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Effectiveness of a Natural Fertilizer from Organic Household Waste (Banana Peel, Orange Peel, Eggshell, and Onion Peel) versus Chemical Fertilizer on The Growth of Chili (Capsicum Annuum L.): A Comparative Analysis

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ABSTRACT

Commercial chemical fertilizers are heavily relied upon to boost crop yields, but their rising costs and negative environmental impacts—such as soil degradation and water contamination—highlight the critical need for sustainable alternatives. This study evaluated the effectiveness of a liquid natural fertilizer formulated from organic household wastes, including banana peels, orange peels, eggshells, onion peels, rice wash water, and molasses, on the growth performance of chili (Capsicum annuum L.) plants. Utilizing an experimental research design, chili seedlings were divided into four groups to compare the organic formulation (at 5 mL and 10 mL concentrations) against a commercial synthetic fertilizer and a water-only control group. The plants were monitored over an eight-day treatment period using two primary metrics: plant height and leaf count. The results demonstrated that the organic formulation is highly effective in promoting key growth parameters. In terms of plant height, the water-only control group achieved the highest average height of 8.6 inches, followed closely by the 10 mL organic fertilizer group at 8.1 inches, while both the chemical fertilizer and 5 mL organic treatments recorded the shortest height at 7.7 inches. Conversely, in the metric of leaf production, the 10 mL organic fertilizer concentration demonstrated the strongest performance, yielding the highest average of 10.6 leaves. The water-only and 5 mL organic groups resulted in 8.4 leaves, whereas the chemical fertilizer group performed the worst, recording the lowest average of 4.2 leaves. These findings confirm that the homemade organic fertilizer can rival and surpass commercial options, particularly in supporting leaf growth. The study concludes that recycling household kitchen waste into a liquid biofertilizer provides a practical, eco-friendly, and cost-effective solution for sustainable urban agriculture.

INTRODUCTION

Capsicum annuum, otherwise known as chili pepper, is one of the most grown and consumed vegetables all around the world due to its flavorful and spicy kick in cuisines. Along with all other plants and crops, they need proper care and attention to thrive strong; their growth depends on certain conditions such as getting enough exposure to sunlight, water supply, and the right nutrients in the soil. Nutrients help plants develop, sprout healthy leaves, and bloom flowers (which later turn into fruits or veggies). While farmers tend to use commercial chemical fertilizers since they quickly supply needed nutrients for plant growth, the rising costs make them too expensive for local ones to afford and harder to access in some places. Besides, some of them contain harsh chemicals that harm not just plants but also the environment (soil health and ecosystems) over time; a few instances include environmental pollution, loss of biodiversity, and soil degradation. Chemical fertilizers have been heavily relied upon to boost crop yields. Nonetheless, utilizing them for an extended period of time can lead to negative consequences such as reduced soil fertility which results in higher acidity levels and disruption in microbial balance (Kielak *et al.*, 2016). Further to that, Chandini *et al.* (2019) indicate that the excessive use of chemical fertilizers leads to environmental pollution, in particular water contamination with high concentrations of nitrates and phosphates. This study features why finding sustainable and eco-friendly alternatives to traditional chemical fertilizers to reduce their negative impact on the environment matters so much.

In response to the critical need for sustainable alternatives, using organic ingredients, the leftovers from our home kitchens, to make an environmentally friendly alternative that not only enriches soil yet also reduces wasted food and gives new life to food scraps that would normally be thrown away would be a good idea to help the environment in the process and save money. This study aims to formulate an affordable, eco-friendly natural fertilizer for healthy plant growth using available and accessible organic household ingredients: banana peels, orange peels, egg shells (rich in calcium), molasses (sugar source), rice wash water (full of minerals), and onion peels—which are stuff commonly discarded and tossed out as trash—to promote urban agriculture through recycling kitchen waste into valuable soil amendments and help people become self-sustaining.

Specifically, the studies detail the benefits of the aforementioned ingredients: Molasses acts as a valuable natural fertilizer for plant growth through providing

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carbohydrates, as well as altering the carbon-to-nitrogen ratio in the soil to improve its microbial ecology, and it also reduces plant-parasitic nematodes and gives other benefits for plant growth (Pyakurel *et al.*, 2019). Furthermore, banana peels, orange peels, and eggshells offer a rich source of phosphorus and potassium and can be mixed altogether in the right proportions in order to make a balanced biofertilizer; such formulations can improve soil health, enhance crop output, and support sustainable farming practices (Itamah *et al.*, 2025). Additionally, onion peels are packed with beneficial phytochemicals that can boost soil fertility and plant resistance to diseases when used as a fertilizer (Rajput & Khandale, 2022), and rice wash water contains plenty of essential NPK (nitrogen, phosphorus, and potassium) nutrients that support healthier plant development (National Nutrition Council). By utilizing this readily available organic waste, the research addresses the high cost and adverse effects of commercial chemical fertilizers, offering a practical, sustainable, and economically beneficial solution for plant nourishment.

Objectives of the Project

General Objectives

The overall objective of this research experiment was to assess the effectiveness of a natural fertilizer formulated from organic (banana peel, orange peel, eggshells, onion peel, rice water, ad molasses) household ingredients as an eco-friendly alternative to commercial fertilizers. It aims to investigate its potential growth in terms of plant height and number of leaves of chili plants.

Specific Objectives

1. To test the effectiveness of the formulated products on plant growth.
2. To investigate the potential effect of using this natural fertilizer on plant growth.
3. To compare the growth performance of a plant using natural fertilizer versus using other commercial fertilizers.

LITERATURE REVIEW

Due to the wide global cultivation of Capsicum annuum, commonly known as chili, a diverse species including varieties like sweet peppers and jalapeño, there are various scientific investigations concerning its importance for human consumption and medicinal applications. Chili is recognized as more than just a spice; it is a rich reservoir of bioactive compounds (Azlan *et al.*, 2022). According to Faisal & Mustafa (2025), chili contains a wealth of phytonutrients, flavonoids, and capsaicinoids, suggesting they can act as an alternative treatment for numerous health conditions such as oxidative stress, inflammation, cancer, and microbial diseases. Additionally, their study specifically highlighted evidence suggesting that capsaicinoids and capsaicin may help alleviate the symptoms of serious viral infections like COVID-19. They propose that this positive effect is due to the way capsaicin interacts with the TRPV1 receptor, which then aids in the management of chronic conditions.

We can find chili peppers every day in our markets, and as we observe, there are times when the chilies appear large, shiny, and vibrant, while in other times they are small and dull. This happens because chili plants respond differently depending on the type of fertilizer used and the growing conditions. Since chili is widely used in many households, it is grown throughout different seasons, but off-season often has difficulties in production. Unpredictable weather conditions, poor soil fertility, and misuse of fertilizers are some of the problems identified by Khaitov *et al.* (2019) in their study, where they found that the lack of proper organic matter and nutrients can significantly affect the growth and yield of chili plants. Problems within the plant should not be the only concern for improving the quality and productivity of chilies because many chili growers lack proper training on fertilizer management, their fertilization practices remain not ideal. According to Wardah & Budi (2019) they found that before training, farmers scored low on fertilization knowledge, but after training, their understanding substantially improved. This suggests that training is critical for improving chili farmers' fertilizer use — whether organic, chemical, or a mix — and for boosting yields.

According to (Castellanos *et al.* 2017) Many greenhouse-vegetable growers cannot participate in the organic market due to the scarcity of organic fertilizers, which are able both to (a) satisfy the crop's nutritional needs similarly to when using a nutrient solution, and (b) be regarded as biological, ecological, or in general terms "sustainable." The entire crop management was 100% organic according to United States organic standards. We found that vermicompost—obtained from the metabolism of Eisenia fetida feed with cow manure plus maize waste—was able to supply the needed nutrients to the cultivars to obtain a growth and yield similar to the plants supplied with nutrient solution. The overall results suggest that organic sources of nutrients may be able to supply the needs of greenhouse hot peppers as alternative for organic farmers. Treatment with vermicompost showed the general best behavior in all the plants.

According to (Ramamoorthy *et al.* 2024) Agriculture plays a vital role in the food security and economies of Asian countries. They observed that numerous metric tons of vegetable and fruit wastes are disposed of annually. The study aimed to convert the food wastes encompassing the vegetable and fruit wastes into solid and liquid organic fertilizer and to evaluate their influence on the growth (germination, phytochemicals, and biomolecules) of Solanum Lycopersicon and Capsicum annum. Solanum Lycopersicon, known as the tomato, and Capsicum annum, known as the bell pepper or chili pepper, are globally significant crops valued for their medicinal properties and economic importance. The pot experiment was performed with organic fertilizers (solid and liquid organic fertilizer) and compared with the influence of chemical fertilizer and control soil without fertilizers. As the result of experimentation, the liquid organic fertilizer

effectively enhanced the biometric profile and chlorophyll content of S. Lycopersicon and C. annum. The results of a 30-days pot experiment with various fertilizer treatments showed significant influence of liquid organic fertilizer on the fresh and dry weight biomass of both S. Lycopersicon and C. annum. Subsequently, the solid organic fertilizer showed considerable influence on test crops, and the influence of these organic fertilizers was more significant than the chemical fertilizer on crop growth in 30-days experiment. These results suggest that the sustainable approach can effectively convert vegetables and fruit waste into valuable organic fertilizer enriched with plant growth supporting essential nutritional elements.

Instead of rejecting onion peels and throwing them away, Zhang *et al.*, (2024) indicated that onion peel extracts could encourage root development, act as a mild foliar fertilizer, and can even repel pests. The aforementioned material also improves plant growth performance and antioxidant activity through bioactive substances such as flavonoids and carbohydrates; therefore, onion peels can be converted to beneficial agricultural inputs, e.g., soil amendments. In a similar way, washed rice water is a form of organic waste created while cleaning the rice before preparation. Washed rice water contains dissolved nitrogen including carbohydrates, proteins, vitamins (thiamin, riboflavin and niacin), and minerals which can stimulate beneficial microbial activity in soil and induce growth of plant. The application of rice water was reported to increase the growth of vegetables including lettuce, water spinach, pak choy, eggplant, mustard and tomato (Abba *et al.*, 2021).

Khanyile and colleagues (2024) also noted banana peels could be good resource for biofertilizer production because it could serve as a valuable source of potassium, phosphorus, and calcium nutrients. Most studies have reported that the banana peels noticeably increased the growth parameters of different plant species grown. Further to that, Bhargaw *et al.* (2024) pointed out that crushed eggshells supply bioavailable calcium carbonate to soil, which is important to somehow prevent problems like blossom-end rot in vegetables or fruits.

MATERIALS AND METHODS

Project Type

In this study, we utilized an experimental research design in order to evaluate whether a natural fertilizer created from household organic materials - namely banana and orange peels; eggshells; onion skins; rice water; and molasses could have a positive effect on growing chili plants. In addition to being beneficial to the environment for it can be an eco-friendly alternative to commercial fertilizers, this research will help to identify the cause-and-effect relationship between the type of fertilizer applied and the development or health of the chilies. Several measures of growing metrics (how tall the plants got and how many leaves they grew) for each group will be observed and tracked, and these results are about to be compared amongst the four groups.

The chili seedlings and seedling bags are bought in a MG farm supply located at Barangay Sto. Cristo district, Guimba Nueva Ecija. Since each of them varied in size and condition, we used simple random sampling: wherein we assigned numbers per plant and grouped them based on the numbers drawn. In Brgy. Cabileo, Cuyapo, Nueva Ecija, we prepared the needed materials such as trays of chili seedlings, soil, seedling bags. We set up the experiment with four separate group for comparison.

All groups were kept under the same level of care and conditions for all of them which were provided treatments -- equal amount of sunlight, water, and air -- so the only real difference was the type or amount of fertilizer. This way, we could really see what impact each type of fertilizer had on the plants and figure out if homemade options hold up in real gardening.

Table 1: Experimental Groups and Fertilizer Treatments

1	Commercial or Synthetic Fertilizer
2	Natural or Organic Fertilizer ((Banana Peel, Orange Peel, Eggshell, Onion Peel, Rice Water, and Molasses)
3	Water (H_2O)

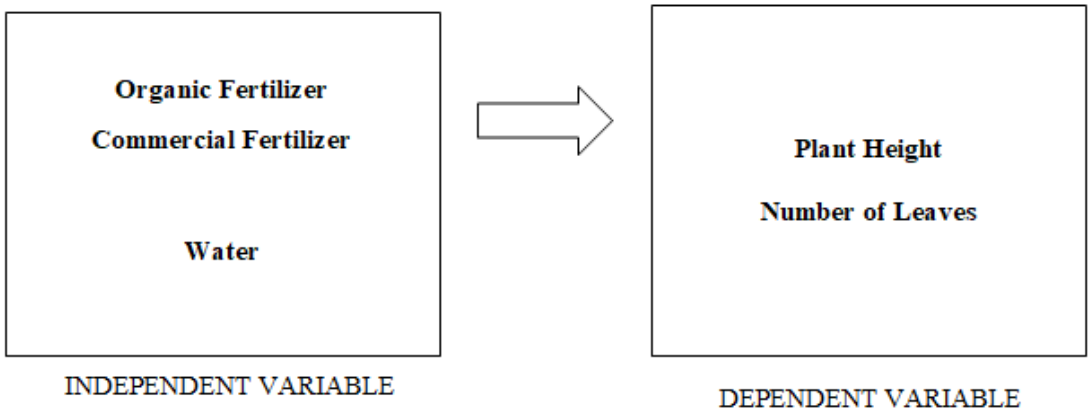

Figure 1: Conceptual Framework of the Study

Preparation of Organic Fertilizer

The researchers followed the organic fertilizer preparation methodology recommended by Fernando *et al.* (2023), sourcing waste materials such as orange peels, eggshells, banana peels, molasses, onion peels, and rice water from household refuse. The procedure began with the collection and preparation of the solid waste: banana peels, orange peels, eggshells, and onion peels were thoroughly rinsed to remove debris. The peels were cut into small pieces, and the eggshells were crushed. Separately, the molasses was melted. The prepared solid ingredients were then added to a blender in a 1:1 ratio and initially blended until finely chopped. Next, a mixture of melted molasses, rice water, and plain water (using a 1:4 ratio of rice water to plain water) was added, and the entire solution was liquefied in the blender for three minutes. Once it's become watery and doesn't have any hard ingredients inside the blender, the mixture is strained using a clean cloth into a basin and then transferred to a lidded bottle for 7 days of fermentation.

Following fermentation, the resulting liquid organic fertilizer will be applied to five small chili plants to test its effectiveness. The effectiveness will be measured using plant height and leaf count as metrics. These experimental plants will be compared against control groups treated with plain water and a chemical fertilizer.

Materials Used

The materials used in this study to be able to make our organic liquid fertilizer are banana peels, orange peels, onion peels, eggshells, rice water and a blender. For the fermentation we used a basin, white strainer cloth, measuring cup, weighing scale, and empty bottle with a lid. Lastly, for observation and application, we used a syringe to measure the amount of organic and chemical fertilizer to be put in the plant, and we also used a ruler to measure the height of the plants.

RESULT AND DISCUSSION

This chapter of the study analyzes and presents the data obtained about the growth parameters and number of leaves of chili plants involved in this study.

Table 2: Data of growth parameters and number of leaves of chili plant before treatment.

Before treatment application		
	Average Plant height (inch)	Number of Leaves
Organic 5mL	7.1	0.25
Organic 10 mL	8	0.26
Chemical	7.3	0.25
Water	8.3	0.26

Before the treatment of Organic Fertilizer

This table show the plant height and no. of leaves of 4 groups of chili plants were measured and listed. The mean for plant height ranges from 7.1 to 8.3 inches. While the number of leaves ranges from 0.25 to 0.26 centimeters. In this table, it clearly shows that the means of each group are close with each other. The mean for the plant height for organic of 5ml treatments is 7.1, for organic 10ml is 8, for chemical 5ml is 7.3, for water 5ml is 8.3, the individual means of treatments was closed to the mean, suggesting that plant height of the watering was similar from each other. The lowest plant height was observed in treatment 5ml with 7.1 mean, and it was only 1.2 away from the overall mean. While the highest individual group mean was observed in both treatments 5ml and 10ml with 8.3 cm plant height and only .3 away from the overall mean.

Table 3: Result of ANOVA in growth parameters and number of leaves of chili plant.

ANOVA (Plant Height)		
Source of Variation	P-value	F crit
Between Group	0.006538799	2.769430932
ANOVA (Number of Leaves)		
Source of Variation	P-value	F crit
Between Group	0.38280526	2.769430932

The analysis of variance revealed that both plant height and no. of leaves of the studied chili plants were significantly different from each other after 8 days of treatment. Plant height had a p-value of 0.006538799 which is less than 0.05, and this means that there is a significant difference among the treatments, while as the no. of leaves had a p-value lower than 0.05 (0.38280526). When the p-values for the growth parameters were compared to each other, it was observed that the plant height of the experimented chili plants was more affected compared to its no. of leaves.

Data after 8 days of treatment

Table 4: Data of chili plant growth parameters and number of leaves.

8 days after treatment application		
	Average Plant height	Number of Leaves
Organic 5 mL	7.7	8.4
Organic 10 mL	8.1	10.6
Chemical	7.7	4.2
Water	8.6	8.4

This table presents data on chili plant growth parameters 8 days after treatment application. The growth parameters included in this table are average plant height, average number of leaves. Water shows the highest plant height (8.6 inch), followed closely by organic 10ml (8.1 inch). The chemical and organic 5ml has the shortest plant height (7.7 inch). This suggests that treatments Organic and water resulted in greater plant heights compared to the chemical treatment, with water being the most effective. Organic also has the highest number of leaves (10.6). The chemical group has the lowest number of leaves (4.2). All treatments show an improvement in plant height, with water again being the most effective. with water and organic showing the most significant improvement.

Table 5: Result of ANOVA in growth parameters and number of leaves of chili plant.

PLANT HEIGHT		
Treatment	Mean	Group
Water	8.20	a
Chemical	7.27	a
Organic 5 mL	7.67	a
Organic 10 mL	7.60	a

NUMBER OF LEAVES		
Treatment	Mean	Group
Organic 10 mL	8.07	a
Water	6.13	ab
Organic 5 mL	7.40	bc
Chemical	9.53	c

Post Hoc Analysis grouped the treatments by their mean. The highest mean plant height, which was 8.20, occurred in the water treatment. According to the analysis, the water treatment was statistically the same compared to the chemical treatment (7.27), organic 5ml (7.67), and organic 10 mL (7.60). In all these treatments, there is no great difference. This shows that water was as effective as the rest of the treatments in enhancing the plant height.
In terms of number of leaves, the statistical tool used in this study suggests that the chemical treatment with the value of 9.53 was the most effective in influencing the number of leaves of the plants. Organic 10 ml and water were somewhat near the means of the treatments. While organic 5ml had an effect, it was not as effective compared to the other two treatments. The negative control group showed a remarkably different effect compared to the treated groups.

CONCLUSION

This study evaluated the effectiveness of a liquid organic fertilizer made from banana peels, orange peels, eggshells, onion peels, rice wash water, and molasses on the growth of chili (Capsicum annuum L.). Results showed that the organic fertilizer, particularly at the 10 mL concentration, effectively promoted plant growth and produced the highest average number of leaves (10.6) among all treatments. Although the water-only group recorded the greatest plant height, the 10 mL organic fertilizer treatment showed comparable growth. The organic fertilizer also outperformed the commercial chemical fertilizer in leaf production. These findings indicate that recycled household waste can be transformed into an effective, eco-friendly, and cost-efficient fertilizer that supports sustainable gardening and agricultural practices.

Recommendation

Future studies should extend the duration of the experiment to evaluate the long-term effects of the organic fertilizer on plant yield and fruit production. Researchers are also encouraged to test additional fertilizer concentrations to determine the most effective application rate. Clear guidelines for comparison treatments should be provided to improve reproducibility. Home gardeners and farmers may use the 10 mL organic fertilizer formulation as a practical and affordable alternative to chemical fertilizers. The ingredients can also be manually crushed when blending equipment is unavailable.

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