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Impact of Super Absorbent Polymer and Polyacrylamide on Water Holding Capacity on Ultisol, Lampung

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ABSTRACT

Methods of soil and water conservation in tropical wetlands have been carried out is using chemicals to increase the stability of soil aggregates and water-holding capacity. The experiment aims to improve soil stability using Polyacrylamide (PAM) and Super Absorbent Polymer (SAP) materials. Experiment was carried out in R&D Dept. PT. Great Giant Pineapple (PT. GGP), Lampung. The treatment was to mix ingredients into the water with variations the ratio of ingredients (g): water (ml), among others, 1:100, 1:200, 1:300, and 1:400. Next, the SAP/PAM material is mixed into 100 g of soil with a dose of 0 g, 4 g, 8.5 g and 10 g of SAP. After the soil was mixed with the SAP, take as much as 15 g and place it in a pot containing 1 kg of soil. Results experiment show the SAP is a polymer capable of increasing water availability in ultisols and sand used in the experiment and can increase the water content by 18% if compared control. Meanwhile, PAM is a more dominant polymer in its function as an aggregate adhesive instead of a water binder. Super Absorbent Polymer (SAP) and Polyacrylamide (PAM) can chemically function as chemicals for soil conservation.

Keywords: Super absorbent polymer, polyacrylamide, water holding capacity, ultisol

INTRODUCTION

Indonesia is a country that has a humid tropic climate, which is characterized by high relative humidity (more than 90%), high rainfall (more than 1500 mm year^{-1}), and temperatures ranging from 18^{o}-38^{o}C. The high rainfall in the humid tropic, high soil erodibility on ultisols, and high intensity of tillage on dry land can lead to high erosion rates. High soil erosion is exacerbated by the cultivation of monocultures on a large scale, which causes the soil not to have a canopy to withstand the blows of rainfall. Ramadhani and Nuraini (2018), Ultisols have low nutrient content, acidic pH, and high aluminum saturation caused by high rainfall. Ramadhani et al. (2023) showed that ultisols have a higher clay fraction component than a sand fraction. The high clay content can increase compaction in the soil. The problem in soils with high clay content is during high rainfall seasons, resulting in high runoff. But the dry season results in low water available in the soil. So this is the problem of ultisols. So it is necessary to add material to improve the stability of ultisol aggregates.

Various conservation methods have been carried out, including vegetative, mechanical, and chemical. One of the materials that can improve the stability of soil aggregates is the application of soil organic matter. However, the high rainfall in Lampung made organic matter very easy to leach. Cahyono et al. (2019) added that the problem with wet tropical land (especially Lampung) is high rainfall, accelerating the decomposition process and causing high leaching. Using soil amendments, including polyacrylamide (PAM) and Super Absorbent Polymer (SAP), is one option for protecting the soil from erosion.

PAM and SAP are soil ameliorant materials. Septiyana et al. (2016) explained, ameliorant materials are materials that can increase soil fertility and provide plant nutrients. Nurida and Jubaedah (2019) adding that the application of soil amendments can increase the availability of soil nutrients and can increase corn production in Lampung soil. Awad et al. (2012) explained that the application of PAM and biopolymers is a soil conservation technology.

PAM is a water-soluble polymer grouped in the form of a compound formed by the polymerization of acrylamide (Green, 2001). PAM is a polymer used for various purposes. The primary use of PAM in agriculture is to stabilize soil and prevent erosion (Inbar et al., 2015). The form and type of PAM used in erosion control are large, negatively charged (anionic) molecules (12-15 Mg per mole) soluble in water. The chemical structure of polyacrylic acid has an ionizable -COOH functional group. These polymer chains can be cross-linked at -OH.

Polyacrylamide (PAM) can stabilize soil structure but cannot remediate already poorly structured soil (Mamedov et al., 2021). In areas with arid and Mediterranean climates, PAM applications can be effectively used to improve and stabilize soil structure, increase soil infiltration, efficiently use irrigation water, and reduce erosion rates (Mamedove et al., 2020). PAM is a water-soluble polymer grouped in the form of a compound formed by the polymerization of acrylamide (Green, 2001). In addition, the application of PAM to soil is able to support the growth and survival of fungi and bacteria which function as soil aggregators (Caesar-TonThat et al., 2008). Dou and Wu (2012) explained that the PAM application was able to increase the infiltration volume compared to without the PAM application. In addition, applications without PAM have greater soil mass loss compared to PAM applications.

Super Absorbent Polymer (SAP) from Chinafloc is a highly absorbent-based water retainer that can increase water holding capacity for several years, reduce water loss, reduce irrigation frequency by up to 50% and reduce evaporation of water from the soil. Super absorbent polymer (SAP) is a material capable of absorbing up to 200 times the weight of liquid hydrogel material. Despite the pressure, the SAP material forms a gel structure and maintains the absorbed water content. SAP is made from acrylic acid monomer as raw material, plus cross-linking through suspension polymerization.

Super Absorbent polymers (SAP) are also a chemical conservation method widely used as a water-retaining material in agriculture and horticulture. When SAP is applied and mixed with soil, it can bind water and nutrients and is released slowly to plants in limited water conditions (Islam et al., 2011). This experiment tests SAP as a water-retaining material and PAM as a water-soluble polymer as a chemical method for improving soil physical properties.

MATERIALS AND METHODS

This research was conducted at R&D Dept. PT. Great Giant Pineapple (PT. GGP), Lampung. The research used a completely randomized design method, with experiments on a laboratory scale and

Figure 1. Measurement and mixing of materials with water.

(a) (b) (c) (d)

Figure 2. Mixing materials with soil. (a) K (100 g + 0 g SAP), (b) A (100 g + 4 g SAP), (c) B (100 g + 8.5 SAP), (d) C (100 g + 10 g SAP).

Figure 3. Sampling 15 g of soil and mixing with 1 kg of soil.

Figure 4. PAM and SAP Solution Filtering.

SAP PAM WATER SAP PAM WATER

(1 : 200) (1 : 300)

Figure 5. Comparison of the results of dissolving SAP and PAM.

greenhouse experiments. The research used is ultisols soil, sandy soil, and conservation material, including Super Absorbent Polymer (SAP) from China and Polyacrylamide (PAM). The experimental procedure is (1) Mixing PAM/SAP ingredients with water: Prepare glass beakers for SAP and PAM materials (Figure 1). Each glass beaker added 1 g of SAP/PAM; Then water was added according to the treatment with the ratio of SAP/PAM ingredients, namely: (a) 1g: 100ml, (b) 1g: 200ml, (c) 1g: 300ml, and (d) 1g: 400ml. Then dissolve until blended within 1 minute. Next, the solution was weighed. (2) Application of SAP material with soil (Figure 2). The soil used in this study is 100 g. This study was repeated 4 times for each treatment. The treatments in this study are (a) K (100 g + 0 g SAP), (b) A (100 g + 4 g SAP), (c) B (100 g + 8.5 SAP), and (d) C (100 g + 10 g SAP). After the soil was mixed with the SAP material according to the treatment, 15 g was placed in a pot containing 1 kg of soil (Figure 3). Then, the soil is watered according to the conditions of field capacity (Figure 4).

RESULTS AND DISCUSSION

Applying a higher concentration of PAM in water showed could bind soil particles. The higher the concentration of PAM in the water, the more viscous the solution and shaped like glue (Figure 5). Based on the experimental results, SAP is an effective water-retaining material; it is evident from the laboratory observations that the SAP solution has thick gel bubbles. Busscher et al. (2007) showed that applying Polyacrylamide (PAM) with a dose of 120 mg kg^{-1} can increase and improve the aggregation of loamy sand textured soils in America.

Athena et al. (2007) added that the application of PAM was able to increase the stability of soil aggregates if the compared to without the application of PAM. SAP is a polymer material that can absorb up to 200 times the weight of liquid hydrogel materials. When the SAP material is mixed with water, it forms a gel structure and retains the water content it absorbs. SAP is made of acrylic acid monomer as raw material, plus cross-linking through suspension polymerization.

Furthermore, after conducting observation tests in the laboratory regarding the comparison of SAP and PAM materials dissolved in water, the material was applied to the soil, which aimed to see the ultisol soil's water-holding capacity after applying SAP and PAM materials. Based on the observations results, it shows that the soil that has been applied to SAP can increase the water holding capacity. So that the SAP material can effectively bind the groundwater used in the experiment (Figure 6). Based on the observations results, it was shown that treatment C (100 g soil + 10 g SAP) had a higher soil water holding capacity compared to other treatments. SAP materials can also reduce the water loss rate in ultisols (Figure 7). In addition, applying SAP materials has higher water availability compared to the control 12 days after application (Figure 8). Similarly, other research found that when SAP is applied and mixed with soil, it can bind large amounts of water and nutrients and release slowly to plants under water-limited conditions in Islam et al., 2011). So, applying SAP material is very profitable during the dry season because it can bind water to the soil during the dry season.

Based on the results, the SAP material also has a good effect on increasing water availability in sandy soils. It can be seen that SAP can increase the water

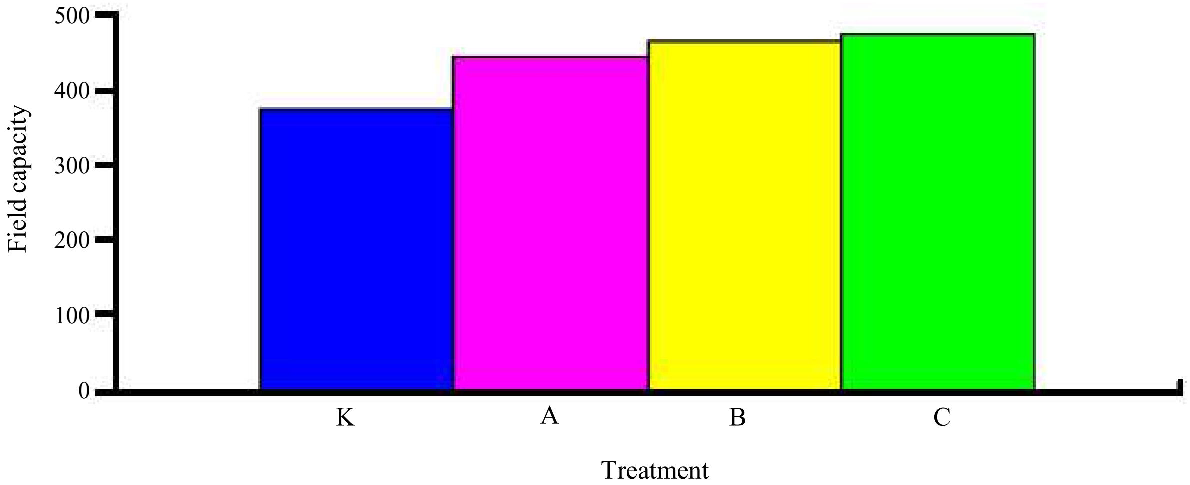
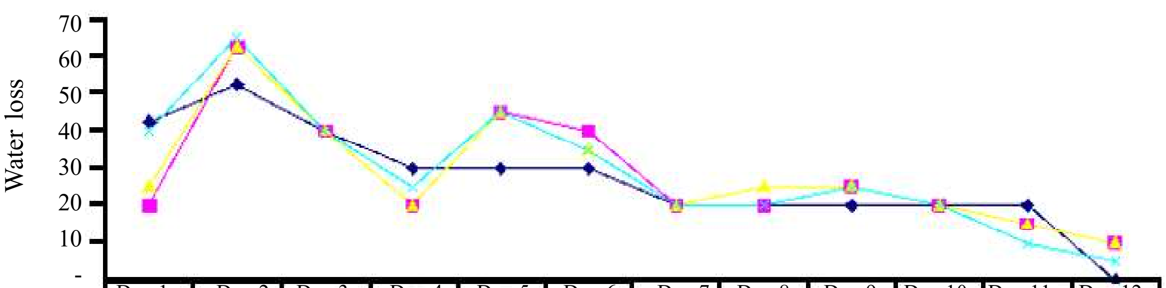
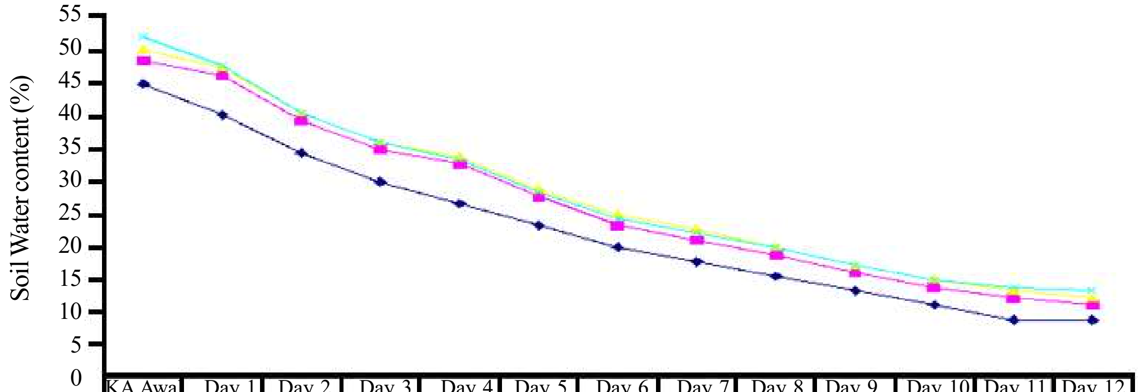


Figure 6. The field capacity of soil treated with SAP. (a) K(100 g + 0 g SAP), (b) A(100 g + 4 g SAP), (c) B (100 g + 8.5 SAP) and (d) C (100 g + 10 g SAP).



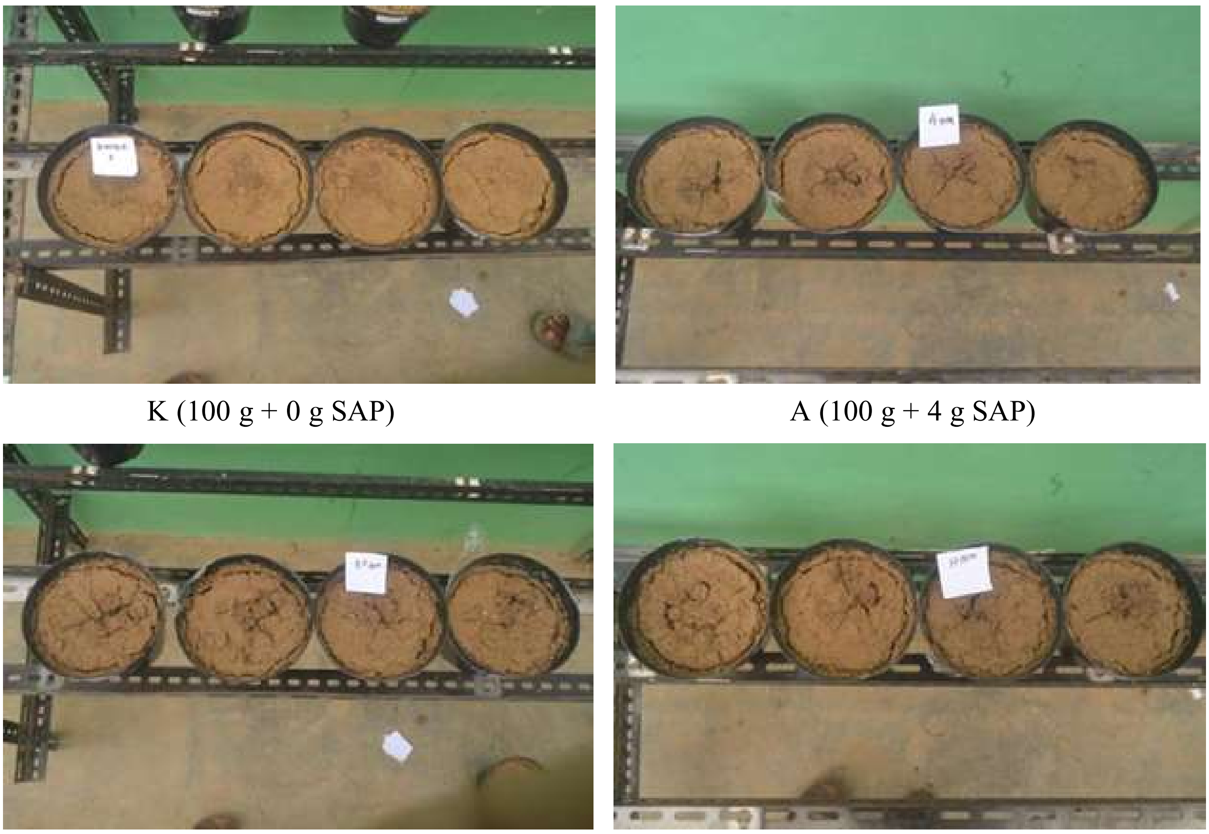
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
K	43	53	40	30	30	30	20	20	20	20	20	-
A	20	63	40	20	45	40	20	20	25	20	15	10
B	25	63	40	20	45	35	20	25	25	20	15	10
C	40	65	40	25	45	35	20	20	25	20	10	5

Figure 7. Water loss in various SAP treatments. (a) K (100 g + 0 g SAP), (b) A (100 g + 4 g SAP), (c) B (100 g + 8.5 SAP) and (d) C (100 g + 10 g SAP). —◆— : K, —■— : A, —▲— : B, —✳— : C.



	KA Awa	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12
K	45%	40%	34%	30%	27%	23%	20%	18%	16%	13%	11%	9%	9%
A	49%	46%	39%	35%	33%	28%	23%	21%	19%	16%	14%	12%	11%
B	50%	48%	41%	36%	34%	29%	25%	23%	20%	17%	15%	13%	12%
C	52%	48%	41%	36%	33%	28%	24%	22%	20%	17%	15%	14%	13%

Figure 8. The trend of decreasing water content in various SAP treatments. (a) K (100 g + 0 g SAP), (b) A (100 g + 4 g SAP), (c) B (100 g + 8.5 SAP) and (d) C (100 g + 10 g SAP). : K, : A, : B, : C.



K (100 g + 0 g SAP) A (100 g + 4 g SAP)

B (100 g + 8.5 g SAP) C (100 g + 10 g SAP)

Figure 9. Comparison of soil treated with SAP.

content by 18% when compared to the control (Figure 10).

In sandy soil, the water content and rate of decrease in water content in the soil-applied to SAP was also higher than in the control (Figure 11). When SAP is applied and mixed with soil, it can bind large amounts of water and nutrients and released slowly to plants in limited water conditions (Islam et al., 2011). The level of water losses in the soil experiment that was applied to PAM did not show

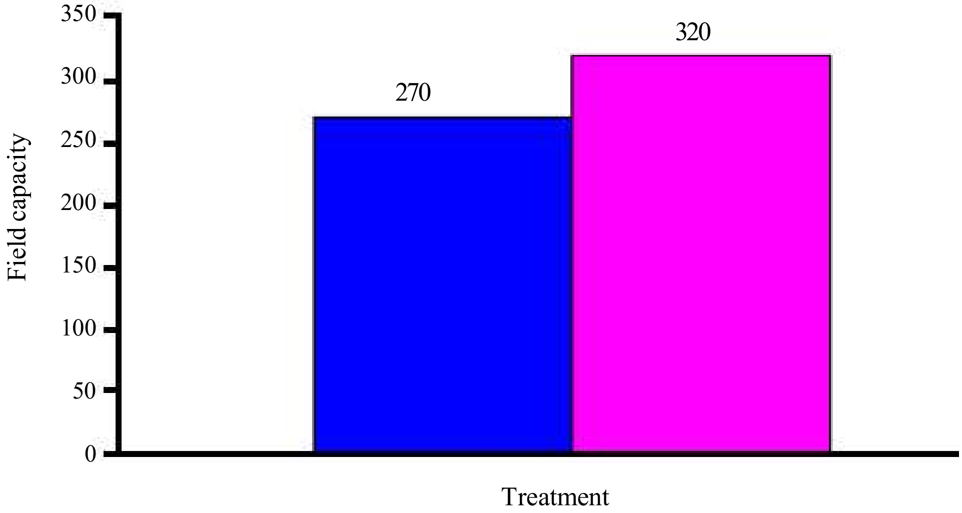
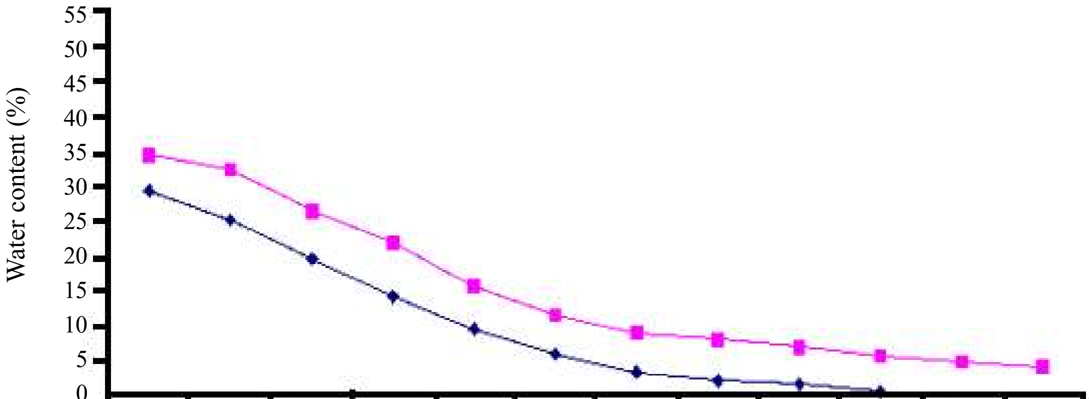


Figure 10. Comparison of SAP-treated soil with control on sandy soil.



	1	2	3	4	5	6	7	8	9	10	11	12
Kontrol	29%	25%	20%	14%	10%	6%	3%	2%	2%	1%		
SAP	35%	32%	27%	22%	16%	12%	9%	8%	7%	6%	5%	4%

Figure 11. The rate of decrease in soil water content in the soil applied to SAP vs. control. ◆ : Kontrol, ■ : SAP.

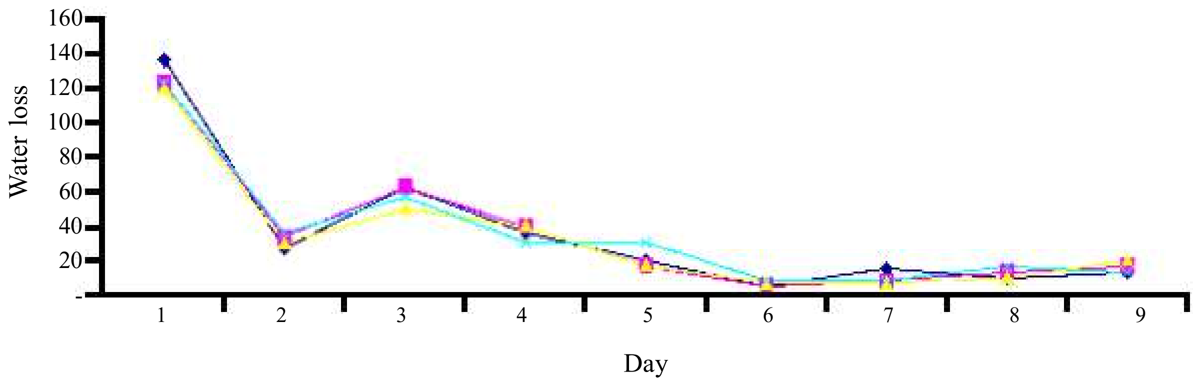
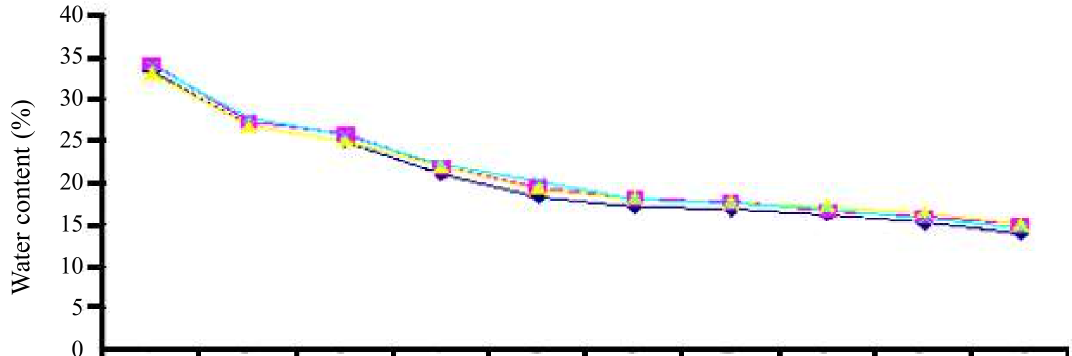


Figure 12. Water loss in various PAM applications (a) K (100 g + 0 g SAP), (b) A (100 g + 4 g SAP), (c) B (100 g + 8.5 SAP) and (d) C (100 g + 10 g SAP). ◆ : A, ■ : K, ▲ : B, ✕ : C.



	1	2	3	4	5	6	7	8	9	10
K	33%	27%	25%	21%	18%	17%	17%	16%	15%	14%
A	34%	27%	26%	22%	19%	18%	18%	17%	16%	15%
B	33%	27%	25%	22%	19%	18%	18%	17%	16%	15%
C	34%	28%	26%	22%	20%	18%	18%	17%	16%	15%

Figure 13. The rate of decrease in soil water content in the soil that was applied to SAP vs. control. (a) K (100 g + 0 g SAP), (b) A (100 g + 4 g SAP), (c) B (100 g + 8.5 SAP) and (d) C (100 g + 10 g SAP). : K, : A, : B, : C.

a significant difference compared to the control (Figure 12). PAM is more of a material to protect and strengthen soil aggregates, not a water-retaining material such as SAP. The rate of decrease in water content in the PAM treatment was also not different from that of the control (Figure 13).

CONCLUSIONS

The application of Super Absorbent Polymer (SAP) can increase the water-holding capacity in ultisols and sandy soils. The SAP application can increase water availability in the soil by 18% compared to the control on ultisols and sandy soils. In addition, PAM material is a dominant polymer that functions as an aggregate adhesive.

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