bio fertilizer
T_4	1/2 RDOA of urea + TSP & MOP + 750ml/ha Bio fertilizer
T_5	1l/ha Bio fertilizer (Biofilm biofertilizer) alone

This experiment conducted using poly bags with height of 45 cm and diameter 40 cm. The pots were filled with the Top soil: Red soil: Compost in the ratio 2:1:1. Holes were made on bottom side of the bags to remove excess water. All of the pots were kept in the experiment area, with 30 cm between them. A total of 100 seeds were placed in a petri dish lined with moist Whatman paper. After 48 hours, the germination rate for the selected variety was determined by calculating the percentage of seeds that had germinated. The result showed a germination rate of 98%. Two seeds were seeded in each polybag after being soaked for 2 hours.

Irrigation was done twice a day in the morning and evening during the experimental period. Recommended inorganic fertilizer was applied to the radish plants according to the treatment structure. The basal fertilizer was applied two days before planting and the top dressing fertilizer was applied 3 weeks after planting according to DOA recommendation.

As per product label description recommendations. One liter of bio film biofertilizer is sufficient for 01 acre. Dilution guidelines are also specified on the product label. The fertilizer application was applied as soil application. In the study, the amount of urea was controlled, with half of the recommended dosage applied. Additionally, biofertilizer was incorporated in varying quantities in according to the treatment structure. The seedlings were thinned after 7 to 10 days of sowing, once seedlings have developed 2 to 3 true leaves. Keep the strongest seedling in each polybag and discard the weaker ones.

Weeding was done at two weeks interval in the pots. It was done manually. Leafy caterpillar's attacks were observed and those were controlled chemically in the stage of infestation by using profenopos insecticide (2ml/L).

Growth and yield parameters were collected. They are plant height, number of leaves, leaf area, leaf dry weight and fresh weight(g), Storage root (Tuber) length (cm), Fresh weight of storage root (g), Dry weight of storage root (g).

The plant height for each plant across all treatments and replications was recorded at one week's intervals. The measurements were taken from the ground surface to the growing tip of the plant using a meter scale. The numbers of leaves on each plant for each replication of all treatments were counted manually at one week's intervals, starting from planting and continuing until the final harvest. The leaf area of each leaf from every plant in each replication across all treatments was measured by manually. Weight of the plant in each replication in all treatment was measured using an electric balance. The plant was measured without allowing it to dry. Each plant in each replication in all treatment were cut into small pieces and placed in papers trays and then they were dried at 105°C in the oven until constant weight was gained and the dry weight was measured using electronic balance.

Storage root lengths of each plant in each replication in all treatments were measured by using measuring scale. Tuber of each plant in each replication in all treatments were collected and their fresh weight was measured by using an electronic balance. Tuber of each plant in each replication in all treatments were collected and their dry weight was measured by using an oven. Finally, the data were analyzed statistically using Minitab (Version 17), and mean comparisons among treatments were conducted using Turkey's HSD mean separation procedure at a 5% significance level.

III. RESULTS AND DISCUSSION

A. Growth parameters

Plant height is a key indicator of crop growth and nutrient uptake efficiency (Islam et al., 2017). Plant height of radish was measured at weekly interval (Table 02) and there were significant differences ($P<0.05$) among treatment up to 6^{th} week after planting (WAP). The findings indicate that bio fertilizer application significantly influenced plant height, with treated plants exhibiting greater growth compared to the control groups.

At the early growth stage (Weeks 1-2), plant height differences among treatments were minimal, indicating uniform germination and establishment. However, from Week 3 onward, radish plants treated with bio fertilizer T_3 and T_4 demonstrated a significant increase in height compared to the control treatment T_1. The tallest plants were observed in T_4 (38.31 cm), followed by T_3 (37.81 cm), while the control groups T_1 recorded the shortest plants at 34.55 cm at the 6^{th} week after planting.

Mean value in a column having dissimilar letter/letters indicate significant differences at 5% level of significance by Turkey's HSD test.

B. Number of Leaves

Radish plants treated with bio fertilizers, particularly T3 and T4, shown increased leaf development compared to the control (T1). The highest number of leaves was recorded in T4 (15.5 leaves). In contrast, the control treatment T1 exhibited the lowest leaf count, averaging 11.9 leaves at the 6 weeks after planting. This trend highlights the potential of bio fertilizers to enhance vegetative growth in radish plants.

It was observed that there were significant differences ($P < 0.05$) in leaf numbers among treatments. The combined application of inorganic fertilizers and bio fertilizers resulted in enhanced vegetative growth (Rather et al., 2018).

Table 02: Plant height of radish (cm) at different week after planting

Treatment	Week after planting (WAP)				
	2nd	3rd	4th	5th	6th
T_1	9.30±0.05^a	14.99±0.11^b	20.18±0.06^c	26.62±0.18^c	34.55±0.39^{ab}
T_2	9.65±0.01^a	14.51±0.10^c	20.55±0.05^d	25.15±0.09^d	35.75±0.10^b
T_3	9.96±0.04a	15.33±0.03^b	23.97±0.08^b	28.81±0.10^b	37.81±0.24^a
T_4	10.54±1.87^a	16.24±0.10^a	23.20±0.05^a	31.07±0.05^a	38.31±0.48^a
T_5	7.64±0.05^a	10.92±0.05^d	13.82±0.18^d	16.88±0.18^d	20.43±1.19^c
P-value	0.002	0.000	0.000	0.004	0.000

Radish plants treated with bio fertilizers, particularly T_3 and T_4, shown increased leaf development compared to the control (T_1). The highest number of leaves was recorded in T_4 (15.5 leaves). In contrast, the control treatment T_1 exhibited the lowest leaf count, averaging 11.9 leaves at the 6 weeks after planting. This trend highlights the potential of bio fertilizers to enhance vegetative growth in radish plants.

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Table 03: Number of leaves per plant at different week after planting

Treatment	Week after planting (WAP)				
	2nd	3rd	4th	5th	6th
T_1	4.60±0.16^{cd}	5.90±0.23^c	7.60±0.16^c	9.60±0.16^c	11.90±0.23^c
T_2	5.10±0.10^{bc}	6.80±0.24^b	8.50±0.16^b	10.40±0.16^b	12.60±0.16^{bc}
T_3	5.40±0.16^{ab}	7.60±0.16^{ab}	8.90±0.10^b	10.60±0.16^b	12.90±0.23^b
T_4	5.90±0.16^a	8.40±0.16^a	10.20±0.13^a	12.20±0.13^a	15.50±0.22^a
T_5	4.10±0.10^d	5.80±0.20^c	7.60±0.22^c	8.00±0.21^b	9.50±0.16^{bc}
p-value	0.000	0.000	0.010	0.000	0.002

Mean value in a column having dissimilar letter/letters indicate significant differences at 5% level of significance by Turkey's HSD test.

C. Leaf area (cm^2)

The initial growth period, all treatments exhibited similar leaf area, suggesting uniform seedling establishment. However, from Week 3 onward, significant variations were observed among treatments. Radish plants treated with bio fertilizers, particularly T_3 and T_4, showed greater leaf expansion compared to the control (T_1). At Week 6, the highest leaf area was recorded in T_4 (156.8 cm²), followed by T_3 (150.5 cm²), while the control treatment (T_1) exhibited the lowest leaf area (128.95 cm²). This indicates that bio fertilizer application positively influenced leaf area development. The increase in leaf area resulting from the application of organic and bio fertilizers can be attributed to their combined effect on soil properties. These fertilizers enhance both the physical and chemical characteristics of the soil, making macro- and micronutrients more readily available. Additionally, they promote enzymatic activities, which contribute to improved plant growth and development (Asghar *et al*., 2006).

Table 04: Leaf area (cm^2) per plant at different week after planting

Treatment	Week after planting (WAP)				
	2nd	3rd	4th	5th	6th
T_1	16.00±0.21^c	27.15±0.26^d	50.50±0.30^d	69.20±1.43^c	128.95±1.59^c
T_2	16.65±0.15^c	32.70±0.56^c	56.95±0.36^c	84.40±0.53^b	146.60±1.31^b
T_3	17.45±0.22^b	40.75±0.39^b	63.80±0.42^b	87.05±0.32^b	150.55±0.51^b
T_4	21.20±0.23^a	43.55±0.79^a	70.20±1.41^a	93.25±1.21^a	156.80±1.45^a
T_5	14.45±0.15^d	23.50±0.27^e	47.75±0.50^d	60.85±0.23^d	103.05±1.66^d
P-value	0.000	0.000	0.000	0.000	0.000

Mean value in a column having dissimilar letter/letters indicate significant differences at 5% level of significance by Turkey's HSD test.

ISBN 978-955-627-161-4

D. Yield parameters

1) Fresh and oven dry weight of plant

Radish plant was harvested 6th WAP and fresh and oven dry weight of plant were recorded. Average fresh and oven dry weight of plants are given in Table 05. Average fresh and oven dry weight of radish cutting are ranges from 32.73 to 57.82 and 3.5 to 7.01 g respectively. There were significant differences ($p<0.05$) among treatments and high values were obtained in treatment T_4. The result in this study real that combination of inorganic fertilizer with bio fertilizer (Biofilm) improve the crop leaf yield. The use of bio fertilizers significantly improved both the growth and yield characteristics of radish (Baloch *et al*., 2014).

Table 04: Fresh and oven dry weight (g) of plant 6th week after planting

Treatment	6th Week after planting (WAP)	
	Fresh weight	**Dry weight**
T_1	36.40 ± 0.78^{cd}	4.43 ± 0.09^{c}
T_2	38.84 ± 0.47^{c}	4.67 ± 0.02^{c}
T_3	43.58 ± 0.84^{b}	5.30 ± 0.10^{b}
T_4	57.82 ± 2.05^{a}	7.01 ± 0.29^{a}
T_5	32.73 ± 0.55^{d}	3.50 ± 0.05^{d}
p-value	0.001	0.000

Mean value in a column having dissimilar letter/letters indicate significant differences at 5% level of significance by Turkey's HSD test.

2) Storage root length and diameter

It was observed that there were significant differences ($p<0.05$) among the storage root length and diameter at 6th WAP (Table 06). Average tuber length and diameter of radish are ranges from 5.06 to 18.18 cm and 1.50 to 4.88 cm respectively. The high value obtained in the treatment T_4 and lowest value obtained in T_5. Jin *et al*. (2024) reported that, compared to inorganic fertilization and organic fertilization replacing 30% of chemical fertilizers with organic fertilizers increase in radish yield.

Table 06: Tuber length (cm) and diameter (cm^2)

Treatment	6th Week after planting (WAP)	
	Tuber length	**Tuber diameter**
T1	15.04 ± 0.19^{b}	4.12 ± 0.08^{c}
T2	13.55 ± 0.11^{c}	3.51 ± 0.07^{d}
T3	17.49 ± 0.12^{a}	4.49 ± 0.11^{b}
T4	18.18 ± 0.05^{a}	4.88 ± 0.04^{a}
T5	5.06 ± 0.31^{d}	1.50 ± 0.08^{e}
p-value	0.000	0.001

Mean value in a column having dissimilar letter/letters indicate significant differences at 5% level of significance by Turkey's studentized test

IV. CONCLUSION

Growth parameters such as plant height, number of leaves, and leaf area were notably higher in treatments biofertilizer combined with inorganic compared to inorganic alone as well as biofertilizer alone. The tallest plants were observed in T_4, and the highest number of leaves was recorded in T_4, indicating the positive impact of biofertilizers on vegetative growth. Similarly, leaf area development was significantly enhanced in treatments incorporating biofertilizers, with T_4 recording the highest value at the 6th week after planting. Yield parameters such as fresh and oven-dry weights of the plant and also exhibited significant variations among treatments. The combination of biofertilizers and inorganic fertilizers resulted in the highest fresh and dry weight values in T_4, Additionally, tuber length and diameter were significantly greater in T_4 compared to other treatments, emphasizing the role of biofertilizers in improving tuber development. The results align with previous studies that suggest biofertilizers enhance soil microbial activity, improve nutrient availability, and contribute to better plant growth and yield. The study supports the use of biofertilizers in combination with inorganic fertilizers as a sustainable approach to improving crop yield. Future research should focus on optimizing the biofertilizer formulations and exploring their long-term effects on soil health and productivity.

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ISBN 978-955-627-161-4