Response of corn plants (*Zea mays* L.) to application of zeolite coated urea as nitrogen slow release fertilizer

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Abstract. This research aims to determine the growth response of corn plants (*Zea mays*) given zeolite coated urea fertilizer as a nitrogen slow-release fertilizer. This research uses Randomized Group Design (RGD) with 3 repeats. The observation parameters are: Corn plant growth including corn cob weight (grams), corn cob length (cm) and corn kernel weight (grams) which are measured after harvest. The research results showed that there was interaction between zeolite coated urea fertilizer and the corn plant growth results with different results than other treatments namely negative control (only Mono Potassium Phosphate fertilizer) and tending to be better than positive control (urea fertilizer and Mono Potassium Phosphate).

1. Introduction

Corn (*Zea mays*) is an important food crop because corn is the second-largest source of carbohydrate consumed after rice and greatly liked by the Indonesian community. Besides that, corn is one of the important food crops in the world [6]. The demand for corn keeps increasing, which puts pressure on producers to make improvements in their cultivation systems to increase their production yields. One approach used by Indonesian farmers to increase their productivity is by maintaining soil fertility as an aspect of cultivation which is inextricably linked to the increase of corn plant productivity.

Fertilizers can increase corn harvest yields both qualitatively and quantitatively. This is due to the capacity of fertilizer to increase the availability of nutrients, improve plant health and reduce the development of the disease. Fertilizers usually used with plants are organic fertilizers (for example, manure fertilizers) and inorganic fertilizers (for example urea fertilizer and NPK fertilizer) [3:10]. Urea fertilizer contains a high amount of nitrogen and is also required by plants to support their metabolic processes, but urea fertilizer is easily lost by volatilization, evaporation, and leaching so that special treatment is needed to prevent leaching [11:13].

The level of nitrogen loss from the soil will be faster if the soil has low absorption capacity or low cation exchange capacity (CEC). A number of methods are used by farmers so that corn plants are not lacking in nitrogen, among which are increasing the dosage of urea above the recommended dosage. But the use of excessive urea fertilizer can impact the cost of fertilizing corn plants causing financial losses to farmers because it is not adequately compensated by the increase in corn plant
production [12]. To achieve that, a method is required to increase the soil absorption capacity or CEC by adding organic materials which have a very high CEC such as zeolite which acts as an ion exchanger, with the expectation that the nutrients provided through fertilization can be by bound by the zeolite so that they will not be easily leached into the soil before being utilized by the plants, thus increasing the efficiency of the fertilization [10].

Mixing zeolite into the soil reduces the rate of nitrification due to ammonium (NH$_4^+$) being adsorbed in the zeolite mineral lattice [9]. Zeolite has a high cation exchange capacity so that it is often used as a caution exchanger in various applications [5]. Because of the characteristics possessed by zeolite, it is used as a substance mixed with urea fertilizer. A mixture of urea fertilizer with zeolite is expected to be capable of increasing the efficiency of fertilization and increasing corn plant growth.

2. Methodology
Corn variety HJ 21 Agritan was planted using pots at the Cereal Plant Research Centre (Balitsereal) in Maros which were arranged based on one variable Randomized Group Design (RGD) with 3 repeats. The research which was conducted from August to December 2017 used type of fertilizer as the research variable. The types of fertilizer consisted of Mono Potassium Phosphate fertilizer coated with zeolite with 3 concentrations of zeolite namely UPK Zeolite 10%, UPK Zeolite 30%, and UPK Zeolite 50%. The application of fertilizer was done twice, namely one week after planting (WAP) and five WAP with compositions of UPK Zeolite 10% in the amount of 4.18 grams, UPK Zeolite 30% in the amount of 4.98 grams and UPK Zeolite 50% in the amount of 5.70 grams. Mono Potassium Phosphate has used a negative control with a composition of 1.9 grams, and urea fertilizer and Mono Potassium Phosphate were used as a positive control in the amount of 5.7 grams.

The corn plant growth response can be seen by using the research parameters namely corn cob weight (grams) which is the dry weight of the corn cob which has been husked weighed with a digital scale. Corn cob length (cm) is the length of a corn cob which has been husked measured from the base of the cob to the tip using a ruler. Corn kernel weight (grams) is the kernels that have been removed from the cob and weighed with a digital scale. The research results data were analysed using the analysis of variances method (F test)/ANOVA with a confidence level $\alpha = 0.05\%$. Treatments that showed a significant effect were further analysed with the Duncan test.

3. Results and Discussion
3.1. Cob Weight (grams)
With respect to the growth of corn plants (Zea mays) with the application of zeolite coated urea, the research results showed a response with respect to cob weight. From the further analysis of cob weight, the results showed a difference from other treatments. This showed that the application of zeolite coated urea gave the highest results whereas those receiving no treatment had the lowest results. It can be surmised that the formation of the cob during the generative phase requires nutrients so that the application of zeolite urea fertilizer with a concentration of 10% had better results compared to not giving treatment (Control). Nitrogen (N) is a nutrient that is very important for plant growth. The total nitrogen content of urea is about 45-46%. High of the nitrogen content is greatly needed for the initial growth of corn plants. The effect of the use of nitrogen on the quality and quantity of yields is in improving the process of fully filling the kernels so they can become firm and prevent the reduction in size of kernels at the tip of the cob, which has a positive correlation with cob weight in corn plants.
Table 1. Average cob weight (grams)

| Treatment                                           | Average Cob Weight (grams) |
|-----------------------------------------------------|----------------------------|
| Control                                             | 55.83<sup>a</sup>          |
| Urea, Phosphate, Potassium (UPK)                    | 119.88<sup>b</sup>         |
| UPK Zeolite 10%                                     | 120.92<sup>b</sup>         |
| UPK Zeolite 30%                                     | 115.91<sup>b</sup>         |
| UPK Zeolite 50%                                     | 119.65<sup>b</sup>         |

Note: The same letter indicates that there is no significant difference based on the results of the Duncan test with confidence level $\alpha = 0.05$.

Figure 1. Average cob weight (grams)

3.2. Cob Length (cm)

The results of further analysis of cob length showed different results compared to other treatments. The highest cob length was shown by zeolite coated urea treatment with a concentration of 10% and the lowest by the group not given any treatment. It can be suggested that this result is because the control did not have many nutrients in the soil because fertilizer given treatment is capable of providing adequate nitrogen (N) in the soil for generative growth, which is the formation and development of the corn cob [2]. The level of nitrogen has an effect on the photosynthesis process, hence the nitrogen absorbed by the plant has a large effect on the length of the cob.

Table 2. Average cob length (cm)

| Treatment                                           | Average Cob Length (cm) |
|-----------------------------------------------------|-------------------------|
| Control                                             | 10.05<sup>a</sup>       |
| Urea, Phosphate, Potassium                          | 15.00<sup>b</sup>       |
| UPK Zeolite 10%                                     | 14.25<sup>b</sup>       |
| UPK Zeolite 30%                                     | 13.95<sup>b</sup>       |
| UPK Zeolite 50%                                     | 14.87<sup>b</sup>       |

Note: The same letter indicates that there is no significant difference based on the results of the Duncan test with confidence level $\alpha = 0.05$. 
Application of zeolite to the soil which has low Caution Exchange Capacity (CEC) can raise the soil CEC [14]. When zeolite is applied to soil, because it has a high capacity to absorb nutrients, especially Potassium (K) and Ammonium (NH$_4$), the capacity of the soil to bind those substances can increase. Reducing the loss of nitrogen whether through leaching or nitrification can increase the production yield of plants [11]. The increase in production due to the application of zeolite is caused by an increase in the efficiency of nitrogen, especially reducing the leaching of nitrates. The use of zeolite 3 and 6 ton/Ha results in twice the amount of accumulated nitrogen compared to the control which is treated with N fertilizer. Zeolite can inhibit the conversion of NH$_4$ to nitrates by 30–40% [14].

### 3.3. Kernel Weight (grams)

The results of further analysis for kernel weight showed different results compared to other treatments. With respect to kernel weight, the highest values were shown by zeolite coated urea treatment with a concentration of 30% whereas the lowest values were shown by the group not given treatment (Control). Nitrogen (N) is the main component of chlorophyll, [8]. The N content of the leaves will remobilize N to the kernels, cause a longer photosynthesis process and help the plant continuously fill the kernels. With the addition of zeolite, nitrogen (N) can bring about a change in the quality and quantity of the yield through improving the process of filling the kernels at the tip of the cob. Photosynthesis is also affected by the stay-green characteristic of the variety of corn. The variety of corn used in this research was HJ21 Agritan [4]. Stay-green plants delay the aging of leaves at the time of kernel fill and can achieve a higher yield [7].

**Table 3. Average kernel weight (grams)**

| Treatment                  | Average Kernel Weight (%) |
|----------------------------|---------------------------|
| Control                    | 37.22$^a$                 |
| Urea, Phosphate, Potassium | 90.45$^b$                 |
| UPK Zeolite 10%            | 84.31$^b$                 |
| UPK Zeolite 30%            | 72.80$^{ab}$              |
| UPK Zeolite 50%            | 94.41$^b$                 |

*Note: The same letter indicates that there is no significant difference based on the results of the Duncan test with confidence level $\alpha = 0.05$.***
Figure 3. Average kernel weight (grams)

The characteristic of zeolite is a three-dimensional crystal structure that has the capacity for reversible hydration and exchange of cations. If urea fertilizer is added to soil together with zeolite, ammonium (NH$_4^+$) will be trapped temporarily in the zeolite pores and then slowly released to be taken up by plant roots. Because of this, zeolite plays a role in binding cations (NH$_4^+$), resulting in an increased cation efficiency. It is reported that the loss of urea fertilizer in soil can be reduced by making slow-release fertilizer (SRF) made of a mixture of urea and zeolite with a ratio of urea 70% : zeolite 30%, with the result that 30% of urea fertilizer can be retained, and the zeolite causes a reduction in residue from the oxidation of ammonium to nitrate. [1].

4. Conclusion
The growth of corn plants with zeolite coated urea treatment produced different results compared to positive control and negative control treatment. Based on the results of the research carried out, namely the growth response of corn plants (Zea mays) with application of zeolite coated urea as a nitrogen slow release fertilizer, it can be concluded that for corn cob weight and corn cob length the greatest effect was found with application of zeolite coated urea with concentration 10%. Whereas for corn kernel weight the greatest effect was found with the application of zeolite coated urea with a concentration of 30%.

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