International Journal of Life Science and Agriculture Research

ISSN (Print): 2833-2091, ISSN (Online): 2833-2105

Volume 03 Issue 08 August 2024

DOI: https://doi.org/10.55677/ijlsar/V03I8Y2024-06

Impact Factor: 6.774 , Page No : 678-681

Effect of NPK and ZK Fertilizers on N-total, N Uptake, and Yield of Shallots (*Allium cepa* var. *aggregatum*) on Inceptisol

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ABSTRACT: Shallots are one of the most important horticultural commodities in Indonesia, with high market demand. This study aims to assess the impact of the use of NPK and ZK (potassium sulfate) fertilizers on total nitrogen content in the soil, nitrogen uptake, and yield of shallots on Inceptisol soil type. The experiment was conducted at the Soil Chemistry and Plant Nutrition Experimental Field, Faculty of Agriculture, Universitas Padjadjaran, from September to December 2023. The research design used in the experiment was a Randomized Group Design (RAK) with 6 treatments consisting of 1 control treatment, 1 NPK (16-16-16) treatment, and 4 treatments of a combination of NPK + ZK fertilizer doses. The results showed that the NPK + ZK fertilizer treatment influenced the N-total, N uptake, and yield of shallot bulbs. The application of ¾ NPK + ½ ZK fertilizer gives the best results of N-total, N uptake, and yield of shallot bulbs.

Published Online: August 13, 2024

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KEYWORDS: Crop Productivity, Fertilizer Efficiency, Nutrient Content.

INTRODUCTION

Shallots (*Allium cepa* var. *aggregatum*), is one of the important horticultural commodities in Indonesia that has high economic value. Stable and increasing market demand makes shallot cultivation one of the main focuses in the agricultural sector. To achieve optimal yields, effective fertilization is essential. Fertilizing with the right ingredients can improve soil fertility and the efficiency of nutrient utilization by plants (Havlin et al., 2014). In Indonesia, Inceptisol soils are often used for shallot farming, but these soils generally have relatively low fertility and require special treatment to increase their productivity (Fageria, 2016).

NPK fertilizer is one type of fertilizer commonly used in crop cultivation because it contains three main nutrients, namely nitrogen (N), phosphorus (P), and potassium (K). Nitrogen plays a role in vegetative growth and biomass formation, phosphorus supports root development and flowering, while potassium is important for disease resistance and water regulation (Kumar et al., 2020). The application of NPK fertilizers in Inceptisol soils can have a significant impact on increasing total N content and nitrogen uptake in shallot plants, which in turn can affect crop yields (Basir et al., 2020).

In addition to NPK fertilizer, ZK (potassium sulfate) fertilizer is also an important ingredient in onion cultivation. Potassium sulfate contains potassium in a form that can be easily absorbed by plants and sulfur, which plays an important role in protein synthesis and bulb formation (Fan et al., 2019). Potassium functions in regulating water balance in plants and increasing resistance to environmental stress, which can have an impact on increasing the quality and quantity of shallot yield (Richardson et al., 2015).

This study aims to assess the effect of NPK and ZK fertilizer treatments on N-total, nitrogen uptake, and shallot yield on Inceptisol soil. By understanding how each fertilizer and the combination of the two affect these parameters, it is hoped that useful information can be obtained for more efficient and sustainable shallot cultivation practices. This research was conducted with the hope of contributing to the improvement of shallot productivity as well as providing better guidance for farmers in the use of fertilizers on Inceptisol soils.

MATERIALS AND METHODS

The experiment was conducted at the Soil Chemistry and Plant Nutrition Experimental Field, Faculty of Agriculture, Universitas Padjadjaran, Sumedang Regency at an altitude of ± 752 m above sea level (above sea level) from November 2020 to January 2021. N-total analysis and N uptake were conducted at the Laboratory of Soil Chemistry and Plant Nutrition, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor. The materials used in this experiment are: Inceptisol planting media, Batu Ijo shallot bulbs, NPK fertilizer at a dose of 300 kg ha^{-1} and ZK fertilizer at a dose of 300 kg ha^{-1} .

The design used in this study was a Randomized Group Design (RAK), consisting of 6 treatments. Each treatment was repeated 4 times with 2 experimental units, where 1 unit was used until the maximum vegetative phase and the other 1 unit was used until harvest, so there were a total of 48 experimental treatments. Observations were made on various growth components such as plant height which was observed starting 14 HST and every week until the plants reached the maximum vegetative phase at 46 HST. Plant height measurements were taken from the soil surface to the tip of the highest leaf. In addition, observations were also made of symptoms of pests and plant diseases from planting to harvesting, because pest or disease attacks can affect yield and other test parameters. The symptoms were observed directly on the shallot plants.

Sampling was done when the plants reached the maximum vegetative phase. Soil samples were taken weighing 200 g around plant roots (rhizosphere) at a depth of 0-20 cm. Leaf samples were taken for nutrient analysis in plant tissues, by taking all parts of shallot leaves from the soil surface to the tip of the bulb. Soil and leaf samples were then analyzed at the Soil Chemistry and Plant Nutrition Laboratory, Faculty of Agriculture, Universitas Padjadjaran. Bulb yield was measured from the second unit by weighing all bulbs per treatment. Onion harvesting was done at 64 HST, when the plants were old with soft stem necks, fallen leaves, and most of the leaves turned yellow. Harvesting is done carefully so that the bulbs are not damaged and is done in the morning, followed by cleaning the bulbs from the soil.

RESULTS AND DISCUSSION

N-total

Soil N-total (Total Nitrogen) refers to the total nitrogen content contained in the soil, which includes nitrogen in organic and inorganic forms. Based on the results of statistical test analysis, the effect of treatment on N-total can be seen in Table 1.

Table 1. Effect of NPK and ZK Fertilizer Treatments on Soil N-total Content

	Treatment	-total (%)
A)	¾ NPK + ½ ZK fertilizer	0,13 a
B)	¾ NPK + 1 ZK fertilizer	0,21 b
C)	¾ NPK + 1 ½ ZK fertilizer	0,19 b
D)	1 NPK + 1 ZK fertilizer	0.27 bc
E)	¾ NPK + ½ ZK fertilizer	0, 37 d
F)	¾ NPK + 1 ZK fertilizer	0,32 c

Description: Treatment mean values marked with the same letter in the same column indicate not significantly different based on Duncan's Multiple Range Test at the 5% real level.

Based on the results of the analysis presented in Table 1, it shows that there is a significant difference in the N-total content of the soil due to fertilization. This shows that the dose of NPK can increase soil nitrogen content. Treatment E (¾ NPK + ½ ZK fertilizer) showed the highest soil N-total content when compared to other treatments with N-total value reaching 0.37%.

NPK fertilizers contain nitrogen in the form of compounds such as ammonium (NH_4^+) or nitrate (NO_3-). When applied, nitrogen from NPK fertilizers directly increases the N-total content of the soil. This nitrogen is available to plants and soil microorganisms, which helps increase soil N-total concentration (Havlin et al., 2014; Fageria, 2016). Potassium (K) in ZK fertilizer plays an important role in increasing the efficiency of nitrogen use by plants. Potassium supports various plant functions, including photosynthesis and osmotic regulation, which improves plant health and its capacity to absorb nitrogen more effectively. This can lead to increased soil N-total content as plants can use nitrogen more efficiently and reduce nitrogen losses through volatility or leaching (Ghorbani et al., 2018). The combination of NPK and ZK fertilizers provides synergistic benefits in increasing soil N- total content. NPK fertilizer provides direct nitrogen, while ZK fertilizer improves nitrogen use efficiency and reduces nitrogen losses. This synergy helps increase soil N-total in a more sustainable and productive way (Fageria, 2016; Kumar et al., 2020).

N uptake

Nitrogen is an essential nutrient for shallots as it plays a role in the synthesis of protein, chlorophyll and nucleic acids, which support vegetative growth and yield. Onion nitrogen uptake is the amount of nitrogen absorbed and used by shallot plants from the soil for growth and development. Based on the results of statistical test analysis of plant N uptake in Table 2, it shows that the application of NPK and ZK fertilizers has a significant effect on shallot N uptake.

Table 2. Effect of NPK and ZK Fertilizer Treatments on N Uptake of Shallot Plants

	Treatment	N uptake (mg/plant)
A)	¾ NPK + ½ ZK fertilizer	27,31 a
B)	¾ NPK + 1 ZK fertilizer	40,14 b
C)	¾ NPK + 1 ½ ZK fertilizer	48.38 bc
D)	1 NPK + 1 ZK fertilizer	57,72 d
E)	¾ NPK + ½ ZK fertilizer	72,92 e
F)	¾ NPK + 1 ZK fertilizer	67,14 c

Description: Treatment mean values marked with the same letter in the same column indicate not significantly different based on Duncan's Multiple Range Test at the 5% real level.

The results of N uptake analysis based on Table 2 show that treatment E (¾ NPK + ½ ZK fertilizer) is the treatment that has the highest N uptake of 72.92 mg/plant. Fertilization is a crucial aspect in agriculture that affects plant health and yield. In shallot (Allium cepa), nitrogen (N) is one of the main nutrients that support vegetative growth, bulb formation, and yield quality. Therefore, fertilization with NPK (Nitrogen, Phosphorus, Potassium) and ZK (Potassium Sulfate) can significantly affect nitrogen uptake by plants.

Nitrogen in NPK plays a role in the synthesis of proteins, nucleic acids and chlorophyll, all of which are crucial for photosynthesis and plant growth. Application of NPK fertilizer increases the availability of nitrogen in the soil, thereby increasing nitrogen uptake by plants. Research shows that the application of NPK fertilizer can significantly increase the nitrogen content in onion leaves and bulbs, which has a positive impact on growth and yield (Kumar et al., 2020; Basir et al., 2020). ZK, which contains potassium sulfate, also plays an important role in increasing nitrogen uptake by plants. Potassium functions in the process of nitrogen metabolism, assisting in the transportation of nitrogen from the roots to other plant parts. Potassium also plays a role in stomatal regulation, which affects photosynthetic efficiency and nitrogen assimilation. Research shows that potassium can increase the efficiency of nitrogen utilization by plants, improve plant structure, and increase crop yields (Fan et al., 2019). In the presence of ZK, shallot plants can utilize nitrogen more efficiently, which in turn increases total nitrogen uptake.

A combination of NPK and ZK fertilizers often has a greater impact than using either fertilizer alone. NPK fertilizers provide essential nitrogen, while ZK helps improve nitrogen use efficiency and crop quality. This combination increases nitrogen availability in the soil and improves nitrogen metabolic processes in the plant, which results in increased nitrogen uptake. Research by Zhang et al. (2016) showed that a combination of inorganic and organic fertilizers, including ZK, can significantly increase nitrogen content in plants.

Shallot Yield

NPK and ZK fertilizers play an important role in onion growth, affecting various aspects of crop productivity, including bulb number, dry weight and wet weight. Both affect the plant through different but complementary mechanisms. The results of statistical analysis of the three parameters show that the application of NPK and ZK fertilizers has a significant effect on the yield of shallot bulbs as shown in Table 3.

Table 3. Effect of NPK and ZK Fertilizer Treatments on the Number of Bulbs, Wet Weight,
Dry Weight of Shallot Plants

	Treatment	mber of Bulbs	Weight (g)	Weight (g)
A)	¾ NPK + ½ ZK fertilizer	3,5 a	14,5 a	9,8 a
B)	¾ NPK + 1 ZK fertilizer	5,5 b	20,2 b	12.6 ab
C)	¾ NPK + 1 ½ ZK fertilizer	6,0 c	24,1 c	16,3 b
D)	1 NPK + 1 ZK fertilizer	6.3 cd	25,3 c	17,5 b
E)	¾ NPK + ½ ZK fertilizer	7,3 e	30,4 d	22,6 d
F)	¾ NPK + 1 ZK fertilizer	6,5 d	28.3 cd	19,4 c

Description: Numbers followed by the same letter in the same column are not significantly different according to Duncan's multiple range test at the 5% level.

Based on the analysis results in Table 3. shows that the application of NPK + ZK fertilizer has a significant effect on the wet weight of bulbs and dry weight of shallot bulbs. Fertilizer treatment E (¾ NPK + ½ ZK fertilizer) has the highest yield with the number of bulbs of 7.3; average bulb wet weight of 30.4 g; and bulb dry weight of 22.6 g, but not significantly different from treatment F (¾ NPK + 1 ZK fertilizer) on the wet weight parameter. Treatment E (¾ NPK + ½ ZK fertilizer) is the best treatment for the parameters of the number of tubers, wet weight and dry weight of tubers because the fertilizer on ZK is less when compared

to ZK fertilizer in treatment F.

NPK fertilizers contain nitrogen, phosphorus and potassium which are essential for plant growth. Nitrogen plays a role in leaf formation and a strong root system, which supports the formation of more tubers. Phosphorus is important for root development and tuber formation, while potassium promotes plant health and disease resistance (Havlin et al., 2014). Research shows that proper NPK application can significantly increase the number of shallot bulbs as it supports root growth and bulb health (Kumar et al., 2020). ZK fertilizer functions to increase the efficiency of nutrient utilization and metabolic processes in plants. Potassium plays a role in the regulation of stomatal opening and nutrient transport, which supports the uptake of nutrients from the soil and their distribution to the bulbs (Fan et al., 2019). Potassium can also increase plant resistance to environmental stress and disease, which supports optimal tuber formation. The application of ZK often increases the number of onion bulbs through improved plant health and nutrient utilization efficiency.

CONCLUSIONS AND IMPLICATIONS

1. There is an effect of NPK and ZK fertilizers on N-total, N uptake, wet weight and dry weight of shallot bulbs.
2. Treatment E (¾ NPK + ½ ZK fertilizer) is the treatment that gives the best results and is more economical in increasing N-total, N uptake, wet weight and dry weight of shallot bulbs.

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