The Effect of Weed Management on Seed Banks in Paddy Rice Fields

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Abstract

Weeds are one of the problems in rice plants, so the presence of weeds in rice fields must be controlled. Different ways of managing weeds on agricultural land can affect the seed bank of weeds in the soil. This study aims to determine differences in weed seed banks due to differences in weed management, especially the use of herbicides in lowland rice. The study was conducted at the Agricultural Training and Development Research Center, Faculty of Agriculture, Padjadjaran University, Bandung Regency, Indonesia from May–July 2020. The study used a paddy field plot consisting of intensive, less intensive use of herbicides and non-herbicide use. This research was conducted with survey and descriptive methods to see the type and composition of weeds at a certain depth and to see differences in seed banks. Observations were made including analysis of weed vegetation, community coefficients, weed diversity, weed dominance and differences in seed bank from depth. The results showed that there were 7 weed species found, namely *Rorippa palustris, Monochoria vaginalis, Leptochloa chinensis, Echinochloa crus-galli, Eclipta prostate, Lindernia procumbens,* and *Marchantia polymorpha*. Weed management with herbicides is proven to reduce weed populations that grow.
Keywords: weed, seed bank, herbicide, lowland rice

Introduction

Weeds are one of the problems in rice plants that can cause a decrease in production to reach 15-42% for lowland rice and 47-87% for upland rice (Denny Kurniadie *et. al.*, 2019). Weeds can directly affect the main crop due to competition for nutrients, water, and light. The existence of competition with weeds causes the growth of rice plants to be inhibited, plants to be stunted, and abnormalities that arise in plant tissues (Merry Antralina *et. al.*, 2015). Therefore, we need a control that can reduce weed competition with rice as the main crop. Knowledge of the types of species that will grow in a field can be one of the references in determining the right weed control policy in the future.

Weeds that grow in a place are influenced by weed propagules available in that land. Propagules are dormant weeds that can develop into new weeds if environmental conditions are favorable. Propagules themselves can be in the form of seeds, stolons and rhizomes that are in the soil (Byrne *et. al.*, 2017). Weed seeds in the soil/ha can reach millions in number consisting of about 50 species. This can be influenced by previous tillage and vegetation on it (Lauren M. Schwartz-Lazaro and Josh T. Copes, 2019). Seeds of annual species (annual species) can usually survive in the soil for years as a reserve of viable seeds (Shiferaw *et. al.*, 2018). The number of weed seeds can reach millions of numbers per hectare because weed seeds can accumulate in the soil so that their density increases.

There are various ways to control paddy rice weeds, the control can be done manually, mechanically, technical culture, or using chemicals. According to Barbas *et. al.* (2020) the most widely used control method is chemically using herbicides. Judging from the technology and habits of farmers in managing weeds in lowland rice, it can be grouped into 3 types of management, namely, (1) weed management that uses fully human power (weeding and or using gasrok), (2) weed management using a mixture of human and chemical energy. , and (3) fully chemical/herbicide weed management. Among various weed control methods, chemical control methods (using herbicides) tend to increase (quality and quantity) from year to year in many countries in the world (Abouziena and Haggag, 2016). Continuous weed control using herbicides can cause weeds to become tolerant of certain types of herbicides that can cause resistance (Kraehmer *et. al*., 2014).

To find out differences in weed seed banks due to differences in weed management in lowland rice, it is necessary to conduct research.

Materials and Methods

The research was conducted at the Agricultural Training and Development Research Center Faculty of Agriculture, Padjadjaran University, Baleendah District, Bandung, Indonesia from May–July 2020. The study was conducted using three plots of rice fields consisting of from intensive use of herbicides, less intensive and not using herbicides.

The tools used during the study were paralon pipes with a diameter of 10 cm, a length of 30 cm that had been marked, a flush tool, a seed bank container (food container) as many as 84 samples, which were coded with infraboard with details of 7 plots and soil depth (0 -5 cm, 5-10 cm, 10-15 cm, 15-20 cm) on each plot.

This research was conducted with survey and descriptive methods to see the type and composition of weeds at a certain depth and to see differences in seed banks found in intensive, less intensive, and non-herbicide use in paddy fields. . Spraying herbicides more than once before planting is categorized as intensive herbicide use in paddy fields. Spraying herbicides once before planting is categorized as lowland rice fields with less intensive use of herbicides. The absence of herbicide spraying before planting is categorized as rice paddy fields not using herbicides.

This research was conducted by taking 7 soil sample points on each land consisting of rice fields with normal, continuous and infrequent herbicide intensification. Soil depth required for each soil sampling at each point such as 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm. So the number of soil samples totaled 84 samples from 7 points from each land, 4 samples depth from each point.

Observation

After thirty-five days, observations were made on the types of weeds that grew and the number and composition of the population of the existing group weeds and looked for differences in the types and compositions of weeds from each field. The observed response variables include:

a. Vegetation analysis

Vegetation analysis is the way to study the composition and vegetation structure or plants colony. Weed vegetation analysis carried out by picking up the weed from destructive plot 0.25 m2 and grouped per weed species. Dry weight per species and total measured by means of weighting the dried weed in the oven until reaching constant weight at temperature of 800C. Furthermore, the counting of weed Importance Value (IV), Summed Dominance Ratio (SDR), weed diversity index, dominance index (D), weed type and weed species dominance index (D) with following formulas:

Weed Importance Value (IV) is value obtained from the calculation :

1. Density

$$\text{Absolute density} = \frac{\text{Number of individuals type}}{\text{Number of plots}}$$

Relative Density $= \frac{\text{absolute density of a species}}{\text{absolute density of all species}}$ X 100%

2. Frequency

Absolute frequency $= \frac{\text{The number of plots of that species is}}{\text{Number of plots}}$

Relative Frequency $= \frac{\text{The absolute frequency of a species}}{\text{Absolute frequency of all species}}$ X 100%

3. Domination

Absolute Domination $= \frac{\text{Number of individuals of a species}}{\text{Number of plots where the species is located}}$

Relative Dominance $= \frac{\text{Absolute dominance of a species}}{\text{Absolute dominance of all species}} \times 100\%$

4. Important Value = Relative Density + Relative Frequency + Relative Dominance

1. SDR (*Summed Dominance Ratio*)

SDR $= \frac{\text{Important Value}}{3}$

b. Community Coefficient (C)

The assessment of the community coefficient value used is based on Bonham (1989) which can be seen in Table 1 below. According to Tjitrosoedirdjo, et al (1984) the community coefficient value (C) can be calculated by the following formula:

$$(C) = 2\frac{W}{A+B} \times 100\%$$

Information:

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

A = The sum of all the quantities in the first community

B = The sum of all the quantities in the second community

Table 1. Community Coefficient Benchmark Value

Benchmark value	Information
91%-100%	There is a very high community similarity (Very equal)
71-90%	There are similarities in the same community (Same)
56-70%	Similar level of community similarity (Similar)
45-55%	Low level of similarity or different (Different)
< 45%	Very different degree of similarity (Very different)

c. Species Diversity Index (H')

Species diversity was determined using the Shannon-Wiener Diversity Index formula and assessed using the criteria as in Table 2.

$$H' = -\sum_{n=i}^{n} \left(\frac{ni}{N}\right)\left(\ln \frac{ni}{N}\right)$$

Information:

H' = Shannon-Wiener diversity index

Ni = The number of significant values of a species

N = The total number of significant values

Ln = Natural logarithm

Table 2. Benchmark Value of Diversity Index

Benchmark value	Information
H < 1	Low diversity, poor, very low productivity as an indication of heavy pressure and unstable ecosystem
1,0 < H < 3,322	Moderate diversity, moderate productivity, moderately balanced ecosystem conditions, moderate ecological pressure.
H>3,322	High diversity, stable ecosystem stability, high productivity, resistant to ecological stress

d. Weed Dominance Index (D)

The assessment of the value of the weed dominance index was carried out by analyzing using the Simpson's index.

$$D = \sum_{i=1}^{S} Pi2$$

Information:
C = Simpson's Index
S = Number of Species
Pi = ni/N i.e. the proportion of weeds of type i and all weeds (ni = number of weeds of type i, N = total number of weeds in total n).

Table 3. Benchmark Value of Weed Domination Index

Benchmark value	Information
D < 1	There is no dominant species
D = 1	There is a dominant species

Results and Discussion

Weed Vegetation Analysis

Weed vegetation analysis was carried out covering Density, Frequency, Dominance in order to obtain Summed Dominance Ratio (SDR) data which aims to see which weed species are dominant in the research sample.

Based on the data in table 4, it shows that the types of weeds found in paddy fields that are not intensively using herbicides are 7 weed species, namely *Rorippa palustris, Monochoria vaginalis, Leptochloa chinensis, Echinochloa crus-galli* and *Marchantia polymorpha*. The highest SDR value was obtained by *Marchantia polymorpha* species with a value of 60.95%, which means that *Marchantia polymorpha* species was the most dominant weed. The lowest SDR value in the observation of non-intensive rice field research samples was shown by the weed species *Echinochloa crus-galli* with a value of 1.74%.

Table 4. Analysis of Weed Vegetation in Non-Intensive Rice Fields Using Herbicides

Weed Name	Density		Frequency		Domination		Important Value (%)	SDR (%)
	Absolute	Relative	Absolute	Relative	Absolute	Relative		
Rorippa palustris	32.71	25.30	1.00	35.00	32.71	25.30	85.61	28.54
Eclipta prostate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Monochoria vaginalis	0.43	0.33	0.29	10.00	0.43	0.33	10.66	3.55

Leptochloa chinensis	0.43	0.33	0.43	15.00	0.43	0.33	15.66	5.22
Echinochloa crus-galli	0.14	0.11	0.14	5.00	0.14	0.11	5.22	*1.74
Lindernia procumbens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Marchantia polymorpha	95.57	73.92	1.00	35.00	95.57	73.92	182.85	60.95
Total	129.29	100.00	2.86	100.00	129.29	100.00	300.00	100.00

Description: * = Weeds that are not dominant

The data in table 5 shows that the types of weeds found in less intensive herbicide rice fields are 7 weed species, namely *Rorippa palustris, Eclipta prostate, Monochoria vaginalis, Leptochloa chinensis, Echinochloa crus-galli, Lindernia procumbens,* and *Marchantia polymorpha.* The dominant weed was shown by *Marchantia polymorpha* species with a value of 61.14% in less intensive paddy fields. The lowest SDR value in the observation of non-intensive rice field research samples was shown by weed species *Eclipta prostate, Monochoria vaginalis,* and *Echinochloa crus-galli* with a value of 1.25% which means weeds are not dominant.

Table 5. Analysis of Weed Vegetation in Less Intensive Rice Fields Using Herbicides

Weed Name	Density		Frequency		Domination		Important Value (%)	SDR (%)
	Absolute	Relative	Absolute	Relative	Absolute	Relative		
Rorippa palustris	12.57	13.17	1.00	24.14	12.57	13.17	50.49	16.83
Eclipta prostate	0.14	0.15	0.14	3.45	0.14	0.15	3.75	*1.25
Monochoria vaginalis	0.14	0.15	0.14	3.45	0.14	0.15	3.75	*1.25
Leptochloa chinensis	4.57	4.79	0.86	20.69	4.57	4.79	30.27	10.09
Echinochloa crus-galli	0.14	0.15	0.14	3.45	0.14	0.15	3.75	*1.25
Lindernia procumbens	1.86	1.95	0.86	20.69	1.86	1.95	24.58	8.19
Marchantia polymorpha	76.00	79.64	1.00	24.14	76.00	79.64	183.42	61.14
Total	95.43	100.00	4.14	100.00	95.43	100.00	300,00	100.00

Description: * = Weeds that are not dominant

The data in table 6 shows that the types of weeds found in intensive paddy fields using herbicides are 4 weed species, namely *Rorippa palustris, Eclipta prostate, Monochoria vaginalis,* and *Marchantia polymorpha*. The highest SDR value was obtained by the species

Marchantia polymorpha with a value of 54.57%. The lowest SDR value in the observation of intensive rice field research samples using herbicides was shown by the weed species *Monochoria vaginalis* with a value of 5.83%.

Table 6. Analysis of Weed Vegetation in Intensive Rice Fields Using Herbicides

Weed Name	Density		Frequency		Domination		Important Value (%)	SDR (%)
	Absolute	Relative	Absolute	Relative	Absolute	Relative		
Rorippa palustris	54.71	31.50	1,00	29,17	54,71	31,50	92,16	30,72
Eclipta prostate	1.43	0.82	0,86	25,00	1,43	0,82	26,64	8,88
Monochoria vaginalis	0.71	0.41	0,57	16,67	0,71	0,41	17,49	*5,83
Leptochloa chinensis	0.00	0.00	0,00	0,00	0,00	0,00	0,00	0,00
Echinochloa crus-galli	0.00	0.00	0,00	0,00	0,00	0,00	0,00	0,00
Lindernia procumbens	0.00	0.00	0,00	0,00	0,00	0,00	0,00	0,00
Marchantia polymorpha	116.86	67.27	1,00	29,17	116,86	67,27	163,71	54,57
Total	173.71	100.00	3,43	100,00	173,71	100,00	300,00	100,00

Description: * = Weeds that are not dominant

Table 7. Average SDR

No	Weed Name	group	Average SDR		
			Ricefield Not Intensive	Less Intensive Rice Field	Intensive Rice
1	*Rorippa palustris*	broad-leaved weed	28.54	16.83	30.72
2	*Eclipta prostate*	broad-leaved weed	0.00	1.25	8.88
3	*Monochoria vaginalis*	broad-leaved weed	3.55	1.25	5.83
4	*Leptochloa chinensis*	grass	5.22	10.09	0.00
5	*Echinochloa crus-galli*	grass	1.74	1.25	0.00
6	*Lindernia procumbens*	broad-leaved weed	0.00	8.19	0.00
7	*Marchantia polymorpha*	Moss	60,95	61.14	54.57
Total			100.00	100.00	100.00

The data in table 7 shows that the species *Marchantia polymorpha* is the dominant weed from the research samples taken from three locations, namely non-intensive, less intensive and less intensive rice fields. But in contrast to the lowest SDR values obtained differently in the three locations. The research data shows that broadleaf weeds are more common than grass weeds. According to Peruzzi *et. al.* (2017), manual weed control can change soil structure and cause weed seeds, especially broad-leaved weeds to be lifted to the soil surface.

The weeds found in this study were quite different from those usually found in a study. Common weeds that grow in paddy fields include *Echinochloa cruss galli, Schoenoplectus juncoides,* and *Monochoria vaginalis* which can reduce biomass by 79% per square meter (Maimunah *et. al*., 2021). In walik jerami rice, the dominant weeds species were identified, namely *Lindernia crustacea, Marsilea crenata, Scirpus lateriflorus, Fimbristylis miliacea, Monochoria vaginalis, Cyperus halpan, Cyperus difformis,* and *Cyperus tenuispica* (Pane *et. al*., 2002).

Changes in weed composition can be caused by many factors. It takes a habitat or environment that is very suitable for the growth of weeds (Mahgoub, 2019). Sims *et. al.* (2018) stated that weed growth is related to seed deposit in the soil and the suitability of the seed environment for germination. The change of location from the sampling of the research soil to the research location can cause differences in factors such as lighting, temperature and humidity. This may have an impact on the paddy soil samples studied, causing changes in the composition of weeds that are usually encountered. Changes in factors that affect the growth of certain weeds.

Sims *et. al.* (2018) stated that changes in weed composition are accelerating with more frequent land preparation, changes in cropping patterns and the application of herbicides used. One application of herbicide with the active ingredient glyphosate can cause changes in the composition of growing weeds, so that *Marchantia polymorpha* and broadleaf weeds to become more dominant. This reference shows that there is no data showing the use of different herbicide doses is directly proportional to the seed bank owned in paddy fields. The use of herbicides can change the composition of weeds in terms of the duration of use which shows changes in weed populations from the time before the use of herbicides and after the use of herbicides, which means that weed management in the form of intensification of herbicides can reduce certain weed populations against the seed bank of weeds in lowland rice fields.

The larger the dose given, the faster the changes in weed populations that grow on a land, not changing the overall seed bank owned in each land. So that the use of herbicide doses as a factor in paddy fields can help change the diversity and dominance of weeds that will grow from time to time on a land, or it can be said that differences in weed seed banks can be influenced by differences in weed management in lowland rice.

Community Coefficient (C)

Community coefficient is a parameter used to compare two vegetation communities from two areas. Comparisons were made between three areas separated based on the intensive use of herbicides. According to Tjitrosoedirdjo (1984) if the C value is greater than 75% then the two areas have a fairly high population similarity, but if the C value is less than 75% then the area has a low population similarity.

Table 9. Community Coefficient (C) on the Research Sample

No	Comparison Area	Community Coefficient (%)
1	*A : B*	85,50
2	*A : C*	86,66
3	*B : C*	73,90

Note: A = Non-Intensive Land, B = Less Intensive Land, C = Intensive Land

The data in Table 9 shows that in non-intensive and semi-intensive rice fields using herbicides have a C value of 85.50%, which means they have the same population. In non-intensive rice fields compared to intensive herbicides, the community has the same community and has the highest C value among the existing comparisons. In paddy fields, the herbicide-intensive and semi-intensive fields have the same similarity value, but have the lowest C value compared to the others. This population similarity is thought to be due to the absence of population differences of a weed in the use of herbicides in a paddy field.

In the research conducted, it can be found that there are similarities in weed populations. This may be due to the location of the area in each sampling area close to each other and the similarity of the rice varieties planted. If the microenvironment of a habitat remains relatively unchanged, changes in the composition of weed species will run very slowly or will not change at all (Halus Satriawan and Zahrul Fuady, 2019).

Species Diversity Index (H')

The species diversity index is an index that expresses community structure and ecosystem stability. The better the species diversity index, the more stable an ecosystem. This diversity index usually uses the Shannnon index, the Margalef index, and the Simpson index.

Table 10. Species Diversity Index (H')

No	Weed Name	Species Diversity Index (H')		
		Ricefield Not Intensive	Less Intensive Rice Field	Intensive Rice
1	*Rorippa palustris*	0.36	0.30	0.36
2	*Eclipta prostate*	0.00	0.05	0.22
3	*Monochoria vaginalis*	0.12	0.05	0.17
4	*Leptochloa chinensis*	0.15	0.23	0.00
5	*Echinochloa crus-galli*	0.07	0.05	0.00
6	*Lindernia procumbens*	0.00	0.20	0.00
7	*Marchantia polymorpha*	0.30	0.30	0.33
Total		1.00	1.18	1.08

The data in Table 10 shows that in non-intensive paddy fields using herbicides, the H' value is 1.00, which is in accordance with the benchmark value of the diversity index, which means that diversity is moderate. Meanwhile, in semi-intensive hebicide rice fields, the H' value obtained is 1.18, which means that it has moderate diversity. Then in herbicide-intensive paddy fields, the H' value is 1.08 which shows moderate diversity of weed species. However, compared to the three research samples from the three paddy fields, the lowest value was found in non-intensive paddy fields, the highest species diversity value was found in semi-intensive paddy fields.

A community has high species diversity if the community is composed of many species. Conversely, a community with low species diversity if the community is composed of few species (Yayan Sumekar, 2019). The category value of all samples shows the same category, which has moderate diversity. So from the data obtained the species/types of weeds on the three lands have moderate diversity in each land. It can be concluded that the use of herbicide doses in a field is not directly proportional to species diversity in the composition of the seed bank.

Weed Dominance Index (D)

The dominance index is used to determine species richness and the balance of the number of individuals of each species in the ecosystem (Saitama *et al*., 2016).

Table 11. Weed Domination Index (D)

No	Weed Name	Weed Domination Index (D)		
		Ricefield Not Intensive	Less Intensive Rice Field	Intensive Rice
1	*Rorippa palustris*	0.08	0.03	0.09
2	*Eclipta prostate*	0.00	0.00	0.01
3	*Monochoria vaginalis*	0.00	0.00	0.00
4	*Leptochloa chinensis*	0.00	0.01	0.00
5	*Echinochloa crus-galli*	0.00	0.00	0.00
6	*Lindernia procumbens*	0.00	0.01	0.00
7	*Marchantia polymorpha*	0.37	0.37	0.30
Total		0.45	0.42	0.40

In Table 11 it is shown that the non-intensive rice field research sample using herbicides has a D value of 0.45 which means that there are no weed species that dominate. In semi-intensive land, the value of D obtained is 0.42, which means that there is no dominant weed species. A D value of 0.40 was obtained in intensive paddy fields, which means that there are no weed species that dominate.

The table 11 shows that no dominant weed species was found from the research samples taken from the three locations. Although the species diversity index is classified as moderate, it is not followed by individual weed species that dominate. This can indicate that there is no difference in weed dominance that is influenced by the use of herbicide doses.

Changes in the composition of weeds in an ecosystem can be caused by natural processes or due to human intervention. The interaction between biotic and abiotic factors is one of the causes of changes in weeds (Thesome *et. al*., 2020). The use of herbicides can cause morphological changes in weeds that cause suppression of weed populations (Hasan *et. al*., 2021). This is in line with the observational data, which means that the application of a certain dose of herbicide can suppress a weed population so that there is no dominance by a weed species.

Observation of Weed Numbers from Differences in Soil Depth

Based on Table 12, it is noted that each land has a different number of weeds. At a soil depth of 15-20 cm, the highest number of weeds was recorded at each location where the research sample was taken. But the table above does not show any change the more the number of weeds the deeper the soil sample is taken. In non-intensive paddy fields at a depth of 5-10 cm, there are more weeds than those at a depth of 10-15 cm. However, in semi-herbicide-intensive and herbicide-intensive paddy fields, the deeper the number of weeds, it can be seen from the observation data that the number of weeds increases at each depth of the soil. The difference in the number of individuals obtained from one place to another is also influenced by environmental factors where it grows such as temperature, humidity, soil, growing space and light (Yussa *et. al*., 2015).

Table 12. Weeds of Depth Difference

Soil Depth	Ricefield Not Intensive	Less Intensive Rice Field	Intensive Rice

	Total	Average	Total	Average	Total	Average
0-5 cm	148	21.14	30	4.29	171	24.43
5-10 cm	231	33.00	144	20.57	251	35.86
10-15 cm	216	30.86	228	32.57	368	52.57
15-20 cm	310	44.29	266	38.00	426	60.86

Weed management in the form of herbicides can reduce the seed bank of weeds in lowland rice fields, it is not proven if it is seen from the number of weeds recorded that the lowest number of weeds is recorded in less intensive paddy fields, which means that the use of herbicides can suppress the number of weeds that will grow but if excessive can make weed species certain and resistant so that it continues to grow (Umiyati *et. al*., 2018). But the seed bank owned by a land depends on many factors. Seed bank is weed seed that can accumulate in the soil, this causes its density to increase. This is in accordance with observational data from the number of weeds which is increasing according to the depth of the soil sample taken.

Conclusion

Based on the results of the study obtained the following conclusions:

1. There is no difference in weed seed bank in terms of community, species diversity and no weeds dominate in different weed management. In non-herbicide-intensive paddy fields, there were 5 weed species, namely *Rorippa palustris, Monochoria vaginalis, Leptochloa chinensis, Echinochloa crus-galli, Marchantia polymorpha*. In semi-intensive paddy fields, 7 weed species were recorded, namely *Rorippa palustris, Eclipta prostate, Monochoria vaginalis, Leptochloa chinensis, Echinochloa crus-galli, Lindernia procumbens, Marchantia polymorpha*. In herbicide intensive paddy fields, there are only 4 weed species, namely *Rorippa palustris, Eclipta prostate, Monochoria vaginalis, Marchantia polymorpha*.
2. Weed management with the use of herbicides is proven to reduce weed populations that grow. However, the use of different herbicides does not change the composition and diversity of different seed banks in the soil, but suppresses weed populations that will grow.

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References

Abouziena, H.F. and W.M. Haggag. 2016. Weed Control In Clean Agriculture: A Review. *Planta Daninha*, Vol. 34 (2) : 377-392. https://doi.org/10.1590/S0100-83582016340200019.

Maimunah, M.A., V. Kautsar, P.O. Bimantara, S.M. Kimani, R. Torita, K. Tawaraya, H. Murayama, S.N.H. Utami, B.H. Purwanto, and W. Cheng. 2021. Weeding Frequencies Decreased Rice–Weed Competition and Increased Rice N Uptake in Organic Paddy Field. *agronomy*, Vol. 11(1904) : 1-12. https://doi.org/10.3390/agronomy11101904.

Barba´s, P., B. Sawicka, B.K. Marczak, and P. Pszczółkowski. 2020. Effect of Mechanical and Herbicide Treatments on Weed Densities and Biomass in Two Potato Cultivars. *Agriculture*, Vol. 10 (45) : 1-16. doi:10.3390/agriculture10100455.

Bonham, Charles D. 1989. Measurements for Terrestrial Vegetation. A Wiley-Interscience publication. New York.

Byrne, M.J., V.L. Williams, and E.M. Wojtasik. 2017. The viability of propagules of alien plant species sold for traditional medicine in South Africa. *South African Journal of Botany*, Vol. 109 (2017) : 281-287. https://doi.org/10.1016/j.sajb.2017.01.206.

Denny Kurniadie, Maulydina Irda, Uum Umiyati, Dedi Widayat, Sudarjat and Ceppy Nasahi. 2019. Weeds Diversity of Lowland Rice (Oryza sativa L.) with Different farming System in Purwakarta Regency Indonesia. *Journal of Agronomy*, Vol. 18 (1): 21-26. DOI: 10.3923/ja.2019.21.26.

Halus Satriawan and Zahrul Fuady. 2019. Short Communication:Analysis of weed vegetation in immatureandmature oil palm plantations. *Biodiversitas*, Vol. 20 (11) : 3292-3298. DOI: 10.13057/biodiv/d201123.

Hasan, M., M.S.A.Hamdani, A.M. Rosli, and H. Hamdan. 2021. Bioherbicides: An Eco-Friendly Tool for Sustainable Weed Management. *Plants*, Vol. 10 (1212) : 1-21. https://doi.org/10.3390/plants10061212.

Kraehmer, H., A.V. Almsick, R. Beffa, H. Dietrich, P. Eckes, E. Hacker, R. Hain, H.J. Strek, H. Stuebler, and L. Willms. 2014. Herbicides as Weed Control Agents: State of the Art: II. Recent Achievements. *Plant Physiology*, Vol. 166 (2014) : 1132–1148. https://dx.doi.org/10.1104%2Fpp.114.241992.

Lauren M. Schwartz-Lazaro and Josh T. Copes. 2019. A Review of the Soil Seedbank from a Weed Scientists Perspective. Agronomy, Vol. 9 (369) : 1-13. doi:10.3390/agronomy9070369.

Merry Antralinaa, Ida Nur Istina, YuyunYuwariah, Tualar Simarmata. 2015. Effect of Difference Weed Control Methods to Yield of Lowland Rice In The SOBARI. *Procedia Food Science*, Vol. 3 (2015): 323 – 329. doi: 10.1016/j.profoo.2015.01.035.

Mahgoub, A.M. 2019. The impact of five environmental factors on species distribution and weed community structure in the coastal farmland and adjacent territories in the northwest delta region, Egypt. *Heliyon*, Vol. 5 (e01441) : https://doi.org/10.1016/j.heliyon.2019.e01441.

Pane, H., E. S. Noor, Z. Susanti, and M. Mortimer. 2002. Weed Characterization in Walik Jerami Rice in Rainfed Lowland Area. *Penelitian Pertanian Tanaman Pangan*, Vol. 21 (3) : 6-14. http://pangan.litbang.pertanian.go.id/files/hpane.pdf.

Peruzzi, A., L. Martelloni, C. Frasconi, M. Fontanelli, M. Pirchio, M. Raffaelli. 2017. Machines for non-chemical intra-row weed control in narrow and wide-row crops: a review. *Journal of Agricultural Engineering*, Vol. 48 (2) : 57-70. https://doi.org/10.4081/jae.2017.583.

Shiferaw, W., S. Demissew, and T. Bekele. 2018. Ecology of soil seed banks: Implications for conservation and restoration of natural vegetation. *International Journal of Biodiversity and Conservation*, Vol. 10(10) : 380-393. DOI: 10.5897/IJBC2018.1226.

Sims, B., S. Corsi, G. Gbehounou, J. Kienzle, M. Taguchi, and T. Friedrich. 2018. Sustainable Weed Management for Conservation Agriculture: Options for Smallholder Farmers. *agriculture*, Vol. 8 (0) : 1-20. doi:10.3390/agriculture8080000.

Teshome, D.T., G.E. Zharare, and S. Naidoo. 2020. The Threat of the Combined Effect of Biotic and Abiotic Stress Factors in Forestry Under a Changing Climate. *Frontiers Plant Science*, Vol. 11 (601009) : 1-19. doi: 10.3389/fpls.2020.601009

Tjitrosedirdjo, S., I.H. Utomo dan J. Wiroatmodjo. 1984. Pengelolaan Gulma di Perkebunan. Badan Penerbit Kerjasama Biotrop Bogor dan Gramedia, Bogor, 210 p.

Umiyati, U., D. Kurniadie., D. Widayat., I. Abdurrahim. 2018. Efektivitas herbisida Bentazone Sodium (370 g/L) dan MCPA DMA (62 g/L) dalam mengendalikan gulma pada budidaya padi sawah. *Jurnal Kultivasi*, Vol. 17 (3) : 716-722. https://www.readcube.com/articles/10.24198%2Fkultivasi.v17i3.18731.

Yussa, I. P., Chairul dan Z. Syam. 2015. Analisis vegetasi gulma pada kebun kopi Arabika (Coffea arabica L.) di Balingka, Agam, Sumatera Barat. *Jurnal Biologi Universitas Andalas*, Vol. 4 (1) : 83-89. http://jbioua.fmipa.unand.ac.id/index.php/jbioua/article/view/123.

Yayan Sumekar. 2019. Weed diversity in carrot (Daucus carota L.) crop in Majalengka Regency, West Java Province, Indonesia. *Reserch on Crops*, Vol. 20 (1) : 109-115. DOI : 10.31830/2348-7542.2019.015.