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INCREASING THE EFFICACY AND SAFETY OF BUTACHLOR AND ITS 2,4-D MIXTURE IN DIRECT WET-SEEDED RICE (*ORYZA SATIVA* L.)

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ABSTRACT

On pre-germinated wet seeded rice, the 2-4 days before seeding (DBS) treatments for butachlor (1 kg. a.i./ha.) and 6-8 DBS treatment for the butachlor + 2,4-D combination (0.75 + 0.5 kg. a.i./ha.) provided improved crop safely, better control of grasses, sedges and broadleaves and higher yields compared with the 6-9 days after seeding herbicide treatments. Screen (R) solution, when properly coated on seeds before germination prior to sowing at 1.3 ml./kg. and at higher concentrations effectively served as rice seed safener in field plots treated with the increased concentrations of 2 kg. a.i./ha. butachlor and 1 + 0.67 kg. a.i./ha. butachlor + 2,4-D even when these herbicides were applied at 2 days before seeding.

Introduction

Direct seeding of pre-germinated rice under puddled condition offers several advantages over transplanting. These include dramatic reduction in production costs and manpower requirements and increased frequency of planting. The latter is especially relevant in the "Kabsaka Program" on 235,000 hectares in Iloilo wherein two rice plantings are targeted per wet season to realize increased income for the farmers. This necessitates direct seeding as the practical approach due to the time constraints within the seven months wet period. Also, with the opening up of the Magat River Irrigation Project in Northern Luzon, there will be very limited time to plant the additional 75-80 thousand hectares. To take advantage of the monsoon rains when labor is scarce, the logical choice is direct seeding instead of transplanting rice.

Weed control, however, is more difficult and critical in direct wet-seeded than in transplanted rice (DeDatta and Bernasor, 1971). Under direct seeded conditions, the rice plants are not in rows. Manual weeding is impractical because weeders cannot move through the field without destroying some rice plants (Chang and DeDatta, 1974). Moreover, it is compounded by the difficulty of distinguishing between young grasses and rice seedlings due to similarities in some morphological features.

Currently, butachlor, a selective pre-emergence herbicide that controls most

annual grasses, sedges and some broadleaves has a very good fit in transplanted and direct-seeded pre-germinated rice. It offers the most appropriate alternative to manual weeding.

Occasionally, cases of butachlor phytotoxicity on wet seeded rice have been observed (Ahmed and Moody, 1979; Madrid *et al.*, 1979, Noriel and Mercado, 1981). Adjusting the time of butachlor application (Arceo and Mercado, 1981) and the use of naphthalic anhydride (Mabbayad and Moody, 1982) have been suggested to improve crop safety.

This research was conducted to determine the best time of application of butachlor and its 2,4-D mixture for optimum weed control and yield and the possibility of using Mon 4606 (Screen$^{(R)}$) as a safener to reduce herbicide phytotoxicity in broadcast wet-seeded rice.

Materials and Methods

Experiments were cooperatively carried out during the 1981 dry season at the Maligaya Rice Research and Training Center, Visayas Rice Experiment Station, Bicol Experiment Station, and UPLB Central Experiment Station to determine the best time for butachlor application. Butachlor (Machete$^{(R)}$ EC) was tested at 1 kg. a.i./ha. along with 2 times handweeding and untreated control in 18-20 m^2 plots.

Times of application were 2 and 4 days before seeding (DBS) as well as 6 days after seeding (DAS) for butachlor while handweeding was done at 20 and 40 DAS. Butachlor + 2,4-D mixture (Rogue EC and 6G) at 0.75 + 0.5 kg. a.i./ha. was likewise tested during the 1983 dry season in Nueva Ecija and applied at 6 and 8 DBS and 6 and 9 DAS along with untreated control.

For the safener experiment, higher doses of 2 kg. a.i./ha. butachlor and 1 + 0.67 kg. a.i. butachlor + 2,4-D (Rogue) were applied at 2 DBS. The Screen$^{(R)}$ rates tried were 0, 1.3, 2.6, 5.2 and 10.4 ml./kg. seed. Seeds were thoroughly coated by mixing with the indicated amount of the antidote solution in basin after soaking but before germination. The Screen-treated and pre-germinated seeds were sown on farmers' field plots of CLSU, Muñoz, Nueva Ecija and Hacienda Cayco-Fernandez, Victoria, Laguna during the 1983 dry and wet seasons, respectively.

Herbicides were applied on thoroughly prepared and properly levelled plots with 3-5 cm. water depth. Plots were drained completely before sowing pre-germinated seeds at 100 kg./ha. Water depth was controlled normally thereafter but young rice seedlings were never fully submerged. Replicated experimental units were arranged in randomized complete block design. Fertilizers and insecticides were applied as part of normal rice growing practices to give the rice plants optimum nutrients and protection from pests.

Crop injury ratings in terms of stand and growth reduction and weed control by species were visually assessed at 10, 20 and 40 days after sowing. Grain yield from the plots were taken at harvest and adjusted to 14% moisture content.

Results and Discussion

In the 1981 dry season direct seeded (DS) rice trials conducted at the four (4) government rice research stations, the 2 and 4 DBS butachlor applications improved crop stand by 8-9% in the 20 DAS evaluation (Table 1). There was not much difference in growth reduction and at 40 DAS, the herbicide-treated plants were well on their way to recovery. The stand and growth reductions for the DAS and DBS treatments ranged from 4-8%. In terms of weed control, the 2 and 4 DBS treatments also had lesser populations of grasses (*Echinochloa crus-galli* ssp. *hispidula* (Retz.) Honda), broadleaves (*Monochoria vaginalis* (Burm f. Prest) and sedges (*Cyperus difformis* L./*Scirpus supinos*) than the 6 DAS treatments in both the 20 and 40 DAS evaluations. Handweeding twice did not reduce the stand and growth of rice plants, gave the best weed control ratings (90-96%) and the highest mean yield of 4.46 MT/Ha. This was followed in descending order by the yield from 2 DBS treatment (4.24 MT/Ha.), 4 DBS (3.87 MT/Ha.), 6 DAS (2.95 MT/Ha.) and the least from the untreated plots (2.37 MT/Ha.). Apparently, the 2-4 DBS butachlor application offers tangible benefits in terms of crop safety, weed control and eventually in yield, compared with the 6 DAS treatment. The observations herein concur with the earlier report that the 2 DBS (Arceo and Mercado, 1981) and 3 DBS (Mabbayad and Moody, 1982) application of butachlor improved the stand and growth of rice plants and provided better weed control compared to 6 DAS treatment. Using the proper rate and timing of butachlor application coupled with good water management will considerably help eliminate grasses like *Echinochloa crus-galli, E. glabrescens* and *E. colona* and sedges like *Cyperus difformis.* If the broadleaves predominate later on, 2,4-D may be applied at 25 DAS to minimize weed competition with rice.

In rice fields where broadleaves present serious problems right from the start of the planting season, it may be preferable to initially use the butachlor + 2,4-D mixture. For good weed control, 16-20 days old ordinary and 9-11 days old "dapog" seedlings may be transplanted and treated with the mixture at 0-4 and 2-4 days after transplanting, respectively, with resulting higher yields. However, some direct wet-seeded rice varieties may not be tolerant to the butachlor + 2,4-D mixture at 0.75 + 0.5 kg. a.i./ha. even when applied at 2-4 DBS resulting in considerable phytotoxicity. To alleviate the problem, 6 and 8 DBS along with 6 and 9 DAS Rogue applications were carried out in Gapan, Nueva Ecija during the 1983 dry season using a sensitive rice variety. In the 20 and 40 DAS evaluations, the stand and growth reductions were only 0-3% for the 6 and 8 DBS treatments but considerable for the 6 DAS (67% SR and 12% GR at 40 DAS) and lesser for the 9 DAS (11-19% SR and 4-12% GR at 40 DAS) treatments (Table 2). The 20 and 40 DAS % grasses, sedges and broadleaf control were better for the 6-8 DBS treatments (98-100%) compared with the 6 DAS treatments (93-100%). The % weed control from 9 DAS butachlor + 2,4-D treatments were also excellent (93-100%) but stand and growth of rice plants were also seriously affected at 20 DAS, consi-

Table 1. Timing of application, mean yield, toxicity rating and % weed control of butachlor (Machete EC) on direct-seeded rice during the 1981 dry season.

Location	*Rep.*	*Treatment*	*Rate kg. a.i./ha.*	*Time Time Application*	*Mean Yield MT/Ha.*	*MEAN CROP INJURY 20 DAS% SR*	*GR*	*40 DAS% SR*	*GR*	*MEAN % WEED CONTROL RATING 20 DAS EC*	*MV*	*CD/SS*	*40 DAS EC*	*MV*	*CD/SS*
BEST	3	Machete EC	1.0	4 DBS	3.87	11	11	5	5	91	88	94	85	83	89
MRRTC	3	Machete EC	1.0	2 DBS	4.24	12	12	8	6	85	89	97	84	83	91
VRES	3														
&		Machete EC	1.0	6 DAS	2.95	20	12	7	4	85	80	87	83	78	80
UPLB	3														
		Handweeded	2 x	20 + 40 days	4.46	0	0	0	0	94	92	96	93	90	93
		Untreated	–	–	2.37	0	0	0	0	0	0	0	0	0	0

*EC = *Echinochloa crus-galli*
MV = *Monochoria vaginalis*
CD/SS = *Cyperus difformis/Scirpus supinos*

Table 2. Timing of application, toxicity rating and % weed control of butachlor and 2,4-D mixture (Rogue) on direct-seeded rice during the 1983 dry season in Nueva Ecija

Rep.	Treatment (Form)	Rate (kg. a.i./ha.)	Time	Mean Yield MT/Ha.	Mean Phytotoxicity Rating 20 DAS % SR	GR	40 DAS % SR	GR	Mean % Weed Control Rating* 20 DAS EC	MV	CD	40 DAS EC	MV	CD
6	Rogue EC	.75 + .5	6 DBS	4.41	0	0	0	0	100	100	100	99	98	99
	Rogue EC	.75 + .5	8 DBS	4.51	3	1	1	0	100	100	100	100	100	100
	Rogue EC	.75 + .5	6 DAS	1.06	92	91	67	12	93	96	97	93	100	95
	Rogue EC	.75 + .5	9 DAS	3.20	53	51	19	12	100	100	100	98	97	93
	Rogue 6G	.75 + .5	9 DAS	3.15	32	30	11	4	100	99	98	99	98	96
	Untreated	–	–	2.21	0	0	0	0	0	0	0	0	0	0

*EC = *Echinochloa crus-galli*
MV = *Monochoria vaginalis*
CD = *Cyperus difformis*

Table 3. Safening effect of Screen(R) on pre-germinated direct sown rice in field plots treated with high doses of butachlor (Machete) and butachlor + 2, 4-D (Rogue) at 2 days before seeding.

Location & Season	*Rep*	*Treatment*	*Rate (kg. a.i./ha.)*	*Screen Rate ml/kg. seed*	*AVERAGE PHYTOTOXICITY*					
					10 DAS %		*20 DAS %*		*40 DAS %*	
					SR	*GR*	*SR*	*GR*	*SR*	*GR*
CLSU	3	Machete	2	–	22	0	17	2	0	0
(1983 Dry Season)		Machete	2	1.3	1	0	6	0	0	0
&		Machete	2	2.6	1	1	1	0	0	0
HCF	3	Machete	2	5.2	0	0	0	0	0	0
(1983 Wet Season)		Machete	2	10.4	0	0	0	0	0	0
		Rogue	1 + 0.67	–	44	4	41	3	20	0
		Rogue	1 + 0.67	1.3	17	4	15	1	11	0
		Rogue	1 + 0.67	2.6	1	1	1	0	0	0
		Rogue	1 + 0.67	5.2	0	0	0	0	0	0
		Rogue	1 + 0.67	10.4	0	0	0	0	0	0

derably recovering at 40 DAS. Grain yield was highest from 8 DBS Rogue treatment (4.51 MT/Ha.) followed by 6 DBS (4.41 MT/Ha.), 9 DAS (3.20 MT/Ha.), 9 DAS (3.15 MT/Ha.), untreated (2.21 MT/Ha.) and the least from 6 DAS (1.06 MT/Ha.). Therefore, with proper rate and timing, the butachlor + 2,4-D mixture can be safely used on direct wet-seeded rice to realize excellent weed control and high rice yields. However, rice seedlings in treated fields should never be submerged in water.

Due to phytotoxicity problems associated with herbicide treatments on direct wet-seeded rice, the use of antidotes gained increased attention recently. At IRRI, Mabbayad and Moody (1982) found that treatment with naphthalic anhydride (NA) improved rice stand and grain yield even when butachlor was applied at planting time or 3 DAS. Without NA, butachlor application at 3 DAS resulted in the shortest plants. In the United States, Screen has been demonstrated to be an effective safener in sorghum from herbicide injury due to alachlor. Results of studies demonstrated that Screen protects sorghum from alachlor at rates of 0.06% to 0.125% a.i. w/w. Without Screen, there would be complete loss of sorghum stand due to alachlor (Schumacher, pers. commun.). Since butachlor is also an acetanilide herbicide, the efficacy of Screen in reducing its phytotoxicity on puddle sown rice was also tested at 1.3, 2.6, 5.2 and 10.4 ml./kg. seed correspondingly equivalent to 0.06%, 0.125%, 0.25%, and 0.5% a.i. (w/w). However, the concentrations of herbicides used were twice that recommended for butachlor and 33% higher for the butachlor + 2,4-D mixture and they were applied at 2 DBS. As revealed by the 10, 20 and 40 DAS evaluation of herbicide phytotoxicity (Table 3), just like in alachlor used on sorghum, Screen can act as safener for butachlor and its 2,4-D mixture on direct seeded rice under Philippine situations at concentrations 0.06 to 0.125% a.i. (w/w). Pre-germinated seeds sown on butachlor-treated plots have fully recovered at 40 DAS even without Screen. However, for the simultaneous evaluation on butachlor + 2,4-D treated plots, 0.125% of the antidote was needed to nullify phytotoxicity. Screen can therefore be applied on butachlor and butachlor + 2,4-D-sensitive DS rice varieties to minimize the stand and growth reductions resulting from herbicide exposure of seedlings.

Increased weed control efficacy and improved crop safety resulting in higher grain yields in direct puddle-sown rice is possible by 2-4 DBS application of butachlor, 6-8 DBS application of butachlor + 2,4-D mixture and the use of Screen as seed safener. This weed control technology should facilitate 2 cropping seasons with high yielding and short maturing variety like IR-36 and realize 7-10 MT/Ha. grain yield per year as opposed to the 1.5-2 MT/Ha. from single cropping of the traditional variety.

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Keith Moody, Discussant

Wet-seeding (sowing of pregerminated seed on to puddled soil) is increasing in importance as a method of growing rice in the Philippines. Herbicides are often recommended for weed control in wet-seeded rice because of the difficulties encountered with hand weeding when rice seeds are broadcast onto the soil surface. However, selectivity is often marginal because the rice and weeds are at the same stage of development. Consequently, the rice plant and the weeds may show the same degree of susceptibility to the applied herbicide.

There are many ways that herbicide selectivity in wet-seeded rice can be improved. The authors describe two. One of these, which involves no monetary outlay on the part of the farmer, is altering the time of application of the herbicide. By applying butachlor and the proprietary mixture of butachlor + 2,4-D before seeding the authors obtained less crop injury, better weed control, and higher yields compared with the conventional application time of 6 days after seeding.

Herbicide application before seeding did not completely eliminate herbicide phytotoxicity because stand reduction and growth reduction was observed with both herbicides. When water control is poor and the field is flooded at or soon after planting severe stand reduction might occur even though the herbicide is applied before seeding. To minimize stand and growth reductions resulting from exposure of the seedlings to herbicides the authors have used a crop safener, MON 4601.

Without a doubt, MON 4601 does fulfill its purpose but the farmer may be reluctant to use such a compound because of the expense involved and having to soak seeds in the safener adds one more step to the production process. Combining the herbicide with the safener as has been done for other products is an alternative that should be considered.

Another method of reducing herbicide toxicity is to reduce the rate of herbicide applied. This may result in less crop damage and less monetary input without loss of weed control. The farmer may even be willing to accept some loss of weed control if he can be guaranteed a good stand at less cost. Weeds which escape the herbicide treatment can then be removed by hand.

Wet-seeding of rice will continue to increase in importance in the Philippines if the problems of controlling weeds and damage due to herbicides can be solved. The type of research that the authors describe needs to be continued and other approaches for reducing herbicide damage should also be considered. With the concerted effort of everyone concerned, the farmer in the not-too-distant future, will be guaranteed that every time he plants wet-seeded rice and applies a herbicide he will not have to worry about herbicide damage.