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Analysis of Chloride Level in Rice Field Water after Fertilization in Ketapang Village by Argentometric Titration Method

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ABSTRACT

Introduction: *Agriculture plays an important role in Indonesia's international development, providing rice, corn and wheat to meet the needs of the community. Agricultural development can increase food availability and food security, as well as improve the economy and welfare of the community. One of the villages in Banyuwangi, namely Ketapang Village, is an area where most of the population works in the agricultural sector. KCl fertilizer is one type of fertilizer that is often used in rice fields to increase rice yield.*
Objective: *This study aims to analyze chloride levels in rice field water after fertilization using KCl fertilizer, with the aim of determining the effectiveness of fertilizers that can be absorbed by plants.*
Methods: *This research was conducted at the Chemistry Laboratory of STIKES Banyuwangi in March 2024. Mohr's Argentometric titration method was used for chloride analysis. Rice field water samples were collected from Ketapang Village.*
Results: *The analysis showed significant variation in the percentage of chloride absorbed by plants at eight different paddy field sites after fertilization with KCl. The percentage of chloride absorbed ranged from 49.37% to 97.31%.*
Conclusions: *The analysis showed significant variation in the percentage of chloride absorbed by plants after fertilization with KCl. Sites with a high percentage of chloride content can be considered a good indicator of fertilizer effectiveness, indicating that plants are able to absorb nutrients optimally. This has important implications in evaluating the quality of fertilization applied by farmers and can contribute to increased productivity and health of rice plants.*

Introduction

Agriculture plays an important role in Indonesia's international development. Agriculture provides staple foods such as rice, corn and wheat to meet the food needs of the community (X. Li et al., 2023). The development of agriculture can increase food availability and food security, as well as increase the economy and improve the welfare of the community (Bozsik et al., 2022; Pawlak & Kołodziejczak, 2020). Ketapang is one of the villages in Banyuwangi, East Java province, where most of the people work in the agricultural sector.

Agriculture is a human activity that includes farming, animal husbandry, fisheries and forestry (Liu et al., 2024). Every farm requires fertilizer which acts as a source of nutrients for plants. Fertilizers used are usually organic fertilizers, inorganic fertilizers and biological fertilizers (Aryal et al., 2021). Organic fertilizers such as manure, and compost (J. Li et al., 2021; Tian et al., 2022). Inorganic fertilizers such as urea, NPK, and KCl fertilizers (Swify et al., 2023). While biological fertilizers such as rhizobium, mycorrhiza and others that contain microorganisms that are useful to help plants absorb nutrients and increase plant resistance to disease (Mącik et al., 2020; Mushtaq et al., 2021; Qomariyah, Ayu, et al., 2022).

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Nitrogen (N) fertilizer has several types, namely Urea, ZA, NPK Phonska (Zhang et al., 2023). Urea fertilizer is the most widely used in Indonesia (Hartono et al., 2021). Urea fertilizer is in the form of white granules and is easily soluble in water (Klimczyk et al., 2021; Swify et al., 2023). NPK fertilizer is a compound fertilizer consisting of three main macronutrients namely nitrogen (N), phosphorus (F), and potassium (K) which are used to increase the resistance of rice plants to pests and diseases (Olagunju et al., 2024; Sinha & Tandon, 2020). Potassium Chloride (KCl) is a fertilizer containing the nutrients potassium (K) and chlorine (Cl) that is widely used in rice fields to increase rice yields (Soumare et al., 2023; Ye et al., 2022).

Water soluble fertilizers are widely used in rice fields because they are easily absorbed by rice plants and are not easily washed away by rainwater so that they are more efficient than water insoluble fertilizers (Allouzi et al., 2022; Zhao et al., 2024). However, this kind of fertilizer is more costly and there is a tendency for the nutrients to be absorbed by the rice paddy, which may lead to fertilizer depletion and environmental contaminants that may endanger aquatic organisms contaminated by water-soluble fertilizers. This research therefore performed an analysis of chloride levels in paddy field water after fertilization to investigate the effectiveness of fertilizers that may be absorbed by plants.

Methods

This research was conducted at the Chemistry Laboratory of STIKES Banyuwangi in March 2024.

(1) Tools and Materials

This study uses the Mohr method Argentometric titration method. The tools used in this study are stative 2 pieces, burette (Iwaki) size 50 mL as much as 4 pieces, Erlenmeyer (Pyrex) size 100 mL as much as 6 pieces, measuring cup (Iwaki) size 50 mL as much as 2 pieces, measuring cup (Pyrex) size 25 mL as much as 2 pieces, drop pipette 4 pieces, universal indicator pH paper, beaker (Pyrex) size 100 mL as much as 4 pieces, spoon 1 piece, watch glass 2 pieces, and flask (Iwaki) size 100 mL as much as 2 pieces.

The materials used in this study are rice field water samples in Ketapang Village, in the morning and afternoon. Samples were taken at 4 different points (rice field plots) as much as 600 mL at each collection point with a total of 2,400 mL taken in the morning, distilled water, 5% potassium chromate (K_2CrO_4) indicator, 0.014 N sodium chloride (NaCl) solution and 0.014 N silver nitrate ($AgNO_3$) solution.

(2) Work Procedure

A. Standardization of Silver Nitrate Solution ($AgNO_3$)

In this study, a 0.014 N NaCl solution of 25 mL was put into a 100 mL Erlenmeyer glass, after which 5 drops of 5% K_2CrO_4 indicator solution were added and stirred, then titrated with 0.014 N solution that had been given an indicator and $AgNO_3$ solution until a white precipitate change occurred, and the volume of $AgNO_3$ solution was recorded and then the normality of the $AgNO_3$ standard solution was calculated with the formula:

$$\text{N AgNO}_3 = \frac{\text{V NaCI} \times \text{N NaCI}}{\text{V AgNO}_3}$$

Where:

V $AgNO_3$ is the amount of volume of $AgNO_3$ suspension (mL)

N $AgNO_3$ is the normality of silver (II) nitrate suspension

V NaCl is the volume of sodium chloride suspension (mL)

N NaCl is the normality of sodium chloride suspension

B. Blank titration

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The aquadest 25 mL is placed into a glass Erlenmeyer 100 mL after which added 5 drops of 5% K_2CrO_4 indicator solution. Aquadest which has been treated with an indicator is finally titrated with Silver (II) Nitrate standard solution. until the end point of the titration until it changes brick red color, then the volume of $AgNO_3$ is recorded.

C. Chloride Content Analysis

A total of 25 ml of sample was put into Erlenmeyer glass and added 5 drops of 5% K_2CrO_4 indicator solution. The sample that has been given an indicator is then titrated with $AgNO_3$ standard solution until the end point of the titration which is marked by the formation of a brick red precipitate color. After that, the volume of $AgNO_3$ used was recorded and the chloride content was calculated using the following formula:

$$\frac{(A - B) \times N \times 35{,}45}{V} \times 1000$$

Where:
A is the volume of Silver (II) Nitrate standard solution for sample titration (mL)
B is the volume of Silver (II) Nitrate standard solution for blank titration (mL)
N is the normality of Silver (II) Nitrate standard solution
V is the sample volume (mL)

Results

Table 1 Standardization of $AgNO_3$ Solution

No.	Titration to-	$AgNO_3$ Volume
1.	1	6.3 mL
2.	2	6.9 mL
3.	3	6.6 mL
	Average	6.6 mL

Table 2 Blank Titration

No.	Titration to-	$AgNO_3$ Volume
1.	1	2.5 mL
2.	2	2.3 mL
3.	3	2.8 mL
	Average	2.5 mL

Table 3. Sample Titration, Chloride Content Analysis Results, and Percentage of Cl^- absorbed by plants

Sample Location Point	Titration To-	$AgNO_3$ Volume	Chloride Content	Cl^- Absorbed	Percentage of Cl^- Absorbed
A (downstream)	1	3.4 mL	83.32 mg/L	81.25 mg/L	49.37%
	2	4.2 mL			
	3	3.3 mL			
	Average	3.63 mL			
B (downstream)	1	3.0 mL	51.62 mg/L	112.95 mg/L	68.63%
	2	4.0 mL			
	3	2.6 mL			
	Average	3.2 mL			
C (downstream)	1	2.5 mL	33.92 mg/L	130.65 mg/L	79.39%
	2	3.8 mL			

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	3	2.6 mL			
	Average	2.96 mL			
D (upstream)	1	3.0 mL	16.96 mg/L	147.61 mg/L	89.69%
	2	2.8 mL			
	3	2.4 mL			
	Average	2.73 mL			
E (downstream)	1	2.3 mL	33.92 mg/L	130.65 mg/L	79.39%
	2	2.3 mL			
	3	4.3 mL			
	Average	2.96 mL			
F (upstream)	1	2.8 mL	14.75 mg/L	149,82 mg/L	91.04%
	2	2.8 mL			
	3	2.5 mL			
	Average	2.7 mL			
G (upstream)	1	2.8 mL	4.42 mg/L	160.15 mg/L	97.31%
	2	2.5 mL			
	3	2.4 mL			
	Average	2.56 mL			
H (upstream)	1	2.7 mL	7.37 mg/L	157.20 mg/L	95,52%
	2	2.8 mL			
	3	2.3 mL			
	Average	2.6 mL			

Note: The initial concentration of chloride ions in fertilizer is 164.57 ppm

Discussion

In this study, rice field water samples were used which were obtained in the agricultural area of Kalipuro District, Banyuwangi Regency, namely Ketapang Village. The physical characteristics of these two rice field water samples were found to be slightly cloudy and slightly smelly, and around the water collection site there were many rice field snails, while the initial pH was 7.0 so it did not require the addition of acids or bases for further analysis.

Chloride analysis in this study used the Mohr method Argentometric titration. In this method, potassium chromate indicator (K_2CrO_4) and silver nitrate standard solution ($AgNO_3$) were used. The beginning of the research carried out was to standardize the silver nitrate solution with NaCl (Sodium Chloride) with the aim of knowing the actual normality of $AgNO_3$ (Table 1). The normality of $AgNO_3$ obtained from the titration and calculation results is 0.014 N.

The sample solution in argentometric titration with the Mohr method must be in a neutral state. This is because AgOH (silver hydroxide) precipitate will form in an alkaline atmosphere due to hydroxide ions reacting with $AgNO_3$, while in an acidic atmosphere $Ag_2Cr_2O_4$ (silver dichromate) precipitate will form (Qomariyah, Susanto, et al., 2022; Qomariyah, Yusuf, et al., 2022; Rahbar et al., 2019).

Furthermore, a blank titration (Table 2) is carried out using distilled water as a titrated substance with the K_2CrO_4 indicator and as a titrating substance, $AgNO_3$. This blank titration stage is carried out with the aim of obtaining a volume ratio of silver nitrate to precipitate Ag_2CrO_4 which is the equivalence point or end point of the titration.

The principal of Mohr's approach is recognized by the presence of Silver (I) Chloride, which creates a white sediment. However, at the end point of the titration in this experiment a cloudy brick red precipitate was obtained. In the rice field water sample, the AgCl precipitation reaction before the end point of the titration is difficult to observe. This is because there are other chloride ions in the rice field water, which causes the silver Ag^+ ions to precipitate out the Cl^- ions.

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Therefore, at the end point of the titration, Ag^+ ions react with chromate ions CrO_4^- forming a brick red precipitate Ag_2CrO_4.

The following chemical reactions occur:

Before the end point of the titration:

$AgNO_{3(aq)} + Cl^-(aq) \rightarrow AgCl_{(s)} + NO3^-(aq)$

After the end point of the titration:

$K_2CrO_{4(aq)} + 2AgCl_{(S)} \rightarrow Ag_2CrO_{4(S)} + 2KCl_{(aq)}$

Based on the calculation results in Table 3 above, the chloride contents after fertilization using KCl fertilizer in the 8 location points of rice field water samples are different. In this study, we analyzed the percentage of chloride absorbed by rice plants in eight different rice field locations after fertilization with KCl. The analysis was conducted using the Argentometric Titration method. The results obtained showed significant variations in the percentage of chloride absorbed by the plants at each location. The percentage of chloride absorbed ranged from 49.37% to 97.31%. The location point with the highest percentage occurred at 97.31% (G point location) where the ground is higher (upstream), while the location point with the lowest percentage was 49.37% (A point location) where the ground is lower (downstream).

The percentage level of chloride absorbed by rice plants is an important indicator to evaluate the effectiveness of fertilization with KCl (Light et al., 2022). Chloride uptake by plants is directly related to the availability of nutrients in the soil and the ability of plants to absorb them.

These results show that the percentage of chloride absorbed by plants tends to increase (Geilfus, 2019; Wang et al., 2023) along with the concentration of KCl used in fertilization. Sites with higher chloride percentages generally showed more effective fertilization in providing chloride nutrients to plants.

The results of this study have important implications in evaluating the quality of fertilization applied by farmers. Sites with a high percentage of chloride content (upstream) can be considered a good indicator of fertilizer effectiveness, indicating that plants are able to absorb nutrients optimally.

In the long run, effective fertilization will contribute to increased rice productivity. High percentage chloride levels can also be attributed to optimal plant health and growth, which in turn can positively affect crop yields.

Conclusion

The analysis showed significant variation in the percentage of chloride absorbed by rice plants at eight different paddy field sites after fertilization with KCl. The percentage of chloride absorbed ranged from 49.37% to 97.31%. The results of this study have important implications in evaluating the quality of fertilization done by farmers. Sites with a high percentage of chloride content (upstream) can be considered a good indicator of fertilizer effectiveness, indicating that plants are able to absorb nutrients optimally.

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