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The Use of Crushed Mussel (Perna Viridis) Shells and Chicken's (Gallus Gallus Domesticus) Eggshells as A Soil Amendment to Reduce Acidity and Enhance the Growth of Pechay (Brassica Rapa Subsp. Chinensis)

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ABSTRACT

This study is to determine the effectiveness of crushed mussel (Perna viridis) shells and chicken's (Gallus gallus domesticus) eggshells as natural soil amendments in reducing acidity and enhancing the growth of pechay (Brassica rapa subsp. chinensis). The methodology used was a six-week greenhouse experiment employing a completely randomized design with treatments consisting of distilled water only, commercial lime, and varying shell powder concentrations (5%, 10%, and 15%). Research findings and interpretation revealed that soils treated with shell powders showed increased pH levels and improved plant growth compared to distilled water, with the 10% and 15% treatments performing similarly to commercial lime in terms of plant height, biomass, and leaf development. The conclusion drawn is that crushed mussel shells and chicken eggshells are viable, eco-friendly, and low-cost alternatives to commercial lime in reducing soil acidity and enhancing pechay growth, though further studies are recommended to assess long-term impacts and scalability in larger farming systems.

Keywords: Amendment, Mussel Shells, Eggshells, Pechay, Soil Acidity, Soil pH

INTRODUCTION

Soil acidity affects crop productivity because it reduces the availability of nutrients and increases the levels of toxic elements like aluminum (Khaled & Sayed, 2023). Low soil pH reduces the availability of nutrients like calcium and phosphorus, which affects crop growth. The pechay (Brassica rapa subsp. chinensis) crop is very sensitive to soil acidity, which makes it a good crop for use in soil amendment research (Lagon et al., 2022). Lime is commonly applied as a soil amendment for acidity correction, but it is not easily accessible by some local farmers. This treatment can also be very expensive and less available to smallscale farmers. At the same time, mussel shells (Perna viridis) and chicken egg shells (Gallus gallus domesticus) can potentially increase the pH level in the soil since they contain calcium carbonate. Although previous studies have already explored the use of shell materials in the treatment of the soil, there is limited research done to study the combined effect of mussel shells and chicken eggshells in the growth performance of pechay. This study evaluates the effectiveness of crushed mussel shells and chicken eggshells as natural, low-cost soil amendments to reduce acidity and enhance pechay growth.

Research Questions

1. Is there a significant difference in soil pH among soils treated with different concentrations of shell powder, commercial lime, and distilled water?
2. Is there a significant difference in the plant height of pechay under different soil treatments?
3. Is there a significant difference in the leaf length of pechay under different soil treatments?
4. Is there a significant difference in the leaf width of pechay under different soil treatments?
5. Is there a significant difference in the dry weight of pechay under different soil treatments?
6. Is there a significant difference in the number of leaves of pechay under different soil treatments?
7. Is there a significant difference in soil pH and pechay growth performance among the 5%, 10%, and 15% shell powder treatments?

METHODS

Study Design

This study utilized a quantitative experimental approach to examine the effects of shell-derived soil amendments on selected soil properties and plant growth parameters. Key variables measured included soil pH, plant height, total biomass, and leaf dimensions. Pulverized shells from green mussels (Perna viridis) and chicken eggs (Gallus gallus domesticus) were applied to the soil at percentage of 5%, 10%, and 15%. For comparison, distilled water served as the negative control, while commercial lime functioned as the positive control.

Pechay (Brassica rapa subsp. chinensis) was selected as the test crop. Plant responses were regularly monitored to determine whether shell-based amendments could provide a viable and sustainable substitute for commercialized liming agents in enhancing soil condition and crop performance. The controlled experimental arrangement facilitated systematic comparison among treatments and enabled clear evaluation of their effects on soil characteristics and plant development.

The collected data were translated using descriptive statistics to show overall trends. A one-way ANOVA was conducted to determine if significant differences existed among treatments, followed by Tukey's HSD test to identify specific group differences. Careful measurement and proper research procedures were followed to ensure reliable and credible results.

Figure 1. Flowchart of Data Procedures

Data Gathering Procedures

The study involved 75 pechay (Brassica rapa subsp. chinensis) plants grown in controlled greenhouse conditions. The experiment used a Completely Randomized Design (CRD), with pots randomly assigned to five treatments. This approach ensured unbiased distribution and equal replication (Zakharchenko & Tunguz, 2020). Each treatment group had 15 plants, with each pot containing 1.25 kg or 1250 g of synthetic acidic soil (Imakumbili et al., 2019).

The concentrations were derived relative to the soil mass of 1250 g per pot. For the positive control (T1), the lime requirement formula used a soil texture factor of 4 for loamy soils. This resulted in 312.5 g of commercial lime per pot (Guarçoni & Sobreira, 2017). For the shell-based treatments, percentages were calculated from the soil mass: 5% = 62.5 g, 10% = 125 g, and 15% = 187.5 g. Each amount was divided equally between mussel shell and chicken eggshell powders (Tao et al., 2024). This method followed greenhouse soil amendment protocols that base concentrations on soil weight to ensure uniformity and comparability among treatments (Kaur et al., 2023; Lolas et al., 2024).

Table 1. Treatment Setup Based on Amendment Proportion by Weight

Treatment	**Amendment %**	**Total Amendment (g)**	**Mussel Shell (g)**	**Eggshell (g)**
T0	Negative Control (Distilled Water)	0 g	0 g	0 g
T1	Positive Control (Calcium Carbonate Lime)	312.5 g	-	-
T2	5%	62.5 g	31.25 g	31.25 g
T3	10%	125 g	62.5 g	62.5 g
T4	15%	187.5 g	93.75 g	93.75 g

Instruments

The study employed a range of laboratory equipment, agricultural tools, and statistical instruments to ensure accurate data collection and analysis. A calibrated digital soil pH meter was used weekly to monitor changes in soil acidity, while a sieving mesh tool and food processor were utilized to prepare mussel shells and chicken eggshells into fine powder with uniform particle size. Thermoformed red pots served as planting containers, and distilled water was applied as a neutral medium and negative control. The experiment was conducted inside a greenhouse to maintain controlled temperature, humidity, and light conditions, thereby minimizing external variability. Plant growth was measured using a digital caliper for height and leaf dimensions, and an SF 400 digital weighing scale (10 kg capacity) was used to record dry biomass after harvest. Data were systematically encoded in Microsoft Excel spreadsheets for organization and analysis. Statistical treatments included descriptive statistics to summarize soil and plant growth data, one-way ANOVA to test significant differences among treatments, and Tukey's HSD post-hoc test to identify specific treatment differences. All instruments were pilot-tested during the initial soil calibration phase, with minor adjustments such as refining shell particle size and recalibrating the pH meter to ensure measurement accuracy.

Data Analysis

The following statistical tools were employed to analyze the gathered data:

Descriptive Statistics (Mean and Standard Deviation) were used to summarize soil pH values and plant growth indicators (height, leaf length, leaf width, number of leaves, and dry weight).

One-way ANOVA was applied to determine significant differences among treatments in terms of soil pH and growth performance (Tae Kyun Kim, 2017).

Tukey's Honest Significant Difference (HSD) Post-Hoc Test was conducted to identify specific treatment groups that differed significantly from one another (Emile et al., 2024).

The Completely Randomized Design (CRD) served as the experimental framework, ensuring equal probability of assignment and reducing systematic error (Hussain & Ali, 2019).

All measurements were encoded weekly into spreadsheets, with n = 15 plants per treatment, covering six weeks of soil pH and growth monitoring. Outlier values were checked during entry, and missing data were reduced through consistent measurement methods (Plate N). Derived variables such as mean soil pH per week and average growth performance per treatment were calculated to provide a reliable basis for comparison.

RESULTS

This section presents the findings of the study entitled "An Experimental Study on the Use of Crushed Mussel (Perna viridis) Shells and Chicken (Gallus gallus domesticus) Eggshells as a Soil Amendment to Reduce Acidity and Enhance the Growth of Pechay (Brassica rapa subsp. chinensis)." The results are organized according to the research problems and supported by statistical analysis using one-way ANOVA and Tukey's HSD test.

Table 2. Mean Soil pH per Treatment After Six Weeks

Treatment	Description	Mean Soil pH	Interpretation
T0	Distilled Water Only	5.18	Strongly Acidic
T1	Commercial Lime	6.82	Slightly Acidic to Neural
T2	5% Shell Powder	5.94	Moderately Acidic
T3	10% Shell Powder	6.63	Slightly Acidic
T4	15% Shell Powder	6.79	Slightly Acidic to Neutral

The results show that soils treated with crushed shells exhibited increased pH levels compared to the control (distilled water only). The 10% and 15% shell powder treatments (T3 and T4) significantly improved soil pH, performing comparably to commercial lime (T1).

The one-way ANOVA revealed a significant difference in soil pH among treatments ($p < 0.05$), leading to the rejection of the null hypothesis. Tukey's HSD test further showed that T3 and T4 were not significantly different from commercial lime but were significantly different from the control group.
These findings confirm that crushed shells, which are rich in calcium carbonate, effectively neutralized soil acidity. This supports the findings of Irfa'I et al. (2022), who reported that calcium carbonate extracted from green mussel shells has liming properties comparable to commercial lime. The results imply that natural shell waste can serve as a practical and sustainable alternative to synthetic soil amendments, especially in areas experiencing soil degradation. According to Kalladithodi (2024), who experimented using crab shell, mussel shell, and coconut shell charcoal, showed inconsistent effects across different plant species, with some treatments failing to outperform conventional fertilizers. Additionally, Li et al. (2025) stated that shell powder applications may alter cadmium dynamics in soil, requiring careful management.

Table 3. Growth Performance of Pechay Under Distilled Water Only (Week 1-6)

Variable (Mean)	W1	W2	W3	W4	W5	W6
Plant Height (mm)	7.2	36.1	52.6	21.3	138.7	164.7
Leaf Length (mm)	5.4	30.8	48.5	78.9	116.4	135.6
Leaf Width (mm)	6.0	28.1	42.7	69.5	104.3	124.0
No. of Leaves	1.0	3.0	3.7	4.0	4.3	4.3
Fresh Weight (g)	-	-	-	-	-	19.7

Table 3 shows that pechay grown under distilled water alone exhibited gradual increases in plant height, leaf length, leaf width, and number of leaves from Week 1 to Week 6. However, despite this upward trend, the final fresh weight remained low at 19.7 g, indicating limited biomass accumulation and weaker overall growth compared to amended treatments.
This finding is supported by Wiser & Blom (2016), who explained that distilled water serves only as a neutral control and does not supply essential minerals needed for plant development. Similarly, Jia et al. (2025) emphasized that proper soil pH correction is necessary to enhance nutrient uptake and improve plant biomass, which explains the limited growth observed in this treatment.

Table 4. Growth Performance of Pechay Under 5% of Shell Powder (Weeks 1-6)

Variable (Mean)	W1	W2	W3	W4	W5	W6
Plant Height (mm)	9.1	38.5	55.6	99.2	153.4	175.2
Leaf Length (mm)	6.2	32.7	50.8	82.4	120.9	134.6
Leaf Width (mm)	7.0	30.5	45.9	73.8	109.8	122.1
No. of Leaves	1.3	3.3	3.7	4.7	5.0	5.1
Fresh Weight (g)	-	-	-	-	-	30.3

Table 4 shows that pechay treated with 5% green mussel and eggshell powder exhibited steady and consistent growth from Week 1 to Week 6. All growth parameters—plant height, leaf length, leaf width, and number of leaves—increased progressively, with higher values than the distilled water treatment. By Week 6, the plants reached a fresh weight of 30.3 g, indicating improved biomass accumulation. These results suggest that even a low concentration of shell powder was able to enhance soil conditions and promote better plant development.

This finding is supported by Khairnar & Nair (2019), who reported that powdered eggshells improved vegetative growth due to their calcium carbonate content. Similarly, Wong et al. (2023) found that eggshell amendments positively influenced plant height and leaf development. These studies support the observed improvement in pechay growth under the 5% shell treatment.

Table 5. Growth Performance of Pechay Under 10% of Shell Powder (Weeks 1-6)

Variable (Mean)	W1	W2	W3	W4	W5	W6
Plant Height (mm)	4.9	41.2	53.4	103.4	173.2	206.8
Leaf Length (mm)	4.9	38.4	49.1	84.6	142.5	157.3
Leaf Width (mm)	5.6	31.8	46.5	77.3	130.6	143.7
No. of Leaves	1.0	3.3	3.7	4.3	5.0	5.2
Fresh Weight (g)	-	-	-	-	-	50.2

Table 5 shows that pechay treated with 10% green mussel and eggshell powder demonstrated consistent and accelerated growth over the six-week period. From Week 2 onward, plant height, leaf length, leaf width, and number of leaves increased steadily. By Week 6, the plants reached a fresh weight of 50.2 g, indicating greater biomass accumulation and more vigorous development compared to lower treatments. This suggests that the 10% shell mixture more effectively improved soil conditions and nutrient availability.

This result is supported by Irfa'I et al. (2022), who confirmed that green mussel shells contain high levels of calcium carbonate capable of neutralizing soil acidity. Likewise, Urjintseren & Byambaa (2024) verified the high calcium carbonate content of eggshells, which contributes to improved plant growth when used as a soil amendment. These findings support the stronger growth observed under the 10% shell treatment.

Table 6. Growth Performance of Pechay Under 15% of Shell Powder (Weeks 1-6)

Variable (Mean)	W1	W2	W3	W4	W5	W6
Plant Height (mm)	7.8	45.3	60.2	112.5	190.7	231.6
Leaf Length (mm)	6.3	41.8	54.9	92.7	161.3	179.6
Leaf Width (mm)	6.9	35.2	49.8	85.1	149.4	165.2
No. of Leaves	1.0	3.7	4.0	4.7	5.3	5.1
Fresh Weight (g)	-	-	-	-	-	60.2

Table 6 shows that pechay treated with 15% mussel and eggshell powder experienced the most pronounced growth from Week 1 to Week 6. Plant height increased substantially from 7.8 mm to 231.6 mm, while leaf length and leaf width continuously improved throughout the experiment. The number of leaves gradually increased, with a slight decrease in Week 6 that may indicate leaf maturation rather than reduced growth. The fresh weight reached 60.2 g, reflecting strong biomass accumulation and vigorous plant development. These results suggest that the 15% shell mixture was highly effective in improving soil conditions and promoting optimal growth.

This finding aligns with Kaewprachu & Jaisan (2023), who confirmed that green mussel shells are rich in calcium carbonate and can function as natural liming agents. Similarly, Khairnar & Nair (2019) reported that higher levels of calcium-rich amendments significantly enhanced vegetative growth. These studies support the strong growth performance observed under the 15% shell treatment.

Table 7. Growth Performance of Pechay Under Commercial Lime (Weeks 1-6)

Variable (Mean)	W1	W2	W3	W4	W5	W6
Plant Height (mm)	6.5	39.8	58.9	109.7	187.6	231.1
Leaf Length (mm)	5.8	40.1	57.6	96.2	170.4	191.0
Leaf Width (mm)	6.2	33.9	52.3	89.6	158.8	174.8
No. of Leaves	1.0	3.7	4.3	4.7	5.0	5.3
Fresh Weight (g)	-	-	-	-	-	40.9

Table 7 shows that pechay treated with commercial lime exhibited steady growth from Week 1 to Week 6. Plant height increased markedly from 6.5 mm to 231.1 mm, while leaf length and width also improved consistently throughout the experiment. The number of leaves gradually rose to 5.3 by Week 6. However, the fresh weight reached 40.9 g, which indicates moderate biomass accumulation compared to the higher shell treatments.

This result is consistent with Spackman (2023), who explained that calcium carbonate lime effectively neutralizes soil acidity and reduces aluminum toxicity, thereby improving plant growth. Similarly, Guarçoni & Sobreira (2017) reported that proper lime application enhances nutrient availability and supports vegetative development. These studies support the improved growth observed under the commercial lime treatment.

Table 8. ANOVA Results Comparing Soil pH and Growth Performance

Variable	df (Between)	df (within)	F	p-value
Soil pH	4	-	56.32	< .001
Plant Height	4	-	48.91	< .001
Plant Weight (dry)	4	-	62.18	< .001
Leaf Length	4	-	41.76	< .001
Leaf Width	4	-	38.29	< .001
Number of Leaves	4	-	9.84	< .001

Table 8 shows that the one-way ANOVA revealed highly significant differences among treatments for all measured variables ($p < .001$). Soil pH, plant height, dry weight, leaf length, leaf width, and number of leaves were all significantly affected by the type of soil amendment. The high F-values for plant height (48.91) and dry weight (62.18) indicate strong treatment effects, confirming that growth performance varied considerably across treatments. These findings demonstrate that soil amendment type played a major role in influencing both vegetative growth and biomass accumulation in pechay.

This result is supported by Tae Kyun Kim (2017), who explained that ANOVA is an effective statistical tool for detecting significant differences among multiple treatment groups. Similarly, Dong (2023) emphasized that significant F-values indicate that treatment effects, rather than random variation, are responsible for differences in outcomes. These studies support the conclusion that the soil amendments significantly influenced pechay growth.

Table 9. Post-Hoc Test (Tukey HSD) for Soil pH

Comparison	Mean Difference	p-value	Interpretation
Distilled Water vs. 5% Shell	-0.73	<.001	Significant
Distilled Water vs. 10% Shell	-0.93	<.001	Significant
Distilled Water vs. 15% Shell	-1.17	<.001	Significant
Distilled Water vs. Commercial	-1.05	<.001	Significant
5% vs. 10% Shell	-0.20	.041	Significant
5% vs. 15% Shell	-0.44	<.001	Significant
10% vs. 15% Shell	-0.24	.018	Significant
10% vs. Commercial	-0.12	.221	Not Significant
15% vs. Commercial	0.12	.198	Not Significant

Table 9 presents the Tukey HSD post-hoc test results for soil pH. The findings show that all shell powder treatments (5%, 10%, and 15%) and the commercialized amendment significantly increased soil pH compared to the distilled water control ($p < .001$). Significant differences were also observed among shell concentrations, indicating that higher application rates generally led to greater increases in soil pH. However, no significant difference was found between 10% shell powder and the commercial amendment, as well as between 15% shell powder and the commercial amendment, suggesting comparable effectiveness in neutralizing soil acidity.

These results are consistent with Guarçoni & Sobreira (2017), who reported that increasing lime rates significantly raises soil pH up to an optimal level. Similarly, Irfa'I et al. (2022) confirmed that mussel shells are rich in calcium carbonate and function similarly to commercial lime in reducing soil acidity. This supports the comparable performance observed between higher shell treatments and the commercial amendment.

Table 10. Post-Hoc Test (Turkey HSD) for Plant Height

Comparison	p-value	Interpretation
Distilled vs. All Shell Treatments	<.001	Significant
5% vs. 10% shell	.032	Significant
10% vs. 15% shell	.014	Significant
15% vs. Commercial	.671	Not Significant

The analysis showed that plants grown with distilled water were significantly shorter than all other treatments ($p < .001$), indicating that the absence of soil amendment limits growth. Plant height increased progressively with higher shell concentrations. Significant differences were observed between 5% and 10% ($p = .032$) and 10% and 15% shell ($p = .014$), demonstrating a dose-dependent effect. The 15% shell treatment was statistically comparable to commercial lime ($p = .671$), suggesting that high shell concentration can match conventional soil amendments in promoting plant height.

The significant increase in plant height with higher shell concentrations reflects the ability of calcium-rich amendments to improve nutrient uptake and support vegetative growth (Kennedy, 2022). Similar studies have shown that eggshell and mussel shell powders can enhance plant height by neutralizing acidic soils and increasing nutrient availability (Kaewprachu & Jaisan, 2023; Urjintseren & Byambaa, 2024).

Table 11. Post-Hoc Test (Turkey HSD) for Dry Weight

Comparison	p-value	Interpretation
Distilled vs. All Shell Treatments	<.001	Significant
5% vs. 10% shell	.009	Significant
10% vs. 15% shell	.021	Significant
15% vs. Commercial	.018	Significant

Dry biomass followed a similar trend. Plants treated with distilled water had significantly lower dry weight than all shell-amended treatments ($p < .001$). Significant increases were observed from 5% to 10% ($p = .009$) and 10% to 15% shell ($p = .021$), showing progressive improvement in biomass with increasing shell concentration. Interestingly, the 15% shell treatment produced higher dry weight than commercial lime ($p = .018$), highlighting the potential of shell powder to outperform conventional fertilizer in biomass accumulation.

The progressive increase in dry biomass with shell amendments, especially the superior performance of 15% shell, aligns with findings that shell powder improves overall plant vigor and supports greater biomass accumulation (Vu et al., 2022). This demonstrates that calcium from biowaste effectively contributes to structural growth and nutrient assimilation.

Table 12. Post-Hoc (Tukey HSD) for Leaf Length Across Treatments

Comparison	Mean Difference	p-value	Interpretation
Distilled Water vs 5% Shell	-6.12	.041	Significant
Distilled Water vs 10% Shell	-18.34	< .001	Significant
Distilled Water vs 15% Shell	-27.91	< .001	Significant
Distilled Water vs Commercial	-32.47	< .001	Significant
5% vs 10% Shell	-12.22	.009	Significant
5% vs 15% Shell	-21.79	< .001	Significant
10% vs 15% Shell	-9.57	.018	Significant
10% vs Commercial	-14.13	.004	Significant
15% vs Commercial	-4.56	.214	Not Significant

Table 12 shows that the type and concentration of soil amendment significantly influenced vegetative growth and leaf development of pechay. Leaf consistently improved from 5% to the 15% treatment performed just as well as the commercial soil amendment, suggesting that it can be effective alternative for commercial products. This highlights the potential of green mussel and eggshell powder as a cost-effective and sustainable soil amendment for pechay cultivation.

Improvements in leaf length with higher shell concentrations are consistent with studies showing that calcium-rich amendments promote leaf expansion and photosynthetic capacity in crops (Irfa'I et al., 2022).

The comparable performance of 15% shell and commercial lime indicates that natural shell powders can match conventional fertilizers in morphological traits.

Table 13. Post-Hoc (Tukey HSD) for Leaf Width Across Treatments

Comparison	Mean Difference	p-value	Interpretation
Distilled Water vs 5% Shell	-5.86	.047	Significant
Distilled Water vs 10% Shell	-19.71	< .001	Significant
Distilled Water vs 15% Shell	-31.14	< .001	Significant
Distilled Water vs Commercial	-34.88	< .001	Significant
5% vs 10% Shell	-13.85	.006	Significant
5% vs 15% Shell	-25.28	< .001	Significant
10% vs 15% Shell	-11.43	.013	Significant
10% vs Commercial	-15.17	.003	Significant
15% vs Commercial	-3.74	.327	Not Significant

Table 13 shows that the Tukey HSD analysis revealed significant differences in leaf width among most treatments. Plants grown with distilled water had narrower leaves compared to all shell-amended treatments and the commercial fertilizer, showing that amendments improved leaf expansion. Leaf width generally increased with higher shell concentrations, and the 15% shell treatment performed comparably to the commercial fertilizer ($p = .327$).

The wider leaves observed under shell amendments suggest enhanced cell elongation and division due to improved soil pH and calcium availability (Yang et al., 2023). This supports previous findings that oyster and mussel shells can improve leaf morphology by stabilizing soil conditions and nutrient balance.

Table 14. Post-Hoc (Tukey's HSD) for Number of Leaves Across Treatments

Comparison	Mean Difference	p-value	Interpretation
Distilled Water vs 5% Shell	-0.63	.032	Significant
Distilled Water vs 10% Shell	-0.89	.004	Significant
Distilled Water vs 15% Shell	-1.01	.002	Significant
Distilled Water vs Commercial	-1.08	.001	Significant
5% vs 10% Shell	-0.26	.211	Not Significant
5% vs 15% Shell	-0.38	.094	Not Significant
10% vs 15% Shell	-0.12	.634	Not Significant
10% vs Commercial	-0.19	.412	Not Significant
15% vs Commercial	-0.07	.781	Not Significant

Table 14 shows the post-hoc analysis showed that plants irrigated with distilled water produced a significantly lower number of leaves compared to all shell-amended treatments and the commercial fertilizer, confirming the positive effect of soil amendments on leaf development.

In contrast, no significant differences were detected among the shell-amended treatments (5%, 10%, 15%)

and the commercial lime ($p > .05$). This indicates that while soil amendments increased the number of leaves compared to the control, increasing the concentration beyond 5% did not result in a statistically significant additional increase in leaf number. This supports Galvan et al. (2021), who reported that leaf count in pechay is a stable growth indicator, less responsive to soil amendments.

Although the number of leaves increased with all amendments compared to distilled water, the lack of significant differences among shell treatments reflects the relative stability of leaf initiation once adequate nutrients are available (Vasquez et al., 2024). This indicates that even lower concentrations of shell powder can sufficiently support leaf production in pechay.

CONCLUSION

The study confirmed that crushed mussel (Perna viridis) shells and chicken (Gallus gallus domesticus) eggshells are effective natural soil amendments for reducing soil acidity and enhancing the growth performance of pechay (Brassica rapa subsp. Chinensis). The calcium carbonate content of these biowaste materials successfully neutralized acidic soil conditions, resulting in improved nutrient availability and healthier plant development.

Among the treatments, the 15% shell powder (T4) consistently produced the highest soil pH, plant height, and dry biomass, performing comparably to commercial lime and surpassing it in certain growth parameters. This demonstrates that shell-based amendments can serve as practical, sustainable, and locally available substitutes for commercial lime, particularly in resource-limited agricultural settings.

The rejection of the null hypothesis further validates that soil amendment type and concentration significantly influence soil chemical properties and plant growth. Overall, the findings highlight the potential of agricultural and household biowaste to address soil acidity while promoting environmentally responsible farming practices and advancing sustainable agriculture.

References

1. Dong, Y. (2023). Descriptive Statistics and Its Applications. Highlights in Science, Engineering and Technology, 47, 16–23. https://doi.org/10.54097/hset.v47i.8159
2. Emile, C., Sacla, E., Honfo, H., & Glèlè, R. (2024). Heliyon On the use of post-hoc tests in environmental and biological sciences : A critical review. Heliyon, 10(3), e25131. https://doi.org/10.1016/j.heliyon.2024.e25131
3. Galvan, J. P. D., Adorio, M. D., Ruth, M., Simon, A. C., Razote, R. P., John, A., & Galvan, P. D. (2021). Growth and yield performance of pechay (Brassica napus L .) in hydroponics system as influenced by magnetic field. 19(1), 1–8.
4. Guarçoni, A., & Sobreira, F. M. (2017). Classical Methods and Calculation Algorithms for Determining Lime Requirements. 1–11.
5. Hussain, Z., & Ali, S. (2019). Comparative Study on Breaking Strength of Burnt Clay Bricks Using Novel Based Completely Randomized Design (CRD). Civil Engineering Journal (Iran), 5(5), 1162–1174. https://doi.org/10.28991/cej-2019-03091320
6. Imakumbili, M. L. E., Semu, E., & Semoka, J. (2019). Soil collection and preparation for pot experiments V . 1. 1–6.
7. Irfa'I, M. A., Prihanto, A., Muryanto, S., Jamari, J., Ismail, R., & Bayuseno, A. P. (2022). Precipitated Calcium Carbonate Derived from Green Mussel Shells Extracted from Magnesium Chloride Containing Solution. IOP Conference Series: Earth and Environmental Science, 1098(1).

https://doi.org/10.1088/1755-1315/1098/1/012021
8. Jia, X., Speck, A., Feng, X., & Lee, C. W. (2025). Impact of Water pH and Cultivar on Lettuce Growth , Water Use Efficiency , and Nutrient Use Efficiency in Deep Water Culture Systems. 1–19.
9. Kaewprachu, P., & Jaisan, C. (2023). Physicochemical Properties of Chitosan from Green Mussel Shells (Perna viridis): A Comparative Study. Polymers, 15(13), 1–14. https://doi.org/10.3390/polym15132816
10. Kalladithodi, S. (2024). A study on effect of various soil amendments [crab shell powder , clam shell powder , green mussel shell powder , coconut shell charcoal and eggshell powder] on the growth of Tomato plants (Solanum lycopersicum). 11(1), 452–462.
11. Kaur, N., Brym, Z., Sharma, L. K., Alberto, L., & Oyola, M. (2023). Nitrogen fertilization impact on hemp (Cannabis sativa L .) crop production : A review. March, 1557–1570. https://doi.org/10.1002/agj2.21345
12. Khairnar, M. D., & Nair, S. S. (2019). Study on Eggshell and Fruit Peels As a Fertilizer. Proceedings of International Conference on Sustainable Development, 978, 25–27. https://www.researchgate.net/publication/332878769_STUDY_ON_EGGSHELL_AND_FRUIT_PEELS_AS_A_FERTILIZER
13. Khaled, F., & Sayed, A. (2023). Soil pH and its influence on nutrient availability and plant health. International Journal of Advanced Chemistry Research, 5(2), 68–70. https://doi.org/10.33545/26646781.2023.v5.i2a.204
14. Lagon, J. R. M., Abad, R. G., Bayogan, E. R. V., & Silvosa-Millado, C. S. C. (2022). Growth and Yield of Screenhouse-grown potted Pechay (Brassica rapa L. ssp. chinensis cv. Black Behi) in selected Davao-produced Composts. Mindanao Journal of Science and Technology, 20(2), 206–227. https://doi.org/10.61310/mndjstea.0990.22
15. Li, H., Wu, Y., Li, J., Han, T., & Liu, K. (2025). Long-term oyster shell powder applications increase crop yields and control soil acidity and cadmium in red soil drylands. February, 1–12. https://doi.org/10.3389/fpls.2025.1506733
16. Lolas, A., Molla, K., Georgiou, K., Apostologamvrou, C., Petrotou, A., Skordas, K., & Vafidis, D. (2024). Evaluating the Liming Potential of Mytilus galloprovincialis Shell Waste on Acidic Soils. Conservation, 4(4), 778–791. https://doi.org/10.3390/conservation4040046
17. Spackman, J. (2023). PRECIPITATED CALCIUM CARBONATE AS A LIME.
18. Tae Kyun Kim. (2017). Understanding one-way anova using conceptual figures. Korean Journal of Anesthesiology, 70(1), 22–26.
19. Tao, J., Chen, D., Wu, S., Zhang, Q., Xiao, W., Zhao, S., Ye, X., & Chu, T. (2024). The Comprehensive Effects of Biochar Amendments on Soil Organic Carbon Accumulation, Soil Acidification Amelioration and Heavy Metal Availability in the Soil–Rice System. Agronomy, 14(11). https://doi.org/10.3390/agronomy14112498
20. Urjintseren, P., & Byambaa, J. (2024). Determination of Egg Shell Structure and Mineral Composition Using <i>SEM - EDS</i> and Identification the Possibility to Produce Fertilizer. Journal of Materials Science and Chemical Engineering, 12(03), 21–30. https://doi.org/10.4236/msce.2024.123003
21. Vasquez, F. Y. C., Fuentes, A. G. P., & Casinillo, L. F. (2024). Evaluating eco-friendly soil neutralizers : The use of pulverized eggshells and clam shells in enhancing rice field soil acidity. 11(1), 101–109.

22. Vu, N., Dinh, T., Le, T., Vu, T., Nguyen, T., Pham, T., Vu, N., Koji, S., Hama, S., Kim, I., Jang, D., Kim, D., & Tran, A. (2022). yield of groundnut (Arachis hypogaea L .). Plant Production Science, 25(4), 413–420. https://doi.org/10.1080/1343943X.2022.2120506
23. Wiser, L., & Blom, T. J. (2016). The Effect of Nitrogen and Phosphorus Ratios and Electrical Conductivity on Plant Growth. American Journal of Plant Sciences, 07(12), 1590–1599. https://doi.org/10.4236/ajps.2016.712150
24. Wong, C., Wen, Z., Ashikin, S., Bahari, N., Aliah, A., Tumiran, R. A., Faisal, N., Suzaina, J., & Sy Ing, O. (2023). The Effects of Eggshell and Egg Membrane Amendments on Soil and Plant Growth. International STEM Journal, 4(2), 38–49.
25. Yang, X., Liu, K., Wen, Y., Huang, Y., & Zheng, C. (2023). Application of Natural and Calcined Oyster Shell Powders to Improve Latosol and Manage Nitrogen Leaching.
26. Zakharchenko, E., & Tunguz, V. (2020). Effect of Ammonium Sulfate and Phosphogypsum Application on Nutrients Dynamics. Bulletin of Sumy National Agrarian University. The Series: Agronomy and Biology, 4(42), 61–69.