벼와 피에서 Dithiopyr의 吸收 및 移行과 選擇性 機作*

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Absorption and Translocation of Dithiopyr and its Mechanism of Selectivity in Rice and Barnyardgrass*

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ABSTRACT

Nutrient culture study was initiated to examine the selectivity of dithiopyr (S, S-dimethyl 2-difluoromethyl)-4-(2-methylpropyl)-6-(trifluoro methyl)-3, 5-pyridine dicarbothiate) in rice (*Oryza sativa* L.) and barnyardgrass (*Echinochloa crusgalli* Beauv.). Absorption and translocation of ^{14}C-dithiopyr in rice and barnyardgrass were also investigated to determine their selective mechanism.

Rice was very tolerant, but barnyardgrass was susceptible to dithiopyr. The absorption of dithiopyr was greater in barnyardgrass than in rice and most of them remained in the roots of both species. Dithiopyr was absorbed by roots and basal shoots of both species. Translocation of dithiopyr was very low but was higher in barnyardgrass than in rice.

Therefore, this study suggest that the selectivity of dithiopyr between rice and barnyardgrass may be mainly attributed to the absorption and translocation of dithiopyr in plants.

Key words : Dithiopyr, selectivity, absorption, translocation, rice, barnyardgrass

INTRODUCTION

Many annual weeds such as barnyardgrass, *Monochoria vaginalis* Presl. *Cyperus difformis* L. are serious weeds in transplanted rice fields in Korea.

Dithiopyr developed by Monsanto company is active to most annual weeds, especially barnyardgrass and *Monochoria vaginalis* with very low dosage. Control of barnyardgrass was obtained at 0.06kg ai/ha with preemergence application and dithiopyr showed long persistence with longevity of 70 days[3,7]. This herbicide was safe on transplanted rice and acceptable rice safety was obtained at recommended rate. Ryang et al.[7] reported that transplanted rice was safe to dithiopyr at rate of 0.48kg/ha. Rice treated had good safety at shallow transplanting if the basal stem of rice was in the soil[3].

Dithiopyr showed insufficient control efficacy to paddy perennial weeds and hence mixture

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treatments with sulfonylurea herbicides were developed. The mixture application of dithiopyr with bensulfuron-methyl or pyrazosulfuron-ethyl showed good control of major annual and perennial weeds[2].

Mode of mechanism of dithiopyr has not been understood yet, but Molin et al.[5] reported that dithiopyr arrested cell division in prometaphase and reduced spindle microtubules in dividing cells and thus altered regulation of tubulin polymerization. Lehnen and Vaughan[4] proposed that dithiopyr destabilizes microtubules as they are formed so that only short microtubules result. Armbruster et al[1] also suggested that mode of action of dithiopyr may be to alter microtubule polymerization and stability by interacting with microtubule associated protein and/or microtubule organizing centers rather than interaction directly with tubulin.

The objectives of this study were to examine the differential selectivity of dithiopyr in rice and barnyardgrass and to determine selective mechanism of dithiopyr by the study of absorption and translocation of ^{14}C-dithiopyr in both species.

MATERIALS AND METHODS

Plants : To evaluate the selectivity of dithiopyr between rice and weed, rice clutivar Chuchung(*Oryza sativa* L. cv. Chuchung) and barnyardgrass were used. To compare the growth response of plants to dithiopyr, seedlings of two species were grown in Kasugai nutrient solution until 2 and 4 leaf stage in growth chamber(25/20℃, day/night). Roots of rice and barnyardgrass seedlings were treated to dithiopyr at the rate of 10^{-8}, 5×10^{-8}, 10^{-7}, 5×10^{-7}, 10^{-6} M for 10 days and transferred to Kasugai nutrient solution and grown for 4 days. Dry weight of roots and shoots was measured after plant harvest. Each treatment was replicated 3 times using 3 plants for each replication.

Absorption and translocation : For absorption and translocation study, ^{14}C-dithiopyr supplied by Monsanto company was used, which was pyridine ring-labelled with a specific activity of 72.5μCi/mg. Plants were cultured and treated as previously described. Roots or roots+3cm basal shoots of rice and barnyardgrass seedlings (2 leaf stage) were exposed to 500ml of ^{14}C-dithiopyr at 5×10^{-7}M for 6, 12, 24, and 48 hours. Plants were removed, and roots were throughly washed with distilled water and acetone solution and blotted dry. The plants were sectioned into shoots and roots ; dried at 90℃ oven for 24 hours ; weighed. Plants were combusted by the sample combustion system (Packard Tri-carb 306) and the radioactivity was quantified by the liquid scintillation spectrometer(Packard Tri-carb 2000) with correction for quenching. Translocation rate was calculated by the ratio of radioactivity in the shoots to that in the whole plants. Each treatment was replicated 3 times using 2 plants.

RESULTS AND DISCUSSION

Selectivity of dithiopyr : Rice was inhibited by dithiopyr at 5×10^{-7}M, whereas barnyardgrass at 5×10^{-8}M and thus barnyardgrass showed more susceptible to dithiopyr by germination study(Table 1). By nutrient culture test as shown in Table 2 and 3, dry weight of rice and barnyardgrass was decreased as dithiopyr con-

Table 1. Effect of dithiopyr on dry weight of rice and barnyardgrass 10 days after germination.

Concentration	Dry weight (mg/plant)			
	Rice		Barnyardgrass	
(M)	Shoot	Root	Shoot	Root
Control	92.5a[z]	90.8a	25.5a	12.9a
1×10^{-8}	92.7a	93.1a	25.2a	13.0a
5×10^{-8}	89.2a	91.3a	25.3a	11.8a
1×10^{-7}	88.6ab	91.1a	20.2b	7.0b
5×10^{-7}	79.0b	76.0b	10.3c	2.8c
1×10^{-6}	71.3c	51.5c	9.6c	2.8c

[z] Means within a column followed by the same letter are not significantly different at the 5% level by the Duncan's multiple range test.

Table 2. Dry weight of rice plants and barnyardgrass at 2-leaf stage as affected by dithiopyr treatments under nutrient solution culture.

Concentration (M)	Dry weight (mg/plant)			
	Rice		Barnyardgrass	
	Shoot	Root	Shoot	Root
Control	59.6a[z]	26.2a	65.1a	52.0a
1×10^{-8}	56.0a	18.1b	59.6a	31.9b
5×10^{-8}	44.4b	11.4c	52.9b	7.8c
1×10^{-7}	33.1c	10.3c	45.5c	4.9c
5×10^{-7}	29.6c	8.1d	20.4d	3.5c
1×10^{-6}	27.8c	7.4d	19.6d	3.6c

[z] Means within a column followed by the same letter are not significantly different at the 5% level by the Duncan's multiple range test.

Table 3. Dry weight of rice plants and barnyardgrass at 4-leaf stage as affected by dithiopyr treatments under nutrient solution culture.

Concentration (M)	Dry weight (mg/plant)			
	Rice		Barnyardgrass	
	Shoot	Root	Shoot	Root
Control	102.8a[z]	50.1a	98.4a	115.6a
1×10^{-8}	100.3a	45.6a	96.8a	74.8b
5×10^{-8}	96.2ab	31.9b	88.8b	62.0c
1×10^{-7}	92.5b	28.8b	85.4b	51.9cd
5×10^{-7}	83.0c	27.0b	84.0b	47.1d
1×10^{-6}	80.3c	26.5b	71.1c	45.0d

[z] Means within a column followed by the same letter are not significantly different at the 5% level by the Duncan's multiple range test.

centrations increased. However, this tendency was more remarkable in barnyardgrass than in rice. Dry weight of rice shoots at 4 leaf stage was started to reduce at 10^{-7}M, whereas that of barnyardgrass at 5×10^{-8}M (Table 3). In roots, dry weight of rice was reduced at 5×10^{-8}M or above and barnyabdgrass at 10^{-8}M or above. Root growth of rice and barnyardgrass was more greatly inhibited by dithiopyr treatment compared to shoots of both species. Growth of rice and barnyardgrass was more significantly inhibited at 2 leaf stage than at 4 leaf stage (Table 2). Shoots of 4 leaf rice seedlings were slightly inhibited by dithiopyr, but roots of barnyardgrass were greatly inhibited at lower concentrations of dithiopyr. Therefore, these data indicated that rice was very tolerant to dithiopyr, whereas barnyardgrass was susceptible to dithiopyr.

Absorption and translocation of dithiopyr : As exposure time was extended from 6 hours to 48 hours, the amounts of ^{14}C-dithiopyr absorption was increased in rice and barnyardgrass (Table 4). Rice absorbed higher amount of dithiopyr from 24 hours after treatment but barnyardgrass from 12 hours after treatment. The absorption amounts of ^{14}C-dithiopyr was greater

Table 4. Distribution of ^{14}C activity in rice and barnyardgrass as affected by ^{14}C-dithiopyr treatements by different sites of absorption.

Site of absorption	Application time(hr)	^{14}C-distribution (dpm/mg)			
		Rice		Barnyardgrass	
		Shoot	Root	Shoot	Root
Root	6	14.2 c[z]	781.9 d	18.3 c	995.8b
	12	16.1 c	880.6 c	18.6 c	1020.4 b
	24	30.3 b	1027.2 b	27.3 b	1118.8 ab
	48	58.9 a	1174.4 a	71.2 a	1198.5 a
Root	6	31.1 c	855.2 c	50.9 b	1029.2 c
+	12	34.8 c	876.4 b	50.2 b	1097.7 bc
Shoot	24	46.6 b	1069.9 b	50.8 b	1229.6 ab
(3cm)	48	90.3 a	1314.5 a	116.0 a	1309.4 a

[z] Means within a column followed by the same letter are not significantly different at the 5% level by the Duncan's multiple rang test.

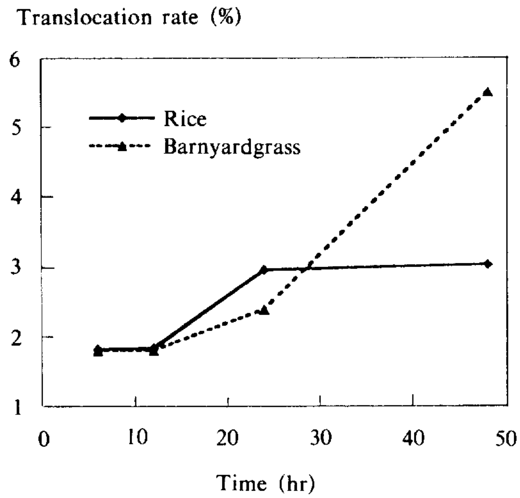

Fig. 1. Translocation rate of ^{14}C derived from ^{14}C-dithiopyr(5×10^{-7} M) from the roots to the shoots in rice and barnyardgrass.

in barnyardgrass than in rice and most of them were remained in the roots of both species (Table 4).

Absorption of dithiopyr was also affected by sites of absorption in plants. Higher amounts of dithiopyr absorption was recognized in the root+3cm basal shoot treatment than in the root treatment alone and this trend was more remarkable in rice(Table 4). Therefore, these results indicated that dithiopyr was absorbed by not only roots but also basal shoots in both species.

Translocation rate of dithiopyr was extremely low in both species . but was slightly higher in barnyardgrass than in rice 2 days after treatment (Fig. 1). Although the difference of translocation between two species was also very low, these results suggested that higher translocation of barnyardgrass could be attributed to susceptibility of barnyardgrass to dithiopyr in part.

Consequently, it may be concluded that difference in selectivity of dithiopyr between rice and barnyardgrass was mainly related to absorption and translocation of dithiopyr in plants.

摘 要

피리딘系 除草劑 Dithiopyr의 벼와 피에 대한 選擇性을 發芽 및 水耕栽培 實驗을 통하여 檢定하였으며 選擇性 機作을 밝히고자 벼와 피에서 ^{14}C-dithiopyr의 吸收 및 移行을 調査하였다.

1. 벼는 피보다 Dithiopyr에 耐性을 보였으나 피는 感受性를 나타냈다. 벼와 피에서 生長沮害는 줄기보다 뿌리에서 더 심한 傾向을 나타냈으며 2葉期에서는 4葉期보다 生長沮害가 더 심하였다.
2. 피는 벼보다 ^{14}C-dithiopyr의 吸收量이 많았으며 뿌리 뿐만 아니라 줄기 基部를 통하여도 吸收되었으며 移行量은 두 草種에서 모두 매우 적었으나 벼보다 피에서 移行速度가 빠른 경향이었다.
3. 따라서 Dithiopyr의 草種간 選擇性은 주로 吸收量과 移行速度의 差異에 基因한다고 생각되었다.

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