

Effect Of Dolomite Lime Dosage And Goat Manure Fertilizer Dosage On The Growth And Yield Of Tomato Plant (*Lycopersicum esculentum* MILL.)

Sigit Permono¹, Luluk Sulistiyo Budi^{1*}, Sri Rahayu¹, Ma'ruf Pambudi Nurwantara¹

¹Faculty of Agriculture, Agrotechnology Studies Program, Merdeka Madiun University, Madiun, East Java, Indonesia

Luluk Sulistiyo Budi : <https://orcid.org/0000-0001-8918-7390>

*Corresponding author : luluksb@unmer-madiun.ac.id

ABSTRACT

This study evaluated the interaction between dolomite lime and goat manure dosages on the growth and yield of tomato plants (*Lycopersicum esculentum* Mill.). The experiment was arranged in a factorial randomized block design with two factors and three replications. Dolomite lime was applied at four levels (0, 5, 10, and 15 g per polybag), while goat manure was applied at 0, 37.5, 75, and 112.5 g per polybag. Observations included soil pH, plant height, number of leaves, leaf area, number of branches, number of fruits per plant, and biomass parameters. Significant interactions between dolomite lime and goat manure were observed for leaf number at 36 and 43 days after transplanting (DAT), leaf area at 43 DAT, number of branches at 36 DAT, and number of fruits per plant at 57 DAT, whereas no interaction occurred for soil pH, plant height, or biomass variables. Dolomite lime improved soil chemical conditions by increasing soil pH, while goat manure enhanced vegetative growth through improved nutrient availability. Optimal combinations differed among parameters. Overall, integrated application of dolomite lime and goat manure effectively enhanced tomato growth and yield under acidic soil conditions.

Keywords: dolomite lime; goat manure; integrated nutrient management; tomato growth, yield components.

INTRODUCTION

Tomato (*Lycopersicum esculentum* Mill.) is one of the most important horticultural crops cultivated worldwide due to its high economic value and nutritional content, including vitamins, minerals, and antioxidants that contribute to human health. Despite its importance, tomato productivity is highly dependent on soil fertility and nutrient availability, which are often constrained in agricultural soils, particularly those characterized by acidity and low base saturation. Soil acidity can limit nutrient uptake and inhibit plant physiological processes, ultimately affecting yield quality and quantity. To overcome these limitations, the application of soil amendments such as dolomite lime and organic fertilizers has been widely recognized as an effective approach to improving soil chemical properties and plant nutrient availability (Brady & Weil, 2016). Therefore, optimizing dolomite lime dosage in combination with organic fertilizers such as goat manure becomes a critical strategy for enhancing tomato growth and yield in a sustainable manner.

In line with this condition, one of the major challenges faced in tomato cultivation is suboptimal growth and yield caused by improper soil management practices, particularly related to liming and fertilization. Inappropriate liming rates may fail to sufficiently correct soil pH, whereas excessive application can lead to nutrient imbalance and reduced nutrient use efficiency (Havlin et al., 2014). Similarly, the use of organic fertilizers without appropriate dosage consideration may not adequately supply essential nutrients required for optimal plant growth. Consequently, it is necessary to investigate how varying dosages of dolomite lime and goat manure fertilizer influence tomato growth and yield. This study hypothesizes that a significant interaction exists between dolomite lime dosage and goat manure fertilizer dosage in improving tomato plant growth and yield.

Empirical evidence supports the importance of addressing soil acidity as a key limiting factor in tomato cultivation, particularly in tropical agricultural regions. Acidic soils are known to reduce the availability of essential nutrients such as calcium, magnesium, and phosphorus, which are vital for plant development (Fageria & Baligar, 2008). Several studies have demonstrated that dolomite lime application effectively increases soil pH while simultaneously supplying calcium and magnesium required for plant growth (Havlin et al., 2014). Organic fertilizers, such as goat manure, have been shown to significantly improve soil physical properties, enhance microbial activity, and increase nutrient availability, thereby contributing to improved crop performance. These benefits are primarily due to the high organic

carbon content and nutrient-rich composition of goat manure, which positively influences soil structure and fertility. The application of goat manure has been associated with increased soil porosity, reduced bulk density, and enhanced moisture retention, all of which are crucial for optimal plant growth. Furthermore, goat manure contributes to the availability of essential nutrients and supports microbial activity, which is vital for nutrient cycling and soil health. These improvements in soil properties and nutrient availability have been linked to enhanced crop yields and quality. Goat manure significantly reduces soil bulk density and increases porosity, improving soil aeration and water retention. Enhanced moisture content in soils treated with goat manure supports better plant growth and resilience against drought (Adekiya et al., 2025). Goat manure is also recognized for its relatively high nitrogen, phosphorus, and potassium content compared to other animal manures (Ayeni & Adetunji, 2010). Nevertheless, studies examining the combined effects of dolomite lime and goat manure dosage on tomato growth and yield remain limited and often produce inconsistent results due to differences in soil characteristics and environmental conditions (Saha et al., 2019).

Given these research gaps, the present study holds significant importance in advancing knowledge on integrated soil fertility management for tomato cultivation. This research provides scientific evidence on the optimal combination of dolomite lime and goat manure fertilizer for improving tomato growth and yield on acidic soils. The findings contribute to sustainable soil fertility management by promoting the efficient and balanced use of organic inputs and soil amendments (Brady & Weil, 2016). Furthermore, this study supports environmentally friendly agricultural practices by reducing reliance on synthetic fertilizers, which are often associated with environmental degradation (Tilman et al., 2002). The results are expected to serve as a valuable reference for farmers, researchers, and policymakers in developing sustainable tomato production systems.

To address the identified problems, this research offers a solution through the evaluation of appropriate dosages of dolomite lime and goat manure fertilizer aimed at improving soil chemical properties and enhancing tomato plant growth and yield. By determining optimal application rates, the study seeks to provide practical and applicable recommendations for integrated soil fertility management. The combined application of dolomite lime and goat manure is expected to correct soil acidity while supplying essential nutrients in a balanced and sustainable manner. Ultimately, this approach is anticipated to improve soil health and crop productivity simultaneously, supporting long-term agricultural sustainability.

Based on the importance of integrated soil amendment strategies, a comprehensive understanding of previous research findings is essential. Numerous studies have examined the individual effects of liming materials and organic fertilizers on soil properties and crop yield. However, variations in soil characteristics, fertilizer dosages, and crop responses indicate that further investigation is still required. Therefore, a systematic review of relevant literature is necessary to identify existing research gaps and establish a theoretical framework for analyzing the combined effects of dolomite lime and goat manure fertilizer on the growth and yield of tomato plants.

RESEARCH METHOD

Research Design

The research will be conducted at Merdeka Madiun University, located on Serayu 79st in Madiun City, at an elevation of approximately 72 meters above sea level. The study will be conducted from March 2024 to June 2024. The materials used in this study were tomato plants of the F1 servo variety, manure, pH meter, dolomite lime, water, polybags measuring 40x40 cm, insecticides, herbicides, NPK fertilizers. The tools used in this study were hoes, watering cans, meters, bamboo, knives, mica plastic for writing treatment combinations, analytical scales, calipers, stationery, and other supporting tools.

Research Target/Subject

This research was conducted using a factorial randomized block design (RBD) with two factors: dolomite lime with four levels: K0 = without dolomite lime, K1 = 1 ton/ha (5 grams/polybag), K2 = 2 tons/ha (10 grams/polybag), and K3 = 3 tons/ha (15 grams/polybag). The goat manure factor with four levels: P0 = without goat manure, P1 = 7.5 tons/ha (37.5 grams/polybag), P2 = 15 tons/ha (75 grams/polybag), and P3 = 22.5 tons/ha (112.5 grams/polybag).

Instruments, and Data Collection Techniques

The types of data, how the data is collected, with which instruments the data is collected, and the techniques for collecting it, need to be explained clearly in this section.

Data analysis technique

Data collected from observations were tested using analysis of variance (ANOVA) at a 5% level. If significant differences were found between the treatments studied, a Duncan's multiple range test (DMRT) was performed at a 5% level.

RESULTS AND DISCUSSION

Soil pH

The analysis of variance results showed no interaction between dolomite lime (K) and goat manure (P) at 22, 29, 36, and 43 DAP on soil pH. The average results of soil pH observations on tomato growth and yield are presented in Table 1.

Table 1. Average Soil PH Parameters in Dolomite Lime Dose and Goat Manure Dose Treatments on the Growth and Yield of Tomato Plants of Various Ages

Combination Treatment	Soil pH			
	Before Treatment/14 HST	21 HST	28 HST	35 HST
Dolomite Lime				
0 gr	5.93 ^a	5.96 ^a	5.85 ^a	5.92 ^a
5 gr	5.83 ^a	6.20 ^b	6.07 ^b	6.18 ^b
10 gr	5.80 ^a	6.42 ^c	6.43 ^c	6.58 ^c
15 gr	5.80 ^a	6.50 ^c	6.60 ^d	6.56 ^c
Goat manure				
0 gr	5.89 ^a	6.28 ^a	6.27 ^a	6.29 ^a
37,5 gr	5.90 ^a	6.19 ^a	6.22 ^a	6.31 ^a
75 gr	5.78 ^a	6.25 ^a	6.23 ^a	6.31 ^a
112,5 gr	5.78 ^a	6.30 ^a	6.24 ^a	6.33 ^a

Description: Numbers followed by the same letter in the same column are significantly different in the 5% Duncan test.

Table 1 indicates that dolomite lime application significantly increased soil pH, particularly at 21, 28, and 35 days after planting (HST). Prior to treatment (14 HST), soil pH values ranged from 5.80 to 5.93 and did not differ significantly among treatments, indicating a uniformly acidic initial soil condition. This homogeneity confirms that observed changes in soil pH were mainly attributable to treatment effects rather than initial soil variability (Brady & Weil, 2017).

At 21 HST, soil pH increased in line with increasing dolomite dosage. Treatments with 10 g and 15 g dolomite resulted in significantly higher soil pH values (6.42–6.50) compared to lower doses. This pattern persisted at 28 HST, where the highest dolomite dosage (15 g) produced the highest soil pH (6.60) and differed significantly from other treatments. These findings are consistent with the role of dolomite as a liming material supplying Ca^{2+} and Mg^{2+} ions that neutralize soil acidity by replacing H^+ and Al^{3+} ions on soil exchange sites (Havlin et al., 2014).

At 35 HST, soil pH values under dolomite treatments remained within a moderately acidic to near-neutral range (5.92–6.58). Although higher dosages maintained higher pH levels, the differences among treatments became less distinct, suggesting soil pH stabilization. This phenomenon is associated with soil buffering capacity once liming reactions approach equilibrium (Foth & Ellis, 1997).

In contrast, goat manure application did not significantly affect soil pH at any observation period, despite slight numerical increases compared to initial conditions. Soil pH values across all manure dosages ranged from 6.19 to 6.33 at 21–35 HST and were statistically similar. This result indicates that goat manure acts primarily as an organic soil amendment rather than a liming agent, improving soil chemical stability and buffering capacity rather than rapidly altering soil pH (Widowati et al., 2004; Havlin et al., 2014).

Overall, the results demonstrate that dolomite lime is the primary factor influencing soil pH improvement, while goat manure contributes indirectly by stabilizing soil chemical properties. Soil pH values approaching neutrality (6.0–6.5), as observed in the 10–15 g dolomite treatments, are considered optimal for tomato growth due to enhanced nutrient availability and reduced aluminum toxicity in acidic soils (Brady & Weil, 2017; Prasetyo & Suriadikarta, 2006).

Plant height (cm)

The analysis of variance results showed no interaction between the dolomite lime (K) and goat manure (P) doses at 22, 29, 36, and 43 days after planting on plant height. The average results of plant height observations on tomato growth and yield are presented in Table 2.

Table 2. Average Plant Height Parameters in Dolomite Lime Dose and Goat Manure Dose Treatments on the Growth and Yield of Tomato Plants of Various Ages

Combination Treatment	Soil pH			
	22 HST	29 HST	36 HST	43 HST
Dolomite Lime				
0 gr	50,17 ^a	64,39 ^a	75,88 ^a	86,78 ^a
5 gr	49,87 ^a	64,39 ^a	77,55 ^a	88,98 ^a
10 gr	48,57 ^a	62,66 ^a	74,43 ^a	84,75 ^a
15 gr	50,03 ^a	65,38 ^a	77,54 ^a	89,19 ^a
Goat manure				
0 gr	45,35 ^a	58,64 ^a	68,43 ^a	79,02 ^a
37,5 gr	49,18 ^a	63,83 ^{ab}	76,68 ^{ab}	88,89 ^b
75 gr	49,87 ^{ab}	64,21 ^{ab}	76,43 ^{ab}	86,76 ^{ab}
112,5 gr	54,25 ^b	70,13 ^b	83,87 ^b	95,03 ^b

Description: Numbers followed by the same letter in the same column are significantly different in the 5% Duncan test.

Table 2 shows that dolomite lime application did not significantly affect tomato plant height at all observation periods (22, 29, 36, and 43 HST). Plant height values under different dolomite dosages were statistically similar at each observation time, as indicated by the same letter notation in each column. This suggests that although dolomite effectively improved soil pH (Table 1), its direct influence on vegetative growth, particularly plant height, was limited during the observed growth stages. According to Havlin et al. (2014), liming materials primarily function to improve soil chemical conditions and nutrient availability rather than directly stimulating vegetative growth parameters such as plant height.

In contrast, goat manure application significantly increased tomato plant height, particularly at later growth stages. At 22 HST, the highest dose of goat manure (112.5 g) resulted in significantly taller plants (54.25 cm) compared to lower doses. This trend became more pronounced at 29 HST, where plants treated with 112.5 g of goat manure reached 70.13 cm, significantly higher than the control. Similar patterns were observed at 36 and 43 HST, with the highest manure dose producing the tallest plants (83.87 cm and 95.03 cm, respectively).

The positive response of plant height to increasing goat manure dosage can be attributed to the high organic matter and nutrient content of goat manure, particularly nitrogen, which plays a crucial role in vegetative growth. Organic fertilizers improve soil structure, increase microbial activity, and enhance nutrient mineralization, thereby supporting continuous nutrient uptake by plants (Brady & Weil, 2017). Nitrogen availability from organic sources is known to promote cell elongation and leaf area expansion, which directly contributes to increased plant height (Marschner, 2012).

Furthermore, the gradual release of nutrients from goat manure likely sustained plant growth over time, explaining the increasingly significant differences observed at later growth stages (36 and 43 HST). This slow-release characteristic of organic fertilizers helps maintain nutrient availability throughout the growing period, reducing nutrient losses and improving nutrient use efficiency (Widowati et al., 2004).

Overall, these results indicate that goat manure plays a more dominant role than dolomite lime in enhancing tomato plant height, while dolomite primarily improves soil chemical conditions that indirectly support plant growth. The combination of improved soil pH from dolomite application and enhanced nutrient availability from goat manure may therefore create optimal conditions for tomato growth and yield.

Number of Leaves

The analysis of variance results showed a significant interaction between the dolomite lime (K) and goat manure (P) doses at 36 and 43 days after planting. However, no interaction was found for leaf number at 22 and 29 days after planting. The average leaf number observations for tomato growth and yield are presented in Figures 1 and 2.

There was an interaction between leaf number at 36 and 43 days after planting, which requires further testing with a Duncan test at the 5% level. The results of the Duncan test are presented in Figures 1 and 2.

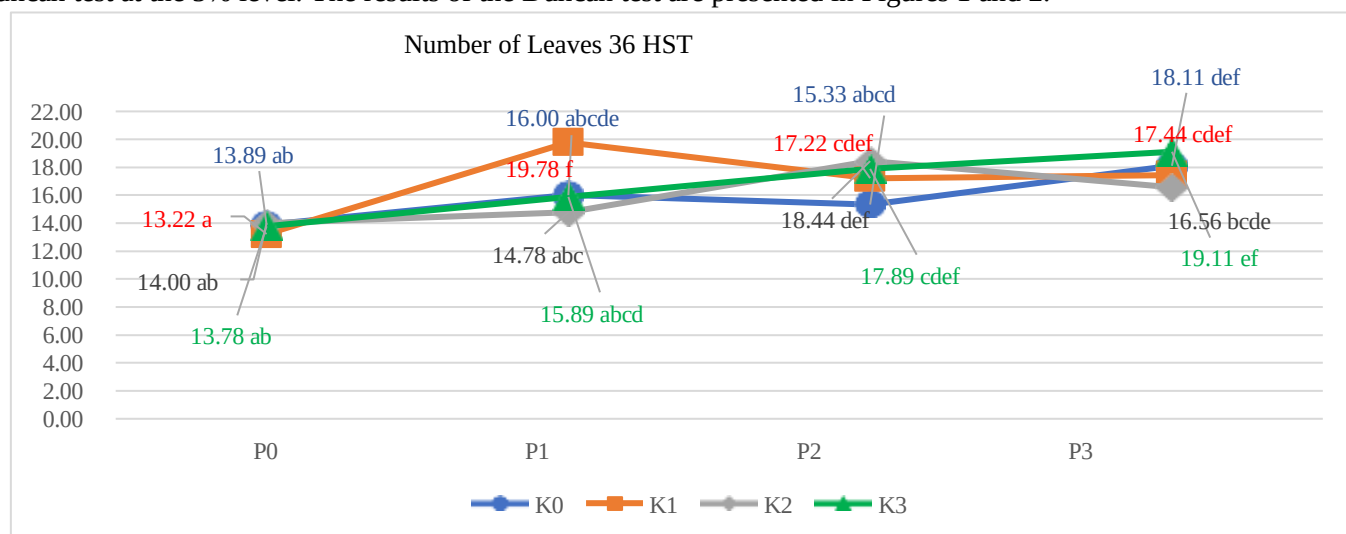


Figure 1. Interaction Curve of Dolomite Lime Dose and Goat Manure Dose on Tomato Plant Growth and Yield at Leaf Number Parameter 36 HST

Figure 1 illustrates the interaction between dolomite lime dosage and goat manure dosage on the number of tomato leaves at 36 days after planting (HST). Overall, the figure shows an increasing trend in leaf number with higher levels of both dolomite lime and goat manure, although the magnitude of response differs among treatment combinations.

At the lowest dolomite level (P0), leaf number ranged from approximately 13.22 to 14.00 leaves, indicating limited vegetative development under minimal soil amendment. Increasing dolomite dosage to P1 and P2 resulted in a noticeable increase in leaf number across goat manure treatments, suggesting that soil pH improvement enhanced nutrient availability and supported leaf formation. This response is consistent with the role of dolomite in supplying Ca and Mg and reducing soil acidity, which improves root activity and nutrient uptake efficiency (Goulding, 2016; Li et al., 2021).

The highest leaf numbers were observed at the P3 level, particularly when combined with higher goat manure doses, reaching values of up to 19.11 leaves. This indicates a positive interaction between dolomite lime and goat manure, where improved soil chemical conditions from liming synergistically interacted with enhanced nutrient supply and organic matter from goat manure. Organic amendments are known to stimulate microbial activity and nitrogen mineralization, which directly supports leaf initiation and expansion (Adekiya et al., 2020; Zhang et al., 2023).

Statistical grouping letters in the figure further indicate that several treatment combinations differed significantly, confirming that leaf number was not only influenced by single-factor effects but also by their interaction. The increase in leaf number at higher treatment levels reflects improved photosynthetic capacity, as leaves are the primary organs for light interception and assimilate production. According to Marschner (2012), sufficient nitrogen and balanced secondary nutrients (Ca and Mg) are critical for leaf development, chlorophyll synthesis, and sustained vegetative growth.

Furthermore, the progressive increase in leaf number at 36 HST represents an important physiological phase in tomato growth, as this stage determines canopy development and future yield potential. Treatments that enhanced leaf number at this stage are therefore likely to contribute positively to biomass accumulation and fruit yield in later growth stages (Taiz et al., 2018).

Overall, these results indicate that the combination of higher dolomite lime and goat manure doses produced the most favorable response in leaf number, highlighting the importance of integrated soil fertility management. Dolomite lime primarily improved soil pH and nutrient availability, while goat manure supplied organic nutrients and enhanced soil biological activity, resulting in synergistic effects on tomato vegetative growth.

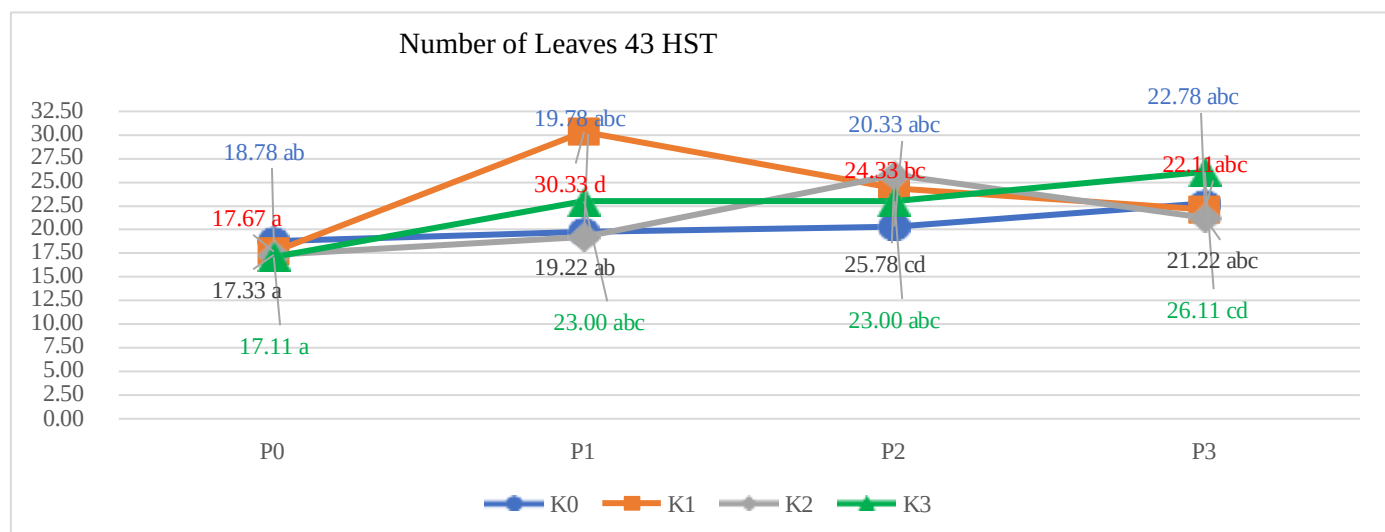


Figure 2. Interaction Curve of Dolomite Lime Dose and Goat Manure Dose on Tomato Plant Growth and Yield at Leaf Number Parameter 43 HST

The interaction between dolomite lime and goat manure doses had a clear influence on tomato vegetative growth, particularly the number of leaves measured at 43 days after transplanting (DAT). Treatments combining both soil amendment sources generally produced a higher number of leaves compared with the control (P0), indicating that the integrated application of organic manure and lime promotes enhanced vegetative development in tomato plants. This finding corresponds to broader evidence that organic amendments such as animal manures increase essential nutrient availability especially nitrogen which supports leaf initiation and expansion (e.g., organic manure enhanced leaf number compared to untreated control in tomato) (Isse, 2024).

The significant differences among treatments (denoted by distinct letters in Figure 2) suggest that the response of tomato leaf number was not strictly linear across all dose combinations. Instead, specific combinations of dolomite lime and goat manure provided optimal conditions for growth, while other combinations showed lesser influence. This pattern is consistent with integrated nutrient management studies indicating that the synergistic effects of organic amendments and soil pH modifiers can improve soil nutrient retention and plant performance more than single inputs alone (Ragasa et al., 2025).

The potential mechanism underlying these results includes the amelioration of soil acidity and enhanced nutrient cycling. Although research specifically on dolomite application in tomato systems remains limited, studies on combined organic amendments and lime reported increased soil fertility and improved yield outcomes in tomato and other crops when organic manure is integrated with liming agents (e.g., combined manure and lime enhanced tomato yield and soil nutrient status in long-term trials). Liming materials such as dolomite lime increase soil pH and base cation availability, thereby improving nutrient uptake and vegetative growth under conditions where soil acidity may otherwise limit productivity (Zhang et al., 2025).

Overall, the current results demonstrate that the application of goat manure in combination with dolomite lime significantly enhances leaf development in tomato at 43 DAT, likely through improved soil nutrient availability, pH adjustment, and organic matter input. Such integrated application aligns with contemporary sustainable soil management approaches that seek to maximize plant growth while maintaining soil health through balanced amendment strategies (organic plus liming input)

Leaf Area (cm²)

Analysis of variance showed a significant interaction between dolomite lime (K) and goat manure (P) doses at 43 days after planting. No interaction was found for leaf area at 22, 29, or 36 days after planting. Average leaf area observations on tomato growth and yield are presented in Figure 3. An interaction for leaf area was observed at 43 days after planting, warranting further testing with a Duncan test at the 5% level. The Duncan test results are shown in Figure 3.

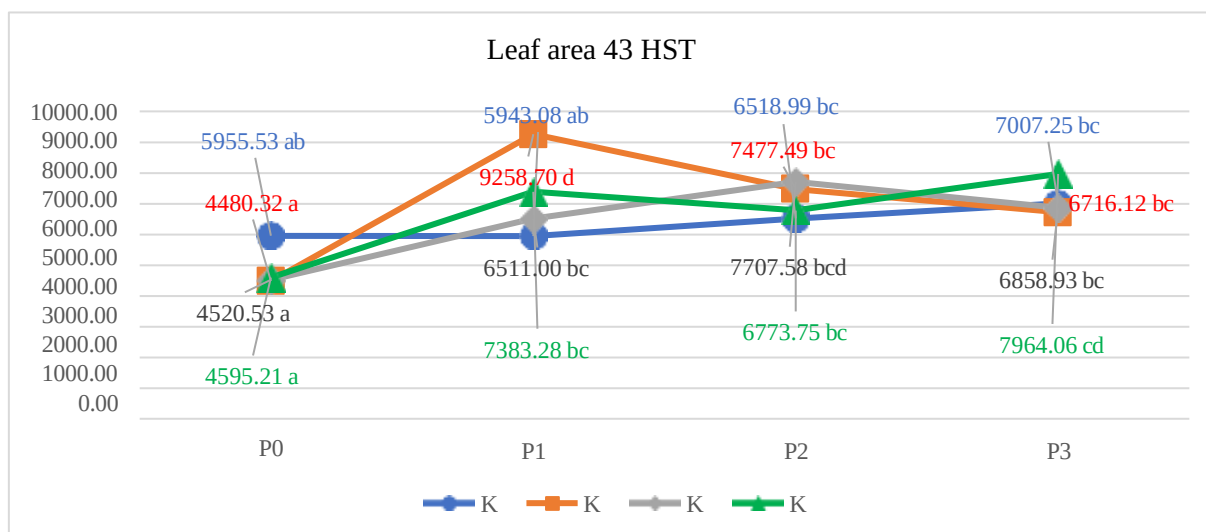


Figure 3. Interaction Curve of Dolomite Lime Dose and Goat Manure Dose on Tomato Plant Growth and Yield on Leaf Area Parameters 43 HST

The results presented in Figure 3 demonstrate a significant interaction between dolomite lime application and goat manure dosage on tomato leaf area at 43 days after transplanting (DAT), as indicated by the non-parallel interaction curves among treatments. Under the control condition without dolomite (P0), increasing goat manure dosage did not substantially enhance leaf area, suggesting that nutrient availability remained suboptimal due to unfavorable soil chemical properties, particularly low soil pH and limited base cation availability. In contrast, moderate dolomite application rates (P1–P2) consistently increased leaf area, with the highest values observed under combinations of P2–P3 dolomite levels and higher goat manure doses, indicating a synergistic effect between soil pH amelioration and organic nutrient supply.

The observed increase in leaf area under these combined treatments is closely associated with the role of dolomite in raising soil pH, reducing Al^{3+} toxicity, and improving Ca and Mg availability, which are essential for cell division and leaf expansion. Simultaneously, goat manure contributes to improved soil organic matter content, enhanced cation exchange capacity, and increased nitrogen availability, thereby promoting chlorophyll synthesis and photosynthetic activity. The interaction of these amendments accelerates canopy development, resulting in significantly greater leaf area compared with single-input treatments.

However, at the highest dolomite rate (P3), leaf area did not consistently exceed that observed at P2, suggesting the presence of an optimal liming threshold, beyond which excessive Ca and Mg may reduce micronutrient availability or induce nutrient antagonism. This finding highlights that balanced combinations of dolomite and organic manure are more effective than excessive application of a single amendment, underscoring the importance of integrated nutrient management for supporting vegetative growth of tomato during the early to mid-growth stages (Li et al., 2019; Havlin et al., 2017; Agegnehu et al., 2016).

Overall, the application of moderate dolomite rates combined with medium to high goat manure doses was the most efficient treatment for enhancing tomato leaf area at 43 DAT, as it created optimal soil conditions for nutrient uptake and plant physiological processes.

Number of Branches

The analysis of variance results showed a highly significant interaction between the dolomite lime (K) and goat manure (P) doses at 36 days after planting. However, the analysis of variance results at 22, 29, and 43 days after planting showed no interaction between dolomite lime (K) and goat manure (P) doses on the number of branches. The average results of observations on the number of branches, growth, and yield of tomato plants are presented in Figure 4.

Given the significant interaction observed at 36 days after planting, further testing was warranted using a Duncan test at the 5% level. The results of the Duncan test are presented in Figure 4.

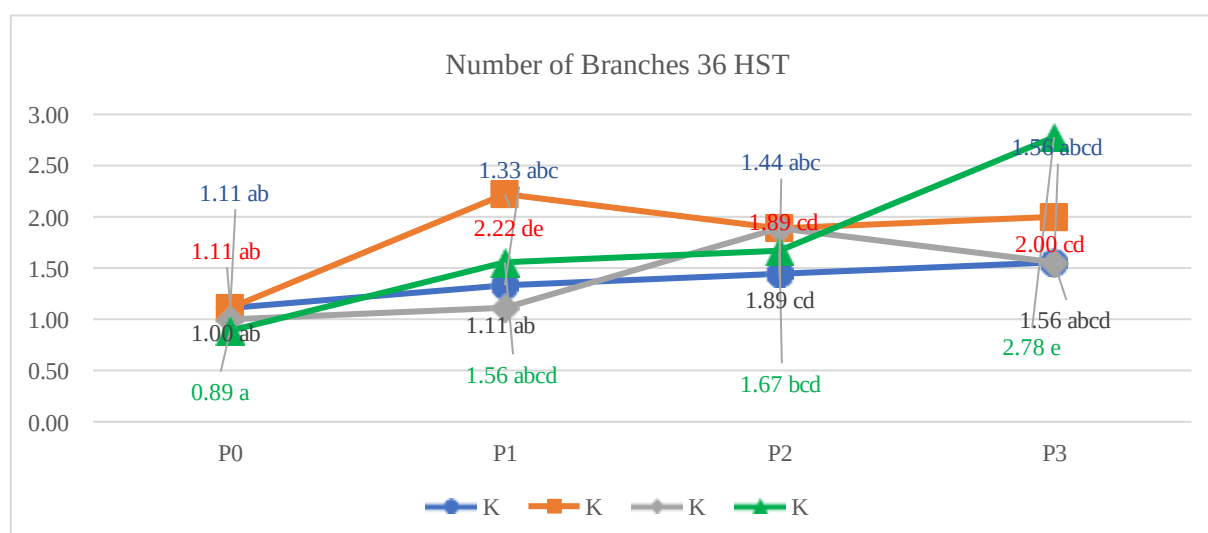


Figure 4 Interaction Curve of Dolomite Lime Dose and Goat Manure Dose on Tomato Plant Growth and Yield at Branch Number Parameter 36 HST

Figure 4 illustrates a significant interaction between dolomite lime and goat manure application on the number of branches of tomato plants at 36 days after transplanting (DAT), as evidenced by the divergent and non-parallel response curves across treatment combinations. Under non-limed conditions (P0), branch number remained relatively low and showed limited responsiveness to increasing goat manure rates, indicating that soil chemical constraints—particularly soil acidity and restricted nutrient availability—may have inhibited lateral shoot development. In contrast, the application of dolomite at moderate to high levels (P1–P3) markedly enhanced branch formation, especially when combined with higher doses of goat manure.

The progressive increase in branch number observed at P2 and P3 suggests that dolomite-induced pH correction improved nutrient availability and root activity, thereby facilitating greater vegetative differentiation. Calcium and magnesium supplied by dolomite play a crucial role in meristematic activity and structural development, which directly influences branching patterns. Concurrently, goat manure contributes readily available nitrogen and organic matter that stimulate cytokinin activity and vegetative growth, promoting axillary bud initiation and branch proliferation. The strongest response was recorded at the highest combined treatment, reflecting a synergistic effect between soil chemical amelioration and organic nutrient input.

However, the relatively modest increase in branch number between P2 and P3 under certain manure levels indicates a tendency toward diminishing returns at excessive liming rates, likely due to nutrient antagonism or reduced availability of micronutrients essential for balanced vegetative growth. This finding underscores that optimal, rather than maximal, application rates of dolomite are more effective when integrated with organic fertilization. Similar interaction effects between liming materials and organic amendments on branching and vegetative architecture have been reported in tomato and other horticultural crops (Havlin et al., 2017; Li et al., 2019; Agegnehu et al., 2016).

Overall, the combination of moderate-to-high dolomite rates with medium-to-high goat manure doses was the most effective strategy for enhancing branch number at 36 DAT, highlighting the importance of integrated soil fertility management in promoting early vegetative vigor and structural complexity in tomato plants.

Number of Fruits Per Plant

The analysis of variance showed a significant interaction between the dolomite lime (K) and goat manure (P) doses at 57 days after planting. However, the analysis of variance at 71 and 85 days after planting showed no interaction between the dolomite lime (K) and goat manure (P) doses on the number of fruits per plant. The average results of observations on the number of fruits per plant on tomato plant growth and yield are presented in Figure 5. There was an interaction between the number of fruits per plant at 57 days after planting, which requires further testing with a Duncan test at the 5% level. The results of the Duncan test are presented in Figure 5.

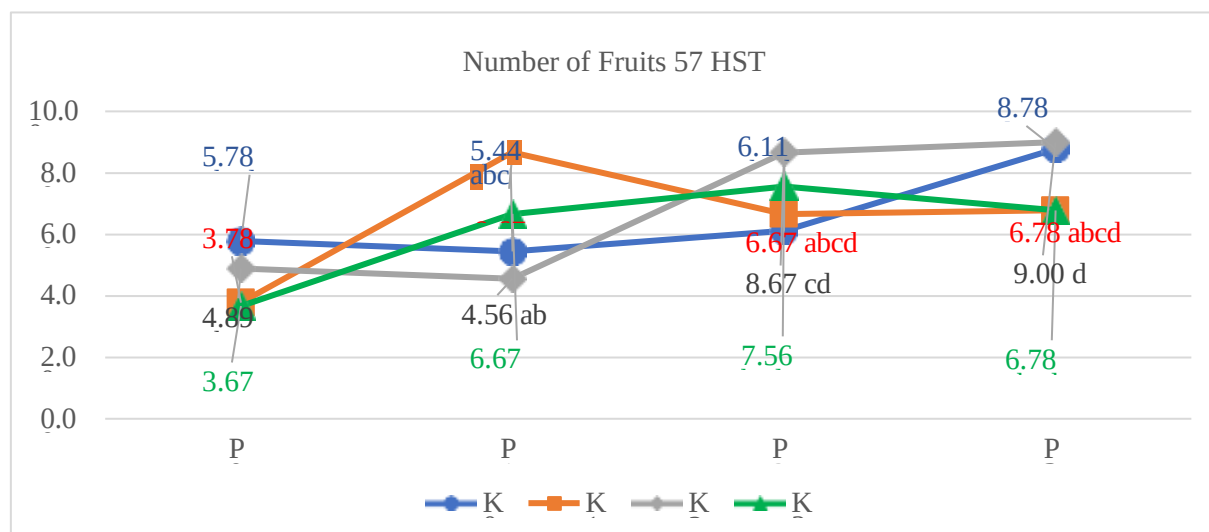


Figure 5. Interaction Curve of Dolomite Lime Dose and Goat Manure Dose on Tomato Plant Growth and Yield at the Parameter of Number of Fruits per Plant 57 HST

Figure 5 indicates a significant interaction between dolomite lime and goat manure application on the number of fruits per tomato plant at 57 days after transplanting (DAT), as reflected by the non-linear and crossing interaction patterns among treatments. Under low or absent dolomite application, fruit number remained relatively limited despite increases in goat manure dose, suggesting that suboptimal soil pH and nutrient imbalance constrained reproductive development. In contrast, moderate to high dolomite levels markedly enhanced fruit set, particularly when combined with medium to high doses of goat manure, resulting in the highest number of fruits per plant at 57 DAT.

The improvement in fruit number under combined treatments can be attributed to the role of dolomite in correcting soil acidity, increasing the availability of Ca and Mg, and improving nutrient uptake efficiency during the reproductive phase. Calcium is especially critical for flower retention and fruit set, while magnesium supports photosynthate translocation to developing fruits. Simultaneously, goat manure supplies essential macronutrients, particularly nitrogen and potassium, and enhances soil organic matter, which collectively support flowering intensity and fruit initiation. The synergistic interaction between liming and organic fertilization thus promotes a more favorable physiological balance between vegetative and reproductive growth.

However, the absence of a consistent increase in fruit number at the highest dolomite rate across all manure levels suggests the existence of an optimum liming range, beyond which additional dolomite does not further enhance reproductive performance and may even induce nutrient antagonism or reduce micronutrient availability. This pattern emphasizes that balanced nutrient management is more effective than excessive amendment inputs. Similar findings regarding the interactive effects of liming materials and organic amendments on tomato yield components have been reported in recent studies (Agegnehu et al., 2016; Havlin et al., 2017; Li et al., 2019).

Overall, the results demonstrate that the combination of moderate to high dolomite doses with medium to high goat manure application is the most effective strategy for increasing the number of fruits per tomato plant at 57 DAT, highlighting the importance of integrated soil fertility management for optimizing tomato reproductive performance.

Fresh Plant Sludge Weight (g)

The analysis of variance results showed no interaction between the dolomite lime (K) and goat manure (P) doses at 92 days after planting on fresh plant sludge weight. The dolomite lime (K) dose factor had no significant effect on fresh plant sludge weight at 92 days after planting. The goat manure (P) dose factor had a significant effect on fresh plant sludge weight at 92 days after planting. The average observations of fresh plant sludge weight on tomato growth and yield are presented in Table 3.

Table 3. Average Parameters of Fresh Plant Stumper Weight in Dolomite Lime Dose and Goat Manure Dose Treatments on the Growth and Yield of Tomato Plants of Various Ages

Combination Treatment	Fresh Plant Stove Weight (g)
	92 HST
Dolomite Lime	
0 gr	1271,26 ^a
5 gr	1409,79 ^a
10 gr	1174,31 ^a
15 gr	1212,65 ^a
Goat Manure	
0 gr	987,21 ^a
37,5 gr	1322,53 ^b
75 gr	1421,65 ^b
112,5 gr	1336,62 ^b

Description: Numbers followed by the same letter in the same column are significantly different in the 5% Duncan test.

Table 3 shows that dolomite lime application did not significantly affect fresh plant biomass weight at 92 HST, as indicated by the same letter notation across all dolomite doses. Although numerically the 5 g dolomite treatment produced the highest fresh biomass (1409.79 g), this value was not statistically different from other dolomite treatments. This result suggests that the role of dolomite lime was primarily limited to improving soil chemical properties, particularly soil pH, rather than directly enhancing biomass accumulation at harvest time. Similar findings have been reported, where liming improved nutrient availability but did not always translate into a significant increase in vegetative biomass when soil acidity was not a major limiting factor during later growth stages (Li et al., 2021).

In contrast, goat manure application significantly increased fresh plant biomass, as indicated by different letter groupings in the Duncan test. The application of goat manure at 37.5 g, 75 g, and 112.5 g resulted in significantly higher fresh biomass weights (1322.53–1421.65 g) compared to the control (987.21 g). The highest biomass was recorded at the 75 g goat manure dose (1421.65 g), indicating an optimal level of organic nutrient supply for biomass production.

The positive effect of goat manure on fresh biomass can be attributed to its high organic matter content and balanced macro- and micronutrients, particularly nitrogen, which plays a central role in photosynthesis, leaf expansion, and biomass accumulation. Organic manure also enhances soil physical properties, such as aggregation and water-holding capacity, thereby improving root growth and nutrient uptake efficiency (Adekiya et al., 2020; Zhang et al., 2023).

Furthermore, the gradual mineralization of nutrients from goat manure provides a sustained nutrient supply throughout the plant growth cycle, supporting continuous vegetative development until harvest. This slow-release characteristic reduces nutrient losses and improves nutrient use efficiency, which is critical for achieving higher fresh biomass in tomato plants (Khalid et al., 2022). The absence of a further significant increase at the highest dose (112.5 g) suggests a threshold beyond which additional organic inputs no longer proportionally enhance biomass accumulation.

Overall, these findings indicate that goat manure is a more decisive factor than dolomite lime in increasing fresh plant biomass of tomato, while dolomite functions indirectly by creating favorable soil chemical conditions. The combination of soil pH improvement through dolomite application and organic nutrient supply from goat manure may therefore represent a sustainable strategy to optimize tomato growth and yield.

Dry Sludge Weight (g)

The analysis of variance showed no interaction between the dosage of dolomite lime (K) and goat manure (P) at 105 days after planting on the dry sludge weight parameter. The average results of observations of dry sludge weight on tomato plant growth and yield are presented in Table 4.

Table 4. Average Parameters of Dry Plant Slab Weight in Dolomite Lime Dose and Goat Manure Dose Treatments on the Growth and Yield of Tomato Plants of Various Ages

Combination Treatment	Weight of Dry Plant Sludge (g)
	92 HST
Dolomite Lime	
0 gr	83,06 ^{ab}
5 gr	92,08 ^b
10 gr	79,16 ^a
15 gr	84,88 ^{ab}
Goat Manure	
0 gr	71,85 ^a
37,5 gr	83,03 ^b
75 gr	91,41 ^b
112,5 gr	92,88 ^b

Description: Numbers followed by the same letter in the same column are significantly different in the 5% Duncan test.

Table 4 shows that both dolomite lime and goat manure applications influenced the dry plant biomass weight of tomato plants at 92 HST, although their effects differed in magnitude and consistency.

Dolomite lime application resulted in variable dry biomass responses. The 5 g dolomite treatment produced the highest dry biomass (92.08 g) and was significantly higher than the 10 g treatment (79.16 g), while the 0 g and 15 g treatments showed intermediate values and were not consistently different. This pattern suggests that moderate dolomite application was more effective than higher doses in supporting dry matter accumulation.

The increase in dry biomass at moderate dolomite levels may be attributed to improved soil pH conditions, which enhance nutrient availability—particularly phosphorus, calcium, and magnesium—thereby promoting photosynthesis and dry matter partitioning (Havlin et al., 2014; Li et al., 2021). However, the absence of a linear increase at higher dolomite doses indicates that excessive liming does not necessarily translate into higher biomass and may reduce the availability of certain micronutrients such as Fe and Mn, which are essential for plant metabolic processes (Goulding, 2016).

In contrast, goat manure application showed a clear and significant positive effect on dry plant biomass. Dry biomass increased progressively with increasing manure dose, from 71.85 g in the control to 92.88 g at the highest dose (112.5 g). The 75 g and 112.5 g treatments resulted in significantly higher dry biomass compared to lower doses, indicating that organic nutrient supply strongly influenced dry matter accumulation.

This response reflects the role of organic manure in improving soil organic carbon, nutrient availability, and microbial activity, which together enhance nutrient uptake efficiency and assimilate production (Adekiya et al., 2020; Zhang et al., 2023). Dry biomass is a reliable indicator of cumulative photosynthetic performance and carbon assimilation, suggesting that goat manure supported sustained vegetative growth throughout the crop cycle.

Moreover, the gradual mineralization of nutrients from goat manure provides a continuous nutrient supply, favoring the conversion of photosynthates into structural plant components, thereby increasing dry matter accumulation rather than merely increasing water content in tissues (Mandal et al., 2019).

Overall, these results indicate that goat manure had a stronger and more consistent effect on dry plant biomass than dolomite lime, while dolomite primarily played a supporting role by optimizing soil chemical conditions. The combination of moderate dolomite application and adequate goat manure dosage appears to be an effective strategy for maximizing dry biomass production, which is closely associated with improved yield potential in tomato cultivation.

CONCLUSION

The results of this study demonstrate that the application of dolomite lime and goat manure fertilizer exerts a significant interactive effect on the growth and yield of tomato plants (*Lycopersicum esculentum* Mill.). Across all observed parameters, including leaf area, number of branches, and number of fruits per plant, combined applications consistently outperformed single-input treatments, indicating a clear synergistic relationship between soil pH amelioration and organic nutrient supply.

Moderate to high dolomite dosages effectively improved soil chemical conditions, thereby enhancing nutrient availability and uptake, which was reflected in increased vegetative growth, as shown by greater leaf area and higher branch numbers during early to mid-growth stages. The addition of goat manure further strengthened these responses by supplying essential macronutrients and organic matter, promoting photosynthetic capacity and structural development. These improvements in vegetative growth translated into enhanced reproductive performance, as evidenced by a higher number of fruits per plant at 57 DAT under integrated treatments.

The lack of consistent yield increases at the highest dolomite application rates indicates the presence of an optimal liming threshold. Beyond this threshold, further application does not enhance yield and may disrupt nutrient balance. These results underscore the importance of balanced nutrient management, rather than excessive input application, for maximizing tomato growth and yield.

Overall, the combined application of dolomite lime at moderate rates with medium to high doses of goat manure represents an effective and sustainable fertilization strategy for tomato cultivation, particularly in acidic soils. This integrated approach not only improves vegetative vigor and yield components but also supports more efficient nutrient use, contributing to sustainable soil fertility management in horticultural production systems.

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AUTHOR CONTRIBUTIONS

The contributors to this research consist of: "Conceptualization and Methodology, Luluk Sulistiyo Budi; Formal Analysis and Investigation, Sigit Permono; Data Curation and Writing – Original Draft Preparation, Sri Rahayu; Writing – Review & Editing, Ma'ruf Pambudi Nurwantara".

DISCLOSURE

The authors declare that they have no conflict of interest.

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