Controlled Release of Oxyfluorfen from the Variously Complexed Formulations

I. Model Study of Releasing Rate in Paddy Field

Guh, J.O., Y. I. Kuk, S.U. Chon* and D.K. Kim**

數種 結合劑型으로부터 Oxyfluorfen의 放出制御研究

I. 논 條件에서의 放出速度 模型研究

具滋玉・鞠龍仁・千相旭*・金東均**

ABSTRACT

Field experiment was conducted to develop a model of controlled release of oxyfluorfen by using various split applications. Rice and some weed species was included in this study. The models of split applications were 10-10-0, 10-10-10, 20-20-0, 20-10-10, 20-20-20, 0-40-0, and 0-0-0g/Ha at 3days before transplanting, and 11 days after transplanting, respectively. Rice injury appeared dispeared at 20 g/Ha of oxyfluorfen on low leaf sheath but disappeared at few days. The injury was reduced by split application even at the same rate of application. However, no injury was siginificant at 30 days after transplanting. Barnyardgrass, Monochoria, and arrowhead were most susceptible to oxyfluorfen, but bulruch and most perennial weeds recovered after temporary growth inhibition. Therefore, to develop oxyflourfen for use in rice transplanting of adult rice seedling, split application with reduced rates, and development of expected to be tank-mixed or premixed with other perennial herbicides to abtain droad spectrum of weeds.

INTRODUCTION

Diphenylether herbicides have been long used selectively in rice. Nitrofen was the first one used commercially, and chloronitrofen, chloromethoxynil and bifenox have been being used since that. They have alcoxy or methoxycarvarbonyl group at the ortho position, so that they are safe to rice and have strong activities on broadleaf weeds including some of perennials(2, 10). Also, they require light for activity due to Cl group at the position 2(7). However, the mechanism of the action and physiological activity on plants are not completely solved(4, 11). Recently oxyfluorfen and acifluorfen were developed, which have 10 to 40 times stronger in activity than other diphenylether herbicides existed already(2). Acifluorfen controls jointvetch in rice and soybeans(5, 8). However, oxyfluorfen is used for control of perennials or weed control in orchards while various tests were conducted to use in rice(3). The reason for oxyfluorfen to be used in rice is to reduce the problems of environmental polution, toxicity and cost by use of minimum dose because of high activity, also, synergistic effects were expected form the mixture of other herbicides with diphenylether herbicides. For this reasons the authors reported many articles on physiological mechanisms of rice resistance and on feasibility of breeding (1).

It is recognized to develop the controlled-release formulations of oxyfluorfen to reduce rice injury and enhance herbicidal activity(9). Therefore, the research was conducted to seek for the pattern of controlled release by applying various split treatment of oxy-

* 全南大學校 農科大學 College of Agriculture, Chonnam National University, Kwangju 500-757, Korea.
** 롬엔드하스아시아 Rohm and Haas Asia, Seoul 135-080, Korea.

fluorfen. In other words, according to the preliminary result on oxyfluorfen injury to rice, because the low leaf sheath of rice was bleached right after treatment due to quick release, this study was tried to select the appropriate model with split application of small amount and to evaluate control spectrum of weeds for development of mixed formulations with other herbicides.

MATERIALS AND METHODS

Experiment was conducted at rice fields of Chonnam National Unversity on a clay loamy soil using rice cultivar Samgang which is a high yielding cultivar. Germinated rice seed were grown in seeding trays for 20 days. Rice seedlings were transplanted at 90 hills/3.3cm^2 with 3 seedlings/hill.

The models of split application of oxyfluorfen are in Table 1. Oxyfluorfen (2-chloro-4-trifluoromethyl-phenyl-3-ethoxy-4-nitrophenylether) was applied at 3DBT, 4DAT, and/ or 11DAT sequentially. Experiment was arranged in a randomized complete block design with 3 replications. Each plot was 7m^2 (3.5×2 m). All plots were flooded 3cm deep throughout the experiment. During harrowing, annual weed-seeds (*Echinochloa crus-galli*, *Monochoria vaginalis*, and *Scirpus juncoides*) and propagules of perennial weeds (*Sagittaria pygmaea*, *Eleocharis kuroguwai*, *Potamogeton distinctus*, and *Cyperus serotinus*) were broadcast and planted, respectively. Standard methods were utilized for fertilization and disease insect control.

RESULTS AND DISCUSSION

Table 2 shows crop injury and herbicidal activity at 8 and 14days after transplanting (DAT) for two or three times of split applications.

There was generally no injury at 8DAT, but at 15 DAT there was a slight injury on leaf sheath of rice in which the symptom was brownish. The injury was increased with increased rate of application, but it tended to decreased with split application. In other words, split treatments of 20-20-0, and also those of 20-20-20 injuryed less than those of 0-40-0.

Oxyfluorfen controlled most of annual weeds at 8

Table 1. Split application model of oxyfluorfen used in the experiment.

Chemical	Total rate (g ai/Ha)	Application time, formulation, rate(g ai/Ha)		
		3DBT(EC)	4DAT(GR)	11DAT(GR)
Oxyfluorfen	20	10	10	0
Oxyfluorfen	30	10	10	10
Oxyfluorfen	40	20	20	0
Oxyfluorfen	40	20	10	10
Oxyfluorfen	60	20	20	20
Oxyfluorfen	40	0	40	0
Check	0	0	0	0

Table 2. Visual rating(0-9 at CH=0) of weedy efficacy and crop phytotoxicity at 8 and 15days after rice transplanting.

Split-appl. of oxyflu.	8DAT				15DAT				
	Phyto.	Ech.c.	Sci.j.	Bro.L.	Phyto.	Ech.c.	Sci.j.	Mon.v.	Pot.d
10-10-0	0	8.3	8.3	5.5	0	9.0	8.0	9.0	8.0
10-10-10	0	7.6	7.6	5.0	0	9.0	7.6	9.0	8.5
20-20-0	0	8.7	8.7	6.3	1.0	9.0	9.0	9.0	7.8
20-10-10	0	8.7	8.7	7.3	0.5	9.0	8.2	9.0	7.7
20-20-20	0	8.6	8.6	6.5	1.8	9.0	8.5	9.0	8.3
0-40-0	0	9.0	9.0	9.0	2.0	9.0	9.0	9.0	8.7
0- 0-0	0	0	0	0	0	0	0	0	0

* Ech.c. : *Echinochloa crus-galli*, Sci.j. : *Scirpus juncoides*, Bro.L. : Broad leaf total, Mon.v. : *Monochoria vaginalis*, Pot.d. : *Potamogeton distinctus*, respectively.

DAT and controlled completely barnyardgrass and monochoria by any treatment model at 15DAT when perennial weeds began to emerge. However, control of pondweed and bulrush was decreased when total rate of application is low or when the number of split application was increased. As indicated in the result of Peterson(6), this is because oxyfluorfen released 30 seconds to a few minutes after application in flooded rice(about 20% of the total) is related with herbiidal efficacy and the rest is inactivated by adsorbing to precipitated mud.

At 30 and 50DAT any treatment did not show bleaching effect on rice but some treatments affected plant height abd tiller number of rice (Table 3). All treatments reduced rice plant height at 30DAT, compared to untreated check, and inhibition of plant height increased with increased rate of application and decreased by increased split application with small doses. The number of tillers was similar to the result of plant height. However, rice growth at 50DAT was higher in all treatments than in untreated check due to better control of weeds, but there was no significant difference among treatments. Similar results were reported by Murphy *et al*.(5) with acifluorfen in soybean.

When herbicidal efficacy was visually rated at 30 DAT(Table 4), oxyfluorfen at 40g/Ha applied at 4 DAT gave the best control of weeds among treatments. The herbicidal effect was somewhat lower by three times of split application than by single application od at 60g/Ha. But split application of 20-10-10 and 10-10-10 g/Ha showed better weed control than that of 20-20-0 and 10-10-0 g/Ha, respectively. Especially when oxyfluorfen was applied at 40 g/Ha, split application of 20-20-0 g/Ha, split application of 20-20-0 g/Ha increased control of monochoria, barnyardgrass and arrowhead. Therefore, because annual weeds, except for bulrush, are susceptible to oxyfluorfen but because they emerged for a long period of time, it was thought that split application even at the same rate of application could improve control efficacy than single application. However, the effect was lower than when applied single at 4 DAT. This was probably due to inactivation of oxyfluorfen by promoting soil adsorption when rice was transplanted because the first oxyfluorfen was applied before transplanting. On the other hand, as shown in Table 5, the herbicidal activity at 50DAT was higher by 2 or 3times of split application before and after transplanting than single treatment of 0-40-0 g/Ha

Table 3. Variation in crop growth at 30 and 50 days after rice transplanting.

Split-application of oxyfluorfen	30DAT		50DAT	
	Plant height(cm)	No. tillers	Plant height(cm)	No. tillers
10-10-0	43.1	22.1	72.0	24.7
10-10-10	42.1	23.6	70.6	23.3
20-20-0	41.8	23.0	73.2	24.5
20-10-10	43.6	22.9	73.3	24.5
20-20-20	41.9	21.4	71.7	23.9
0-40-0	40.5	20.5	72.0	22.0
0-0-0	44.1	22.1	70.7	21.2

* Abbreviation : refer to Table 2.

Table 4. Visual ratings(0-9 at CH=0) in weeding efficay at 30 days after rice transplanting.

Split-application of oxyfluorfen	Weed species						
	Ech.c.	Mon.v.	Sci.j.	Sag.p.	Pot.d.	Ele.k.	Cyp.s.
10-10-0	1.3	8.3	1.7	6.0	0.0	2.3	3.0
10-10-10	4.0	8.3	1.3	2.0	0.3	3.7	3.3
20-20-0	6.7	8.7	3.0	5.0	1.3	4.3	5.3
20-10-10	9.0	9.0	2.7	9.0	2.0	2.7	3.7
20-20-20	9.0	9.0	4.7	9.0	4.0	4.7	8.3
0-40-0	9.0	9.0	6.0	9.0	5.0	5.0	8.5
0-0-0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

* Abbreviations : refer to Table 2.

Table 5. Variations in weeding efficacy (control percentage) at 50 days after rice transplanting.

Split-appli. of oxyflu.		Weed species							T.	Efficacy[3]
		Ech.c.	Mon.v.	Sci.j.	Sag.p.	Pot.d.	Ele.k.	Cyp.s.	No.	Wt.
10-10-0	No[1]	43	94	68	74	0	50	88	61[bc]	
	Wt[2]	65	98	54	72	0	59	90		73[b]
10-10-10	No	87	94	86	0	0	27	68	51[c]	
	Wt	92	96	83	0	0	38	74		80[ab]
20-20-0	No	87	100	68	54	0	33	82	70[b]	
	Wt	96	100	91	67	0	59	85		89[E]
20-10-10	No	87	100	71	66	41	60	82	73[a]	
	Wt	90	100	72	65	43	75	90		87[a]
20-20-20	No	100	100	75	86	49	60	88	78[a]	
	Wt	100	100	73	86	48	58	93		89[a]
0-40-0	No	100	100	39	29	50	35	10	53[c]	
	Wt	100	100	50	35	45	30	19		76[b]
0-0-0	No	0	0	0	0	0	0	0	0[b]	
	Wt	0	0	0	0	0	0	0		0[c]

[1] No. of weeds per m^2, [2] Fresh weights (g) of ween per m^2, [3] The same alphabetical letters in a column indicate no significant difference at 95% probability level of DMRT.

because control of perennial weeds was higher by split treatment than by single treatment. The herbicidal activity was also increased with increased rate of application. Therefore oxyfluorfen activates continuously by rereleasing the active ingredient into water rather than is inactivated by simulated soil adsorption.

Oxyfluorfen, which has 10 to 40 times higher activity than nitrofen(2) and has typical models of diphenylether herbicides, can not selectively control germinating annuual weeds but shows high herbicidal activity at low rate of application on annual weed plants. In addition, because rice plants at 20days old were exposed to oxyfluorfen, oxyfluorfen injured rice slightly. However, like other diphenylether herbicides, oxyfluorfen is not extremely safe to rice (2, 10). Simply rice is reletively tolerant to oxyfluorfen, like bulrush. Most perennial weeds are tolerant to oxyfluorfen because oxyfluorfen bleaches by contact at early growth stages of perennial weeds but the perennials regrow actively by release of oxyfluorfen with time. However, control of arrowhead was relatively high.

The results indicated that to develop oxyfluorfen for use in rice oxyfluorfen injury to rice should be reduced. To do that reduced rate of oxyfluorfen is applied or split application is required or controlled -release formulation need to be made. Another way is to transplant adult rice seedlings (3). Therefore, oxyfluorfen should be applied at reduced rates to inhibit crop injury. Also, it was desirable for oxyfluorfen to be tank-mixed with other herbicides to control pernnial weeds too because oxyfluorfen controlled barnyardgrass, Monochoria, and arrowhead only. In the long run, to reduce crop injury by oxyfluorfen, 1). oxyfluorfen is slowly rereleased for a long time by promoting soil adsorption right after application, 2). controlled release formulation is developed to prevent excess release at once, or 3). the system of split appliccation needs to be developed, which application before transplanting is possible.

摘 要

高度의 選擇活性物質로 알려진 oxyfluorfen (2-chloro-4-trifluoromethyl-3-ethoxy-4-nitrophenylether)을 水稻用 除草劑로서 藥骸없이 使用할 수 있도록 開發하기 위하여 放出制御模型을 假定하였으며, 이를 探索하기 위한 여러 方式의 分施模型을 벼와 여러 雜草種에 適用하여 圃場에서 比較檢討하였다. 分施模型은 移秧前 3日, 移秧後 4日과 11日의 3時期로 나누어 oxyfluorfen을 10-10-0, 10-10-10, 20-20-0, 20-10-10, 20-20-20, 0-40-0, 0-0-0 g ai/Ha가 되도록 달리하였다. 試驗을 通하여, 벼의 藥害는 엽초하부의

褐班으로 20g ai/Ha이상 處理된 境遇, 處理後 11日경부터 잠시 나타나났다가 수일만에 사라졌으며 同量이라도 分施함으로써 輕減되었으며 이앙 30일 이후의 벼 생육에는 어떤 처리도 有意的으로 영향하지 않는 傾向이었다. 雜草가운데, 一年生의 피와 물달개비 및 多年生의 올미는 oxyfluorfen에 매우 민감한 반응을 보였으나 일년생의 올챙고랭이와 대부분의 多年生 草種들은 일시적인 生育沮害를 경과한후 즉시 再生하는 耐性反應을 보였다. 따라서 水稻用 oxyfluorfen의 개발을 위하여서는 벼의 藥害輕減을 위하여 可及的 苗令을 크게 하거나 藥量을 줄이는 동시에 移秧前處理를 竝行한 分施體系化, 또는 移秧前에 처리될 수 있는 緩效性 放出制御型의 製型開發이 바람직하며, 殺草 spectrum을 넓히기 위한 多年生 專門藥劑와의 混合再開發 및 混用硏究가 기대된다.

LITERATURE CITED

1. Guh, J.O., and Y.M.Lee, 1987. Studies on the Physiological Mode of Action of Herbicide and Its use on Plant Breeding (Contented 10 Reports on Oxyfluorfen Seletivity and rice Varietal Tolerance). Korean Corperation of Academic Improvement.
2. Guh, J.O., K.U.Kim, and K.H.Lee 1990. Weed Science(Korean) Korean Coll. of Broadcast. Corr.
3. Huy, Z., A.L.Tu, and R.I.Yih. 1989. The Development of Weed Control Technique with Goal 2E in Transplanted Rice. Proc. II. of the 12 th. APWSS Conf. : 511-518
4. Masuda, T., S.Yamato, H.Kouji, and S.Matsunaka. 1989. Action Machanism of Diphenylether Herbicides. -Stimulation of 5-Aminolevulinic Acid Synthesis Induced by Decrease of Heme Content. Proc. I. of the 12th APWSS Conf. : 285-290.
5. Murphy, T.R. and B.J. Gossett. 1984. Control of Cowpea (*Vigna unguiculata*) in Soybean (*Glycine max*) with Acifluorfen. Weed Sci. 32 : 427-431
6. Peterson R.F. 1989. Private Communications on Agricultural Formulation Research. Memorandum No. 89-136/Rhom & Haas.
7. Ryang H.S., J.O. Guh, J.Y. Pyon, and Y.W. Kwon. 1987. New Ed. Weed control (Korean). Hyangmun-Co.
8. Smith, R. 1986. Personal communications.
9. Tsujia, K. 1982. Controlled Release Pesticides Formulations. J. Pesticide Sci.(Japan) 7 : 539-548.
10. Weed Sci. Soc. Am. 1983. Herbicide Handbook of the Weed Science Soc. of Am.
11. Yoshimoto, T., Y. Funakoshi, T. Fujita, Y. Enomoto, and K. Okano. 1989. Effects of 3′ Substituents on Diphenyl Ether Compounds. J. Pestuicide Sci. (Japan). 14 : 465-474