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Application of BioPrime Nano Fertilizer on the Four Stages of Robusta Coffee Development in Kalinga, Philippines

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ABSTRACT

The study was conducted to test the effect of BioPrime Nano fertilizer on the four stages of Robusta coffee development: at the germination stage, early growth, field growth, and rejuvenated coffee trees. Coffee seeds without parchment and soaked in BioPrime solution germinates faster and has a higher germination percentage. Coffee seedlings applied with BioPrime Nano Fertilizer improved the growth and development. Applying 5 grams of BioPrime Nano Fertilizer is the optimum dosage for rejuvenated coffee trees to improve yield. Applying growth enhancers like BioPrime Nano Fertilizer significantly affects coffee plants' growth, development, and productivity. The study results can be a basis for promoting nano fertilizers as a substitute to inorganic fertilizers, which are bulky to apply, especially in the case of coffee farms in Kalinga, Philippines, which are found in mountainous areas. Studies on applying BioPrime Nano fertilizer in Robusta coffee are pioneering, especially in Kalinga; these results can be the basis for further studies to develop protocols for applications for coffee and other crops.

Keywords: Robusta Coffee, Germination, Early Growth, Field Growth, Rejuvenated Coffee, BioPrime Nano Fertilizer

1. INTRODUCTION

Robusta coffee, also known as *Coffea canephora*, is a commonly cultivated coffee species highly valued for its strong flavor and high caffeine content. In recent years, there has been a growing interest in using nano fertilizers in agriculture due to their ability to improve nutrient uptake efficiency and enhance plant growth. One such innovation is the BioPrime Nano Fertilizer, specially designed to deliver essential nutrients to crops more efficiently and sustainably.

Applying BioPrime Nano Fertilizer on Robusta coffee has shown promising results in increasing crop yield and improving overall plant health. The nano-sized particles in the fertilizer enable coffee plants to absorb essential nutrients better, leading to improved root development, enhanced photosynthesis, and increased resistance to pests

and diseases. The controlled release mechanism of BioPrime Nano Fertilizer also ensures that the nutrients are delivered to the plants at the right time and in the right amount, thereby reducing wastage and environmental pollution. Overall, applying BioPrime Nano Fertilizer on Robusta coffee holds great potential in boosting productivity and sustainability in coffee cultivation practices.

As the agriculture industry continues to evolve, embracing new technologies like nanotechnology-based fertilizers may be key to meeting the growing demand for food and ensuring a sustainable future for future generations.

As coffee production plays a significant role in the agricultural industry, it is crucial to explore innovative methods for increasing the yield and quality of coffee beans. This study aims to investigate the application of BioPrime Nano Fertilizer on coffee plants to enhance growth and productivity. Previous research suggests that nano fertilizers can improve nutrient absorption and plant utilization, leading to increased yield and quality of crops. By utilizing advanced nanotechnology in agriculture, we can potentially revolutionize how fertilizers are applied and optimize plant growth. Through rigorous experimentation and data analysis, this research aims to provide valuable insights into the effectiveness of BioPrime Nano Fertilizer on coffee plants, ultimately contributing to the sustainability and competitiveness of the coffee industry.

2. MATERIALS AND METHODS

2.1 Presowing and Germination

The study was conducted at the KSU Plant Nursery. It was divided into two groups: the first was coffee seeds with parchment, and the second was coffee seeds, in which parchment was removed. The study was composed of three treatments: control, T0, control; T1, coffee seeds soaked in tap water for 48 hours; and T2, coffee seeds soaked in BioPrime solution for 48 hours. After soaking for 48 hours, the coffee seeds were sown in a prepared sowing bed with fine sand as soil media with groves facing down, arranged in a straight line 1 centimeter apart and 2 centimeters deep. The study was laid out following a Complete Randomized Design. After sowing, it was covered with a net and UV plastic sheets for protection. One hundred seeds were used for every treatment; numbers of germinated seeds were recorded after 45 days. Percent germination was computed by dividing the number of germinants by the total seeds sown multiplied by 100.

2.2 Early Growth Performance

The study was also conducted at the KSU plant nursery. The study was laid out following a Randomized Complete Block Design with three treatments and five replications. A total of 150 coffee seedlings were used in this study. To serve as a control, T1 application of inorganic fertilizer was based on the soil analysis result, and T2 coffee seedlings were applied with 5 grams of BioPrime nano fertilizer. Application of treatment was made only once during the start of the study; the study was conducted for six months; the data gathered was diameter, which is measured at the root collar using a vernier caliper, and height, which is measured using a ruler from the root collar up to the base of the apical shoot.

2.3 Field Growth Performance

The study area is located in the experimental area of Kalinga State University, which is particularly intended for the practicum area of the Bachelor of Agricultural Technology. The study was laid out following a Randomized

Complete Block Design with four treatments and three replications; T1 is based on the recommendation of soil analysis, T2 is 75% reduction of inorganic fertilizer plus the application of 5 grams of BioPrime nano fertilizer, T3 is 50% reduction of inorganic fertilizer plus application of 5 grams of BioPrime nano fertilizer and T4 is 100% inorganic fertilizer plus application of 5 grams of BioPrime nano liquid fertilizer. Application of Treatment was made twice after planting and three months after planting; observation was done for eight months. The data gathered were measured by diameter above the root collar using a vernier caliper, height measured from the root collar to the base of the apical shoot using a meter stick, and the number of branches and axils per branch.

2.4 Application on Rejuvenated Robusta Coffee Plants

The project is located and conducted at the coffee demonstration area of the Kalinga State University, Bulanao main Campus from July 16, 2022-April 2023. Sixteen rejuvenated old coffee plants were selected as sample plants for this experiment. The study was laid out following a Randomized Complete Block Design with four treatments and four replications: T0 is control (No Application), T1 is applied with 2.5 grams (83.5 ppm) lower concentration of BioPrime Nano Fertilizer, T2 applied with 5.0 grams (167 ppm) general recommended rate for BioPrime Nano Fertilizer, and T4 applied with 10.0 grams (334 ppm) higher concentration BioPrime Nano Fertilizer. The application was made twice during the pinhead-size berries in July and October when the berries started maturing. Data gathering began from January to March; the data gathered included the number of cherries per axil, the number of axils per branch, the average weight of individual cherries, and the yield per tree.

2.5 Data Analysis

The data was analyzed using the Analysis of Variance (ANOVA). Turkeys post hoc test was used to test significance differences using the software jamovi 2.3.21.

3. RESULTS

3.1 Presowing and Germination

Table 1. Percent germination of coffee seeds with and without parchment soaked in tap water and BioPrime solution.

Factor A	Factor B		F-Test
Treatments	With Parchment	Removed Parchment	
T0 (Control)	49.5% ^c	79.5% ^c	
T1 (Soaked in tap water)	63.0% ^b	82.0% ^b	
T2 (Soaked with BioPrime Solution)	69.0% ^a	83.5% ^a	
F-Test	***	***	
Average	60.5% ^b	81.7% ^a	***

Results of coffee seed germination shown in Table 1 show that coffee seeds soaked in BioPrime solution give the best result compared to those in tap water and unsoaked seeds. In the case of coffee seeds with parchment and removed parchment, coffee seeds

that parchment removed germinate faster and have a higher percentage than coffee seeds with parchment.

3.2 Early Growth Performance

Table 2. Diameter and height of coffee seedlings applied with inorganic fertilizer and BioPrime nano fertilizer.

Treatment	Diameter	Height
T0	12.18b	45.84c
T1	12.60a	49.38b
T2	12.60a	58.38a
F-Test	***	***

Table 2 presents the diameter and height after six months of coffee seedlings applied with inorganic fertilizer and BioPrime nano fertilizer. The result shows that the average diameter of coffee seedlings applied with inorganic fertilizer and BioPrime nano fertilizer gives similar results and is larger than those without application. Regarding height, coffee seedlings applied with BioPrime nano fertilizer give higher results than coffee seedlings applied with inorganic fertilizer and coffee seedlings without application.

3.3 Field Growth Performance

Table 3. Field growth performance of coffee seedlings applied with inorganic fertilizer and BioPrime nano fertilizer.

Treatment	Diameter(mm)	Height (cm)	No. of Branches	No. of Axils
T0	19.9d	93.7c	13b	13b
T1	26.0a	110.3a	17a	20a
T2	24.6b	96.5b	17a	19a
T3	22.3c	93.7c	13b	12b
F-Test	***	***	***	***

Table 3 presents the results of the field growth performance of robusta coffee seedlings applied with inorganic fertilizer and BioPrime nano fertilizer. After eight months of observation, diameter of coffee seedlings applied with 75% reduction of inorganic fertilizer plus application of 5 grams of BioPrime nano fertilizer gives the highest result, followed by coffee seedlings applied with 50% reduction of inorganic fertilizer plus 5 grams of BioPrime nano fertilizer, next is coffee seedlings applied with 100% inorganic fertilizer plus 5 grams of BioPrime nano fertilizer and lastly is the coffee seedlings applied with 100% inorganic fertilizer. In terms of height, coffee seedlings applied with 75% inorganic fertilizer plus 5 grams BioPrime nano fertilizer gives the best result, followed by coffee seedlings applied with 50% inorganic fertilizer plus 5 grams BioPrime nano fertilizer, coffee seedlings applied with 100% inorganic fertilizer plus 5 grams BioPrime nano fertilizer and coffee seedlings applied with 100% inorganic fertilizer gives a similar result. In case of the number of branches and a number of axils/nodes, coffee seedlings applied with 75% and 50 % inorganic fertilizer plus 5 grams BioPrime nano fertilizer produce more branches and axils/nodes compared to coffee seedlings applied with 100% inorganic fertilizer and 100% inorganic fertilizer plus 5 grams BioPrime nano fertilizer.

3.4 Rejuvenated Robusta Coffee Trees Applied with BioPrime Nano Fertilizer

Table 4. Yield performance of rejuvenated coffee trees applied with BioPrime nano fertilizer.

TREATMENT	The average number of Fruits per axil	The average number of axil with fruits	The average weight of cherries (g)	Yield per tree (kg)
T0	10.03b	5.07b	0.91c	1.41d
T1	13.13b	5.33b	0.82d	1.72c
T2	24.00a	7.03a	1.08a	5.46a
T3	23.33a	6.67a	0.93b	4.34b
F- Test	***	***	***	***

As shown in Table 4, coffee plants with 5.0 grams of BioPrime 5-5-5 Nano fertilizer have the highest number of coffee cherries, followed by coffee plants with BioPrime 10.0 grams and coffee plants with 2.5 grams and No application, respectively. Coffee plants with 5.0 grams have the highest number on the axils that bear coffee cherries, followed by 10.0 grams, 2.5 grams, and No application, respectively. On the weight of coffee cherries, coffee plants with 5.0 grams have the highest average weight, followed by 10.0 grams, No application, and 2.5 grams, respectively. Coffee plants with 5.0 grams have the highest yield on the average yield per tree, followed by 10.0 grams, 2.5 grams, and No application, respectively.

4. DISCUSSION

Applying BioPrime nano fertilizer to the different stages of coffee development gives significant results on the tested parameters. In the germination stage, coffee seeds with parchment soaked in BioPrime solution are significantly different compared to coffee seeds soaked in water, with a difference in percent germination of 6%, and coffee seeds unsoaked with a difference in percent germination of 19.5%. Coffee seeds without parchment soaked in Bioprime solution are significantly different from coffee seeds soaked in tap water, with a 1.5% difference in percent germination, and coffee seeds unsoaked with a 4% difference in percent germination. Overall, coffee seeds without parchment have a higher percent of germination than coffee seeds with parchment, with a difference of 21.2%. In the early growth stage of coffee, the diameter of coffee seedlings applied with BioPrime nano fertilizer significantly differs from coffee seedlings without application, with a difference of 0.42 mm. The height of coffee seedlings applied with BioPrime nano fertilizer is significantly different from that of coffee seedlings applied with inorganic fertilizer, with a difference of 9 centimeters, and coffee seedlings without application, with a difference of 12.54 centimeters.

In the open field trial of treatment one (T1), a combination of 5 grams of BioPrime nano fertilizer + 75% inorganic fertilizer was better than the other combinations. The 5-gram Bioprime nano fertilizer was effective with a minimal reduction of the inorganic fertilizer supplement at a 75 percent rate. The result of the study indicates that the use of inorganic fertilizers can be reduced. Cost efficiency was decreased when using nutrients necessary for the coffee plants.

When the organic fertilizer was reduced to a 50% rate plus 5 grams of Bioprime nano fertilizer, a slight decrease in the data gathered on plant stem

diameter, height, branches, and axils was noted. A reaction of the applied chemical composition of the two different nutrients supplied (Inorganic and Bioprime nano fertilizer) seems to have caused the decrease. The result indicates that the efficacy of bioprime was affected by the supply of the nutrients required with inorganic fertilizer, as manifested by gathered data on the tested parameters.

Similarly, the decrease went further when 100% inorganic fertilizer was combined with 5 grams of BioPrime nano fertilizer. This indicates that over-application will have a negative effect on coffee plants, as manifested by the gathered data on the parameters tested.

The study further revealed that a 100% Inorganic Fertilizer (T0) that served as the Farmer's Practice was enough to supply the required nutrients for the coffee plants. However, applying BioPrime nano fertilizer as a growth enhancer will significantly improve coffee's growth and reduce the cost of inorganic fertilizer.

Applying BioPrime nano fertilizer on rejuvenated coffee trees significantly improved their yield performance. Coffee trees applied with 5 grams of BioPrime nano fertilizer had an average yield of 5.46 kilograms per tree. The average yield per tree of rejuvenated coffee trees applied with ten (10) grams of BioPrime nano fertilizer is 4.34 kilograms. When decreased to 2.5 grams of BioPrime nano fertilizer, the average yield of rejuvenated coffee trees is 1.72 kilograms per tree, which is still higher than the average yield per tree of coffee trees with no application at 1.41 kilograms.

Application of BioPrime Nano Fertilizer on Robusta Coffee are pioneering studies conducted. The result of this study can be a basis for further studies in the future to develop protocols for applying growth enhancers like BioPrime Nano Fertilizer to formulate the optimum application for application to improved growth, development, and productivity of coffee and other crops.

5. CONCLUSION

Based on the results of the study on applying BioPrime Nano Fertilizer in the different stages of coffee development, there is a significant difference in the parameters tested. In germination, coffee seeds without parchment and soaked in BioPrime solution yield a higher percentage of germination. In the early growth of coffee, seedlings applied with BioPrime nano fertilizer are not significantly different in diameter compared to coffee seedlings applied with inorganic fertilizer but significantly different in height. In the open field trials, coffee seedlings applied with 75% inorganic fertilizer plus 5 grams of BioPrime nano fertilizer give the best result regarding diameter, height, number of branches, and axils/nodes produced compared to other treatments. For rejuvenated coffee trees, the yield of coffee trees applied with 5 grams of BioPrime nano fertilizer gives the highest yield compared to the different treatments. Applying BioPrime Nano Fertilizer on Robusta coffee has shown promising results in increasing crop yield and improving overall plant health

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APPENDICES

Germination Percentage (With Parchment)						
		T0	T1	T2		
T0	Mean difference	—	- ***	- ***	13.5	19.50
T1	Mean difference		—	-6.00 ***		
T2	Mean difference			—		
Germination Percentage (Without Parchment)						
		T0	T1	T2		
T0	Mean difference	—	- ***	-4.00 ***	2.50	
T1	Mean difference		—	-1.50 ***		
T2	Mean difference			—		
Note. * p < .05, ** p < .01, *** p < .001						
Germination Percentage						
		With Parchment	Removed Parchment			
With Parchment	Mean difference	—		-21.2 ***		
Removed Parchment	Mean difference			—		
Note. * p < .05, ** p < .01, *** p < .001						

Appendix Table 1. Tukey Post-Hoc Test on percent germination.

Diameter						
		T0	T1	T2		
T0	Mean difference	—	-0.420 ***	-0.420 ***		
T1	Mean difference		—	0.000		
T2	Mean difference			—		
Height						
		T0	T1	T2		
T0	Mean difference	—	-3.54 ***	-12.54 ***		
T1	Mean difference		—	-9.00 ***		
T2	Mean difference			—		
Note. * p < .05, ** p < .01, *** p < .001						

Appendix Table 2. Tukey Post-Hoc Test on early growth performance

Diameter (mm)							
		T0	T1	T2	T3		
T0	Mean difference	—	-6.10 ***	-4.70 ***	-2.40 ***		

T1	Mean difference	—	1.40 ***	3.70 ***		
T2	Mean difference		—	2.30 ***		
T3	Mean difference			—		
Height (cm)						
		T0	T1	T2	T3	
T0	Mean difference	—	-16.6 ***	-2.80 ***	0.00	
T1	Mean difference		—	13.80 ***	16.60 ***	
T2	Mean difference			—	2.80 ***	
T3	Mean difference				—	
No. of Branches						
		T0	T1	T2	T3	
T0	Mean difference	—	-4.00 ***	-4.00 ***	0.00	
T1	Mean difference		—	0.00	4.00 ***	
T2	Mean difference			—	4.00 ***	
T3	Mean difference				—	
No. of Axils						
		T0	T1	T2	T3	
T0	Mean difference	—	-7.00 ***	-6.00 ***	1.00 ***	
T1	Mean difference		—	1.00 ***	8.00 ***	
T2	Mean difference			—	7.00 ***	
T3	Mean difference				—	
Note. * p < .05, ** p < .01, *** p < .001						

Appendix Table 3. Tukey Post-Hoc Test on the field growth performance of coffee.

NO. OF CHERRIES PER AXIL						
		T0	T1	T2	T3	
T0	Mean difference	—	-3.10	-14.0 ***	-13.300 ***	
T1	Mean difference		—	-10.9 ***	-10.200 ***	
T2	Mean difference			—	0.667	
T3	Mean difference				—	
NO. OF AXIL WITH FRUITS						
		T0	T1	T2	T3	
T0	Mean difference	—	-0.267	-1.97 ***	-1.600 ***	
T1	Mean difference		—	-1.70 ***	-1.333 ***	
T2	Mean difference			—	0.367	
T3	Mean difference				—	
AVERAGE WEIGHT OF CHERRIES						
		T0	T1	T2	T3	
T0	Mean difference	—	0.090 ***	-0.170 ***	-0.0200 ***	
T1	Mean difference		—	-0.260 ***	-0.1100 ***	

T2	Mean difference	—			0.1500	***	
T3	Mean difference				—		
AVERAGE YIELD							
		T0	T1	T2	T3		
T0	Mean difference	—	-0.300 ***	-4.00 ***	-2.90 ***		
T1	Mean difference		—	-3.70 ***	-2.60 ***		
T2	Mean difference			—	1.10 ***		
T3	Mean difference				—		
Note. * p < .05, ** p < .01, *** p < .001							

Appendix Table 4. Tukey Post-Hoc Test on the yield performance of rejuvenated coffee.

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