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Effect Bioameliorants and Interval of Ready-to-Absorb Nutrient Solution on Soil Health, Crop Productivity, and Quality of Chili Pepper Yields

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ABSTRACT: Red chili peppers have high economic value due to increasing consumer demand, particularly in large cities, which require about 800,000 tons per year. Despite an increase in production from 1,360,571 tons in 2021 to 1,475,821 tons in 2022, productivity is hindered by reduced harvested area and soil degradation due to the excessive use of chemicals and inorganic fertilizers. This study aims to examine the interaction between bioameliorant application and intervals of ready-to-use nutrient solution on soil health, productivity, and the quality of chili yields, as well as to determine the optimal dosage. The study utilized a factorial Randomized Block Design (RBD) with two factors: bioameliorant dosage (0, 3, and 6 tons/ha) and ready-to-absorb nutrient solution application intervals (every 1, 3, and 5 days), with three replications. Observed responses included populations of PSB, Azotobacter, Azospirillum, total bacterial populations, organic carbon (C-Organic), pH, fruit number per plant, fruit weight per plant, and yield quality. The results indicated that the interaction between bioameliorant and ready-to-absorb nutrient solution intervals significantly affected C-Organic levels. Total bacterial populations were independently influenced by bioameliorant dosage and ready-to-absorb nutrient solution intervals, while fruit weight per plant and grade B yield quality were independently influenced by ready-to-absorb nutrient solution intervals. The highest C-Organic level was achieved with 6 tons/ha of bioameliorant and ready-to-absorb nutrient solution applied every day. The highest total bacterial population was obtained with 6 tons/ha of bioameliorant. The highest total bacterial population and fruit weight per plant were achieved with ready-to-absorb nutrient solution applied daily.

KEYWORDS: bioameliorant, nutrient solution, productivity, red chili, soil health.

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1. INTRODUCTION

Red chili plants are one of the horticultural crops with significant economic value. Large cities with populations of one million or more require about 800,000 tons/year or 66,000 tons/month of chilies (Ermawati et al., 2021). In line with this, according to data from the Badan Pusat Statistik, (2022), household consumption of large chilies increased by 9.94%, from 446.46 thousand tons in 2020 to 490.83 thousand tons in 2021. The increase in chili consumption in Indonesia must be supported by adequate production. Throughout 2022, the production of red chilies in Indonesia reached 1,475,821 tons, an increase from 1,360,571 tons in 2021 (Badan Pusat Statistik, 2023). The rise in consumption demands an expansion of cultivated land area; however, the reality does not meet this expectation. According to data from the Badan Pusat Statistik, (2022), the harvested area for large chili plants in Indonesia has been declining over the past three years. The harvested area for large chili plants in Indonesia decreased from 133,729 hectares in 2020 to 49,713 hectares in 2022. This decline in harvested area is also influenced by the conditions of the areas where red chili plants are cultivated.

The reduction in agricultural land area is one of the causes of decreased production. Cultivation in polybags is an alternative method that can address the reduction in land area and is both easy and cost-effective to implement (Iskandar, 2016). Cultivation in polybags requires careful attention to seed selection, seedling preparation, choice of growing media, planting, maintenance, and harvesting (Warnita & Aisman, 2017). The increase in red chili production is closely linked to the application of fertilizers, with inorganic fertilizers being commonly used due to their availability, despite their relatively higher cost (Dewanto et al., 2013). However, over time, the excessive use of inorganic fertilizers has led to negative environmental impacts and a decline in soil quality, such as a decrease in soil organic matter content, a reduction in soil microbial populations, and diminished soil permeability (Simarmata & Herdiyantoro, 2017). If this situation persists, agricultural production, especially of red chili plants, will decline due to the deteriorating environmental conditions, particularly concerning the availability of nutrients and microbial populations in the soil. Engineering the growing media with the addition of bioactive ameliorants is one way to improve soil conditions. The use of soil conditioners (ameliorants) combined with bioactive agents, commonly known as bioameliorants, can address the issue of declining soil quality.

Good soil quality can enhance plant growth without causing environmental disturbances. Soil quality can be improved using soil conditioners (ameliorants). According to Ai Dariah et al., (2015), one effective method to accelerate soil quality restoration is through the use of soil conditioners. Plants have varying nutrient application intervals to achieve optimal yields. Research conducted by Pratiwi et al., (2021), found that applying tofu wastewater solution (Nitrogen 0.04%, Total Phosphorus 0.006%, Potassium 0.05%) once during irrigation produced the highest fruit yield in red chili plants, although it did not significantly improve plant growth. Ready-to-absorb nutrient solution applications can enhance soil quality. These solutions can replace inorganic fertilizers, which have adverse effects on soil when used excessively. Typically used in hydroponic systems, ready-to-absorb nutrient solution will be tested in soil media with different application intervals. The application of bioameliorants with the interval of ready-to-absorb nutrient solution is expected to optimize the enhancement of soil health, productivity, and quality of red chili yields. General findings from Sianturi dkk., (2021) suggest that longer intervals between nutrient solution applications tend to result in lower plant growth and yields. This study applied nutrient application intervals of 1, 3, and 5 days.

This research aims to investigate the interaction between bioameliorants and the interval of ready-to-absorb nutrient solution on soil health parameters (Phospate Sol

2. MATERIALS AND METHODS

2.1 Time and Place of Research

The research was conducted from August 2023 to December 2023 at the D3 Experimental Field, Faculty of Agriculture, Universitas Padjadjaran. Soil microbial analysis was performed at the Soil Biology Laboratory, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, West Java. Soil chemical analysis was carried out at the Soil Fertility and Plant Nutrition Laboratory, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, West Java.

2.2 Tools and Materials

The tools used in this study include: 1) Shovel, 2) Soil sieve, 3) Seedling tray, 4) Bucket, 5) Measuring cup, 6) Total Dissolve Solid (TDS) meter, 7) Water drum, 8) Sprayer, 9) Analytical balance, 10) Ruler, 11) Vernier caliper, 12) Writing instruments, 13) Documentation tools, 14) Polybags, 15) Laboratory equipment for soil microbiological analysis, 16) Laboratory equipment for soil chemical analysis.

The materials used in this study are: 1) Large red chili seed (*Capsicum annuum* L..) of the Pilar F1 variety, 2) *Trichoderma* sp. at a dose of 12 kg/ha, 3) Bioameliorants (comprising 50% coconut shell biochar, 25% blotong compost dust, 10% dolomite, 10% guano, 2.5% humic acid, 2.5% BIO fertilizer) at doses of 0, 3, and 6 tons/ha, 4) Stock solution A and stock solution B with application intervals of every 1, 3, and 5 days, 5) Inceptisol soil from Jatinangor, 6) Water, 7) Pesticides, 8) Materials for soil microbiological analysis, 9) Materials for soil chemical analysis.

2.3 Experimental Design

The experimental design used is a Randomized Block Design (RBD) with a factorial pattern employing two treatment factors.

The first factor is the dosage of bioameliorants (b), consisting of three levels:

b0: 0 ton/ha
b3: 3 ton/ha
b6: 6 ton/ha

The second factor is the interval of ready-to-absorb nutrient solution application (i), consisting of three levels:

i1: every 1 day
i3: every 3 day
i5: every 5 day

Each treatment was replicated three times, resulting in 27 experimental units. Each experimental unit consists of 2 plants: one plant grown until the end of the vegetative stage and the other until harvest. The total number of plants is 54.

Tabel 1. Combination of Bioameliorants and Interval of Ready-to-Absorb Nutrient Solution Application

Interval of Ready-to-Absorb Nutrient Solution Application	Bioameliorant (tons/ha)		
	0 (b0)	3 (b3)	6 (b6)
Every 1 day (i1)	b0i1	b3i1	b6i1
Every 3 day (i3)	b0i3	b3i3	b6i3
Every 5 day (i5)	b0i5	b3i5	b6i5

2.4 Analysis Design

The data from the study were statistically analyzed using a Factorial Randomized Block Design (RBD) with the SPSS application at a 5% significance level. If the test results show significant effects, they will be followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. Correlation analysis was conducted to determine whether there is a significant relationship between variables. The correlation coefficient for red chili yields was determined using the Pearson correlation test. The strength of the linear correlation between connected variables was tested using the SPSS application. Linear regression analysis was performed to measure the effect of two or more independent variables on a dependent variable.

3. RESULT AND DISCUSSIONS

3.1 Supporting Observation

3.1.1 Initial Soil Analysis

Initial soil analysis included microbiological analysis. According to the results, Jatinangor Inceptisols contain 2.6×10^6 CFU g^{-1} of Phosphate Solubilizing Bacteria (PSB); 1×10^5 CFU g^{-1} of *Azotobacter* bacteria; 1.4×10^6 CFU g^{-1} of *Azospirillum* bacteria; and a total bacterial population of 8.3×10^6 CFU g^{-1}.

Chemical analysis was also performed on the initial soil. Jatinangor Inceptisols have a slightly acidic pH (H_2O) with a value of 6.05. The organic carbon content of this soil is categorized as low (1.5%), total nitrogen is in the medium category (0.23%), available phosphorus is very low (0.001 ppm), potential phosphorus is very high (0.06%), total potassium is medium (0.03%), and exchangeable potassium is high (0.04%).

Based on the initial soil analysis results, a pH H_2O value of 6.05 is considered highly suitable for red chili plants, and an organic carbon content of 1.5% is also highly suitable for red chili plants (Pertami et al., 2022). Therefore, it can be concluded that the pH and organic carbon content of the soil used in this study are suitable for red chili cultivation.

3.1.2 Observation of Plant Pest and Diseases

Observation of pest and diseases in this experiment focused ont the primary pests and diseases affecting chili plants. The pest and diseases observed in this experiment are as follows:

1.Fruit Fly Pest

The fruit fly (*Bactrocera* sp.) was found attacking red chili plants as they entered the generative phase. This pest is known as a direct pest because it attacks the fruit part of the red chili plant. Yield losses can occur if the intensity of the attack is high (Susanto dkk., 2019). Symptoms of an infestation include black spots at the base of the fruit. The fruit fly pest was controlled in this experiment using glumon. Glumon was applied to used drinking cup bottles and placed on top of ajjr (ajir), and it was also applied to the poles of the screenhouse.

2.Anthracnose Disease

During the experiment, the disease anthracnose caused by the fungus *Colletotrichum capsici* was also observed attacking the chili plants. Symptoms of this fungal infection include circular sunken spots on the chili fruit with a brown center and light brown surrounding area, which expand and become soft rot. The center may show clusters of black dots, leading to the entire fruit drying and shriveling at advanced stages of damage (Marsuni, 2020). According to Norsalehah et al., (2022), nthracnose can cause significant fruit weight loss. If not properly controlled, this disease can result in up to 100% loss of production.

3.1.3 Plant Height

lant height was measured starting at 1 week after transplanting (WAT) and continuing up to 7 WAT. According to Figure 1, the highest plant height at the end of the observation was shown by plants with the treatment combination b6i1, at 74.70 cm at 7 WAT. The lowest plant height was observed in the treatment combination b6i5, at 47.90 cm. The graph also shows that the treatment with a nutrient solution application interval of every 1 day (i1) resulted in the highest plant height compared to every 3 days (i3) and every 5 days (i5). This is because the plants received more nutrients and absorbed more nutrients, enabling better cell formation, particularly phosphorus, which affects plant height. Daryanti et al., (2022), stated that shorter nutrient solution application intervals improve plant height.

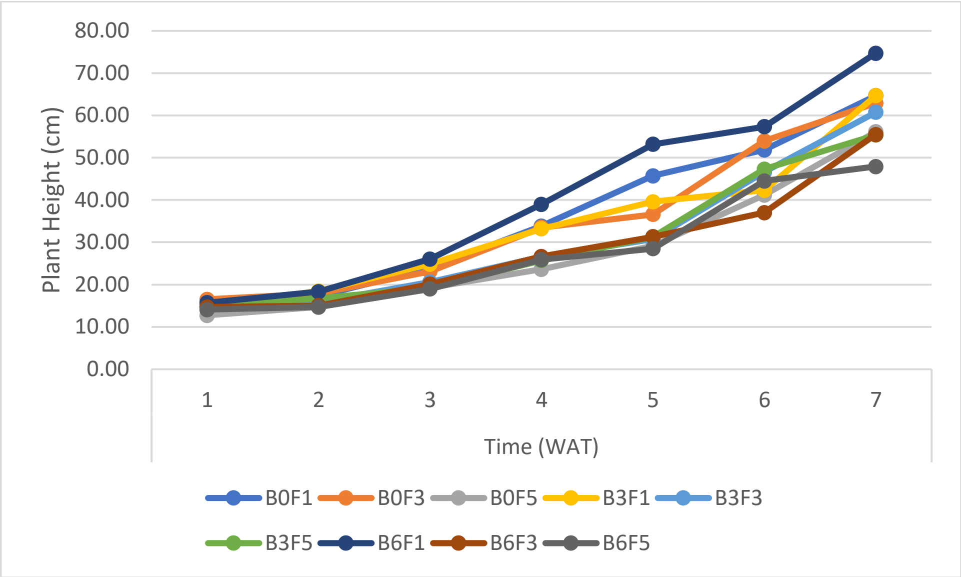

Figure 1. Graph of Plant Height Growth Due to the Interaction of Bioameliorants (b) and Ready-to-Absorb Nutrient Solution Application Intervals (i)

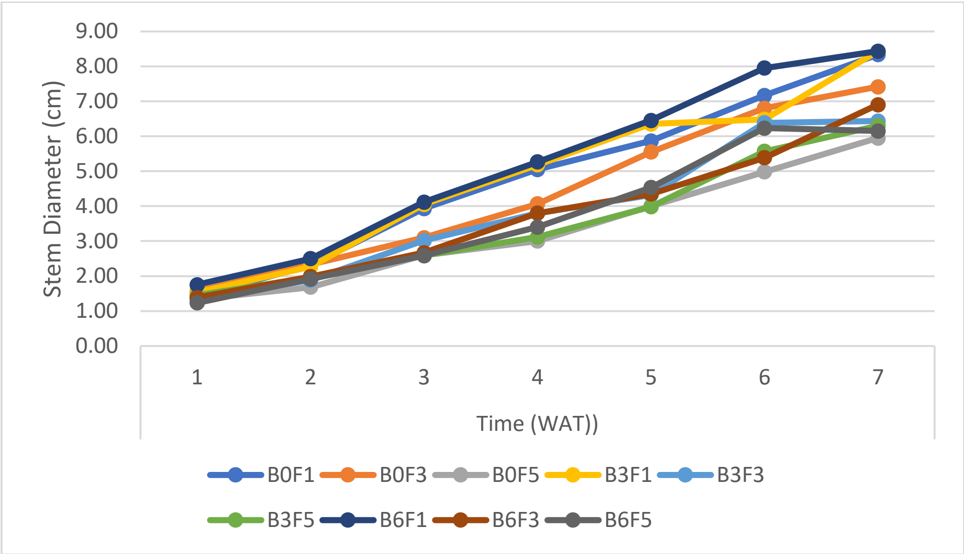

Figure 2. Graph of Stem Diameter Growth Due to the Interaction of Bioameliorants (b) and Ready-to-Absorb Nutrient Solution Application Intervals (i)

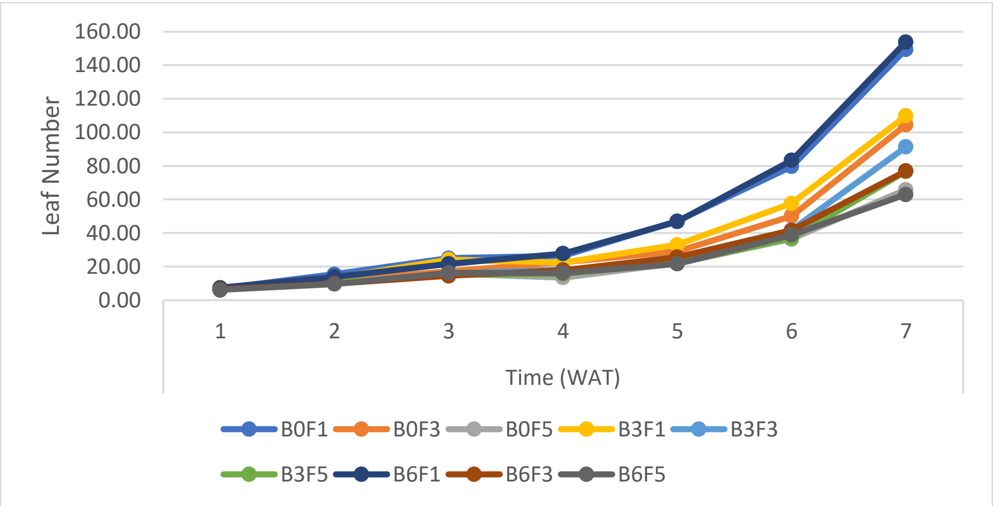

Figure 3. Graph of Leaf Number Development in Plants Due to the Interaction of Bioameliorants (b) and Ready-to-Absorb Nutrient Solution Application Intervals (i)

3.1.4 Stem Diameter

Based on observations from 1 week after transplanting (WAT) to 7 WAT (Figure 2), the stem diameter of chili plants increased. The largest stem diameter at the end of the observation period was shown by the combination of treatments b3i1 and b6i1, measuring 8.43 mm. Meanwhile, the smallest stem diameter at the end of the observation period was exhibited by the combination of treatment b0i5. Treatment with a nutrient solution application interval of one day (i1) showed a larger stem diameter compared to intervals of three days (i3) and five days (i5) for ready-to-absorb nutrient solution application, respectively.

The ready-to-absorb nutrient solution treatment with a one-day interval (i1) indicated that plants received sufficient nutrients for nutrient fulfillment. Adequate supply of P and K nutrients can enhance stem diameter growth. Phosphorus (P) plays a role in enlarging plant cells and stimulating cell division, while Potassium (K) strengthens plant stems (Nurrahmadhan dkk., 2022).

3.1.5 Leaf Number

Observations of leaf number from 1 WAT to 7 WAT (Figure 3) showed a tendency for leaf number to increase. The graph indicated the lowest number of leaves at the end of the observation period in the combination of treatment b6i5, with 65 leaves. Meanwhile, the highest leaf number was observed in the combination of treatment b6i1, with 154 leaves. Overall, the range of leaf numbers from lowest to highest was observed in treatments with nutrient solution application intervals of five days (i5), three days (i3), and one day (i1), respectively. This suggests that more frequent application of ready-to-absorb nutrient solution results in a higher number of leaves produced. Increased leaf production enhances photosynthesis processes and increases plant food reserves.

3.2 Main Observation

3.2.1 Population of Phosphate Solubilizing Bacteria (PSB), Azotobacter, and Azospirillum

The initial soil analysis showed that the population of PSB was 2,6 x 10^6 CFU g^{-1}, Azotobacter was 1 x 10^5 CFU g^{-1} and Azospirillum was 1,4 x 10^6 CFU g^{-1}. With the application of bioameliorant and the interval of ready-to-absorb nutrient solution application, the populations of PSB, Azotobacter, and Azospirillum increased compared to the initial soil analysis. However, the independent effect of bioameliorant on the populations of PSB, Azotobacter, and Azospirillum did not show significant results.

The increased bacterial populations compared to the initial soil analysis are likely due to the application of BIO fertilizer in the bioameliorant. BIO fertilizer, which contains nitrogen-fixing bacteria and phosphate-solubilizing bacteria, can increase the populations of PSB, *Azotobacter*, and *Azospirillum*. This finding aligns with research by Pebrianti et al., (2023) which indicates that BIO fertilizer positively affects the number of phosphate-solubilizing bacteria and nitrogen-fixing bacteria, thereby enhancing the availability of N and P for plants. However, a small amount of BIO fertilizer may not significantly influence the increased populations of PSB, Azotobacter, and Azospirillum.

The increase in the populations of PSB, Azotobacter, and Azospirillum compared to the initial soil analysis is likely due to the phosphorus and nitrogen content in the solution. The availability of phosphorus and nitrogen in the soil can both increase and decrease the populations of PSB, Azotobacter, and Azospirillum. Sofatin et al., (2017) mentioned that nutrient availability in the soil can enhance the populations of nitrogen-fixing bacteria and phosphate-solubilizing bacteria; however, excessive nutrients may reduce microbial populations.

Table 2. Independent Effects of Bioameliorant (b) dan Interval of Ready-to-Absorb Nutrient Solution (i) on Populations of PSB, Azotobacter, and Azospirillum at Maximum Vegetative Stage

Treatment	PSB (CFU g^{-1})	Azotobacter (CFU g^{-1})	Azospirillum (CFU g^{-1})
Bioameliorant (b)			
b0	4,80 x 10^6 a	1,81 x 10^5 a	5,56 x 10^6 a
b3	4,83 x 10^6 a	1,91 x 10^5 a	5,73 x 10^6 a
b6	4,83 x 10^6 a	2,38 x 10^5 a	5,17 x 10^6 a
Interval of Ready-to-Absorb Nutrient Solution Application (i)			
i1	5,24 x 10^6 a	2,48 x 10^5 b	5,77 x 10^6 a
i3	4,78 x 10^6 a	2,14 x 10^5 ab	6,03 x 10^6 a
i5	4,43 x 10^6 a	1,48 x 10^5 a	4,66 x 10^6 a

Note: Mean values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at a 0.05 significance level.

3.2.2 Total Bacterial Population

The results of the variance analysis showed no interaction between bioameliorant and ready-to-absorb nutrient solution application interval, so the independent effects on the total bacterial population are presented. The b6 treatment was significantly different from the b0 and b3 treatments. The increase in total bacterial population may be due to the application of bioameliorant containing organic matter. Bioameliorant containing organic matter serves as an energy source for bacteria (Sinaga et al., 2018). The b6 treatment was significantly different from the b0 and b3 treatments. The increase in total bacterial population may be due to the application of bioameliorant containing organic matter. Bioameliorant containing organic matter serves as an energy source for bacteria (Kaharu et al., 2021). Moreover, the increase in C-Organic content due to ameliorant application can boost microbial activity, thus promoting optimal microbial growth (Situmorang et al., 2019).

Table 3. **Independent Effects of Bioameliorant (b) dan Interval of Ready-to-Absorb Nutrient Solution (i) on Total Bacterial Population at Maximum Vegetative Stage**

Treatment	Total Bacterial Population (CFU g^{-1})
Bioameliorant (b)	
b0	$1{,}44 \times 10^7$ a
b3	$1{,}35 \times 10^7$ a
b6	$1{,}68 \times 10^7$ b
Interval of Ready-to-Absorb Nutrient Solution Application (i)	
i1	$1{,}70 \times 10^7$ b
i3	$1{,}53 \times 10^7$ b
i5	$1{,}24 \times 10^7$ a

Note: Mean values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at a 0.05 significance level.

The effect of the application of the ready-to-absorb nutrient solution showed significant differences. The total bacterial population in treatments i1 ($1{,}70 \times 10^7$ CFU g^{-1}) and i3 ($1{,}53 \times 10^7$ CFU g^{-1}) significantly affected i5. This increase was due to the availability of nutrients required by bacteria. Bacteria utilize inorganic fertilizers as an energy source for their metabolism and growth (Arifin et al., 2021). The ready-to-absorb nutrient solution application intervals of one day (i1) and three days (i3) could increase bacterial populations because they optimally provided the energy needs of microbes. This microbial abundance can be an indicator of soil health, as it has a sensitive response to land management and plant productivity (Antralina et al., 2015).

3.2.3 C-Organic Content

The application of bioameliorant containing organic matter and the nutrient solution containing inorganic matter can increase the C-Organic content in the soil. The interaction between b6i1 showed the best results with a C-Organic content of 2.41%. The combination of organic-based fertilizers with inorganic fertilizers can increase the C-Organic content in the soil (Syamsiyah et al., 2023). Additionally, biochar in the bioameliorant, according to the study by Herhandini et al., (2021), states that the higher the dose of biochar, the higher the increase in soil C-Organic content. This is consistent with the treatment of bioameliorant at a dose of 6 tons/ha, which showed the best treatment. Aytenew & Bore, (2020) also stated that increasing the dose of soil amendments positively contributes to the increase in soil C-Organic content. This is also because biochar is dominated by stable C compounds, which can reduce C loss due to decomposition (Herhandini et al., 2021).

Table 4. **Interaction Between Bioameliorant (b) and Ready-to-Absorb Nutrient Solution (i) on C-Organic Content at Maximum Vegetative Growth**

Bioameliorant (b)	Interval of Ready-to-Absorb Nutrient Solution Application (i)		
	i1	i3	i5
b0	1,32 a A	2,09 a B	2,11 a B
b3	2,09 b A	2,22 ab A	2,21 a A
b6	2,41 b A	2,47 b A	2,24 a A

Notes:

- Mean values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at a 0.05 significance level.
- Lowercase letters read vertically, comparing between 2 Bioameliorants at the same Interval.
- Uppercase letters read horizontally, comparing between 2 Intervals at the same Bioameliorant.

3.2.4 Soil pH Levels

Large red chili plants require a pH value of 6–7.5 to support optimal growth (Pakpahan, 2018). The independent application of bioameliorant and the interval of ready-to-absorb nutrient solution did not significantly increase the pH value. However, the application of bioameliorant and the interval of ready-to-absorb nutrient solution resulted in soil pH levels between 6.69 and 6.88, which are still within the range that can optimize the growth of large red chili plants and are higher than the initial soil analysis value of 6.05. The provision of ready-to-absorb nutrient solution containing Ca and Mg can increase soil pH levels. However, this increase is moderated by the application of bioameliorant, as bioameliorant can maintain soil pH. Ameliorants have buffering properties, allowing them to stabilize soil pH.

Table 5. Independent Effects of Bioameliorant (b) dan Interval of Ready-to-Absorb Nutrient Solution (i) on Soil pH Levels at Maximum Vegetative Stage

Treatment	pH
Bioameliorant (b)	
b0	6,69 a
b3	6,85 a
b6	6,88 a
Interval of Ready-to-Absorb Nutrient Solution Application (i)	
i1	6,74 a
i3	6,86 a
i5	6,82 a

Note: Mean values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at a 0.05 significance level.

3.2.5 Number of Fruits and Fruit Weight per Plant

The application of bioameliorant did not significantly affect the increase in the number and weight of fruits per plant. Red chili plants require sufficient nutrients to support their growth, particularly potassium (K) for flower and fruit formation. The bioameliorant treatment, which contained only a minimal amount of K, was insufficient to optimize flower and fruit formation during the generative phase. This aligns with the findings of Trinurani Sofyan et al., (2019) which state that K is essential for the formation of flowers and fruits during the generative phase. Moreover, the small doses of dolomite and guano in the bioameliorant did not significantly increase the number and weight of fruits. This observation is consistent with the research of Situmorang et al., (2019) which noted that the addition of dolomite and guano in small doses did not result in a significant difference in yield components compared to treatments without dolomite and guano.

The study results show that the average number of fruits per plant was only 26, differing from the varietal description, which indicates that the Pilar F1 chili variety can produce up to 83 fruits per plant. This discrepancy is attributed to the limited number of harvests, which were conducted only five times with three-day intervals. Additionally, flower drop before fruit set contributed to the lower number of fruits per plant. The number of fruits produced is influenced by the number of flowers formed (Ali, 2015).

Table 6. Independent Effects of Bioameliorant (b) dan Interval of Ready-to-Absorb Nutrient Solution (i) on Number of Fruits and Fruit Weight per Plant at Maximum Vegetative Stage

Treatment	Number of Fruits per Plant	Fruit Weight per Plant (g)
Bioameliorant (b)		
b0	19,33 a	124,00 a
b3	18,67 a	103,17 a
b6	18,89 a	86,02 a
Interval of Ready-to-Absorb Nutrient Solution Application (i)		
i1	20,89 b	148,43 b
i3	18,89 ab	93,03 a
i5	17,11 a	71,72 a

Note: Mean values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at a 0.05 significance level.

The independent effect of ready-to-absorb nutrient solution application intervals significantly influenced the fruit weight per plant. A ready-to-absorb nutrient solution application interval of one day (i1) resulted in an average fruit weight of 148.43 g per plant compared to an interval of five days (i5), which produced an average weight of 71.72 g per plant. This is likely because frequent application of the nutrient solution ensures that the plants receive adequate nutrients. This finding is consistent with the study by Sianturi et al., (2021) which indicated that more frequent nutrient solution applications lead to increased fruit weight.

3.2.6 Quality of Yield

Sorting was performed to separate healthy red chili peppers with normal and good shape. Damaged fruits, those attacked by pests and diseases, and those that were not fully red were immediately separated. The percentage distribution of fruit quality was calculated based on the number of harvested fruits. According to the quality standards for red chili, the b0i3 treatment produced the highest percentage of grade A red chili fruits, at 59.7%. Situmorang et al., (2014) mentioned that red chili fruits with greater length and diameter tend to fall into higher quality categories (such as grade A or B) and are preferred by consumers.

Table 7. Classification Results of Red Chili Quality Based on Red Chili Quality Standards

Perlakuan	Grade A	Grade B	Grade C	Grade BS
b0i1	36,7 %	47,7 %	8,3 %	7,3 %
b0i3	59,7 %	32,8 %	4,5 %	3 %
b0i5	44,4 %	41,7 %	5,6 %	8,3 %
b3i1	37 %	56,2 %	4,8 %	2 %
b3i3	54,3 %	38,6 %	5,3 %	1,8 %
b3i5	36,8 %	50,9 %	8,8 %	3,5 %
b6i1	28,3 %	65,7 %	2 %	4 %
b6i3	33,2 %	55 %	5,9 %	5,9 %
b6i5	27,8 %	41,7 %	8,3 %	22,2 %

Tabel 8. **Independent Effects of Bioameliorant (b) and Interval Ready-to-Absorb Nutrient Solution (i) on the Fruit Grading of Red Chili Plants**

Treatment	Grade A	Grade B	Grade C	Grade BS
Bioameliorant (b)				
b0	11,11 a	6,56 a	1,78 a	1,22 a
b3	10,11 a	12,44 a	1,44 a	0,56 a
b6	6,44 a	6,56 a	0,89 a	1,78 a
Interval of Ready-to-Absorb Nutrient Solution Application (i)				
i1	12,11 a	16,44 b	1,78 a	1,67 a
i3	9,89 a	8,44 a	1,00 a	0,67 a
i5	5,67 a	5,89 a	1,33 a	1,22 a

Note: Mean values followed by the same letter are not significantly different according to Duncan's Multiple Range Test at a 0.05 significance level.

The interaction between the application of bioameliorant and the interval of ready-to-absorb nutrient solution application does not significantly affect the fruit grading of red chili plants. The independent effect of bioameliorant application shows that the grade BS quality is lower compared to grades A, B, and C. This is likely because the bioameliorant treatment can enhance the disease resistance of chili plants. The application of ameliorants can increase the disease resistance of chili plants, thereby producing more fruit compared to treatments without ameliorants (Situmorang et al., 2019).

An interval of one day (i1) for ready-to-absorb nutrient solution application shows significantly different results compared to intervals of three days (i3) and five days (i5) for grade B quality. This is likely due to the provision of nutrients increasing microbial activity. The application of inorganic fertilizers also influences plant growth, production, and microbial activity (Pangaribuan et al., 2017). Additionally, the increase in rhizobacteria can reduce disease attacks on plants (Situmorang et al., 2019).

3.2.7 Correlation of Soil Health Components with Yield Components

Correlation analysis uses soil health components, yield components, and yield quality. The results of the Pearson correlation test are presented in Table 9. Based on the Pearson correlation test, the correlation between yield components, i.e., the number of fruits per plant with the population of phosphate solubilizing bacteria (PSB), Azotobacter population, Azospirillum population, total bacterial population, organic carbon content (C-Organic), and pH does not have a significant effect. Similarly, the relationship between fruit weight per plant and the population of PSB, Azotobacter population, Azospirillum population, total bacterial population, and pH does not show a significant effect. However, the correlation between fruit weight per plant and C-Organic content is significant. The fruit weight per plant correlates negatively with C-Organic content with a moderate relationship (r = -0.60).

The relationship between fruit weight per plant and C-Organic content shows a negative correlation, meaning that the lower the C-Organic content, the higher the fruit weight per plant, and vice versa, the higher the C-Organic content, the lower the fruit weight per plant.

Table 9. Correlation Among Soil Health Components, Yield Components, and Yield Quality

	Number of Fruit per Plant	Fruit Weigh per Plant	Yield Quality (Grade A)	Yield Quality (Grade B)	Yield Quality (Grade C)	Yield Quality (Grade BS)
PSB	.348	.303	.298	.029	.122	-.208
Azotobacter	.268	-.019	-.075	.427*	.286	.194
Azospirillum	.197	.123	.059	.110	-.277	-.087
Total Bacterial Population	.330	.200	.247	.372	.123	-.177
C-Organic	-.278	-.598**	-.505**	-.018	-.186	-.093
pH	-.075	-.100	-.026	-.035	-.033	.053

3.2.8 Results of Regression Analysis Between Soil Health Components and Yield Quality on Fruit Weight Per Plant

Regression analysis between fruit weight per plant (Y) with population of PSB (X1), population of Azotobacter (X2), population of Azospirillum (X3), total bacterial population (X4), C-Organic (X5), pH level (X6), yield Quality grade A (X7), yield Quality grade B (X8), yield Quality grade C (X9), and yield quality grade BS (X10) can be seen in Tables 10 & 11.

Table 10. Coefficient of Determination

Model	R	R Square	Adjusted R Square	Std. Error
1	.690[a]	.476	.149	53.64302

The results of the coefficient of determination test in Table 10 show a correlation coefficient (R) value of 6.90. From these results, the coefficient of determination (R2) is calculated to be 0.476, indicating that the influence of the independent variables on the dependent variable is 47.6%.

Tabel 11. **Results of Regression Analysis of Soil Biological Factors, Soil Chemistry, and Yield Quality on Fruit Weight Per Plant**

		Unstandardized Coefficients		Standardided Coefficients			Correlations			Collinearity Statistics	
Model		B	Std.Error	Beta	t	Sig.	Zero-order	Partial	Part	Tolerance	VIF
1	(Contstant)	136.226	495.146		.275	.787					
	X1	4.826	8.007	.135	.603	.555	.303	.149	.109	.656	1.523
	X2	.108	17.446	.002	.006	.995	-.019	.002	.001	.413	2.421
	X3	3.094	6.854	.115	.451	.658	.123	.112	.082	.505	1.979
	X4	3.145	4.058	.173	.775	.450	.200	.190	.140	.658	1.519
	X5	-100.341	38.177	-.623	-2.628	.018	-.598	-.549	-.476	.582	1.717
	X6	13.630	72.742	.045	.187	.854	-.100	.047	.034	.565	1.769
	X7	.053	2.497	-.006	-.021	.983	.428	-.005	-.004	.388	2.576
	X8	.705	2.077	.103	.339	.739	.211	.085	.061	.355	2.819
	X9	4.044	11.427	-.093	-.354	.728	.005	-.088	-.064	.476	2.101
	X10	.356	6.089	.012	.059	.954	-.022	.015	.011	.808	1.238

a.Dependent Variable : Y (Bobot Buah Per Tanaman)

Based on Table 11, the multiple linear regression equation obtained is:

$$Y = 136.226 + 4.826X1 + 0.108X2 + 3.094X3 + 3.145X4 – 100.341X5 + 13.630X6 + 0.53X7 + 0.705X8 + 4.044X9 + 0.356X10$$

The results of the multiple linear regression equation indicate that C-Organic has a negative effect on fruit weight per plant. This means that C-Organic content will decrease the fruit weight per plant. Conversely, BPF population, Azotobacter population, Azospirillum population, total bacterial population, pH level, grade A quality, grade B quality, grade C quality, and BS grade quality have a positive effect on fruit weight per plant, indicating that any increase in BPF population, Azotobacter population, Azospirillum population, total bacterial population, pH level, grade A quality yield, grade B quality yield, grade C quality yield, and BS grade quality yield will increase the fruit weight per plant.

4. CONCLUSION

1. The interaction of bioamelioran application with the interval of ready-to-absorb nutrient solution application significantly affects C-Organic content. There is an independent effect of bioamelioran on the total bacterial population. The independent effect of the interval of ready-to-absorb nutrient solution application significantly affects the total bacterial population, fruit weight per plant, and grade B quality yield.
2. The application of 6 tons/ha of bioamelioran with ready-to-absorb nutrient solution application interval of once daily results in the highest C-Organic content. The highest total bacterial population is obtained with the application of 6 tons/ha of bioamelioran. The highest total bacterial population, fruit weight per plant, and highest quality results are achieved with ready-to-absorb nutrient solution application interval of once daily.
3. C-Organic content shows a significant correlation with fruit weight per plant. The correlation between C-Organic content and fruit weight per plant is negative. The independent variables have a 47.6% influence on the dependent variable.

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