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Weed diversity in rice fields with different cultivation technologies and weeding frequencies

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Abstract
Differences in weed diversity in paddy fields can occur due to different cultivation technology factors. The population density in paddy rice weed communities can affect the level of weed competition with plants. The research objective was to determine the relationship between planting and weeding system technology on weed diversity in lowland rice. The method used is the experimental method with Split Plot Design as the main plot is the cultivation system (S) and the subplot is weeding frequency (P). The data obtained is used to analyze the Summed Dominance Ratio (SDR), and the Diversity Index (H') value. The results showed that lowland rice cultivation technology and weeding frequency had an effect on the weed species found. The SRI system found 12 species, the conventional system found 13 species and the zerotillage system found 14 species. If no weeding is carried out, the dominant weed in the SRI and conventional systems is Cyperus difformis, while in the zerotillage system, it is Sphenoclea zeylanica. Cultivation technology interacts with the frequency of weeding on the weed diversity index, with low to moderate levels of diversity.

Keywords: Cropping system, rice, weed, weeding, weed diversity

Introduction

The creation of new habitat on agricultural land makes the species composition different from that in forests or agricultural land (Feher & Prus, 2020) [6]. Weed species have the ability to adapt to various agroecosystems and dynamic climatic conditions (Faisal *et al*., 2003) [5]. Cultivation methods, cultivated plant species, and the growing environment will influence the growth and spread of weeds. The presence of weeds in lowland rice can cause yield loss, therefore the magnitude of lowland rice yield loss can be influenced by cultivation methods (Singh *et al*., 2016) [17].

The presence of weeds on organic rice fields such as the System of Rice Intensification (SRI) is more numerous, but less diverse compared to conventional fields. (Mutakin *et al*., 2021) [11] stated that the weed species found in the conventional system were 20 types of weeds with the dominant weed Ludwigia hyssopifolia, whereas in the SRI system there were 17 weed species with the dominant weed Echinocloa crus-galli. The weed population in conventional rice cultivation systems can be suppressed by flooding, while in the SRI method, weed growth will be higher because the irrigation system is generally random and chemical herbicides are not applied. The no-till planting system (zero tillage) is a cultivation technology that involves no land processing at all. In the zerotillage system, weed control is usually carried out using herbicides (Shannora, 2020) [15].

The presence of weeds can inhibit the growth and development of rice, resulting in crop yield loss. Yield loss occurs due to the growth of weeds at the same time as rice plants have the ability to grow faster (Raj & Syriac, 2017) [12]. The organic cultivation system is considered to have the advantage of restoring soil fertility, but there are more weeds growing on the land, so a larger workforce is needed to weed the weeds (Sudinto, 2015) [18].

Weeding is an effort to control weeds which can physically harm the growth of rice crops. Weeding in rice plantations must be done quickly (Siagian, 2013) [16]. If weeding is done after the weeds have flowered, the weed roots from the soil will not be lifted properly and will encourage the growth of viable weed seeds, thus providing an opportunity for them to reproduce and spread.

Lowland rice cultivation technology causes the growth and presence of different weed species and populations, because the growth of lowland rice weeds is influenced by various factors related to technical culture such as tillage, fertilization, flooding, and weed control methods. A shift in weed species and composition in a different direction is due to the application of different cultivation systems, so this will have an impact on control measures. Therefore, the diversity of weeds in cultivation technology as well as the influence of cultivation technology and control measures against weeds on rice plants is important to study as a first step in determining control policies. The aim of this research is to determine the relationship between cultivation and weeding technology on the diversity of rice weeds.

Materials and Methods

The experiment was carried out in the Garut Regency area which is located at an altitude of 690 meters above sea level with rainfall type C based on (Schmidt, F. H dan Ferguson, 1951) [13]. The experimental materials used included Ciherang cultivar rice seeds, organic fertilizer, chemical fertilizer and herbicides. The tools used include; soil processing tools, rice maintenance tools, prim (square frame made of wood) measuring 0.5m x 0.5m, plastic bags, label paper, stationery, measuring tools, and weed laboratory equipment. The research method used is an experimental method with a Split Plot Design. The main plot is the planting system (S) which includes 3 levels, namely s1: SRI planting system, s2: conventional planting system, s3: zero tillage planting system. As a subplot, weeding (P) includes 4 levels of treatment, namely p0: no weeding, p1: weeding three times at an age (20, 40, and 60 DAP), p2: weeding once at an age (40 DAP) and p3: weeding twice age (40 and 60 DAP). Weeds were observed from 5 sample points in each treatment plot covering an area of 0.25 cm2 at 20, 40 and 60 DAP. Weeds are removed and the roots are cleaned and then separated into groups. Each group is separated again according to type and the population is calculated. The data obtained was used to analyze the Summed Dominance Ratio (SDR) with the formula proposed by (Chaves, 1982) [3], namely

$$\text{Relative density} = \frac{\text{absolute density value of a type}}{\sum \text{absolute density value of all types}} \times 100\%$$

$$\text{Relative frequency} = \frac{\text{the absolute frequency value of a type}}{\text{absolute frekuency values of all types}} \times 100\%$$

$$\text{Relative dominance} = \frac{\text{The absolute dominance value of a species}}{\sum \text{absolute dominance value of all types}} \times 100\%$$

$$\text{Absolute density} = \frac{\sum \text{individual specific types of weeds in the plot}}{\text{Plot area}}$$

$$\text{Absolute frequency} = \frac{\sum \text{plot found a type}}{\sum \text{entire observation plot}}$$

$$\text{Absolute dominance} = \frac{dry\ weight}{\text{plot area}}$$

$$\text{SDR} = \frac{\text{important score}}{3}$$

To obtain the Diversity Index (H') value, the data was analyzed using the Shannon-Wiener formula (Khadka *et al*., 2016) [9]

Results and Discussion

Lowland rice cultivation technology and the frequency of weeding influence the species and populations of weeds found. In the System of Rice Intensification (SRI), conventional and zero tillage trial plots, 16 species were found consisting of 11 species of broad-leaf weeds, 3 species of narrow-leaf weeds and 2 species of puzzle weeds. There are fewer weed species found in the SRI planting system compared to conventional and zero tillage systems. In the SRI system 12 species were found, in the conventional system 13 species were found and in the zerotillage system 14 weed species (Table 1)

Table 1: Composition of Weeds Found in Several Planting and Weeding Systems Observed at Ages 20, 40 and 60 HST

Weeds species	**Planting System**		
	S1	**S2**	**S3**
A. Broadleaf Group			
Conyza sumtrensis	√	√	√
Ludwigia octovalvis	√	√	√
Pistia scratiotes (L)	√	√	√
Salvinia molesta		√	√
Commelina benghalensis	√	√	
Sphenoclea zeylanica	√	√	√
Monocoria vaginalis	√	√	
Portulaca oleracea		√	√
Ludwigia hisopolia			√
Commelina nudiflora (L.)			√
Limnocharis flava	√	√	√
B. Narrow Leaf Group			
Cynodon dactylon	√	√	√
Echinochloa crus-galli (L)	√	√	√
Hydrilla verticillata L. R	√		√
C. Puzzle Group			
Cyperus difformis	√	√	√
Fimbristilis miliacea	√	√	√
∑ species	12	13	14

Description: S1 (S.R.I planting system), S2 (Conventional planting system), S3 (zero tillage).

Table 1 shows that there are 7 species of weeds that grow without overlap with all cultivation systems. 1.) Portulaca oleracea, Salvinia molesta Monocoria vaginalis, Commelina benghalensis, Commelina nudiflora (L.), Ludwigia hisopolia, and Hydrilla verticillata L. R. This condition illustrates that cultivation system technology has been able to differentiate the presence of weed species in lowland rice communities. The presence of weed types in crops is influenced by differences in crop management, such as water management and fertilization techniques. Another influencing factor is the morphological characteristics and characteristics of the constituent plants which influence the microclimate, resulting in different responses to weed types (Irakiza *et al*., 2022) [8] The large number of weed species that grow in rice plantations can also be caused by soil processing and manure input (Aditya Wira Tantra dan Edi Santosa Studi *et al*., 2016) [1].

Summed Dominance Ratio value

The large population of weed species in a habitat can determine the level of weed dominance. Based on Summed Dominance Ratio (SDR) analysis, the weed species found in each cultivation technology and weeding frequency show different SDR values (Table 2).

Table 2: Summed Dominance Rate (SDR) Values for Lowland Rice Cultivation Technology and Weeding Frequency at 60 DAP (%)

Weeds Species	**S1**				**S2**				**S3**			
	p_0	**p_1**	**p_2**	**p_3**	**p_0**	**p_1**	**p_2**	**p_3**	**p_0**	**p_1**	**p_2**	**p_3**
Cyperus difformis	46,57	4,37	3,68	15,90	51,10	14,62	12,35	3,94	13,57	0,00	3,29	5,02

Fimbristylis miliacea	23,34	25,84	41,07	23,94	26,99	13,63	13,50	38,95	18,43	14,36	7,31	4,16
Pistia scratiotes (L.)	14,09	44,39	7,81	33,33	0,00	0,00	6,86	10,04	11,44	3,85	31,62	41,34
Conyza sumtrensis	8,54	13,78	23,62	8,99	6,55	2,03	4,78	0,00	1,70	0,00	2,22	5,09
Ludwigia octovalvis	7,46	9,91	22,61	13,37	1,29	6,32	4,99	0,00	5,61	7,67	9,99	5,35
Salvinia molesta	0,00	0,00	0,00	0,00	2,68	50,39	44,72	44,12	5,79	29,59	31,43	28,35
Sphenoclea zeylanica	0,00	0,00	0,00	0,00	4,23	4,81	0,00	2,95	20,07	5,01	0,00	2,97
Monocoria vaginalis	0,00	0,00	0,00	0,00	0,00	2,66	0,00	0,00	0,00	0,00	0,00	0,00
Ludwigia hisopolia	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,54	6,95	0,00
Commelina nudiflora (L)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,75	0,00
Limnocharis flava	0,00	1,71	0,00	2,35	2,58	0,00	6,05	0,00	0,00	0,00	0,00	0,00
Cynodon dactylon	0,00	0,00	1,21	2,13	4,58	5,54	6,76	0,00	11,42	5,91	2,96	0,00
Echinochloa crus-galli (L.)	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,78	0,00	0,00
Hydrilla verticillata L. R	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	11,98	27,29	147	7,72
	100	100	100	100	100	100	100	100	100	100	100	100

Description: S1 (S.R.I planting system), S2 (Conventional planting system), S3 (zero tillage). p0; not carried out Weeding Frequency, p1; Weeding Frequency 1 times age (40) DAP p2; Weeding Frequency 2 times age (40 and 60) DAP p3; Weeding frequency 3 times the age (20, 40 and 60) DAP

Cyperus difformis (puzzle group) in SRI and conventional cultivation technology shows the highest SDR value, namely; on SRI cultivation technology 46.57% and on conventional 51.10%. In the vegetative phase, the SDR value of Cyperus difformis was the highest. This type of weed has the characteristic of growing in clumps and densely, so it has the opportunity to produce more allelopathic substances than other types of weed. This weed is also very competitive in rice cultivation because it produces a lot of seeds and is very easy to grow (Holm, L.R.G, Plucknett, R.L, J.V. Pancho, 1987) [7]

Zero tillage cultivation technology shows that the SDR value of weed species is relatively even, with the highest SDR value shown in the species Sphenoclea zeylanica 20.07% (broad leaf group). After weeding, the highest SDR value for each cultivation system technology decreased. In the SRI system, the SDR value of Cyperus difformis decreased to 3.68%. In the conventional system there was a reduction in Cyperus difformis up to 3.94%. Meanwhile, in zero tillage, there was a decrease in Sphenoclea zeylanica up to 0.00%. The decrease in the SDR value of the highest weed species in each weeding frequency treatment, spurred an increase in the SDR value of other weed species growing in each cultivation technology which was previously suppressed.

Diversity Value (H')

After the SDR value for all species is known, the diversity index (H') value is then calculated (Shannon, C. E., 1949) [14] data is calculated based on weed species. Species diversity is a measure of the population diversity of a community. If the species richness in a community increases, the H' value will increase, and the distribution will be more even (Suwastika & Pitopang, 2018) [20].

Changes in the composition of weed diversity can occur due to the application of cultivation technology which is influenced by the frequency of weeding. This happens because in cultivation systems there are different ways of meeting plant needs. Implementation of a puddle system and provision of nutrients (Syaifudin & Putra, 2022) [21]. Using inorganic fertilizer in conventional cultivation technology and zero tillage results in the plant growing environment in cultivation technology being different from the SRI system which applies a shallow irrigation system and only uses organic fertilizer, so that in the SRI rice cultivation system aerobic weed species can grow quickly without standing water.

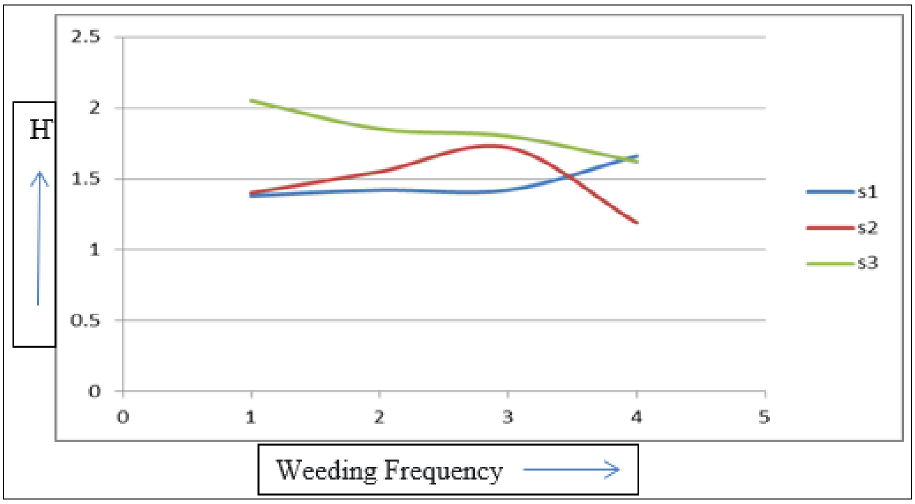
Based on Table 3, it is known that at the age of 60 HST in the treatment without weeding, the SRI and conventional cultivation technologies showed low weed diversity values, while the zerotillage cultivation technology showed moderate weed diversity. After weeding frequency treatment, either once, twice and three times, weed diversity in all cultivation technologies became low (Mardiyanti *et al*., 2013) [10] stated that rice fields are land for cultivating rice plants, therefore the diversity of plant types that live in rice field ecosystems tends to be limited depending on management.

Table 3: H' Value of Weeds in Lowland Rice Cultivation Technology and Weeding Frequency at Age 60 HST

Cultivation Technology	Weeding Frequency			
	p_0	p_1	p_2	p_3
SRI	1,38	1,42	1,42	1,66
Conventional	1,4	1,55	1,72	1,19
Zero tillage	2,05	1,85	1,8	1,62

Information
$H' \leq 1$ = Very low diversity
$1 < H' \leq 2$ = Low diversity
$2 < H' \leq 3$ = Medium diversity
$3 < H' \leq 4$ = High diversity
$H' > 4$ = Very high diversity

The rates of weed diversity values in SRI and conventional cultivation technologies tend to be opposite after weeding, while in zero tillage cultivation technology they tend to decrease linearly (Figure 1). From Figure 1 it is known that the rate of diversity in SRI cultivation technology is related to weeding frequency once and twice tended not to change, but when weeding three times there was an increase in weed diversity values. In contrast to conventional technology, from weeding once it continues to increase to weeding twice, from weeding twice to three times there is a decrease. This causes an intersection of the diversity value rate lines between SRI and conventional cultivation technology between two to three times weeding. Meanwhile, in zero tillage cultivation technology, the frequency of weeding is one to three times, showing a linear decrease in diversity values, and finally intersecting with the conventional system of weeding three times.



Note: 1 = p0 (without weeding, 2 = P1 (1time weeding), 3 = p2 (2 times weeding), 4 = p3 (3 times weeding)

Fig 1: Changes in Weed Diversity Values (H') in the Cultivation System and Weeding Frequency

(Mardiyanti *et al*., 2013) [10] explained that plant diversity in rice field agroecosystems is limited depending on management activities. Organic agricultural land is land that is free from chemicals, making it easier for plants and weeds to grow, in this condition the weed species that grow next will be suppressed. (Apriani *et al*., 2018) [2].

According to (Sumekar *et al*., 2017) [19] The differences in weed species are caused by different cultivation methods, so they provide different responses. The number of species and number of individual weeds found will affect the diversity index value (Estaranti *et al*., 2017) [4].

Conclusion

Lowland rice cultivation technology and the frequency of weeding influence the weed species found. If weeding is not carried out, the dominant weed in the SRI and conventional systems is Ciperus difformis, while in the zerotillage system it is Sphenoclea zeylanica. Cultivation technology interacts with weeding frequency on the weed diversity index, with low to medium diversity levels.

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