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Research Article

The Effect of Herbicides and Cultivation Systems on Rice (*Oryza sativa* L.) Yield

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ABSTRACT

The rice cultivation systems commonly used by farmers are the transplanted (called 'Tapin') and the direct-seeded (called 'Tabela') system. The Tabela system has many advantages over the Tapin system but has a weakness: the increase in weed population due to water conditions during transplantation. Therefore, weed management is necessary to increase rice yields. One way to control weeds is by applying herbicides. Using a single active ingredient herbicide continuously increases the chances for weeds to develop resistance against these active ingredients. Therefore, mixing herbicides with different active ingredients can be an alternative to improve weed management. This study aims to determine the effect of weed control and cropping systems to suppress weeds and provide the highest growth and rice yield. The research was conducted at the Agricultural Training and Development Research Center (*Sanggar Penelitian Latihan dan Pengembangan Pertanian* [SPLPP]) of the Faculty of Agriculture, Universitas Padjadjaran, Ciparay, Bandung Regency. This research was designed as a separate plot design with ten treatments and three replications with the main plot of cropping system and subplots of weed control. Weed management treatments consisted of bensulfuron-methyl 12% and bispyribac-sodium 18%; penoxsulam 15 g/L and pretilachlor 385 g/L; cyhalofop-butyl 100 g/L; manual weeding; and untreated control. Results that showed significant differences were tested using Duncan's test (DMRT) with $\alpha = 5\%$. Results showed that the Tabela system combined with bensulfuron-methyl 12% and bispyribac-sodium 18% suppressed weed growth and provided good growth and rice yield.

Keywords: cropping system; herbicide; Tabela; Tapin; weeding

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple crop for the people of Indonesia (Simanjuntak *et al.*, 2016). According to the Indonesia Bureau of Statistics (*Badan Pusat Statistik*), rice production in Indonesia reached 54.65 million tons of milled dry grain, or equal to 34.3 million tons of rice in 20202 (*Badan Pusat Statistik*, 2021).

In Indonesia, farmers usually practice the rice transplantation (Tapin) system in their fields. The Tapin system is done by cultivating rice plants in nurseries, and seedlings are moved after reaching a certain age. The Tapin system has been practiced from generation to generation due to its easiness and low risks. However, rice transplantation has the disadvantage of requiring higher labor and a longer performance time (Umiyati *et al.*, 2020). These disadvantages can be avoided by direct seeding cultivation (Tabela) systems. The Tabela system can reduce labor and is considered more economically efficient than Tapin. Direct seeding is an improvement of the technology currently used by farmers. Direct seeding can reduce labor by 25–30%, water by 21%, production facilities by 5–10%, and produce 10–25% of more yield with higher quality than transplanting (Kurniadie *et al.,* 2020). However, the use of direct seeding has been reported to increase weed populations.

Weed occurrences in rice plantations using either Tapin or Tabela system can reduce crop productivity and development. Yield reduction due to weeds can reach 48% in transplanting and 78% in direct seeding (Utami *et al.,* 2020).

Weed management should be done in Tapin and Tabela systems to increase rice productivity. Weed management can be done using various techniques, including mechanical and chemical. Mechanical management uses manual weeding techniques that require high labor and long hours, causing farmers to rely on chemical herbicides. Chemical management is quick and effective for weeds (Pratiwi *et al.,* 2016). According to Umiyati *et al.* (2020), herbicides containing active ingredients of penoxsulam effectively manage sedge and broad leaf weeds in rice productions that used transplanting.

Current weed management has focused on using solely one herbicide active ingredient. The usage of one herbicide active ingredient continuously can result in resistant weed populations. Mixing herbicide-active ingredients can increase the spectrum of managed weeds. Panjaitan and Nugroho (2020) showed that mixing herbicides with different modes of action could manage weeds in different target sites and reduce the possibilities to cause resistance. Herbicides that contained mixtures of bensulfuron-methyl and bispyribac-sodium or penoxsulam and pretilachlor were examples of herbicides mixtures with broader spectrums compared to single herbicides. Widyasmara *et al.* (2019) stated that herbicides containing bensulfuron-methyl and bispyribac-sodium were effective to manage in direct seeding rice production by 56%. Research by Widayat and Sumekar (2022) stated that penoxsulam and pretilachlor with the dosage of 1–3 L/ha suppressed the growth of broad leaf and grass weeds in rice fields that used transplanting. This study aimed to determine the effect of weed management of different herbicides and planting systems to suppress weed population, crop growth, and yield.

MATERIALS AND METHODS

This study was conducted between September to November 2021 at *Sanggar Penelitian Latihan dan Pengembangan Pertanian* (SPLPP), Faculty of Agriculture, Universitas Padjadjaran, Ciparay, Bandung. This location was located at ±700 m.a.s.l, had inceptisols soil and type D3 rain rates according to classifications of Oldeman (1975) (Utami *et al.*, 2020).

Rice cultivars used in this study was Ciherang, while herbicides used were Benfuron 12/18 WP (bensulfuron-methyl 12% and bispyribac-sodium 18%), Juno 15/385 (penoxsulam 15 g/L and pretilachlor 385 g/L), Exran 100 EC (cyhalofop-butyl 100 g/L). During this study, fertilizers applied included Urea, SP36, and KCI. Meanwhile, the tools used in this study were semiautomatic sprayer knapsack and T-jet nozzles, measuring beakers, oven, and analytical scales.

This study was set as a split-plot design consisting of two factors: the planting system as the main plot and the weed management technique as the subplot with three replications. Results were tested using an ANOVA and Duncan Multiple Range Test (DMRT) at confidence levels of 95%. The main treatment consisted of two treatments, including Tapin system (T1) and Tabela system (T2), while the sub-treatment was weed management that consisted of various herbicides, i.e., bensulfuron-methyl 12% + bispyribac-sodium 18% at a dosage of 100 g/ha (P1); penoxsulam 15 g/L + pretilachlor 385 g/L at the dosage of 2 L/ha (P2); cyhalofop-butyl 100 g/L at the dosage of 2 L/ha (P3); manual weeding (P4); and without weed management or untreated control (P5) resulting in 30 plots (Table 1). Herbicides used were post-emergence herbicides

Table 1. Treatment list and combinations

Main plot planting system	Sub-plot weed management				
	P1	P2	P3	P4	P5
Transplanting (Tapin, T1)	T1P1	T1P2	T1P3	T1P4	T1P5
Direct seeding (Tabela, T2)	T2P1	T2P2	T2P3	T2P4	T2P5

Notes: bensulfuron-methyl 12% + bispyribac-sodium 18% at dosage of 100 g/ha (P1), penoxsulam 15 g/L + pretilachlor 385 g/L at dossage of 2 L/ha (P2), cyhalofop-butyl 100 g/L at dossage of 2 L/ha (P3), manual weeding (P4), and without weed management or untreated control (P5) and applied 14 days after planting (DAP) using a semiautomatic knapsack sprayer at a volume spray of 400 L/ha and T-jet nozzles with pressures of 1 kg/cm^2.

Observations done in this study included vegetation analysis before and after herbicide application. Meanwhile, after herbicide application, observations were done on additional parameters at 3 and 6 weeks after herbicide applications (WAHA), including weed dry weight (WDW), the number of tillers, and plant height. Phytotoxicity was also observed in 1, 2, and 3 WAHA. Dried milled grain (DMG) was recorded at the end of planting season.

RESULTS AND DISCUSSIONS

Vegetation Analysis of Weed Populations

Vegetation analysis was done before herbicide application to obtain preliminary insights into weed populations in the used research field (Table 2). Results from preliminary vegetation analysis showed four sedge weed species, three broad leaf weed species (*Ludwigia octovalvis*, *Monochoria vaginalis*, and *Limnocharis flava*), and two grass weed species (*Echinochloa crus-galli* and *Leersia hexandra*). Dominant sedge weed species were *Fimbristylis miliacea* (24.50%), *Cyperus difformis* (17.06%), *C. iria* (17.61%), and *C. rotundus* (10.03%).

During this study, weed species composition in the field did not change and was still dominated by sedge weeds. *F. miliacea* was the most dominant weed species in the field due to its seed not having any dormancy stages, can germinate quickly, and resulting in abundant new tillers. *F. miliacea* has high reproduction rates, produces many tillers, and has quickly become a dominant species in research fields (Zarwazi *et al.*, 2016).

Table 2. Vegetation analysis of weed

No.	Weed Species	Weed Type	SDR (%)
1	*Fimbristylis miliacea*	Sedge	24.50
2	*Ludwigia octovalvis*	Broad Leaf	5.80
3	*Cyperus difformis*	Sedge	17.06
4	*Cyperus iria*	Sedge	17.61
5	*Cyperus rotundus*	Sedge	10.03
6	*Echinochloa crus-galli*	Grass	7.79
7	*Limnocharis flava*	Broad Leaf	3.78
8	*Leersia hexandra*	Grass	7.20
9	*Monochoria vaginalis*	Broad Leaf	6.23
	Total		100.00

Notes: SDR = Summed Dominance Ratio

Weed Dry Weight Observation

***Fimbristylis miliacea* Dry Weight.** *Fimbristilis miliaceae* was the dominant weed species in the research field. The dry weight of *F. miliaceae* showed no significant differences between the planting system at 3 and 6 WAHA (Table 3). *F. miliaceae* dry weight was significantly different compared to untreated control at 3 and 6 WAHA, but not significantly different compared to manual weeding at 3 and 6 WAHA. This showed that management using bensulfuron-methyl 12% + bispyribac-sodium 18% at a dosage of 100 g/ha (P1) and penoxsulam 15 g/L + pretilachlor 385 g/L (P2) effectively managed weed and required less time and cost. These results were consistent with the finding from Lolitasari and Saifuddin (2019) that demonstrated that weed management using herbicides with mixed active ingredients was more effective than manual weeding due to the shorter time required, which reduced expenses. Both herbicides with mixed active ingredients were applied post-weed emergence, systemic active ingredients, and translocated across the plant body, causing it to effectively managed sedge weed.

The application of cyhalofop-butyl herbicide, a singular active ingredient herbicide, showed higher *F. miliaceae* dry weight compared to manual weeding treatment. This is caused due to cyhalofop-butyl is categorized as a post-emergence systemic herbicide that suppresses the function of acetyl coenzyme-A carboxylase of grass weeds. In addition, manual management was done by manually weeding, that reduced average weed dry weight (Kurniadie *et al.*, 2021).

***Cyperus iria* Dry Weight.** *Cyperus iria* was the second most dominant weed species. *C. iria* dry weight between the planting systems was not significantly different at 3 and 6 WAHA (Table 4). Herbicide treatment (P1, P2, P3) showed significantly different dry weights compared to manual weeding (P4) and untreated control (P5) at 3 WAHA.

Observation at 6 WAHA showed that the dry weight of herbicide application (P1, P2, P3) was not significantly different compared to manual weeding

Table 3. The effect of planting system and weed management on the dry weight of *Fimbristylis miliacea* at 3 and 6 weeks after herbicide application

Treatment	Weed Dry Weight (g/m^2) 3 WAHA	6 WAHA
Planting system		
Transplanting (Tapin, T1)	2.36[a]	3.98[a]
Direct seeding (Tabela, T2)	2.30[a]	4.14[a]
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	2.09[a]	3.80[ab]
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	2.18[a]	3.98[b]
P3 (cyhalofop-butyl 100 g/L)	2.53[b]	4.38[bc]
P4 (manual weeding)	1.90[a]	3.18[a]
P5 (without weed management/untreated control)	2.97[c]	4.95[c]

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on the DMRT post-hoc test at confidence levels of 95%

Table 4. The effect of planting system and weed management on the dry weight of *Cyperus iria* at 3 and 6 weeks after herbicide application

Treatment	Weed Dry Weight (g/m^2) 3 WAHA	6 WAHA
Planting system		
Transplanting (Tapin, T1)	1.85[a]	2.71[a]
Direct seeding (Tabela, T2)	2.03[a]	2.96[a]
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	1.47[a]	2.41[a]
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	1.58[a]	2.44[a]
P3 (cyhalofop-butyl 100 g/L)	1.85[ab]	2.69[a]
P4 (manual weeding)	2.28[bc]	2.94[a]
P5 (without weed management/untreated control)	2.53[c]	3.71[b]

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on DMRT post-hoc test at confidence levels of 95%

(P4) but not significantly different to the untreated control (P5). These results show that herbicide application (P1, P2, P3) effectively managed *C. iria* at 3 and 6 WAHA. Previous research showed that these herbicide active ingredients effectively managed weed species in rice fields (Widayat & Sumekar, 2019; Widyasmara *et al*., 2019; Kurniadie *et al*., 2020).

***Echinochloa crus-galli* Dry Weight.** Weed species dominance is based on Summed Dominance Ratio (SDR), and *E. crus-galli* was the most abundant weed species but not the most dominant species in the research field, with SDR value of 7.79% (Table 5). *E. crus-galli* dry weight was not different between planting systems in 3 and 6 WAHA. Dry weight of weed management using herbicides treatments at 3 and 6 WAHA showed significantly different compared to untreated control but not significantly different compared to manual weeding. This implies that herbicide treatment effectively managed *E. crus-galli* to 6 WAHA. The herbicide used in this study contained systemic active ingredient and effectively managed *E. crus-galli* (Guntoro & Fitri, 2013). Herbicide that contains cyhalofop-butyl and penoxsulam has a broad management spectrum, including grass and sedge weed, by inhibiting metabolism and seed development (Umiyati *et al.,* 2021).

***Ludwigia octovalvis* Dry Weight.** *Ludwigia octovalvis* was the main broad leaf weed in rice fields during 3 the 6 WAHA, but *L. octovalvis* dry weight was not significantly different between planting systems (Table 6). Herbicide application showed not

Table 5. The effect of planting system and weed management on dry weight of *Echinochloa crus-galli* at 3 and 6 weeks after herbicide application

Treatment	Weed Dry Weight (g/m²)	
	3 WAHA	6 WAHA
Planting system		
Transplanting (Tapin, T1)	0.96[a]	1.17[a]
Direct seeding (Tabela, T2)	0.91[a]	0.03[a]
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	1.00[ab]	1.23[a]
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	0.79[a]	0.87[a]
P3 (cyhalofop-butyl 100 g/L)	0.79[a]	0.82[a]
P4 (manual weeding)	0.94[ab]	0.93[a]
P5 (without weed management/untreated control)	1.15[b]	1.64[b]

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on DMRT post-hoc test at confidence levels of 95%.

Table 6. The effect of planting system and weed management on dry weight of *Ludwigia octovalvis* at 3 and 6 weeks after herbicide application

Treatment	Weed Dry Weight (g/m²)	
	3 WAHA	6 WAHA
Planting system		
Transplanting (Tapin, T1)	0.95[a]	0.92[a]
Direct seeding (Tabela, T2)	1.05[a]	0.92[a]
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	0.96[ab]	0.78[ab]
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	0.78[a]	0.73[a]
P3 (cyhalofop-butyl 100 g/L)	0.75[a]	0.77[ab]
P4 (manual weeding)	1.12[ab]	0.88[ab]
P5 (without weed management/untreated control)	1.41[b]	1.45[b]

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on DMRT post-hoc test at confidence levels of 95%.

significantly different dry weight compared to manual weeding, but significantly different compared to untreated control at 3 and 6 WAHA. This showed that the herbicide used in this study effectively managed *L. octovalvis* until 6 WAHA. *L. octovalvis* is a broad leaf weed species that is susceptible to herbicides due to *L. octovalvis* large surface area that causes high herbicide absorption (*Badan Penyuluhan dan Pengembangan SDM Pertanian*, 2015).

Total Dry Weight

Total dry weight includes the dry weight of all weeds in each replication and treatment plot. Based on statistical analysis, there were interactions between the planting system and weed management on total dry weight at 6 WAHA (Table 7). Both planting systems combined with untreated treatment resulted in high total dry weight compared to other treatment combinations. This implies that herbicide application combined with either planting system was able to manage weeds at 6 WAHA.

Total dry weight significantly differed between planting systems at 3 and 6 WAHA. Herbicide application had significantly lower total dry weight compared to untreated control. However, it was not significantly different to manual weeding at 3 and 6 WAHA implying that used herbicides effectively managed weed until 6 WAHA. Research by Widyasmara *et al.* (2019) showed that bensulfuron-methyl 12% and bispyribac-sodium 18% application in rice fields using direct seeding significantly reduced the total dry weight of weed by 56%.

Tabel 7. The effect of planting system and weed management on total weed weight at 3 and 6 weeks after herbicide application

Treatment	Weed Dry Weight (g/m^2)	
	3 WAHA	6 WAHA
Planting system		
Transplanting (Tapin, T1)	3.39^a	5.19^a
Direct seeding (Tabela, T2)	3.34^a	5.41^a
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	2.95^a	4.72^a
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	2.83^a	4.93^a
P3 (cyhalofop-butyl 100 g/L)	3.16^a	5.27^a
P4 (manual weeding)	3.31^a	4.50^a
P5 (without weed management/untreated control)	4.58^b	7.06^b

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on DMRT post-hoc test at confidence levels of 95%.

Table 8. Phytotoxicity observation after herbicide application

Treatment	Dosage/ha (L/ha)	Observation		
		1 WAHA	2 WAHA	3 WAHA
T1P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	100 g	0.00	0.00	0.00
T1P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	2 L	0.00	0.00	0.00
T1P3 (cyhalofop-butyl 100 g/L)	2 L	0.00	0.00	0.00
T1P4 (manual weeding)	-	0.00	0.00	0.00
T1P5 (without weed management/untreated control)	-	0.00	0.00	0.00
T2P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	100 g	0.00	0.00	0.00
T2P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	2 L	0.00	0.00	0.00
T2P3 (cyhalofop-butyl 100 g/L)	2 L	0.00	0.00	0.00
T2P4 (manual weeding)	-	0.00	0.00	0.00
T2P5 (without weed management/untreated control)	-	0.00	0.00	0.00

Notes: WAHA = week after herbicide application.

Rice Phytotoxicity Due to Herbicide Application

Phytotoxicity is plant mortality caused by herbicide application. Observations were done visually weekly at 1, 2, and 3 WAHA (Table 8). Herbicide selectivity is affected by plant target, herbicide characteristics, dosage, types, and environmental factors (Weed Science and Society of America, 2002).

Rice Growth and Productivity

Number of Tillers. Results showed interactions between planting systems and weed management effect on the number of tillers at 3 WAHA (Table 9). The number of tillers at the Tabela system was higher than the Tapin system at 3 WAHA due to stress avoidance from transplanting (Makmur *et al.*, 2020).

Observations at 3 and 6 WAHA, bensulfuron-methyl 12% and bispyribac-sodium 18% produced significantly higher tiller numbers compared to untreated control. This implies that weeding management effectiveness affects the number of rice tillers. Kurniadie *et al.* (2020) stated that herbicide effectiveness in managing weeds increased growing space and nutrients absorption for rice plants that increased tiller numbers.

Plant Height. Results showed that there were interactions between planting systems and weed management at 3 and 6 WAHA (Table 10). Herbicide application resulted in no significant differences in plant height compared to untreated control. However, there was significant differences compared to manual weeding due to reduced competition. Plant height from crops planted using the Tabela system was significantly higher than the Tapin system based on observation at 3 and 6 WAHA.

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Table 9. Effect of weed treatment on tiller numbers at different planting systems

Treatment	Number of Tillers	
	3 WAHA	6 WAHA
Planting system		
Transplanting (Tapin, T1)	19.17[a]	22.17[a]
Direct seeding (Tabela, T2)	20.09[a]	27.22[a]
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	24.02[b]	25.62[b]
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	19.60[bc]	23.38[b]
P3 (cyhalofop-butyl 100 g/L)	22.14[cd]	24.35[b]
P4 (manual weeding)	17.36[ab]	30.78[c]
P5 (without weed management/untreated control)	15.05[a]	19.41[a]

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on DMRT post-hoc test at confidence levels of 95%.

Table 10. Effect of weed treatment on plant height at different planting systems

Treatment	Rice Plant Height (cm)	
	3 WAHA	6 WAHA
Planting system		
Transplanting (Tapin, T1)	56.38[b]	70.51[b]
Direct seeding (Tabela, T2)	52.61[a]	64.75[a]
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	54.66[ab]	66.14[a]
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	52.22[a]	64.93[a]
P3 (cyhalofop-butyl 100 g/L)	55.00[ab]	66.48[a]
P4 (manual weeding)	57.24[b]	74.42[b]
P5 (without weed management/untreated control)	53.37[ab]	66.19[a]

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on DMRT post-hoc test at confidence levels of 95%.

Table 11. Effect of weed treatment on Dried Milled Grain at different planting systems

Treatment	Dried-Milled Grain (DMG)	
	DMG/2×2 m^2 (g)	DMG/ha (kg)
Planting system		
Transplanting (Tapin, T1)	2,960.82[a]	6,675.28
Direct seeding (Tabela, T2)	2,966.81[a]	6,691.90
Weed management		
P1 (bensulfuron-methyl 12% + bispyribac-sodium 18%)	3,182.49[b]	7,160.74
P2 (penoxsulam 15 g/L + pretilachlor 385 g/L)	3,161.90[b]	7,114.27
P3 (cyhalofop-butyl 100 g/L)	3,108.71[b]	7,069.59
P4 (manual weeding)	3,294.57[b]	7,412.69
P5 (without weed management/untreated control)	2,071.45[a]	4.660.67

Notes: WAHA = week after herbicide application. Similar letters in the same column showed non-significant differences based on DMRT post-hoc test at confidence levels of 95%.

These results were consistent with the ones from Makmur *et al.* (2020).

Dried-Milled Grain (DMG). Dried-milled grain results were not significantly different between planting systems (Table 11). Pandawani and Putra (2015) showed that the Tabela system produced similar yield to the Tapin system or even higher with optimum cultivation practices. The highest yield loss was showed by cyhalofop-butyl 100g/L combined with the Tabela system by 5.1%. Yield loss even reached 41.2% without management. This is due to cyhalofop-butyl 100g/L treatment consisting only of one active ingredient compared to other herbicides that contain several active ingredients. Higher weed populations will increase crop competition and result in higher yield loss (Widayat & Purba, 2015).

CONCLUSION

Weed management using herbicides that contained mixed bensulfuron-methyl 12% + bispyribac-sodium 18% and mixed penoxsulam 15 g/L + pretilachlor 385 g/L were able to suppress several weed species, including *Fimbristylis miliacea, Cyperus iria, Echinochloa crus-galli*, and *Ludwigia octovalvis* in both Tapin and Tabela systems. Weed management using herbicides that contain active ingredient mixtures, such as bensulfuron-methyl 12% and bispyribac-sodium 18% or penoxsulam 15 g/L and pretilachlor 385 g/L, or herbicides containing a single active ingredient, such as cyhalofop-butyl 100g/L, did not result in phytotoxicity on rice plants. Weed management and planting systems using Tabela increased rice productivity.

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