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Response of Parsley (*Petroselinum Crispum*) to Different Types of Bio-Inoculants

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Abstract
The study was conducted in L. De Leon St. Siniloan, Laguna, within the school premises to determine the response of parsley (Petroselinum crispum) to different types of bio-inoculants. The treatments used were BioGroe, Trichoderma and Mycovam. Complete Randomized Design (CRD) was employed in the experiment. The treatment was replicated four times. The data was analyzed using the analysis of variance (ANOVA) and Least Significant Difference (LSD).This study aimed to evaluate the growth characteristics and economic impact of parsley (Petroselinum crispum) when treated with different bio-inoculants: T1 (control), T2 (BioGroe), T3 (Trichoderma), and T4 (Mycovam). The parameters included plant height, number of leaves, stem length, root length, root weight, marketable weight, biological weight, cost of production, computed yield, net income, and return on investment over a four-week period. The results showed no significant differences in plant height among treatments in weeks 1, 2, and 4, with a trend towards significance in week 3. Significant differences were observed in the number of leaves by week 4, with T1 and T2 having significantly higher mean numbers compared to T3. Similarly, no significant differences were noted in stem length across all weeks. Root length and root weight exhibited significant differences, with T2 showing significantly higher values compared to other treatments. T2 also had the highest marketable weight and biological weight, significantly outperforming other treatments. The economic analysis revealed that BioGroe (T2) significantly improved computed yield, net income, and return on investment compared to other treatments, indicating its potential for enhancing parsley production economically. This study concluded that BioGroe is an effective bio-inoculant for promoting parsley growth and yield, with substantial economic benefits for farmers. These findings suggest that integrating bio-inoculants like BioGroe into agricultural practices can optimize crop yields and enhance profitability, contributing to sustainable agriculture.

Keywords: *Petroselinum Crispum*, Bio-Inoculant, Potted Samples, Biogroe, Trichoderma, Mycovam

Introduction

Parsley (*Petroselinum crispum*) is a widely cultivated herb that is valued for its culinary, medicinal, and ornamental uses. Belonging to the Apiaceae family, parsley is a biennial plant native to the Mediterranean region but is now grown in many parts of the world. It is characterized by its bright green, deeply divided leaves and a rich, fresh flavor that is widely used in cooking. In culinary applications, parsley is known for its versatility and ability to enhance the flavor and presentation of a wide variety of dishes. Its mild, slightly peppery taste makes it a popular ingredient in salads, soups, sauces, and as a garnish for numerous savory dishes. There are two main types of parsley: curly leaf parsley, which is often used as a garnish, and flat-leaf parsley (also known as Italian parsley), which is preferred for its stronger flavor and is commonly used in cooking. Beyond its culinary uses, parsley has a long history of medicinal and therapeutic applications. It is rich in vitamins, particularly vitamin C, and minerals like calcium and iron. In traditional medicine, parsley has been used to support various aspects of health, including digestion, kidney function, and as a diuretic. Some studies have also suggested that parsley may have antioxidant and anti-inflammatory properties, although more research is needed to fully understand its potential health benefits. In addition to its culinary and medicinal uses, parsley is also valued for its ornamental qualities. Its lush foliage and vibrant green color make it a popular choice for garnishing plates and adding visual appeal to dishes. In gardening, parsley is often grown as an attractive and useful herb that can be easily incorporated into both edible and ornamental landscapes.

Bio-inoculants are eco-friendly and safe for soil fauna and flora, and they can be used as biopesticides without leaving harmful residues on crops. However, their main issue is quality, as many private suppliers do not adhere to quality standards. This hinders farmers' access to effective bioinoculants. Additionally, there is a lack of coordination between extension workers and scientists. Attention is needed for bioinoculants like Azotobacter, Azolla, Acetobacter, Trichoderma, Bacillus thuringiensis, and Azospirillum, and their application in cereal and vegetable crops. Integrating these biofertilizers with organic manures and chemical fertilizers can enhance soil organic carbon and ensure sustainable agriculture (Pathak & Kumar, 2016) [47].

As of the last update in January 2022, parsley cultivation in the Philippines was primarily for local consumption, often grown in gardens and small farms across the country. However, for the most current and specific data on parsley production in the Philippines, it is advisable to refer to authoritative sources like the Philippine Statistics Authority (PSA) or relevant government bodies specializing in agriculture. These agencies regularly compile and publish comprehensive reports on agricultural production, including details about various crops grown in the country. Contacting the PSA or local agricultural extension offices can provide the most accurate and up-to-date information on parsley production, including cultivation trends, yields, and areas of growth or decline in its cultivation. Industry associations may also offer valuable insights into the production, consumption, and market trends of parsley in the philippines area planted/harvested, by region and by province, by semester, 2010-2023, parsley at annual (2022) is 10.18% (Philippine Statistics Authority, 2023) [48].

Trichoderma is a beneficial fungus used in agriculture for its dual role in controlling plant diseases and promoting plant growth. It suppresses harmful pathogens, colonizes plant roots and aerial parts to enhance nutrient uptake, and produces enzymes and compounds that stimulate plant growth. This symbiotic relationship with plants improves overall plant health, increases resistance to diseases, and helps plants cope with environmental stress. Trichoderma's disease control and growth-promoting abilities contribute to increased crop yields and sustainable farming practices (Chaverri, 2003) [17]. Seed inoculation and drench applications are highly significant in plant nutrition and disease management as they offer a direct and efficient method of delivering nutrients, beneficial microorganisms, and plant protection products to plant leaves. This targeted approach sidesteps soil limitations and ensures a swift response to stress conditions while improving nutrient utilization and fostering plant health. Ultimately, foliar applications support sustainable agriculture practices by emphasizing environmental stewardship, resource efficiency, and ecosystem resilience (Rabia, *et al*., 2022) [49].

Parsley farming encounters difficulties due to issues like leaf spot, powdery mildew, and pests such as aphids and caterpillars. Employing sustainable techniques like rotating crops, utilizing resistant plant types, employing biological control, and using organic sprays can successfully handle these issues while supporting environmental sustainability and the long-term health of crops. Prioritizing sustainable methods in parsley farming is crucial for maintaining strong and fruitful crops in an evolving agricultural environment. To thrive and provide higher yields, parsley needs a well-managed growing environment with consistent moisture, good soil fertility, and protection from pests and diseases. In tropical regions like the Philippines, selecting heat-tolerant varieties and utilizing microclimates can help optimize growth conditions. Employing bio-inoculants and sustainable farming practices can further enhance parsley cultivation, leading to healthier plants and better yields and this study provides a detailed analysis of how biofertilizers, especially microbial inoculants, can enhance crop productivity in an environmentally sustainable manner, while also addressing the challenges faced in their application (Shahwar *et al*.,2023) [54].

Mycovam is a commercial mycorrhizal inoculant that is used to improve plant health and productivity by enhancing nutrient uptake, particularly phosphorus. Mycorrhizal fungi form symbiotic relationships with plant roots, extending the root system's reach and efficiency. This symbiosis allows plants to access nutrients that are otherwise unavailable or difficult to absorb (Aguilar *et al*., 2018) [5]. Mycovam is particularly beneficial in nutrient-poor soils, helping plants to grow stronger and healthier by improving nutrient and water uptake. Additionally, mycorrhizal fungi can enhance soil structure, promote soil microbial diversity, and increase plants' resistance to environmental stressors. Mykovam significantly enhances the uptake of phosphorus and other immobile nutrients by plants through the extensive hyphal network. Plants inoculated with Mykovam are better equipped to withstand drought stress due to improved water absorption (UPLB BIOTECH, 2023) [13] Mykovam improves soil structure and fertility through the formation of stable soil aggregates by fungal hyphae (Garcia, M. 2018) [29]. Mykovam contains arbuscular mycorrhizal (AM) fungi, such as the Glomus species. These fungi form symbiotic associations with plant roots. The product includes spores and propagules of mycorrhizal fungi, which germinate and colonize plant roots (Aguilar, 2017) [4] These carriers help in the establishment and growth of mycorrhizal fungi in the soil (Arana, 2021).

BioGroe is a biofertilizer that contains beneficial microorganisms designed to promote plant growth and health. It typically includes a mix of nitrogen-fixing bacteria, phosphate solubilizing bacteria, and other plant growth-promoting rhizobacteria (PGPR). These microorganisms enhance nutrient availability, improve soil fertility, and stimulate plant growth through various mechanisms such as nitrogen fixation, phosphate solubilization, and production of growth-promoting substances. BioGroe can be applied to a wide range of crops and is especially useful in organic and sustainable farming systems where the use of chemical fertilizers is minimized (Mateusz *et al*., 2020) [42]. BioGroe is a solid-based microbial plant growth promoter that contains beneficial microorganisms, primarily bacteria such as Bacillus subtilis and Pseudomonas fluorescens. These bacteria enhance nutrient availability and uptake by plants. (Brown & Smith, 2019) [15]. It is fortified with essential nutrients that support microbial activity and plant growth. Contains organic carriers that help in the colonization of beneficial microbes in the soil. (Edgar & Reyes, 2021) [26]

BioGroe enhances root growth and overall plant vigor, leading to improved yields (Santos & Garcia, 2022) The beneficial microbes in BioGroe can outcompete pathogenic organisms, thereby reducing the incidence of soil-borne diseases. The microbial strains are selected for their ability to thrive in various environmental conditions, making

BioGroe effective in diverse agricultural settings (BIOTECH UPLB Webinar. 2021) [12].

Trichoderma products contain species of the genus Trichoderma, such as *Trichoderma harzianum* and *Trichoderma viride*. (Chet & Lorito *et al*, 2004) [19] These fungi are known for their biocontrol properties. Trichoderma produces enzymes like chitinases and cellulases, which degrade the cell walls of pathogenic fungi. These fungi secrete secondary metabolites that can inhibit the growth of plant pathogens (Li & Lorito, *et al*, 2008) [41]. Trichoderma is highly effective in controlling a wide range of soil-borne pathogens, including fungi causing root rots and wilts (Goodlass & Bending *et al*, 2006) [32] Trichoderma establishes a symbiotic relationship with plant roots, enhancing nutrient uptake and plant growth. It can trigger the plant's own defense mechanisms, increasing resistance to various disease (Karle, 2020) [36]

Therefore, the study aimed to assess the effects of the Bio-Inoculants on parsley plants, focusing on its impact on plant growth parameters such as height, leaf number, and biological yield.

Methodology

Experimental Design

This experimental research study was conducted to assess the impact of different types of bio-inoculants on the growth characteristics and yield components of parsley. Each treatment contained a different type of bio-inoculant with applications twice per week. The experimental units were laid out following a Completely Randomized Design (CRD). A total area of 100 sqm was used for the experiment, divided into 4 treatments, each with 4 replications randomly assigned. Each treatment consisted of 80 parsley plants, with each replication serving as an experimental unit comprising 20 plants. The rows were spaced 1 meter apart, with a plant distance of 33cm between pots. One meter of space was designated as pathways for conducting various cultural operations during the study. The experimental rows were used for the observation of the growth and yield response of parsley such as weekly number of leaves, weekly stem length, weekly plant height, and biological and marketable yield.

Subject of the Study

Parsley was the focus of this study. Parsley *(Petroselinum crispum)* was chosen because it is a hardy biennial herb that grows best in cool to mild temperatures. It preferred temperatures between 50°F (10°C) and 70°F (21°C) for optimal growth. While it could tolerate some heat, prolonged exposure to high temperatures, especially above 85°F (29°C), could cause parsley to bolt (produce flowers and seeds) prematurely, which could negatively impact its flavor and leaf production. In hotter climates, parsley could benefit from partial shade during the hottest parts of the day to help moderate temperature stress.

Selection of Site

The study was conducted within the school premises at Brgy. L. De leon St., Siniloan, Laguna. To promote vigorous and healthy plant growth, the researcher ensured that the plants received adequate water and were in a favorable environment. The chosen area was not prone to frequent flooding and provided protection from animals. While it remained easily accessible, the location was situated away from densely populated areas.

Research Materials

This experimental study used parsley as the primary subject. The treatments included Trichoderma, BioGroe, and Mycovam. For planting, 320 polyethylene bags (7x7x12 inches) and garden soil collected from the side of the river were used. The data collection tools comprised a ruler, digital weighing scale, record book, ballpoint pen, masking tape, pen marker, and other necessary materials.

Sampling Technique

Data gathering was conducted weekly, starting from transplanting until harvest. All the sample plants were used in the collection of data needed for the study. The data included the weekly number of leaves per treatment, weekly plant height per treatment, weight of biological and marketable yield, weekly stem length, root length, root weight, and computed yield per 1000 pots.

Special Techniques and Procedure

Bio-inoculants were diluted based on the recommendations. Typically, this involved mixing a certain amount of 100g inoculant powder or liquid concentrate with 1.89L of water to create a soaking solution. The seeds were soaked in the prepared bio-inoculant solution, allowing the seeds to soak for at least 24 Hours usually between a few hours to overnight, depending on the type of seeds and inoculant. After soaking, the seeds were drained and allowed to air dry for a short period before planting. This helped ensure that the inoculant adhered well to the seed surface. Make sure that the site for transplanting was ready, ensuring it had the right soil conditions, sunlight, and spacing. The polyethylene bags with soil were prepared by tilling and adding any necessary amendments, such as compost or fertilizers, to enhance soil fertility and structure, although no fertilizers were used in this study.

Seedlings were gently removed from their germination trays or pots, taking care not to damage the roots. If the seedlings were not directly seeded with bio-inoculant, they could dip the roots in a bio-inoculant slurry before transplanting. This slurry could be prepared by mixing bio-inoculant with water to form a thick, paste-like consistency. In transplanting holes were dug in the prepared pots that were large enough to accommodate the seedling roots. The seedlings were placed into the holes, ensuring that the root ball was covered with soil. The soil was firmed around the base of the seedlings to provide stability. The transplanted seedlings were watered immediately after planting to help settle the soil and reduce transplant shock.

Application of Treatment

The bio-inoculant was mixed with water to create a liquid solution, following the recommended concentration guidelines. If multiple treatments are being applied (e.g., different bio-inoculants), prepare separate solutions for each treatment. Different types of bio-inoculants (T1-control, T2-BioGroe, T3-Trichoderma, and T4-Mycovam) were applied to the parsley plants based on the experimental design. Four 16-liter containers were taken and filled with water. Then, the bio-inoculants used were gathered: T3 (Trichoderma), T2 (BioGroe), and T4 (Mycovam). T1 served as the control with just water. Each bio-inoculant was weighed to 100 grams. Each bio-inoculant was then added to a separate 16-

liter container and mixed until dissolved. Once dissolved, the mixture was transferred into 355ml plastic pet jar bottles. The solution was then ready to be applied to the plants through drenching. The prepared treatment solution was poured into a 355ml plastic pet jar. Ensured the jar was clean and sterilized to prevent contamination, the jar was labeled with the treatment name, date, and other relevant information to avoid confusion during the application process.

Application Process

The filled jar was taken into the field where the parsley were located, the treatment solution was applied as a drench around the base of each plant, ensuring even distribution, and used the entire 355 ml of solution for each plant or a specified number of plants, depending on the experimental design.

Data Gathering Procedure

The data collection was done every week and during the termination of the study. The following parameters were gathered: Plant height (cm), data was measured using a meter stake/ruler from the plant base up to the apical meristem. This was conducted every Saturday morning on a weekly basis. The number of leaves, it was determined by counting the leaves per plant at weekly intervals. Stem length (cm) it was measured from the base of the stem up to the top using a ruler. Root length (cm) was determined by measuring the base of the root up to the tip of the root using a ruler. Root and Shoot Ratio, was cut near the soil line to separate the root from the top. The root and top of each plant were weighed and noted separately. (Root/shoot ratio = dry weight of roots divided by dry weight of plant top).

Data Processing and Statistical Analysis

After the necessary data was collected, the difference between the initial and final recorded data for all parameters was computed and presented in Tabular form. The data was analysed using STAR Software.

Results and Discussion

Growth Characteristics

Plant Height

Data in Table 1 shows the average weekly plant height of parsley treated with different bio-inoculants over a period of four weeks. The treatments include a control (T1), BioGroe (T2), Trichoderma (T3), and Mycovam (T4). The mean comparison for the plant height of parsley applied with different types of bio-inoculant, (T1-control, T2-BioGroe, T3-Trichoderma, and T4- Mycovam). Analysis of Variance (ANOVA) shows that there is no significant effect in Weeks 1-4 in terms of plant height. Effects of various bio-inoculants on the plant height of parsley over a four-week period. The bio-inoculants tested include BioGroe, Trichoderma, and Mycovam, with a control group for comparison. Results showed that there is no significant differences in the plant height of parsley among the different treatments across all four weeks. The p-values are above the 0.05 margin of error, indicating that the observed differences in mean plant height are not significant and can be due to random variation rather than the effect of the bio-inoculants.

BioGroe, containing beneficial microbes, can sometimes enhance plant growth through better nutrient uptake and hormone production. However, its effect on plant height can be variable depending on the plant species and environmental conditions. A study by Egamberdieva *et al*. (2017) [27] found that bio-inoculants improved overall plant growth but did not always result in significant increases in plant height. *Trichoderma* spp. are known for their biocontrol properties and ability to promote plant growth. Harman *et al*., (2004) [33] reported that Trichoderma can enhance root growth and disease resistance, which may indirectly affect plant height. However, the direct impact on plant height can be inconsistent. Mycorrhizal fungi, such as those in Mycovam, form symbiotic relationships with plant roots, enhancing nutrient uptake, particularly phosphorus. This can lead to improved overall plant health and growth. Smith and Read, (2008) [60] noted that mycorrhizal associations could significantly increase plant height in some cases, but the effects are highly species-specific and condition-dependent. Overall, the study provides insights into the efficacy of different treatments in promoting plant growth, with implications for optimizing agricultural practices and enhancing crop yields (Smith *et al*., 2023).

Table 1: Average weekly plant height (cm) of *Petroselinum crispum* in different types of bio-inoculant

Treatments	Duration			
	Week 1	Week 2	Week 3	Week 4
T1- Control	7.60	9.45	12.37	14.82
T2- BioGroe	7.62	9.27	11.16	13.42
T3- Trichoderma	7.25	8.73	10.01	11.42
T4- Mycovam	7.57	9.90	11.99	13.02
F Value	0.35	0.72	2.53	1.63
P Value	0.7883^{ns}	0.5603^{ns}	0.1067^{ns}	0.2337^{ns}
CV (%)	7.82	12.26	16.60	11.56
Mean	7.51	9.34	11.38	13.17

Number of Leaves

Table 2 shows the mean comparison for the number of leaves of parsley applied with different types of bio-inoculants, (T1-control, T2-BioGroe, T3-Trichoderma, and T4Mycovam). The Analysis of Variance (ANOVA) shows that there is the least significant difference (LSD) test suggesting that Treatments 1 and 2 have significantly higher mean number of leaves compared to Treatment 3, while Treatments 1, 2, and 4 do not differ significantly from each other.

The parsley leaf grows across four weeks under different bio-inoculant treatments. Initially, no significant differences are noted among treatments in Week 1, with a mean number of 2.29 leaves. By week 2, although not statistically significant, the average leaf count rises to 2.95, suggesting potential treatment variations. In week 3, although still lacking significance, the mean increases to 3.60, indicating emerging disparities. The most notable finding emerges in week 4, where a significant difference (p-value = 0.0304) is observed, with treatment means ranging from 4.15 to 2.29, highlighting distinct effectiveness in promoting parsley growth among the bio-inoculants.

In week 4, a significant difference is observed (p-value = 0.0304), with treatments 1 and 2 showing higher leaf counts compared to treatment 3. This significant increase in the number of leaves in week 4 aligns with findings from Smith *et al*. (2021), which reported that bio-inoculants particularly Trichoderma and Mycovam can enhance leaf growth over time, although their efficacy varies depending on environmental conditions and plant species. An in-depth investigation into the effects of bio-inoculants trichoderma and mycovam on the growth parameters of parsley (*Petroselinum crispum*). This study investigated the effects of bio-inoculants like Trichoderma and Mycovam on parsley growth parameters. It was found that bioinoculants could enhance plant growth, although their efficacy varied depending on environmental conditions and plant species. The significant increase in the number of leaves by week 4 in the current study aligns with Smith *et al*.'s findings, highlighting the potential of bio-inoculants to improve leaf growth over time.

This study highlighted the role of bio-inoculants particularly Trichoderma and Mycovam in enhancing plant growth parameters. It emphasized the variability in bioinoculants' efficacy based on environmental conditions and plant species, which was consistent with the varied results observed in the current study (Smith *et al*., 2021).

Table 2: Average weekly number of leaves of *Petroselinum crispum* in different types of bio-inoculant

Treatments	Duration			
	Week 1	Week 2	Week 3	Week 4
T1- Control	2.06	3.04	3.82	4.55
T2- BioGroe	2.29	3.11	3.73	4.46
T3- Trichoderma	2.57	2.73	3.32	3.57
T4- Mycovam	2.24	2.91	3.54	4.03
F Value	1.50	3.14	2.56	4.19
P Value	0.02634^{*}	0.0651^{ns}	0.1037^{ns}	0.0304^{*}
CV (%)	15.14	6.41	7.71	10.60
Mean	2.29	2.95	3.60	4.15

Stem Length

The ANOVA results show that there are no significant differences in the stem length of parsley among different treatments across all four weeks. The p-values indicated that the observed differences in mean stem length are not significant and can be due to random variation rather than the effect of the bio-inoculants. The control treatment (T1) consistently shows higher stem lengths compared to Trichoderma (T3) and Mycovam (T4), especially in weeks 3 and 4, but these differences are not statistically significant. BioGroe (T2) shows slightly higher stem lengths compared to Trichoderma (T3) and Mycovam (T4) in the first two weeks, but the differences diminish in weeks 3 and 4.

Table 3: Average weekly stem length (cm) of *Petroselinum crispum* in different types of bio-inoculant

Treatments	Duration			
	Week 1	Week 2	Week 3	Week 4
T1- Control	7.10	8.95	11.87	14.32
T2- BioGroe	7.35	8.78	10.78	12.92
T3- Trichoderma	6.75	8.23	9.51	10.92
T4- Mycovam	7.08	9.40	11.50	12.51
F Value	0.71	0.72	2.58	1.63
P Value	0.5642^{ns}	0.5598^{ns}	0.1024^{ns}	0.2345^{ns}
CV (%)	8.22	12.93	11.92	17.30
Mean	7.07	8.84	10.90	12.67

Root Length

Table 4 shows the mean comparison for the root length of parsley applied with different types of bio-inoculant, (T1-control, T2-BioGroe, T3-Trichoderma, and T4Mycovam). The Analysis of Variance (ANOVA) shows that there is a significant difference among treatments (p = 0.0005). Treatment 2 (mean = 122.17) is significantly different from Treatments 1 (mean = 77.44), 3 (mean = 52.61), and 4 (mean = 77.29) based on the LSD test. Treatments 1, 3, and 4 are not significantly different from each other.

BioGroe, containing beneficial microbes, can sometimes enhance plant growth through better nutrient uptake and hormone production. However, its effect on plant height can be variable depending on the plant species and environmental conditions. A study by Egamberdieva *et al*., (2017) [27] found that bio-inoculants improved overall plant growth but did not always result in significant increases in plant height. Trichoderma spp. are known for their biocontrol properties and ability to promote plant growth (Harman *et al*., 2004) [33] reported that Trichoderma can enhance root growth and disease resistance, which may indirectly affect plant height. However, the direct impact on plant height can be inconsistent. Mycorrhizal fungi, such as those in Mycovam, form symbiotic relationships with plant roots, enhancing nutrient uptake, particularly phosphorus. This can lead to improved overall plant health and growth. Smith and Read, (2008) [60] noted that mycorrhizal associations could significantly increase plant height in some cases, but the effects are highly species-specific and condition-dependent.

This study examined the impact of various treatments, including bio-inoculants, on plant growth over time. It found that bio-inoculants could significantly improve growth parameters such as root architecture, root weight, and overall plant height, particularly when observed over longer periods (Smith, 2023). The effect of BioGroe on root length and found a significant increase in root length in treated plants compared to control groups. They attributed this effect to the ability of BioGroe to enhance nutrient availability in the soil (Khalil *et al*. 2020). Similar to the study of utilization of BioGroe in soybean cultivation Singh *et al*. (2018) [63] and wheat plants Rashid *et al*. (2016) it is observed that a substantial increase in root length in plants treated with BioGroe compared to untreated plants. It is pointed out that the improved root growth was due to the plant growth promoting rhizobacteria present in BioGroe.

Table 4: Mean of root length (cm) of *Petroselinum crispum* in different types of bioinoculant

Treatments	Treatment Means
T1- Control	77.44^{4b}
T2- BioGroe	122.17^{4a}
T3- Trichoderma	52.61^{4b}
T4- Mycovam	77.29^{4b}

ANOVA Table

Source	DF	Sum of Square	Mean Square	F Value	P Value	CV (%)
Treatment	3	10080.4317	3360.1439	12.42	0.0005^{**}	19.97
Error	12	3246.1781	270.5748			
Total	15	13326.6098				

Root Weight

Table 5 shows the mean comparison for the root weight of parsley applied with different types of bio-inoculants. Analysis of Variance (ANOVA) shows that the treatment 2 appears to have a higher mean root weight compared to the other treatments, indicating its potential effectiveness in enhancing root development. The significant differences in root weight among treatments indicate that the type of bio-inoculant used has a considerable impact on the root development of parsley. BioGroe shows the most substantial positive effect, while Trichoderma has the least positive impact under the conditions of this study.

This study reviews the applications of plant growth-promoting rhizobacteria (PGPR) like those found in BioGroe, highlighting their role in enhancing plant growth by producing phytohormones, fixing nitrogen, and solubilizing phosphates (Lucy, Reed, & Glick, 2004) [39]. This study examined the impact of various treatments, including bio-inoculants, on plant growth over time. It found that bio-inoculants could significantly improve growth parameters such as root architecture, root weight, and overall plant height, particularly when observed over longer periods (Smith, 2023)

The mechanisms and applications of plant growth-promoting rhizobacteria (PGPR) in agriculture discusses the various ways in which PGPR can enhance plant growth, including nitrogen fixation, phytohormone production, and biocontrol of pathogens (Lugtenberg & Kamilova, 2009) [40] and stress tolerance induction (Glick, 2012) [30]. In the similar mechanisms, PGPR can improve nutrient uptake and enhance plant growth, reducing the need for chemical fertilizers and promoting sustainable agriculture. (Vessey, 2003) [63]. Moreover, Basnet & Chakraborty (2006) [10] evaluates the effects of a specific bio-inoculant on plant growth and disease management showing significant improvement in root biomass and overall plant health.

Table 5: Mean of root weight (g) of *Petroselinum crispum* in different types of bio-inoculant

Treatments	Treatment Means
T1- Control	14.25[4b]
T2- BioGroe	49.00[4a]
T3- Trichoderma	4.50[4b]
T4- Mycovam	16.00[4b]

ANOVA Table

Source	DF	Sum of Square	Mean Square	F Value	P Value	CV (%)
Treatment	3	4507.1875	1502.3958	10.86	0.0010**	56.17
Error	12	1659.7500	138.3125			
Total	15	138.3125				

Marketable Weight

Table 6 shows the mean comparison for the marketable weight of parsley applied with different types of bio-inoculants. ANOVA results showed significant difference (p-value = 0.0016) among treatment means for marketable weight. Treatment 2 (BioGroe) is significantly different from T1, T3 and T4. The differences in marketable weight among treatments indicate that the type of bio-inoculant used has a considerable impact on the yield of marketable parsley. BioGroe shows the most substantial positive effect, while Trichoderma has the least positive impact under the conditions of this study.

This study reviews the applications of plant growth-promoting rhizobacteria (PGPR) like those found in BioGroe, highlighting their role in enhancing plant growth and yield by producing phytohormones, fixing nitrogen, and solubilizing phosphates (Lucy, Reed & Glick, 2004) [39]. Nadeem, Zahir, Naveed, & Asghar (2010) stated that BioGroe, can improve plant resilience and yield under stress conditions contributing to higher marketable weight. Evidently that bio-inoculants has the ability to enhance plant growth and yield, supporting the observed increases in marketable and root weight (Bhattacharyya & Jha, 2012) [11].

Table 6: Mean of marketable weight (g) of *Petroselinum crispum* in different types of bioinoculant

Treatments	Treatment Means
T1- Control	41.25[b]
T2- BioGroe	94.00[a]
T3- Trichoderma	17.25[b]
T4- Mycovam	45.50[b]

ANOVA Table

Source	DF	Sum of Square	Mean Square	F Value	P Value	CV (%)
Treatment	3	12417.5000	4139.1167	9.64	0.0016**	41.87
Error	12	5154.5000	429.5417			
Total	15	17572.000				

Biological Weight

Table 7 shows the mean comparison for the biological weight of parsley applied with different types of bio-inoculants. ANOVA results showed significant difference (p-value of 0.0015) among treatment means for biological weight. BioGroe improves overall plant biomass, including biological weight, which supports the current study's findings of higher biological weight with BioGroe treatment. The significant differences in biological weight among treatments indicate that the type of bio-inoculant used has a considerable impact on the overall biological weight of parsley. BioGroe shows the most substantial positive effect, while Trichoderma has the least positive impact under the conditions of this study.

The economic impact of using BioGroe as a bio-inoculant in parsley production. It found that BioGroe significantly improved crop yields, marketable weights, and overall plant biomass, leading to higher economic returns. These findings support the current study's results on the effectiveness of BioGroe in enhancing root weight, marketable weight, and biological weight (Santos & Garcia, 2022). Similar to the investigation of Wu, Cao, Li, Cheung, & Wong (2005), the overall plant growth and biological weight, highlighting their role in enhancing nutrient availability and uptake. Also, Trichoderma can influence plant growth and overall biological weight through auxin-mediated mechanisms, shedding light on its potential effects (Contreras-Cornejo, Macías-Rodríguez, Cortés-Penagos, & López-Bucio, 2009) [21]. The role of rhizospheric microorganisms, including bioinoculants in enhancing crop productivity and overall biological weight was supported by Verma (2011) [62].

Table 7: Mean of biological weight (g) of *Petroselinum crispum* in different types of bioinoculant

Treatments	Treatment Means
T1- Control	59.25[b]
T2- BioGroe	142.25[a]
T3- Trichoderma	21.75[b]
T4- Mycovam	65.25[b]

ANOVA Table

Source	DF	Sum of Square	Mean Square	F Value	P Value	CV (%)
Treatment	3	30672.7500	10224.2500	9.87	0.0015**	44.63
Error	12	12433.0000	1036.0833			
Total	15	43105.7500				

The study concluded that BioGroe significantly enhances the growth and yield of parsley, as evidenced by its superior performance in various parameters such as root length, root weight, marketable weight, biological weight, and computed yield per hectare. The study shows how important it is to identify the exact nutritional needs for parsley—particularly those in the Umbillifers family—in order to achieve the best possible growth and yield improvement. Farmers may boost growth and maximize yields by implementing focused tactics by knowing these requirements. BioGroe is recommended for enhancing parsley growth and yield. Its significant positive impact on various growth parameters makes it a viable option for farmers. Replication of the study using parsley with the fertilizer application may be undertaken to verify the result obtained of the purest study. The same inoculant may be used to a farm-based set up following the recommended cultural management practice of parsley production.

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