Herbicidal Activities and Selectivity of a New Rice Herbicide DPX-F5384

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Introduction

DPX-F5384 is one of the sulfonylurea herbicides discovered and developed by E. I. du Pont de Nemours and Co., Inc. Chlorsulfuron and sulfometuron methyl have been commercialized, while metsulfuron methyl and DPX-F6025 are at the final step of development for registration.

As a selective herbicide for transplanted and direct-seeded rice, DPX-F5384 was selected from among many sulfonylurea compounds as shown the previous paper.⁵⁾ The compound is active at a rate as low as 20~50 g a.i./ha and has excellent activity on most annual and perennial weeds which infest rice paddies.^{4,5)}

In this report, we elucidate some of the salient biological and physical properties of DPX-F5384, such as herbicidal activity, safety for rice plant, selectivity and mobility in paddy soil.

Materials and Methods

Chemistry of the compound and physical and chemical properties are shown in Table 1.

Herbicidal Activity and Crop Safety

1) Wagner pot test

Pre-emergence herbicidal activities and crop safety under paddy conditions were deter-

mined through greenhouse pot tests.

The test was conducted using 200cm² Wagner pots filled with paddy soil (alluvium clay loam, O. M. =5.9%). After adding fertilizer (N. P. K, 15-15-15, 1.5g/pot), the weed seeds and tubers listed in Table 2 were planted in the top soil and water was intr-

Table 1. Physicochemical properties of DPX-F5384

○Chemical structure:

- Molecular weight: 410.40
- Physical state: White to pale yellow, solid
- Melting point: 185 - 188°C
- Vapor pressure: 1.3×10^{-5} mm Hg at 20°C
- Solubility in organic solvent (20°C):

Methylene chloride	11,720 ppm
Acetonitrile	5,380
Ethyl acetate	1,660
Acetone	1,380

○Solubility in buffered water (25°C):

	ppm	final pH*
pH5 (0.05M Sodium Phosphate Buffer)	2.9	4.8
pH6 (0.05M Sodium Phosphate Buffer)	12.0	5.8
pH7 (0.05M Sodium Phosphate Buffer)	120.0	6.9
pH8 (0.05M Sodium Phosphate Buffer)	1200.0	7.8

*Final pH measured after solvent was saturated with DPX-F5384

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duced to a depth of 1cm above the soil. Rice seedlings (cv. "Nihonbare") at the 2.2 leafstage were transplanted at the rate of 4 seedlings (2 stands)/pot and water to a depth of 3cm was added.

After transplanting of rice seedlings, the chemicals (granule formulation) were applied as pre-emergence treatments to the weeds. Every treatment including an untreated check, was replicated three times. After that, the pots were kept in the greenhouse for 30 days, and then weed control and crop injury were visually judged by a zero to 10 rating system: zero=no effect, ≥ 3 =unacceptable, and 10=complete kill. The above-the-soil part of the rice plants was then cut off and put in an electric dryer maintained at 70°C for 48 hours to measure the dry weight.

2) Concrete pot test

Using concrete pots 50×50cm in size, the test was conducted in a similar manner as the wagner pot test under outdoor conditions replicated two times. Seeds of weeds listed in Table 3 were incorporated into the paddy soil. After introducing the water, rice seedlings of the 2.2 leafstage (cv. "Nihonbare") were transplanted at the rate of 2 plants/stand, with 8 stands/pot. After watering to a 3cm depth, the chemicals (granules) were applied to the water. Starting 24 hours after application, water was leaked at the rate of 2cm/day for 2 days. Water was maintained at a depth of 3cm through the test periods. Herbicidal activity and crop safety were evaluated 30 days after application.

3) Field test

The test in the paddy field (diluvium clay loam, O. M. =15.7 %) was carried out in Ushiku, Ibaraki Prefecture as follows: Plots for weed control and crop safety evaluation were 1m² and 2m², respectively, and were replicated two times. Rice seedlings of the 2.5 leafstage were transplanted by hand on May 14, 1981 and the chemicals (granules) were applied 5 days and 12 days after trans-

planting. Herbicidal activity and crop safety were rated visually 30 days after application. Number of stems, plant height and dry weight of the above-the-soil part were then measured.

Sensitivity Difference between Gramineous and Broadleaf Plants

Upland soil (diluvium clay loam, O. M. = 6.9%) was evenly laid 2cm thick into shallow containers. Water solutions of DPX-F5384 at the various rates shown in Table 5 were uniformly sprayed on the soil surface, and the soil was sufficiently mixed. Each treated soil was transferred into a plastic container. Seeds of rice (*Oryza sativa*, cv. Nihonbare), wheat (*Triticum aestivum*, cv. Norin-61), Chinese cabbage (*Brassica pekinensis*, cv. Santosai) and spinach (*Spinacia aleracea*, cv. Symphony) were sown on the soil surface. Also, rice as well as other upland crops was grown under upland conditions. Rating was made 14 days after sowing.

Mobility in paddy soil

The test was conducted using plastic cylinders each consisting of ten connected rings, each ring 10cm in diameter and 1 cm in depth. The middle 5 rings and bottom 2 rings were filled with sieved paddy soil (alluvium loam) and sand, respectively. These cylinders were put in water containers, then water was added until the level reached the surface of the soil at the top of the cylinders. After puddling, water was introduced to a depth of 3 cm above the soil. DPX-F5384 granules at the rate of 75 and 150 g a. i./ha were applied to the water at the top of the cylinders. After 24 hours, water was drawn down at the rate of 1 cm/4 hours until fully drained. Soil held in each ring was transferred into a plastic containers. Water was added to simulate paddy conditions. Then 15 seeds of *Echinochloa oryzicola* and *Scirpus juncoides* were sown on the soil. Fresh shoots of both weeds were weighed 14 days after the seeding.

Table 2. Herbicidal activity and crop injury of DPX-F5384 (Greenhouse Pot Test)

Chemicals	Rate g a. i./ha	Timing DAT	Crop Injury		Weed Control					
			V. C.	D. W.	Eo	Mv	Bl	Sj	Sp	Cs
DPX-F5384	25	3	0	105	0	10	10	8	9	10
	50		0	102	5	10	10	9.5	9.5	10
	100		2	90	7	10	10	10	10	10

DAT: after transplanting, Timing: Pre-emergence to weeds V. C.: Visual Count (0~10 rating scale),
D. W.: Dry Weight of Shoot (% of untreated check)

Eo: *Echinochloa oryzicola*, Mv: *Monochoria vaginalis*, Bl: Annual Broadleaf weeds,
Sj: *Scirpus juncoides*, Sp: *Sagittaria pygmaea*, Cs: *Cyperus Serotinus*

Table 3. Herbicidal activity and crop injury of DPX-F5384 (Outdoors Pot Test)

Chemicals	Rate g a. i./ha	Herbicidal Activity											
		Pre-emergence						Post-emergence					
		Rice	Eo	Bl	Sj	Sp	Cs	Rice	Eo	Bl	Sj	Sp	Cs
DPX-F5384	50	0	4	10	9.5	9.5	9.5	0	3	10	9	9	9
	100	1	7	10	10	10	10	0	5	10	9.5	9.5	9.5
	200	3	9	10	10	10	10	1	7	10	10	10	10
Butachlor	1,500	2	10	10	9.5	0	8	0	9	9	7	9	6

Abbreviation of weed names is same as shown in Table 2.

Timing: Pre-emergence= 3 DAT

Post-emergence= 12 DAT

Results

Herbicidal Activity and Crop Safety

Wagner Pot Test and Concrete Pot Test

As shown in Tables 2 and 3, herbicidal activity of DPX-F5384 was remarkably high. Annual broadleaf weeds were completely controlled by DPX-F5384 at 25 g a. i./ha. Also, at 50 g a. i./ha good to excellent control of perennial weeds such as *Scirpus juncoides*, *Sagittaria pygmaea*, and *Cyperus serotinus* was obtained. Although weeds germinated and emerged in treated paddy soil, susceptible species ceased growing shortly thereafter. Stunted weeds exhibited mild chlorosis, reddening, and progressive necrosis as secondary symptoms. The herbicidal symptoms and processes of DPX-F5384 were similar to that of chlorsulfuron and metsulfuron.^{1,2)} Most weeds eventually died while certain relatively tolerant species remained green. However, these were also severely suppressed

and kept noncompetitive except for *Echinochloa oryzicola*.

Rice plants were tolerant to DPX-F5384. Slight retardation of growth was caused by DPX-F5384 at 100 g a. i./ha, but plant activities recovered rapidly.

Field Test

Complete control of annual broadleaf weeds and excellent control of perennial weeds were obtained with DPX-F5384 at 50 g a. i./ha. However, even at 200 g a. i./ha control of *Echinochloa oryzicola* was not acceptable. Slight growth retardation on rice was observed at 200 g a. i./ha, but its recovery was rapid (Table 4).

Sensitivity Difference between Gramineous and Broadleaf Plants

Remarkable differences in sensitivity to DPX-F5384 were seen between gramineous plants and broadleaf plants as shown in Table 5. Although phytotoxicity of DPX-F5384 even at 2 g a. i./ha was observed on Chinese

Table 4. Herbicidal activity and crop injury of DPX-F5384

(Field Test)

Chemicals	Rate g a.i./ha	Timing DAT	Weed Control							Crop Injury			
			Eo	Mv	Bl	Ea	Sj	Sp	Cs	V. C.	P. H.*	N. S.*	D. W.*
DPX-F5384	50	5	3	10	10	10	9.5	9.5	9.5	0	102	100	105
	100		6	10	10	10	9.5	10	10	1	101	104	100
	200		9	10	10	10	10	10	10	2	100	102	96
Butachlor	1,500		9.5	7	9.5	10	9	0	5	1	97	98	99

Timing: 0~0.5 leaf stage of weeds, 3 leaf stage of rice

Eo: *Eleocharis acicularis*, Abbreviations same as shown in Table 2.

V. C. : Visual count (0~10 rating scale),

P. H.* : Plant height (% of untreated check)

N. S.* : No. of stems ()

D. W.* : Dry weight ()

○ Weed control and crop safety tests were conducted in separate plots.

Table 5. Sensitivity of various crops to DPX-F5384

Treatment	Dose g a.i./ha	Rice		Wheat		C. Cabbage		Spinach	
		V. C.	F. W.	V. C.	F. W.	V. C.	F. W.	V. C.	F. W.
DPX-F5384	0	0	100*	0	100**	0	100***	0	100****
	0.4	0	102	0	105	1	78	1	105
	2	0	105	0	100	4	57	5	67
	10	0	110	0	105	6	30	6	40
	100	0	107	0	115	8	22	8	20

V. C. : Visual Count (0~10 rating scale)

F. W. : Fresh Weight of Shoot (% of untreated check)

* : 0.07g/plant, ** : 0.23g/plant, *** : 0.23g/plant, **** : 0.1g/plant

Table 6 Mobility in paddy soil

Compound	Dose g a.i./ha	Pant	Fresh Weight (% of check)			
			0~1cm*	1~2cm*	2~3cm*	3~4cm*
DPX-F5384	75	Ec	78	78	100	104
		Sj	15	60	100	100
	150	Ec	48	57	100	109
		Sj	10	48	96	100
Butachlor	1,500	Ec	0	57	78	109
		Sj	0	52	95	110

Ec : *Echinochloa oryzicola*, Sj : *Scirpus juncoides*

* Soil layer in cylinder

cabbage and spinach, there was no phytotoxicity at 100 g a.i./ha on the above-the-soil part of rice and wheat.

Mobility in Paddy Water

Relative mobility of DPX-F5384 in paddy soil was assessed by bioassay method as shown

in Table 6. Severe and moderate growth inhibition on *Scirpus juncoides* was observed in the soil from the top and second ring, respectively. The result suggests DPX-F5384 is relatively immobile in the soil, which is similar to butachlor. Although it was not as

apparent, a similar indication was seen on *Echinochloa oryzicola*.

Discussion

Data presented here indicate that DPX-F5384 at a rate as low as 25 g a.i./ha provides excellent control of annual and perennial broadleaf weeds and sedges. At 50 g a.i./ha (pre- and post-emergence), the compound shows excellent control of *Scirpus juncoides*, *Sagittaria pygmaea* and *Cyperus serotinus*.

Rice plants were reasonably tolerant to DPX-F5384 up to 200 g a.i./ha rate under the tested conditions.

The mobility in paddy soil was minimal and similar to that of butachlor, which leached about 2 cm under the experimented conditions. These results also support the consistent activity of the compound.

As to the environmental safety, Ray has recently discovered that sulfonylurea herbicides inhibit cell division and plant morphogenesis by blocking the first step in the biosynthesis of the essential amino acids, valine and isoleucine in plants.³⁾ Our toxicological studies to date prove the very low toxicity of the compound.*

DPX-F5384 is promising as a new herbicide for paddy rice in terms of high biological activity, crop safety, low toxicity for mammals, wildlife and aquatic organisms.⁵⁾

Summary

DPX-F5384, methyl 2-[[[[(4,6-dimethoxy-2-pyrimidin-2-yl) amino] carbonyl] amino] sulfonyl] methyl benzoate was studied for biological activity, selectivity and mobility in paddy soil. At 25 g a.i./ha, the compound

showed excellent control of annual broadleaf weeds and sedges in pot tests. Perennial weeds such as *Eleocharis acicularis*, *Scirpus juncoides*, *Sagittaria pygmaea*, and *Cyperus serotinus* were controlled at 50 g a.i./ha, however, control of *Echinochloa oryzicola* was not acceptable even at 200 g a.i./ha.

Rice plants were tolerant to DPX-F5384. Slight growth retardation was observed with the treatment at 200 g a.i./ha, but rice plants recovered rapidly.

The results of sensitivity in comparison with broadleaf crops indicated that rice is more highly tolerant to DPX-F5384 than Chinese cabbage or spinach.

Mobility of the compound in paddy soil was relatively limited (2 cm) and similar to that of butachlor.

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新水稻用除草剤 DPX-F5384 の作用特性

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摘 要

DPX-F5384 の除草活性、作物安全性、選択性および水田土壌中での移動性について検討した。除草活性と作物安全性に関しては、温室内外でのポット試験と圃場試験によって検定した。また、イネ科作物と広葉作物との間の感受性の差異については、本剤の所定量を処理した畑土壌で、水田土壌中での薬剤の移動性は、シリンダーを用いた標準試験法により検定した。それらの結果は下記のように要約される。

1. 本剤 25g a.i./ha の出芽前土壌処理と出芽後土壌兼茎葉処理は、水田の1年生広葉雑草およびカヤツリグサ科雑草に対し、ほぼ完全な防除効果を示した (Table 2)。
2. ホタルイ、マツバイ、ウリカワおよびミズガヤツリなどの多年生雑草に対しては、本剤 50gai/ha の出芽前土壌処理および出芽後土壌兼茎葉処理で、すぐれた防除効果が認められた。しかしながら、タイヌビエは本剤に対し感受性が低く、200gai/ha の薬量でも十分な防除効果を示さなかった (Table 2, 3, 4)。
3. 水稻に対する安全性については、本剤 100~200gai/ha の出芽前、後の土壌および土壌兼茎葉処理で、イネに軽度の生育抑制が観察されたが、生育抑制は比較的短期間に回復した (Tables 3, 4)。
4. イネ科作物と広葉作物の本剤に対する感受性には、大きな差異が認められた。イネ科作物 (イネ、ムギ) は本剤に高い耐性を示したが、広葉作物は顕著な感受性を示した (Table 5)。
5. 水田土壌中における本剤の移動性は比較的小さく、ブタクロールとほぼ同程度であった (Table 6)。