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Comparative Study of Productivity of Organic and Conventional Agriculture in Maize Crops in East Java

Muhammad Hazmi[1], Dewa Oka Suparwata[2]
[1]Universitas Muhammadiyah Jember
[2]Universitas Muhammadiyah Gorontalo

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ABSTRACT

This study provides a comparative analysis of the productivity of organic and conventional maize farming in East Java, employing a quantitative approach with 40 sample farms. Utilizing a Likert scale from 1 to 5, data were collected and analyzed using SPSS version 26. The findings indicate that while conventional farming demonstrates higher average yields, the difference in productivity between the two systems is statistically significant but not substantial. Organic farming shows competitive productivity, particularly in the long term, due to its positive impact on soil health and sustainability. The study highlights the potential of organic farming as a viable alternative to conventional practices in maize cultivation, offering valuable insights for policymakers and farmers in East Java.

Corresponding Author:

Name: Muhammad Hazmi
Institution: Universitas Muhammadiyah Jember
Email: mhazmi.hazmi@gmail.com

1. INTRODUCTION

In East Java, maize is a very important crop, and the shift towards sustainable agricultural practices, including organic farming, is receiving increasing attention. This research highlights several aspects of sustainable agriculture and its impact on productivity and environmental health. Firstly, sustainable agricultural practices, such as the use of organic fertilisers and plant-based pesticides, have been shown to positively affect agricultural productivity and food security in East Java. A study involving 250 farmers showed that such practices correlated significantly with increased production and better food security, despite the challenges posed by climate change [1]. This suggests that sustainable practices can increase productivity, potentially offsetting the yield gap traditionally associated with organic farming. Furthermore, the role of women in adopting sustainable practices is crucial. Women have been shown to significantly increase the adoption of organic fertilisers and plant-based pesticides, which are critical for organic farming [2]. This highlights the importance of gender-inclusive policies in promoting sustainable agriculture. However, organic maize production in East Java faces challenges in meeting demand. Despite the high demand for organic maize, production levels are insufficient, indicating a gap between consumption and supply [3]. This gap suggests that while organic farming is beneficial for sustainability, it may require further support and optimisation to match the productivity levels of conventional farming. In addition, innovative solutions such as the use of rabbit urine as a liquid organic fertiliser have been explored to reduce reliance on inorganic fertilisers and improve soil health [4].

The productivity of agricultural systems is a critical factor in determining the viability and adoption of farming practices. Conventional agriculture (CA) is often associated with higher productivity due to the use of synthetic fertilizers, pesticides, and high-yield crop varieties. In contrast, organic farming (OF) eschews synthetic inputs, relying on natural processes, which some argue could lead to lower yields. Research indicates that organic farming generally results in lower yields compared to conventional methods. A study by Connor highlights that organic agriculture is less productive per unit area, with crop-yield ratios of organic to conventional systems ranging from 0.30 to 0.74, often less than 0.5 in productive areas suited for crop intensification [5]. This lower productivity is attributed to the reliance on organic fertilizers, which necessitates additional land for nitrogen-fixing crops, thereby reducing overall yield efficiency [5]. Despite these challenges, organic farming offers significant environmental and health benefits. It enhances soil health by promoting a robust microbiome and reducing harmful residues in food, such as pesticides and nitrates, which are prevalent in conventional farming [6]. Organic produce is also found to be richer in essential nutrients, offering superior nutritional value [6]. Furthermore, organic farming can be economically viable, especially for small-scale farmers, due to the premium prices organic products can command in the market [6], [7]. To address the productivity gap, Integrated Nutrient Management (INM) has been proposed as a viable alternative. INM combines organic, inorganic, and biological nutrient sources to optimize nutrient use efficiency and maintain soil health, potentially stabilizing crop production while reducing environmental impact [8].

In East Java, where maize serves as both a staple food and a source of income for farmers, understanding the comparative productivity of organic and conventional maize farming is essential. This study seeks to fill the gap in existing literature by providing a comparative analysis of these two farming practices in the context of maize crops in East Java.

2. LITERATURE REVIEW

2.1 Organic Farming

Organic farming is essentially rooted in principles that emphasise environmental stewardship, biodiversity, and the avoidance of synthetic inputs. Organic farming relies on practices such as crop rotation, organic fertiliser, and biological pest control to maintain soil fertility and ecological balance [9], [10]. The environmental benefits of organic farming are well documented, including improved soil health, reduced pesticide residues, and increased biodiversity [9], [11]. These benefits are achieved through sustainable practices that prioritise soil vitality and ecosystem health, which contrasts with the detrimental impacts of high-input conventional agriculture [9], [10]. However, the productivity of organic farming compared to conventional methods is still a matter of debate. Some studies show that organic farming can be as productive as conventional farming under certain conditions, especially in low-input farming systems [11]. Organic systems have been shown to perform comparably to conventional systems, especially during the dry season, and use significantly less energy and are more efficient [11]. This suggests that organic farming can be a viable alternative in certain contexts, especially where resource efficiency and environmental sustainability are prioritised. In contrast, other studies have shown that while organic farming excels in terms of environmental benefits, it generally has lower yields than conventional farming, especially in intensive farming systems [12]. The need for higher yields to meet growing food demand often leads to the use of hybrid crops and chemical inputs in conventional agriculture, which can result in higher productivity but at the expense of environmental health [12]. This highlights the critical trade-off between maximising crop yields and maintaining ecological integrity. In conclusion, while organic farming offers great environmental benefits and can be productive under certain conditions, overall yields compared to conventional farming vary depending on the farming context. The choice between organic and conventional methods should consider both environmental impacts and productivity needs, with organic farming offering a sustainable path in the appropriate context [9], [11]. These findings are critical for understanding the potential trade-offs between yield and sustainability in organic maize farming in East Java.

2.2 Conventional Farming: Efficiency and Challenges

Conventional agricultural practices, particularly in maize production, have historically been associated with higher yields due to the use of synthetic fertilisers, pesticides and GMOs, as evidenced by the success of the Green Revolution in improving food security globally [13]. However, these practices have significant environmental drawbacks, including soil degradation, water pollution, and biodiversity loss [14]. In contrast, organic farming offers a sustainable alternative by not using synthetic inputs and improving soil health through natural fertilisers, which enhance soil microbiome activity and nutrient cycling [6]. Organic farming practices have been shown to improve soil health and reduce harmful chemical residues in food, offering nutritional benefits and potentially reducing health risks associated with conventional farming [6]. Despite these advantages, organic farming faces challenges such as increased weed density and diversity, which can hamper crop yields [15]. However, integrated weed management strategies, such as diverse crop rotations and the use of mulches, can mitigate these issues, keeping weed densities at manageable levels [15]. The transition to organic farming is driven by environmental sustainability and consumer demand for healthier food options, which can improve the economic viability of small-scale farmers by allowing them to obtain higher prices for organic produce [6]. In addition, sustainable agricultural practices, including organic farming, contribute to public health and sustainable development by reducing greenhouse gas emissions and conserving natural resources [16]. While conventional farming remains effective in maximising maize yields, especially in areas such as East Java, the sustainability of these practices is increasingly being questioned. The integration of sustainable agronomic practices, such as the use of plant growth-promoting microorganisms and nanotechnologies, can reduce dependence on synthetic inputs and increase yields sustainably [15].

2.3 Comparative Studies on Organic and Conventional Farming

Comparative studies between organic and conventional agriculture reveal a complex landscape influenced by crop type, regional conditions, and specific agricultural practices. A meta-analysis indicates that organic farming generally yields 19-25% less than conventional farming, but this gap can be mitigated through practices like crop rotation and organic pest management [5], [15]. Specifically, in corn production, organic systems can achieve competitive yields over time, although initial yields may be lower due to the transition period required for soil recovery and the establishment of organic practices [17]. Research highlights that organic farming often faces challenges such as increased weed density, which can reduce yields and increase production costs [15]. However, integrated weed management strategies, including diversified crop rotation and intercropping, can significantly reduce weed density and improve yield outcomes [15]. Additionally, organic farming practices, such as non-inversion minimum tillage, have been shown to enhance soil organic carbon and microbial biomass, contributing to long-term soil health and potentially improving yields over time [17]. Economic analyses suggest that while conventional farms typically achieve higher gross incomes, organic farms can be more economically efficient due to lower input costs and higher product prices [18]. This economic efficiency is particularly evident in specialized organic farms, such as those focused on crop production or dairy, which can achieve similar or better economic outcomes compared to conventional systems [18]. Despite these advantages, organic agriculture's lower productivity per unit area remains a significant limitation, particularly in regions suited for high-intensity conventional farming [5]. This lower productivity necessitates a larger land area to achieve equivalent production levels, posing challenges for global food security and land conservation [5].

East Java's agricultural landscape, characterized by diverse agroecological conditions, presents a complex scenario for comparing organic and conventional maize farming. The adoption of organic farming in East Java is limited by several factors, including market access, knowledge dissemination, and initial investment costs. These challenges are echoed in the broader context of sustainable agricultural practices in Indonesia, where Agricultural Extension Services (AES) are crucial for disseminating knowledge and fostering innovation, yet face barriers such as limited awareness and technological constraints [19]. Organic farming offers long-term benefits in soil health and crop resilience, which are critical for sustainability. However, the immediate yield advantages and perceived reliability of conventional farming make it the dominant practice in East Java. This preference is partly due to the economic pressures faced by farmers, as highlighted in studies on horticultural and soybean farming in the region. For instance, the lack of financing and the need for supporting infrastructure significantly impact farmers' income and productivity, making conventional methods more appealing due to their lower initial costs and quicker returns [20], [21]. Moreover, the sustainability of farming practices in East Java is influenced by ecological, economic, social, institutional, and technological dimensions. Research on corn farming on post-sand mining land in Malang, East Java, indicates that while economic and social dimensions show moderate sustainability, ecological and technological aspects are weak, suggesting that organic farming could potentially address these weaknesses by enhancing soil health and reducing dependency on chemical inputs [22]. Understanding the comparative productivity of these systems in East Java is crucial for informing future agricultural policies and practices in the region.

2.4 Research Gap

While numerous studies have explored the productivity of organic and conventional farming systems globally, there is a lack of specific research focused on maize production in East Java. This gap is particularly relevant given the region's importance as a maize-producing area in Indonesia. The present study aims to address this gap by providing a comparative analysis of the productivity of organic and conventional maize farming in East Java, using a robust quantitative approach.

3. METHODS

3.1 Research Design

The study employs a quantitative research design to compare the productivity of organic and conventional maize farming practices in East Java. A comparative approach is used to analyze the differences in productivity between the two farming systems, allowing for a systematic evaluation of their effectiveness. The research is designed to test the hypothesis that organic farming can be as productive as conventional farming in maize cultivation, using statistical methods to assess the significance of the observed differences.

3.2 Sampling Technique

The study was conducted with a sample size of 40 maize farms located in various regions of East Java. The sampling technique employed was purposive sampling, ensuring that the selected farms represented a mix of both organic and conventional farming practices. The farms were chosen based on criteria such as farm size, type of maize grown, and the farming practices employed (organic or conventional). This approach ensured that the sample was representative of the broader farming practices in the region, providing a robust basis for comparison.

3.3 Data Collection

Data collection was carried out through structured interviews and on-site observations. Farmers were interviewed using a structured questionnaire designed to capture information on farm productivity, input use, farming practices, and challenges faced. The questionnaire included items rated on a Likert scale from 1 to 5, where 1 indicated strong disagreement and 5 indicated strong agreement. The Likert scale was used to measure perceptions and attitudes related to farming practices, environmental impact, and economic viability.

Productivity data, including yield per hectare, input costs, and labor use, were collected directly from the farms. The data collection process was conducted over a growing season to ensure the accuracy and reliability of the information.

3.4 Data Analysis

Data analysis was conducted using SPSS version 26, a widely used statistical software package in social sciences for quantitative data analysis. The analysis involved several key steps: Descriptive statistics were employed to summarize the sample's key characteristics, including mean, median, and standard deviation for the variables of interest, providing an overview of productivity levels and input use across organic and conventional farms. Reliability analysis using Cronbach's alpha assessed the internal consistency of the Likert scale items, ensuring the scale's reliability for further analysis. An independent samples t-test was conducted to compare the mean productivity of organic and conventional maize farms, determining whether there was a statistically significant difference between the two groups. Pearson correlation analysis examined relationships between factors such as input use, farming practices, and productivity, identifying key factors influencing productivity in both farming systems. Finally, multiple regression analysis assessed the impact of various independent variables, such as input use and farming practices, on maize productivity, providing insights into the relative importance of different factors in determining farm productivity.

The hypotheses tested in this study were as follows:

H1: There is a significant difference in productivity between organic and conventional maize farming practices.

H2: The use of organic farming practices is positively correlated with long-term soil health and sustainability.
H3: Conventional farming practices are associated with higher short-term yields but may have negative environmental impacts.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The descriptive statistics for the study sample provide an overview of the key variables related to maize productivity in both organic and conventional farming systems. The average yield per hectare was found to be higher in conventional farms compared to organic farms, with mean values of 8.5 tons per hectare and 7.2 tons per hectare, respectively. Input costs were also higher for conventional farms, particularly for synthetic fertilizers and pesticides, which constituted a significant portion of the total expenses.

Labor use, measured in person-days per hectare, was more intensive in organic farms, reflecting the labor-intensive nature of organic farming practices, which often require manual weeding and the application of organic fertilizers. Despite these differences, the standard deviations for most variables were relatively low, indicating a consistent pattern across the sample.

4.2 Reliability Analysis

The reliability analysis of the Likert scale items used to measure farmers' perceptions and attitudes revealed a Cronbach's alpha of 0.825, indicating good internal consistency. This suggests that the scale was reliable for assessing the respondents' views on farming practices, environmental impact, and economic viability.

4.3 Comparative Analysis of Productivity

An independent samples t-test was conducted to compare the mean productivity of organic and conventional maize farms. The results indicated a statistically significant difference in productivity between the two groups ($t = 2.458$, $p < 0.05$). Conventional farms, on average, produced higher yields per hectare compared to organic farms. However, the margin of difference, while significant, was not as large as might be expected, suggesting that organic farming can be competitive in terms of yield, particularly in the long term.

4.4 Correlation Analysis

Pearson correlation analysis revealed several significant relationships between farming practices and productivity. For conventional farms, there was a strong positive correlation between the use of synthetic fertilizers and yield ($r = 0.685$, $p < 0.01$). In contrast, for organic farms, a positive correlation was found between crop rotation practices and yield ($r = 0.543$, $p < 0.05$), indicating that organic methods relying on natural processes can effectively enhance productivity.

Interestingly, a negative correlation was observed between the intensity of pesticide use and long-term soil health indicators ($r = -0.491$, $p < 0.05$) in conventional farms, suggesting that while these inputs boost short-term productivity, they may have adverse effects on soil sustainability.

4.5 Regression Analysis

Multiple regression analysis was performed to assess the impact of various factors on maize productivity. For conventional farms, the model showed that synthetic fertilizer use was the most significant predictor of yield ($\beta = 0.564$, $p < 0.01$), followed by pesticide use ($\beta = 0.318$, $p < 0.05$). For organic farms, the significant predictors were crop rotation ($\beta = 0.442$, $p < 0.05$) and organic fertilizer application ($\beta = 0.395$, $p < 0.05$). The R-squared values for the models were 0.62 for conventional farms and 0.57 for organic farms, indicating that these variables explained a substantial portion of the variance in productivity.

4.6 Discussion

The results of this study provide important insights into the comparative productivity of organic and conventional maize farming in East Java. While conventional farming demonstrated higher average yields, the margin of difference was not as pronounced as might be expected, particularly considering the environmental costs associated with conventional practices. The findings support the argument that organic farming, when properly managed, can offer competitive yields, especially in the long term, due to its positive impact on soil health and sustainability.

The significant positive correlations between organic practices such as crop rotation and yield suggest that organic farming can be a viable alternative to conventional methods, particularly in regions where sustainability is a key concern. The negative correlation between pesticide use and soil health in conventional farms highlights the potential long-term risks associated with heavy reliance on chemical inputs, which could undermine productivity over time.

These findings are consistent with previous research that suggests organic farming can be as productive as conventional farming under certain conditions, particularly when environmental factors are taken into account. The question of whether organic farming can be as productive as conventional farming under certain conditions is supported by various research findings. The study by [18] highlights that while organic farms in Poland produced lower cereal yields compared to conventional farms, they achieved higher economic efficiency due to lower input costs, suggesting that under specific economic conditions, organic farming can be competitive with conventional methods. This aligns with the notion that organic farming can be as productive when environmental and economic factors are considered. Moreover, organic farming is recognized for its environmental benefits, which can indirectly support productivity. [9] emphasize that organic farming enhances soil health and reduces environmental degradation, which are crucial for sustainable productivity. This environmental stewardship can lead to long-term productivity gains, especially in degraded lands. However, challenges such as lower yields and increased labor requirements are noted by [8] who suggest that integrating organic practices with modern technologies, such as Integrated Nutrient Management (INM), can optimize productivity while maintaining sustainability. This integration could potentially bridge the productivity gap between organic and conventional farming. On the other hand, [23] point out that while organic farming may not always match the productivity of conventional farming, it can produce higher quality fruits due to enhanced natural processes. This quality aspect can be a significant factor in evaluating productivity, especially in markets that value nutritional quality over quantity. Lastly, [15] highlight the issue of increased weed density in organic systems, which can hinder productivity. However, they suggest that effective weed management strategies, such as crop rotation and mulching, can mitigate these challenges and support productivity in organic farming. The study contributes to the ongoing debate by providing empirical evidence from East Java, a region where maize is a critical crop.

5. CONCLUSION

The findings of this study offer significant insights into the comparative productivity of organic and conventional maize farming in East Java. Conventional farming, characterized by the use of synthetic fertilizers and pesticides, demonstrated higher average yields in the short term. However, the difference in productivity between conventional and organic farming, while statistically significant, was not as large as anticipated. This suggests that organic farming, with its focus on environmental sustainability and natural inputs, can achieve competitive yields, particularly over the long term.

The positive correlation between organic farming practices, such as crop rotation, and maize productivity underscores the potential of organic farming as a sustainable alternative to conventional methods. Furthermore, the negative correlation between pesticide use and long-term soil health in conventional farms raises concerns about the sustainability of conventional practices in maintaining soil fertility and productivity over time.

These findings align with existing literature that suggests organic farming can be as productive as conventional farming under certain conditions, particularly when environmental factors are considered. The study contributes to the ongoing discourse on sustainable agriculture by providing empirical evidence from East Java, a region where maize is a critical crop for both food security and economic development.

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