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by Jaya Negara Negara

RESEARCH ARTICLE | MAY 30 2023

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AIP Conference Proceedings 2596, 060001 (2023)
https://doi.org/10.1063/5.0134409

Experimental Model to Increase Water Holding Capacity in Dry Land Irrigation

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Abstract. As one of the provinces in Eastern Indonesia, West Nusa Tenggara Province has a vast dry land potential of almost 161.874 ha spread over the southern, eastern, and northern parts of Lombok Island, while on Sumbawa Island, it is distributed in all districts. In general, the dry land irrigations are limited rain and soil texture. The texture of dry land irrigated soil on the island of Lombok is generally sandy, so the productivity is very high. The ability of the soil to hold water is deficient, and the time to bind soil moisture is short. Likewise, the rain intensity of dry land irrigation on Lombok Island is very short, causing the low success rate of dry land irrigation agricultural production is very low. To increase the ability of porous soils their resistance to irrigation water efforts to improve soil texture by replacing the sandy porous soil layer by replacing or mixing the porous soil in the root zone with fine-grained soil. The research design was carried out in a laboratory with experimental modeling. Modeling is done by mixing porous soil with fine-grained soil in several portions of the mixture. Furthermore, rainfall modeling was carried out with several variations of rain intensity and measurements of soil moisture and runoff were carried out both through the surface and below the surface. The composition of the soils mixture used is 25% and 50%. Rain is simulated with 20 minutes, 40 minutes, and 60 minutes of rain duration. The modeling results show that mixing porous soil with

fine-grained soil can increase soil moisture and water-binding time in the root zone is longer. For the percentage of fine-textured soil 25% with a rain duration of 20 minutes, the humidity can be increased to 48.25%, for 40 minutes, the moisture rises to 52.50%, and at a rain duration of 60 minutes, the humidity increases to 50.94%.

INTRODUCTION

The dry land area in West Nusa Tenggara Province is dominated by its cultivation activities, including rainfed rice farming, fields, plantations, and mixed gardens. Dryland productivity is very low because it is influenced by several factors, including the common utilization of water-saving technology, very porous soil conditions, and limited water availability. The dryland farming management system is very different from conventional irrigation, which has very high complexity and variety with an increased risk of failure. To make dry land into productive land is very difficult because it is faced with various constraints, including:

1. Physical and technical factors include low soil fertility, very high soil porosity, low rainfall intensity.
2. Socio-economic aspects of the community include small-scale farming.
3. The realization of the use of dry land for agriculture is still low.
4. Dryland processing is done simply.
5. Sustainable dryland conservation is very low.

The principle of giving water to dry land is the use of water that is efficient, effective, economical, and on target. The availability of water on dry land has always been an inhibiting factor because rainwater that falls on the surface cannot fill water reserves in the soil [1]. Irrigation of dry land needs to pay attention to soil properties and climate, water sources, and types of plants. Soil physical properties that need attention are especially soil texture and structure [2]. It is crucial to improve the texture of dryland soils with high porosity

Proceedings of the 1st Unhas International Conference on Agricultural Technology (UICAT 2021)
AIP Conf. Proc. 2596, 060001-1–060001-7; https://doi.org/10.1063/5.0134409
Published by AIP Publishing. 978-0-7354-4429-4/$30.00

into a land that can bind and hold water for a long time. In achieving this goal, the modeling of the mixing of porous soil with fine-textured soil is carried out.

Sustainable dryland management is a management system that aims to improve the quality of dry land to support productive agriculture that can meet the needs of human life sustainably without reducing the quality of the land resource itself [3, 4]. used asphalt material by layering it on specific areas and spraying it on the soil surface to retain water, reduce erosion of the porous soil surface layer and reduce direct evaporation through the soil surface. The addition of finer textured soil to marginal sandy soils, which are generally relatively lower in physical and chemical properties, can change some soil properties for the better. These properties include increasing the soil texture class to be refined from sand to clay or sandy loam [5]. Soil texture is the ratio of relatively acceptable to coarse fine soil fractions of various sizes (clay, silt, and sand). Water in the soil is retained by the surface absorption forces of the soil grains and the tension between the water molecules [6]

Around the soil grains, there is a hygroscopic membrane of water which is absorbed intensively. The farther the water is from the surface of the soil grains, the weaker the absorption force. The force that resists the movement of water is called the water holding capacity and is expressed by the energy required to separate the water from the soil. Water that can move in the soil is capillary water and gravitational water. Because the water-holding force is considered to work under the maximum rising water pressure, it is calculated as capillary tension or capillary potential [7]. Generally, the force is expressed in pF, which is the logarithm of the water pressure h (cm) or log 10 h. The amount of water that the soil can hold is called its water holding capacity.

The maximum water holding capacity of the soil is the capacity at high groundwater levels. In this situation, water with pF = 0 is found in the part of the soil layer closest to the groundwater level. In comparison, the minimum water holding capacity is the amount of water remaining from the natural drainage of saturated soil expressed in percentage (%).

MATERIALS AND METHODS

Materials

The materials used in the research are in the form of:

a. Porous soil was taken from dry land locations.
b. Fine-grained soil in the form of humus soil.

Research Equipment

The equipment research used is a set of rain-flow modeling tools to model the soil mixture, show in Fig. 1.

a. Rainfall recorder.
b. Soil sampling tool.

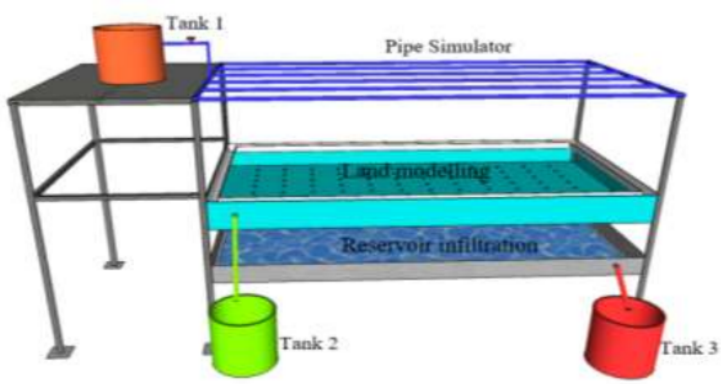


FIGURE 1. Rainfall Simulator.

Methods

Soil Sampling

Research material in the dry land location of North Lombok Regency, arid land with very porous soil conditions.

Preliminary test

Test the modeling tools to ensure that all devices are working correctly.

Running model

The running model is done by modeling rain flow on modified land. The modeled soil mixtures are 1%: 25% and 1%: 50%.

Data analysis

Step of analysis include:

a. Rainfall intensity
The intensity of rainfall is expressed in terms of rain per unit time. The unit used is mm/hour. Rain intensity equation value:

$$I = \frac{R}{t} \quad (1)$$

Where:
I = rainfall intensity (mm/minute);
R = depth of rainfal (mm); and
t = rainfall duration (minute).

b. Soil texture analysis
Soil texture indicates the state of the smoothness and roughness of the soil. The size of each grain in the soil. The USDA classifies soil texture into:
- Sand: granules with a diameter of 2.0 mm to 0.05 mm;
- Silt: granules with a diameter of 0.05 mm to 0.002 mm; and
- Clay: granules with a diameter smaller than 0.002 mm.

c. Soil Permeability
Soil permeability is defined as the nature of the porous material that allows the flow of seepage from liquids in the form of water or oil to flow through the pore cavities. Using the constant head method, the soil permeability test is very suitable for granular soil types. In the following equation, the magnitude of the coefficient of soil permeability is obtained by:

$$k = \frac{Q \,.\, L}{h \,.\, A \,.\, t} \quad (2)$$

Where:
k = soil permeability coefficient;
Q = volume of water contained in the glass (m^3);
L = length of the test object (m);
A = area of the test object (m2); and
t = time (hour).

d. Soil moisture analysis
Soil moisture is the ratio between the weight of water contained in the soil and the dry weight of the soil expressed in percent (%). The following equation can calculate the value of Soil moisture:

$$\%\, Moisture\ Content = \frac{Ww}{Ws} \quad (3)$$

Where:
Ww = water weight; and
Ws = Soil weight.

RESULTS AND DISCUSSION

Soil Moisture Existing Condition

Soil moisture content testing was carried out on porous soil from dry land, clay soil, and humus soil as a mixer. The results of the soil moisture test are shown in Fig. 2 below.

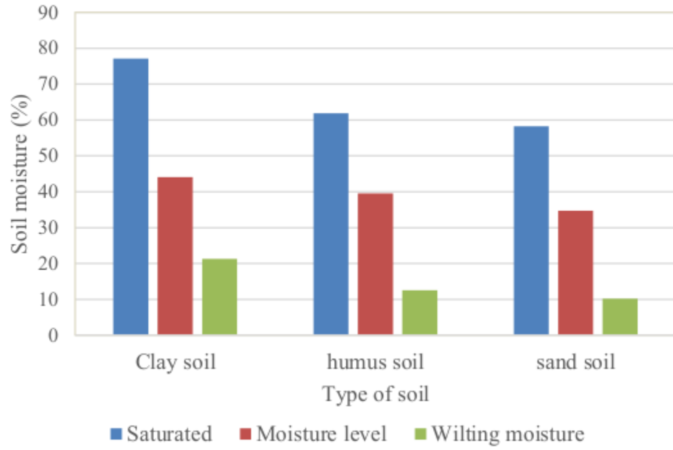


FIGURE 2. The Moisture Content of Each Soil.

The graph Fig. 2 shows that dry land sandy soil has the lowest moisture content compared to clay and humus soils.

Rainfall Intensity

Testing the intensity of rain on a rainfall simulator using a manual rain gauge. The duration of the rain given is 20 minutes, 40 minutes, and 60 minutes, respectively.

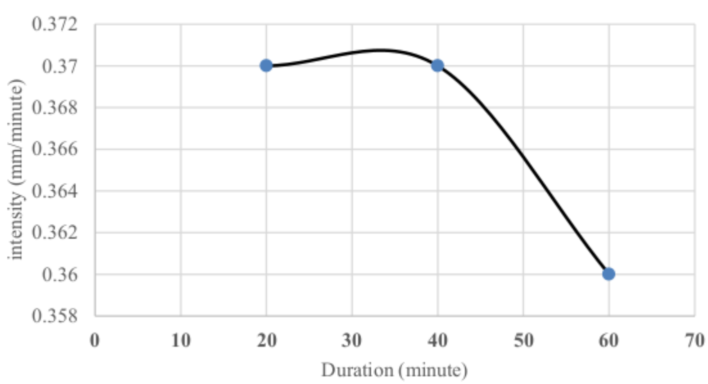


FIGURE 3. Rainfall Intensity.

Based on Fig. 3. It shows that the average rainfall intensity that occurs with a duration of 20 minutes, 40 minutes, and 60 minutes is 0.37 mm/minute.

Soil Moisture

The soil moisture conditions are porous after being given rain with an intensity of 0.37 mm/minute. The moisture value varies at each depth. Humidity trends show a very significant decrease, especially at 0 hours. In the soil surface layer, the average humidity ranges from 30% to 35%, and at a depth below 30 cm, the constant humidity is 5%. Soil moisture trends to be steady at 24 hours to 72 hours, especially at a soil depth of 5 cm to 35 cm, which is in the range of 15% to 23%, as shown in Fig. 4(a)(b)(c).

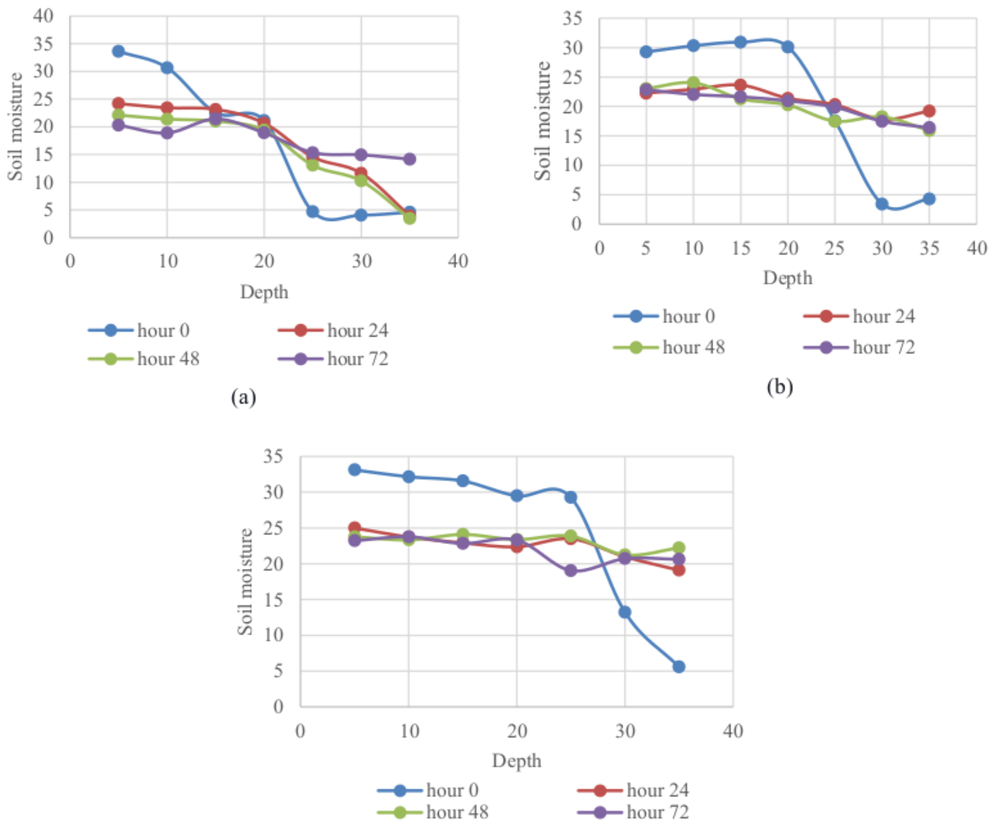


FIGURE 4. (a) Graph of Soil Moisture at Each Depth for a Rain Duration of 20 Minutes; (b) Graph of Soil Moisture at Each Depth for a Rain Duration of 40 Minutes; (c) Graph of Soil Moisture at Each Depth for a Rain Duration of 60 Minutes.

Soil Moisture with a Mixture of Porous with Hummus 1%: 0.25%

In the soil mixture with a ratio of 1 porous: 0.25 humus (1%: 0.25%), the moisture behavior increased both with the provision of rain with a duration of 20 minutes, 40 minutes, and 60 minutes. Soil moisture becomes very
stable and lasts up to a depth of 72 cm, especially at rain durations of 40 minutes and 60 minutes. The average soil moisture in these conditions ranges from 20% to 35%. The soil moisture behavior in this treatment is shown in Fig. 5 (a)(b)(c).

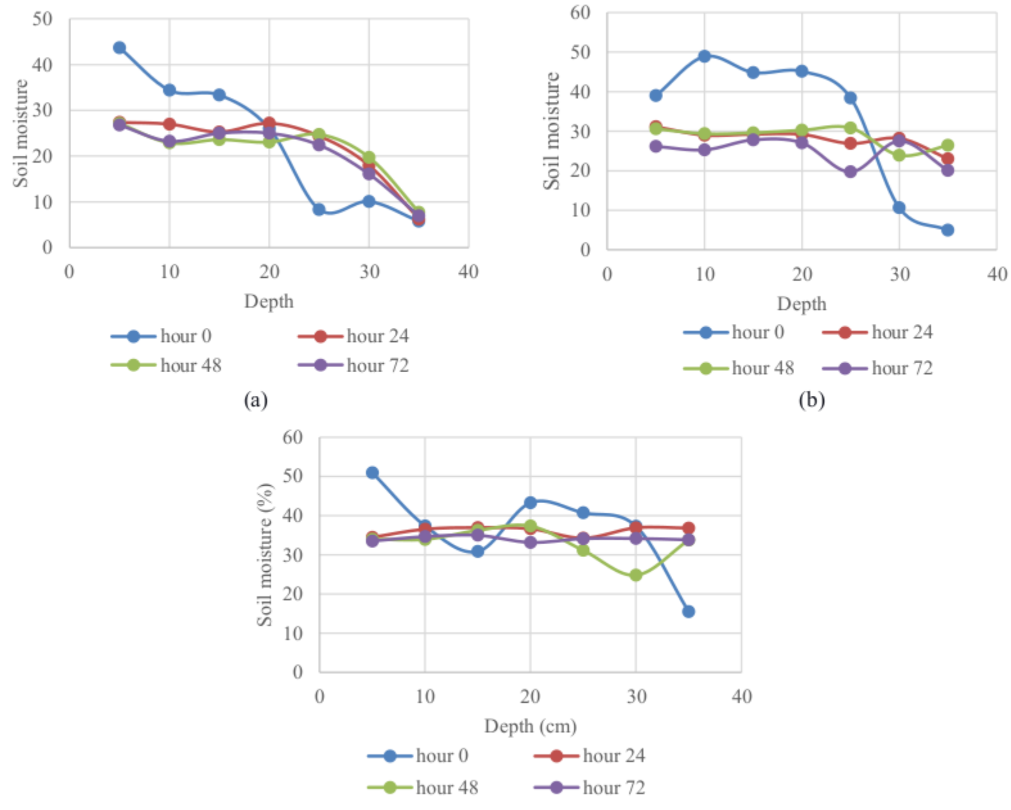
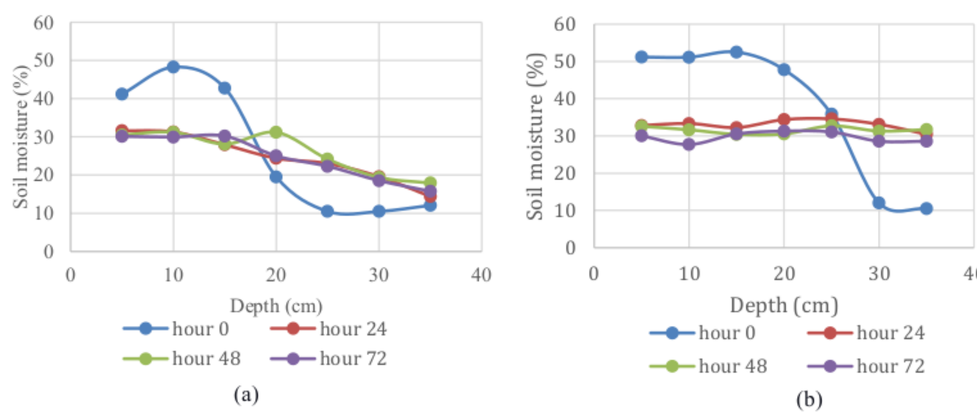
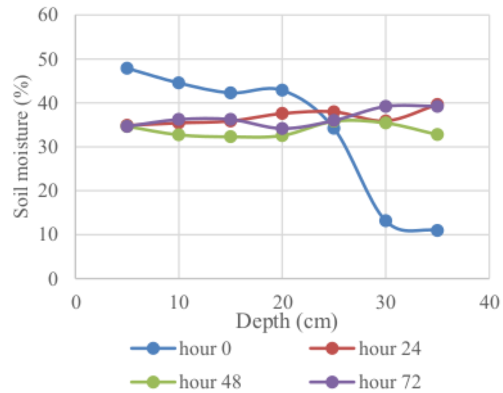


FIGURE 5. (a) Graph of Soil Moisture at Each Depth with a Rain Duration of 20 Minutes with a Mixture Of 1%: 0.25%; (b) Graph of Soil Moisture at Each Depth with a Rain Duration of 40 Minutes with a Mixture of 1%: 0.25% (c) Graph of Soil Moisture at Each Depth with a Rain Duration of 60 Minutes with a Mixture of 1%: 0.25%.

Soil Moisture Mixture of Porous and Hummus with a Ratio of 1%: 0.5%

The pattern shown from soil moisture with a mixture of 1% porous and 0.5% humus is almost the same as the pattern of a 1% absorbent: 0.25% humus, but the increase in moisture is more significant, especially at the rain duration of 40 minutes and 60 minutes. Humidity at 72 hours increased very significantly at all depths, namely between 30% to 40%.





(c)

FIGURE 6. (a) Graph of Soil Moisture at Each Depth at a Rain Duration of 20 Minutes with a Mixture of 1%: 0.50 %; (b) Graph of Soil Moisture at Each Depth at a Rain Duration of 40 Minutes with a Mixture of 1%: 0.50% (c) Graph of Soil Moisture at Each Depth at a Rain Duration of 60 Minutes with a Mixture of 1%: 0.50%.

CONCLUSION

Based on the analysis results by modifying the porous land by mixing it with fine-grained soil, the results are very significant. Treat the porous soil mixture with hummus in a ratio of 1%: 0.25% and 1%: 0.50% and on the provision of rain with a duration of 20 minutes, 40 minutes, and 60 minutes, the increase in soil moisture ranged from 20% - 50% within a period time 72 hours. The shows that the treatment by giving a mixture of humus soil will be very beneficial for providing irrigation water for dry land.

ACKNOWLEDGMENTS

This research was entirely carried out in the Geotechnical and Hydraulics and Coastal Engineering Laboratory, Department of Civil Engineering, University of Mataram. Soil samples were taken from the dry land area of the North Lombok Regency. We express our appreciation to all parties who have supported this research.

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8