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The Application of Slow Release NPK Fertilizer on Inceptisols to Changes of Soil Chemical Properties and Growth of Sweet Corn (*Zea mays* L. *saccharata*).

Fardian Khairul Hakim[1,*], Emma Trinurani Sofyan[2], Rija Sudirja[2], Benny Joy, Anni Yuniarti[2], Diyan Herdiyantoro[2]

[1]Department of Soil Science and Land Resouces Management, Agriculture Faculty, Universitas Padjadjaran –
[2]Magister of Soil Science, Agriculture Faculty, Universitas Padjadjaran
*Email : fkhakim96@gmail.com

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***Abstract*— *Effort to increase the efficiency of fertilizer use, reduce loss of nutrients in the soil due to leaching, evaporation and reduce residues which can be one of the causes of soil damage, slow release fertilizer is needed. This slow-release fertilizer can optimize plant growth and production as well as nutrient absorption by plants because the release of nutrients is according to the time and amount needed by the plant, while fertilization costs can be reduced because this type of fertilizer is only applied once in a growing season. The experiment was carried out to determine the effectiveness of inorganic fertilizers (NPK) which are slow release with various types of coating percentages to help provide nutrients slowly for sweet corn to grow and produce optimally and reduce environmental pollution due to excessive fertilizer application on the soil. The pot experiment was carried out using a Randomized Block Design (RBD) which consisted of four treatments with the percentage of slow release fertilizer (SRF) i.e. 0%, 3-4%, 5-6% and 7-8%. Each treatment was repeated six times. The results showed that in 60 days after application of slow release NPK fertilizer gave the best effect for improving the chemical properties of Inceptisol (N-total, P-potential, and K-potential), by releasing the entire content of 75.03%. Slow Release NPK fertilizer with 0% coating percentage gave the best effect on the chemical properties of Inceptisol and increased growth (plant height and stem diameter) of sweet corn (Zea mays L. saccharata).*

***Keywords*— coated, NPK, N total, P potential, slow release, Anorganic.**

I. INTRODUCTION

The availability of nutrients in the soil is the main factor that determines the success of cultivating a plant, but the nutrients in the soil have a high mobilization which causes the unavailability of nutrients in the soil due to leaching or loss in other forms. One of the soil orders that have problems with low nutrient content is Inceptisols. The low content of macronutrients (N, P and K), a slightly acidic pH value (5.6), is an obstacle to the utilization of Inceptisols [1].

Efforts can be made to improve Inceptisol soil conditions by applying inorganic fertilizers containing nitrogen, phosphorus and potassium. However, excessive application of inorganic fertilizers to the soil can affect the environment, reactions in the soil such as P fixation, NO_3 and N_2O volatilization. Ahmed et al. [2] stated that to minimize environmental pollution due to the use of inorganic fertilizers with excessive doses, the use of Slow Release Fertilizer (SRF) in agricultural practice is an important and effective method.

According to Himmah et al. [3] Slow Release Fertilizer (SRF) is made to release nutrients slowly and according to plant nutrient needs. The use of this type of fertilizer can minimize soil and water pollution caused by the application of excessive fertilizer doses and fertilizer leaching. The results of Trenkel's research [4] show that the application of slow release fertilizer has the potential to reduce the use of fertilizer doses by 20-30% recommended from conventional fertilizers while getting the same results. The advantage of using slow-release fertilizers is to maintain the concentration of available nutrients in the soil, reduce runoff and loss of nutrients in the soil due to leaching due to the slow rate of nutrient release [5].

Slow release fertilizer is expected to support plant nutrient needs in accordance with the required dose based on the age of the plant. Fertilizers with these characteristics generally use materials that are able to retain the nutrients contained in the fertilizer so that it does not release quickly [6]. The application of Slow Release Fertilizer (SRF) in the rate of release of nutrients contained in the fertilizer will be controlled by the coating material that coats the fertilizer. Ahmad et al. [7] stated that polymer coated fertilizers are the most popular type of this SRF technology. One of the synthetic polymers used as coatings for inorganic fertilizers is polyurethane. Slow release fertilizers coated with polyurethane are made from the direct reaction between polyol reactants and isocyanates on the surface of fertilizer particles [8]. Therefore, it is necessary to experiment to determine the effectiveness of inorganic fertilizers that are slow release with various types of coating percentages to help provide nutrients slowly for plants, especially growth of sweet corn optimally and reduce environmental pollution.

II. MATERIALS AND METHODS

Inceptisol from Jatinangor was used which belongs to the Fluventic Eutrudepts sub group which has a pH of 6.25, soil N of 0.23%, total P 24.93 mg100g^{-1} and K 23.88 mg100g^{-1} with a dusty clay texture. NPK coated with polyurethane is a compound NPK fertilizer that is slow release. Talented variety sweet corn was used as an indicator plant.

The experimental design used a Randomized Block Design which consisted of four treatments with the percentage of slow release fertilizer (SRF) i.e. 0%, 3-4%, 5-6% and 7-8%. Each treatment was repeated six times. 10 kg of soil in polybags by 30x40 cm. The dose of NPK applied was 0.17 g per kg of soil.

The observed soil parameters were total N, potential P, potential K and soil pH at 15, 30, 45 and 60 days after fertilizer application. Growth parameters observed were plant height and stem diameter periodically every week (14-56 days after planting).The data obtained were tested statistically using Fisher's exact test at a significance level of 5%, if the effect was very real or significant, then to find out the difference between the mean treatment values, the Duncan's Multiple Range Test (DMRT) test was carried out at a significant level of 5%.

III. RESULTS AND DISCUSSION

Soil Nitrogen

The results showed that the application of slow-release NPK inorganic fertilizer had a statistically significant effect on the total N content of Inceptisol soil. The results of statistical analysis can be seen in Table 1.

Each treatment released a different total nitrogen. The difference in nitrogen release in each treatment could be due to differences in the percentage of coating on the outer layer of fertilizer. Treatment D (SRF 7-8%) had a very slow release pattern when compared to treatment C (SRF 5-6%), treatment B (SRF 3-4%) or with treatment A (SRF 0%). due to the influence of the percentage of the coating applied to the fertilizer which inhibits the release of nutrients in the fertilizer.

Table 1. Effect of Slow Release NPK Fertilizer on Total Soil N

Treatments		Soil N-total (%)			
		15 d	30 d	45 d	60 d
A	NPK SRF 0%	0,21 d	0,23 c	0,25 c	0,28 d
B	NPK SRF 3-4%	0,19 c	0,20 b	0,21 b	0,24 c
C	NPK SRF 5-6%	0,18 b	0,18 a	0,20 b	0,22 b
D	NPK SRF 7-8%	0,17 a	0,17 a	0,18 a	0,20 a

Note: The numbers followed by the same letter are not significantly different according to the DMRT test at the 5% level.

The coating method is a coating that is applied to the surface of the fertilizer which functions to bind NPK fertilizer so that it does not evaporate easily when exposed to sunlight and also the fertilizer lasts longer so that it is not carried away by water [9]. The results of statistical tests on the release of N-Total for each treatment showed a significant difference in all fertilizer treatments tested.

The average soil N-total content at 15-30 days after application (DAA) in each treatment decreased when compared to the initial soil N-total content of 0.23 (medium category). This is because the slow release NPK fertilizer has not released the nutrient content in the fertilizer optimally, while the roots of corn plants at the age of 14-28 days after planting (DAP) have begun to develop and absorb nutrients in the soil in the early vegetative phase [10]. Other factors that can reduce N in the soil are denitrification, volatilization, leaching, and soil surface erosion [11].

The total N-content of soil occurring at 45-60 DAA in treatment A (0% SRF) experienced a significant increase when compared to other SRF treatments. Inceptisol soil N-total treatment A (0% SRF) at 45 DAA increased by 8% and at 60 DAA increased 17.85 % when compared to the initial N-total, but treatment B (SRF 3-4%) could increase N-total soil by 4.16% at 60 DSA. This is because in treatment A (0% SRF) the nutrient content in the fertilizer can be quickly available in the soil, in contrast to NPK fertilizer which is coated with polyurethane in various percentages.

Soil P_2O_5

During the incubation period, the release of phosphorus (P) in each treatment gave significantly different results (Table 2). The P data presented represents the change in P-potential content in Inceptisol soil from the release of P which was given SRF fertilizer with various types of coating percentages.

Table 2. Effect of Slow Release NPK Fertilizer on Soil P_2O_5

Treatments		**Soil P_2O_5 (mg/100g)**			
		15 d	**30 d**	**45 d**	**60 d**
A	NPK SRF 0%	25,10 d	25,18 d	25,23 c	25,25 d
B	NPK SRF 3-4%	25,00 c	25,04 c	25,11 b	25,14 c
C	NPK SRF 5-6%	24,91 b	24,95 b	24,98 a	25,04 b
D	NPK SRF 7-8%	24,88 a	24,92 a	24,97 a	25,01 a

Note: The numbers followed by the same letter are not significantly different according to the DMRT test at the 5% level.

The release of P in slow-release fertilizers occurred gradually, nutrients released from SRF did not dissolve immediately after application and increased during 60 days of incubation. The greatest release of P element since the beginning of sampling (15-60 DAA) was obtained from treatment A (0% SRF) with a total percentage of release of 76.78%. The advantage of fertilizer in the form of granules is that it has a larger surface area so that the greater the reaction surface area, the solubility of fertilizer will be faster and nutrients will be available more quickly [12].

The release of P elements from SRF with a coating percentage of 3-4% was able to release the total P contained in the fertilizer by 41.61%. The release of P in treatment C (SRF 5-6%) was able to release a total of 11.18% P, while treatment D (SRF 7-8%) was only able to release a total P of 4.72%. The type of fertilizer in treatment B (SRF 3-4%) has a coating that will affect the pattern of phosphorus nutrient release. When fertilizer is applied, the coating will slowly dissolve first until it decays completely before finally the nutrients contained in the fertilizer will be dissolved [13].

According to Trenkel's research [4] fertilizers can be categorized as SRF must meet the following three criteria: a) within 24 hours SRF must release less than 15% of nutrients, b) within 28 days of nutrients that must be released less than 75%, c) at least 75% of nutrients should be released within 40-60 days after application of fertilizer. Based on this statement, treatment B (SRF 3-4%), treatment C (5-6%), and treatment D (7-8%) could not be said to be a slow-release fertilizer.

Soil K_2O

The application of slow release NPK inorganic fertilizer had a statistically significant effect on the potential K content of Inceptisol soil (Table 3).

Table 3. Effect of Slow Release NPK Fertilizer on Soil K2O

Treatments	**Soil K_2O (mg/100g)**

		15 d	30 d	45 d	60 d
A	NPK SRF 0%	23,99 d	24,10 d	24,19 d	24,24 d
B	NPK SRF 3-4%	23,93 c	23,98 c	24,05 c	24,12 c
C	NPK SRF 5-6%	23,87 b	23,91 b	23,96 b	23,99 b
D	NPK SRF 7-8%	23,84 a	23,87 a	23,91 a	23,95 a

Note: The numbers followed by the same letter are not significantly different according to the DMRT test at the 5% level.

Treatment A (SRF 0%) showed the highest solubility of K nutrients compared to other treatments at 7.78% or an increase of 0.45% from the initial K-potential value of 23.88 mg/100g. The total solubility of the highest to lowest K elements released by SRF for 60 days after application was obtained from treatment A (0% SRF) of 73.28% and followed by treatment B (SRF 3-4%) 40.09%, treatment C (SRF 5-6%) 16.10% and the lowest was obtained from treatment D (SRF 7-8%) of 2.82%.

Coating on slow-release fertilizer will affect the solubility of potassium. Based on research by Saleem et al. [14] that slow-release fertilizer with coating is able to release nutrients gradually and is 14% better than fertilizer without coating. Polyurethane coating material is an oil-based hydrophobic polymer system that functions as a diffusion barrier for excessive release of potassium nutrients [8]. The coating material changes its structure during release due to interaction with water that enters through the surface pores and will be slowly degraded over time and will end in the release of potassium nutrients contained in fertilizers.

Nutrient K is a macro nutrient for plants that is needed in large quantities after N and P. Potassium has a role in plant metabolic processes. The transfer or movement of K mainly through the process of diffusion and soil K nutrient levels need to be known to determine the amount of fertilizer applied for efficient fertilization. Potassium is often lost due to leaching and is in an unavailable form because it is bound by clay minerals. According to Lasindrang [15] that slow-release fertilizers can increase the efficiency of nutrient uptake and reduce the loss of K nutrients due to leaching. This is because the slow-release fertilizer has low solubility in water and releases nutrients gradually over a long period of time for plants, therefore the availability of K nutrients is expected to always be available in the soil so that later it will be absorbed by plants in the form of K^+ ions.

Soil Acidity (pH)

The soil acidity decreased with incubation time. The pH value in the initial soil media analysis was obtained at 6.25. At 15 days after application, it is shown in Table 5. that treatment A (SRF 0%) experienced a significant decrease in pH value compared to treatment B (SRF 3-4%), C (SRF 5-6%) and D (SRF 7-8). %) with a decrease in pH to 6.14. Treatment C (SRF 5-6%) and D (SRF 7-8%) at 15 days after did not give significant results. At 30 days after application of treatment A (0% SRF) the pH value of the soil was reduced to 5.98 from 6.25 or 4.5% (Table 4).

Table 4. Changes in the Value of Soil Acidity (pH)

Treatments		Soil pH			
		15 d	30 d	45 d	60 d
A	NPK SRF 0%	6,14	5,98	5,80	5,50
B	NPK SRF 3-4%	6,24	6,14	6,03	5,83
C	NPK SRF 5-6%	6,25	6,18	6,09	6,01
D	NPK SRF 7-8%	6,26	6,21	6,17	6,06

A significant decrease was experienced by each treatment at 60 days after application, treatment A (SRF 0%) could reduce the pH value of the soil to 5.50, treatment B (SRF 3-4%) could reduce the pH value of the soil to 5.83, treatment B (SRF 3-4%) decreased the pH value to 5.83, and treatment C (SRF5-6%) can reduce the pH value of the soil to 6.01 and treatment D (SRF 7-8%) can reduce the pH value of the soil to 6.06 from the initial soil pH value of 6.25. The pH value of a solution is usually affected by the hydrolysis of the salt [16].

Plant Height

Observation of plant height during the study showed that there was a significant difference between the treatments of slow release NPK fertilizer starting from 14 days after planting (DAP) to 56 DAP The results showed that the application of slow release NPK fertilizer coated with polyurethane polymer did not give the best results on the growth of sweet corn plant height. The highest results in plant height observations were achieved by treatment A (0% SRF) which was 30.03 cm (14 DAP), 42.50 cm (28 DAP), 58.49 cm (42 DAP) and 74.48 cm (56 DAP).). The height of the garden can be said to increase gradually according to the age of the plant along with optimal fertilizer application [17]. Plants will not give maximum results if the necessary nutrients are not available. This is in line with the results of research by Marlina et al. [18] that the application of complete fertilizer N, P, K at the right time and in the right dose can increase the growth and yield of sweet corn.

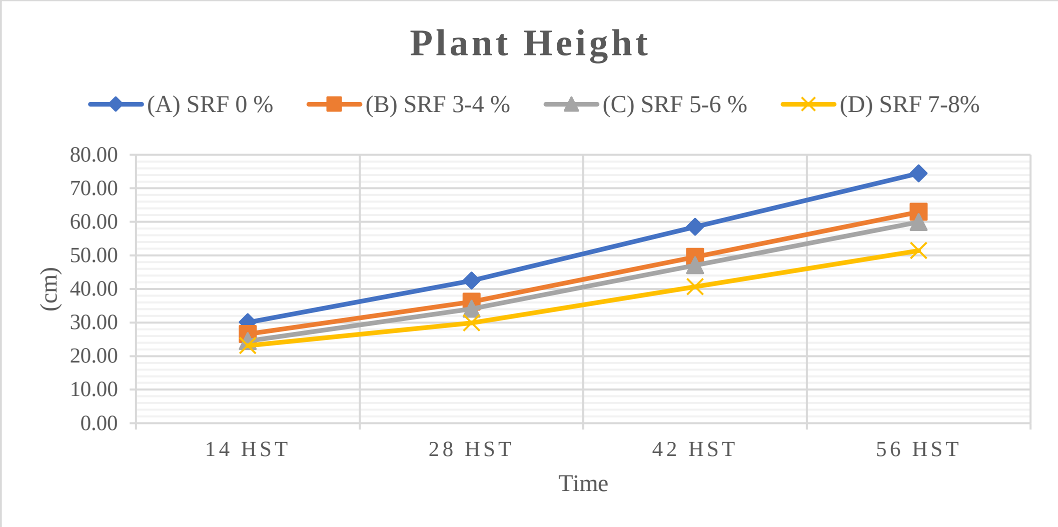

Fig.1. Plant Height of Sweet Corn

Figure 1 shown that the plant height at 14 DAP was uniform. The application of slow release NPK fertilizer had an effect on plant height after sweet corn passed 14 DAP. Mahdianoor et al. [10] stated that plants at the age of 14 DAP entered the stage of becoming new plants or were in a slow growth phase, so that at that phase the plant roots had not developed and had not optimally absorbed nutrients in the soil but already needed nutrients to grow optimally.

The increase in plant height was thought to be due to nitrogen, phosphorus and potassium nutrients in the soil at the beginning of the plant before application was in the medium category and the addition of nitrogen, phosphorus and potassium nutrients released by slow release NPK fertilizers. According to Advinda [19] the element nitrogen is very important for plants because it is a component of cells, amino acids, nucleic acids, chlorophyll, and hormones.

Stem Diameter

The experimental results showed that the addition of slow release NPK fertilizer with 0% coating gave significantly different results between treatments at the age of 14 DAP, but the other treatments were not significantly different from each other. This is because the difference in the percentage of coating applied to each NPK fertilizer, treatment B (SRF 3-4%), treatment C (SRF 5-6%) and treatment D (SRF 7-8%) showed a relatively growth in stem diameter. slower with values of 4.37 mm, 4.19 mm and 4.28 mm, and not significantly different from each other, when compared to treatment A (SRF 0%) with a value of 4.89 mm. According to Mahdianoor et al. [10] at the age of 28 DAP plant roots have started to grow and are actively moving to obtain water and nutrients to support growth and development.

Corn plants at 56 DAP showed a significant difference between treatment A (SRF 0%) and treatment B (SRF 3-4%), treatment C (SRF 5-6%) and treatment D (SRF 7-8%). This happened because the plants that were given SRF 0% had absorbed the nutrients available in the soil well, but the final result of the growth of the stem diameter of the sweet corn plant did not match the description of the Talent Varieties, this variety was able to produce a stem diameter of 29.0 – 32.0 mm [20], while the highest stem diameter value was achieved by treatment A (SRF 0%) of 14.5 mm and the lowest stem diameter value was found in treatment D (SRF 7-8%) of 10, 67mm.

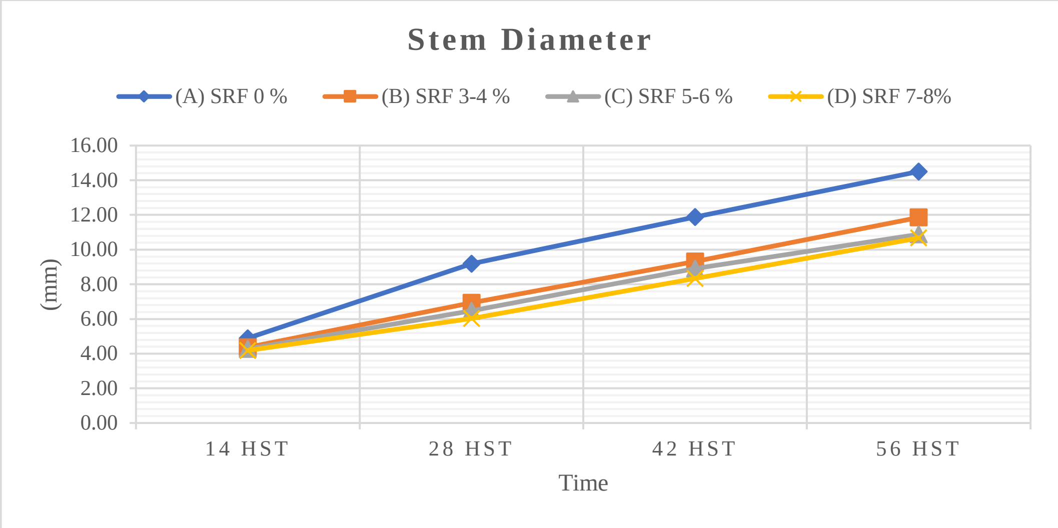

Fig.2. Stem Diameter of plant

Figure 2 shown that the diameter growth of sweet corn in treatment B (SRF 3-4%), treatment C (SRF 5-6%) and treatment D (SRF 7-8%) was inhibited due to the slow release of nutrients in slow-release NPK fertilizers. not in line with expectations because there is no hydrolysis process in the soil between the coating surface and water properly which has an impact on the unavailability of nitrogen, phosphorus and potassium nutrients that are in accordance with the needs of sweet corn plants in order to grow optimally. In contrast to treatment A which was given SRF 0%, this kind of fertilizer will provide the nutrients nitrogen, phosphorus and potassium in fertilizers that are needed by plants to be optimal and grow faster. Research by Irfan et al. [21] showed that the coating on the slow-release fertilizer functions to control the pattern of nutrient release through the diffusion process, then the nutrient dissolution process occurs in the fertilizer and ends in the release of nutrients.

IV. CONCLUSION

Based on the experimental results, it can be concluded that within 60 days the treatment of NPK inorganic fertilizer which is Slow Release gives the best results for improving the chemical properties of Inceptisol soils (N-total, P-potential, and K-potential), by releasing the entire content of 75, 03%. Slow Release NPK fertilizer with 0% coating percentage gave the best results on the chemical properties of Inceptisol soil (N-total, P-potential and K-potential) and increased growth (plant height and stem diameter) of sweet corn (*Zea*). *mays* L. saccharata) Variety of Talents.

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