The Effect of Straw Mulch on Several Factors of Soil's Water Retaining Capacity During One Season of Upland Rice in Latosol Kemang, Bogor

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Abstract. To maximize the availability of water for plants, data on the amount, intensity and distribution of rain is needed, the amount of water infiltration, the maximum ability of the soil to retain water, the amount of water lost from the root zone, the water requirements of plants, and the dynamics of soil moisture. This study aims to determine the effect of straw mulch on several factors of available water in the soil during one growing season of upland rice in Kemang, Bogor. The study was conducted by factorial experiment with upland rice plants treated with straw mulch as much as 3 tons/ha and 6 tons/ha of straw mulch spread evenly on the soil surface or added to the soil and stirred evenly. Then analyzed the soil at the time of planting and harvest: soil organic matter content, water content, bulk density and porosity. The organic matter content of the soil at planting is higher than at harvest. Giving straw mulch which is put into the soil and stirred evenly is more effective in increasing the soil organic matter content. Giving more straw mulch can increase the amount of soil macro pore space and conversely the amount of soil micro pore space decreases. The available water content of the soil at planting is generally higher than at harvest. Applying straw mulch in large quantities means that the available water content of the soil is also quite high and if straw mulch is spread over the surface, the available water content of the soil is higher.

Keywords: Ability to hold water, available water and straw mulch

1 Introduction

Indonesia has a large and diverse territory, and each region has its own unique conditions, including its climate. This causes interactions between plants with different climatic conditions from one place to another. Information on climatic conditions of a place plays an important role in the development of agriculture in that place, because by knowing the relationship between plants and climate, predictions can be made of planting time, harvest time, occurrence of drought (water deficit), flooding (water surplus), pest and disease attacks, determining the appropriate type of plant, and so on. Climate data taken from a climatology station in a location is analyzed and interpreted to find out and understand its characteristics, so as to obtain information to be used in

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various development sectors, including in agriculture, is to adapt farming systems and technology packages to local climatic conditions [1].

The rainfall component is the only component of water input for agricultural land. For this reason, the use of rainfall data for various regional agro-climate analysis needs to be considered. In its application, the results of agro-climate analysis using monthly average rainfall values tend to only provide certain climate patterns. Therefore, the use of opportunity values in predicting rainfall is necessary to avoid the risk of drought due to over estimation or wastage of water/rain resources and time due to under estimate[2].

Differences in climatic conditions in each region will have different implications for the condition of the land water balance in each region. Due to the varied climatic conditions, it is necessary to know the groundwater condition periodically (at least monthly) by calculating the land water balance in each region. Its benefits include providing input to planners in developing better agricultural management measures taking into account the local climate. In addition, the results of land water balance calculations in an area can provide an overview of the growing season in that area; taking into account soil moisture content under optimum conditions, periods of water deficit and crop water requirements at various stages of plant development[3].

The movement of water in the soil in dry land is very important in the movement of nutrients (nutrient transport) and can be used to estimate the availability of water for plants. The availability of water for plants on dry land is still a problem, especially recently with regard to the impact of global climate change which affects the hydrological cycle. Rain, which is the main source of water on dry land, does not always come in sync with the water needs of plants, so that crop production cannot reach optimum. During heavy rains, most of the water can be lost through surface runoff or percolation to the zone beneath the roots, making it unavailable to plants. On days without rain the plants can lack water. Research in an effort to increase water availability for dry land plants has been carried out through improving soil structure, adjusting cropping patterns, and irrigation efficiency[4]. However, these efforts are rarely carried out by farmers.

To maximize water availability for plants, data on the amount, intensity and distribution of rain is needed, the amount of water infiltration (infiltration), the maximum ability of the soil to retain water, the amount of water lost from the root zone, plant water requirements, and soil moisture dynamics. Until now there has been no research on the relationship between the properties of rain and the movement of water or the dynamics of water content in the soil. The dynamics of water content in dryland soil is largely determined by the movement of water, as well as the rate of change of water content in the soil[5].

The movement of water as well as the rate of change of water content in the soil is largely determined by the characteristics of the soil pores that make up the soil structure, such as pore distribution and pore continuity. As a result of the various soil management practices that have been carried out by farmers, dry land has a very varied soil structure, which affects its pore characteristics. Differences in soil structure due to various management, can affect the soil's ability to retain water and the movement of both saturated and unsaturated water in the soil[6].

Based on the description above, to address the water demand in dry land, information is needed about the relationship between rainfall and water movement and its dynamics in soils that have different pore characteristics due to differences in soil management[7]. This information is useful in soil management on dry land, especially in relation to water conservation and its availability to plants. This study aims to examine: 1). Movement of water in soils with different pore characteristics due to management, 2). The pore characteristics that most influence the movement of water and the dynamics of water content, and 3). Availability of water on dry land with different pore characteristics due to soil management.

This study aims to determine the effect of straw mulch on several factors of available water in the soil during one growing season of upland rice in Kemang, Bogor.

2 Research Method

The research was conducted from February 2022 during one growing season of upland rice on agricultural land in Kemang, Bogor Regency. The soil in the study area is reddish brown Latosol.

The study was conducted with a factorial experiment arranged in a randomized block design with 3 replications. Upland rice plants treated with organic matter in the form of straw mulch with the following distribution: Po (without straw mulch), P1 (3 tons/ha straw mulch spread evenly on the soil surface), P2 (6 tons/ha straw mulch spread evenly on the soil surface), P3 (3 tons/ha of straw mulch put into the soil and mixed thoroughly), and P4 (6 tons/ha of straw mulch put into the soil and mixed evenly), and K (without plants and without straw mulch). Upland rice plants were planted with a spacing of 20 x 30 cm and given basic fertilizers per hectare, namely 200 kg of urea, 200 kg of TSP and 100 kg of KCl.

This research was conducted on agricultural land with upland rice plants. The soil at the time of planting and harvesting was analyzed for soil organic matter content using the Walkley and Black method, the texture was determined by the pipette method and the water content was determined by determining the stress curve pF 1.0; pF 2.0; pF 2.54 and pF 4.2, bulk density and porosity with intact soil samples.

3 Result and Discussion

3.1 Soil Organic Matter Content

Based on the research results presented in Table 1, the soil organic matter content at planting is higher than at harvest. Giving more and more straw mulch, the soil organic matter is also higher. Statistical analysis showed that the effect of providing organic matter in the form of straw had a significant effect on the soil organic matter content at harvest. The soil organic matter content at harvest in the plots treated with P1 (3 tons/ha of straw mulch spread evenly on the soil surface) was not statistically significantly different from that of P3 treatment (3 tons/ha of straw mulch was added to the soil and stirred evenly). But the soil organic matter content in the two treatments P1 (3 tons/ha straw mulch spread evenly on the soil surface) and P3 was significantly different when compared to the P4 treatment plot (6 tons/ha straw mulch was added to the soil and stirred evenly). This shows that the provision of straw mulch which is inserted into the soil and stirred evenly is more effective in increasing the soil organic matter content.

Table 1. Average soil organic matter content at planting and harvesting of upland rice

Treatment	Average soil organic matter content **(%)**		
	When Planting	At Harvest*	Decline
Po	2.2	1.4ab	36.36
P1	2.3	1.3a	43.48
P2	2.1	1.4ab	33.33
P3	2.0	1.3a	35.00
P4	2.1	1.6b	23.81

*Numbers followed by different letters in the column at harvest indicate a significant difference at the 5% level.

The treatment of straw mulch had a significant effect on the soil organic matter content at harvest, but the organic matter content when compared between planting and harvesting decreased. The largest decrease in soil organic matter content occurred in the plots treated with P1 (3 tons/ha of straw mulch spread evenly on the soil surface) and P3 (3 tons/ha of straw mulch put into the soil and stirred evenly). This is presumably because the amount of straw mulch that is added is less or even that is not given straw mulch. The P4 treatment (6 tons/ha of straw mulch put into the soil and stirred evenly) showed the lowest reduction in organic matter content. This is presumably because straw mulch which is put into the soil and stirred evenly in large quantities relatively quickly and effectively turns into soil organic matter during one growing season of upland rice. Straw mulch can increase infiltration and soil organic matter content so that it can improve granulation which in turn is expected to increase the amount of water that the soil can hold at a certain water stress level. The ability of soil to hold water at a certain water stress level is influenced by texture, structure, and percentage of organic matter[8].

3.2 Soil Macro Pore Space

Table 2 shows the average soil macro pore space. The amount of soil macro pore space at planting is lower than at harvest. Statistical analysis showed that straw mulch had a significant effect on the amount of soil macro pore space at harvest. The amount of soil macro pore space at harvest in the plots treated with Po was not statistically significantly different from treatments P1 (3 tons/ha straw mulch spread evenly on the soil surface) and P3 (3 tons/ha straw mulch put into the soil and stirred evenly), but the amount of macro pore space in the three treatments was significantly different from the plots treated with P2 (6 tons/ha straw mulch spread evenly on the soil surface) and P4 (6 tons/ha straw mulch put into the soil and stirred evenly). This shows that the provision of straw mulch with a greater amount can increase the amount of soil macro pore space.

The treatment of straw mulch significantly affected the amount of soil macro pore space at harvest, but the amount of soil macro pore space when compared between planting and harvest increased. The largest increase in soil macro pore space occurred in the plots treated with P2 (6 tons/ha of straw mulch spread evenly on the soil surface) and P4 (6 tons/ha of straw mulch was added to the soil and stirred evenly). This is presumably because the amount of straw mulch that is added is less or not even given mulch. The P4 treatment (6 tons/ha of straw mulch put into the soil and stirred evenly) showed the highest increase in the number of soil macro pore spaces. The increase in soil macro pore space is thought to be due to the straw mulch treatment. The presence of straw mulch causes the conditions underneath to be very suitable for increasing microbial activity which tends to be active in aerobic conditions, so that animals such as caterpillars, worms etc. are stimulated for their activities. The activities of these animal form hole which eventually become large pores.

Table 2. Average soil macro pore space at planting and harvesting of upland rice

Treatment	Average soil macro pore space **(%)**		
	When Planting	At Harvest*	Delta
Po	20.2	19.5a	- 3.47
P1	19.5	21.1ab	8.21
P2	19.2	22.8b	18.75
P3	19.2	22.1ab	15.10
P4	18.8	22.7b	20.74

*Numbers followed by different letters in the column at harvest indicate a significant difference at the 5% level.

3.3 Soil Micro Pore Space

Table 3 shows the average soil micro pore space. The amount of soil micro pore space at the time of planting is higher than at harvest. Statistical analysis showed that straw mulch had a significant effect on the amount of soil micro pore spaces at harvest. The amount of soil micro pore space at harvest on the plots treated with Po was not statistically significantly different compared to the P2 treatment (6 tons/ha straw mulch spread evenly on the soil surface) and P4 (6 tons/ha straw mulch put into the soil and stirred evenly), but the amount of micro pore space in the three treatments was significantly different from the plots with treatment P1 (3 tons/ha straw mulch spread evenly on the soil surface) and P3 (3 tons/ha straw mulch put into the soil and stirred evenly). This shows that the provision of straw mulch with a greater amount of the amount of soil micro pore space is lower.

The treatment of straw mulch had a significant effect on the amount of soil micro pore spaces at harvest, however, when compared between the time of planting and after harvest, there was a decrease in the number of soil micro pore spaces. The largest reduction in soil micro pore space occurred in the plots treated with P1 (3 tons/ha of straw mulch spread evenly on the soil surface) and P3 (3 tons/ha of straw mulch was added to the soil and stirred evenly). The P4 treatment (6 tons/ha of straw mulch put into the soil and stirred evenly) showed the lowest decrease in the number of soil micro-pore spaces. The decrease in micro pore space is thought to be caused by the treatment of straw mulch which can increase microbial activity which forms large pores.

Table 3. Average soil micro pore space at planting and harvesting of upland rice

Treatment	Average soil micro pore space (%)		
	When Planting	At Harvest*	Decline
Po	46.0	43.7ab	5.00
P1	47.5	45.4b	4.42
P2	50.7	42.6ab	15.98
P3	48.2	44.4b	7.88
P4	47.0	39.2a	16.60

*Numbers followed by different letters in the column at harvest indicate a significant difference at the 5% level.

3.4 Available Water Content in Soil

Table 4 shows the available water content in the soil. The available water content of the soil at planting is generally higher than at harvest. Statistical analysis showed that the application of straw mulch had a significant effect on the available water content of the soil at harvest. The available water content of the soil at harvest in the plots treated with Po was not statistically significantly different from the P3 and P4 treatments (6 tons/ha of straw mulch was put into the soil and stirred evenly), but the available water content in the soil in the three treatments was significantly different from plots treated with P2 (6 tons/ha straw mulch spread evenly on the soil surface). Giving straw mulch with a large amount of available water content of the soil is also quite high. This shows that the provision of straw mulch is spread over the surface, the available water content of the soil is higher.

Table 4. The average available water content in the soil at the time of planting and harvesting of upland rice

Treatment	Average available water content (%)		
	When Planting	At Harvest*	Decline
Po	10.0	7.4ab	17.8
P1	10.8	7.5ab	25.7
P2	10.7	9.2b	8.9
P3	11.3	6.7a	40.7
P4	11.2	7.1a	36.6

*Numbers followed by different letters in the column at harvest indicate a significant difference at the 5% level.

The treatment of straw mulch significantly affected the available water content of the soil at harvest, but the available water content in the soil when compared between planting and harvesting decreased. The largest reduction in soil available water content occurred in the plots treated with P3 (3 tons/ha of straw mulch put into the soil and mixed thoroughly) and P4 (6 tons/ha of straw mulch put into the soil and mixed evenly). The P2 treatment (6 tons/ha of straw mulch spread evenly on the soil surface) showed the lowest decrease in available soil water content. The decrease in available water content is thought to be caused by the treatment of straw mulch which is spread over the soil surface to inhibit evaporation.

The availability of water in the soil is also affected by the ability of the soil to hold water. Table 5 shows the water content in the soil at the time of planting and at harvest. The statistical results show that the application of straw mulch has no significant effect on the soil's ability to hold water with a stress curve of 1,0 pF; pF 2,0; pF 2,54 and pF 4,2 at harvest. However, the ability of the soil to hold water when compared between planting and harvesting has decreased. The amount of decrease in the ability of the soil to retain water in the plots treated with P1 (3 tons/ha of straw mulch was spread evenly on the soil surface) and P3 (3 tons/ha of straw mulch put into the soil and stirred evenly) was greater than in the plots with P2 treatment (6 tons/ha straw mulch spread evenly on the soil surface) and P4 (6 tons/ha straw mulch put into the soil and stirred evenly), thus the more mulch given, the higher the soil's ability to hold water so that the water content is available in the soil also getting higher.

Table 5. Soil water content at the time of planting and harvest with the determination of the stress curve pF 1.0; pF 2.0; pF 2.54 and pF 4.2.

Treat-ment	Soil water content **(%)**							
	pF 1,0		pF 2,0		pF 2,54		pF 4,2	
	When Planting	At Harvest	When Planting	At Harvest	When Planting	At Harvest	When Planting	At Harvest
Po	54.5	50.1	47.8	45.3	42.2	44.5	33.5	35.6
P1	53.7	48.6	49.6	42.3	44.4	42.2	34.6	34.3
P2	56.2	57.3	51.7	53.0	48.7	52.7	40.0	36.6
P3	55.9	53.3	53.0	46.2	50.3	45.4	37.3	36.6
P4	56.4	58.1	52.7	49.1	48.6	45.4	40.9	42.1

4 Conclusion

This research can be concluded that

1. The organic matter content of the soil at planting is higher than at harvest. Giving straw mulch which is put into the soil and stirred evenly is more effective in increasing the soil organic matter content.
2. The amount of soil macro pore space at planting is lower than at harvest and conversely the number of soil micro pore space is higher. Giving more straw mulch can increase the amount of soil macro pore space and conversely the amount of soil micro pore space decreases. This was clearly seen in the P4 treatment (6 tons/ha of straw mulch was added to the soil and stirred evenly).
3. The available water content of the soil at planting is generally higher than at harvest. Applying straw mulch in large quantities means that the available water content of

the soil is also quite high and if straw mulch is spread over the surface, the available water content of the soil is higher. This is the provision of straw mulch which is spread over the soil surface to inhibit evaporation and a higher water holding capacity.

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