

Shredded Paper as Soil Enhancer in the Growth of Mustard (*Brassica Rapa* Subsp. *Oleifera*) and Pechay (*Brassica Rapa*)

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Abstract. The escalating global reliance on synthetic fertilizers has precipitated critical soil degradation, characterized by increased acidification and nutrient leaching that leads to environmental issues like aquatic eutrophication. This study addresses the urgent need for sustainable soil restoration by investigating the efficacy of composted shredded paper as a low-cost, cellulosic soil amendment to enhance the growth performance of *Brassica rapa* (Pechay) and *Brassica rapa* subsp. *oleifera* (Mustard). Utilizing a randomized experimental design in a controlled greenhouse environment, the research evaluated three amendment concentrations (10:1, 10:2, and 10:3) against an unamended control. Systematic assessments were conducted over a 30-day duration to quantify changes in hydro-physical properties, chemical pH shifts, biomass accumulation, and potential nitrate toxicity. The findings reveal that shredded paper amendments significantly optimize soil physical architecture, most notably reducing water infiltration time from a baseline of 24.67 seconds to 3.33 seconds in the 10:3 treatment group. Chemically, the amendment served as an effective buffering agent, mitigating soil acidity by elevating pH levels from an acidic 5.5 to a more neutral 6.2. While germination rates remained consistent across all variables, *Brassica rapa* exhibited peak vegetative vigor at the 10:2 ratio, showing marked increases in shoot length and total biomass. Critically, nitrate levels remained well below the 2000 mg/kg toxicity threshold, confirming the safety of the produce for human consumption. These results demonstrate that upcycling paper waste not only improves soil hydraulic conductivity and fertility but also offers a scalable strategy for carbon sequestration and waste management in urban and school-based agricultural systems.

Introduction

Modern farming systems have become heavily reliant on synthetic chemicals, a practice that proves detrimental to both environmental stability and economic viability. While commercial fertilizers are intended to provide essential nutrients and boost plant growth, their repeated use without organic replenishment gradually strips the soil of its natural health, leading to long-term infertility. This unsustainable cycle is particularly evident in high-altitude regions like Benguet, Philippines, where steep topography and persistent chemical application have rendered vast tracts of land unproductive due to accelerated acidification and nutrient depletion. Beyond the fields, excessive fertilizer runoff triggers eutrophication in aquatic ecosystems, creating oxygen-depleted zones that starve fish and other organisms, thereby threatening biodiversity and human food sources.

To address this global crisis of soil degradation, established knowledge suggests that restoring soil function requires the reintegration of organic matter to improve porosity, moisture retention, and cation exchange capacity. Integrating composted shredded paper into agricultural practices offers a dual-purpose solution, transforming institutional waste into a valuable carbon-rich amendment that balances high-nitrogen inputs and improves soil architecture. Recent studies indicate that organic waste revalorization effectively reduces soil bulk density and buffers pH levels; however, a significant gap remains in utilizing school-generated paper waste. Despite the mandates of the Organic Agriculture Act of 2010, many

educators and farmers continue to view shredded paper as an inert burden, often resulting in its wasteful disposal through dumping or burning rather than its conversion into bio-based fertilizer.

Previous literature presents conflicting results regarding paper-based amendments, noting that while they boost organic carbon and stimulate microbial activity, immature compost may trigger nitrogen immobilization and hinder plant development. There is a critical, underexplored need for precise data on the specific concentration ratios of school-based paper waste required to enhance short-term crops without inducing nitrogen competition. Addressing this gap is essential for transitioning toward a circular economy model that supports initiatives like the *Gulayan sa Paaralan* (School Garden). By fostering a resilient biological ecosystem and supporting carbon sequestration, these amendments can mitigate greenhouse gas emissions while reducing the agricultural sector's dependence on harmful chemical inputs.

Consequently, this study addresses three focused questions: how varied ratios of composted shredded paper affect soil water infiltration and pH, the impact of these amendments on the germination and biomass of *Brassica rapa* (Pechay) and *Brassica juncea* (Mustard), and whether the application of paper-based compost maintains nitrate toxicity within safe consumption limits. The primary goal is to evaluate the efficacy of composted shredded paper as a soil conditioner, while the secondary goal is to test its influence on the morphological health of these leafy vegetables. The following sections detail the experimental methods, the results of the statistical analysis using ANOVA and Tukey HSD, and a discussion on the practical implications for sustainable, school-based organic agriculture.

Theoretical Framework

The conceptual foundation of this study is grounded in the Soil Quality Paradigm, which evaluates soil health through the integration of physical, chemical, and biological indicators. This framework is anchored in the Circular Economy Theory, proposing that institutional waste specifically cellulose-rich paper can be revalorized as a soil amendment to restore degraded agricultural lands. By transitioning from a linear "take-make-waste" model to a circular system, school-generated paper waste is transformed from a disposal burden into a carbon-rich (C) substrate that facilitates essential soil functions such as mineralization and nutrient cycling.

At the core of the physical framework is the Organic Matter Stabilization Theory, which explains the causal relationship between organic amendments and soil architecture. As microorganisms decompose the shredded paper, they produce polysaccharides and fungal hyphae that act as "microbial glues," binding sand, silt, and clay into water-stable aggregates. This process directly influences the dependent variables: an increase in organic matter leads to a measurable decrease in bulk density (compaction) and a corresponding increase in macroporosity, which enhances the infiltration rate of water. These structural improvements are critical for the root development and hydrologic stability required by short-term crops.

Chemically, the framework utilizes Acid Neutralization and Cation Exchange Theory to address the specific soil constraints found in the Benguet region. The application of composted paper introduces basic cations and organic colloids that neutralize hydrogen ions (H⁺), effectively raising the soil pH and mitigating Aluminum (Al³⁺) toxicity, which otherwise stunts root growth in acidic environments. This rise in pH further enhances the Cation Exchange Capacity (CEC)—the soil's ability to hold and release nutrients like Potassium (K⁺) and Calcium (Ca²⁺) by increasing the density of negatively charged binding sites derived from the dissociation of organic acids.

These interrelated physical and chemical shifts provide the biological environment necessary for the optimal growth of *Brassica rapa* (Pechay) and *Brassica juncea* (Mustard). By maintaining a balanced Carbon-to-Nitrogen (C:N) ratio, the amendment supports microbial communities that release nutrients in a steady, slow-release format. This logical alignment ensures that the research questions regarding soil infiltration, pH stabilization, and plant biomass are addressed within a cohesive scientific structure. The framework serves as a roadmap for the subsequent Methods and Results sections, providing a theoretical lens through which the effectiveness of paper-based compost as a sustainable agricultural tool can be validated.

Methodology

Research Design

This study utilized a true experimental research design to evaluate the efficacy of composted shredded paper as a soil amendment. This design was selected to establish a cause-and-effect relationship between the varying concentrations of the amendment and the resulting soil quality and plant growth metrics. The experiment was conducted within a controlled greenhouse environment at Bokod National High School to mitigate the influence of external confounding variables such as fluctuating sunlight, temperature, and inconsistent water exposure. The setup involved a control group (pure soil) and three experimental treatment groups defined by paper-to-soil ratios of 10:1, 10:2, and 10:3. To ensure internal validity, each treatment was replicated three times, and soil media were placed in uniform transparent containers

to allow for standardized observation of water infiltration. This systematic manipulation of independent variables—shredded paper concentration allowed for a precise comparison of soil pH, water retention, and the morphological development of both *Brassica rapa* and *Brassica rapa subsp. oleifera*.

Materials

The study was conducted between December 2019 and March 2020 at the Bokod National High School's *Gulayan sa Paaralan* greenhouse in Benguet. To minimize external environmental variables like temperature and sunlight, the researchers utilized a controlled greenhouse setting. The primary amendment material consisted of shredded school waste, specifically quiz papers, used notebooks, and printed bond papers, while excluding glossy, colored, or cardboard materials to maintain consistency. Key biological and technical materials included Ramgo brand Pechay and Mustard seeds, plastic planter pots, and precision measurement tools such as a micrometer, weighing scale, and ruler for data collection.

Data Gathering Procedure

The data gathering procedure began with the preparation of a standardized soil medium and a three-month composting process for shredded school waste. Recyclable papers were manually shredded into small pieces to prevent clumping and mixed into 10 kg of sieved soil at specific ratios (10:1, 10:2, and 10:3) to facilitate decomposition and oxygen diffusion. Once the compost reached a crumbly, dark consistency, 24 plastic planter pots were prepared and sown with six seeds each of *Brassica rapa* and *Brassica rapa subsp. oleifera*. Environmental variables were controlled within a greenhouse, where the subjects received daily monitored watering and filtered sunlight to ensure consistent growth conditions for the duration of the 30-day study. The researchers employed a multi-faceted testing protocol to evaluate soil and plant health across the experimental treatments. Soil quality was assessed through an innovative water infiltration test using transparent containers for visual monitoring and professional laboratory pH analysis conducted in Baguio City. Plant growth was quantified by calculating germination percentages on the seventh day and measuring biomass and elongation of shoots and roots at 15 and 30-day intervals. Finally, to ensure food safety, nitrate toxicity levels were measured using a Greentest Eco 6 digital probe, which analyzed the electrical conductivity within the plant tissues to estimate nitrate concentration (mg/kg) against safety thresholds.

Data Analysis

The study employed a One-Way Analysis of Variance (ANOVA) using IBM SPSS Statistics (v.25) to determine the significance of the results. This single-factor analysis was essential for testing the null hypothesis across the four independent groups (Control, T1, T2, and T3) to identify any statistically significant differences in the means of soil quality and plant growth metrics. Because ANOVA identifies that a difference exists but does not specify where, the Tukey Post Hoc Test was subsequently utilized to perform pairwise comparisons. This allowed the researcher to pinpoint exactly which shredded paper concentration ratio produced significantly better results in terms of biomass, elongation, and infiltration time compared to the other treatments. All inferential tests were measured against a significance level of $\alpha = 0.05$, ensuring that the conclusions regarding the effectiveness of the paper amendment were statistically robust and reliable.

Results and Discussion

The Effect of Amending the Soil with Composted Shredded Paper to Enhance Soil Quality

To determine the effect of the soil with composted shredded paper on soil quality, the time of water infiltration was first determined.

Water Infiltration Time in Soil of Various Quality.

A one-way ANOVA was conducted to compare the effects of composted shredded paper on the time of water infiltration in the soil with varied concentrations of amendment.

Treatment	Mean (Sec)	SD
Control	24.67	3.51
1	9.33	1.52
2	6.67	1.53
3	3.33	1.53

Note: Each treatment has three replicates. The amount of water is constant at 200 ml.

Table 1. Summary Table for the Mean Time of Water Infiltration

As shown in Table 1, the control group exhibited the slowest infiltration rate, with a mean time of 24.67sec (SD= 3.51) for 200 ml of water to drain. In contrast, the time required for infiltration decreased progressively as the concentration of shredded paper increased, reaching a minimum of 3.33 sec (SD=1.53) in treatment 3 (10:3 ratio). A one-way ANOVA confirmed that these differences were statistically significant, $F(3, 8) = 55.26$, $p = .0001$. Post hoc Tukey HSD testing revealed that all treatments differed significantly from the control ($p < .05$). Notably, a significant difference was also found between Treatment 1 and Treatment 3 ($p = .041$), indicating that higher concentrations of paper amendment are significantly more effective at increasing the rate of water movement through the soil profile.

These results suggest that the integration of paper fibers effectively reduces soil compaction and enhances porosity. The application of composted shredded paper significantly altered the soil's physical structure, specifically its hydraulic conductivity. The shredded paper acts as a "brown" organic material that, upon composting, improves soil aggregate stability. By binding smaller soil particles into larger aggregates, the amendment creates a higher proportion of macropores, which facilitates rapid water penetration and reduces the risk of surface crusting.

These findings corroborate the work of Xing et al. (2020), who noted that organic residues improve soil texture and bulk density. Furthermore, the results align with Chow et al. (2002), who observed that adding fiber pulp to agricultural soil increased hydraulic conductivity by fostering larger soil aggregates. While Zhu (2024) highlighted that unspecified organic matter impacts adsorption and porosity, this study provides concrete evidence that school-based waste paper is a specific, viable organic side stream that decomposes to improve soil structural integrity.

These data support the use of shredded paper as a low-cost soil conditioner to remediate compacted soils in agricultural settings. The ability of the paper to enhance water absorption suggests it could play a vital role in moisture management for vegetable production. To build on these results, future studies should investigate the water-holding capacity of the soil over a longer duration to determine if the rapid infiltration also translates to sustained moisture availability for the plant roots during dry periods.

Effect of Composted Shredded Paper on Soil pH

From the result of the soil analysis conducted at the Regional Soils Laboratory in Baguio City (Appendix O) revealed that amending soil with composted shredded paper led to a significant increase in soil alkalinity. The initial soil pH of 5.5 (strongly acidic) rose to 6.2 (acidic) following the amendment, accompanied by a substantial increase in organic matter from 1.01% to 2.39%. This shift is particularly beneficial for the growth of *Brassica rapa*, which thrives in pH levels between 5.5 and 6.8.

The observed increase in pH suggests that shredded paper acts as an effective buffering agent. While the decomposition of organic matter typically produces hydrogen ions (H^+) that increase acidity, this study suggests that paper waste often containing calcium carbonate-based fillers used in manufacturing acts as a mild alkaline agent. This process, coupled with the decarboxylation of organic anions and the release of basic cations (Ca, K, Mg), helps neutralize acidic soil conditions. Furthermore, the increase in organic matter enhances the soil's Cation Exchange Capacity (CEC), allowing it to better retain base cations that displace acidity-causing aluminum and hydrogen ions.

These findings align with Kumar et al. (2020) and Chrysargyris et al. (2021), who reported that paper waste can increase pH by up to 1.5 units, making it an efficient tool for pH correction in acidic soils. However, the results present a nuanced contrast to researchers like McCauley (2019) and Zhou (2019), who argue that organic matter accumulation generally correlates with increased acidity due to humification and nitrification. This discrepancy highlights that the impact of paper on soil chemistry is highly dependent on the paper type; specifically, school-based bond papers likely contain alkaline coatings that override the natural acidifying effects of cellulose decomposition.

These results confirm that composted shredded paper is not only a source of carbon but also a functional amendment for soil pH remediation. For school gardens with acidic soil profiles, this provides a low-cost alternative to agricultural lime. To maximize these benefits, it is recommended that the paper be fully composted to allow the initial microbial acid-production phase to pass, ensuring a stable, pH-balanced medium for vegetable production.

The Effect of Composted Shredded Paper on Percent Germination, Biomass, and Elongation of the Shoot and Root of Brassica rapa subsp. oleifera (mustard) and Brassica rapa (Pechay)

The effect of composted shredded paper on the seed germination, elongation, and biomass of the shoot and roots is indicated in terms of percentage. The study utilized a one-way ANOVA to evaluate the effect of composted shredded paper on the germination rates of *Pechay* and *Mustard*.

Name of Species	Treatments	Mean	Std. deviation	Test of Homogeneity of Variance		ANOVA	
				Levene's Statistics	Sig.	F	Sig.
Pechay	Control	83.33	16.503	.318	.812	.431	.736
	One	88.67	9.815				
	Two	88.67	9.815				
	Three	94.33	9.815				
Mustard	Control	83.33	16.503	.389	.764	2.002	.192
	One	50.00	17.000				
	Two	83.33	16.503				
	Three	72.33	25.423				

Note: Values are the mean of the three replicates + SD; Levene's Statistics and ANOVA result. Each value is at the level of significance for a 95% interval. P is not significant at $P > .05$

Table 2. ANOVA Summary Table for the Percentage of Seed Germination of Pechay and Mustard

As detailed in Table 2, the mean germination for Pechay ranged from 83.33% in the control to 94.33% in Treatment 3, while Mustard ranged from 50.00% (Treatment 1) to 83.33% (Control and Treatment 2). Statistical analysis confirmed no significant difference among treatments for either species, as p-values exceeded the .05 threshold, specifically $p = .736$ for Pechay and $p = .192$ for Mustard. Consequently, the null hypothesis was accepted, indicating that composted shredded paper does not significantly influence the initial sprouting phase of these vegetables.

These findings imply that *Brassica rapa* species are capable of independent nutrient uptake during their earliest life stage. Germination is primarily fueled by internal energy reserves stored within the cotyledons rather than external soil nutrients or carbon provided by paper amendments. The shredded paper serves as a chemically inactive medium during this phase, primarily because the 3–5 day germination window for these species is too short for the paper to decompose and release significant nutrients. Therefore, while composted paper improves soil structure for mature plants, it remains an inert material during the germination process as long as basic requirements like water, sunlight, and oxygen are met.

The results suggest that *Brassica rapa* can germinate successfully across varied soil qualities. While the paper did not act as a growth stimulant, its potential benefit as a mulch for moisture conservation as noted in studies on *Komatsuna* spinach by Mon & Oue (2023) remains relevant for maintaining the water potential necessary for successful emergence. The use of paper as a soil additive aligns with home gardening practices where paper containers prevent transplant shock, eventually decomposing into organic matter.

Because this study focused on the total percentage of germination, the researcher recommends future investigations into whether different soil conditions and paper enhancements cause a delay in seed emergence. Further longitudinal study could determine the exact point at which decomposing paper begins to transition from an inert medium to an active nutrient source for the developing seedlings.

Average Shoot and Root Length and Biomass

The integration of composted shredded paper showed varied effects on the primary growth parameters of both species. In the first 15 days, no significant differences were observed in the shoot length or root length of pechay ($p = .831$ and $p = .626$, respectively) or mustard ($p = .309$ and $p = .321$, respectively) across all treatment groups. By day 30, while mustard growth remained statistically consistent with the control group ($p > .05$), pechay exhibited a significant increase in shoot length with a probability value of .023, which is below the .05 significance threshold. Specifically, pechay in treatment 2 achieved a mean shoot length of 14 cm (SD= 1.8), a notable increase from the control mean of 8.8 cm (SD= 1.1).

Parameter	Treatment	Plant Species							
		Pechay				Mustard			
		Day 15		30		Day 15		30	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Shoot Length (cm)	0	6.8	0.7	8.8	1.1	5.5	1.00	12.5	1.0
	1	7.1	0.66	11.8	1.45	7.00	1.10	12.8	1.0
	2	6.9	0.85	14	1.8	6.30	0.75	13.3	2.3
	3	6.5	0.80	12.7	1.97	6.30	0.62	13.0	2.0
	P value	.831	NS	.023	S	.309	NS	.947	NS
Root Length (cm)	0	2.5	0.75	14.33	1.53	3.5	0.82	5.7	0.90
	1	3.5	1.4	19.33	2.52	5.03	1.34	5.7	1.30
	2	3.3	0.76	18.33	2.52	3.77	1.05	6.1	1.85
	3	3.4	0.85	21.00	3.61	4.03	0.63	5.8	1.2
	P value	.626	NS	.072	NS	.321	NS	.920	NS
Biomass (g)	0	.53	.00	.87	.15	.40	.10	.73	.06
	1	.50	.00	1.4	.15	.50	.10	.80	.10
	2	.50	.00	1.57	.31	.50	.10	.87	.15
	3	.50	.00	1.2	.17	.50	.10	.77	.06
	P value	.441	NS	.015	S	.552	NS	.452	NS

Note: Values are the mean of the three replicates and SD. Each mean difference is tested at the 95% level of significance. P is not significant if $P > .05$.

Table 3. Average Shoot and Root Length and Biomass of Pechay and Mustard in 15 and 30 Days

Biomass, which reflects a plant's ability to capture sunlight and minerals, followed a similar trend to elongation. For the first 15 days, composted shredded paper had no significant effect on the biomass of either pechay ($p = .441$) or mustard ($p = .552$). However, at the 30-day mark, pechay demonstrated a statistically significant response to the amendment with a p-value of .015. The biomass for Pechay reached its peak in treatment 2 at 1.57 g ($SD = .31$), compared to the control group's .87 g ($SD = .15$). Mustard biomass remained unaffected throughout the study duration. These findings suggest that while the amendment is initially inert during the germination and early seedling stages, it becomes biologically active as the plant matures. The significant growth in Pechay's shoot length and biomass by day 30 indicates that the composted paper eventually created a favorable environment, likely by improving soil structure and water retention. The lack of observable effects in the first 15 days may be attributed to the slow mineralization rate of cellulosic paper waste, which requires a longer duration to release essential nutrients in plant-available forms. The study validates that recycled cellulosic waste can serve as an effective agricultural input, aligning with the "circular economy" principles mentioned by Olanrewaju et al. (2020). However, the researchers noted that the three-month composting period may have been insufficient for the rapid growth cycle of *Brassica rapa*. This supports the claim that slowly decomposing organic materials, like paper, may require the addition of other organic sources or longer composting times to maximize nutrient mineralization for short-term crops.

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Control	treatment 1	-3.033	1.3180	.177	-7.254	1.187
	treatment 2	-5.200*	1.3180	.018	-9.421	-.979
	treatment 3	-3.900	1.3180	.070	-8.121	.321
Treatment 1	Control	3.033	1.3180	.177	-1.187	7.254
	treatment 2	-2.167	1.3180	.409	-6.387	2.054
	treatment 3	-.867	1.3180	.910	-5.087	3.354
Treatment 2	Control	5.200*	1.3180	.018	.979	9.421
	treatment 1	2.167	1.3180	.409	-2.054	6.387
	treatment 3	1.300	1.3180	.761	-2.921	5.521
Treatment 3	Control	3.900	1.3180	.070	-.321	8.121
	treatment 1	.867	1.3180	.910	-3.354	5.087
	treatment 2	-1.300	1.3180	.761	-5.521	2.921

Note: Dependent Variable: Shoot length (cm) of Pechay, Tukey HSD. Based on observed means. *The mean difference is significant at the 0.05 level.

Table 4. Results of the Shoot Length of Pechay from Post hoc Test Tuckey HSD

The study utilized a Tukey HSD post hoc test to identify specific growth differences, revealing that treatment 2 (10:2 ratio) was the most effective concentration for enhancing Pechay shoot length after 30 days ($p = .018$). While no significant biomass changes occurred within the first 15 days, significant improvements emerged by day 30, particularly in Treatment 1 ($p = .040$) and Treatment 2 ($p = .013$). These findings suggest that the benefits of shredded paper are time-dependent, as a prolonged decomposition period of 12 to 15 weeks is necessary for microorganisms to convert cellulose into humus and stabilize essential macronutrients like nitrogen and potassium. Conversely, higher concentrations like the 10:3 ratio (treatment 3) failed to produce significant growth, likely due to an excessive carbon-to-nitrogen ratio that triggered nitrogen immobilization and competition between microbes and plant roots. Ultimately, the researchers concluded that while paper amendments attract beneficial organisms like earthworms, the material must be fully decomposed to neutralize organic acids and ensure a nutrient-rich, non-toxic medium suitable for vegetable production.

Effect of Composted Shredded Paper on the Nitrate Toxicity Level of Brassica rapa subsp. oleifera (mustard) and Brassica rapa (Pechay)

The study assessed the safety of the harvested crops by measuring nitrate levels using a Greentest Eco Model V6, which confirmed that all samples remained significantly below the established safety threshold of 2000 mg/kg. Mean nitrate concentrations for the treatment groups were recorded at 20 mg/kg at 15 days and 40 mg/kg at 30 days, notably lower than the control group's levels of 30 mg/kg and 70 mg/kg, respectively. These findings imply that composted shredded paper facilitates a balanced, gradual release of nitrogen, preventing the excessive nitrate accumulation often associated with synthetic fertilizers. Because shredded paper is carbon-rich but nitrogen-poor, the slight increase in nitrate detected by day 30 represents the healthy mineralization of organic nitrogen into plant-available forms. To optimize these results, the researcher recommends a composting period of at least 30 days to ensure nitrogen stabilization. Furthermore, integrating vermicomposting or nitrogen-rich organic materials like animal manure is advised to enhance the nutrient profile of the paper-based amendment while maintaining a safe, non-toxic environment for vegetable production.

Conclusion and Implications

Conclusions

Based on the findings of the study, the following conclusions are derived:

1. a. Amending the soil with composted shredded paper improved soil quality by increasing its water infiltration time.
- b. Amending the soil with composted shredded paper increased the soil pH from strongly acidic to acidic.
2. a. There is no effect of the shredded paper as a soil amendment on the seed germination percentage for both the pechay and mustard in all three ratios of concentration (10:1, 10:2, and 10:3).
- b. There is an effect of composted shredded paper on the root length and biomass of pechay under 30 days but no effect under 15 days of the three treatments applying the ratio of concentration - 10:1, 10:2, and 10:3. There is no significant effect of composted shredded paper on the root and shoot length, and biomass of mustard during the 30-day of the three treatments applying the ratio of concentrations like 10:1, 10:2, and 10:3.
3. The use of shredded paper as a soil amendment is safe for vegetable production. The results show very low nitrate toxicity levels (<2000 mg) for both mustard and pechay across all trials. The amendment actually helps prevent excessive nitrate accumulation, ensuring the vegetables are safe for consumption

Recommendations

Based on the foregoing conclusions, the following are recommended:

1. Composted shredded paper can be utilized along with sand as a remedy to improve compacted soils like clay in the agricultural fields. Also, composted shredded paper can be amended to acidic soil to reduce soil acidity at a low cost.
2. Prolonging the composting period for the decomposition of shredded paper is highly recommended to facilitate cellulose decomposition and improve soil quality. The addition of Vermiworms or other microorganisms during composting is highly encouraged to improve the nitrogen content of soil.
3. Increase consumption of crops from organic farming, as the use of natural soil amendments like composted shredded paper helps ensure the product is low in nitrate toxicity. In addition, public schools should maintain their existing Gulayan gardens and be encouraged to use composted shredded paper to amend and improve the soil quality in the school garden.
4. Further study is encouraged for other researchers to duplicate this study, but to use other plant samples and have a longer duration for the shredded papers to decompose.

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Data Availability Statement

Data sharing does not apply to this article as no new data were created or analyzed in this study; all data used were obtained from previously published sources as cited in the reference list.

References

- Ayllara, M. S., Olanweraju, O. S., & Odeyemi, O. (2020). Waste management through composting: Challenges and potentials. *Sustainability*, 12(11), 4456. <https://doi.org/10.3390/su12114456>
- Bondi, C., Castellini, M., & Iovino, M. (2025). Temporal variability of the physical quality of a sandy loam soil amended with compost. *Biologia*, 80(1), 1221–1232.
- Busby, R. R., Torbert, H. A., & Prior, S. A. (2019). Soil and vegetation responses to amendment with pulverized classified paper waste. *Soil and Tillage Research*, 194, 104328. <https://doi.org/10.1016/j.still.2019.104328>
- Calubaquib, M., Navarrete, I., & Sanchez, P. (2017). Properties and nutrient status of degraded soils in Luzon, Philippines. *Philippine Journal of Science*, 146(3), 253–261. <https://philjournalsci.dost.gov.ph>
- Dayegamiye, A. N. (2010). Mixed paper sludge effects on corn yield, nitrogen efficiency and soil properties. *Agronomy Journal*, 98(6), 1471–1478. <https://doi.org/10.2134/agronj2006.0137>
- de Freitas, E. M., et al. (2023). Evapotranspiration and crop coefficient of *Physalis peruviana* cultivated with recycled paper as mulch. *Scientia Horticulturae*, 320, 112212. <https://doi.org/10.1016/j.scienta.2023.112212>
- de Souza, R. P., et al. (2021). Successive crops of lettuce fertilized with organic compost produced from cellulose paper residues. *Journal of Agricultural Sciences*, 13(1), 1–7. <https://doi.org/10.5539/jas.v13n1p1>
- Farhain, M. M., et al. (2024). Paper mill wastes and biochar improve physiochemical properties and reduce heavy metals leaching risks in podzolic soils. *Environmental Research Communications*, 6(5), 055018.
- Judd, L., Jackson, B., & Fonteno, W. (2015). Advancements in root growth measurement technologies. *Plants*, 4(3), 369–392. <https://doi.org/10.3390/plants4030369>
- Kang, M. W., et al. (2022). Enhancement of soil physical properties and soil water retention with biochar-based soil amendments. *Science of The Total Environment*, 836, 155746. <https://doi.org/10.1016/j.scitotenv.2022.155746>
- Kumar, R. P., & Padmapriya, P. (2020). Utilization of paper waste for the production of organic compost. *IJIRSET*, 9(6), 4615–4621. <http://www.ijirset.com>
- Li, Y., Feng, G., & Tewolde, H. (2023). Biochar derived from papermill factories improves soil physical and hydraulic properties. *Biochar*, 5(1).
- Madramootoo, C. A., et al. (2023). Growth and yield of tomato on soil amended with waste paper based hydrogels. *Scientia Horticulturae*, 310, 111752. <https://doi.org/10.1016/j.scienta.2022.111752>
- Mahdjoub, N., et al. (2022). Pulp and paper mill sludge; a soil amendment. *Detritus*, 20, 70–77. <https://doi.org/10.31025/2611-4135/2022.15180>
- Mon, M. M., & Oue, H. (2023). Effects of shredded paper mulch on Komatsuna spinach. *Agronomy*, 13(10), 2502.

- <https://doi.org/10.3390/agronomy13102502>
Neina, D. (2019). The role of soil pH in plant nutrition and soil remediation. *Applied and Environmental Soil Science*, 2019. <https://doi.org/10.1155/2019/5794869>
- Oyebiyi, O. O., et al. (2026). Organic amendments for sustainable agriculture. *C*, 12(1), 7. <https://doi.org/10.3390/c12010007>
- Pandolfi, A., et al. (2025). Effects of sustainable landscaping practices on beetles. *PeerJ*, 13, e20415. <https://doi.org/10.7717/peerj.20415>
- Rabel, D. O., et al. (2020). Recycled alkaline paper waste influenced growth and structure of *Pinus taeda*. *New Forests*, 52(2), 249–270. <https://doi.org/10.1007/s11056-020-09818-9>
- Räty, M., et al. (2023). Improving coarse-textured mineral soils with pulp and paper mill sludges. *Geoderma*, 438, 116617. <https://doi.org/10.1016/j.geoderma.2023.116617>
- Vannucchi, F., et al. (2021). De-inked paper sludge and mature compost as substrate components. *Journal of Cleaner Production*, 290, 125176. <https://doi.org/10.1016/j.jclepro.2020.125176>
- Zhang, S., et al. (2023). Effects of soil amendments on soil acidity and crop yields. *Journal of Environmental Management*, 345, 118531. <https://doi.org/10.1016/j.jenvman.2023.118531>
- Zhou, J., et al. (2019). Effects of soil pH and texture on soil carbon and nitrogen. *PeerJ*, 7, e7816. <https://doi.org/10.7717/peerj.7816>
- Zhu, X. (2024). Distribution and driving mechanism of soil inorganic carbon. *Catena*, 247, 108475. <https://doi.org/10.1016/j.catena.2024.108475>
- Zoghlami, R. I., et al. (2023). Assessment of earthworm viability after de-inking paper sludge amendment. *Agriculture*, 13(3), 547. <https://doi.org/10.3390/agriculture13030547>

Appendices

Appendix A provides the field layout, Percent Seed Germination of Pechay, Water Infiltration Rate (Sec), Shoot and Root Length and Biomass of Pechay and Mustard and other related data to the study which are uploaded in GitHub for viewing and reference of readers, researchers, and authors. In addition, a version-controlled copy of the appendix together with accompanying documentation and update history, is hosted in a public GitHub repository, which can be accessed through the provided [link](#).