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CONTROL OF HERBICIDE RESISTANT ECHINOCHLOA ORYZOIDES WITH PRE AND POST EMERGENT HERBICIDES BASED ON THE LEAF STAGES

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ABSTRACT

The effect of weed control was investigated, based on the leaf growth stages and/or several different herbicide treatments, for an integrated weed management of herbicide resistant Echinochloa oryzoides in a rice field. The effectiveness of soil-applied herbicide treatments for pre-emergent control of E. oryzoides resistant to herbicides was very high with oxadiargyl 1.7% EC, oxadizon 12% EC, and fentrazamide·oxadiargal 3.3% EC. Pentaxazon 5% SC achieved over 98% of weed control, although some E. oryzoides emerged 31 days after the treatment. Up to the 2nd leaf growth stage of E. oryzoides, six herbicides, azimsulfuron·carfenstole 1.05% GR, bensulfuron-methyl·benzobicyclone· mefenacet 24.52% SC, bensulfuron-methyl·fentrazamide 7% SC, bensulfuron-methyl· mefenacet·oxadiargyl 21.6% SC, benzobicyclon·mefenacet·penoxulam 21.5% SC and mefenacet·pyrazosulfuron -ethyl 3.57% GR achieved 100% control. However, only two herbicides, benzobicyclone·mefenacet·penoxulam 21.5% SC and mefenacet· pyrazosulfuron-ethyl 3.5% GR could control E. oryzoides up to the 3rd leaf growth stage. The study indicates that it is very important to select the right herbicides for treatment and apply them at the correct timing to achieve a high level of control of E. oryzoides resistant to ACCase- and ALS-herbicides.

Key words: ACCase; cyhalofop-butyl; *Echinochloa oryzoides*; herbicide resistance.

INTRODUCTION

Barnyard grass [*Echinochla oryzoides* (Ard.) Fritsch], widely distributed in the world, reduces rice grain production greatly and is one of the most problematic weeds in paddy fields. For example, only four to eight barnyard grass plants/ m^2 may decrease rice yield by seven to 13%. It is very difficult to obtain good rice grain production when barnyard grass occurs in high abundance (Kwon *et al*., 2002).

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It is anticipated that occurrence of barnyard grass will be significantly increased when large-scale rice cultivation is undertaken on the reclaimed land at Seosan in Korea, and the area used for direct seeding is increased. This will increase the use of acetyl Co a carboxylase (ACCase) foliar-applied herbicides such as cyhalofop-butyl and fenoxaprop-P-ethyl. It will also be increasingly difficult to control weeds using these kinds of herbicides. Therefore, it is very important to detect at the early stages whether or not weeds are herbicide resistant. Subsequent treatments of foliar-applied herbicides should be different depending on whether herbicide resistant weeds are present.

Park *et al*. (2010) reported that barnyard grasses resistant to ACCase foliar-applied herbicides also show resistance to acetolactate synthase (ALS) herbicides. To effectively control weeds showing cross resistance, an integrated weed management strategy would be required, based on the selection of appropriate herbicides and the treatment timing at the correct leaf growth stages. Lim *et al*. (2010) reported the occurrence of barnyard grasses resistant to ACCase herbicides such as cyhalofop-butyl and fenoxaprop-p-ethyl on the reclaimed land at Seosan of Choongnam in Korea.

This study, therefore, was conducted to evaluate the response to available herbicides, and to develop effective control strategies for barnyard grasses resistant to herbicides, based on herbicides with different modes of action.

MATERIALS AND METHODS

Chemical response testing to develop the integrated weed management strategies against herbicide resistant barnyard grasses was conducted with *E. oryzoides* resistant to herbicides. Seeds were collected on October, 2009 from resistant population from Jooksanmyeon, Gimjaesi of Jeonbuk, Korea and were conserved at 4^0C until April, 2010.

The barnyard grass plants were raised from these seeds and planted in 1/2000a Wagner pots filled with paddy soil. Chemical responses were observed on pre-emergence and post-emergence treatments respectively. Ten different soil applied herbicides were tested for pre-emergence treatment as given in Table-1.

In the second study, 14 different herbicides, including butachlor 5% GR, azimsulfuron · thiobencarb 7.05% GR, mefenacet · pyrazosulfuron-ethyl 3.57% GR, and bensullfuron-methyl · fentrazamide 7% SC were used as post-emergence herbicides, based on the leaf stages of barnyard grass with soil-applied herbicides. Herbicides for post-emergence were applied at different leaf stages of barnyard grass: i.e. 1, 2, and 3 leaf stages, at the recommended field rates of the herbicides.

All experiments were conducted in a glasshouse and had untreated controls. Experimental treatments were replicated three times and treatments were randomized. The weed control effect of each herbicide was investigated by measuring the dry weight of barnyard grasses in each pot and comparing with the untreated control at 45 days after pre-emergence treatment and 34~38 days after post-emergence treatment.

The data were subjected to an ANOVA and presented as a mean± standard deviation of at least three replicates. The mean values were separated by using the Least Significant Difference test at $P<0.05$.

Table-1. Soil-applied herbicides applied as pre-emergence treatments to control barnyard grasses resistant to ACCase and/or ALS inhibitors herbicides

Herbicide[1]	Dosage (g a.i./ha)	Treatment time[2]
benzobicyclon 3.5% SC	140	IAP~2DBT
butachlor 33% EW	1,320	IAP~2DBT
oxadiargyl 1.7% EC	68	IAP~3DBT
oxadizon 12% EC	480	IAP~2DBT
pentoxazon 5% SC	200	IAP
pretilachlor 37% EW	1,480	IAP~2DBT
benzobicyclone·pretilachlor 12% SE	480	IAP
benzobicyclone·thiobencarb 32.5% SE	1,300	IAP
pentrazamide·oxadiagil 3.3% EC	132	IAP~2DBT
Untreated	-	-

[1)] SC: suspension concentrate; EW: oil emulsion in water; EC: emulsifiable concentrate; SE: suspension emulsion; [2)] IAP: immediately after puddling; 2DBT: 2 days before transplanting.

RESULTS AND DISCUSSION

Weed control using pre-emergence treatments

Ten different soil-applied pre-emergence herbicides were applied at the time of harrowing or two days before transplanting, and the weed control effects measured at 45 DAT. All herbicides applied achieved over 90% weed control by 10 days after treatment (data not shown). However, only five of them, butachlor 33% EW, oxadizon 12% EC, pentoxazon 5% SC, oxadiargyl 1.7% EC, and pentrazamide· oxadiagil 3.3% EC, could control over 95% of barnyard grasses (Table-3).

Plant height and dry weight are shown in Table 3. The results show that butachlor 33% EW, oxadizon 12% EC and the others will

provide effective control of barnyard grasses resistant to herbicides in the rice field, if the treatments are applied at the time of harrowing.

Table-2. Soil-applied herbicides applied as post-emergence treatments to control barnyard grasses resistant to ACCase and/or ALS inhibitors herbicides

Herbicide[1)]	Dosage (g a.i./ha)	Treatment time (Leaf stage)		
		1	2	3
butachlor 5% GR	1,500	○	-	-
pretichlor 37% EW	555	○	-	-
esprocarb·pyrazosulfuron-ethyl 5.07% GR	1,521	○	○	-
azimsulfuron·carfenstole 1.05% GR	315	○	○	-
azimsulfuron·thiobencarb 7.05% GR	2,115	○	○	-
bensullfuron-methyl·benzobicyclon·mefenacet 24.52% SC	1,226	○	○	-
bensullfuron-methyl·fentrazamide 7% SC	350	○	○	-
bensullfuron-methyl·indanofan 3.4% SC	170	○	○	-
bensullfuron-methyl·mefenacet·oxadiargyl 21.6% SC	1,080	○	○	-
benzobicyclon·penoxulam 3.48% SC	174	○	○	-
dymuron·imazosulfuron·oxaziclomefone 11.5% SC	575	○	○	-
benzobicyclon·mefenacet·penoxulam 21.5% SC	1,075	○	○	○
Pyrazosulfuron-ethyl·pyriftalid 0.67% GR	201	○	○	○
mefenacet·pyrazosulfuron-ethyl 3.57% GR	1,071	○	○	○
Untreated	-	-	-	-

[1)] GR: granule; EW: oil emulsion in water; SC: suspension concentrate

Weed control using post-emergence treatments
Effect at 1st leaf growth stage

Fourteen different soil-applied herbicides were applied at the 1st leaf growth stage and weed control effects measured 38 days after treatment. The results (Table 4) indicate 100% control of barnyard grass by treatment with bensullfuron · methyl · benzobicyclon · mefenacet 24.52% SC, bensullfuron-methyl · fentrazamide 7% SC, dymuron · imazosulfuron · oxaziclomefone 11.5% SC, benzobicyclon · mefenacet · penoxulam 21.5% SC and mefenacet · pyrazosulfuron-ethyl 3.57% GR. On the other hand, azimsulfuron · carfenstole 1.05% GR, bensullfuron-methyl · indanofan 3.4% SC, bensullfuron-methyl · mefenacet · oxadiargyl 21.6% SC and pyrazosulfuron-ethyl · pyriftalid 0.67% GR provided 96-99% weed control.

Table-3. Growth status and weed control effect of barnyard grasses resistant to ACCase after treatment of soil-applied pre-emergence herbicides

Herbicide	Plant height (cm)	Dry weight (g/pot)	Weed control (%) at 45 DAT
benzobicyclon 3.5% SC	47.6	8.9 c	66.8
butachlor 33% EW	26.3	1.5 d	94.4
oxadiargyl 1.7% EC	0.0	0.0 d	100.0
oxadizon 12% EC	0.0	0.0 d	100.0
pentoxazon 5% SC	28.5	0.4 d	98.5
pretilachlor 37% EW	53.0	7.1 c	73.5
benzobicyclone·pretilachlor 12% EW	40.8	2.9 d	89.2
benzobicyclone·thiobencarb 32.5% EW	50.8	8.5 c	68.3
pentrazamide·oxadiargyl 3.3% EC	0.0	0.0 d	100.0
Untreated	49.4	26.8 a	-
C.V(%)[1)]	27.1		

[1)] Means with the same letters in a row did not significantly differ at 5% by DMRT.

A few herbicides achieved 80~90% weed control, while esprocarb · pyrazosulfuron-ethyl 5.07% GR and azimsulfuron · thiobencarb 7.05% GR could control less than 50% of the barnyard grasses resistant to herbicides (Table-4).

Effect at 2nd leaf growth stage

The weed control effects of the fourteen different soil-applied post-emergence herbicides on the 2nd leaf growth stage of *E. oryzoides* are provided in Table 4. One hundred percent control of barnyard grass was obtained by six herbicides, i.e., azimsulfuron · carfenstole 1.05% GR, bensullfuron- methyl· benzobicyclon · mefenacet 24.52% SC, bensullfuron · methyl · fentrazamide 7% SC, bensullfuron · methyl · mefenacet · oxadiargyl 21.6% SC, benzobicyclon · mefenacet · penoxulam 21.5% SC, and mefenacet · pyrazosulfuron-ethyl 3.57% GR at the 2nd leaf growth stage.

Effect at 3rd leaf growth stage

Treatment timing is very important for controlling barnyard grasses, because the tillers are formed right after the 3rd leaf growth stage. Herbicide treatments must be applied by this time, or weed control becomes very labor-intensive. One hundred percent control of barnyard grass was obtained 34 days after treatment with the treatments of benzobicyclon·mefenacet·penoxulam 21.5% SC and mefenacet· pyrazosulfuron-ethyl 3.57% GR (Table-4).

Table-4. Weed control effect of soil-applied post-emergence herbicide treatments at the 1 to 3 leaf growth stage of barnyard grasses resistant to ACCase inhibitors herbicides

Herbicide	Weed control (%)[1)]		
	1	2	3[2)]
butachlor 5% GR	78.0	-	-
pretichlor 37% EW	63.1	-	-
esprocarb·pyrazosulfuron-ethyl 5.07% GR	82.8	66.8	-
azimsulfuron·carfenstole 1.05% GR	98.5	100.0	-
azimsulfuron·thiobencarb 7.05% GR	90.3	32.1	-
bensullfuron-methyl·benzobicyclon·mefenacet 24.52% SC	100.0	100.0	-
bensullfuron-methyl·fentrazamide 7% SC	100.0	100.0	-
bensullfuron-methyl·indanofan 3.4% SC	98.5	89.2	-
bensullfuron-methyl·mefenacet·oxadiargyl 21.6% SC	98.9	100.0	-
benzobicyclon·penoxulam 3.48% SC	48.5	32.8	-
dymuron·imazosulfuron·oxaziclomefone 11.5% SC	100.0	94.0	-
benzobicyclon·mefenacet·penoxulam 21.5% SC	100.0	100.0	100.0
pyrazosulfuron-ethyl·pyriftalid 0.67% GR	96.3	96.6	91.8
mefenacet·pyrazosulfuron-ethyl 3.57% GR	100.0	100.0	100.0

[1)] Weed control effects at 34~38 days after treatment; [2)] Leaf growth stages.

Table 5. Summary of effective soil-applied post-emergence herbicides at the 1 to 3 leaf growth stage of barnyard grasses resistant to ACCase inhibitors herbicides

Herbicide	Treatment time[1)]	Weed control effects[2)]		
		1	2	3
azimsulfuron·carfenstole 1.05% GR	15 DAT	○	◎	-
bensulfuron-methyl·benzobicyclon·mefenacet 24.52% SC	15 DAT	◎	◎	-
bensulfuron-methyl·fentrazamide 7% SC	15 DAT	◎	◎	-
bensulfuron-methyl·indanofan 3.4% SC	15 DAT	○	△	-
bensulfuron-methyl·mefenacet·oxadiagyl 21.6% SC	15 DAT	○	◎	-
dymuron·imazosulfuron·oxaziclomefone 11.5% SC	15 DAT	◎	○	-
benzobicyclon·mefenacet·penoxulam 21.5% SC	10~12 DAT	◎	◎	◎
pyrazosulfuron-ethyl·pyriftalid 0.67% GR	15 DAT	○	○	○
mefenacet·pyrazosulfuron-ethyl 3.57% GR	5~15 DAT	◎	◎	◎

[1)] DAT: days after treatment

[2)] Weed control effects: ◎ 100%, ○ 91~99%, △ 89% (at 34~38 days after treatment)

Weed control achieved by the soil-applied post-emergence treatment at each leaf growth stage are summarized in Table 5. Four of them, i.e., azimsulfuron·carfenstole 1.05% GR, bensullfuron- methyl ·benzobicyclon· mefenacet 24.52% SC, bensullfuron-methyl·fentrazamide 7% SC, and bensulfuron- methyl·mefenacet·oxadiagyl 21.6% SC could control the barnyard grasses resistant to herbicides until the 2nd leaf growth stage.

Benzobicyclon· mefenacet· penoxulam 21.5% SC, pyrazosulfuron- ethyl· pyriftalid 0.67% GR and mefenacet· pyrazosulfuron-ethyl 3.57% GR showed great weed control effect from leaf stages 1 to 3. A few could achieve over 90% of weed control effect, but not 100%.

CONCLUSIONS

The effectiveness of soil-applied herbicide treatments for pre-emergent control of *E. oryzoides* resistant to herbicides was very high with oxadiargyl 1.7% EC, oxadizon 12% EC, and fentrazamide·oxadiargal 3.3% EC. Six soil-applied post-emergence herbicides achieved perfect control of *E. oryzoides* up to the 2nd leaf growth stage, while only two herbicides, benzobicyclone· mefenacet· penoxulam 21.5% SC and mefenacet· pyrazosulfuron-ethyl 3.5% GR could control the weed up to its 3rd leaf growth stage.

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REFERENCES CITED

Kwon, O.D., I.K. Yong, D.L. Lee, H.R. Shin, I.J. Park, E.B. Kim and J.O. Guh. 2002. Growth and yield of rice as affected by competitive period of resistant *Monochoria vaginalis* biotypes to Sulfonylurea herbicides. Kor. J. Weed Sci. 22(2):147-153.

Lim, S.H., J.S. Song, C. Zhang and D.S. Kim. 2010. ACCase inhibitor cyhalofop-butyl resistance in *Echinochloa oryzicola* collected in Chungnam and Jeonbuk province, Korea. Kor. J. Weed Sci. 30(Supp. 1):45-46.

Park, T.S., B.I. Ku, D.K. Kang, M.K. Choi, H.K. Park, K.B. Lee and J.K. Ko. 2010. Response of the resistant biotype of *Echinochloa oryzoides* to ACCase and ALS inhibitors, and effect of alternative herbicides. Kor. J. Weed Sci. 30(3):291-299.