

ALTERNATIVE HERBICIDES TO PROPANIL AND MCPA FOR WEED CONTROL IN WET-SEEDED RICE

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ABSTRACT

Emulsifiable concentrates of herbicides Oxyfluorfen (Goal), Oxadiazon / Propanil (Ronstar PL), and Piperophos / 2.4 D (Rilof H) were tested and compared with Propanil and MCPA for their weed control efficacy in wet-seeded rice. Oxyfluorfen applied pre-emergence and Piperophos / 2.4 D and Oxadiazon / Propanil applied post emergence controlled the dominant weeds including grasses and sedges as effectively as Propanil and MCPA. Oxadiazon / Propanil and Piperophos / 2.4 D showed insignificant toxicities in rice and gave comparable rice yields to Propanil and MCPA. Oxyfluorfen was found to be fairly phytotoxic on rice when applied as a spray mixture and the rice yields were significantly reduced. When applied as a sand mixture Oxyfluorfen caused no appreciable crop damage and the rice yields were also equal to Propanil and MCPA. The practical advantage of the herbicides over Propanil and MCPA are briefly discussed.

INTRODUCTION

Adoption of high yielding cultivars and expansion of the cultivated area have resulted in a steady increase in rice production during the past two decades in Sri Lanka. Seventyfive percent of the ricelands are now planted to modern rice cultivars, but average rice yields still remain much below the potential (Ranaweera *et. al.* 1980). Weeds have been recognized as one of the critical factors responsible for low yields with modern cultivars (Velmurugu 1980). Farmers in Sri Lanka have depended on the traditional rice cultivars with their tall, vigorously growing, long-age plants to provide competition for weeds. The replacement of these cultivars with modern, short-statured ones has resulted in a marked increase in the weed population. Amarasinghe (1975 — 76) reported that the labour requirement for weeding increased from 3.8 to 7.1 man days per hectare with the replacement of traditional cultivars by modern cultivars in the Minipe Colanization Scheme.

Weed competition in rice varies with the type of cultivar and the method of crop establishment as well. Siriwardana and Amarasinghe (1982) reported that the absence of weed control causes a greater crop loss in wet-seeded than in transplanted rice. However, the majority of ricelands in the Dry Zone are in wet-seeded rice because of the increased cropping frequency it permits and the higher labour costs involved in transplanting. Most of the dominant weeds in wet-seeded rice closely resemble rice seedlings at early stages of growth and as a result, manual weeding is difficult and time-consuming. In the Dry Zone, where there is a considerable demand for labour and the cultivated fields are fairly large, herbicides could play a major role in reducing the weed competition in wet-seeded rice.

Although several herbicides have been reported as promising in wet-seeded rice (Gunawardana and Siriwardana, 1974; Velmurugu 1980; Gunasena, Daniel and Dayaratna 1982), Propanil and MCPA are the most popular among farmers in the Dry Zone. However, despite their wide-scale usage, weed control has become a serious problem in wet-seeded rice in most parts of the Dry Zone. Propanil is mainly effective on grassy weeds while MCPA controls only sedges and broadleaves. As grasses and sedges are the major weeds in rice fields, the two herbicides have to be adopted as a package for effective control of weeds. However, for economic reasons, most farmers use only one of these herbicides. In addition, to achieve maximum efficacy, Propanil demands stringent field conditions (Jayasekara and Velmurugu, 1966), which are often difficult to meet under farm conditions. As a result, there is a growing demand for alternative herbicides to Propanil and MCPA.

The present paper summarizes the results of four field experiments on chemical weed control in wet-seeded rice in the Dry Zone.

MATERIALS AND METHODS

Four experiments were conducted using the herbicides Oxyfluorfen (Goal), Oxadiazon/Propanil (Ronstar PL) and Piperophos/2.4 D (Rilof H) during Maha 1981/82, Yala 1982 and Maha 1982/83. The first three experiments, each of which included a hand-weeded and an unweeded check, were conducted at the Maha Illuppallama Agricultural Research Station. The fourth experiment was a multilocal trial conducted on farmer fields

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in the Mahaweli H area. In all of the experiments the herbicides were compared with the standard herbicide treatment, Propanil followed by MCPA.

In Experiment 1 (Maha 1981/82), three rates of Oxyfluorfen, 0.12, 0.18, 0.24 kg a.i./ha, three rates of Oxadiazon/Propanil, 0.16/0.06, 0.32/0.12, 0.48/0.18 kg a.i./ha and three rates of Piperophos/2.4 D, 0.25/0.13, 0.33/0.17, 0.41/0.21 kg a.i./ha were applied as tank mixtures. Oxyfluorfen was applied on a drained field 3—4 days after seeding (DAS), while Oxadiazon/Propanil was applied at 8—10 DAS. Piperophos/2.4 D was applied on 1—2 cm of standing water 6—8 DAS.

In Experiment 2 (Yala 1982), Oxyfluorfen and Piperophos/2.4 D were further evaluated. Oxyfluorfen was applied as a sand mixture (EC formulation thoroughly mixed with 60 kg per ha. of clean dry sand) at three rates, 0.6, 0.12 and 0.18 kg a.i./ha, at 3—4 and 6—8 DAS on fields having 1—2 cm of standing water. Two rates of Piperophos/2.4 D, 0.33/0.17 and 0.41/0.21 kg a.i./ha were applied as in Experiment 1.

In Experiment 3 (Maha 1982/83), each herbicide was tested at one rate. Oxyfluorfen was applied two days before seeding (DBS) and 3—4 DAS at 0.12 kg a.i./ha. In pre-seeding application it was applied as both a sand and a tank mixture, on 2—3 cm of standing water on a levelled field which was drained and seeded 2 days later. Post seeding application was done as in Experiment 2. Oxadiazon/Propanil at 0.24/0.21 kg a.i./ha and Piperophos/2.4 D at 0.41/0.21 kg a.i./ha were applied as in Experiment 1.

Based on the results of the first three experiments, the most effective treatment of each herbicide was further tested in farmer fields in the fourth experiment. The treatments were tested at seven locations, three on well-drained soils and four on poorly drained soils.

In all the experiments fields were thoroughly drained before application of Propanil and MCPA. Propanil was applied 8—10 DAS and MCPA at 20—25 DAS employing 2.8 kg a.i./ha and 0.8 kg a.i./ha of the each herbicide respectively.

Land preparation for the first three experiments consisted of one ploughing followed by two harrowings and a levelling operation. Soil bunds were constructed between 3×5 m plots. All treatments were replicated four

times in a randomized block design. The farmers prepared the land for the fourth experiment and their level of land preparation was varied. Usually fields with well drained soils were not as well prepared as poorly drained fields and as a result a certain amount of left over weeds, particularly vegetative propagules of perennials were found in well drained soils. At each location one replicate of each treatment was placed in bunded fields of 6×6 m. Modern rice cultivars, either Bg 34-8 or Bg 276-5 (3 months) were wet-seeded at a rate of 100 kg/ha in all the experiments.

In the first three experiments, weed counts at 4 weeks after rice emergence and weed samples at maximum flowering were taken from two 0.25 m² quadrats placed at random from the sampling area of each plot. Herbicide toxicity was assessed visually during the first 4 weeks after rice plant emergence. Rice plant counts were also taken, similar to weed counts, 2 weeks after rice emergence. Grain yield samples were taken from a 2×3m sampling area and converted to kg/ha at 14% moisture. A similar set of observations, except for rice plant and weed counts, were made from the fourth experiment.

RESULTS AND DISCUSSION

Major weed species occurring in the first three experiments were essentially the same, with grasses and sedges predominating. The dominant grasses were *Echinochloa colona* (L) Link, *E. crusgalli* (L) Beauv and *Leptochloa chinensis* (L) Nees, while commonly found sedges were *Cyperus iria* L, *C. difformis* L, *Fimbristylis miliaceae* (L) Vahl and *F. dichotoma* (L) Vahl. Broadleaf weeds were relatively rare except for *Sphenoclea zelanica* Gaertn and *Monochoria vaginalis* (Burm f) Presl. However, these two weed species were less significant than grasses and sedges.

In Experiment 1, all herbicides gave a significant control of weeds over the unweeded check (Table 1). However, the degree of weed control varied with different herbicides and in all cases increased with increasing application rates. Oxadiazon/Propanil and Oxyfluorfen, except at their lowest application rate, controlled the majority of the weeds as effectively as Propanil and MCPA, and their residual effect lasted over 4-5 weeks. The effect of Piperophos/2.4 D on weeds was relatively slow and the affected weeds showed a gradual kill over a 2-3 week period. The herbicides showed varied toxicities on rice. Oxyfluorfen caused a fairly high

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toxicity, followed by Oxadiazon / Propanil and Piperophos / 2.4 D. Most of the leaves and sometimes the entire shoots of rice seedlings were scorched by Oxyfluorfen, an effect more pronounced with increasing application rates. This resulted in a significant reduction in rice stand (Table 1). Oxadiazon / Propanil and Piperophos / 2.4 D caused no mortality in rice. The former slightly scorched the leaf tips while the latter caused stunting and twisting in scattered patches.

Grain yield was lowest from the unweeded check and highest from the hand-weeded treatment (Table 1). All herbicide treatments gave significantly higher than the control. Oxadiazon / Propanil increased yield with increased rates of application, which could be attributed to more effective weed control at the higher rates. However, despite the increasing level of weed control, Oxyfluorfen and Piperophos / 2.4 D gave comparatively low yields at higher application rates due to increased phytotoxicity.

In Experiment 2, Oxyfluorfen and Piperophos / 2.4 D treatments showed an appreciable degree of weed control over the unweeded check (Table 2). However, the efficacy of Piperophos / 2.4 D was relatively low compared to the standard herbicide treatment. The performance of Oxyfluorfen was similar to that of Piperophos / 2.4 D when applied 6—8 DAS, but performed as well as the standard treatment when applied 3—4 DAS. Although Oxyfluorfen is a contact, non-systemic herbicide with residual effect (Rohm and Hass Company 1978), its poor weed control at 6—8 DAS could be attributed to insufficient area of contact of the herbicide on emerged weeds when applied in a sand mixture. Better control of weeds by Oxyfluorfen at 3—4 DAS appears to be due to the absence of emerged weeds at the time of application. A noteworthy feature observed with Oxyfluorfen is reduced phytotoxicity when applied with sand. It caused only slight to moderate leaf burning and rice plants recovered after several days. Piperophos / 2.4 D did not appear to be phytotoxic. Grain yields from all herbicide treatments were significantly higher than the unweeded control (Table 2).

The results of Experiment 3 confirm the efficacy of the herbicides in controlling weeds in wet-seeded rice (Table 3). As in Experiment 2 Oxyfluorfen was only slightly phytotoxic when applied in a sand mixture. Piperophos / 2.4 D and Oxadiazon / Propanil also showed mild phytotoxicity. The herbicide treated plots gave significantly higher rice yields than the

control (Table 3). Average yields in Experiment 3 were considerably lower than in the previous two experiments due to unexpected heavy rains which occurred during the flowering stage of the crop.

The results of the first three experiments clearly demonstrated that there are several herbicide treatments which could be successfully adopted for weed control in wet-seeded rice. This is evident also from the results of Experiment 4 in which weed flora showed a considerable variability in different locations. Well-drained soils were dominated by grassy weeds, of which *Echinocloa colona* and *E. crusgalli* were the most common, while poorly-drained soils supported both sedges and grasses. The same sedge species were predominant in the first three experiments. Total weed growth also varied between locations. In general well-drained soils supported a heavier weed growth than poorly-drained soils (Table 4). Rice soils in the Mahaweli area receive irrigation in rotational issues and both poorly and well-drained soils receive the same amount of water. Rasiah (1980) reported that there is a wide variability in soil moisture from well-drained to poorly-drained soils when both soils are irrigated at the same frequency. The observed variability in weed growth at different test locations could be attributed to this wide range in soil moisture, since weed growth in rice fields is largely influenced by soil moisture and standing water (Bhan 1983, Ahamad and Moody 1978).

High weed densities at different locations resulted in a significant reduction in grain yield. Grain yield also showed a significant negative correlation with weed dry weight (Figure 1). This indicates that weeds have a direct impact on grain yield. The pattern of weed growth further shows that yield losses are greater in well-drained soils than in poorly-drained soils. As the fourth experiment was unreplicated, it precludes statistical treatment of data. Hence only the trends of treatments are discussed here. The herbicide treatments controlled weeds effectively at all poorly-drained locations, irrespective of their differential weed growth and the results were similar to that of Propanil and MCPA (Table 4). However, their performance appeared to be somewhat inferior on well-drained soils. This discrepancy appeared to be related to the difference in weed flora represented at the two soil types. It was observed that poorly-drained soils were entirely colonized by weed seedlings, while seedlings as well as vegetatively propagated weeds occurred on well-drained soils. The herbicides failed to control vegetatively propagated weeds. Thus the relatively poor performance of herbicides in

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well-drained soils was due to the presence of vegetatively propagated weeds. However, their emergence did not cause much yield reductions (Table 5). Grain yields testify to the effectiveness of Oxyfluorfen, Piperophos/2.4 D and Oxadiazon/Propanil for weed control under farmer conditions (Table 5). The application of these herbicides resulted in an appreciable yield increase over the unweeded control in both poorly-drained and well-drained soils. Their yields were comparable with that of the standard herbicide treatment. This confirms that the new herbicide combinations could be adopted as alternatives to Propanil and MCPA in controlling weeds in wet-seeded rice. Gidnavar (1981) and Govindra Singh and Dheer Singh (1982) also reported that Oxyfluorfen could be successfully adopted to control weeds in rice when applied pre-emergence while Uchida, Koizumi and Green (1975) and Gunasena, Daniel and Dayaratna (1982) also reported that Piperophos/2.4 D effectively controls weeds in wet-seeded rice.

Oxadiazon/Propanil, Oxyfluorfen and Piperophos/2.4 D have the advantage of a 4—5 week residual effect due to their pre-emergence activity. Further Oxyfluorfen and Piperophos/2.4 D do not lose their effectiveness in rainy weather. On the other hand Propanil, a contact herbicide, requires dry weather and rain can nullify the herbicidal effect. Thus the new herbicides are more adoptable than Propanil over a wide range of farmer conditions.

CONCLUSION

Oxyfluorfen, Oxadiazon/Propanil and Piperophos/2.4 D were found to be promising herbicides in wet-seeded rice. Their weed control efficacy appears to be equivalent to that of Propanil and MCPA. In addition, they possess a 4—5 week residual effect and Oxyfluorfen and Piperophos/2.4 D can be applied during rainy conditions. Therefore these herbicides have an advantage over Propanil and MCPA for weed control in wet-seeded rice.

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Table 1. Effect of herbicides on weed control, toxicity and grain yield in wet-seeded rice (81 — 82 maha season)

<i>Treatment</i>	<i>Rate</i> <i>kg ha.i./a</i>	<i>Weed count</i> <i>no/0.5 m^a</i>	<i>Weed weight</i> <i>g/0.5 m^a</i>	<i>Rice count</i> <i>no/0.5 m^a</i>	<i>Toxicity</i>	<i>Grain yield</i> <i>kg/ha</i>
Oxadiazon/Propanil	0.16/0.06	4.3	10.3	49.5	2	4188
- do -	0.32/0.12	2.0	5.0	50.3	2.5	4578
- do -	0.48/0.18	1.0	3.8	51.5	3.0	5000
Oxyfluorfen	0.12	21.7	10.4	45.0	2.0	4066
- do -	0.18	2.5	3.9	38.0	3.0	4255
- do -	0.24	1.3	1.9	43.5	4.0	3847
Piperophos/2.4 D	0.25/0.13	52.3	44.3	51.5	1.0	3211
- do -	0.33/0.17	39.3	36.5	48.3	2.0	4144
- do -	0.41/0.21	31.0	21.8	49.5	2.5	3368
Propanil fb* MCPA	2.8/0.8	2.5	3.6	50.8	1.0	4900
Hand weeding		11	6.3	52.8	—	4911
Unweeded control		202	205	49.8	—	1444
LSD (P=0.05)		8.4	5.7	5.9	—	294
CV (%)		18.7%	13.5%	5.1%	—	6.1%

* followed by

** O-no toxicity, 10 - total kill

Table 2. Effect of herbicides on weed control phytotoxicity and grain yield in wet-seeded rice (82 yala season)

<i>Treatment</i>	<i>Rate</i> <i>kg a.i./ha</i>	<i>Weed count</i> <i>No/0.5 m^a</i>	<i>Weed weight</i> <i>gm/0.5 m^a</i>	<i>Rice count</i> <i>No/0.5 m^a</i>	<i>Toxicity</i>	<i>Grain yield</i> <i>(kg/ha)</i>
Oxyfluorfen	0.6	54.3	15.3	41	0.5	5430
„	0.12 3-4 DAS**	20.0	5.7	46	1.0	5583
„	0.18	8.3	3.5	40	1.5	5489
„	0.06	63	22.5	44	0.0	4811
„	0.12 6-8 DAS**	44.3	20.7	44	0.5	4919
„	0.18	29.3	18.5	42	1.0	5126
Piperophos	0.33/0.17	130.0	32.5	43	0.0	4023
2.4 D	0.41/0.21	82.0	20.5	45	0.5	4899
Propanil	2.8/0.8	13.5	5.4	42	0.5	5386
fb MCPA						
Hand weeding		9.8	6.0	40	—	5962
Unweeded control		193.0	49.5	42	—	3783
L.S.D (P = 0.05)		9.9	3.2	ns	—	368
CV (%)		111.7	12.3	—	—	10.3

Table 3 Effect of herbicides on weed control, toxicity and grain yield in wet seeded rice (82/83 maha season)

<i>Treatment</i>	<i>Rate kg a.i./ha</i>	<i>Weed</i>	<i>Weed</i>	<i>Rice</i>	<i>Toxicity</i>	<i>Grain yield kg/ha</i>
		<i>weight In/0.5 m²</i>	<i>count No/0.5 m²</i>	<i>count No/0.5 m²</i>		
Oxyfluorfen	0.12,2 DBS*	12.8	6.7	45	1.0	3600
- do -	0.12,2 DBS**	16.5	7.5	48	1.0	3891
- do -	0.12,3-4DAS***	15.3	5.0	50	1.5	3691
Piperophos/2.4 D	0.41/0.21	26.0	7.0	45	0.5	4020
Oxadiazon/Propanil	0.24/0.09	5.0	5.8	48	1.5	3649
Propanil fb MCPA	2.8	8.8	5.4	48	0.5	3895
Hand weeding	—	15.3	1.5	50	—	3837
Unweeded control	—	189.3	38.9	46	—	2775
L.S.D. (P=0.05)		5.1	1.5	NS	—	253
CV (%)		9.4	10.3	—	—	9.3

* - applied as a sand mixture 2 days before sowing

** - applied as spray mixture 2 days before sowing

*** - applied as a spray mixture 3—4 days after sowing

Table 4. Effect of herbicides on weed growth in wet-seeded rice in farmer fields—weed dry weight gm/0.5 m²

<i>Treatment</i>	<i>Rate kg ai/ha</i>	<i>Poorly drained soil</i>					<i>Well drained soil</i>			
		<i>Loc.</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Average</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Average</i>
		<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>		<i>I</i>	<i>II</i>	<i>III</i>	
Oxadiazon/Propanil	0.24/0.09	10.07	4.2	5.4	1.9	5.4	62.8	14.0	48.3	41.7
Piperophos/2.4 D	0.41/0.21	4.1	6.0	19.4	7.5	9.3	39.1	58.5	40.2	45.9
Oxyfluorfen	0.12	9.2	2.1	18.6	6.1	8.8	7.1	64.1	10.8	27.3
Propanil fb MCPA	2.0/8.0	1.2	4.2	19.6	9.1	7.5	7.2	32.0	19.3	19.5
Unweeded control		13.5	37.1	75.0	10.6	57.9	107.1	110	109	109.6

Table 5. Effect of herbicides on grain yield in wet seeded rice in farmer fields - kg/ha.

<i>Treatment</i>	<i>Rate kg ai/ha</i>	<i>Poorly drained soil</i>					<i>Well drained soil</i>			
		<i>Loc.</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Average</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Loc.</i>	<i>Average</i>
		<i>I</i>	<i>II</i>	<i>III</i>	<i>IV</i>		<i>I</i>	<i>II</i>	<i>III</i>	
Oxadiazon/Propanil	0.24/0.09	6090	6220	7585	6110	6501	5260	4835	4315	4970
Piperophos/2.4 D	0.41/0.21	5820	6100	4880	6715	5878	5675	6080	6090	5948
Oxyfluorfen	0.12	6840	5450	7425	7090	6701	7625	5950	5535	6250
Propanil fb MCPA	2.8/0.8	6335	6200	7115	6425	8518	5050	4875	4790	4905
Unweeded control		6160	5160	4330	3750	4850	3575	3115	3160	3283

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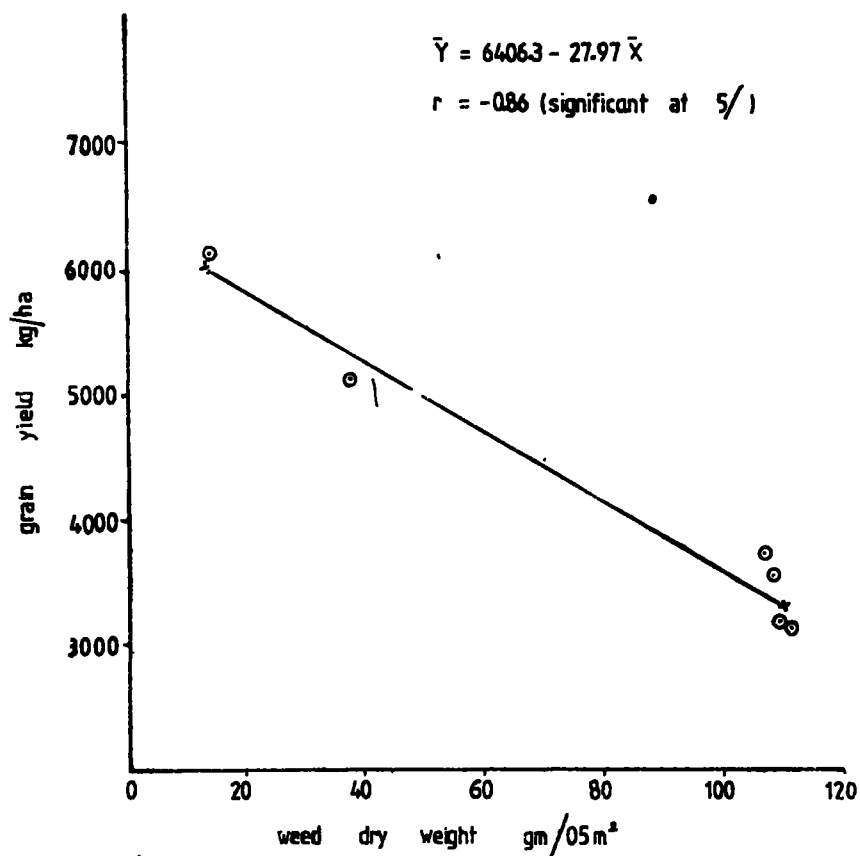


Figure 1. Regression of grain yield on weed dry weight