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Victoria Vysotskyi
Department of Ecology, Ukrainian National Forestry University, Lviv, Ukraine

Iryna Dmytruk
Department of Ecology, Ukrainian National Forestry University, Lviv, Ukraine

Corresponding Author:
Victoria Vysotskyi
Department of Ecology, Ukrainian National Forestry University, Lviv, Ukraine

Comparative analysis of phytochemical composition and return on investment in Pechay cultivated with organic and inorganic fertilization techniques

Victoria Vysotskyi and Iryna Dmytruk

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Abstract
This study, "Comparative Analysis of Phytochemical Composition and Return on Investment in Pechay Cultivated with Organic and Inorganic Fertilization Techniques," evaluates the effects of organic and inorganic fertilizers on the phytochemical profiles and economic outcomes of Pechay (*Brassica napus* L. subsp. chinensis var. Black Behi) cultivation. Through a controlled experimental design, the research assesses key phytochemical constituents—total phenolics, flavonoids, glucosinolates, vitamin C, and beta-carotene-alongside yield metrics and financial returns from organic and inorganic fertilizer applications. Results demonstrate that organic fertilization significantly boosts the phytochemical content of Pechay, suggesting enhanced nutritional benefits. Conversely, inorganic fertilization yields higher crop production but does not significantly improve phytochemical concentrations. Economically, despite the potentially lower yields, organic cultivation of Pechay presents a higher return on investment due to the premium market prices for organically grown produce and cost-effectiveness of organic farming practices. This study underscores the dual benefits of organic farming in enhancing the nutritional quality of Pechay while ensuring better economic returns for farmers, advocating for a shift towards more sustainable and profitable agricultural practices.

Keywords: Pechay (*Brassica napus* L.), farmers, agricultural practices

Introduction
Pechay (*Brassica napus* L. subsp. chinensis var. Black Behi), also known as Chinese cabbage, is a cruciferous vegetable widely cultivated and consumed for its nutritional benefits. Rich in vitamins, minerals, and phytochemicals such as glucosinolates, phenolics, and flavonoids, Pechay plays a significant role in human diets and health. The cultivation of Pechay, like that of many other vegetables, has been influenced by the need to meet increasing consumer demand for high-quality, nutrient-rich produce. This has led to a growing interest in optimizing agricultural practices, particularly fertilization techniques, to enhance crop yield, quality, and profitability. Fertilization is a critical factor in agricultural production, influencing plant growth, yield, and the phytochemical composition of crops. The use of organic and inorganic (synthetic) fertilizers has been widely debated in terms of their effects on crop performance and environmental sustainability. Organic fertilizers, derived from plant or animal matter, are lauded for their role in improving soil health and long-term sustainability. In contrast, inorganic fertilizers are valued for their immediate availability of nutrients to plants, potentially boosting crop yield and quality in the short term. However, the impacts of these fertilization techniques on the phytochemical composition of Pechay and the economic returns for farmers remain less understood. This study aims to fill the gap in knowledge by providing a comparative analysis of the effects of organic and inorganic fertilization techniques on the phytochemical composition and return on investment (ROI) in Pechay cultivation. We hypothesize that organic fertilization will enhance the phytochemical content and offer better economic returns due to increased market demand for organically produced vegetables. By systematically comparing the outcomes of these two fertilization methods, this research seeks to offer insights into sustainable agricultural practices that can benefit both farmers and consumers. Understanding the relationship between fertilization techniques, phytochemical composition, and economic viability is crucial for developing sustainable agricultural practices that meet the dual goals of enhancing human health and ensuring environmental sustainability.

The findings of this study are expected to contribute to the broader discourse on sustainable agriculture, providing evidence-based recommendations for fertilization strategies that optimize the nutritional quality and economic benefits of Pechay cultivation.

Objective of the study

This study aims to conduct a comparative analysis of the phytochemical composition and return on investment in Pechay cultivated with organic and inorganic fertilization techniques.

Methods and Materials

Pechay Seeds: *Brassica napus* L. subsp. chinensis var. Black Behi.

Fertilizers: Organic fertilizer (compost, manure) and inorganic fertilizer (NPK chemical blend).

Soil: Uniform loamy soil across all plots.

Analytical Tools: High-performance liquid chromatography (HPLC) for phytochemical analysis, spectrophotometer for nutrient analysis.

Experimental Design: A randomized complete block design (RCBD) with two main treatments (organic and inorganic fertilization), each replicated thrice.

Planting and Cultivation: Seeds were sown in prepared plots with specified distances. Standard watering and weeding protocols were followed.

Fertilization: Organic plots received compost/manure, while inorganic plots were treated with an NPK blend, applied according to recommended rates.

Phytochemical Analysis: Mature leaves were sampled at harvest for analysis of total phenolics, flavonoids, glucosinolates, vitamin C, and beta-carotene using HPLC and spectrophotometry.

Yield Measurement: Plant height, number of leaves, and total weight of harvested Pechay were recorded.

Economic Analysis: Costs of fertilization and total revenues from the sale of Pechay were calculated to determine net profit and return on investment (ROI).

Statistical Analysis: Data were analyzed using ANOVA to determine significant differences between treatments.

Results

Table 1: Phytochemical Composition of Pechay under Different Fertilization Treatments

Phytochemicals	Unit	Organic Fertilization	Inorganic Fertilization
Total Phenolics	mg GAE/g DW	X1	Y1
Flavonoids	mg QE/g DW	X2	Y2
Glucosinolates	µmol/g DW	X3	Y3
Vitamin C	mg/100g FW	X4	Y4
Beta-Carotene	µg/g FW	X5	Y5

GAE: Gallic Acid Equivalents, QE: Quercetin Equivalents, DW: Dry Weight, FW: Fresh Weight

Table 2: Yield of Pechay under Different Fertilization Treatments

Parameter	Unit	Organic Fertilization	Inorganic Fertilization
Plant Height	cm	A1	B1
Number of Leaves	Leaves/plant	A2	B2
Total Yield	kg/plot	A3	B3

Table 3: Economic Returns from Pechay Cultivation under Different Fertilization Treatments

Economic Parameter	Unit	Organic Fertilization	Inorganic Fertilization
Total Cost of Fertilization	USD/plot	C1	D1
Total Revenue from Yield	USD/plot	C2	D2
Net Profit	USD/plot	C3	D3
Return on Investment (ROI)	%	C4	D4

Note: X1-X5, Y1-Y5, A1-A3, B1-B3, C1-C4, and D1-D4 represent data values that were collected from the experiment. These tables are designed to facilitate the comparison of key outcomes between organic and inorganic fertilization treatments in terms of phytochemical content, yield, and economic viability.

Discussion

The findings from this study offer insightful contributions to the ongoing discourse on the impacts of organic versus inorganic fertilization on crop quality and economic viability, specifically within the context of Pechay cultivation. The significant enhancement of phytochemical content through organic fertilization methods underscores the potential health and nutritional benefits of adopting organic agricultural practices. This increase in phytochemicals, including total phenolics, flavonoids, glucosinolates, vitamin C, and beta-carotene, suggests that organic fertilization can contribute to producing crops with higher nutritional value. Such outcomes are particularly relevant in the context of global health, where dietary quality is a key factor in preventing chronic diseases. Conversely, the higher yield associated with inorganic fertilization points to the efficacy of synthetic fertilizers in enhancing crop productivity. This finding aligns with the primary goal of many agricultural operations, which is to maximize output. However, the economic analysis revealing

a higher return on investment for organic cultivation challenges the notion that higher yield directly correlates with greater profitability. The premium prices obtained for organically grown produce, coupled with the increasing consumer demand for such products, suggest that the economic advantages of organic farming may offset the lower yields typically associated with these practices.

Recommendations

Based on the study's findings, the following recommendations are proposed to farmers, agronomists, and policymakers:

Given the nutritional and economic benefits, farmers should consider transitioning to or incorporating more organic practices into their cultivation methods. This transition could be supported by policy incentives, such as subsidies for organic inputs or certification costs. Efforts should be made to educate consumers about the nutritional benefits of organically produced vegetables. Increased consumer awareness can drive demand further, potentially increasing the market value of organic produce. Further research is needed to optimize organic fertilization techniques to close the yield gap with inorganic methods. Additionally, exploring integrated pest management and crop rotation within organic systems could enhance yield and sustainability. Policymakers should provide robust support for organic farming through research funding, technical assistance for farmers, and market development for organic products. Policies that reduce the barriers to organic certification can also encourage more farmers to adopt organic practices. Future studies should include comprehensive assessments of the environmental impacts of organic versus inorganic fertilization practices. Such analyses can help in understanding the broader implications of these practices on soil health, water use, and biodiversity. It is crucial to conduct further economic analyses that consider long-term profitability, market trends, and consumer preferences. Studies focusing on the economic resilience of organic farming in the face of climate change and market fluctuations can provide deeper insights into the sustainability of these practices.

Conclusion

The research conducted on the "Comparative Analysis of Phytochemical Composition and Return on Investment in Pechay Cultivated with Organic and Inorganic Fertilization Techniques" has yielded significant insights into sustainable agriculture practices. The study revealed that organic fertilization enhances the phytochemical composition of Pechay, including vital nutrients such as total phenolics, flavonoids, glucosinolates, vitamin C, and beta-carotene, compared to inorganic methods. This suggests that organic cultivation can produce crops with superior nutritional profiles, potentially offering greater health benefits to consumers. Despite the higher yields typically associated with inorganic fertilization, our economic analysis indicates that organic cultivation of Pechay is more profitable in the long term. This is attributed to the premium prices that organically grown produce commands in the market, coupled with the increasing consumer demand for foods cultivated using sustainable practices. Therefore, while inorganic fertilization may offer immediate advantages in terms of yield, organic fertilization presents a holistic approach that balances environmental sustainability, crop quality, and economic viability. This study underscores the importance of integrating sustainable practices into agricultural production to enhance food quality and ensure the economic well-being of farmers. It advocates for a shift towards organic farming methods, which not only contribute to healthier produce but also support the sustainability of agricultural ecosystems. In conclusion, adopting organic fertilization techniques in Pechay cultivation offers a promising path towards achieving higher nutritional value in crops and better returns on investment for farmers. This aligns with global efforts to promote sustainable agriculture practices that benefit the environment, economy, and society. Future research should focus on optimizing organic cultivation methods to further enhance yield and quality, ensuring that sustainable farming remains a viable and attractive option for the agricultural community.

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