Umiyati U · Kurniadie D · Fauzi

The effect of pre- and post-emergence herbicide on weeds and rice yield in the direct seeding system

Abstract. Indonesian rice production has been unable to fully meet national demand, partly due to weed competition, which can reduce rice yields by up to 80% if left uncontrolled. This study aimed to evaluate the effectiveness of pre-emergence herbicides containing pretilachlor (300 g/L) and post-emergence herbicides containing cyhalofop + ethoxysulfuron (330 g/L) for weed control in direct-seeded rice, and to determine the optimal dosage. Herbicides active ingredient is pretilachlor are a category of pre-emergence herbicides used in rice cultivation; these herbicides are systemic and are used to control sedges, grasses and broadleaf weeds. The cyhalofop + ethoxysulfuron herbicide is a post-emergence herbicide mixture that can suppress the growth of sedges, broad-leaved weeds and grasses . The study was conducted at PT. Syngenta Indonesia R&D Cikampek Site from August to December 2024, using a Randomized Group Design (RGD) with four replications and six treatments, namely two doses of pre-emergence herbicide (1.0 and 0.5 L/ha), two doses of post emergence herbicide (1.0 and 0.5 L/ha), manual weeding, and control (without treatment). The parameters observed included the weed vegetation analysis, dry weight of weeds, and the components of rice plant growth and yield. The results showed that pre-emergence herbicides with the active ingredient pretilachlor 300 g/L and post-emergence herbicides with the active ingredient mixtures of cyhalofop + ethoxysulfuron 330 g/L are effective in controlling various important weeds in the direct seeding system of rice cultivation, such as *Cyperus iria, Echinochloa crus-galli, Fimbristylis miliacea*, and *Leptochloa chinensis*, thus helping rice plants grow optimally and increasing yields. Pre-emergence herbicide with the active ingredient pretilachlor 300 g/L at a dose of 1.0 L/ha gave the best results in suppressing weed growth and increasing rice yields compared to other treatments.

Keywords: *Echinochloa crus-galli* · Pre-emergence herbicide · Pretilachlor · Rice cultivation · Weed growth

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Umiyati U[1]* · Kurniadie D[1] · Fauzi[1]
[1] Department of Agronomy, Faculty of Agriculture, Universitas Padjajaran. Jalan Raya Bandung Sumedang km. 21, Jatinangor, Sumedang, 45363, Indonesia
*Correspondence: uum.umiyati@unpad.ac.id

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Introduction

Rice (*Oryza sativa* L.) is a major staple crop and one of the worlds's most important sources, alongside wheat and corn. In Indonesia, around 98.35% of households consume rice, with an average annual consumption of 82.87 kg per capita (Maulana et al., 2024). In 2024, rice production in Indonesia reached 53.14 million tons, representing a decrease of 838.27 thousand tons (1.55%) from 53.98 million tons in 2023. One of the reasons for this decline is the reduction in the harvested area, which reached 10.21 million hectares in 2023, then decreased by 167.57 thousand hectares or 1.64% to 10.05 million hectares in 2024 (Central Statistics Agency, 2025).

One approach to increasing rice production is the adoption of planting technologies that shorten the production cycle, such as direct seeding. Direct seeding is a method of planting rice by sowing seeds directly on the land without seedling and transplanting. The planting time is shorter so that less labor is required, and planting costs can be reduced. In addition, fertilization becomes more practical and economical because it is only done on certain rows. Observation and control of pests and plant diseases also become easier to do. Water use is more efficient because irrigation is done intermittently or in bursts (Kumar et al., 2023). Furthermore, the number of high-quality rice seedlings and grains increases because sunlight can freely penetrate through the rows (Pitojo, 2003). However, the direct seeding system has several disadvantages, including rapid weed growth that can interfere with crop growth, and the appearance of rats, birds, and golden apple snails, which are recurring problems in every planting season (Sahardi et al., 2021).

Weeds are defined as plants that grow undesirable and are able to compete with the main crop, thereby potentially reducing rice yields (Nugraha et al., 2024). Weed growth on agricultural land can trigger competition for resources such as light, oxygen (O_2), carbon dioxide (CO_2), nutrients, water, and growing space, which ultimately suppresses crop production (Padang et al., 2017). In rice crops, competition with weeds risks causing yield losses of up to 10–15%, and even up to 86% if control measures are not taken (Zarwazi et al., 2016). In rice fields, common weeds include *Fimbristylis miliacea, Echinochloa crus-galli*, and *Monochoria vaginalis*, which can cause a 57% reduction in rice yields (Umiyati et al., 2018).

Weed control can be carried out in various ways such as preventive control, technical cultivation, manual and mechanical methods, chemical and biological methods, and an integrated approach (Situmorang et al., 2023). Chemical control using herbicides is one of the most efficient in terms of time and labor (Simanjuntak et al., 2016), and is more cost-effective in terms of labor requirements compared to manual weeding (Kurniadie et al., 2019). Herbicides are grouped into three categories based on their application time, namely pre-planting herbicides, pre-emergence herbicides, and post-emergence herbicides (Aditya, 2021). The last two categories are commonly used in rice cultivation.

Herbicides with the active ingredient pretilachlor are classified as systemic pre-emergence herbicides and are effective in killing sedges, grasses, and broadleaf weeds. Pretilachlor plays a crucial role in preventing weed germination and the activation of weed seeds stored in the soil, which in turn can affect crop yield (Fillols & Callow, 2010). A popular post-emergence herbicide in rice cultivation is the cyhalofop + ethoxysulfuron formulation, which is capable of suppressing the growth of sedges, broadleaf weeds, and grasses in rice crops. The success of herbicide use inhibiting weed diversity in cultivated land has prompted the authors to conduct further research using pre-emergence and post-emergence herbicides to control weeds in paddy rice plants using the direct seeding system. This study aims to contribute valuable insights into the sustainable management of weeds in direct seeding system.

Materials and Methods

This research was conducted from August to December 2024. In Experimental Farm D3, PT Syngenta Indonesia R&D Site Cikampek, West Java Province at an altitude of 12 meters above sea level with the climate type C2 according to Oldeman. The tools used in this study were a semi-automatic sprayer with a T-jet nozzle, a measuring cup, an oven, a scale, a tape measure, a treatment board, a camera, stationery, plastic bags, and a hoe. The materials used were Ciherang rice seeds, urea, SP-36, and KCl fertilizers, and herbicide A with the active ingredient pretilachlor 300 g/l and herbicide B with the active ingredient cyhalofop + ethoxysulfuron 330 g/l.

The research design used was Randomized Block Design consisting of six treatments, replicated four times each, so that there were 24 experimental units pretilachlor 300 g/l herbicide treatment including a dose of (A) 1.0 L/ha; (B) 0.50 L/ha; herbicide treatment cyhalofop + ethoxysulfuron 330 g/L including doses of (C) 1.0 L/ha; (D) 0.50 L/ha; (E) manual weeding 1 time; and (F) control (without treatment). The spray volume was calibrated at 400 L/ha. Spraying of pre-emergence herbicides with the active ingredient pretilachlor is carried out on rice plants aged 2-3 days after planting, while spraying of post-emergence herbicides containing cyhalofop + ethoxysulfuron (330 g/L) is carried out at the age of 10-12 days after planting.

The observations comprised supporting and main variables. Supporting observations included vegetation analysis, calculated as the mean of relative density, relative dominance, and relative frequency; environmental conditions; and rice phytotoxicity, which was visually assessed across the entire plant population at 1, 2, 3, 4 weeks after application (WAA). The main observations included total weed dry weight, measured at 3 and 6 WAA from two 50 x 50 cm quadrats per treatment plot, as well as rice plant growth, yield components, and grain yield. The observations of plant height were carried out by randomly taking 12 samples of rice plants at 3 and 6 WAA. Quantitative data processing was analyzed by using the variance method (ANOVA) at the 5% significance level. When a significant difference was found, the Duncan Multiple Range Test was employed by using the SMART-STAT software.

Results and Discussion

Vegetation Analysis. Weed vegetation analysis is a scientific approach aimed at understanding and evaluating the composition and distribution of weeds in a specific area or field (Lewu et al., 2024). Weed dominance can be determined using the Summed Dominance Ratio (SDR), an indicator of vegetation dominance. Observations showed that there were eight species of three weed groups in the research area, as shown in the Table 1. These weed groups include sedges, grasses, and broadleaf weeds. There were two species of sedges, four species of grasses, and two species of broadleaf weeds. Weed diversity in a field can be influenced by several factors, such as light, soil cultivating, nutrients, crop cultivation methods, and planting distances (Imaniasita, 2020). Based on the SDR value (%), the most dominant weed in the experimental site was *Fimbristylis miliacea* (30.01%) which is included in the sedges category. The sedges weed is a very adaptive weed and is able to grow in various soil conditions including tolerant of inundation so that it becomes one of the dominant weeds in the experimental field (Pranasari et al., 2012).

Table 1. Vegetation analysis

No	Weed Species	Type	SDR (100%)
1	*Cyperus iria*	Sedges	10.50
2	*Cynodon dactylon*	Grasses	12.75
3	*Echinochloa crus-galli*	Grasses	11.86
4	*Fimbristylis miliacea*	sedges	30.01
5	*Leptochloa chinensis*	Grasses	11.73
6	*Ludwigia octovalvis*	Broadleaf	6.75
7	*Monochoria vaginalis*	Broadleaf	5.16
8	*Panicum stoloniferum*	Grasses	11.24
Total			100.00

Phytotoxicity. Phytotoxicity is a sign of plant damage caused by chemicals. Symptoms of phytotoxicity depend on the type of chemical and the type of plant (Nugroho et al., 2023). Observations showed that pre-emergence and post-emergence herbicide treatments at doses of 0.5 L/ha to 1.0 L/ha did not cause any symptoms of poisoning in direct seeding rice plants during observations (1-4 WAA). Rice plants experiencing symptoms of poisoning by herbicides have brownish-yellow leaf color changes or abnormal growth. Visual observations did not show any symptoms of poisoning after herbicide application on rice plants. Herbicides containing the active ingredient pretilachlor and the combination of cyhalofop + ethoxysulfuron are selective herbicides that effectively control weeds growing around rice plants without causing phytotoxic effects on the crop. Rice plants can tolerate certain herbicides because of their ability to rapidly metabolize and detoxify these compounds, thereby reducing their toxic effects on plant growth and development (Apriadi et al., 2013).

Table 2. Phytotoxicity rice plants

Code	Treatment	Doses (L/ha)	Toxicity Rate (%)			
			1 WAA	2 WAA	3 WAA	4 WAA
A	Pretilachlor 300 g L^{-1}	1.0	0	0	0	0
B	Pretilachlor 300 g L^{-1}	0.5	0	0	0	0
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	0	0	0	0
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	0	0	0	0
E	Manual Weeding	-	0	0	0	0
F	Control	-	0	0	0	0

Note: 0 = no toxicity. WAA = Weeks After Application

Table 3. Dry Weight of *Fimbristylis miliacea*

Code	Treatment	Doses (L/ha)	Average Dry Weight of *Fimbristylis miliacea* (g/0.25 m^2)	
			3 WAA	6 WAA
A	Pretilachlor 300 g L^{-1}	1.0	0.00 a	0.00 a
B	Pretilachlor 300 g L^{-1}	0.5	0.01 a	0.00 a
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	0.38 a	0.00 a
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	0.74 a	3.32 b
E	Manual Weeding	-	0.14 a	0.24 a
F	Control	-	2.70 b	4.15 c

Note: The average values marked with the same letter in the same column show no significant difference based on the Duncan's Multiple Range Test at the 5% significance level. WAA = Weeks After Application.

Dry Weight of *Fimbristylis miliacea*. *Fimbristylis miliacea* was the most dominant weed species in the experimental fields. Table 3 shows that in the observation of 3 WAA, herbicide treatment and manual weeding showed better results in suppressing weeds compared to the control which had the highest dry weight of 2.70 g. Meanwhile, in 6 WAA, the herbicide treatment with the active ingredient pretilachlor 300 g/L dose of 0.5-1.0 L/ha and the mixed herbicides of cyhalofop + ethoxysulfuron 330 g/L dose of 1.0 L/ha had the lowest dry weight *Fimbristylis miliacea* and was significantly different from the control treatment which had the highest dry weight of 4.15 g.

Herbicides containing the active ingredient pretilachlor can effectively suppress the growth of *Fimbristylis miliacea* from 3 to 6 WAA. This finding is consistent with Yadav et al. (2018), who reported that the application of pretilachlor + pyrazosulfuron in rice fields provided 91-96% control of *F. miliacea,* a sedge weed commonly found in rice ecosystems. On the other hand, the treatment of cyhalofop + ethoxysulfuron 330 g/L at a dose of 1.0 L/ha was able to control *Fimbristylis miliacea* at 3 and 6 WAA, but optimal control was found at 6 WAA. The mixture of cyhalofop and ethoxysulfuron has a non-antagonistic interaction, thus increasing the effectiveness of overall weed control, especially in controlling *Fimbristylis miliacea*. Application of cyhalofop 100 EC with doses starting from 15 L/ha resulted in a mortality rate of *Fimbristylis miliacea* of 58.56% (Indriani et al., 2023).

Dry Weight of *Echinochloa crus-galli*. Table 4 indicates that in the observation of 3 WAA, the herbicide treatment of pretilachlor 300 g/L dose of 0.5-1.0 L/ha, cyhalofop + ethoxysulfuron 330 g/L dose of 1.0 L/ha and manual weeding effectively controlled *Echinochloa crus-galli* and was significantly different from the control. Meanwhile, in the observation of 6 WAA, the herbicide treatment of pretilachlor 300 g/L dose of 1.0 L/ha, cyhalofop + ethoxysulfuron 330 g/L dose of 1.0 L/ha and manual weeding treatment gave the best results with the lowest dry weight value and was significantly different from the control which produced the highest dry weight value of 1.48 g. These two types of herbicides work by inhibiting the enzyme acetyl-CoA carboxylase (ACCase), which plays an important role in fatty acid synthesis resulting in disruption of cell membrane formation and lipid structure, inhibiting weed growth and development, which ultimately leads to death. This herbicide can control *Echinochloa crus-galli* weeds up to 97.44%, resulting in a significant increase in rice yields, ranging from 20.38% to 30.62% compared with untreated plots (Zhu et al., 2012).

Table 4. Dry weight of *Echinochloa crus-galli*

Code	Treatment	Doses (L/ha)	Average Dry Weight of *Echinochloa crus-galli* (g/0.25 m^2)	
			3 WAA	6 WAA
A	Pretilachlor 300 g L^{-1}	1.0	0.27 a	0.07 a
B	Pretilachlor 300 g L^{-1}	0.5	0.32 a	0.65 bc
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	0.13 a	0.48 ab
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	0.90 b	1.07 cd
E	Manual Weeding	-	0.08 a	0.33 ab
F	Control	-	1.52 c	1.48 d

Note: The average values marked with the same letter in the same column show no significant difference based on Duncan's Multiple Range Test at the 5% significance level. WAA = Weeks After Application.

Table 5. Dry weight of *Leptochloa chinensis*

Code	Treatment	Doses (L/ha)	Average Dry Weight of *Leptochloa chinensis* (g/0.25 m^2)	
			3 WAA	6 WAA
A	Pretilachlor 300 g L^{-1}	1.0	0.05 a	0.14 a
B	Pretilachlor 300 g L^{-1}	0.5	0.02 a	0.76 a
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	0.28 ab	0.34 a
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	0.68 b	5.21 b
E	Manual Weeding	-	0.03 a	0.59 a
F	Control	-	1.62 c	10.56 c

Note: The average values marked with the same letter in the same column show no significant difference based on Duncan's Multiple Range Test at the 5% significance level. WAA = Weeks After Application.

Dry Weight of *Leptochloa chinensis*. Table 5 shows that the application of the herbicide containing pretilachlor could suppress the growth of *Leptochloa chinensis* weeds at 3 to 6 WAA. Pretilachlor 300 g/L has a control effectiveness value of 98.64% according to research conducted by Chauhan et al. (2014) which stated that the herbicide containing pretilachlor is effective in controlling various grass and broadleaf weeds with an effectiveness of more than 92%. On the other hand, the application of the herbicides of cyhalofop + ethoxysulfuron 330 g/L at a dose of 1.0 L/ha was also able to suppress the growth of *Leptochloa chinensis* weeds from 3 to 6 WAA. Cyhalofop-butyl is a selective herbicide that can suppress the growth of *Leptochloa chinensis* by inhibiting fatty acid synthesis, thereby inhibiting overall weed development as reported by Sudhana et al. (2018) & Fang et al. (2020). In addition, the effectiveness of the herbicide mixture of cyhalofop + ethoxysulfuron with a concentration of 330 g/l in controlling *Leptochloa chinensis* weeds reached 96.73%. Research by Guntoro and Fitri (2013) and Jacob et al. (2014) also showed that the herbicide with the active ingredient cyhalofop-butyl can control *Leptochloa chinensis* weeds up to 96% in rice cultivation using a direct seeding system.

Dry Weight of *Cyperus iria*. *Cyperus iria* is a sedge weed that reproduces vegetatively through stolon and rhizomes at the base of the stem, as well as generatively through seeds that can produce thousands of seeds (Ilham, 2014). Table 6 show that pretilachlor 300 g/L at a dose of 0.5-1.0 L/ha had the lowest dry weight in *Cyperus iria* at both 3 and 6 WAA. Pretilachlor 300 g/ha has shown significant control of *Cyperus* spp., including *Cyperus iria*, and effectively reduces weed density and biomass, thus contributing to better yields (Manhas et al. 2012). Meanwhile, in 6 WAA, the herbicide treatment cyhalofop + ethoxysulfuron 330 g/L at a dose of 1.0 L/ha was effective in suppressing *Cyperus iria*. In line with research conducted by Li et al. (2021), herbicides such as cyhalofop and fenoxaprop are post-emergence herbicides that can control grass weeds, but their control effectiveness weakens for sedge weeds because this type of weed has deep rhizomes so that the active ingredient of the herbicide requires time to be absorbed into the tissue.

Table 6. Dry weight of *Cyperus iria*

Code	Treatment	Doses (L/ha)	Average Dry Weight of *Cyperus iria* (g/0.25 m^2)	
			3 WAA	6 WAA
A	Pretilachlor 300 g L^{-1}	1.0	0.01 a	0.00 a
B	Pretilachlor 300 g L^{-1}	0.5	0.00 a	0.00 a
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	1.04 b	1.43 a
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	1.45 b	4.31 b
E	Manual Weeding	-	0.03 a	0.55 a
F	Control	-	3.17 c	22.88 c

Note: The average values marked with the same letter in the same column show no significant difference based on the Duncan's Multiple Range Test at the 5% significance level. WAA = Weeks After Application.

Table 7. Dry weight of other weeds

Code	Treatment	Doses (L/ha)	Average Dry Weight of Other Weeds (g/0.25 m^2)	
			3 WAA	6 WAA
A	Pretilachlor 300 g L^{-1}	1.0	0.00 a	0.19 a
B	Pretilachlor 300 g L^{-1}	0.5	0.03 a	0.00 a
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	0.03 a	1.58 a
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	0.13 b	7.78 b
E	Manual Weeding	-	0.05 a	0.03 a
F	Control	-	1.48 c	17.61 c

Note: The average values marked with the same letter in the same column show no significant difference based on Duncan's Multiple Range Test at the 5% significance level. WAA = Weeks After Application.

Dry Weight of Other Weeds. Table 7 shows that in observations 3 and 6 WAA, the herbicide treatment containing pretilachlor 300 g/l and cyhalofop + ethoxysulfuron 330 g/L showed an effect on the dry weight of other weeds including *Cyperus difformis, Monochoria vaginalis, Ludwigia octovalvis*, and *Sphenoclea zeylanica*. In observations 3 WAA, the herbicide treatment pretilachlor 300 g/L dose of 1.0 L/ha and 0.5 L/ha, the herbicide treatment cyhalofop + ethoxysulfuron 330 g/L dose of 1.0 L/ha, and the manual weeding treatment had the lowest dry weight and was significantly different from the control treatment which had the highest dry weight, namely 1.48 g. The analysis of the 6 WAA observations showed a significant effect of herbicide treatment on weed dry weight. Pretilachlor 300 g/L at doses of 0.5–1.0 L ha^{-1} and manual weeding resulted in the lowest weed dry weight and were not significantly different from cyhalofop + ethoxysulfuron 330 g/L at 1.0 L ha^{-1}, which recorded a dry weight of 1.58 g. In contrast, the control treatment produced the highest weed dry weight (17.61 g) and differed significantly from these treatments. It was implied that treatment with herbicides can significantly reduce the dry weight of other weeds when compared to the control. Pretilachlor is effective in controlling various types of weeds, including grasses, broadleaf weeds and sedges, with a control rate exceeding 92% (Chauhan et al., 2014) while the herbicide with the active ingredient cyhalofop-butyl is effective in controlling grass weeds, but its efficacy against sedge weeds is lower (Li et al., 2021).

Total Dry Weight of Weeds. Total dry weight of weed in present experiment are presented in Table 8 which points out that the application of pretilachlor 300 g/L herbicide and the mixed herbicides of cyhalofop + ethoxysulfuron 330 g/L significantly affected the total weed dry weight. Based on the analysis results of observations of 3 WAA, the pretilachlor 300 g/L herbicide treatment at a dose of 0.5-1.0 L/ha and manual weeding treatment had the lowest total weed dry weight and was significantly different from the control treatment which produced the highest total weed dry weight value of 10.58 g. Data from observations of 6 WAA showed that the herbicide treatment with the active ingredient pretilachlor 300 g/L at a dose of 1.0 L/ha and manual weeding treatment was significantly different from the control treatment which had the highest total weed dry weight value of 87.45 g. The herbicide pretilachlor 300 g/l had a weed control effectiveness of 98.64%, better than manual weeding and the herbicide cyhalofop + ethoxysulfuron 330 g/L at the same level. This is evidenced by the lower total weed dry weight. The effectiveness of pre-emergence herbicides compared to post-emergence herbicides in lowland rice is influenced by several factors, including the chemical nature of the herbicide, application time, soil conditions, and the specific weed species targeted. Cyhalofop is relatively non-persistent in soil but can persist longer in water. Dry conditions in some experimental plots following herbicide application, combined with high daytime temperatures, may have accelerated water evaporation and consequently reduced herbicide effectiveness. Pre-emergent herbicides are more persistent and have high mobility in the soil, so that pre-emergent herbicide performance is optimal in preventing weed growth, while post-emergent herbicides are easily washed out and degraded or absorbed by soil particles more quickly (Tomlin, 2005). Pre-emergent herbicides are applied before weed germination, thus providing a proactive approach to weed management, while post-emergent herbicides target existing weeds. Pre-emergent herbicides, such as pendimethalin and pretilachlor, are most effective when applied before planting or immediately after, because they effectively inhibit weed germination (Dilipkumar et al., 2024).

Growth and Yield of Rice Plants. Pre-emergent herbicides were applied before weed germination, thus providing a proactive approach to weed management, while post-emergent herbicides targeted the existing weeds. Pre-emergent herbicides, such as pendimethalin and pretilachlor, are most effective when applied before planting or immediately after, because they effectively inhibit weed germination (Dilipkumar et al., 2024). In the observation of 3 WAA, the notation showed no significant difference in all treatments, but in the observation of 6 WAA, the height of rice plants in the control treatment gave the lowest results the average height of plants at 72.44 cm and was not significantly different from the other treatments. This is because herbicide treatment is able to control and reduce weed populations. The absence of weeds that interfere with the growth of rice plants allows rice plants to grow optimally.

Table 8. Total dry weight of weeds

Code	Treatment	Doses (L/ha)	Total Dry Weight of Weeds (g/0.25 m^2)	
			3 WAA	6 WAA
A	Pretilachlor 300 g L^{-1}	1.0	0.33 a	1.22 a
B	Pretilachlor 300 g L^{-1}	0.5	0.37 a	4.71 a
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	1.84 a	6.84 ab
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	4.00 b	32.04 b
E	Manual Weeding	-	0.33 a	3.81 a
F	Control	-	10.58 c	87.45 c

Note: The average values marked with the same letter in the same column show no significant difference based on Duncan's Multiple Range Test at the 5% significance level. WAA = Weeks After Application.

Table 9. Growth and yield of rice plants

Code	Treatment	Doses (L/ha)	Plant Height		Rice Crop Yield	
			3 WAA	6 WAA	Productive Tillers	Dried Milled Grain (ton/ha)
A	Pretilachlor 300 g L^{-1}	1.0	38.00 a	75.73 ab	9.50 a	6.79 a
B	Pretilachlor 300 g L^{-1}	0.5	39.69 a	77.02 a	7.25 c	5.35 c
C	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	1.0	37.94 a	77.92 a	8.75 b	6.08 b
D	Cyhalofop + Ethoxysulfuron 330 g L^{-1}	0.5	37.75 a	77.16 a	6.00 d	4.44 d
E	Manual Weeding	-	37.38 a	75.39 ab	8.25 b	6.67 a
F	Control	-	38.26 a	72.44 b	5.25 e	3.55 e

Note: The average values marked with the same letter in the same column show no significant difference based on Duncan's Multiple Range Test at the 5% significance level. WAA = Weeks After Application.

Weeds cause a decrease in the growth and yield of cultivated plants through a competitive mechanism in obtaining growth factors (Moenandir, 2010). One of the essential nutrients that supports the vegetative growth of plants is nitrogen. Fertilizer application, especially urea fertilizer, has a significant effect on the vegetative formation of rice, including increasing plant height and the number of tillers (Darwati & Noeriwan, 2019).

Productive tillers are rice tillers that produce panicles that usually appear when the rice plant is about to enter the generative phase. The application of Pretilachlor 300 g/L at a dose level of 1.0 L/ha and the mixed herbicide cyhalofop + ethoxysulfuron 330 g/L at a dose level of 1.0 L/ha has the highest average number of tillers with values of 9.50 tillers and 8.75 tillers respectively then is different from the control treatment which has the lowest average of 5.25 tillers. The low number of productive tillers has the potential to reduce crop yields, which is caused by uncontrolled weeds during the critical period. The critical period is a time when cultivated plants and weeds compete actively. Therefore, determining the right timing and strategy for weed control is very important to prevent a decline in crop yields (Safrina et al., 2024).

Dry milled grain is grain that has undergone a drying process so that it has a maximum water content of 14%, a maximum of 5% green or chalky grains, a maximum of 3% dirt or voids, a maximum of 3% red grains and a maximum of 3% damaged grains. The treatment of pretilachlor 300 g/L at a dose of 1.0 L/ha produced a dry grain weight of 678.83 g/m^2, higher when compared to the treatment of cyhalofop + ethoxysulfuron 330 g/L herbicide at the same level, which produced a dry grain weight of 608 g/m^2 and was not significantly different from the manual weeding treatment but significantly different from the control treatment which had the lowest dry grain weight of 355.25 g/m^2 or equivalent to 3.55 tons/ha (Table 9).

Weeds in rice paddy fields compete for nutrients, growing space, sunlight and other growth factors, thus causing disruption to rice plant growth that impacts production yields. Increased competition between rice plants and weeds in obtaining growth factors can cause a decrease in the rate of photosynthesis in rice plants, which has the potential to inhibit the process of translocation of photosynthesis results for panicle formation and filling (Antralina, 2012). Weed control using herbicides is effective in suppressing weeds so that it can increase the yield of rice crops in the direct seeding system, control using herbicides also provides economic benefits for farmers because it is more cost-effective in terms of labor requirements compared to manual weeding in larger areas (Kurniadie et al., 2019).

Conclusion

The use of pre-emergence herbicide pretilachlor 300 g/L is effective in controlling various important weeds in direct-seeding system of rice cultivation, such as *Fimbristylis miliacea*, *Cyperus iria, Echinochloa crus-galli,* and *Leptochloa chinensis*, so that rice plants can grow optimally and produce higher yields.

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