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Efficacy of the HPPD inhibitors benzobicyclon and tefuryltrione in rice fields planted using automated transplanters

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ABSTRACT

This study was conducted to evaluate the efficacy of herbicide mixtures in controlling annual and perennial weeds in paddy fields where rice seedlings were transplanted using automated transplanters. The herbicide mixtures were benzobicyclon+pyrimisulfan SC (BP SC), tefuryltrione+ipfencarbazone SC (TI SC) and benzobicyclon+imazosulfuron+pyriminobac-methyl SC (BIP SC). The annual weeds *Monochoria vaginalis*, *Murdannia keisak, Aeschynomene indica* and *Echinochloa crus-galli* and perennial weeds *Sagittaria trifolia, Eleocharis kuroguwai* and *Scirpus juncoides* were identified in the experimental sites. Experimental results showed that both annual and perennial weeds were effectively controlled by the application of these herbicide mixtures. On the other hand, these herbicides did not have any effect on rice height, number of tillers, and culm and panicle length. The yield in herbicide treatments was similar to that in hand-weeded control. The results of this study indicated that HPPD inhibiting herbicides mixtures could be used to provide an effective weed control in paddy fields of Korea.

Key words : Benzobicyclon, herbicide mixture, HPPD, rice, tefuryltrione, weed control

INTRODUCTION

In Korea, automated transplanters, such as walking-type and riding-type transplanters, have been widely used for transplanting rice in the paddy fields as it can greatly reduce labour cost compared to hand-transplanting (Kim *et al.*, 2012). Currently, 86.3% of all rice farmers in Korea are estimated to plant rice seedlings using transplanters (Park and Lee, 2011). However, machine-transplanting can lengthen the growth period of rice in the field, which consequently also lengthens the period of competition with weeds. In view of this situation, effective weed control early in the season is crucial to reduce weed occurrence in paddy fields where rice is machine-transplanted.

A 2014-survey showed that dominant weeds in paddy fields in Korea were *Echinochloa crus-galli* (17.3%) and *Monochoria vaginalis* (12.4%). Compared to a survey in 2000, the occurrence of *E. crus-galli* significantly increased from 7.8%, while *Monochoria vaginalis* changed little (Ha *et al.*, 2014). This increase of *E. crus-galli* occurrence is attributed to herbicide resistance (Itoh *et al.*, 1997; Park *et al.*, 2014a). Currently, HPPD inhibiting herbicides can effectively control herbicide-resistant weeds in Korea. Additionally, HPPD inhibiting herbicides are often used as a tank-mix partner with other herbicides or for co-formulation with another active ingredient since they are known to be less antagonistic with other herbicides (Kim, 2006; Won *et al.*, 2015).

Benzobicyclon, which is a novel paddy-bleaching HPPD inhibiting herbicide, can effectively control annual and perennial sedge and broadleaf weeds (Park *et al.*, 2014b). For example, *Scirpus juncoides* can be effectively controlled until the 5-leaf stage (Sekino *et al.*, 2008; Song *et al.*, 2011; Won *et al.*, 2013). Likewise, Park *et al.* (2012) reported that a

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HPPD inhibitor, tefuryltrione can effectively control sulfonylurea-resistant weeds.

The objective of the study was to evaluate the safety of benzobicyclon plus pyrimisulfan SC (BP SC) and tefuryltrione plus ipfencarbazone SC (TI SC) to rice and the efficacy of these herbicides in controlling annual and perennial weeds in paddy rice fields of Korea.

MATERIALS AND METHODS

The experiment was carried out with three repetitions in the fields of Chungnam National University in 2014. Rice seedlings (10.8 cm plant height, 2.1 leaf, and 0.98 g/ 100 plants dry weight) were planted in the field using a transplanter (Name : DP480, Model : J45400466, Manufacturer : Daedong) with a crop space of 15 cm and a row space of 30 cm on May 22, 2014.

The herbicide treatments consisted of BP SC (3.5% benzobicyclon+1% pyrimisulfan), TI SC (5% tefuryltrione+6% ipfencarbazone) and BIP SC (4% benzobicyclon+1.55% imazosulfuron+ 0.6% pyriminobac-methyl). The herbicides were applied at 5 L/ha using a sprayer (Name : Electric Li-ion Rechargeable Battery sprayer, Model : KS-PK2000, Manufacturer : KWANG SUNG SPRAYERS) 11 days after transplanting. A hand-weeded control was included in the experiment for comparison. The measurement index included the number and dry weight of weeds. In a crop safety experiment, BP SC (5 and 10 L/ha) and TI SC (5 and 10 L/ha) were applied at different concentrations 11 days after transplanting. Likewise, hand-weeded and untreated weedy control treatments were included for comparison. The plant height and the number of tillers were measured 40 days after application of herbicides, and the injury to the rice was visually rated. The culm length, the panicle length and number, and yield of rice were measured at maturity.

RESULTS AND DISCUSSION

Efficacy Experiment

The results of survey showed that *Monochoria vaginalis*, *Murdannia keisak*, *Aeschynomene indica*, *Echinochloa crus-galli*, *Sagittaria trifolia*, *Eleocharis kuroguwai,* and *Scirpus juncoides* were found in the experimental site. The results of the efficacy trial showed that BP SC, TI SC and BIP SC were almost equally efficacious in controlling these weeds (Table 1). This result is consistent with another study that showed tefuryltrione mixed with other herbicides could provide excellent control of *Scirpus planiculmis* (Park *et al.*, 2012).

Phytotoxicity Experiment

The plant height in the herbicide treatments at 10 L/ha was shorter by approximately 1 cm than that measured in the hand-weeded control 40 days after application. The number of rice tillers in the BP SC treatment was slightly smaller than that measured in the hand-weeded control (Table 2). However, the effect on tillers did not negatively affect yield as yields in the BIP SC treatment did not differ from that in the hand-weeded control (Table 3). In addition, the rice yield components of BP SC and TI SC treatments were similar to the BIP SC and

Table 1. Effects of herbicide mixtures on the annual and perennial weed species at 40 days after application

Treatment	Control value (%)						
	Annual weeds				Perennial weeds		
	MV	MK	AI	EC	ST	EK	SJ
BP SC	98.3[a]	98.1[a]	95.9[a]	97.3[a]	99.6[a]	98.7[a]	99.2[a]
TI SC	98.2[a]	98.1[a]	94.1[a]	96.5[a]	100.0[a]	98.1[a]	99.2[a]
BIP SC	97.9[a]	96.8[a]	94.1[a]	96.5[a]	97.5[a]	97.8[a]	98.4[a]
HW	98.3[a]	98.7[a]	100.0[a]	98.1[a]	100.0[a]	98.7[a]	99.2[a]

BP : Benzobicyclon+Pyrimisulfan, TI : Tefuryltrione+Ipfencarbazone, BIP : Benzobicyclon+Imazosulfuron+Pyriminobac-methyl and HW : Hand-weeded.
MV : *Monochoria vaginalis,* MK : *Murdannia keisak,* AI : *Aeschynomene indica,* EC : *Echinochloa crus-galli,* ST : *Sagittaria trifolia,* EK : *Eleocharis kuroguwai* and SJ : *Scirpus juncoides*.
Means followed by the same letter in a column are not significantly different by Duncan's multiple range test at P≤0.05.

Table 2. Effect of herbicide mixtures on plant height and tillers of rice at 40 days after application

Treatment	Plant height (cm)		No. of tillers	
	5 L/ha	10 L/ha	5 L/ha	10 L/ha
BP SC	62.3±0.1[1]	61.9±1.0	20.8±0.5	20.5±0.4
TI SC	62.5±0.5	62.1±0.8	21.7±0.4	21.1±0.5
HW	63.1±0.6	-	22.1±0.5	-

BP : Benzobicyclon+Pyrimisulfan, TI : Tefuryltrione+Ipfencarbazone and HW : Hand-weeded.
[1]Standard error.

hand-weeded treatments (Table 3). This result is consistent to a previous study (Park *et al.*, 2013) that reported that the panicle length and number, and culm length of rice were similar to those in the treatment of benzobicyclon mixed with other herbicides, however, significantly higher than those in the untreated weedy control.

CONCLUSION

The study explored that the efficacy of mixture of HPPD-inhibiting herbicides controlled annual and perennial weeds in the paddy fields. This study result indicated that BP SC or TI SC herbicide mixtures effectively controlled annual and perennial weeds. Additionally, the phytotoxic effect of the herbicide mixtures was not obviously observed from the rice height, number of tillers, and culm and panicle length. Also, the yield of rice did not differ between herbicide treatments and hand-weeded treatment. Thus, these mixture herbicides (BP SC, TI SC) can be used to control annual and perennial weeds in paddy fields where rice seedlings are transplanted by machine.

Table 3. Effect of herbicide mixtures on yield and the yield components of rice

Treatment	Culm length (cm)	Panicle length (cm)	No. of panicles (plant/m^2)	Yield (kg/10 a)
BP SC	71.8±0.8[1]	22.5±0.4	18.7±0.4	633.0±4.2
TI SC	72.0±0.8	22.4±0.3	19.8±0.3	638.0±9.2
BIP SC	71.2±1.0	22.1±0.4	18.8±0.4	626.0±3.2
HW	72.3±0.6	22.4±0.3	20.2±0.3	650.0±9.3
UWC	69.1±0.6	21.0±0.3	14.5±0.4	410.0±5.5

BP : Benzobicyclon+Pyrimisulfan, TI : Tefuryltrione+Ipfencarbazone, BIP : Benzobicyclon+Imazosulfuron+Pyriminobac-methyl, HW : Hand-weeded and UWC : Untreated weedy control.
[1]Standard error.

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