Effect of differences in soil tillage and application of organic fertilizers on soil water content and yield of upland rice

J Barus¹, Y Pujiharti², Endriani³ and E Novitasari¹

¹ Lampung Assessment Institute for Agricultural Technology, Lampung, Indonesia
² Indonesian Center for Food Crops Research and Development, Bogor, Indonesia

E-mail: junitabarus65@gmail.com

Abstract. The research objective was to increase upland rice yield and balancing it with efforts of land conservation to maintain sustainable land productivity. It has been conducted in the research station of Lampung Assessment Institute for Agricultural Technology (AIAT). The treatments were arranged in a factorial randomized block design with three replications. The treatment in the main plot was the method of tillage whereas the subplot was organic fertilizers. The tillage methods were: (1) Maximum tillage and without ditch, (2) Minimum tillage with ditch. The organic fertilizer treatments were control, bio urine plus 10 L ha⁻¹, bio urine plus 20 L ha⁻¹, biodecomposer 10 L ha⁻¹, and biodecomposer 20 L ha⁻¹. The upland rice variety was Inpago 12. The variables observed were soil water content, growth and yields of rice. The results showed that the minimum soil tillage with ditch provided a higher soil water content than the maximum tillage. Likewise, the application of liquid organic matter from local microorganisms (biodecomposer) increased soil water content compared to the control. Application of bio urine plus 20 L ha⁻¹ significantly increased plant height and yield. The highest dry grain was obtained in the treatment of minimum tillage and biodecomposer 20 L ha⁻¹.

1. Introduction

Upland rice is usually planted on dry land that does not have irrigation facilities such as on paddy fields. Therefore, soil management before planting is very important to make it a good planting medium. Unstable and uneven yearly rainfall cause upland rice to be at risk of water stress and the yields are not optimal [1]. In general, dry land in Indonesia has been degraded which is characterized by soil compaction, decreased water absorption, water imbalance, blocked aeration, and increase surface runoff and soil erosion [2]. For this reason, soil conservation measures are required which aims to protect the soil against damage caused by raindrops falling, slowing runoff, increasing infiltration capacity and improving aeration and providing water supply for plant. Soil tillage is usually applied before planting to improve soil structure and aeration, so that the seeds can germinate and grow well. The research results show that differences in soil cultivation (maximum tillage or minimum tillage) have a significant effect on the growth and yield of cassava [3].

Organic matter content in dry land is generally low to very low. Soil organic C content is an indicator of soil fertility that affects other soil properties in supporting plant growth [4]. Additionally, organic matter has an impact on soil chemical fertility, especially on increasing soil C-total content [5], increasing infiltration water, reducing soil evaporation, and increasing groundwater storage capacity [4]. Returning organic matter can improve the physical quality of the soil indicated by aggregate stability, density of contents, total porosity, and soil water content [6, 7]. Increasing water retention capacity is...
an important role for organic matter in dry land, where water availability often becomes a constraint in

crop production. Application of land conservation techniques and organic fertilizers improve soil

g properties and reduce soil erosion [8].

In agricultural systems under conventional tillage, water infiltration is influenced by land preparation

and its interaction with the physical properties of the soil and surface vegetal cover. Water infiltration

into the soil is more influenced by the vegetal cover, depending on land use type, and by the soil tillage

system [9].

This study aimed to study the differences in soil cultivation methods and application of several types

of liquid organic matter to soil moisture content and upland rice yields.

2. Materials and methods

The research was carried out in the research station of Lampung Assessment Institute for Agricultural

Technology (AIAT), Negaratru Village, Natar District, South Lampung, from March to July 2019. The

treatments applied are A. Method of tillage, and B. Organic fertilizers. More detail is as follows: A1. Maximum tillage

(the ground was plowed twice and leveled) and without moat, A2. Minimum tillage

(the ground was plowed once and leveled) and make a moat around the plot, B0. Control (without

organic fertilizer), B1. Application of bio urine plus 10 L ha\(^{-1}\), B2. Application of bio urine plus 20 L

ha\(^{-1}\), B3. Application of biodecomposer 10 L ha\(^{-1}\), and B4. Application of biodecomposer 20 L ha\(^{-1}\).

The treatments were arranged in a factorial randomized block design with three replications and the plot

size of each treatment was 10 x 10 m. Bio ur

in application was carried out twice during the vegetative

period of the plant. Meanwhile, the biodecomposer application was carried out only once before planting

rice by spraying it evenly on the plant remaining of the previous crop on the ground. Bio urin plus used

in this study is fermented cow urine and other local ingredients. Biodecomposers used are made from

several kinds of fruits like tomatoes, star fruit, which was fermented for three weeks. Each plot was

planted with Inpago 12 varieties of upland rice. The variables observed were soil water content (%),
growth and rice yields.

3. Results and discussion

Based on observations, soil tillage and application of liquid organic matter have an effect on soil

moisture content. Using the LSD further test (0.05), it can be seen that the soil minimum tillage treatment

by making trenches around the plot provides a higher soil water content than the maximum tillage (table

1). Likewise, the application of liquid organic matter from local microorganisms (MOL) increased soil

water content compared to control.

| Liquid organic matter | Soil tillage treatments |
|-----------------------|-------------------------|
|                       | Maximum tillage | Minimum tillage |
| Control               | 24.28 a           | 23.88 c           |
| Bio urine plus 10 L ha\(^{-1}\) | 25.37 a           | 26.46 bc          |
| Bio urine plus 20 L ha\(^{-1}\) | 25.89 a           | 26.52 bc          |
| Biodecomposer 10 L ha\(^{-1}\) | 26.33 a           | 28.59 a           |
| Biodecomposer 20 L ha\(^{-1}\) | 27.31 a           | 30.86 a           |
| BNT (0.05)            | 3.75               |

Means with the same letter are not significantly different (P ≤ 0.05), means of three replicates.

Conservation cultivation (minimum tillage or no tillage) is an alternative land preparation that can

maintain high soil productivity. Making trenches in the plots increases soil moisture and yields of dry

grain from rice harvests [10]. The results of research by [11] showed that the minimum tillage system

significantly affects the soil water content at the permanent wilting point and available water at a soil
depth of 20 to 40 cm. [12] reported that application of organic matter (crops biomass residues) significantly increase soil water content compared to control.

The chemical properties of the soil after the application of liquid organic matter can be seen in table 2. The effect of liquid organic matter has made the soil pH value vary from 4.48 to 4.88. Based on the soil pH range, the criteria including for acid soil. The highest soil pH value was obtained in the maximum tillage treatment and without trench plus the application of biodecomposer dose of 10 L ha⁻¹, that is 4.88.

Soil levels of Organic-C and total-N are also low. The highest C-organic content was obtained in the minimum soil treatment with trench plus the application of MOL dose of 20 L ha⁻¹, that is 1.09 %. While the highest N-total soil content was in the minimum tillage treatment with trench plus the application of MOL dose of 10 L ha⁻¹, that is 0.18 %. [13] reported that compost application increased soil C-Organic content from 1.26% to 1.36%. Compost as an organic multi nutrient fertilizer, contains significant amounts of valuable plant nutrients including N, P, K, Ca, Mg and S, and a variety of essential trace elements [14].

The amount of nutrients absorbed by plants from the mineralization of organic matter is relatively small. Even though there has been an overhaul of organic matter and mineralization of nutrient elements from these organic materials, the number of plants can absorb is still relatively small. Most of nitrogen absorbed by plants comes from the addition of N fertilizers (urea) and a little from the further mineralization of N from pre-existing organic matter. The results of the study by Saputra et al. [15] showed that the application of organic fertilizers did not significantly increase soil N-total content and rice N uptake. The increase in N uptake was predicted to be increased due to the effect of adding inorganic fertilizers (urea).

The availability of nutrients for plants depends on the type of added organic matter. From the materials that have not been fully decomposed, the containing nutrient elements cannot be directly absorbed by plants. However, their effect is greater on improving soil physical properties compared to compost that has been further decomposed in the soil [16].

Table 2. The levels of C-Organic, N-total, and soil pH with soil tillage treatments and application of local liquid organic matter (bio urin and biodecomposer).

| No | Treatments | C-Organic (%) | N-total (%) | pH (H₂O) |
|----|------------|---------------|-------------|----------|
| 1  | A1B0       | 1.04          | 0.13        | 4.55     |
| 2  | A1B1       | 1.02          | 0.14        | 4.64     |
| 3  | A1B2       | 1.04          | 0.17        | 4.68     |
| 4  | A1B3       | 1.07          | 0.16        | 4.58     |
| 5  | A1B4       | 1.08          | 0.15        | 4.69     |
| 6  | A2B0       | 1.04          | 0.12        | 4.48     |
| 7  | A2B1       | 1.06          | 0.14        | 4.67     |
| 8  | A2B2       | 1.08          | 0.15        | 4.75     |
| 9  | A2B3       | 1.08          | 0.18        | 4.88     |
| 10 | A2B4       | 1.09          | 0.17        | 4.67     |

A1 (Maximum tillage and without trench); A2 (Minimum tillage by trenching); B0. Control (No organic matter); B1. Application bio urine plus 10 L ha⁻¹; B2. With the application of bio urine plus 20 L ha⁻¹; and B3. Biodecomposer application a dose of 10 L ha⁻¹; B4 Biodecomposer of 20 L ha⁻¹.

The effect of soil tillage treatment was not significant on the height of upland rice plants at harvest. The effect of local liquid organic fertilizer treatment significantly increased plant height (p <0.05) (table 3). The highest plant was 88.88 cm found at the minimum tillage treatment and application of MOL 20 L ha⁻¹. The highest number of panicles was 13, and the longest panicle was 19.5 cm.
significantly increased yields of both lowland rice and upland rice compared to control on Ultisol soil [18]. Application of liquid organic matter had the effect on increasing the amount of filled grain and rice yields (table 4). From the harvest component data, it can be seen that the highest amount of filled grain is 117.75 in the minimum tillage treatment with trenching and MOL application of 20 L ha⁻¹. Meanwhile, the number of empty unhulled rice did not significantly affect the yield of upland rice in this study ranged from 1.9 to 2.4 t ha⁻¹. This yield is rather low compared to the average yield of upland rice, which is around 3 t ha⁻¹. The low yields at harvest time are due to the large number of bird pests, thus reducing the yield by about 50 percent. The effect of adding straw compost mixed with goat manure at a rate of 5 Mg ha⁻¹ significantly increased yields of both lowland rice and upland rice compared to control [17]. Application of Widelia rostrata, Asystasia gangetica, and Thitonia diversifolia plant biomass mixed with 1:1 manure at a dose of 7.5 - 2.5 Mg ha⁻¹ significantly increased the yield of maize [18]. The addition of a soil organic conditioner at a rate of 5 to 20 Mg ha⁻¹ significantly increased cobs weight and corn shelled yield compared to control on Ultisol soil [19], if chemical fertilizers are reduced by half of the recommendation, application of 5 Mg ha⁻¹ of corn litter compost has not been able to significantly increase the yield of shelled corn [20].

**Table 3.** Data on plant height and number of panicles of upland rice plants at harvest with soil treatment and application of liquid organic matter.

| No | Treatments | Plant height (cm) | Number of panicles | The length of the panicle |
|----|------------|-------------------|--------------------|--------------------------|
| 1  | A1B0       | 74.88 b           | 9.75 a             | 17.90 a                  |
| 2  | A1B1       | 76.88 b           | 12.50 a            | 18.20 a                  |
| 3  | A1B2       | 81.00 ab          | 11.25 a            | 18.08 a                  |
| 4  | A1B3       | 82.25 ab          | 10.75 a            | 19.50 a                  |
| 5  | A1B4       | 81.00 ab          | 11.75 a            | 16.88 a                  |
| 6  | A2B0       | 77.25 b           | 10.50 a            | 17.90 a                  |
| 7  | A2B1       | 85.00 a           | 13.00 a            | 18.68 a                  |
| 8  | A2B2       | 81.00 ab          | 12.25 a            | 18.55 a                  |
| 9  | A2B3       | 81.50 ab          | 12.50 a            | 18.63 a                  |
| 10 | A2B4       | 88.88 a           | 13.00 a            | 17.75 a                  |

BNT (0.05) 10.05

A1 (Maximum tillage and without trench); A2 (Minimum tillage by trenching); B0 Control (No organic matter); B1 Application bio urine plus 10 L ha⁻¹; B2 with the application of bio urine plus 20 L ha⁻¹; and B3 Biodecomposer application a dose of 10 L ha⁻¹; B4 Biodecomposer of 20 L ha⁻¹.

**Table 4.** Numbers of filled grain with soil tillage treatments and application of liquid organic matter.

| Liquid organic matter | Numbers of filled grain |
|-----------------------|-------------------------|
| Control               | Maximum tillage         |
| Bio urine plus 10 L ha⁻¹ | 91.40 b         |
| Bio urine plus 20 L ha⁻¹ | 96.15 b         |
| Biodecomposer 10 L ha⁻¹ | 111.50 ab        |
| Biodecomposer 20 L ha⁻¹ | 121.00 a        |

| Minimum tillage |
|-----------------|
| Bio urine plus 10 L ha⁻¹ | 95.80 b         |
| Bio urine plus 20 L ha⁻¹ | 103.50 ab       |
| Biodecomposer 10 L ha⁻¹ | 114.25 ab       |
| Biodecomposer 20 L ha⁻¹ | 117.75 a        |

BNT (0.05) 20.87

Means with the same letter are not significantly different (P ≤ 0.05), means of three replicates.
4. Conclusions
The soil minimum tillage treatment by making trenches around the plot provides a higher soil water content than the maximum tillage. Likewise, the application of liquid organic matter from local microorganisms (MOL) increased soil water content compared to control. Application of local liquid organic fertilizer with dosage 20 L ha⁻¹ significantly increased plant height, filled grain and rice yield.

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Table 5. Rice yield with soil tillage treatments and application of liquid organic matter.

| Liquid organic matter       | Maximum tillage | Minimum tillage |
|-----------------------------|-----------------|-----------------|
| Control                     | 1.90 b          | 2.10 a          |
| Bio urine plus 10 L ha⁻¹    | 2.10 ab         | 2.25 a          |
| Bio urine plus 20 L ha⁻¹    | 2.30 a          | 2.30 a          |
| Biodecomposer10 L ha⁻¹     | 2.25 ab         | 2.35 a          |
| Biodecomposer 20 L ha⁻¹    | 2.35 a          | 2.40 a          |
| BNT (0.05)                  | 0.37            |

Rice Yield (t ha⁻¹)

Means with the same letter are not significantly different (P ≤ 0.05), means of three replicates.
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