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# Research Article
# Weeds Diversity of Lowland Rice (*Oryza sativa* L.) with Different farming System in Purwakarta Regency Indonesia

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## Abstract

**Background and Objective:** Lowland rice (*Oryza sativa* L.) is the staple food for most of Indonesian. Weed an important constraints in increasing rice production in Indonesia that has to be overcome. Weeds reduce the crop yield due to compete with light absorption, oxygen, $CO_2$, space and nutrients. This study aimed to find out the weeds diversity in organic and conventional rice farming system in Purwakarta Regency west Java Indonesia. **Materials and Methods:** The materials used in this research were land map and questionnaire. The tools used in this research were squared meter (1.0×1.0 m), gauge, scissors, plastic bag, label paper, analytical scales and dryer oven. The method used was qualitative method (weed survey by giving questionnaires to farmers) and quantitative method by using vegetation analysis. This research was conducted from December, 2017 to February, 2018. **Results:** The vegetation analysis showed that weed diversity on conventional farming system consist of 3 species of grasses, 1 species of sedges and 5 species of broad leaf, whereas in organic farming system consist 2 species of grasses, 1 species of sedges and 4 species of broad leaf. Weeds with the highest SDR (Summed Dominance Ratio) value in both conventional and organic farming system is *Fimbristylis miliacea*. **Conclusions:** Weed population in conventional and organic farming system was different. This study can be useful to determine an effective and efficient post emergent wed management strategy for the following season.

Key words: Weed diversity, lowland rice, conventional farming, vegetation analysis, organic farming, rice production, *Fimbristylis miliacea*

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Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food and belongs to one of the most important cereal food grain in the world[1,2]. More than half of the population in the world and the majority of population in Asia countries consume rice on a daily basis[3]. More than 90% of population in Indonesia also consume rice on daily basis. Rice play an important role in increasing global food security and Indonesia along with China, India, Bangladesh and Vietnam are the top five rice producing countries in the world[4]. An effort to increase rice production and productivity should be carried out in order to meet the increasing demands of the growing population in the world. Weed management become an important factor in increasing rice production program. This due to weeds can reduce the yield and quality of rice by competing for available resources, such as sunlight, water, nutrient, $CO_2$ and spaces[5]. Weed infestation will affect both quality and quantity of rice grains[6]. Weeds can inhibit crop growth, development and productivity due to its ability to produce seeds in large quantities, have rapid germination, rapid initial growth and high density[7]. Yield losses due to weeds have been known in all the rice growing regions of the world and the yield losses can be causing total yield failure. Yield losses due to weeds were greater than the losses due to pest and diseases[8]. Yield losses due to weeds in transplanted lowland rice were 20-74%, 28-89% in direct seeded lowland rice and 48-100% in upland rice[9]. Rice yield reduction in Indonesia due to weeds are 15-42% for lowland rice and 47-87% for upland rice[10]. Yield losses due to weeds in rice depend on various factors such as weed density[11], weed type[12], duration of weed competition[6], time of emergence of weeds relative to rice, cultural factors and location[13] and rice cultivar[14].

There are many factors affecting weed diversity at each location of observation, such as light, nutrient, soil tillage, cultivation methods and differences in crop spacing or plant density used[15]. There are many factors that influence the abundance of weed species in rice field such as latitude, altitude, rice cultural method, soil moisture regime, crop rotation, soil and air temperatures, land preparation, fertilization, rice cultivar, weed control technology and interactions of those factors[12]. Each rice production system has different weed composition[3]. Weed infestation under direct seeding system was higher than transplanting system[12]. Weed community will change in response to climatic changes, method of rice cultivation and weed management[8]. The warm temperature and high humidity in Indonesia will encourage a diversity of weeds to grow. Weed diversity, composition and abundance usually occur as a response to different method of crop establishment and herbicide use in rice[16]. Weed diversity and composition under different type of lowland rice cultivation in Indonesia (conventional system and System of rice intensification) should be different. Weeds problems in rice field in Indonesia are mostly region specific or district specific or site specific, so it is very important to find out weed diversity and composition in the two most common rice farming systems (conventional and System of rice intensification) in Purwakarta regency West Java Indonesia.
The purpose of this research was to find out the diversity of weeds in organic and conventional rice planting system in order to predict weed composition and determine an effective and efficient post emergent weed management strategy for the following season.

## MATERIALS AND METHODS

The research was carried out in the rice farming belongs to farmers in Pondok Salam and Pasawahan sub-districts in Purwakarta Regency West Java Indonesia. The research was conducted in December, 2017 up to February, 2018. The materials used in this research were land map, base map and questionnaire. The tools used in this research were squared meter (1.0×1.0 m), gauge, scissors, plastic bag, label paper, machetes, analytical scales and dryer oven. The method used was qualitative method (weed survey by giving questionnaires to farmers) and quantitative method by using vegetation analysis. It was conducted to determine the composition of weeds based on their species, density and species dominance. The identification of the weed species was carried out according to method that developed by Chaves and Bhandari[17] and Barnes and Chan[18]. The square method (1.0×1.0 m) was used to sample and classify the weed species. Weeds were counted in 5 quadrates to determine weed species, density and dominance.

In each sub-district, there would be one village with each experiment of two organic rice fields and two conventional rice fields. At each sample location, weed analysis was done systematically (5 times) for each rice field area with quadratic method, the square size used was 1.0×1.0 m. The data analysis was carried out by quantitative analysis to find out the Diversity Index (H') based on Shannon-Wiener, the weed dominance index was calculated by using Simpson index, Important Weed Value Index (INP) and dry weight. The above ground weed

vegetation was harvested and separated by species (for identification), oven-dried at 80°C for 48 h (for dominance evaluation)[19].

The value of Species Diversity Index (H') can be interpreted using criteria according to method developed by Barbour *et al.*[20]. The H' values typically range from 0-7. If H'<1, the category is very low, if H'>1-2, the category is low, if H'<2-3, the category is medium, if H'>3-4, the category is high, if H'>4, the category is very high.

## RESULTS

**Weed vegetation analysis:** The results in Table 1 showed that weed vegetation analysis was recorded 9 weed species in conventional farming system and 7 weed species in organic farming system. The weed composition in conventional farming system was dominated by broad leaf species with 5 species *Alternanthera philoxeroides*, *Bacopa monnieri*, *Ludwigia glandulosa*, *Monochoria vaginalis* and *Sphenoclea zeylanica*, 3 species of grasses: *Cynodon dactylon, Leersia hexandra* and *Leptochloa chinensis*; 1 species of sedges: *Fimbristylis miliacea*.

There were 7 weed species on organic rice farming system that consist of 2 species of grasses: *Cynodon dactylon* and *Digitaria ciliaris*; 1 spesies of sedges: *Fimbristylis miliacea*; and 4 spesies of broad leaf: *Ludwigia glandulosa*, *Marsilea crenata*, *Monochoria vaginalis* and *Sphenoclea zeylanica*. The dominant weeds in conventional rice farming system were *Fimbristylis miliacea* (40.80%), *Sphenoclea zeylanica* (13.58%) and *Leersia hexandra* (10.42%), whereas the dominant weeds in organic farming system were *Fimbristylis miliacea* (32.86%), *Marsilea crenata* (16.94%), *Sphenoclea zeylanica* (11.93%) and *Digitaria ciliaris* (11.00%).

**Species diversity index (H'):** The data in Table 2 showed that species diversity index in Pondok Salam and Pasawahan sub-districts were categorized as low as 1.84 on conventional rice farming system and 1.77 on organic farming system.

**Community coefficient index (C):** Findings in Table 3 exhibited that the value of weed Community Coefficient Index (C) was 37.80% on conventional farming system and 35.41% on organic farming system. It showed that the weed population both conventional and organic farming systems were heterogeneous.

Table 1: Average of sum dominance ratio of weed in sub-districts of Pondok Salam and Pasawahan

| | | Average of SDR (%) | |
|---|---|---|---|
| Weed species | Type | Conventional | Organic |
| *Alternanthera philoxeroides* | B | 1.94 | - |
| *Bacopa monnieri* | B | 7.87 | - |
| *Cynodon dactylon* | G | 6.79 | 9.43 |
| *Digitaria ciliaris* | G | - | 11.00 |
| *Fimbristylis miliacea* | S | 40.80 | 32.86 |
| *Leersia hexandra* | G | 10.42 | - |
| *Leptochloa chinensis* | G | 4.95 | - |
| *Ludwigia glandulosa* | B | 8.34 | 4.42 |
| *Marsilea crenata* | B | - | 16.94 |
| *Monochoria vaginalis* | B | 5.31 | 7.44 |
| *Sphenoclea zeylanica* | B | 13.58 | 11.93 |
| Total | | 9.00 | 7.0 |

B: Broadleaf, G: Grass, S: Sedge

Table 2: Species diversity index (H') value in Purwakarta regency (Pondok Salam and Pasawahan sub-district on conventional and organic farming system

| Species name | Index value (IV) on conventional farming system | Index value (IV) on organic farming system |
|---|---|---|
| *Alternanthera philoxeroides* | 7.77 | - |
| *Bacopa monnieri* | 31.49 | - |
| *Cynodon dactylon* | 27.15 | 37.73 |
| *Digitaria ciliaris* | - | 44.00 |
| *Fimbristylis miliacea* | 163.18 | 131.46 |
| *Leersia hexandra* | 41.70 | - |
| *Leptochloa chinensis* | 19.80 | - |
| *Ludwigia glandulosa* | 33.35 | 17.69 |
| *Marsilea crenata* | - | 67.78 |
| *Monochoria vaginalis* | 21.24 | 29.75 |
| *Sphenoclea zeylanica* | 54.31 | 71.59 |
| H' | 1.84 | 1.77 |

IV: Indexs value, H': Species diversity index

**Weed dry weight:** The data in Table 4 demonstrated that weed species that has the highest dry weight on conventional farming system was *Spenochlea zeylanica* 40.25 g, whereas weed species with the highest dry weight on organic farming system is *Marsilea crenata* 9.43 g. The weed dry weight in conventional farming system was higher than in organic farming system.

## DISCUSSION

**Weed vegetation analysis:** Weed vegetation analysis was required to determine the weed species, density and dominance. One of the keys for a successful post-emergent weed management strategy is the knowledge of weeds present in the field and the density of each weed species[21]. Generally, a single predominant weed is rarely found under field condition but it was composed by a few weed species[22].

Table 3: Value of community coefficient index (C) in Purwakarta regency on conventional and organic farming system

| | Conventional farming system | | Organic farming system | |
|---|---|---|---|---|
| Species name | Pasawahan | P salam | Pasawahan | P salam |
| *Alternanthera philoxeroides* | 3.9 | - | - | - |
| *Bacopa monnieri* | 11.5 | 4.3 | - | - |
| *Cynodon dactylon* | 10.2 | 3.3 | - | 18,9 |
| *Digitaria ciliaris* | - | - | - | 22,0 |
| *Fimbristylis miliacea* | 15.8 | 65.7 | 36,4 | 29,3 |
| *Leersia hexandra* | 13.6 | 7.2 | - | - |
| *Leptochloa chinensis* | - | 9.9 | - | - |
| *Ludwigia glandulosa* | 7.1 | 9.5 | - | 8,8 |
| *Marsilea crenata* | - | - | 33,9 | - |
| *Monochoria vaginalis* | 10.6 | - | - | 14,9 |
| *Sphenoclea zeylanica* | 27.1 | 29.6 | 29,7 | 6,1 |
| Total dominance value | 100.0 | 100.0 | 100,0 | 100,0 |
| Number of species | 8 | 6 | 3 | 6 |
| C = 2W/a+b×100% | C = 37.80% | | C = 35.41% | |

C: Community coefficient index, W: Sum of the two lowest quantities for each type of community, a: Sum of all quantities in the first community, b: Sum of all quantities in the second community

Table 4: Weed dry weight per species in Pondok Salam and Pasawahan sub-district on conventional and organic farming systems

| | Weed dry weight (g) | |
|---|---|---|
| Spesies name | Conventional | Organic |
| *Alternanthera philoxeroides* | 0.40 | - |
| *Bacopa monnieri* | 0.43 | - |
| *Cynodon dactylon* | 0.95 | 0.83 |
| *Digitaria ciliaris* | - | 0.43 |
| *Fimbristylis miliacea* | 27.85 | 4.75 |
| *Leersia hexandra* | 7.23 | - |
| *Leptochloa chinensis* | 1.23 | - |
| *Ludwigia octovalvis* | 21.73 | 0.48 |
| *Marsilea crenata* | - | 9.43 |
| *Monochoria vaginalis* | 2.18 | 2.35 |
| *Spenochlea zeylanica* | 40.25 | 1.60 |

Weed populations, especially in crop areas were never constant but they were in dynamic state of flux due to the changes in climatic and environmental conditions and husbandry methods[23]. The results showed a composite of mixed weeds of broad leaves, grasses and sedge with the broad leaves being more dominant than the grasses and sedge in organic farming system. In this study, the amount of dominant weed species found in organic farming system (4 weeds species) was higher as compared with the conventional farming system (3 weeds species). This probably due to weed control in organic farming used was hand weeding. Hand weeding was carried out not only to control weed but also reversing the soil that will give an opportunity for the weed seed to germinate and grow. Manual hand weeding will change soil structure and raise up the seed weed especially broad leaf seed weed to the soil surface[24]. *Fimbristylis miliacea* found to be a dominant weed on conventional and organic rice farming system. *Fimbristylis miliacea* is a weed that is commonly found in rice fields in Southeast Asia[25]. *Fimbristylis miliacea* is the most dominant weed grown in lowland rice farming in the vegetative and generative phase[26]. *Fimbristylis miliacea* is dominant weed in lowland rice field due to its ability to produce high amount of tiller[27].

**Species diversity index:** The diversity of weeds is strongly influenced by the environmental conditions[28]. Several factors affecting weed diversity were the type and degree of soil fertility, temperature, altitude, cultivation method, seeding method, water management, soil treatment and weed control technique. Weed distributors are carried out with the help of wind, water, animal and human[29]. The factors that cause diversity of weed species in conventional rice farming system are more varied than in organic farming system. This probably due to different soil treatment and weed control method. Factors affecting weed diversity were soil treatment and weed control technique[30].

The results of this research showed that soil tillage on both conventional and organic farming system used full tillage. The full soil tillage system can provide an opportunity for dormant weed seeds to germinate due to soil reversal and then it grows and develops following plant growth so that it can affect the productivity of plant[29]. On the conventional farming system, weed seeds in the soil are raised above the surface so that the types of weeds that appear become more numerous. In addition to the effect of soil tillage, the number of weeds is also affected by weed control factors[31]. In the conventional soil tillage, most weed control is carried out by using herbicide, in contrast to the soil tillage of organic farming system that used hand weeding. This probably will affect the diversity of weeds on conventional farming system

more varied than in organic farming system. The use of similar herbicides in a sustainable manner makes the weeds to be controlled susceptible to these herbicides. Weed composition change will always occur in any weed control technique, the changes will be more apparent if it is used herbicides[32].

**Community coefficient index (C):** Based on the value of weed Community Coefficient Index (C), it showed that the weed population on both conventional and organic farming systems was heterogeneous and this probably due to different environmental condition and different method of cultivation. Environmental condition and type of cultivation can influence the similarity of weed population[28]. If the value of C is more than 75%, then there was similarity between population in two research areas, whereas if the value of C is less than 75%, then between the two areas there will be a population difference, so it needs a difference in the weed control strategy[33]. Soil tillage keeps the weed seeds in the soil in dormant condition (secondary dormancy). The deposits of the weed seeds cannot germinate due to soil environment conditions that do not support germination[30]. The secondary dormancy in weeds is caused by several environmental factors such as temperature, storage condition, groundwater level and light[34]. Soil tillage causes the weed seeds in the soil appear to surface and germinate. Furthermore, weeds that germinate and grow on cultivated field are controlled manually or by other control methods so as not to give weeds a chance to breed. On conventional and organic farming system, soil tillage is carried out 2-3 times; with repetitive soil tillage practices, the longer the weed seeds in the soil will decrease and eventually the weeds are below the economic control limits.

**Weed dry weight:** The weed dry weight in conventional farming system was higher than in organic farming system and this probably due to higher nutrient content in conventional farming system. Conventional farming system used chemical fertilizer that contain higher amount of macro nutrient. The dry weight of plant reflects the nutrient of plant because the dry weight depends on photosynthesis. The growth and formation of plant vegetative organs affect the dry weight[35]. This process is strongly influenced by the availability of nutrient for plant and the rate of photosynthesis. The more solar energy that convert photosynthesis into photosynthates and the greater of soil fertility, the more increase the total dry weight of the plant.

## CONCLUSION

Based on this research, it was concluded that weed population in conventional and organic farming system was different. The dominant weeds in conventional farming system are *Fimbristylis miliacea*, *Sphenoclea zeylanica* and *Leersia hexandra*, whereas in organic farming system are *Fimbristylis miliacea*, *Marsilea crenata*, *Sphenoclea zeylanica* and *Digitaria ciliaris*. This study can be useful to determine an effective and efficient post emergent weed management strategy for the following season

## SIGNIFICANCE STATEMENT

This study discovered the several dominant types of weeds found in conventional and organic farming system in Purwakarta Regency, Indonesia which can be useful to determine an effective and efficient post emergent weed management strategy. This study could help researchers to know the characteristics of dominant weeds that could affect the yield of rice crop both in conventional and organic farming system.

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