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Influence of urea fertilizer applied with polyacrylate polymer, zeolite and Mimba on growth maize

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Abstract. This research was carried out to study the growth of maize fertilized with a composite of urea with slow release materials (polyacrylate polymer and zeolite) and nitrification inhibitors, Mimba (*Azadirachta indica*). Three times repetitions of Randomized Block design was used in this study. The parameters observed included biomass (g), the weight of cobs (g) and the length of cobs (cm). The weight and the length of corn cobs were measured after harvest. The result of the study shows that the growth of maize applied with urea fertilizer composited with polymeric polyacrylate, zeolite and Mimba was significantly different from the negative control (KH_2PO_4/Mono potassium phosphate) fertilizer and appeared to be significantly better than the positive control (Urea and KH_2PO_4 fertilizers).

1. Introduction

The productivity of corn (*Zea mays* L.) needs to be increased, because it is one of the most important foods and feed crops in the world [6]. The yield increase in corn is determined by the role of Nitrogen (N) fertilizer (Modhej *et al.,* 2008). The use of pure nitrogen 200 kg ha^{-1} helps to create the highest grain with 10.53 t ha^{-1} [20].

As for fertilizers, urea is easily lost through volatilization, evaporation, and leaching (Azeem *et al.,* 2014). Once urea fertilizer is applied to the soil, it changes to ammonium carbonate that hydrolysis by the enzyme urease. This conversion leads to an increase in the concentration of ammonium ion in the soil [9; 17]. High ammonium ion without good retention of urea applied to acidic soil causes loss of ammonia during the first week of field application [1].

Nitrogen can also be lost in the form of ammonium and nitrate through leaching. Nitrate is easily lost because they are negatively charged compared to ammonium ions which are positively charged and linkage to the negative charge of soils. Ammonium ions stored in the soil are readily converted to nitrite, then to nitrate through the nitrification process [9]. This leads to a decrease in the efficient use of nitrogen by plants, which limits crop yield and also contribute to environmental pollution. Leaching of nitrate in the soil increases the concentration of elements such as nitrogen, phosphorus, and potassium in water bodies, causing eutrophication. Nutrients also reach groundwater, which leads to excess dissolved solid such as nitrates in groundwater [3; 8].

The development of slow-release urea fertilizer as new green technology which does not only reduces nitrogen loss, but also changes the nitrogen release kinetics, providing nutrients for plants at compatible speed with their metabolic need [3]. Polyacrylate polymers are a superabsorbent polymer that can absorb water [5]. Ethyl cellulose and poly (acrylic acid-co-acrylamide) are used as coating materials inside and outside respectively. The nitrogen content of the product is 21.1% and its water absorption is 70 times its weight. This shows that product with slow release property, good water retention and environmentally friendly will meet to nutrient *use efficiency* applications in agriculture and horticulture [21]. Polymer-coated urea reduces the concentration of nitrogen in the soil at the beginning of the season, thereby reducing nitrate leaching [22].

The application of zeolite mixture into the soil reduces the rate of nitrification because ammonium (NH_4^+) is absorbed into the zeolite mineral lattice [14]. Zeolites have a high cation exchange capacity and are often used as cheap cation exchangers for various applications. Ions can be mobilized in zeolites by two mechanisms which are; ion exchange and chemisorption. Natural zeolites and nanopore zeolites consist of about 30 to 40% drains with pore diameters of 0.4 to 1.0 nm. Pore space between 35 to 40% is used in loading nitrogen (N) and potassium (K) [4].

Nitrification inhibitor (NI) helps in controlling form changes from NH_4^+ to NO_2^- and NO_3^-. Nitrification inhibitor also helps to decrease NO_3^- loss through leaching, and it improves the effective use of nitrogen [24]. NI is used to inhibit the activity of nitrifying bacteria in the first stage (nitritation) of the nitrification process by inhibiting the growth of temporary nitrifying bacteria (ammonium dioxide) in the range of 7-14 days after application of the material [12; 16]. One of natural component that could act as NI is Mimba (*Azadirachta indica*). The lowest level of soil nitrate found in maize planted soil was urea covered with 5% Mimba. The content of nitrate soil after replicated urea coated 5% Mimba is 13,63 gram/gram soil. It is the lowest level than urea without Mimba such us 14,02 gram/gram soil [13]. This indicates that urea coated Mimba may inhibit nitrification (the change of NH_4^+ to be NO_3^-) with inhibiting nitrifying bacteria.

The characteristics possessed by polyacrylate, zeolite, and Mimba made them useful as a mixture of urea composite polymer fertilizer. It is expected to be able to create slow released urea fertilizer according to plant nitrogen need and improved n*utrient use efficiency*. Moreover, it will increase the growth of maize plants. The aim of the study is to determine the growth maize which fertilized with polyacrylate, zeolite, and Mimba (*Azadirachta indica*).

2. Materials

Materials of this experiment are corn HJ 21 agritan, urea fertilizer, KH_2PO_4 (*Mono potassium phosphate*) fertilizer, polyacrylate, zeolite, and Mimba. Corn HJ 21 agritan is one of the hybrid corn varieties and has stayed green leaves. This experiment used white urea granule. It contains 45% - 46% nitrogen. KH_2PO_4 fertilizer contains potassium and phosphate. Polyacrylate is a super absorbent polymer. Mimba is nature nitrification inhibitor. The part of neem that used in this experiment is seeded pulp of neem.
Methods

The study was conducted at the Indonesian Cereals Research Institute (Balitsereal Maros) from August to December 2017. Maize variety HJ 21 Agritan was planted in pots which were arranged in a randomized one-factor design with 3 repetitions. The fertilizers used for this research are 3,8 gram urea and 1,9 gram KH_2PO_4 (*Mono potassium phosphate* /). It mixed with 0.09 gram polyacrylate,, 1.14 gram zeolite and 0.19 gram Mimba cake (a waste product of oil Mimba. 0.09 gram polyacrylate is 2,5% polyacrylate of 3.8 gram urea. 1,14 gram zeolite is 30% zeolite of 3.8 gram urea. 0.19 gram Mimba is 5% Mimba cake of 3.8 gram urea. It mixed with pellet machine to be granules. Fertilizer was applied once (single polymer) which is one Week After Planting (WAP) as 14.2 grams, and two times (split polymer) which is one WAP and five weeks after planting as much as 7.1 grams. The negative control is 1.9 gram KH_2PO_4 fertilizer, while positive control is 3.8 gram urea and 1.9 gram KH_2PO_4 fertilizers.

The effect of fertilizer on the growth of maize plants was seen by measuring growth factors such as; vegetative biomass of plants, the weight of maize cobs and length of maize cobs. Vegetative biomass of plants was determined by the total of the dry weight of roots, stems, and leaves of plants (gram). The weight of maize cobs was a dry weight. The length of maize cobs was measured the distance from the base to the tip of the cob using a scale in meters.

The results of the research data were analyzed using analysis of variance (Test F) one-way analysis of variance (ANOVA) at the level of confidence α = 0.05%. The treatments that have a significant effect were further tested by Duncan's test with program SPSS statistics 20 ver.

Result and Discussion

Vegetative biomass of plants is a parameter of nitrogen availability for plants which increases growth. Nitrogen affects vegetative growth and it is a major component of chlorophyll which increases photosynthesis [15]. Figure 1 shows that the vegetative biomass of treated maize plant was not significantly different from the control. However, the vegetative biomass of plants was treated by amended polymer composite fertilizers tend to be higher than positive and negative controls. This is because possible that the nitrogen needs were fulfilled in the maize plants needed.

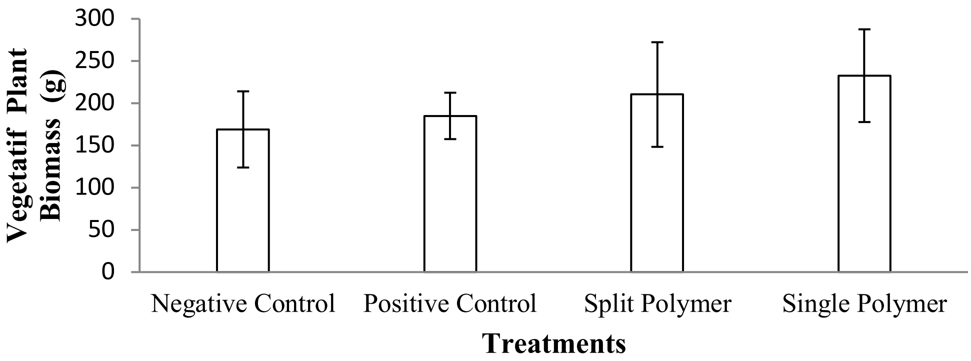

Figure 1. Vegetative Plant Biomass of Maize after Application of Urea, Zeolite, Mimba, and Polyacrylate Treatments 14 WAP. Bar = ± Standard Error.

Nitrogen is the main component of chlorophyll creators [15]. The higher the chlorophyll level, the better photosynthesis, yielding heavy grain [10]. Table 1 show that the weight and the length of maize cobs treated was significantly different from negative controls. This shows that fertilizers are able to provide enough nitrogen in the soil until generative growth (formation and development of Maize cobs). The negatively controlled Maize plant has the lowest cob weight and length because nitrogen is not sufficiently available in the soil until the plant generative growth.

Table 1. Average weight of cob (cm) and cob length (cm) after application of urea, zeolite, mimba, and polyacrylate treatments 14 WAP.

Treatments	Average Weight of Cob (cm)	Average Cob Length (cm)
Negative control	55.83[a]	10.50[a]
Positive control	108.68[b]	15.00[b]
Split application polymer	124.05[b]	15.50[b]
Single application polymer	113.99[b]	16.00[b]

The numbers followed by the same letter mean that there is no significant difference in the level of α <0.05 Duncan

Table 1 shows that the weight and the length of the cobs which significantly different from the negative control treatment. This is due to the inadequacy of soil nitrogen nutrients by negative control fertilizers, thereby causing less of the translocation of nitrogen from leaves to grains during the generative phase. Ribulose 1,5-biphosphate carboxylase/oxygenase (Rubisco) is the main protein in the photosynthesis process of plants that will be degraded, thus could reducing photosynthesis rate and dry weight of plants after harvest [11].

Polymers Split application have highest cob weight. This means that the requirement of maizewas fulfilled up to the generative phase. The composite of urea with polyacrylate, zeolite, and Mimba made a polymer fertilizer to provide nutrients such as nitrogen, phosphorus and potassium in the generative phase until the maize was harvested. Nitrogen, phosphorus, and potassium granular fertilizers coated with poly acids (acrylic acid) can absorb 8.47% potassium (intended by K_2O), 8.51% phosphorus (intended by P_2O_5) and 15.77% nitrogen [23]. This polyacrylate was able to maintain nitrogen, phosphorus, and potassium in the development of maize grains. Besides, Mimba may reduce nitrification rate by 2.5%, while Mimba-coated urea is able to inhibit nitrification so that nitrogen absorption from ammonium was increased [13]. Thus, maintaining the nitrogen form as NH_4^+ improves the fertilizer efficiency to meet the nitrogen plant need in the generative phase. Increased nitrogen uptake by plants would support a lot of assimilation to the cob so that the number of grains and the weight of the cob increased [2].

Table 1 shows the weight of Maize cobs with a higher treatment from the positive control. This was due to positive controls only content urea and KH_2PO_4 fertilizers without polymeric polyacrylate, zeolite, and Mimba. Thus, urea is easily lost from the soil hence the plants lacking nitrogen for the generative phase. Urea applied to plant is susceptible to losses in soil due to evaporation and leaching [3]. Four days after the urea application to the soil, it will oxidize into NO_3^- form [17].

The plant lacks nitrogen thereby causing premature aging. Presumably, because grain development requires nitrogen obtained from vegetative nitrogen remobilization (leaves). Rubisco is the main protein in plant photosynthesis, and the degradation of Rubisco should reduce plastids of leaves and then reduce photosynthetic protein. Nitrogen is a component of chlorophyll which acts as the main molecule that absorbs light energy for photosynthesis. Most nitrogen is allocated to photosynthesis and enzymes [10; 11; 15]. The decrease in photosynthetic protein causes a decrease in photosynthesis rate so that the assimilation for grains decreases.

Polymers split application have the highest weight of maize cobs; this is because maize plants with a split polymer treatment absorb nitrogen sufficiently available in the soil for chlorophyll formation. Hybrid corn has a large post-silking nitrogen uptake [7]. The timing of split polymer fertilization and single polymer affects the availability of nitrogen in the soil. Single polymers fertilizer is only applied once at the beginning, therefore, the availability of nitrogen in the soil has not fulfilled the demand of growth of maize in the generative phase (grain development); meanwhile, the split polymer fertilizer was applied twice, at the beginning and before the formation of grains. Thus, nitrogen in the soil remained sufficient for grain growth. The absorption and assimilation of nitrogen by plants played a significant role in cobs which are; increasing the number of grains per cob and increasing the weight of grains [2]. Efficient translocation and nitrogen assimilation are also very important to ensure the optimal yield of grains [6].

3. Conclusions

The growth of maize in this study treated twice at the beginning and before the formation of grain with composted urea fertilizer, polymer polyacrylate, zeolite, and Mimba were significantly different from negative control (K_2PO_4) and relatively better than the positive control (Urea and K_2PO_4) for increasing weight of cobs.

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