



## IMPROVEMENT OF SOIL C-ORGANIC LEVEL BY ORGANIC MATTER APPLICATION AND THE EFFECT ON SOME LOCAL RED UPLAND RICE VARIETY (*Oryza sativa* L.) IN NORTH SUMATERA

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### ABSTRACT

Contribution of red upland rice is highly expected in the future. However, only a few superior varieties of rice are able to adapt well and last long which affects on production. This study aimed to determine effect of several growing media and some local red upland rice varieties on the growth and production and soil C-organic content. This research was conducted from February-June 2017 at Kasa House, Faculty of Agriculture, UISU, North Sumatra, Medan. This study used factorial randomized block design with three replications. The first factor is growing media (M): control (10 kg soil) (M<sub>0</sub>), 8 kg soil + 1 kg fertilizer + 1 kg cow manure (M<sub>1</sub>), 6 kg soil + 2 kg hay compost + 2 kg cow manure (M<sub>2</sub>), and 4 kg soil + 3 kg hay compost + 3 kg cow manure (M<sub>3</sub>). The second factor is variety (V): Sigambiri (V<sub>1</sub>), Sikariting (V<sub>2</sub>), and Pagai Gara (V<sub>3</sub>). The results showed that The results showed that the best growth and yield of red rice was on the treatment of planting media 3 kg hay compost + 3 kg cow manure + 4 kg soil and Sigambiri varieties. Growing media capable of improving the content of organic C-soil are 3 kg hay compost + 3 kg cow manure + 4 kg soil.

**KEYWORDS:** Growing media, red upland rice, soil C-organic.

### INTRODUCTION

Rice is an important crop in Indonesia. The Indonesian population makes rice as a staple food. Ninety-five percent of Indonesia's population consumes these foods. Rice can cover 63% of total energy sufficiency and 37% protein.<sup>[1]</sup> The demand for rice in the future is expected to increase, in line with population growth. Therefore it is necessary to increase rice production at least according to the rate of population growth, so that sustainable rice production is achieved for local consumption. Therefore the challenges ahead, especially in Indonesia, will be more numerous. Moreover, there are many irrigated land in Indonesia which are converted to non-agricultural interests.<sup>[2]</sup>

There are three types of rice, namely red rice, black rice, and white rice, but the most consumed is white rice.<sup>[3]</sup> Indonesian farmers rarely cultivate the red rice due to long plant life (134 days on average) and high plant morphology (164 cm on average) that make susceptible to fall.<sup>[4]</sup> Therefore red rice is rarely consumed by the Indonesian people, even beside as a carbohydrates source; red rice is also a functional food which contains anthocyanin as antioxidant compound to counteract free radicals. Red rice is the most popular staple food in

Europe, even more popular than in Southeast Asia as the origin region.<sup>[3]</sup> According to Indonesian Ministry of Health report, mashed red rice contains 7.3% protein, 4.2% iron, and 0.34% vitamin B1. In addition, red rice contains carbohydrates, fat, fiber, folic acid, magnesium, niacin, phosphorus, vitamins A and C. Flour of red rice cracked skin can prevent various diseases, including colon cancer, kidney stones, beri-beri, insomnia, constipation, hemorrhoids, blood sugar, and cholesterol.<sup>[5;6]</sup> Therefore, the benefits of red rice for health need to be socialized and must be developed.

In the future, contribution of red upland rice is highly expected. This is due to sufficient availability of non-irrigated land and climate change conditions that dominated by dry season, land conversion to non-agricultural purposes, as well as fertility degradation phenomena which slow down productivity increase of irrigated paddy fields and in turn cannot compensate for the increasing population.<sup>[1]</sup>

In the last decade, the development of upland rice production and productivity in North Sumatra is quite alarming. The province is only able to increase harvest area by around 1.06% and increase productivity by

1.60% per year. According to BPS data in 2005, upland rice productivity is only reach 2.68 tons/ha. This means that there was a productivity increase from the previous year around 5.41%. Upland rice productivity in the last 9 years in North Sumatra is ranged from 0.96%-1.61%.<sup>[7]</sup>

Red upland rice is very important genetic resource for biodiversity and as basic capital needed to develop agricultural industry to fulfill food availability. Efforts to meet red rice supply have been challenged given that only a few rice varieties available which able to adapt well and last long.<sup>[8]</sup>

In addition, the low level of upland rice productivity is also influenced by low soil fertility. Appropriate and balanced fertilization is one way to improve soil fertility. However, there is some negative impact of inorganic fertilizers. According to<sup>[9]</sup>, excessive use of inorganic fertilizers will increase the level of soil pollution which ultimately affects human health. Organic fertilizers become alternatives to these problems, such as cow manure and hay compost.

Cow manure is useful for providing macro and micro nutrients and has high ionic binding capacities which activate organic matter in the soil. Nutrient composition in solid cow manure consisted of a mixture of 0.40% N, 0.20% P<sub>2</sub>O<sub>5</sub> and 0.10% K<sub>2</sub>O. Cow manure as an organic matter provide carbon source and also energy source to support life and breed various types of microbes in the soil. Some microbes contained in organic matter can dissolve nutrients P and K, decompose plant residues and nutrient transformation, so that such nutrients become more available to plants.<sup>[10]</sup> In addition, cow manure can

improve soil structure, so that plant growth can be optimal.<sup>[11]</sup>

Hay compost is not only beneficial in terms of nutrient content, but also has a high C-organic content. Application of hay compost will add the content of soil organic matter. Consistently use of hay compost in the long term will be able to increase the content of soil organic matter and restore soil fertility.

Due to the reason, a study to improve soil C-organic was carried out by application of organic matter and its effect on growth and production of local red upland rice (*Oryza sativa* L.).

## MATERIALS AND METHODS

The research method is Factorial Randomized Block Design which consists of two factors. Factor I is Growing Media (M) consisting of M<sub>0</sub> = control (10 kg soil), M<sub>1</sub> = 8 kg soil + 1 kg hay compost + 1 kg cow manure, M<sub>2</sub> = 6 kg soil + 2 kg hay compost + 2 kg cow manure and M<sub>3</sub> = 4 kg soil + 3 kg hay compost + 3 kg cow manure. Factor II is Variety (V), consisting of V<sub>1</sub> = Sigambiri, V<sub>2</sub> = Sikariting, V<sub>3</sub> = Pagai Gara. The parameters observed were plant height (cm), number of tillers, weight of dry grain, weight of 100 dry milled grain, and percentage of soil C-organic.

## RESULTS AND DISCUSSION

### 1. Results

#### Plant Height

Results of plant height data analysis at 10 Weeks After Planting (MST) can be seen in Table 1.

**Table 1: Average of upland rice plant height at 10 MST with growing media treatment and some local red upland rice varieties.**

| Treatment   | Growing Media (M) |          |          |          | Average V |
|-------------|-------------------|----------|----------|----------|-----------|
|             | M0                | M1       | M2       | M3       |           |
| Variety (V) | .....(cm).....    |          |          |          |           |
| V1          | 150.00            | 156.67   | 156.33   | 157.00   | 155.00 a  |
| V2          | 146.67            | 152.67   | 153.67   | 155.33   | 152.00 a  |
| V3          | 144.67            | 152.67   | 153.00   | 152.00   | 150.58 b  |
| Average M   | 147.11 b          | 154.00 a | 154.33 a | 154.78 a |           |

Note: Numbers followed by not the same letters in the same column are significantly different at 5% level based on the DMRT test.

Table 1 showed that growing media has significant effect on the height of upland rice. The highest plant is M<sub>3</sub> (3 kg hay compost + 3 kg cow manure + 4 kg soil) namely 154.78 cm which was significantly different than without organic matter. In this case, there is an increase of 5.21%.

Rice varieties have significant effect on the height of upland rice. The highest plant is found in V1 (Sigambiri), namely 155.00 cm. In this case, there is an increase of 2.95%.

#### Number of Tiller

Analysis results of Tiller Number data at 8 Weeks After Planting (MST) can be seen in Table 2. Table 2 show that Growing Media has significant effect on the number of upland rice tiller. The highest number of tiller is M<sub>3</sub> (3 kg hay compost + 3 kg cow manure + 4 kg soil) namely 21,99 which was significantly different than without organic matter. In this case, there is an increase of 6,39%.

Varieties treatment had no significant effect on the number of upland rice tillers, but there was a tendency for differences in the number of tillers and better for

varieties V<sub>1</sub> (sigambiri), namely 22.00 tillers. While the combination of Growing Media and several varieties had no significant effect on the number of upland rice tillers,

but the better result found in the combination of Growing Media and varieties (M<sub>3</sub>V<sub>1</sub>), namely 22.33 tillers.

**Table 2: Average of tiller of number at 8 MST with growing media treatment and some local red upland rice varieties.**

| Treatment   | Growing Media (M)  |         |         |         | Average V |
|-------------|--------------------|---------|---------|---------|-----------|
|             | M0                 | M1      | M2      | M3      |           |
| Variety (V) | .....(tiller)..... |         |         |         |           |
| V1          | 21.67              | 22.00   | 22.00   | 22.33   | 22.00     |
| V2          | 20.67              | 21.67   | 20.67   | 21.33   | 21.33     |
| V3          | 19.67              | 20.67   | 22.00   | 22.33   | 21.17     |
| Average M   | 20.67 b            | 21.44 a | 21.55 a | 21.99 a |           |

Note: Numbers followed by not the same letters in the same column are significantly different at 5% level based on the DMRT test.

**Weight of Harvested Dry Grain (g)**

Statistical analysis results of harvested dry grain weight at 12 MST can be seen in Table 3. Table 3 shown that growing media has significant effect on harvested upland rice dry grain weight (g). The highest harvested dry grain

weight is M3 (3 kg hay compost + 3 kg cow manure + 4 kg soil) namely 125.67 g which was significantly different than M0 (without compost) and M1 (8 kg soil + 1 kg hay compost + 1 kg cow manure), namely 116.78 g. In this case, there is an increase of 9.59%.

**Table 3: Average of harvested dry grain weight in growing media treatment and some local red upland rice varieties.**

| Treatment   | Growing Media (M) |          |          |          | Average V |
|-------------|-------------------|----------|----------|----------|-----------|
|             | M0                | M1       | M2       | M3       |           |
| Variety (V) | .....(g).....     |          |          |          |           |
| V1          | 116.33            | 117.00   | 118.33   | 127.00   | 119.66 a  |
| V2          | 114.00            | 116.33   | 117.00   | 124.33   | 117.91 c  |
| V3          | 113.67            | 117.00   | 119.33   | 125.67   | 118.91 b  |
| Average M   | 114.67 c          | 116.78 b | 118.22 a | 125.67 a |           |

Note: Numbers followed by not the same letters in the same column are significantly different at 5% level based on the DMRT test.

Treatment of several varieties has significant effect on harvested dry grain weight of upland rice. The highest dry grain weight is V<sub>1</sub> (Sigambiri) namely 119,66 g which is significantly different from V<sub>2</sub> (Sikariting) and V<sub>3</sub> (Pagai Gara).

upland rice, but better dry grain weight was found in combination of Growing Media and varieties M<sub>3</sub>V<sub>1</sub> (3 kg hay compost + 3 kg cow manure + 4 kg soil and Sigambiri), that is 127.00 g.

Combination of growing media and varieties treatment had no significant effect on harvested dry grain weight of

**Weight of 100 Milled Dry Grain (g)**

Statistical analysis results of the weight of 100 milled dry grains of upland rice can be seen in Table 4.

**Table 4: Average weight of 100 milled dry grains with growing media and some red upland rice varieties treatment.**

| Treatment   | Growing Media (M) |        |        |        | Average V |
|-------------|-------------------|--------|--------|--------|-----------|
|             | M0                | M1     | M2     | M3     |           |
| Variety (V) | .....(g).....     |        |        |        |           |
| V1          | 2.80              | 2.93   | 2.90   | 3.00   | 2.91 a    |
| V2          | 2.93              | 2.70   | 2.77   | 2.80   | 2.80 a    |
| V3          | 2.33              | 2.50   | 2.60   | 2.67   | 2.53 b    |
| Average M   | 2.69 b            | 2.71 a | 2.76 a | 2.82 a |           |

Note: Numbers followed by not the same letters in the same column are significantly different at 5% level based on the DMRT test.

Table 4 shown that growing media treatment has significant effect on the weight of 100 milled dry grains. The highest weight of 100 milled dry grain is Treatment M<sub>3</sub> (3 kg hay compost + 3 kg cow manure + 4 kg soil),

namely 2.82 g which is significantly different from M<sub>0</sub> (without compost), namely 2.69 g.

Treatment of varieties had significant effect on the weight of 100 milled dry of upland rice. Variety which show the highest weight of 100 milled dry grains is V<sub>1</sub> (Sigambiri), namely 2.91 g which is significantly different from V<sub>2</sub> (Sikariting) and V<sub>3</sub> (Pagai Gara).

The combination of growing media and varieties treatment had no significant effect on the weight of 100 milled dry grain of upland rice, but the better weight is found in the combination of growing media and varieties M<sub>3</sub>V<sub>1</sub> (3 kg hay compost + 3 kg manure beef + 4 kg soil and Sigambiri), that is 3.00 g.

#### Percentage of Soil C-Organic

Statistical analysis results of soil C-organic can be seen in Table 5. Table 5 shown that growing media treatment

has significant effect on soil C-organic C. The highest soil C-organic content is found in M<sub>3</sub> (3 kg hay compost + 3 kg cow manure + 4 kg soil), namely 2.37 (%) which is significantly different from M<sub>0</sub> (without compost), namely 1.31%.

Varieties treatment has no significant effect on soil C-organic content. However there is a tendency for differences, where the highest soil C-organic is found in V<sub>1</sub> (Sigambiri), namely 1.86%. Meanwhile the combination of growing media and varieties Treatment had no significant effect on the content of soil C-organic, where better soil C-organic content was found in the combination of growing media and varieties M<sub>3</sub>V<sub>1</sub> (3 kg hay compost + 3 kg cow manure + 4 kg soil and Sigambiri), namely 2.48%.

**Table 5: Average of soil C-organic content with growing media and some local red rice varieties.**

| Treatment   | Growing Media (M) |        |        |        | Average V |
|-------------|-------------------|--------|--------|--------|-----------|
|             | M0                | M1     | M2     | M3     |           |
| Variety (V) | .....(%).....     |        |        |        |           |
| V1          | 1.32              | 1.70   | 1.92   | 2.48   | 1.86      |
| V2          | 1.29              | 1.80   | 1.88   | 1.88   | 1.82      |
| V3          | 1.33              | 1.62   | 2.01   | 2.28   | 1.81      |
| Average M   | 1.31 b            | 1.71 a | 1.94 a | 2.37 a |           |

Note: Numbers followed by not the same letters in the same column are significantly different at 5% level based on the DMRT test.

## 2. DISCUSSION

### *Effect of Growing Media Treatment on Growth and Production of Upland Rice*

The results showed that growing media treatment have good response to the growth and production of upland rice. The growing media treatment are M<sub>0</sub> as control (10 kg soil), M<sub>1</sub> (8 kg soil + 1 kg hay compost) + 1 kg cow manure), M<sub>2</sub> (6 kg soil + 2 kg hay compost + 2 kg cow manure and M<sub>3</sub> (4 kg soil + 3 kg hay compost + 3 kg cow manure). Increasing composition of organic matter to M<sub>3</sub> (4 kg soil + 3 kg hay compost + 3 kg cow manure) significantly increased growth (plant height and number of tillers) and production (harvested dry grain weight and weight of 100 milled dry grain). Meanwhile the treatment is also has significant effect on soil C-organic content.

Hay compost and cow manure contains various nutrients (Appendix 1). Hay compost consisted of Nitrogen 1.04%, P<sub>2</sub>O<sub>5</sub> 0.48%, K<sub>2</sub>O 0.92%, and C-organic 16.68%. Meanwhile cow manure consists of Nitrogen 0.63%, P<sub>2</sub>O<sub>5</sub> 0.21%, K<sub>2</sub>O 0.48%, and C-organic 7.79%. According to<sup>[11]</sup>, besides the macro nutrients, organic fertilizers is also has micro nutrients such as Fe, Mn, B, Cu and Zn.

According to<sup>[12]</sup>, organic matter is also a soil ameliorant material. As soil ameliorant, such material can improve soil aeration, increase soil ability to hold nutrients, increase water holding capacity, increase soil buffering, energy source for soil microorganisms and as a source of nutrients.

Nutrients in these organic materials are used by plants to support vegetative and generative growth. Organic matter can improve soil biological properties which in turn can improve soil physical properties, that is more friable soil. Friable soil will encourage root development to absorb more nutrients and used both for vegetative and generative growth.<sup>[13]</sup>

Nutrients of N, P and K in organic matter are very important elements for the growth and production of upland rice. Such elements have different roles in arranging organic compounds for growth and production. Nitrogen is consisted of amino acids, proteins and chlorophyll which functions to accelerate vegetative growth which increases the number of rice grain. P element is very important as a energy sources. K is important for organic compounds translocation from leaves to branches or parts of meristem and rice grain.<sup>[14: 15]</sup>

Growing media with composition 3 kg hay compost + 3 kg cow manure + 4 kg soil produces the best growth and production compared to only soil growing media. This happens because growing media which is mixed with organic matter can provide a better growing room and production. According to<sup>[16]</sup>, humic acid contained in compost (organic matter) can affect plant growth directly or indirectly. Directly, it can improve soil fertility by changing the physical, chemical and biological conditions of the soil. Indirectly, it can stimulate plant growth and production through its effect on plant root activity to optimally absorbing nutrients.

Treatment of growing media M3 (3 kg hay compost + 3 kg cow manure + 4 kg soil) significantly increases soil C-organic. This is presumably because such compost contains C-organic 16.68% and cow manure 7.79% (Appendix 1). The increase in organic matter can improve the physical and biological properties of the soil. In biology perspectives, organic matter is a food for soil microorganisms. This increase in organic matter will increase the number of soil microorganisms and their activities. The activity of soil microorganisms can improve soil physical properties, namely soil moisture and aeration.<sup>[13]</sup> Organic matter is a food for microorganisms in the soil. Increased organic matter in the soil will increase the activity of microorganisms so that the soil becomes loose and soil aeration increases. Good aeration will support root development and nutrient absorption.

#### ***Effect of Variety Treatment on Growth and Production of Upland Rice***

The results showed that variety treatments have good response to the growth and production of upland rice. The three varieties used for treatment namely V<sub>1</sub> (Sigambiri), V<sub>2</sub> (Sikariting), and V<sub>3</sub> (Pagai Gara) able to significantly increase the growth (plant height and number of tillers) and production (harvested dry grain weight and weight of 100 milled dry grain) of upland rice. Meanwhile, soil C-organic content is not significantly affected by variety treatment. The plants showed differences both in growth and crop production.

Variety treatment show significant effect on the growth as indicated by plant height. The highest plant is found in Sigambiri Variety (V<sub>1</sub>), namely 155.00 cm, which was significantly different from Pagai Gara but not significantly different from Sikariting. Variety treatment also show significant effect on the production of upland rice both on harvested dry grain weight and weight of 100 milled dry grains. The highest harvested grain weight is Variety Sigambiri (V<sub>1</sub>) namely 119.66 g which is significantly different from Variety Pagai Gara (V<sub>3</sub>) and Sikariting (V<sub>2</sub>).

The difference in response, both in the growth and production, may due to differences in the genetic characteristics of the three varieties tested. This difference in genetic traits leads to differences respons of the three varieties to various environmental conditions as indicated by differences in growth activities. According to<sup>[17]</sup>, difference in growth rate among varieties is determined by genetic factors. Furthermore<sup>[18]</sup> statedm that plants will adjusting, through physiological and morphological experience, in accordance with their new environment. Different plant varieties show different growth and yield even though planted in the same environmental conditions.

Of the three variety studied, variety Sigambiri show the most significant difference, both for growth and production of upland rice. This is because Sigambiri is a

local variety that has been released by the Minister of Agriculture as a National superior variety. Whereas V<sub>2</sub> (Sikariting) and V<sub>3</sub> (Pagai Gara) are still as local varieties. National superior varieties have better rice quality. Rice quality is one of the main selection criteria in assembling superior varieties after yield results.<sup>[19]</sup>

#### ***Interaction Effect of Growing Media and Variety on the Growth and Production of Upland Rice***

Combination of growing media and varieties did not significantly effect on plant height, number of tillers, weight of harvested dry grain, weight of 100 milled dry grains and percentage of soil C-organic. However, when compared to without fertilizer treatment, there is a tendency to increase yield.

Although the interactions of the two factors are not significantly different, there is a positive trend in increasing the growth and production of upland crops. It is indicated by better production when compared to the control. In other words, growing media treatment which rich with nutrients and microorganisms will improve soil biological properties and in turn will improve soil physical properties as well as contribute to nutrients N, P and K. Organic growing media also provide macro nutrients and supply soil C-organic which improve soil conditions.

Each variety has the same response to cow manure and hay compost doses. Increasing dosage of manure and compost will increases the growth and production of each variety. This shows that manure and hay compost have very important role for the growth and production of each variety. However, combination of the two treatments in this study has not significant effect on the growth and production of rice plants. This is because the two treatments cover each other in influencing plants.<sup>[20]</sup>

#### **CONCLUSION**

1. Growing media treatment has significant effect on plant height, number of tillers, harvested dry grain weight, weight of 100 milled dry grains and percentage of soil C-organic. The highest effect is found in treatment M3 (3 kg hay compost + 3 kg cow manure + 4 kg soil).
2. Treatment of several varieties has significant effect on plant height, harvested dry grain weight and weight of 100 milled dry grains, but does not significantly affect to the percentage of soil C-organic. Variety V<sub>1</sub> (Sigambiri) show better response to the treatment.
3. Combination of growing media and varieties has no significant effect on all parameters observed, but there is an increase or difference tendency. Combination of M<sub>3</sub>V<sub>1</sub> (3 kg of hay compost + 3 kg cow manure + 4 kg soil and Sigambiri) show the highest response.

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**Appendix 1: Analysis of Hay Compost and Cow Manure****Analysis of Hay Compost**

| No | Analysis                          | Result |
|----|-----------------------------------|--------|
| 1. | Nitrogen (%)v 1.04                |        |
| 2. | P <sub>2</sub> O <sub>5</sub> (%) | 0.48   |
| 3. | K <sub>2</sub> O (%)              | 0.92   |
| 4. | C-Organic (%)                     | 16.68  |
| 5. | C/N                               | 16.03  |

**Analysis of Cow Manure**

| No | Analysis                          | Result |
|----|-----------------------------------|--------|
| 1. | Nitrogen (%)                      | 0.63   |
| 2. | P <sub>2</sub> O <sub>5</sub> (%) | 0.21   |
| 3. | K <sub>2</sub> O (%) 0.48         |        |
| 4. | C-Organic (%)                     | 7.79   |
| 5. | C/N 12.36                         |        |

Source: Analysis was conducted at Soil Science Laboratory, Faculty of Agriculture, UISU Medan, No. 18 / Lab / III / 2017, March 11, 2017.