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Weed Management in Dryland Paddy Farming for Environmental Conservation

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Abstract. Weeds become the major threat in the agriculture system especially for rice crops. Individual density per 0,1 m² could decrease 57% of dryland rice production. We aimed to determine the strategy for manage the rice weeds in eco-friendly dryland as the effort to conserve the biodiversity. The methodology used is mixed method with observation and in-depth interview. The research was conducted in July – Oktober 2018, Sudimoro district, Pacitan Regency, East Java. The weeds that dominantly by important value index is *Alternanthera sessilis* (L.) R.Br. Ex DC (4,41) and *Synedrella nodiflora* (L.) J. Gaertner (2,84). The farmer tends to manage the weed chemically; even 100% respondent admitted the use of 42.86% chemical and mechanical to manage the weeds, meanwhile the rest 57.14% used only chemical (herbicide). To the farmers, the use of herbicide is believed as the most effective solution, it takes only few times, less energy, and more affordable than mechanic control. However, 42.86% of respondents indicated that the weed turned more resistant because even it was sprayed by herbicide, the weeds kept growing up. In the other side, the existence of pollinator insect and odonata were no longer as much as in the past time, moreover, somehow, odonata was totally disappeared. This reflection shows that the quality of ecosystem was disturbed by the use of herbicide. The management using the prior ecological principles is the best solution to conserve the ecosystem. This one can be gained through combining mechanical and biological management.

1. Introduction

Paddy becomes the most important crop commodity in Indonesia and become the main food matter for 95% of Indonesian [1]. Basically, there are two types of paddy, wetland paddy and *gogo* paddy. The wetland paddy used to be planted on the lowland and flooded by water, meanwhile the *gogo* paddy is planted on the high and dryland and do not have to be flooded by water [2]. The utilization of the dryland to plant *gogo* paddy one of the big source to strengthening the food sufficiency to build the agriculture sector in the future [3]. Moreover, the dryland area in Indonesia is around 58.75% [4], even in Sudimoro district, the dryland area hit 93.47% [5], in the percentage, so the dryland is supposed to be optimized to support the local and national rice production. However, there is a major threat for optimized the dryland, the weeds. The average of dryland paddy farming in Sudimoro district continuously decline in



recent 4 years 3,96 (Ton/Ha) in 2017; 4,06 (Ton/Ha) in 2016; 4,06 (Ton/Ha) in 2015; and 4,09 (Ton/Ha) in 2014 [6,7].

Weeds become the major cause that decreases the agriculture production besides another factor that includes plant variety, kinds and fertility of the soil, and the application of cultivation technique [8]. A big amount of weed population could create a competition among the cultivation crops to fulfill the water needs, nutritions, lights, and area to grow [9]. The impact that caused by the weeds tend to be negative because it triggered the loss of production, economy, food resilience, regional stability, poverty, and migration [10]. Because of that condition, weeds existence is always be controlled by the farmer. But, the controlling management of the farmer mostly use chemical like herbicide.

Basically, the use of herbicide is very harmful to the sustainable management of agriculture. Nevertheless, herbicide is still considered as the most ideal for conventional agriculture [11], because herbicide is able to end 90-99% life of weeds [12]. However, in the real condition, the use of pesticide is intriguing another problem. The long-term use of herbicide could lead the weeds become resistant to it [13]. Besides, the use of synthetic herbicides can also contaminate the land, water, and affect human life [14]. Other researchers stated that 80% of spraying herbicides hit the non target that caused the degradation of ecosystem biodiversity [15]. Generally, synthetic herbicide is really effective to weeds management, but the negative sides appeared is bigger than its benefits. Because of that, eco-friendly management for weeds should have been optimized and the sustainable of agricultural ecosystem could be manifested.

2. Method

This research used quantitative approach, the data collecting technique was direct observation and in-depth interview in Panger Kidul village, Sudimoro district, Pacitan regency, East Java for 4 months, from July – Oktober 2018. There were 30 plots to be observed (1 x 1 meter). Kind of weeds from every plot was identified and important value index was calculated. Then there were in-depth interviews with land owners who own said plot and there were 7 respondents. The last observed macro-invertebrates with the roaming methods. The result of observation and interview was proceed using important value index and descriptive analysis.

Important value index formula based on Parmadi et al. (2016) [16]:

$$\text{Density (Di)} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Total number of a quadrats studied}} \quad (1)$$

$$\text{Relative Density (RDi)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all the species}} \quad (2)$$

$$\text{Frequency (F)} = \frac{\text{Number of quadrats in which the species occurred}}{\text{Total number of quadrats studied}} \quad (3)$$

$$\text{Relatif Frequency (RFi)} = \frac{\text{Number of occurrence of the species}}{\text{Number of occurrence of all the species}} \quad (4)$$

$$\text{Important Value Index (IVI)} = \text{RDi} + \text{RFi} \quad (5)$$

3. Result and Discussion

Based on the research found 10 species of weeds had the highest important value index:

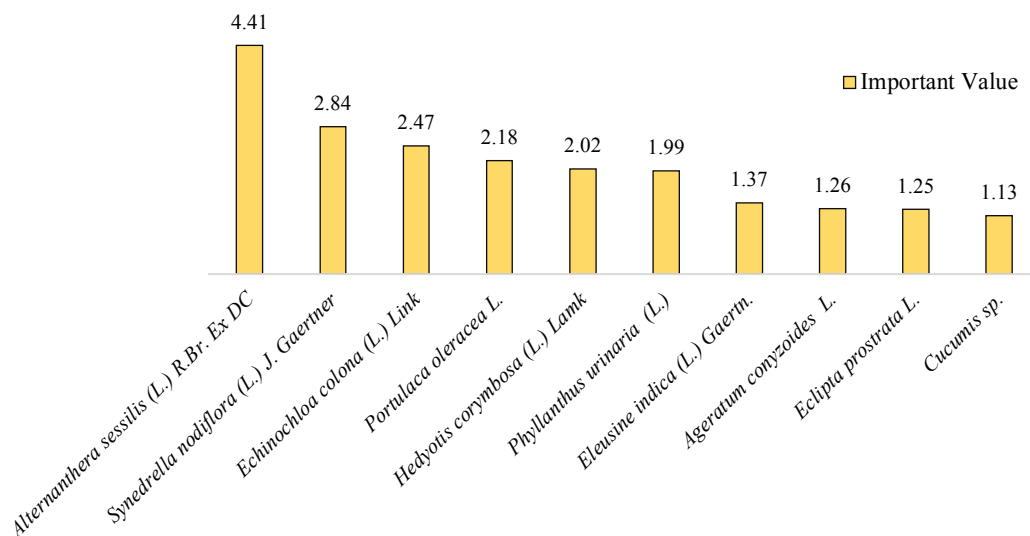


Figure 1. weeds species with the highest important value in the research location

Many species of weeds have the light seed that can be easily carried by the wind. Another interesting finding was a lot of *Alternanthera sessilis* (L.) R.Br. Ex DC and give the significant domination towards dryland area. It was massively dominating this area through a very good vegetative and generative breeding mechanism [17]. It could produce bud on its axillary and there were seeds on each flower that ready to grow. Instead of the seeds, this species could do the breeding through its stem. It's stem was cutout, the cut part will grow fast into a new individual in the humid environment. This research supported the theory of Cordeiro et al. (2017) which stated that generative and vegetative breeding is one of the competitive excellences of weeds which threatened cultivated crops [18].

Table 1. The pattern of weed management was conducted by dryland farmers

| No | Respondent | Kind of management | Time of management | Management obstacles |
|----|------------|--------------------|--------------------|----------------------|
| 1 | A | Chemical | Pre-planting | ++ |
| 2 | B | Chemical | Pre-planting | + |
| 3 | C | Combination | Pre-planting | + |
| 4 | D | Chemical | Pre-planting | +++ |
| 5 | E | Combination | Pre-planting | + |
| 6 | F | Chemical | Pre-planting | +++ |
| 7 | G | Combination | Pre-planting | +++ |

+++ no obstacles; ++ less obstacles; + weeds still growing up

Based on the specific interviews, it found that 100 % respondents had used herbicide to manage weeds. The different was 42.86% of respondents were also used mechanical management, it means that both ways were used in manage the weeds. Meanwhile the rest 57.14% of respondents only used herbicide to manage the weeds on their land. This strengthens the theory of Lechenet et al. (2017) that herbicide is an ideal mechanism type in a conventional agriculture [19]. The farmers indicated that the use of pesticide was the easiest and the most affordable because in implementation, it only needed few time, low cost, and save the energy.

If it was reviewed by the time of manage, it was known that all of the respondents did the control before planting time. The time chosen for manage the weeds became the very important factor. During the land preparation, the farmers must have been sure that the land is free from weeds. Unless the successfulness of cultivating a type of crops will be hampered. The nursling have low resistance towards

weeds in the early growth of crops [20]. The land must be free from weeds during the growth period to optimize the growth of crops. The death risk of crops is very high if it competes with weeds in the beginning phase of growth. This was triggered by the competition to get space to grow, struggling for nutrients, lights, and water [21].

As 42.86% respondents stated that, in the obstacle management side that faced by the farmers, it was known that eventhough weeds had been management using herbicide spray, it would keep growing up. In the other side, 42.86% of respondents stated that management using herbicide was effective already. Nevertheless, it could be stated that this research finding was not suitable with theory found by Wakabayashi and Böger (2002), stated that herbicide used can kill 90-99% of weeds [22]. The finding on the research location was not suitable with that theory because weeds had evolved and became resistance to the synthetic herbicide. This was coherent with the theory of Powles (2014) that stated the continuity of herbicide would lead to weed resistance. If the weeds resisted to the synthetic herbicide, the dose given must be higher than before which lead to more resistance that can be harmful [23]. The farmer also stated that in the past few years, they needed extra effort to manage the land from preparing until harvest time. Because of that, the define eco-friendly strategy of manage the weeds should be implemented to bring benefits to the farmers. Here is the comparison of effectiveness and efficiency of three kinds of weeds management strategy that had been done by the farmers.

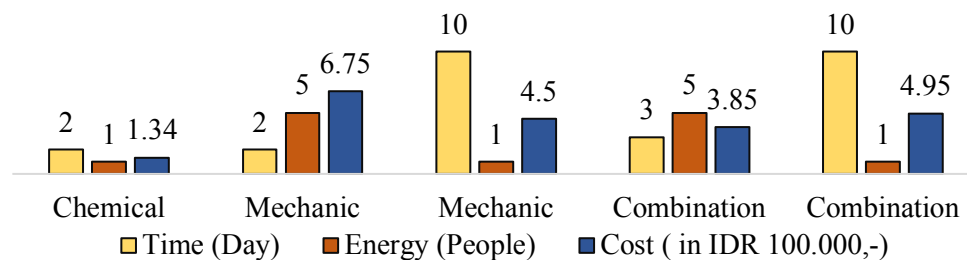


Figure 2. The effectiveness and efficiency comparison of various kinds of weeds management for area sized 30 x 50 meter (0,15 hectare) in every controlling phase

Based on the effectiveness and efficiency comparison result of three kinds of weeds management, it was known that from time indicator, energy, and cost through chemical was more effective and efficient. This case caused different control cost, because everyone was paid around Rp. 35.000,00 per working time and plus with meal cost around Rp. 10.000,00 and the herbicide is Rp 24.000,00 (200 ml for 3rd time usage). The existence of weeds on the crop field brought higher production cost [24]. Nevertheless, chemical control was not an ideal and accurate way, because there were many uncounted and unconsidered factors. For instance, the use of herbicide was very risky to the farmer family health, water and soil pollution, biological explosion, and the degradation of the land. All of the factors were not even calculated, if the chemical control was calculated it must have been highly cost and it is potential to cause unsustainability of agricultural ecosystem, which means, the land can not be planted anymore and the farmer will lose their occupation, and the failure of food resilience will be potentially happened in the future.

According to the result, it could be seen that citizen was not really concerned about the effect and the risk that generated by the use of herbicide. Besides, the continuity of herbicide usage for a long period would endanger the ecosystem sustainability, the use of herbicide contaminated the soil, water, and affected the human's health [25]. Exposure to the herbicide continuous potentially leads to residues in the human body, such as it the organism for example, dragonflies, grasshoppers, butterflies, and other macro-invertebrates. So that exposure to persistent cause these organisms susceptible to die. In addition, herbicide contamination in soil, water, and plants can trigger the migration of a type of organism as

herbicide contamination raises the limiting factor for the life of the organisms. Therefore several species of organisms are no longer occupying the region.

Tabel 2. The existence of macro-invertebrates for environmental healthy indicator

| No | Macro-invertebrates indicators | Frequency be discovered* | | | | | | | | |
|----|---|--------------------------|----|-----|-------------------------|----|-----|-------------------|----|-----|
| | | (5.30 - 7.30 a.m) | | | (10.30 a.m - 00.30 p.m) | | | (3.30 - 5.30 p.m) | | |
| | | I | II | III | I | II | III | I | II | III |
| 1 | <i>Crocothemis servilia</i> (Drury) | - | - | - | - | - | - | - | - | - |
| 2 | <i>Neurothemis ramburii</i> (Brauer) | - | - | - | - | - | - | - | - | - |
| 3 | <i>Orthetrum sabina</i> (Drury) | - | - | - | - | - | - | - | - | - |
| 4 | <i>Potamarcha congener</i> (Rambur) | - | - | - | + | - | - | + | - | - |
| 5 | <i>Diplacodes trivialis</i> (Rambur) | - | - | - | - | - | - | - | - | - |
| 6 | <i>Oxya chinensis</i> (Thunberg) | - | + | - | - | - | - | - | - | + |
| 7 | <i>Atractomorpha crenulata</i> (Fabricius) | - | - | - | - | - | - | - | - | - |
| 8 | <i>Leptosia nina</i> (Fabricius) | + | - | - | - | - | - | - | - | - |
| 9 | <i>Cethosia penthesilea</i> (Cramer) | - | - | - | - | - | - | - | - | - |
| 10 | <i>Papilio memnon</i> (Linnaeus) | - | - | - | - | - | - | - | - | - |
| 11 | <i>Papilio polytes</i> (Linnaeus) | - | - | - | - | - | - | - | + | + |
| 12 | <i>Amathusia taenia</i> (Fruhstorfer) | - | - | - | + | - | - | - | - | - |
| 13 | <i>Mycalesis horsfieldii</i> (Hübner) | - | - | - | - | - | - | - | - | - |
| 14 | <i>Delias hyarate</i> (Linnaeus) | - | - | - | - | - | - | - | - | - |
| 15 | <i>Apis</i> sp. | + | + | - | - | ++ | ++ | - | - | - |

*) – not found; + rarely; ++ medium; +++ often

The respondents said that in recent years dryland paddy production was continuously decrease and after the land was being sprayed by herbicide, the other organism such as butterflies, dragonflies, bees, and another would not appear for months. If it was observed, basically those organisms were not the target for controlled action. Even butterflies and bees are pollinator insects that help to pollinate the cultivated crops. The existence of weeds was being the competitor of cultivated crops in pollinating by pollinator insects and if the chemical control was applied with herbicide [26]. The insects would not get closer to that area, thus pollinator insect can not pollinate crops. In another side, the dragonflies are the bioindicator of the environment quality if there were no dragonflies then the agriculture ecosystem must have been polluted. That dragonflies is one of the environmental quality bioindicators because the nymph of Odonata has high sensitivity towards changes, so the existence of dragonflies can be the indicator of the quality of environmental health [27].

Because of that, the alternative for controlling weeds will be needed to guarantee the sustainability of the agriculture. According to many theory and research findings above, it can be confirmed that the effective and accurate weeds managements must appropriate the ecological principle. The ecology principles that mentioned here is each environmental components interacts each other and give its contribution to generate the ecosystem stability [28]. Therefore, the synthetic chemical compound used from herbicide will delay every ecology phase in the ecosystem [29]. It is not possible to turn this condition immediately by stop using herbicide, but it can be passing through, by changing herbicide usage into integrated mechanical and biological weed management procedures in the preparation phase, initial phase, and to the reproduction phase. This mechanical management process can be done through clean up the land using hoe, sickle and the other same tools. Weed management results can be used for animal feed. It should be understood that the weeds that are fruitful or have seeds need to be cut and burned, then the other part is used for animal feed. This step is necessary so that the manure will not contain weed seeds and the land will not cause the emergence of weeds. Then the fruits and seeds of weeds to be burned to kill the prospective to growth, it becomes more effective control. This mechanical

controlling process can be done through clean up the land using hoe, sickle and the other same tools. In the other side, the controlling management using biological competitor could be promoted by finding a herbivore organism for the weeds species existed.

4. Conclusion

The ideal and accurate strategy of weed management to generate the food resilience, ecosystem and agricultural sustainability is to set the ecological principles into priority. The ecology principles are not only to control the weeds but also to keep the ecosystem sustainability, optimization production, and sustainable dryland management. The best strategy for weed management in dryland paddy farming is mechanical control, biological competitors, and combination.

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