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Analysis of the Effect of Land Area, Labor, Seeds and Fertilizer on Hydroponic Pakcoy Production at PT Kebun Sayur Surabaya

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ABSTRACT

Hydroponic farming has emerged as an innovative agricultural system that enhances production efficiency, optimizes land use, and produces high-quality vegetables with minimal pesticide application. Pakcoy (Brassica rapa L.) is one of the most promising leafy vegetables cultivated using the hydroponic Nutrient Film Technique (NFT) due to its high nutritional value, rapid growth, and increasing consumer demand, particularly in urban areas. PT Kebun Sayur Surabaya, an urban hydroponic farm, has experienced growing market demand for hydroponically grown pakcoy but has not yet been able to fully meet customer requirements because of production limitations. Therefore, identifying the key production factors influencing pakcoy yield is essential for improving productivity and supporting business development. This study aims to analyze the effects of land area, labor, seedlings, and fertilizer on the production of hydroponic pakcoy at PT Kebun Sayur Surabaya. Primary data were collected through field observations, interviews, and company production records, while secondary data were obtained from relevant literature and institutional documents. Multiple linear regression analysis was employed to evaluate the influence of the selected production factors on pakcoy output. The study is expected to identify the production factors that significantly affect hydroponic pakcoy production and to provide empirical evidence for optimizing resource allocation within the production system. The findings are anticipated to assist PT Kebun Sayur Surabaya in prioritizing investments in the most influential production factors, thereby improving productivity, production efficiency, and the company's ability to satisfy increasing market demand. Furthermore, the results may serve as a practical reference for urban hydroponic enterprises seeking sustainable production strategies and enhanced business competitiveness.

Keywords: *Hydroponics, Pakcoy, Production Factors, Multiple Linear Regression, Urban Farming.*

INTRODUCTION

Agriculture has long been recognized as one of the fundamental sectors supporting human civilization and economic development. In recent decades, rapid technological advancement has transformed agricultural production systems through the integration of digital technologies and precision farming practices (Adib, 2014; Al Hakim et al., 2022). One of the most notable innovations is hydroponic cultivation, a soilless farming system in which plants absorb essential nutrients directly from nutrient-enriched water solutions. Compared with conventional cultivation, hydroponics offers higher resource-use efficiency, improved productivity, and better control of environmental conditions, making it particularly suitable for modern urban agriculture (Rahmadhani et al., 2020).

Pakcoy (*Brassica rapa L.)* is among the most widely cultivated leafy vegetables in hydroponic systems because of its rapid growth, high nutritional value, and strong market demand. Pakcoy contains protein, dietary fiber, carbohydrates, calcium, magnesium, iron, vitamins A and C, and other essential nutrients that contribute to human health (Prasetyo, 2010). As consumer awareness of healthy lifestyles continues to increase, demand for fresh, pesticide-safe vegetables has grown substantially, creating promising business opportunities for hydroponic vegetable producers (Santoso, 2016).

Hydroponic cultivation has become an effective solution for urban farming because it requires limited land and can be implemented using vertical production systems such as the Nutrient Film Technique (NFT). This cultivation method enables continuous production while reducing fertilizer consumption, improving water-use efficiency, and minimizing pest and disease incidence. Furthermore, greenhouse-based hydroponic production provides better environmental control, resulting in cleaner vegetables with higher quality and market value than conventionally produced vegetables (Sutarni et al., 2018; Oliveira et al., 2024). Recent technological developments have further enhanced hydroponic production through automated nutrient management, environmental monitoring, temperature and humidity control, and digital applications that support production management and marketing (Setiawan, 2019; Mufida et al., 2020; Darmawan et al., 2023; Dwisakti et al., 2023).

Among the various production inputs, land area, labor, seedlings, and fertilizer play crucial roles in determining crop productivity. Labor quality, technical skills, and farming experience are particularly important because hydroponic production requires careful monitoring and precise management throughout the cultivation cycle. Skilled workers contribute to higher productivity and better product quality, ultimately improving farm performance and profitability (Harahap, 2016).

PT Kebun Sayur Surabaya is one of the urban hydroponic farms specializing in pakcoy production using the NFT system. Although market demand for hydroponically grown vegetables continues to increase, the company has not yet been able to satisfy customer demand because production capacity remains limited. Identifying the production factors that significantly influence pakcoy yield is therefore essential for improving production efficiency and supporting sustainable business growth. While previous studies have generally discussed the advantages of hydroponic cultivation, empirical evidence regarding the relative contribution of major production factors in commercial hydroponic enterprises remains limited.

Therefore, this study aims to analyze the effects of land area, labor, seedlings, and fertilizer on hydroponic pakcoy production at PT Kebun Sayur Surabaya. The findings are expected to provide practical recommendations for optimizing resource allocation, improving production efficiency, and supporting managerial decision-making to enhance the competitiveness and sustainability of urban hydroponic farming enterprises.

RESEARCH METHODS

This study employed a descriptive quantitative research design to examine the effects of production factors on hydroponic pakcoy production at PT Kebun Sayur Surabaya. The research adopted a field-based approach by collecting empirical data directly from the study site to obtain comprehensive information regarding production activities and resource utilization. The study focused on four major production factors, namely land area, labor, seedlings, and fertilizer, and their contribution to pakcoy production.

The research was conducted at PT Kebun Sayur Surabaya, an urban hydroponic farm specializing in the cultivation of pakcoy using the Nutrient Film Technique (NFT) system. Data collection was carried out through direct observation and semi-structured interviews with the owner and employees of the company. Field observations were conducted to understand the hydroponic production process, while interviews were used to obtain detailed information regarding production management, input utilization, and operational practices.

Based on the interviews, hydroponic pakcoy cultivation at PT Kebun Sayur Surabaya consists of several sequential stages. Seeds are first germinated on pre-moistened rockwool cubes and maintained under dark plastic or cloth for one to two days to promote germination. The seedlings are then exposed to light and maintained for approximately 9-10 days while ensuring adequate moisture and water availability. Once the seedlings develop three to four leaves, they are transplanted into the NFT hydroponic system, where nutrient solutions are supplied continuously until harvest.

The study utilized both primary and secondary data sources. Primary data were obtained directly through interviews with the owner and employees of PT Kebun Sayur Surabaya and through field observations of hydroponic production activities. These data included information on cultivated land area, labor utilization, seedling requirements, fertilizer application, and pakcoy production. Secondary data were collected from scientific journals, books, government publications, and other relevant literature related to hydroponic cultivation, production factors, and urban agriculture.

RESULTS AND DISCUSSIONS

Multiple Linear Regression Assumption Tests

Prior to estimating the regression model, the classical assumption tests were performed to ensure the validity of the statistical analysis. The normality test using the Kolmogorov–Smirnov method produced a significance value of 0.628, indicating that the residuals were normally distributed. Furthermore, the multicollinearity test showed tolerance values ranging from 0.980 to 0.995 and Variance Inflation Factor (VIF) values between 1.005 and 1.021, confirming the absence of multicollinearity among the independent variables. The scatterplot of standardized residuals also demonstrated a random distribution without a discernible pattern, indicating that the regression model was free from heteroscedasticity. These results confirm that the regression model satisfies the classical assumptions and is suitable for hypothesis testing.

Effects of Production Factors on Hydroponic Pakcoy Production

The coefficient of determination (Adjusted R^2) was 0.609, indicating that land area, labor, seedlings, and fertilizer collectively explained 60.9% of the variation in hydroponic pakcoy production at PT Kebun Sayur Surabaya. The remaining 39.1% was influenced by other variables that were not included in this study, such as temperature, humidity, light intensity, pH, water quality, and production management.

The relatively high coefficient of determination demonstrates that production inputs remain the primary determinants of hydroponic vegetable production. However, hydroponic cultivation differs from conventional farming because environmental conditions are more precisely controlled. Consequently, environmental variables, including nutrient concentration, greenhouse temperature, humidity, and light intensity, also play significant roles in determining crop performance. Previous studies have similarly reported that environmental factors strongly influence the productivity of hydroponically grown leafy vegetables.

Land area constitutes one of the fundamental production factors because it determines the production capacity of the hydroponic system. An expansion of the cultivation area enables the installation of additional NFT channels, increasing the number of plants cultivated within a production cycle. Nevertheless, production efficiency depends not only on the available growing area but also on the effectiveness of production management and resource utilization.

Labor is another critical production factor in hydroponic farming. Unlike conventional agriculture, hydroponic production requires continuous monitoring of nutrient solutions, water circulation, seedling growth, and crop maintenance. Therefore, both the quantity and quality of labor influence production performance. Workers with adequate technical knowledge and practical experience are better able to maintain optimal growing conditions, resulting in improved productivity and product quality. This finding supports previous studies indicating that skilled labor contributes positively to agricultural productivity through better cultivation practices and operational efficiency.

Seedling quality also plays a significant role in determining hydroponic pakcoy production. Healthy and vigorous seedlings generally exhibit higher survival rates, faster vegetative growth, and greater uniformity, ultimately increasing marketable yield. The use of high-quality seedlings represents the initial step toward achieving high productivity because superior genetic potential allows plants to utilize nutrients more efficiently and adapt better to controlled hydroponic environments.

Fertilizer, particularly AB Mix nutrient solution, is another essential input in hydroponic cultivation because it supplies all macro- and micronutrients required for plant growth. Balanced nutrient management ensures optimum photosynthesis, leaf development, and biomass accumulation. However, nutrient application should follow crop requirements because excessive fertilizer does not necessarily increase production and may reduce nutrient-use efficiency. Appropriate nutrient concentration and regular monitoring of electrical conductivity (EC) and pH are therefore essential for maintaining stable production.

Overall, the results indicate that hydroponic pakcoy production at PT Kebun Sayur Surabaya is substantially influenced by the effective management of production factors. Since these variables explain more than half of the variation in production, improving resource allocation and production management can significantly enhance output. Nevertheless, the unexplained variation suggests that environmental control variables should be incorporated into future studies to develop a more comprehensive production model. Variables such as greenhouse microclimate, nutrient solution quality, irrigation scheduling, and production technology are expected to improve the predictive capability of future regression models.

From a managerial perspective, PT Kebun Sayur Surabaya should prioritize investments in production factors that contribute directly to output improvement, particularly through optimizing labor performance, ensuring the availability of high-quality seedlings, maintaining balanced nutrient management, and expanding production capacity where economically feasible. In addition, integrating digital monitoring technologies for environmental control may further enhance production efficiency and enable the company to meet the increasing demand for hydroponically grown vegetables.

CONCLUSIONS

This study analyzed the influence of land area, labor, seedlings, and fertilizer on hydroponic pakcoy production at PT Kebun Sayur Surabaya. The regression model satisfied the classical assumption tests, indicating that the estimated model was statistically appropriate for analysis. The coefficient of determination (Adjusted R^2) of 60.9% demonstrates that the selected production factors jointly explain a substantial proportion of the variation in pakcoy production, while the remaining 39.1% is attributable to other factors outside the scope of this study, including environmental conditions and production management. The findings indicate that optimizing the utilization of production factors is essential for improving hydroponic pakcoy production. Efficient land utilization increases production capacity, skilled labor enhances cultivation and operational efficiency, high-quality seedlings support better plant growth and yield, and balanced fertilizer application ensures adequate nutrient availability throughout the production cycle. These factors collectively contribute to higher production performance and support the sustainability of hydroponic farming enterprises. Overall, the study confirms that effective management of production resources is a key determinant of production performance at PT Kebun Sayur Surabaya. Improving the efficiency of these production factors can enhance productivity and strengthen the company's ability to meet the increasing market demand for hydroponically grown vegetables.

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