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Suppressing Erosion and N (Nitrogen) Nutrients Loss Using Polyacrylamide under Sweet Corn Cultivation Under Climate Change Issue

Yuliana Eva Agasi [a], Niken Ida Lovita [a], Dwi Rustam Kendarto [a], Ali Rahmat[b]*

[a] Department Agriculture Engineering, Faculty of Agricultural Industrial Technology, Padjadjaran University, Jatinangor, Indonesia

[b] R Research Center for Limnology and Water Resources, National Research and Innovation Agency (BRIN), Indonesia

* Corresponding author: alir001@brin.go.id

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Abstract

Climate change is currently a significant issue that poses a threat to the environment. Climate change can trigger increased rainfall, which promotes erosion in many areas. Erosion can lead to the depletion of nutrients in the soil, ultimately reducing the availability of nutrients for plants and causing a decline in land productivity. This can result in widespread land degradation. To avoid this risk soil conservation is needed. Soil conservation can be done to increase land productivity with chemical methods, such as using soil amendments with polyacrylamide (PAM). PAM is an anionic polymer-based material that can improve soil aggregate stability, infiltration rate, and suppress erosion. The purpose of this study is to determine the effect of PAM on erosion suppression, the loss of N nutrients, and on the growth of sweet corn plants. The results of the analysis showed that there is an effect of PAM on the suppression of erosion and loss of N nutrients in the soil. The dose of PAM of 60 kg/ha was able to suppress erosion by 53.16% and reduce the loss of nutrients N by 15.07%. The most optimal and efficient dose in optimizing sweet corn plant growth is 15 kg/ha.

Keywords: Climate change, Erosion, N Nutrients Loss, Plant Growth, Polyacrylamide.

1. Introduction

Climate change is characterized as alterations in the climate system's state, detectable through shifts in the average and variability of its attributes over an extended duration, often spanning decades or more (Sturrock et al., 2011, Rahmat & Mutolib, 2016). The climate change linked to global warming has resulted in a rise in extreme droughts, floods, and other natural calamities, which amplify the erosion hazard (Park et al., 2011; Amundson et al., 2015). High rainfall due to climate change can trigger erosion in many areas. The erosion potential of land can affect the likelihood of nutrient loss in the soil and lead to a decrease in plant productivity. Erosion can occur as a result of runoff or surface runoff. Surface runoff contributes to erosion when the soil is unable to retain water flowing over its surface, resulting in the displacement of soil particles on the surface. This process can even lead to the loss of topsoil, impacting one of the soil's key components such as organic material, which serves as a source of nutrients for both the soil and plants in the topsoil or tillage layer (Tambun et al., 2012). Erosion is influenced by factors such as rainfall, soil properties, slope, vegetation, and human activity (Hardjowigeno, 2007).

The efforts to control erosion can involve soil conservation through chemical methods. One such soil conservation method is the use of soil conditioner (Arsyad, 2010). Polyacrylamide (PAM) can serve as a soil conditioner that improves soil physical properties, including increased soil porosity, enhanced soil aggregates, and improved soil water absorption, thus reducing soil erosion (Sunandar & Mulyani, 2017). The effectiveness of PAM application in erosion reduction has been demonstrated in previous studies in various countries, including China. A study conducted by Zhang & Miller (1996) found significantly lower rates of surface runoff and soil erosion with the application of PAM compared to soil without PAM treatment. Sojika et al. (2007) noted that synthetic polymer conditioners like PAM were more efficient than organ-ic or inorganic conditioners in enhancing soil stability, infiltration rate, and erosion resistance, with the recommended application rate of 1-20 kg of polymer per hectare. Consequently, PAM can function as a soil conditioner to mitigate erosion, leading to a reduction in nutrient loss caused by erosion. According to Jiang et al. (2010), PAM can enhance plant growth as it facilitates more effective nutrient absorption by plants. Based on the above explanation the purpose of this research is to investigate the effect of polyacrylamide in suppressing the erosion and nitrogen loss as the essential nutrient.

2. Methods

2.1. Research Design

The research was conducted at the Research Center for Limnology and Water Resources, BRIN, Cibinong, West Java, Indonesia. It spanned five months, from January to May 2022. The materials utilized in this study included sweet corn seeds, manure, KCl fertilizer, TSP fertilizer, urea fertilizer, and polyacrylamide (PAM).

The research utilized a completely randomized design (CRD) comprising 5 treatment doses, replicated according to the number of rain events that occurred. The study featured treatments involving different levels of polyacrylamide dosage, namely: P0 (0 kg/ha), P1 (15 kg/ha), P2 (30 kg/ha), P3 (45 kg/ha), and P4 (60 kg/ha), with sweet corn cultivation as the experimental crop. Five plots were employed, corresponding to the number of polyacrylamide (PAM) treatment doses, each measuring 2 x 6 meters in size.

This study analyzes three components: erosion, N nutrient loss, and the agronomic characteristics of sweet corn. Total N nutrients were analyzed using the Kjeldahl method. Data obtained from the experimental results were subjected to ANOVA testing, with significant differences followed by the LSD test at a 5% error level. Analysis of N nutrient loss was conducted at the ICBB laboratory of PT. Biodiversitas Bioteknologi Indonesia.

2.2. Land Preparation and Replotting

Tillage is conducted to expedite the planting process. The tools employed for soil preparation include hoes, machetes, and shovels. Tillage involves clearing the land of weeds or previously grown vegetation. Replotting is undertaken to establish plots according to predetermined dimensions for each plot, measuring 2 x 6 meters. Zinc borders are installed around each plot. Additionally, each plot features a pipe at its end to divert runoff water and erosion sediment into embedded buckets. Gutters are installed in each plot to collect eroded sediment.

2.3. Fertilizer and Polyacrylamide Application

The fertilizers used are as follows: 10 tons/ha for manure, 65.49 kg/ha for TSP fertilizer, 200 kg/ha for urea, and 124.46 kg/ha for KCl. Prior to sowing on the land surface, the fertilizers are thoroughly mixed until homogeneous with a predetermined dose for each plot. Following soil loosening, the basic fertilizer is evenly spread across the entire soil surface, ensuring equal distribution. After a few hours, PAM will be applied at a predetermined dose for each plot, and the plot will be left for 7-10 days before planting.

2.4. Planting, Cultivation, and Harvest

Sweet corn seeds were planted with a spacing of 75 cm x 40 cm, with 2 seeds per planting spot. Irrigation is conducted depending on the condition of the land and the rainfall. The sweet corns will be harvested when they are 60-80 days old.

2.5. Erosion Sampling

Sampling will be conducted on the day following rainfall, with samples collected every morning at 9:00 am. Erosion sediment samples will be collected from gutters and buckets installed on the plot, ensuring that they are taken from areas where soil erosion due to rain has been collected.

3. Results and Discussion

3.1. Effect of Polyacrylamide on Erosion

Rainfall can trigger the process of soil particle destruction, followed by the transportation of soil particles via surface runoff, leading to erosion. Polyacrylamide (PAM) is one of the soil conditioners capable of enhancing soil aggregates, thereby effectively mitigating erosion.

Table 1. Results of ANOVA analysis between treatments and erosion

Component	Treatments				
	P0	P1	P2	P3	P4
Erosion (ton/ha)	4.927 a	3.086 a	2.584 a	4.847 a	2.308 a

Description: a. b = similar letter notation means there is no significant difference at the Duncan test level which has a value of 5%.

Based on Table 1, the ANOVA results indicate that there is no significant difference in erosion among the polyacrylamide (PAM) treatments for eight rain events (P>0.05). This suggests that the erosion data for eight rain events is not statistically significant but still exerts an influence. However, when the ANOVA test was conducted between the control plot, plot 2, and plot 4 for four rainfall events, a significant difference was observed. Since P1 and P2 had insignificant values, the ANOVA test was performed with P2 and P0 as control plot comparisons, along with P4. P3 was excluded from the ANOVA test in Table 2 due to vegetation factors affecting the erosion in P3, rendering PAM ineffective in erosion suppression compared to other plots.

Table 2. Results of ANOVA analysis between P0, P2, P4 and erosion

Component	Treatments		
	P0	P2	P4
Erosion (ton/ha)	9,092 b	4,646 a	4,198 a

Description: a. b = similar letter notation means there is no significant difference at the Duncan test level which has a value of 5%.

Based on the data and analysis results presented above, PAM demonstrates its effectiveness in suppressing erosion during eight rain events in this study. Erosion in P4 exhibited the lowest occurrence compared to other plots across all eight rain events. Conversely, from the first to the third and seventh rains, the control plot (P0) experienced the highest erosion rates compared to other plots. This indicates that the higher the PAM dose as a soil conditioner, the more effective it is in erosion suppression. However, from the fourth to the eighth rainfall, the plot with a PAM dose of 45 kg/ha, or P3, exhibited a higher erosion rate than the other plots. The significant factor contributing to the elevated erosion in P3 was the limited vegetation growth on the plot, with only 37 out of a total of 56 sweet corn plants present.

Vegetation plays a crucial role in erosion prevention by regulating the amount of rainwater reaching the ground through interception. Rainwater hitting the ground can dislodge soil particles, which may then be carried away by surface runoff, leading to erosion. Across the eight rain events, it was observed that a polyacrylamide (PAM) dose of 60 kg/ha reduced erosion by 53.16% compared to the control plots where PAM was not applied.

3.2. Effect of Polyacrylamide on N Nutrients Loss

Soil erosion and displacement can cause the loss of nutrients contained in the soil, so that the nutrients available in the soil for plants can be reduced and cause the growth of a plant to be not optimal.

Table 3. Results of ANOVA analysis between treatments and N nutrients loss

Component	Treatments				
	P0	P1	P2	P3	P4
N Nutrients Loss (%)	0.1825 b	0.1675 ab	0.1650 ab	0.1763 ab	0.1550 a

Description: a. b = similar letter notation means there is no significant difference at the Duncan test level which has a value of 5%.

Based on Table 3, the results of the ANOVA analysis indicated a significant effect of the polyacrylamide (PAM) treatment on the loss of N nutrients (P>0.05). Table 3 revealed that the plot treated with a PAM dose of 60 kg/ha (P4) exhibited the lowest amount of N loss compared to other plots, whereas the control plot (P0) experienced the highest amount of N loss.

Table 4. Comparison of the effect of polyacrylamide (PAM) on the loss of nutrient N with control plot (P0)

Treatment	N Nutrients Loss (%)			
	Treatment Plots	Control Plot (P0)	Difference	Percentage Drop
P1	0.1675	0.1825	0.0150	8.22%
P2	0.1650	0.1825	0.0175	9.59%
P3	0.17625	0.1825	0.00625	3.40%
P4	0.1550	0.1825	0.0275	15.07%

Table 4 shows the comparison of the average amount of N loss that occurred in treatment plots (P1, P2, P3, P4) with the control plot (P0). P4 (PAM 60 kg/ha) were able to minimize the loss of N nutrients that occurred due to soil erosion by 15.07%. Thus, the PAM dose of 60 kg/ha was the most effective dose in suppressing the loss of N nutrients that occurred in this study. Research conducted by Entry and Sojka (2003) also stated that nutrient loss by sediment and runoff was two to five times higher for control plots without PAM (polyacrylamide) application compared to plots treated with PAM (polyacrylamide).

3.3 Effect of Polyacrylamide on Sweet Corn Cultivation

Sweet corn was planted on February 18, 2022 but after 10 days from planting, some sweet corn plants did not grow so replanting was carried out. Replanting is done at the planting point that did not grow on March 1, 2022.

Table 5. Effect of polyacrylamide (PAM) on the growth and yield of sweet corns

Treatment	Plant Height	Stem Diameter	With Cornhusk			Without Cornhusk		
			Corn Weight	Corn Length	Corn Diameter	Corn Weight	Corn Length	Corn Diameter
P0	167,25 a	1,93 a	231,36 a	5,4 a	25,62 a	162,29 a	4,71 a	17,18 a
P1	192,5 ab	2,11 a	296,13 a	5,91 a	29,00 ab	203,21 a	4,82 a	19,76 b
P2	192 ab	2,18 a	266,08 a	5,65 a	28,31 ab	188,26 a	4,8 a	18,12 ab
P3	171,5 a	1,97 a	246,91 a	5,53 a	27,37 ab	176,77 a	4,73 a	18,93 ab
P4	208,875 b	2,33 a	297,35 a	5,86 a	31,06 b	182,07 a	4,62 a	19,56 ab

Description: a. b = similar letter notation means there is no significant difference at the Duncan test level which has a value of 5% , some data was published by Lovita et al 2023.

P4 with 60 kg/ha of PAM is the highest dose in the treatment carried out in this study. Plots with polyacrylamide (PAM) treatment were able to optimize the growth of sweet corn plants compared to plots without PAM dose treatment or control plot (P0). By using a PAM dose of 15 kg/ha, the plot was able to increase by 25.2% fruit weight without cornhusk, 9.4% fruit length with cornhusk, 2.34% fruit length without cornhusk, and 15% fruit diameter compared to the control plot. In addition, plots with PAM treatment of 60 kg/ha were able to increase 24.9% of plant height, 20.7% of plant stem diameter, 28.6% of fruit weight with cornhusk, and 21.2% fruit diameter with cornhusk.

If we look back at Table 1 and Table 2, P4 has the lowest amount of erosion based on 8 rain events, this shows that a high dose of polyacrylamide (PAM) also has a big influence on the soil, which is to suppress erosion and loss of nutrients that occur so it could optimize sweet corn cultivation. Based on this, it can be stated that the 15 kg/ha (P1) and 60 kg/ha (P4) of PAM are optimal in increasing the growth and yield of sweet corns. However, when considering the costs involved, the PAM dose of 15 kg/ha is the most optimal dose to optimize the growth and yield of sweet corns.

4. Conclusion

Polyacrylamide (PAM) influences erosion, the loss of N nutrients, and sweet corn cultivation. Statistically, the effect of PAM on erosion did not exhibit significant differences ($P>0.05$), whereas its impact on N nutrient loss, plant height, fruit diameter with or without cornhusk showed significant variations for each PAM treatment dose ($P<0.05$). The optimal PAM dose for mitigating erosion and N nutrient loss is 60 kg/ha (P4). P4, with a PAM dosage of 60 kg/ha, reduced erosion by 53.16% and decreased the loss of N nutrients by 15.07%.

The optimal doses of polyacrylamide (PAM) to enhance the growth and yield of sweet corn plants are 15 kg/ha and 60 kg/ha. A PAM dose of 15 kg/ha demonstrated the ability to increase corn weight without cornhusk, corn length with and without cornhusk, and corn diameter. Meanwhile, a PAM dose of 60 kg/ha enhanced plant height, stem diameter, corn weight with cornhusk, and corn diameter with cornhusk. However, considering the associated costs, the 15 kg/ha PAM dose emerges as the most optimal and efficient choice to optimize the growth and yield of sweet corn plants.

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