Sulfonylurea Resistant Weeds Occurred in Rice Fields in South-western Region of Korea and Their Response to Several Other Herbicides.

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Abstract: A survey to ascertain the relative occurrence of sulfonylurea(SU) resistant weeds was conducted in paddy fields of the south-western region, Korea in 2000. These fields have been used for monoculture of rice(*Oryza sativa* L.) poduction with wet direct-seeded rice and infant seedling culture with machine transplanting, and have been treated with sulfonylurea-included herbicide mixture for several years. The resistant biotypes of *Monochoria vaginalis*(*M. vaginalis*) and *Lindernia attenuata*(*L. attenuata*) to bensulfuron-methyl(BSM) were newly identified in 8 sites and 2 sites of sampling areas, respectively. The survival rates of resistant biotypes of *M. vaginalis* and *L. attenuata* collected from these sites were ranging from 44 to 80% and from 71 to 100% even at 5 times higher rate of the recommended dose of BSM, respectively. However, the susceptible biotypes of two species were completely controlled at the recommended dose. GR_{50} values(concentration of BSM for inhibiting fresh weight of weeds by 50%) of the resistant *M. vaginalis* and *L. attenuata* sampled from south-western region of Korea were 65 to 128 times and 114 to 140 times respectively higher, than those of the susceptible biotypes. Three SU resistant biotypes of *Monochoria korsakowii*, *M. vaginalis* and *L. attenuata* as of 2000 have confirmed in paddy fields in Korea. Butachlor, pyrazolate, pretilachlor and thiobencarb controlled the SU resistant biotypes of *M. korsakowii*, *M. vaginalis* and *L. attenuata* effectively without serious rice injury in the pot experiment under wet-seeded rice and infant seedling culture with machine transplanting culture.

Key words: Sulfonylurea, herbicide resistance, *Monochoria korsakowii*, *Monochoria vaginalis*, *Lindernia attenuata* , bensulfuron-methyl

INTRODUCTION

Sulfonylurea herbicides have been widely used for weed control in rice fields since their introduction in 1989, Korea. These herbicides inhibit acetolactate synthase(ALS), the first enzyme in the biosynthesis of the branched chain amino acids, valine, leucine,

and isoleucine(Saari et al. 1994). Because these herbicides have a broad control spectrum against sedges and broadleaved weeds occurred in rice fields, they are major components of many commercial herbicides particularly, mixtures used for rice production in Korea. However, the extensive and persistent use of these herbicides with relatively long residual activity and high selection for last ten years in Korea has evolved of resistant weeds to SU mixtures. However, no effective management strategites have been developed to deal with these herbicide resistances. Specially, rice is a very important cash crop in south-western Korea, and rice yield is very high. However, because rice establishment in this area is a wet direct-seeding, there is no option for crop rotation. Thus, the weed pressure is high in most areas, mainly due to grasses and aquatic weeds like *Monochoria korsakowii* and *M. vaginalis*. These weeds resistant to SU herbicides are the major weeds infesting rice fields since farmers rely strongly on the SU herbicides in order to control weeds(Kim et al. 2000).

Ten weeds species and one subspecies evolved resistance to SU herbicides in rice fields in Japan (Itoh and Wang 1999). In Korea, two species in a genus *Monochoria* developed resistant biotypes to these herbicides(Park et al. 1998). Many other putative weeds resistant to SU herbicides are under evalution at present.

In this paper, we report several paddy weeds species resistant to SU herbicides confirmed in rice fields of the south-western Korea where SU-included herbicide mixture repeatedly for several years, and their responses to several other herbicides having different mode of action.

MATERIALS AND METHODS

Survey procedure : This survey greatly conducted with cooperation of agrochemical sellers who are working in the south-western Korea. A field survey was conducted in the rice growing season from late Sept. to early Oct., 2000 in the south-western Korea where farmers claimed poor effect of SU-included herbicides to certain weed species. Seeds were collected from 15 patches of each field where high density of weeds were presented. Distances between sampled patches ranged from 5 to 20 m, depending on the weed distribution at individual sites.

Identification of species : Seeds of the dominant weeds not controlled by SU-included herbicides were collected from rice fields, and they germinated in submerged condition in plastic pots($20 \times 20 \times 15$ cm) in growth chamber(Conviron's E-15), and treated with the recommended doses of BSM. At the flowering time, we evaluated response of weed species to the herbicides and collected seeds.

Resistance testing : Among the sampling fields, seeds of putative SU resistant biotypes of *M. vaginalis* and *L. attenuata* survived at the recommended dose of BSM were collected. Susceptible plants of *M. vaginalis* and *L. attenuata* were obtained from Chungdo, Gyeongbuk province and Chihung, Kyonggi province where SU-included herbicides have never been treated, respectively. The germinated seeds were sown in plastic pot filled with paddy soil(clay loam) with three replications under glasshouse maintaining temperature at 30±5? . BSM of granular type was treated to each biotype of two species with doses of wide range at 7 days after seeding. At 30 days after herbicide treatment, survial rates, fresh weight and GR_{50} were determined.

RESULTS AND DISCUSSION

The suspected resistant biotypes of *M. vaginalis* plants sampled from different sites in south-western region of Korea were truly resistant to sulfonylurea herbicide, the resistant and susceptible biotypes at 7 days after planting were separately treated with different doses of BSM. The resistant biotypes of *M. vaginalis* collected from different

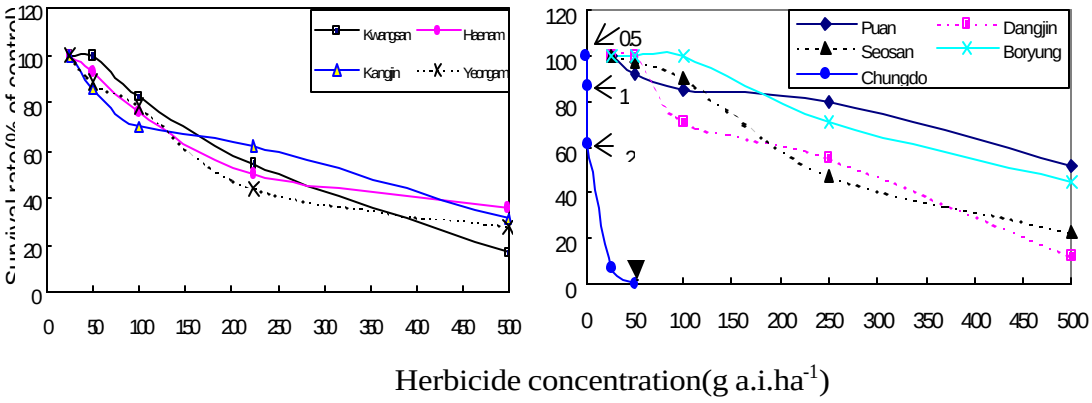

Fig. 1. Effect of bensulfuron-methyl on survival rates of *M. vaginalis* collected from different sites. Note: ↑ shows herbicide dose, ▼shows standard concentration

several sites showed various survival rates 44 to 80% even at 5 times higher the recommended dose of bensulfuron-methyl under greenhouse condition. However, the susceptible biotypes obtained from Chungdo, Gyeongbuk province were completely controlled at recommended dose(Fig. 1).

Fig. 2 shows the effects of BSM on the resistant and susceptible biotypes of *L.*

attenuata sampled from different sites. The putative resistant biotype of *L. attenuata* collected from Kwangsan and Gurye in southern part of Korea demonstrated the high level of resistance BSM, showing approximately 70 and 100% survival of the resistant biotypes even at 5 times higher rate than the recommended dose of BSM at 7 days under greenhouse condition, respectively. However, the susceptible biotypes collected from Chihung city in Kyonggi province were completely killed at half of the recommended dose of BSM.

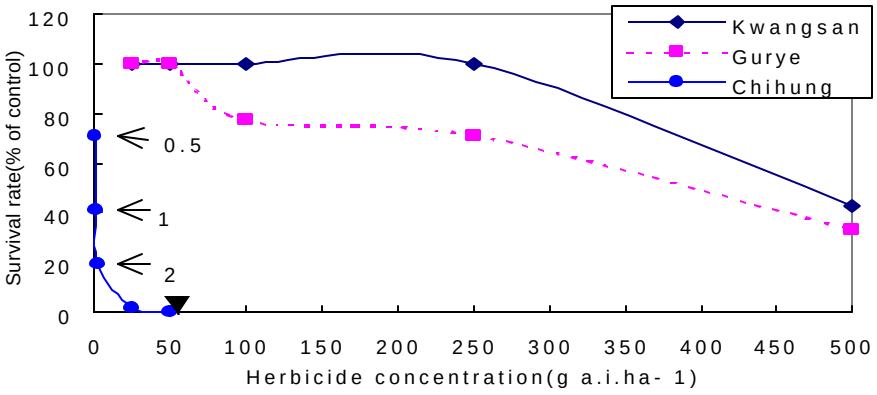

Fig. 2. Effect of bensulfuron-methyl on survival rates of *Lindernia attenuata* collected from different sites. Note: ↑ shows herbicide dose, ▼ shows standard concentration.

SU herbicide resistance was also demonstrated by GR_{50} values, the doses of BSM required to reduce fresh weight accumulation by 50%(GR_{50}) were significantly higher for each of the resistant biotypes compared to the susceptible ones. The GR_{50} values for resistant biotypes of *M. vaginalis* collected from 8 sites of south-western part of Korea varied from approximately 130 to 256 g a.i.ha^{-1} of BSM, but it needs 2 g for the susceptible biotype. Thus, the GR_{50} values of BSM resistant biotypes increased about 65 to 128 times compared with those of the susceptible biotype(Fig. 3).

Fig. 4 shows the effect of BSM on fresh weight of *L. attenuata* collected from different sites. The resistant biotypes of *L. attenuata* exhibited a high level of BSM resistance, GR_{50} values of the resistant biotypes sampled from Gurye and Kwangsan areas increased approximately 114 and 140 times compared with those of susceptible

biotypes based on fresh weight.

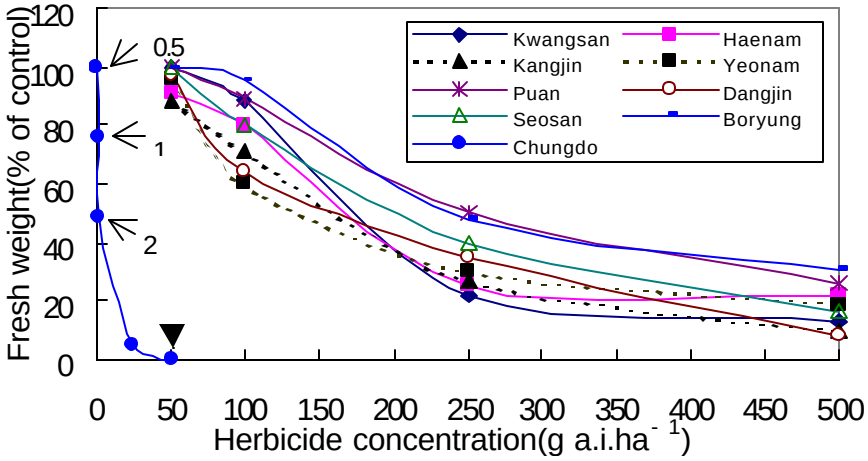

Fig. 3. Effect of BSM on fresh weight of *M. vaginalis* collected from different sites in south-western region of Korea. Note: ↑ shows herbicide dose, ▼ shows standard concentration.

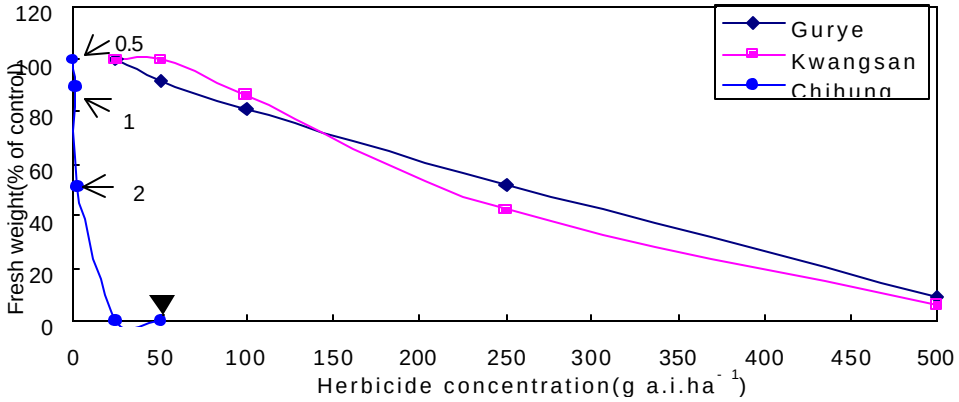

Fig. 4. Effect of BSM on fresh weight of *Lindernia. attenuata* collected from different sites in south-western region of Korea. Note: ↑ shows herbicide dose, ▼ shows standard concentration.

Therefore, it can be concluded the SU resistant biotypes of *M. korsakowii*, *M.vaginalis* and *L attenuata* as of 2000 observed in paddy fields in Korea(Table 1). A bioype of *M. korsakowii* resistant to SU herbicides was first confirmed in about 10,000 ha of the reclaimed paddy fields that had received SU-included herbicide mixtures for 9 consecutive years in 1998(Park et al 1998). The resistant *M. vaginalis* to SU herbicides has appeared in 9 sites of south-western region where herbicide rotation has never been

practised for many years. Also, the SU-resistant *L. attenuata* was founded in Gurye and Kwangsan where SU-included herbicide mixtures had been continuously treated for 4-6 years.

Table 1. The present sistuation of sulfonylurea herbicides resistant paddy weeds confirmed in south-western region of Korea

Species	Occurrence Site	Confirmed Area(ha)	Finding year	Continuous use of SU (years)
M. korsakowii	Seosan	10,000	1998	9
M. vaginalis	Naju	1.0	1999	9
	Kwangsan	2.5	2000	10
	Haenam	3.6	2000	6~8
	Kangjin	1.7	2000	7~8
	Yeongam	1.5	2000	9~10
	Puan	3.7	2000	7~9
	Dangjin	2.5	2000	7~8
	Seosan	3.2	2000	9
	Boryung	8.0	2000	7~8
L. attenuata	Gurye	1.0	1999	4
	Kwangsan	8.5	2000	4~6

Table 2. The activity of nonsulfonylurea herbicides on the resistant paddy weeds and rice under wet-seeded rice and infant seedling culture with machine.

Herbicid	Doses (kg a.i.ha^{-1})	*M. k* [1)]	*M. v* [2)]	*L. a* [3)]	Rice cultivation WSR [4)]	Rice cultivation ISMT [5)]
		—Efficacy—			—Rice injury(0-9)—	
Butachlor G	1.50	O	O	●	3	2
Benfuresate G	0.45	X	X	O	3	2
Esprocure G	0.90	X	X	O	3	2
Molinate G	1.50	X	X	X	2	1
Mefenacef G	1.10	●	X	X	3	1
Pyrazolate G	1.80	●	●	●	1	0
Pretilachlor G	0.45	●	X	●	4	2
Demepiperate G	2.10	X	X	O	3	1
Dehiopyr G	0.09	●	●	●	5	2
Simetryn	0.75	●	●	●	9	9
Thiobencarb G	2.1	O	O	O	2	1

[1)] *M. k* ; *Monochoria korsakowii*, [2)] *M. v* ; *Monochoria vaginalis*, [3)] *L. a* ; *Lindernia attenuata*
[4)] WSR ; Wet-seeded rice, [5)] ISMT ; Infant seedling mechanical transplanting

Note ; ● very effective, O effective, × noneffective

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