

The Effect of Organic Fertilizer Type, Nutrient Composition, and Application Method on Tomato Plant Growth in Plantation Areas in the Cianjur Region of West Java

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Article Info

Article history:

Received May, 2024

Revised May, 2024

Accepted May, 2024

Keywords:

Organic fertilizer

Tomato cultivation

Plant growth

Nutrient composition

Application method

ABSTRACT

This study investigated the effect of organic fertilizer type, nutrient composition, and application method on tomato plant growth in the plantation areas of the Cianjur region, West Java. A randomized complete block design (RCBD) with factorial arrangements was employed, and data were collected using Likert scale ratings from 110 tomato plants. The analysis revealed significant differences in plant growth among different organic fertilizer types, with biofertilizers exhibiting the highest mean growth score. Moreover, fertilizers with balanced nutrient compositions resulted in superior plant growth compared to those with imbalanced compositions. Additionally, foliar spraying emerged as the most effective application method, promoting higher plant growth compared to broadcasting and banding methods. These findings highlight the importance of considering organic fertilizer characteristics and application techniques in optimizing tomato plant growth in agricultural systems.

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1. INTRODUCTION

Tomato (*Solanum lycopersicum*) is indeed a highly significant vegetable globally, valued for both its culinary adaptability and nutritional richness. It belongs to the Solanaceae family and is cultivated extensively worldwide, with major producers being China, India, and the United States [1]. Tomatoes are not only abundant in essential nutrients like vitamins, dietary fibers, and antioxidants but also serve as a source of health-promoting secondary metabolites such as flavonoids and phenolics [2]. The crop's bioactive compounds, including lycopene, β -

carotene, ascorbic acid, and phenolic compounds, contribute to its beneficial health effects, making it a popular choice for a healthy diet and functional food [3], [4]. Additionally, ongoing research focuses on enhancing tomato varieties for specific health-related traits through conventional breeding, genetic investigations, gene mapping, and genetic engineering techniques [5].

Organic farming, utilizing organic fertilizers like compost, manure, and biofertilizers, has gained prominence in agricultural systems due to its sustainable practices that enhance soil fertility, biodiversity, and environmental conservation

compared to conventional synthetic fertilizers [6]–[10]. Organic fertilizers play a crucial role in maintaining soil health, promoting crop yields, and reducing the negative impacts of chemical leaching on soil structure and water quality. Studies show that the application of organic fertilizers significantly affects soil stability, increases organic carbon content, and improves total nitrogen levels in the soil, highlighting their positive impact on soil fertility and sustainability. By prioritizing natural sources and eco-friendly practices, organic farming stands out as a promising solution to address the challenges of modern agriculture, ensuring food safety, resource efficiency, and environmental protection.

In the context of tomato cultivation in the Cianjur region of West Java, Indonesia, the use of organic fertilizers plays a crucial role in enhancing plant growth dynamics. Research on tomato productivity in Indonesia emphasizes the importance of balancing inorganic and organic fertilizers to maintain soil fertility and microbial activity [11]. Studies in Medowo Village highlight the positive impact of farmer participation in producing organic fertilizers for sustainable agriculture, showcasing the benefits of organic farming practices [12]. Additionally, comparisons between organic and inorganic fertilizers in red hot chili production emphasize the environmental benefits of organic fertilizers, which do not leave harmful residues and are more sustainable for agricultural ecosystems [13]. By incorporating organic fertilizers, such as biomass-based fertilizers, Cianjur's tomato cultivation can potentially benefit from increased nutrient absorption, improved plant growth, and sustainable agricultural practices, aligning with Indonesia's goals for agricultural development and environmental conservation [14].

While organic fertilizers hold promise for sustainable agriculture, their efficacy can vary based on several factors, including their source, nutrient composition, and method of application. The choice of organic fertilizer type and its nutrient profile can significantly influence plant nutrient uptake, soil health,

and overall crop productivity. Furthermore, the method of fertilizer application can impact nutrient availability to plants and subsequently affect growth parameters such as plant height, leaf area, stem diameter, and fruit yield. Despite the potential benefits of organic fertilizers, there is a dearth of empirical research specifically tailored to the unique agroecological conditions of the Cianjur region. This knowledge gap hampers the ability of local farmers and agricultural practitioners to make informed decisions regarding organic fertilizer usage, thereby hindering efforts to optimize tomato cultivation practices and maximize yields sustainably. By undertaking a comprehensive quantitative analysis, this study aims to address this gap and provide valuable insights into the optimal utilization of organic fertilizers for tomato cultivation in the Cianjur region.

The primary objective of this research is to investigate the effect of organic fertilizer type, nutrient composition, and application method on tomato plant growth in the plantation areas of the Cianjur region, West Java. Specifically, the study aims to assess the impact of different organic fertilizer types on key growth parameters of tomato plants, analyze the influence of nutrient composition within organic fertilizers on tomato plant development and yield, and evaluate the effectiveness of various application methods of organic fertilizers in promoting optimal growth and productivity of tomato plants.

2. LITERATURE REVIEW

2.1 *Organic Fertilizer Types and Tomato Growth*

Various organic fertilizers, including compost, livestock manure, and biofertilizers, have been extensively studied for their positive effects on tomato plant growth and productivity. Compost, derived from decomposed organic matter, enhances soil structure, water retention, and nutrient availability, ultimately leading to improved tomato growth and yield [15]. Livestock manure, when properly composted and applied, enriches the soil with organic matter

and essential nutrients, thereby enhancing soil fertility and plant performance [16]. Biofertilizers, containing beneficial microorganisms like nitrogen-fixing bacteria and mycorrhizal fungi, play a crucial role in promoting tomato growth by aiding in nutrient uptake and increasing plant resilience to various stresses [17]. These organic fertilizers offer sustainable alternatives to chemical fertilizers, benefiting both crop production and soil health.

2.2 Nutrient Composition and Tomato Development

The composition of nutrients in organic fertilizers significantly influences their effectiveness in enhancing tomato growth and development. Studies have highlighted the importance of balanced ratios of essential macronutrients like nitrogen (N), phosphorus (P), and potassium (K) in optimizing plant physiological processes, including cell division, photosynthesis, and fruit development [12], [18]. While organic fertilizers can boost tomato productivity, excessive or imbalanced nutrient application may lead to nutrient imbalances, soil acidity, or nutrient leaching, negatively impacting plant health and overall yield [19], [20]. Therefore, a meticulous consideration of the nutrient composition in organic fertilizers is crucial to harnessing their full potential and ensuring successful tomato cultivation while avoiding detrimental effects on plant health and productivity [21].

2.3 Application Methods and Nutrient Uptake Efficiency

The method of organic fertilizer application plays a crucial role in influencing nutrient uptake efficiency and subsequent plant growth responses. Different application methods such as broadcasting, banding, and foliar spraying offer distinct advantages and challenges based on soil characteristics, crop nutrient requirements, and environmental conditions. Broadcasting is commonly used for its simplicity and uniform nutrient distribution but may lead to nutrient loss through volatilization or leaching [22]. In contrast, banding and foliar spraying can target nutrients directly to the root zone or

foliage, potentially enhancing nutrient uptake efficiency and reducing losses [23]. However, these methods may require specialized equipment and careful management to ensure proper nutrient delivery and prevent phytotoxicity, highlighting the importance of selecting the most suitable application method based on specific crop and soil conditions [24].

2.4 Research Gaps and the Cianjur Context

While numerous studies have investigated the effects of organic fertilizers on various crops, limited research has specifically addressed tomato cultivation in the context of the Cianjur region in West Java, Indonesia. The Cianjur region is characterized by unique agroecological conditions, including diverse soil types, microclimates, and cropping systems, which may influence the efficacy of organic fertilizers and their suitability for tomato cultivation. Moreover, the socioeconomic dynamics and farming practices prevalent in the region may further shape the adoption and utilization of organic fertilizers by local farmers. Therefore, there is a critical need for empirical research tailored to the specific requirements and constraints of tomato production in the Cianjur region, providing actionable insights to enhance sustainability, productivity, and resilience in agricultural systems.

3. METHODS

The research adopted a randomized complete block design (RCBD) with factorial arrangements to examine the combined effects of organic fertilizer type, nutrient composition, and application method on tomato plant growth. The independent variables included three factors: Organic Fertilizer Type (Compost, Manure, Biofertilizer), Nutrient Composition (Varied ratios of nitrogen (N), phosphorus (P), and potassium (K) in each fertilizer type), and Application Method (Broadcasting, Banding, Foliar Spraying). The study targeted tomato plants grown in plantation areas across the Cianjur region. A total of 110 tomato plants were selected as the sample size, ensuring

adequate representation of the diversity of soil conditions, cropping practices, and environmental factors within the region. The sample size was determined based on considerations of statistical power and the feasibility of data collection within the constraints of time and resources.

3.1 Data Collection

Data collection encompassed two main components: baseline soil analysis and plant growth monitoring. For baseline soil analysis, soil samples were collected from multiple sites within the plantation areas of the Cianjur region to assess baseline soil properties and nutrient levels. Soil parameters such as pH, organic matter content, and nutrient concentrations (N, P, K) were analyzed using standard laboratory methods. Concurrently, plant growth monitoring involved sowing tomato seeds of a uniform variety in prepared plots following the application of organic fertilizers. Throughout the growing season, plant growth parameters, including plant height, leaf area, stem diameter, and fruit yield, were meticulously measured at regular intervals using standardized techniques and equipment.

3.2 Scale and Data Collection Instruments

Data on tomato plant growth parameters were collected using a Likert scale ranging from 1 to 5, where 1 represented very poor growth, 2 indicated poor growth, 3 denoted moderate growth, 4 signified good growth, and 5 represented excellent growth. This Likert scale facilitated the subjective assessment of plant growth by researchers based on predefined criteria, thereby enabling standardized data collection and analysis.

3.3 Data Analysis

Statistical analysis of the collected data was performed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics, including means, standard deviations, and frequency distributions, were computed to summarize the data and describe the central tendency and variability of plant growth parameters across different treatment groups. To evaluate the effects of organic fertilizer type, nutrient

composition, and application method on tomato plant growth, analysis of variance (ANOVA) was conducted. Post-hoc tests, such as Tukey's Honestly Significant Difference (HSD) test, were employed to compare means and identify significant differences between treatment groups. Additionally, regression analysis may be employed to model the relationship between fertilizer variables and plant growth responses, elucidating potential dose-response relationships or interactions between factors. The significance level for all statistical tests was set at $\alpha = 0.05$, indicating a 95% confidence level. The findings of the statistical analysis will be interpreted in the context of the research objectives and used to draw conclusions regarding the impact of organic fertilizers on tomato plant growth in the Cianjur region.

4. RESULTS AND DISCUSSION

The results of the study provide valuable insights into the effect of organic fertilizer type, nutrient composition, and application method on tomato plant growth in the plantation areas of the Cianjur region, West Java. The findings are presented and discussed below in relation to the research objectives outlined in the introduction.

4.1 Effect of Organic Fertilizer Type on Tomato Plant Growth

The analysis of the effect of organic fertilizer type on tomato plant growth revealed significant differences among the treatments. Specifically, the mean growth scores for tomato plants treated with different organic fertilizer types were as follows: Compost had a mean growth score of 3.8, Manure had a mean growth score of 3.5, and Biofertilizer had the highest mean growth score of 4.2. These findings indicate varying degrees of effectiveness in promoting tomato plant growth among the different organic fertilizer types.

A one-way analysis of variance (ANOVA) indicated a significant difference in tomato plant growth among the different organic fertilizer types ($F(2, 107) = 6.78, p < 0.05$). Post-hoc tests using Tukey's Honestly

Significant Difference (HSD) test revealed that tomato plants treated with biofertilizer exhibited significantly higher growth scores compared to those treated with compost ($p = 0.018$) and manure ($p = 0.032$).

The results demonstrate that biofertilizers have a more pronounced positive impact on tomato plant growth compared to traditional organic fertilizers such as compost and manure. This finding aligns with previous research highlighting the benefits of biofertilizers in enhancing soil fertility, nutrient uptake, and plant growth. The higher growth scores observed in plants treated with biofertilizer may be attributed to the presence of beneficial microorganisms that facilitate nutrient solubilization, fixation, and mobilization, thereby promoting plant growth and productivity.

4.2 Influence of Nutrient Composition within Organic Fertilizers

The analysis investigated the influence of nutrient composition within organic fertilizers on tomato plant growth. It revealed notable differences among treatments with varied nutrient compositions. Specifically, tomato plants treated with organic fertilizers having balanced nutrient compositions exhibited a mean growth score of 4.1, while those treated with fertilizers containing imbalanced nutrient compositions had a lower mean growth score of 3.6. These findings suggest that the nutrient composition of organic fertilizers plays a crucial role in determining tomato plant growth, with balanced compositions potentially leading to more favorable growth outcomes.

A one-way analysis of variance (ANOVA) revealed a significant difference in tomato plant growth between treatments with balanced and imbalanced nutrient compositions ($F(1, 108) = 4.56, p < 0.05$). Post-hoc tests confirmed that plants treated with fertilizers containing balanced ratios of nitrogen, phosphorus, and potassium exhibited significantly higher growth scores compared to those treated with fertilizers with imbalanced nutrient compositions.

The results underscore the importance of nutrient balance in organic

fertilizers for promoting optimal tomato plant growth. Fertilizers with balanced ratios of essential nutrients, such as nitrogen, phosphorus, and potassium, were found to enhance plant growth and productivity compared to those with imbalanced nutrient profiles. This finding aligns with established principles of plant nutrition, highlighting the significance of providing plants with adequate and balanced nutrient supplies to support their physiological processes and maximize yields.

4.3 Effectiveness of Application Methods of Organic Fertilizers

The study evaluated the effectiveness of different application methods of organic fertilizers on tomato plant growth, discerning significant differences among the treatments. Tomato plants subjected to various application methods exhibited distinct mean growth scores: Broadcasting resulted in a mean growth score of 3.7, Banding yielded a slightly higher mean growth score of 3.9, while the Foliar Spraying method demonstrated the highest mean growth score of 4.3. These findings underscore the importance of application method in influencing tomato plant growth, with Foliar Spraying showing particular promise in promoting optimal growth outcomes.

A one-way analysis of variance (ANOVA) indicated significant differences in tomato plant growth among the different application methods ($F(2, 107) = 5.21, p < 0.05$). Post-hoc tests using Tukey's Honestly Significant Difference (HSD) test revealed that tomato plants treated with foliar spraying exhibited significantly higher growth scores compared to those treated with broadcasting ($p = 0.023$) and banding ($p = 0.041$) methods.

The results demonstrate that foliar spraying is the most effective application method for promoting tomato plant growth compared to broadcasting and banding methods. Foliar spraying allows for direct nutrient absorption through foliage, facilitating efficient nutrient uptake and translocation within the plant. This may explain the observed higher growth scores in plants treated with foliar spraying,

highlighting the importance of innovative application techniques in maximizing the efficacy of organic fertilizers.

DISCUSSION

The study findings support the positive impact of organic fertilizers on plant growth and yield, aligning with previous research [25], [26]. Unique environmental factors, soil properties, and crop management practices in the Cianjur region may influence the specific effects observed, highlighting the region's distinct agricultural characteristics [27]. Biofertilizers, particularly those containing mycorrhizal fungi, have shown superiority over traditional organic fertilizers in enhancing soil fertility and promoting plant health, reflecting current trends in sustainable agriculture that emphasize the importance of microbial-based fertilizers for long-term agricultural sustainability and productivity [28]. Additionally, the use of bio-technology systems like Biosaka can offer a promising solution to reduce dependence on chemical fertilizers and improve crop yields while positively impacting the economy of local farmers [29].

Implications for Agricultural Practice

The results of this study have practical implications for farmers and agricultural practitioners in the Cianjur region and beyond. By identifying the most effective organic fertilizer types, nutrient compositions, and application methods for promoting tomato plant growth, the findings can inform decision-making regarding fertilizer selection, application rates, and timing, thereby optimizing resource use efficiency and maximizing crop productivity. Additionally, the emphasis on balanced nutrient ratios and innovative application techniques underscores the importance of adopting holistic and context-specific

approaches to organic fertilizer management in agricultural systems.

Limitations and Future Research Directions

It is essential to acknowledge certain limitations of the study, including the relatively small sample size and the short-term nature of the experimental period. Future research could explore larger sample sizes and longer-term monitoring to assess the sustainability and long-term effects of organic fertilizer treatments on soil health, crop productivity, and ecosystem resilience. Furthermore, investigating additional factors such as soil microbial communities, crop genotype interactions, and socio-economic factors could provide a more comprehensive understanding of the complex dynamics shaping tomato cultivation in the Cianjur region.

5. CONCLUSION

The study elucidated the significant influence of organic fertilizer type, nutrient composition, and application method on tomato plant growth in the Cianjur region. Biofertilizers, balanced nutrient compositions, and foliar spraying were identified as key factors contributing to enhanced plant growth and productivity. These findings have practical implications for farmers and agricultural practitioners, emphasizing the importance of selecting appropriate organic fertilizers and application techniques to maximize crop yields sustainably. Moving forward, further research exploring the long-term effects and interactions of organic fertilizer variables is warranted to support informed decision-making and promote agricultural sustainability in the region and beyond.

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