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Weed diversity in rice (*Oryza sativa*) fields with different cultivation technologies in Garut Regency, Indonesia

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ABSTRACT

The presence of weeds in lowland rice cultivation will result in reduced growth and yield of rice plants, so the presence of weeds in cultivated crops must be controlled. Weed control applied to lowland rice cultivation will run effectively and efficiently after knowing the diversity of dominant weeds present in lowland rice cultivation. This study was conducted during 2017-18 at Padjadjaran University, Bandung, Indonesia to determine the diversity of weeds in lowland rice cultivation, both on conventional and SRI technology. The research was conducted on rice fields owned by farmers in four sub-districts in Garut Regency. The method used in this research is non-experimental through the survey method. Sampling was carried out on paddy fields using conventional planting system technology and SRI, each of 42 plots with a quadrant of 0.5 m x 0.5 m spread over four districts. The results showed that the types of weeds found in the conventional system were 20 types of weeds with the dominant weed *Ludwigia hyssopifolia*, in the SRI system there were 17 types of weeds with the dominant weed of *Echinocloa crus-galli*. The value of the diversity index (diversity) of weed species found in lowland rice cultivation in the Garut Regency area both in the conventional system and the SRI system is classified as moderate. The distribution pattern of all types of spatial weeds in lowland rice cultivation in the Garut Regency area, both in the conventional system and the SRI system, is included in the group distribution pattern.

Key Words : Conventional system, dominant weed, lowland rice, SRI system, weed diversity

INTRODUCTION

Weeds that grow in cultivated areas are very detrimental to farmers because they can cause crop yields to be lost. Weeds are able to grow and thrive among cultivated plants (Ramesh et al., 2017). The presence of weeds in cultivated plants will cause competition in taking nutrients, water, sunlight, CO2 and growing space, besides that, weeds can also be used as hosts for pests and diseases (Selvaraj and Hussainy, 2020). Therefore, the presence of weeds in the plantation will cause losses slowly as long as the weeds grow with cultivated plants and will ultimately affect plant growth and yields. (Kastanja, 2015; Saitama et al., 2016; Rathod and Somasundaram, 2017). In general, competition between plants and weeds can result in depressed plant growth, hampering the smooth running of agricultural activities, aesthetics, uncomfortable environment and increasing maintenance costs (Cheng and Cheng, 2015).

Weeds that grow in rice plantations include broadleaf weeds, narrow leaf weeds and enigma (Kurniadie *et al.*, 2020). Weeds are very competitive because they have an efficient breeding mechanism, which is able to reproduce generatively by producing lots of seeds and vegetatively, thus greatly reducing crop yields.

Rice (*Oryza sativa* L.) cultivation in Indonesia is carried out from generation to generation (conventional), this tradition continues to improve in line with the development of cultivation technology. Conventional rice cultivation is carried out by perfecting the soil until it has a mud structure.

Busari *et al.* (2015) suggested that tillage will produce soil structure for root growth, and better soil aeration than without tillage. This kind of tillage simultaneously suppresses the growth of weeds, making it easier to plant and easy roots to grow, but this method requires a higher cost because it will absorb more energy.

The decrease in soil fertility results in a decrease in rice yields. The continuous use of inorganic fertilizers and synthetic pesticides in lowland rice farming has a very bad impact on land fertility, both in terms of physical soil structure and soil bioorganisms. This is shown by the continued decline in rice yields per growing season. This situation can be seen from the average rice production in Indonesia in 2014 as much as 70.83 million tons of dry milled grain or a decrease of 0.45 million tons (0.63 %) compared to 2013 (Happy Hardjo, 2015).

Rice production requires a suitable growing environment for its growth in order to produce optimum production. Soil is a place to grow rice plants and requires fertile conditions both physically, chemically and biologically. Lack of input of organic matter causes reduced soil fertility, resulting in decreased rice production.

In line with efforts to improve land productivity, the concept of a sustainable rice planting system has been developed that takes environmental conditions into account. This system, called the System of Rice Intensification (SRI), is an intensive and efficient method of rice cultivation with a root system management process based on soil, plant and water management. Efforts to increase the availability of nutrients and soil health are decreasing, in the SRI system, fertilization is only done with organic matter. Planting is carried out on seeds aged 7-10 days after sowing (HSS), one perforated seed is planted at a depth of 1-1.5 cm at an average water level of 1 cm.

SRI was developed in an effort to restore soil health, so that it can continuously function as an important living system in the ecosystem and utilize soil to function biologically, can bind a lot of air and water from the environment to maintain plant, animal and human health and reactivate microorganisms in the environment. soil. In the process, it is directed to how farmers can manage agroecosystem elements such as sun, plants, microorganisms, water, air, pests and natural enemies as a potential that can be managed as environmentally friendly agriculture.

Increasing soil fertility will spur the growth of plants and weeds, so that the types of weeds that grow first will grow faster, which will inhibit the growth of the next weeds. Therefore, fertilization that is only done with organic fertilizer in the SRI system makes weeds in this system more numerous and less diverse. Rice weeds in conventional cultivation systems are fewer and more diverse. The use of inorganic fertilizers in conventional systems causes soil fertility to decrease. In less fertile land weed growth becomes slower and the land will be open longer, so it can spur the growth of the next type of weed to grow, so that weeds that grow on conventional land become fewer and more diverse.

Weed control efforts continue to be developed along with the development of cultivation technology. Weed control applied to lowland rice cultivation, both conventional and SRI technology, will run effectively and efficiently after knowing the diversity of dominant weeds present in lowland rice cultivation. For this reason, research on the diversity of weeds in paddy fields is very important to do.

MATERIALS AND METHODS

The research was conducted during June 2017 to February 2018 on rice fields owned by farmers in four sub-districts in Garut Regency, namely in Cisompet, Tarogong Kidul, Cilawu and Bayongbong sub-districts in Indonesia. Field surveys were carried out on weeds, then identification was carried out regarding the diversity of weed species in the Weed Science Laboratory, Faculty of Agriculture, Padjadjaran University, Bandung, Indonesia.

The materials used in this study were a map of the Garut Regency area and a questionnaire for research materials. While the tools used in this study were square meters (0.5 m × 0.5 m), scissors, hoes, tape measure, plastic bags, machetes, analytical scales and drying ovens.

The methods used were both qualitative (weed survey) and quantitative (identification). Each sub-district will be selected randomly at the location of the rice field area as a sample that is spread over various conditions of different altitudes or topography. Each sample location was analyzed diagonally for weed vegetation (5 times) for each area of potato and Chinese cabbage cultivation with the quadratic method, the size of the quadrant used was 0.5 m × 0.5 m. Data analysis was carried out quantitatively to determine the diversity index (H').

Weed vegetation analysis was carried out by taking weeds from destructive plots of 0.25 m^2 and grouped by weed species, dry weight per species and total measured by weighing the weeds that had been dried in the oven until they reached a constant weight at 80°C. Furthermore, the calculation of the importance of weeds, the value of the number of weed dominance, the weed diversity index, the dominance index (D) of weed species and the weed species dominance index (D) with the following formula:

Importance Value is the value obtained from the calculation as proposed by Kurniadie *et. al.* (2019) namely:

$$\text{Relative density of a species} = \frac{\text{Absolute density value of one species}}{\Sigma \text{ Absolute density value of all species}} \times 100\%$$

$$\text{Relative frequency of a species} = \frac{\text{Absolute frequency value of one species}}{\Sigma \text{ absolute frequency value for all species}} \times 100\%$$

$$\text{Relative dominance of a species} = \frac{\text{Absolute dominance value of one species}}{\Sigma \text{ absolute dominance value of all species}} \times 100\%$$

Importance value = Relative Density + Relative Frequency + Relative Dominance

$$\text{Summed Dominance Ratio (SDR)} = \frac{\text{Importance value}}{3}$$

The type of weed that has the largest SDR value means that the weed is the dominant weed.

Knowing the size of the Species Diversity Index (H') in a community whose purpose is to assess the level of diversity of weed communities in an area, using the formula according to Barbour *et al.* (1987). The data is processed using the Ecological Methodology Program.

$$H' = -\sum_{i=1}^{n} (pi)(\ln pi)$$

Where, pi = ni/N

ni = The number of significant values of one species

N = The sum of the significance values of all species

ln = Natural logarithm

In order to interpret the meaning of the Shannon-Wiever Species Diversity Index (H') value, the criteria suggested by Barbour *et al.* (1987) were used. The value of H' usually ranges from 0 to 7. If H' < 1 category is very low, If H' > 1-2 low category, If H' > 2-3 moderate category (medium), If H' > 3-4 high category and if H' > 4 very category high.

Community coefficient was calculated using the following formula described by Tjitrosoedirdjo *et al.* (1984):

$$C = \frac{2W}{a + b} \times 100\%$$

C = community coefficient

W = Sum of the two lowest quantities for the species from each community

(i) Sum of all the quantities in the first community
(ii) Sum of all the quantities in the second community

Determination of the distribution pattern of each type using the ratio between the mean (-X) and standard deviation (SD) with the following criteria:

(i) If the value of SD/-X = 1 then it is distributed randomly.
(ii) If the value of SD/-X>1 then it is distributed in groups.
(iii) If the value of SD/-X < 1 then it is distributed regularly.

RESULTS AND DISCUSSION

Weed Diversity Observed

The results of the research and calculation of weed diversity in lowland rice in Garut Regency, there are differences in the diversity of weed species in the conventional planting system and the SRI system. Based on the data in Table 1, it can be seen that in the conventional system there are 20 species of weeds and in the SRI system there are 17 types of weeds that are present in lowland rice cultivation.

In the conventional system the dominant type of weed in lowland rice is broadleaf weed namely *Ludwigia hyssopifolia* with a Summed Dominance Ratio (SDR) value of 17.975 %, and the co-dominant weed types include *Monochoria vaginalis* (SDR = 15.135 %) and *Echinocloa crus-galli* (SDR = 10.714 %). While in the organic system (SRI) the dominant type of weed in lowland rice cultivation is grass weed namely *Echinocloa crus-galli* with a Summed Dominance Ratio (SDR) of 26.724 %, and the co-dominant weed types include *Pistia stratiotes* weed (SDR = 12.982 %) and *Fimbristylis miliaceae* (SDR = 10.979 %).

Table 1. Value of species diversity of weed species found in conventional and SRI paddy rice planting in Garut Regency

No.	Weed Type	Conventional	SRI
		SDR	SDR
1.	*Azolla pinnata*	0.000	5.125
2.	*Pistia stratiotes*	0.000	12.982
3.	*Salvinia molesta*	0.000	8.171
4.	*Echinocloa crus-galli*	10.714	26.724
5.	*Fimbristylis miliaceae*	1.934	10.979
6.	*Monochoria vaginalis*	15.135	2.755
7.	*Limnocharis flava*	7.480	1.687
8.	*Oxalis corniculata*	1.734	0.000
9.	*Marsilea crenata*	6.162	0.000
10.	*Plantago major*	9.969	0.000
11.	*Sphenoclea zeylanica*	0.368	7.201
12.	*Cyperus iria*	2.170	2.553
13.	*Ludwigia hyssopifolia*	17.975	6.631
14.	*Eleusine indica*	1.382	0.344
15.	*Cyperus difformis*	3.616	8.008
16.	*Ludwigia adscendens*	4.129	3.474
17.	*Bolboschoenus maritimus*	2.324	0.000
18.	*Paspalum dictichum*	9.041	0.234
19.	*Dactiloctenium aegyptium*	0.604	0.000
20.	*Ludwigia octivalvis*	4.247	1.660
21.	*Polygonum hydropiper*	0.000	0.234
22.	*Rottboellia cochinchinensis*	0.315	0.000
23.	*Cynodon dactylon*	0.398	0.000
24.	*Marselia minuta*	0.301	1.238
	Total	100.000	100.000

SRI = System of Rice Intensification; SDR = Summed Dominance Ratio.

Differences in weed diversity occur due to differences in plant cultivation technology applied. In conventional system technology more weed species were found with fewer individuals, while in the organic system technology (SRI) fewer weed species were found with more individuals. In line with the opinion of Marshall *et al.* (2003) that differences in weed populations in cultivated crops are strongly influenced by differences in the applied agricultural system. This shows that soil fertility conditions are different due to cultivation technology, one of which is the application of fertilization technology. The conventional fertilization system prioritizes the use of inorganic fertilizers, while the SRI system prioritizes the use of organic fertilizers such as manure which can increase the physical, chemical and biological fertility of the soil.

The application of organic fertilizer in the SRI system will support the ability of weeds to grow faster and will dominate the land because the soil fertility requirements are met, so as not to provide opportunities for other species to grow. In the opinion of Tippe *et al.* (2020) that different fertilization will affect weed populations in rice plants. The number of weed species in cultivated crops is influenced by plant density, soil fertility, cultivation patterns and soil management (Wu *et al.*, 2019; Fehér *et. al.*, 2020; Scavo and Mauromicale, 2020).

Diversity Index, Community Similarity, Evenness and Weed Dominance

The results showed that the index of weed diversity (H') in all plots in the conventional cropping system studied was 2,368 and in the organic system 2,241 (Table 2). The value of the diversity index (diversity) describes the presence of weed species found in lowland rice plants in the Garut area which is classified as moderate. Rice fields in general have this limited diversity due to waterlogging. Plant diversity in rice field ecosystems tends to be limited depending on human management activities (Turner et al., 2011). The level of weed diversity at the study site, both in conventional and SRI systems, was classified as moderate. This condition illustrates that the diversity of weeds in the rice fields in the Garut area is quite balanced. This conclusion is supported by the types of weeds that dominate almost the entire research area, namely several different types of weeds with relatively non-uniform strata. According to Kunarso and Azwar (2013) canopy closure affects the structure and composition of the understorey. Types of plants with relatively the same canopy cover form the same microclimate. Schumacher et al. (2018) stated that one of the factors that influence the level of species diversity in a community is habitat conditions. The dominance of one type of weed that is high on the land affects the species evenness index. The species evenness index on conventional land is relatively the same as the SRI system (Table 2).

Table 2. Index of diversity, community similarity, evenness of species and weed domination in conventional and SRI planting systems in Garut Regency

No.	Parameter	Cultivation Tecnology	
		Conventional	SRI
1.	Diversity (H')	2.368	2.241
2.	Community Similarity (C')	70.270	70.270
3.	Evenness of Species (e')	0.790	0.791
4.	Weed Domination (D)	0.121	0.125

Weed Spread Pattern

The pattern of distribution of weeds in the conventional and SRI systems of lowland rice in Garut Regency (Tables 3 and 4) shows that of the 24 types of weeds found in the study site, 20 types of weeds were found in the conventional system and 17 species were found in the SRI system. The distribution pattern of all types of spatial weeds found groupings (SD value / average > 1) Certain types with group distribution patterns, caused by seeds or propagation of each plant will generally fall around the parent tree, so that if other conditions support it then it will occur regeneration in the form of new saplings around the parent tree. This type of grouping is generally a dispersal agent in the form of wind, so that if the size of the fruit/seed is relatively large, it cannot spread over a longer radius.

Table 3. Distribution pattern of weed species in conventional technology

No.	Weed Type	Σ	SD	Average	SD/Average	
1.	*Monochoria vaginalis*	148	4.544	3.524	1.289	Group
2.	*Plantago mayor*	81	3.071	1.929	1.593	Group
3.	*Echinocloa crus-galli*	64	2.907	1.524	1.908	Group
4.	*Paspalum diktikum*	59	3.429	1.405	2.441	Group
5.	*Limnocharis flava*	55	2.290	1.310	1.749	Group
6.	*Ludwigia hyssopifolia*	48	3.310	1.143	2.896	Group
7.	*Marsilea crenata*	46	1.973	1.095	1.802	Group
8.	*Cyperus difformis*	28	2.008	0,667	3.012	Group
9.	*Ludwigia octovalvis*	25	1.449	0,595	2.435	Group
10.	*Ludwigia adsendens*	19	1.347	0.452	2.978	Group
11.	*Oxalis corniculata*	12	1.312	0.286	4.592	Group
12.	*Bolboschoenus maritimus*	10	0.790	0.238	3.320	Group
13.	*Fimbristylis miliaceae*	6	0,647	0.143	4.526	Group
14.	*Cyperus iria*	4	0.297	0,095	3.120	Group
15.	*Eleusine indica*	3	0,342	0,071	4.783	Group
16.	*Dactiloctenium aegyptium*	2	0.216	0,048	4.526	Group
17.	*Sphenoclea zeylanica*	1	0.154	0,024	6.481	Group
18.	*Cynodon dactylon*	1	0.154	0,024	6.481	Group
19.	*Rottboellia cochinchinensis*	1	0.154	0,024	6.481	Group
20.	*Marsilea minuta*	1	0.154	0,024	6.481	Group
21.	*Azolla pinnata*	0	0,000	0,000	0,000	-
22.	*Pistia stratiotes*	0	0,000	0,000	0,000	-
23.	*Salvinia molesta*	0	0,000	0,000	0,000	-
24.	*Hidropiper Poligonum*	0	0,000	0,000	0,000	-
	Total	614	8.582	14.619	0,587	

Table 4. Distribution pattern of weed species in SRI technology

No.	Weed Type	Σ	SD	Average	SD/Average	
1.	*Echinocloa crus-galli*	259	9.838	6.167	1.595	Group
2.	*Cyperus difformis*	214	14.274	5.095	2.801	Group
3.	*Pistia stratiotes*	205	5.739	4.881	1.176	Group
4.	*Fimbristylis miliaceae*	140	6.155	3.333	1.847	Group
5.	*Sphenoclea zeylanica*	136	8.132	3.238	2.511	Group
6.	*Salvinia molesta*	124	4.248	2.952	1.439	Group
7.	*Azolla pinnata*	84	3.422	2.000	1.711	Group
8.	*Ludwigia hyssopifolia*	54	3.300	1.286	2.567	Group
9.	*Monochoria vaginalis*	50	3.494	1.190	2.935	Group
10.	*Ludwigia adscendens*	27	1.186	0.643	1.844	Group
11.	*Cyperus iria*	15	1.206	0,357	3.377	Group
12.	*Limnocharis flava*	10	0,656	0.238	2.753	Group
13.	*Marsilea minuta*	6	0.417	0.143	2.922	Group
14.	*Ludwigia octivalvis*	3	0.261	0,071	3.649	Group
15.	*Eleusine indica*	1	0.154	0,024	6.481	Group
16.	*Paspalum diktikum*	1	0.154	0,024	6.481	Group
17.	*Polygonum hidropiper*	1	0.154	0,024	6.481	Group
18.	*Oxalis corniculata*	0	0,000	0,000	0,000	-
19.	*Marsilea crenata*	0	0,000	0,000	0,000	-
20.	*Plantago mayor*	0	0,000	0,000	0,000	-
21.	*Bolboschoenus maritimus*	0	0,000	0,000	0,000	-
22.	*Dactiloctenium aegyptium*	0	0,000	0,000	0,000	-
23.	*Rottboellia cochinchinensis*	0	0,000	0,000	0,000	-
24.	*Cynodon dactylon*	0	0,000	0,000	0,000	-
	Total	1330	62.790	31.667	1.983	

CONCLUSION

The types of weeds found in the conventional system were 20 types of weeds with the dominant weed *Ludwigia hyssopifolia* (SDR of 17.975 %), in the SRI system there were 17 types of weeds with the dominant weed of *Echinocloa crus-galli* (SDR of 26.724 %).The value of the diversity index (diversity) of weed species found in lowland rice cultivation in the Garut Regency area both in the conventional system and the SRI system is classified as moderate. The distribution pattern of all types of spatial weeds in lowland rice cultivation in the Garut Regency area, both in the conventional system and the SRI system, is included in the group distribution pattern.

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