

Effect of Dolomite and NPK on The Growth and Yield of off-Season Shallots

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ABSTRACT

Shallot is a high-value horticultural commodity. Its productivity often declines due to suboptimal soil conditions, such as low pH and imbalanced nutrient availability, especially when cultivated off-season. This study aimed to determine the optimal combination of dolomite and NPK (Nitrogen, Phosphorus, Potassium) fertilizer for the growth and yield of shallot cultivated in the off-season. The research was conducted in Ngringo Village, Jaten District, Karanganyar Regency from February-April 2025. The method used was a factorial Completely Randomized Design (CRD) with two factors and three replications. The first factor was dolomite doses (0; 2000; and 4000 kg.ha⁻¹) and NPK fertilizer doses (250; 375; and 500 kg.ha⁻¹). Observed parameters were plant height, number of leaves, fresh and dry biomass weight, fresh and dry bulb weight, number of bulbs per plant, and bulb diameter. Data were analyzed by analysis of variance (ANOVA) at a 95% significance level and continued with Duncan's Multiple Range Test (DMRT) with 95% significance level when significant differences were found. The results showed no significant interaction between dolomite and NPK fertilizer on shallot growth and yield. Dolomite at 2000 kg.ha⁻¹ significantly increased the number of leaves, while NPK fertilizer had no significant effect. However, 250 kg.ha⁻¹ of NPK fertilizer produced similar results to higher doses, indicating potential fertilizer efficiency. Environmental conditions such as high humidity and low light intensity likely influenced treatment effectiveness.

Keywords: acidic soil; fertilizer efficiency; humidity; Liliaceae; magnesium.

INTRODUCTION

Shallots (*Allium cepa* var. *aggregatum*) are one of the high value horticultural commodities that play an important role as food, kitchen seasoning, and for processing industries (Aryanta 2019; Pratiwi et al. 2020). Brebes Regency is the main center for shallot production in Indonesia, but its productivity has declined in recent years, from 10.4 tons/ha in 2019 to 7.8 tons/ha in 2020 (BPS, 2021). One of the main factors influencing this decline is less-than-

ideal soil conditions, particularly low soil acidity levels (pH), which limits the availability of essential nutrients (Fibrianty et al. 2022). Soil pH that tends to be acidic can reduce the availability of Nitrogen (N), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sulphur (S), as well as increase the solubility of Aluminum (Al) and Iron (Fe), which can bind Phosphorus (P) and make it unavailable to plants (Handayanto et al. 2017). Soil with an

optimal pH supports the activity of microorganisms, improves soil structure, and increases aeration and water retention, making it suitable for the growth requirements of shallots (Asrijal et al. 2018).

One of the efforts to improve acidic soil is by applying dolomite lime, which contains Ca and Mg and functions to neutralize pH and improve soil nutrient balance (Delina et al. 2019; Darsiti et al. 2024). The element Mg plays an important role in the process of photosynthesis by absorbing CO₂ and helping transport the products of photosynthesis from the leaves to storage organs such as roots and bulbs (Ishfaq et al. 2022). Without the element Mg, chlorophyll cannot effectively absorb light, thus disrupting the process of photosynthesis. Magnesium balance in plants is influenced by soil pH, temperature, and the availability of other nutrients (Adriaie, 2025). However, dolomite itself does not provide the essential nutrients N, P, and K that plants need, so it needs to be combined with the application of NPK fertilizer. Lestari et al. (2018) stated that applying dolomite simultaneously with

NPK fertilizer can significantly increase the fresh and dry weight of plants.

Additionally, off-season shallot cultivation is one strategy to maintain supply availability throughout the year, despite facing environmental challenges such as high humidity and low light intensity, which can affect plant growth and yield (Basundari and Krisdianto, 2020). One way to support off-season shallot cultivation is by using UV plastic as shade, which serves to protect plants from direct rainwater splash that causes root and bulb rot, and helps maintain stable environmental temperature and humidity (Husni et al. 2024). Therefore, selecting the correct dosage of dolomite and NPK fertilizer is crucial for supporting optimal shallot growth even when planted off-season.

This research aims to determine the optimal combination of dolomite and NPK fertilizer dosages for the growth and yield of off-season shallots, and to identify the effective and efficient dosage for increasing crop productivity.

MATERIALS AND METHODS

The research was conducted in Ngringo Village, Jaten District, Karanganyar Regency, Central Java, and at the Chemistry and Soil Fertility Laboratory of the Faculty of Agriculture, UNS, as the location for soil analysis. This research was conducted from February to April 2025. Soil analysis was carried out at the Soil Chemistry and Fertility Laboratory of the Faculty of Agriculture, Sebelas Maret University, Surakarta. The materials used are Bima Brebes variety shallot seeds, 30 x 30 cm polybags, dolomite, NPK pearl fertilizer, and manure. The tools used in this research are a scale and a pH meter.

RESULT AND DISCUSSION

General Condition

The air temperature during the study period showed a relatively stable range. The average temperature during the growing season ranged from 25.21°C to 25.79°C, with the maximum temperature recorded between 28.09°C and 28.92°C. This temperature is still within the relatively optimal

The research was conducted using a quantitative method with a factorial Completely Randomized Design (CRD) consisting of two treatment factors. The first factor was dolomite dosage with 3 levels (0; 2000; and 4000 kg.ha⁻¹) and NPK fertilizer dosage (250; 375; and 500 kg.ha⁻¹). From these two factors, 9 treatment combinations were produced with 3 replications, resulting in 27 experimental units. Soil pH was measured at the beginning and end of the study. The observation data were analyzed using a 5% significance level analysis of variance (ANOVA), and if there was a significant effect, it was followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level.

range for shallot growth, which is 25°–32°C (Kartinaty et al. 2018). However, sufficiently low minimum temperatures (around 22°C) can slightly inhibit plant metabolic activity, especially bulb formation. Shallots can still form bulbs in environmental conditions with temperatures around 22°C, but the resulting bulbs tend to be less optimal

compared to higher temperatures (Bagaskara et al. 2023).

Average air humidity is considered quite high, ranging from 87.43-90.45%, although rainfall decreased drastically in the last half of the study month due to the transition from the rainy season to the dry season, from a peak rainfall of 215 mm in the middle of the planting period to only 0 mm at the end of planting. This level of humidity exceeds the optimal limit for shallot growth, which should not be more than 70%. Rainfall has a negative correlation with shallot productivity, so the higher the rainfall, the lower the shallot productivity (Sholikin and Haryono, 2019). Meanwhile, the decrease in rainfall in April actually supported the bulb ripening process, which was approaching the optimal threshold for shallot cultivation. Meanwhile, light intensity significantly increased at 7 Weeks After Planting (WAP), from 70.68% to 84.32%. This increase was due to the decrease in rainfall as the transition from the rainy season to the dry season occurred. The persistent high humidity despite decreasing rainfall is likely caused by limited air circulation. High humidity reduces the rate of transpiration and nutrient absorption. This condition will decrease the availability of nutrients for plant growth, thus hindering its development (Punamasari et al. 2023). Although the research was conducted outside the growing season with relatively high rainfall, high humidity and fluctuating light intensity posed challenges and were expected to affect the effectiveness of dolomite and NPK fertilizer treatments on shallot growth and yield.

SOIL pH

The soil used in this study is alluvial soil with a pH of 6.23, which is slightly acidic and already within the optimal range for shallot growth. Soil pH that already meets optimal growth requirements does not require the application of

dolomite as an effort to increase soil pH (Pangli et al. 2022). Nevertheless, the use of dolomite not only increases soil pH but also adds the nutrients Ca and Mg, which play an important role in the process of photosynthesis.

Table 1. Soil pH measurement

Dolomite (kg.ha ⁻¹)	Initial Soil pH	Final Soil Ph
0	6,23	6,19
2000	6,23	6,64
4000	6,23	7,05

The results of the final soil pH measurements (Table 1) show an increase in pH as the dolomite dosage increases. The treatment without dolomite experienced a slight decrease in pH from 6.23 to 6.19. This decrease is caused by the high rainfall during the study. High rainfall can lead to the leaching of base cations such as Ca, Mg, and K. The reduction of these base cations causes acidic H⁺ and Al³⁺ ions to become more dominant, resulting in a decrease in soil pH (Amar et al. 2022). Additionally, the decrease in pH is also related to the use of NPK fertilizer and other supplementary fertilizers such as nitrogen from urea, which can release hydrogen ions (H⁺) into the soil and increase acidity. NPK fertilizers, especially those containing sulphur and ammonium, can lower soil pH because they produce H⁺ ions during the dissolution and nitrification processes (Kaya 2014; Starast et al. 2007). However, this study used pearl NPK fertilizer that does not contain sulphur, so the resulting pH decrease tends to be mild and insignificant.

Dolomite application at 2000 kg/ha increased soil pH to 6.64, and dolomite at 4000 kg/ha resulted in the highest final pH of 7.05. This increase indicates that dolomite is effective in neutralizing soil acidity, as the calcium and magnesium content in dolomite replaces H⁺ ions on the soil colloid complex.

Table 2. Dolomite and NPK fertilizer on the growth and yield of shallot

Dolomite + NPK (kg.ha ⁻¹)	Plant Height	Number of Leaves	Fresh Biomass Weight	Dry Biomass Weight	Fresh Bulb Weight	Dry Stored Bulb Weight	Number of Bulb per Clump	Bulb Diameter
0 + 500	38,40±3,17	17,56±2,36	11,00±3,88	1,30±0,37	24,00±7,59	20,95±6,61	4,67±0,88	2,49±0,31
0 + 375	36,50±2,58	18,11±2,14	15,50±4,71	1,56±0,43	24,09±6,37	20,51±5,19	5,56±1,84	2,50±0,05
0 + 250	37,07±3,30	16,22±1,17	12,17±2,65	1,31±0,10	19,99±2,18	17,42±2,47	4,33±0,67	2,44±0,09
2000 + 500	36,67±4,63	20,11±1,58	12,48±1,17	1,32±0,14	21,99±5,11	19,07±5,02	4,33±0,33	2,35±0,18
2000 + 375	36,34±2,28	20,78±1,58	12,76±1,34	1,50±0,31	24,94±1,47	21,59±1,39	5,22±1,02	2,34±0,21
2000 + 250	37,63±2,06	20,56±1,95	12,55±1,59	1,43±0,24	25,63±3,20	22,30±3,28	5,78±0,77	2,39±0,13
4000 + 500	36,77±3,56	19,06±1,25	13,08±2,05	1,46±0,24	24,86±1,23	21,55±0,99	5,50±0,17	2,54±0,06
4000 + 375	36,37±3,55	15,33±2,19	11,34±2,40	1,23±0,23	18,40±4,85	15,81±3,98	4,44±0,69	2,23±0,13
4000 + 250	36,43±1,67	15,78±3,27	12,35±2,52	1,31±0,17	19,16±0,69	16,40±0,73	4,44±0,84	2,31±0,19
Significance	0,86	0,29	0,39	0,55	0,24	0,27	0,11	0,42
Coefficient of Variation (%)	0,08	0,11	0,22	0,19	0,19	0,20	0,19	0,07

Plant Height

The observation results show that the shallot plants experienced an increase in plant height every week up to 5 WAP (Figure 1). Plant height will always increase with the plant's age during the vegetative phase, whereas it will tend to stagnate or even decrease when entering the generative phase. Shallot plants showed increased height up to 35 days after transplanting (DAT), but growth began to slow or decline at 42 DAT. This condition occurred because up to 35 DAT, the plants were still in the active phase of producing new shoots and tillers. Entering the following week, the results of photosynthesis are more focused on supporting bulb formation (Rachmawatie, 2018).

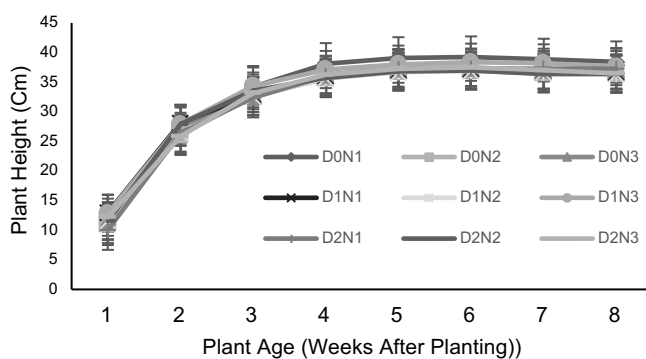


Figure 1. Growth in Plant Height of Shallots

Figure Caption: D0 = without dolomiet, D1 = dolomite 2000 kg.ha⁻¹, D2 = dolomite 4000 kg.ha⁻¹,

N1 = NPK 250 kg.ha⁻¹, N2 = NPK 375 kg.ha⁻¹, N3 = NPK 500 kg.ha⁻¹

The results of the analysis of variance (Table 2) show that there was no interaction between dolomite and NPK treatments on the height of shallot plants. The application of dolomite or NPK fertilizer did not have a significant effect. This is due to environmental factors such as high rainfall and humidity, as well as low light intensity during the vegetative growth period. This condition hinders the process of photosynthesis and plant growth. The growth and production of shallots are highly sensitive to changes in temperature, rainfall, and humidity (Kodrat, 2024).

Air humidity reaching 90.45% decreases the transpiration rate, thus reducing nutrient absorption by plants. As a result, even though the plants were fertilized, nutrient availability and absorption were not optimal, leading to no significant impact on plant height growth (Sofiani et al. 2022). Treatment without dolomite resulted in the most optimal average plant height, while at the highest dolomite dose (4000 kg/ha), plant height was shorter (Table 2). This is believed to be because the initial soil pH (6.23) was already optimal for shallot growth, making the addition of high amounts of dolomite unnecessary. Soil with a pH that is too alkaline can increase alkali levels, which can inhibit growth and

reduce the absorption of essential nutrients needed by shallot plants (Elawati and Fahik, 2022).

Number of Leaves

The number of shallot plant leaves increased every week (Figure 2). As the plant ages, the number of leaves formed increases. During the vegetative phase, shallot plants will continue to produce new leaves as the plant ages (Yeshiwas et al. 2023). The formation of leaves in this shallot plant is influenced by various factors, both environmental and genetic, such as the variety used. However, aging leaves will turn yellow, dry up, and eventually die. This process is a natural part of the plant's life cycle, where old leaves are replaced by new leaves growing from new shoots, resulting in leaf regeneration in the plant.

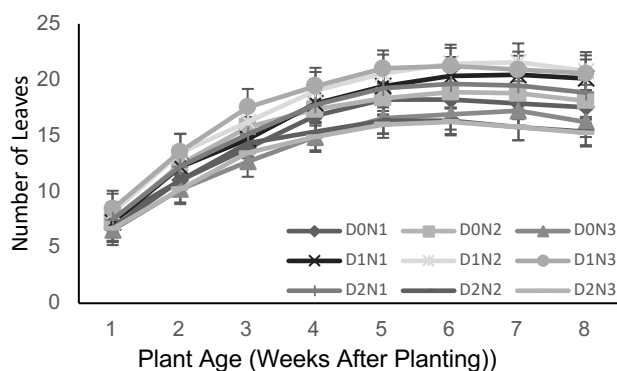


Figure Caption: D0 = without dolomite, D1 = dolomite 2000 kg.ha⁻¹, D2 = dolomite 4000 kg.ha⁻¹, N1 = NPK 250 kg.ha⁻¹, N2 = NPK 375 kg.ha⁻¹, N3 = NPK 500 kg.ha⁻¹

Figure 2. Growth in Number of Leaves of Shallots

The results of the analysis of variance (Table 2) show that NPK fertilizer treatment also did not have a significant effect, but single dolomite treatment had a significant effect. Based on the DMRT post-hoc test, a dolomite dose of 2000 kg/ha resulted in the highest number of leaves (Table 2), which was significantly different from other dolomite treatments. This is because that dosage is able to increase the soil pH to the optimal level needed by plants, thus supporting the absorption of essential nutrients such as N, K, Ca, and Mg, which play a role in chlorophyll and leaf tissue formation. The magnesium contained in dolomite improves

chlorophyll levels and photosynthetic efficiency, as well as increasing the availability of essential nutrients needed for plant metabolic processes (Ilham et al. 2019; Papadakis et al. 2023).

The increase in leaf number is more influenced by the improvement of soil chemical properties through the application of dolomite, particularly in increasing pH and providing essential elements Ca and Mg for chlorophyll formation and cell division. Dolomite contains Ca, which enhances nutrient absorption, and Mg, which plays a role in chlorophyll formation, thereby accelerating the rate of photosynthesis (Tanari et al. 2018).

Fresh Biomass Weight

The results of the analysis of variance (Table 2) show that there was no interaction between dolomite treatment and NPK fertilizer on the fresh weight of the shallot plant biomass. Neither single applications of dolomite nor NPK fertilizer showed any significant effect. This is believed to be due to less-than-optimal environmental conditions during the early growth phase, such as high air humidity, low light intensity, and high rainfall. The fresh weight of the roughage is influenced by the amount of water absorbed by the plants as well as environmental conditions (Behairy et al. 2015).

The application of dolomite does not always increase the fresh weight of the biomass. In fact, at a dosage of 4000 kg/ha, the fresh weight actually decreased compared to without dolomite (Table 2), likely because the initial soil pH was already within the optimal range, so excessive addition of dolomite actually disrupted the nutrient balance. This finding is not consistent with Ilham et al. (2019), who stated that a high dose of dolomite increases the decomposition of organic matter and the activity of microorganisms, thereby enriching nutrient availability.

The variation in NPK fertilizer doses between 250–500 kg/ha also did not show significant differences, indicating that these doses were not yet sufficient to produce different effects on biomass growth. The humid environment and low light in the initial phase also worsen nitrogen absorption, which is an essential element in the formation of vegetative tissues. Nitrogen plays a role in the formation of plant cells, tissues, and organs, and functions in the

synthesis of chlorophyll, proteins, and other important compounds, which directly affects the fresh weight of the plant (Fatirahma and Kastono, 2020).

Dry Biomass Weight

The results of the analysis of variance (Table 2) show that there was no interaction between dolomite and NPK treatments on the dry weight of shallot plant biomass. The application of dolomite or NPK fertilizer did not have a significant effect. The absence of interaction and significant influence from dolomite or NPK fertilizer treatments was due to less-than-ideal environmental conditions during the initial growth phase of the plants, which hindered nutrient absorption. If the applied fertilizer does not meet the plant's nutrient requirements, plant growth will not experience a significant increase (Minangsih et al. 2022).

Unlike fresh weight, which tends to decrease with increasing dolomite dosage, the application of 2000 kg/ha of dolomite actually resulted in the highest dry weight (Table 2). This proves that at a dosage of 2000 kg/ha, dolomite likely helps to optimize soil pH improvement, increase nutrient absorption, and thus make plant tissues denser. The dry matter yield of the biomass indicates the plant's ability to accumulate organic matter during the growing season. If the contribution of nutrients is ignored, the increase in dry weight is expressed as a result of carbon dioxide reduction (Istina, 2016).

Fresh Bulb Weight

Based on the results of the analysis of variance (Table 2), there was no interaction between dolomite and NPK treatments on the fresh weight of shallot bulbs. The absence of interaction and significant effects of both dolomite and NPK fertilizer treatments is due to the fact that plant growth was not optimal from the beginning, resulting in limited photosynthetic products stored in the bulbs. Additionally, unfavorable environmental conditions hinder the process of bulb formation and enlargement. The Mg element contained in dolomite plays an important role in chlorophyll formation, thus optimally supporting the plant's photosynthesis process and influencing the fresh weight of bulbs. However, if the

application and needs are not appropriate, the availability of nutrients in the soil will decrease (Pury et al. 2023).

The formation of shallot bulbs is highly dependent on the results of photosynthesis, which is influenced by light intensity, especially because shallots are long-day plants that require a longer duration of sunlight. Low light intensity reduces the rate of photosynthesis because gas exchange is less than respiration, so increasing the light will accelerate photosynthesis (Handoko and Fajariyanti, 2013). The bulbs will continue to grow and form shoots if the minimum day length is met. However, during the rainy season, low temperatures and lack of sunlight hinder photosynthesis and nutrient absorption, resulting in suboptimal bulb formation (Purba, 2014).

Dry Stored Bulb Weight

Based on the results of the analysis of variance (Table 2), there was no interaction between dolomite and NPK treatments on the dry bulb weight of shallot. Neither the dolomite nor the NPK fertilizer treatments had a significant effect. The absence of interaction and significant effects on both dolomite and NPK fertilizer treatments was due to minimal vegetative growth, which affected the low yield of photosynthesis that could be translocated to the bulb. The increase in fresh and dry bulb weight is influenced by water absorption and the accumulation of photosynthetic products in the leaves, which are then translocated to the bulb (Ramadhan and Sumarni, 2018). The greater the number of leaves and supported by sufficient light intensity, the more starch will accumulate in the bulbs, thus increasing the weight of the bulbs (Lathifah et al. 2017).

The lack of a significant effect from dolomite treatment or NPK fertilizer is believed to be due to unfavourable environmental conditions, such as high humidity and low light, which hinder bulb drying and nutrient absorption. Bulb weight is highly influenced by the availability of macro and micronutrients, where a deficiency will lead to a decrease in yield (Sugirno et al. 2021). Additionally, the dry weight of the bulbs is closely related to the number of

leaves and bulbs per plant, as the more leaves there are, the greater the number of photosynthetic products that will be translocated to the bulbs. It is the accumulation of photosynthates in these bulbs that contributes to the increase in dry weight. The dry weight of bulbs is determined by the amount of photosynthates produced during the bulb formation phase (Lakitan, 2000).

Number of Bulb per Clump

The results of the analysis of variance (Table 2) show that there was no interaction between dolomite and NPK treatments on the number of bulbs per plant. Neither dolomite nor NPK fertilizer treatments had a significant effect. The absence of interaction and significant effects on both dolomite and NPK fertilizer treatments is due to less than optimal vegetative growth of the plants. Bulb yield is influenced by the vegetative processes in shallot plants. This is because the products of plant photosynthesis during the vegetative phase are used for bulb development during the generative phase (Kartini, 2021).

The number of bulbs is closely related to the number of leaves on the shallot plant. The number of tillers, the number of leaves, and the type of shallot variety affect the number of bulbs produced (Husain et al. 2024). The bulb serves as a storage place for the products of photosynthesis that takes place in the leaves, so an increase in the number of leaves tends to be followed by an increase in the number of bulbs. The bulb structure itself is formed from modified and tightly packed leaves or leaf sheaths, so the number of leaves is a major determinant of the number of bulbs formed on shallot plants.

Large bulbs tend to form in large numbers but are small in size due to nutrient competition, while large bulbs in small numbers tend to develop more optimally (Nurhidayah et al. 2016). Environmental conditions such as high humidity and low light intensity during the study were the main limiting factors that hindered the absorption of essential nutrients like N, P, and K, which is why dolomite and NPK fertilizer treatments did not show a significant effect. Phosphorus stimulates root growth and bulb formation, while potassium plays a

role in starch formation and the distribution of photosynthetic products. The products of photosynthesis, such as fructans, will be translocated to the bulbs as reserves, and this process is highly dependent on the efficiency of nutrient absorption, which is influenced by environmental conditions (Supariadi, 2017).

Bulb Diameter

The results of the analysis of variance (Table 2) show that there was no interaction between dolomite and NPK treatments on the bulb diameter of shallot plants. Neither dolomite nor NPK fertilizer treatments had a significant effect. The absence of interaction and significant effects on both dolomite and NPK fertilizer treatments was due to unfavourable plant growth conditions from the beginning. The environment during the early growth phase, characterized by high humidity and low light intensity, also slows down bulb formation. Shallot plants grown in low light intensity environments tend to produce longer, thinner leaves, while the bulb size becomes smaller. This condition occurs due to the low rate of photosynthesis and limited production of photosynthates needed for bulb formation (Sari et al. 2023).

The non-significant effects of single applications of dolomite and NPK fertilizer are caused by environmental conditions that inhibit nutrient absorption, so even though dolomite is applied, the plants still experience a deficiency of essential nutrients like phosphorus, which plays a role in bulb cell formation and division (Pamungkas et al. 2020). Nitrogen is needed from the early stages to maturity because it plays a role in the formation of nucleic acids, chlorophyll, and proteins that support leaf growth and bulb enlargement (Supariadi, 2017). Bulb diameter is inversely related to the number of bulbs; the more bulbs on a single plant, the smaller the bulbs tend to be due to competition for nutrient absorption and photosynthetic products. Conversely, fewer bulbs allow for more focused distribution of nutrients and photosynthates, resulting in larger bulbs (Kurniasari and Arditya, 2024).

CONCLUSIONS AND SUGGESTION

Conclusions

1. The best combination of dolomite and NPK fertilizer treatments was not found.
2. Applying 250 kg/ha of NPK fertilizer yielded the same results as higher doses.
3. A dolomite dose of 2000 kg/ha resulted in higher average leaf count, but did not improve shallot crop yield.

Suggestion

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