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# Effect of Herbicides for the Control of *Fimbristylis miliacea* (L.) Vahl. in Rice

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**Abstract:** The experiment was conducted in the glasshouse at Universiti Putra Malaysia to determine the efficacy of herbicides with different modes of action against a *Fimbristylis miliacea* population and increased rice yield potentiality. Nine early post emergence herbicide treatments such as bensulfuron, cinosulfuron, pyrazosulfuron, cinosulfuron+pretilachlor+safener, 2, 4-D (amine), pretilachlor+safener, bentazone, fentrazamide+propanil and bispyribac-sodium were applied singly or in mixtures. A weed-free (hand-weeded) treatment and an unweeded treatment served as controls. The treatments were arranged in a randomized complete block design with four replications. A weed-free (hand-weeded) treatment and an unweeded treatment served as controls. The treatments were arranged in a randomized complete block design with four replications. Data on crop phytotoxicity, weed control, chlorophyll content, plant height, productive tillers, total tillers, panicle length, grains per panicle, 1000 grain weight, % filled grains per panicle, grain yield and straw biomass were recorded to evaluate efficacy of the different treatments. All tested herbicides were effective in controlling *F. miliacea*, but the herbicides bensulfuron and fentrazamide+propanil increased grain yield by more than 80% compared to the unweeded treatment and were comparable to the weed-free treatment.

**Key words:** Efficacy, herbicide, control, *Fimbristylis miliacea*, rice

## INTRODUCTION

Economic growth and rising labour cost has forced the wide spread use of direct seeding of rice in many region of Asia. In direct-seeded rice weeds are a major problem due to simultaneous emergence of rice and weed seedlings (Rao *et al*., 2007). In addition, a similar morphological feature of grassy weeds and young rice seedlings makes hand weeding difficult (Moody, 1982). Hand weeding also requires very high labour inputs (190 person days $ha^{-1}$) and at the same time it is tedious, time consuming and expensive (Roder and Keobulapha, 1997). Mechanical weeding would not be possible unless sowing is done in rows. Moreover, removal of weeds at their critical period by traditional means may not be possible at peak periods of labour demand. Due to labour scarcity and unsuitability of hand weeding in large-scale farming, obviously the use of herbicides is probably the only attractive or feasible alternative for controlling weeds in direct-seeded rice (Singh *et al*., 2006).

*Fimbristylis miliacea* is a dominant sedge weed in rice, especially in South-East Asia. It is widely accepted that rice herbicides performs differently with different weed species and responses vary with different agro-ecological situations due to soil and climate (Okafor, 1986). Generally, herbicides involve treatments against predominant weeds at particular growth stages; pre-emergence to grasses and post emergence to broadleaves and sedges. Several herbicides show some phytotoxic or injury symptoms on the crop. With most rice herbicides, rice may suffer no more than 30% initial injury which disappear within 2 to 4 weeks (Moody, 1977). In a few cases however phytotoxicity could persist up to crop harvest, but their potentiality is assessed by their consistent ability to eliminate weeds without causing excessive crop damage. Thus, herbicide selectivity plays a critical role in rice weed control. On the other hand, repeated use of the same herbicides, results in herbicide resistance in weeds either slowly or rapidly (Fischer *et al*., 2000; Llewellyn *et al*., 2002). Worldwide, 30 weed species associated with rice have evolved resistance to herbicides, including the most widely used compounds such as propanil, 2, 4-D and some of the more recently introduced sulfonylureas (Valverde *et al*., 2000). In Malaysia, *F. miliacea* has been reported to be resistant to 2, 4-D. The resistant *F. miliacea* biotype required 22 times

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the recommended dose of 2, 4-D for a 50% reduction in growth (Watanabe *et al*., 1997). The resistance evolved due to regular use of the same herbicide year after year with continuous rice cropping. Hence, weed control programmes should incorporate herbicides in mixtures or year to year sequence of products with different modes of action (Valverde *et al*., 2000). Herbicides vary in their mode of action, for example 2, 4-D is a growth regulation inhibitor; sulfonylureas such as bensulfuron, cinosulfuron, pyrazosulfuron and bispyribac-sodium are amino acid synthesis inhibitors; pretilachlor and fentrazamide are cell division and cell growth inhibitors; while bentazon is a photosynthesis inhibitor (Retzinger and Mallory-Smith, 1997). Therefore, the present study was undertaken to evaluate efficacy of herbicides with different modes of action against a *F. miliacea* population.

## MATERIALS AND METHODS

The experiment was conducted in the glasshouse of Faculty of Agriculture at Universiti Putra Malaysia during the period from June 2005 to November 2005. Clay pots, 25 cm in diameter filled with 6 kg air-dried soil collected from a Tanjung Karang ricefield. The soil was Bakau series (Typic Hydraquents) with a silty clay (50.18 clay, 47.61 silt and 2.21% sand) and soil pH value of 4.95. All treatments received fertilizer at the rate of 170 kg N ha$^{-1}$, 80 kg $P_2O_5$ ha$^{-1}$ and 150 kg $K_2O$ ha$^{-1}$ which was equivalent to 1.81 g of urea, 0.82 g of Triple Super Phosphate (TSP) and 1.23 g of Muriate of Potash (MOP) per pot, respectively. Urea was applied as three equal splits at 20, 35 and 55 days after sowing, while TSP and MOP were applied as basal treatments. One thousand *F. miliacea* seeds m$^{-2}$ and 10 g rice seeds m$^{-2}$ of variety MR220 were broadcast sown into each pot. Standard agronomic practices were adopted and crop protection measures were carried out when necessary.

Nine early post emergence herbicide treatments were applied singly or in mixtures (Table 1). A weed-free treatment and an unweeded (untreated weedy) treatment served as controls. Herbicide rates tested and soil conditions were based on current recommended rates. The treatments were arranged in a randomized complete block design with 4 replications. The sprayer was calibrated and all herbicides were applied at a spray volume of 300 L ha$^{-1}$. After herbicide application the pots were placed close together with a border row of extra pots around the entire perimeter to minimize border effects.

Data on crop phytotoxicity, weed control, chlorophyll content, plant height, productive tillers, total tillers, panicle length, grains per panicle, 1000 grain weight, % filled grains/panicle and grain yield and straw biomass were recorded to evaluate efficacy of the different treatments. At 7, 14 and 21 days after herbicide application (DAA), visual assessments on crop tolerance (phytotoxicity rating) and herbicide efficacy (weed control rating) were recorded. Weed control and crop phytotoxicity were assessed visually on a scale of 1-5 (Okafor, 1986) as shown below:

| Scale of 1-5 | Weed control | Phytotoxicity to the crop plants |
|---|---|---|
| 1 | Excellent/satisfactory weed control | Very slight injury |
| 2 | Good weed control | Slight injury |
| 3 | Fair/moderate weed control | Phytotoxic |
| 4 | Poor weed control | Severely phytotoxic |
| 5 | Very poor or no weed control | 100% kill of crop plants |

Plant chlorophyll was measured in the flag leaf after panicle initiation using a chlorophyll meter (SPAD-502, Minolta Camera Co, Osaka, Japan) as SPAD values of intact leaves. The chlorophyll meter provides a simple, quick and non-destructive method for estimating leaf chlorophyll content (Peng *et al*., 1993). Yield and yield components of rice were recorded at harvest. The straw, which includes culms and leaves, were dried in an oven for 48 h at 65°C to determine dry matter. Grain yield was

Table 1: Herbicide treatments used to control of *Fimbristylis miliacea*

| Treatments | Rate | Application time | Soil condition at time of herbicide application |
|---|---|---|---|
| Bensulfuron (Londax WP) | 400 g ha$^{-1}$ | 2-10 DAS | Standing water |
| Cinosulfuron (Setoff 20WG) | 50 g ha$^{-1}$ | 6-10 DAS | Standing water |
| Pyrazosulfuron (Basmin 311WP) | 140-220 g a.i. ha$^{-1}$ | 3-14 DAS | Standing water |
| Cinosulfuron (Setoff)+pretilachlor+safener (Sofit) | 37.5 g+1.2 L | 3-7 DAS | Saturated |
| 2, 4-D (amine) | 500-800 g ha$^{-1}$ | 21-28 DAE | Standing water |
| Pretilachlor+safener (Sofit® N 300EC) | 1.5 L ha$^{-1}$ | 0-3 DAS | Saturated or drained condition |
| Bentazone (Basagran M60) | 2 L ha$^{-1}$ | 15-20 DAS | Drained condition |
| Fentrazamide+Propanil (Lecspro 44.25 WP) (Tank mixture) | 1.75 kg ha$^{-1}$ | 4-7 DAS | Saturated |
| Bispyribac-sodium (Nominee 100SC) | 100 mL ha$^{-1}$ | 10-14 DAS | Saturated |
| Weed free (Hand weeding) | | | |
| Unweeded | | | |

DAS: Days after Sowing; DAE: Days after Emergence adjusted to 14% moisture content. Statistical analysis was performed using the SAS statistical software and means were tested using Tukey's studentized range test at the 5% level of probability.

## RESULTS AND DISCUSSION

**Visual observation of weed control efficacy:** This study revealed excellent control of *F. miliacea* by all herbicides at 21 days after application (Table 2). This finding is in agreement with Lo *et al.* (1990), Ooi and Chong (1990), Allard and Zoschke (1990), Fursch (1999) and Yew *et al.*, (2001). Lo *et al.* (1990) reported that the sulfonylureas of ALS inhibitor such as bensulfuron, cinosulfuron, metasulfuron and pyrazosulfuron were highly effective against the broadleaves and sedges (except metasulfuron), at Bumbong Lima, Malaysia whereas at Telok Cengai cinosulfuron and pyrazosulfuron had somewhat poor activity on *F. miliacea*, while bensulfuron was effective. However, Ooi and Chong (1990) observed cinosulfuron (Setoff) at 15 and 20 g a.i. ha$^{-1}$ applied at 4 and 7 DAT controlled 95-98% of *Marselia crenata*, 77-91% of *F. miliacea*, 100% *Sagittaria guyanensis*, 44-60% of *Ludwigia* spp. and 97-98% of *Monochoria vaginalis* in transplanted rice. Another ALS inhibitor herbicide byspyribac-sodium (Nominee) was highly selective to rice and gave good control of a number of damaging weeds, including grasses (*Echinochloa crus-galli*, *E. colonum*), broadleaves (*S. montevidensis*, *Ludwigia* spp. and *Ammannia coccinea*) and sedges (*F. miliacea*) (Noldin, 1997).

Allard and Zoschke (1990) observed that early post-emergence herbicide Sofit (pretilachlor+fenclorim at 3:1) provided excellent control of the most important annual weed species, including *Echinochloa* spp., *Leptochloa chinensis*, *Cyperus* spp., *F. miliacea*, *Scirpus* spp., *M. vaginalis* and *L. adscendens*. Positive effects on rice grain yield (890-2570 kg ha$^{-1}$ above untreated controls) supported its favorable herbicidal efficacy. Combination of pretilachlor and cinosulfuron at 0.35+0.01 kg ha$^{-1}$ at 4 DAS were found to be effective for control of *E. crus-galli*, *L. chinensis*, *Sphenoclea zeylanica*, *C. difformis* and *Fimbristylis miliacea*. This mixture was very effective when the field was flooded at 3 DAA. When flooding was delayed, weed control efficacy was found to decrease and rice yields were affected.

Fentrazamide and a combination of fentrazamide and propanil (6.75+37.5% w.p.) were efficient in controlling grasses and annual sedges in direct-sown rice in South East Asia (Fursch, 1999). Yew *et al.* (2001) reported a broad spectrum of action including main weed grasses, such as *E. crus-galli* and *L. chinensis*, the sedges *F. miliacea* and *C. difformis* and broad-leaved weeds *Ludwigia* sp. and *Monochoria vaginalis.* In the case of 2, 4-D, earlier findings noted presence of *F. miliacea* biotype resistant to 2 4-D (Watanabe *et al.*, 1997), but in this study all *F. miliacea* weeds were killed. The *F. miliacea* biotype in this study was clearly susceptible to 2 4-D amine.

**Visual observations on crop injury:** The phytotoxic effects on the crop were recorded at 21 DAT (Table 2). Crop injury from pyrazosulfuron, pretilachlor, cinosulfuron+pretilachlor, bispyribac-sodium and 2, 4-D amine were characterized by an initial reduction in plant height and a change in leaf colour. In the case of bispyribac-sodium, leaves were not fully expanded to some extent. Early tillering was observed in cinosulfuron+pretilachlor treated plant. The 2, 4-D amine treated plants showed leaf spreading and adventitious roots were observed above the soil surface. Plants treated with all other herbicides had either recovered or exhibited slight phytotoxic effects at that time. However, all affected plants recovered from the phytotoxicity except plant height at harvest of pyrazosulfuron, cinosulfuron+pretilachlor and 2, 4-D amine treated plants. Generally, after herbicide treatment, some phytotoxic

Table 2: Effect of herbicides on weed control, crop toxicity rating at 21 DAA, chlorophyll content at panicle initiation and rice plant height at harvest

| Treatments | Weed control rating[1] | Crop toxicity rating[1] | Chlorophyll content in crop (SPAD) | Plant height (cm) |
|---|---|---|---|---|
| Weed free (Hand weeding) | 1 | 1 | 40.93dc | 103.90ab |
| Fentrazamide+propanil (Lecspro) | 1 | 1 | 40.31d | 102.54abc |
| Bentazone (Basagran m50) | 1 | 1 | 43.22ab | 102.57abc |
| Bensulfuron (Londax) | 1 | 1 | 40.14d | 101.03abc |
| Cinosulfuron (Setoff) | 1 | 1 | 41.66bcd | 106.28a |
| Pyrazosulfuron (Basmi) | 1 | 2 | 42.44abc | 96.57c |
| Cinisulfuron+pretilachlor | 1 | 2 | 44.13a | 98.50bc |
| Pretilachlor+safener (Sofit) | 1 | 2 | 43.21ab | 101.44abc |
| Bispyribac-sodium (Nominee) | 1 | 2 | 43.83a | 101.84abc |
| 2, 4-D (amine) | 1 | 2 | 43.76a | 98.71bc |
| Unweeded | 5 | 1 | 41.46bcd | 99.14bc |

Means within columns with the same alphabets are not significantly different at p = 0.05 (Tukeys Test), [1]Ratings: 1-Weed Control = Excellent, Crop Injury = Nil or very slight, 5-Weed Control = Nil or very poor, Crop Injury = 100% kill of crops symptoms like reduced plant height, chlorosis and stunting occurred, but most of the time plants recover in 2-4 weeks or at harvest. Similarly, Okafor (1986) observed that initial toxicity due to thiobencarb did not give any significant reduction in plant height at harvest. Bentazon and 2 4-D amine applied post emergence caused only a slight burn and yellowing of the leaves. The rice plants, however, recovered from these phytotoxic effects. On the other hand, Allard and Zoschke (1990) reported excellent crop safety with Setoff®, Sofit®, combinations of Setoff® and Sofit. Lo *et al.* (1990) observed that the sulfonylureas viz. bensulfuron, cinosulfuron, metsulfuron and pyrazosulfuron at single or double dosages were also safe based on visual toxicity rating, tiller counts and plant height measurement. Londax in combination with BAS 514 at upto four times the recommended rates did not show any phytotoxicity symptoms at four weeks after application (Chang, 1988). Tolerance of rice to Lecspro (44.25 WP) was very good when applied at the rate of 1.5- 2 kg $ha^{-1}$at 4-7 DAS and this was reflected in very good yields (5718 kg $ha^{-1}$) (Yew *et al.*, 2001). Smith (1988) observed that fenoxaprop alone or in tank mixtures with thiobencarb or bentazon applied at 4 leaf stage of grasses caused moderate (30-69%) plant chlorosis and stunting during the 5 to 10 days after application. However, the crop recovered from the toxic effects after 2 to 4 weeks (<30%). But when applied 5 days before flooding fenoxaprop alone or in tank mixtures with bentazon or triclopyr gave inconsistent control on tillering grasses and rice was injured resulting in lower grain yields. Thus, it is clear that responses in terms of phytotoxic effects were variable, probably due to differences in one or more environmental factors. In the present study slight phytotoxic effects were evident.

Some weed control treatments manifested significant effects on plant height (Table 2). The tallest plants were recorded in cinosulfuron treatment which was similar to weed-free, bentazon, fentrazamide+propanil, bispyribac-sodium, pretilachlor+safener and bensulfuron treatments. The shortest plants were found in the pyrazosulfuron, control (unweeded), 2, 4-D amine and cinosulfuron+pretilachlor treatments (Table 2). In the control (unweeded) treatment the plant height were severely affected by heavy weed infestation, while the herbicides pyrazosulfuron, 2, 4-D amine and cinosulfuron+pretilachlor had adverse effect on plant height probably due to some physiological effect caused by these herbicide. Begum *et al.* (2003) had observed adverse effects of very low doses of Ronstar 25 EC and the higher dose of Golteer 5G on plant height. Even the lowest dose of Ronstar 25 EC reduced plant height similar to the control (unweeded) treatment.

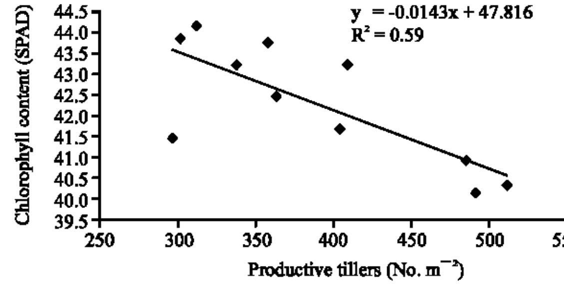


Fig. 1: Relationship between productive tillers and leaf chlorophyll content

Highest chlorophyll content was observed in cinosulfuron+pretilachlor, bispyribac-sodium, 2, 4-D amine, which was similar to bentazon, pretilachlor+safener and pyrazosulfuron treated plants. On the other hand, lowest chlorophyll content was obtained in bensulfuron and fentrazamide+propanil treated plants which were similar to weed-free and unweeded treatments (Table 2). There were indications that with more productive tillers chlorophyll content was lower (Fig. 1). However, treatments with more productive tillers had higher yields which suggest that low chlorophyll content may have been due to gradual recovery from initial herbicide injury at panicle initiation or due to reduced availability of N at this stage which coincided with the 3rd application of N fertilizer. Subsequently, plants in these treatments due high yields. In the case of the unweeded treatment chlorophyll content was also low although productive tiller was lower, probably due to competition and lack of nutrients (Table 2).

**Yield and yield contributing characters of rice:** Treatments had significant influence on production of productive and total tillers $m^{-2}$ (Table 3). Fentrazamide, weed free and bensulfuron produced the highest number of productive and total tillers $m^{-2}$ followed by bentazon, cinosulfuron, pyrazosulfuron and 2, 4-D amine; while lower number of productive tillers $m^{-2}$ was found in the control (unweeded) and herbicide treatments bispyribac-sodium, cinosulfuron+pretilachlor and pretilachlor. Results of this study showed that the unweeded control failed to produce more tillers due to severe *F. miliacea* infestation. The herbicides bispyribac-sodium and cinosulfuron+pretilachlor produced lower number of productive and total tillers compared to other herbicide, but were very effective against the weed. It might be due to phytotoxic physiological effects due to herbicides. Begum *et al.* (2003) found phytotoxic effect with herbicide Ronstar 25 EC @ 1 L $ha^{-1}$ and Golteer 5G @ 12.35 kg $ha^{-1}$. Okafor (1986) had also observed that thiobencarb and

Table 3: Yield and yield contributing characters of rice as affected by weed control treatment

| Treatments | Productive tillers (No. m$^{-2}$) | Total tillers (No. m$^{-2}$) | No. of grains panicle$^{-1}$ | Filled grains panicle$^{-1}$ (%) | 1000-grain weight (g) |
|---|---|---|---|---|---|
| Weed free (Hand weeding) | 484.70a | 500.00a | 111.45ab | 73.11a | 21.26a |
| Fentrazamide+propanil | 510.20a | 525.51a | 102.80ab | 70.14a | 20.91ab |
| Bentazone | 408.16b | 418.37b | 117.60ab | 72.44a | 20.44abc |
| Bensulfuron | 489.80a | 510.20a | 106.90ab | 71.64a | 20.95ab |
| Cinosulfuron | 403.06b | 428.57b | 117.40ab | 74.53a | 20.98ab |
| Pyrazosulfuron | 362.24c | 377.55c | 97.10b | 70.49a | 20.30abc |
| Cinisulfuron+pretilachlor | 311.22de | 331.63de | 104.00ab | 69.40a | 19.50c |
| Pretilachlor+safener | 336.73cd | 341.84d | 112.85ab | 67.77a | 19.59c |
| 2, 4-D amin | 357.14c | 387.76c | 108.40ab | 75.16a | 20.33abc |
| Bispyribac-sodium | 301.02e | 326.53de | 119.73a | 72.89a | 20.12bc |
| Unweeded | 295.92e | 311.02e | 106.65ab | 72.13a | 19.96bc |

Means within columns with the same alphabets are not significantly different at p = 0.05 (Tukeys Test)

Table 4: Production of straw and grain yield due to weed control treatments

| | Straw | | Grain | |
|---|---|---|---|---|
| Herbicide treatments | Biomass (g m$^{-2}$) | Increase (%) | Yield (g m$^{-2}$) | Increase(%) |
| Weed free (Hand weeding) | 905.73a | 73.25 | 808.16a | 96.03 |
| Fentrazamide+propanil | 913.35a | 74.71 | 792.21a | 92.16 |
| Bensulfuron | 907.80a | 73.64 | 755.21ab | 83.18 |
| Cinosulfuron | 721.18b | 37.95 | 684.41bc | 66.01 |
| Bentazon | 670.02c | 28.16 | 650.75cd | 57.85 |
| 2, 4-D amine | 661.58c | 26.55 | 555.66de | 34.78 |
| Pyrazosulfuron | 637.98cd | 22.03 | 543.81e | 31.91 |
| Bispyribac-sodium | 588.31ef | 12.30 | 484.23ef | 17.45 |
| Pretilachlor+safener | 599.92de | 14.75 | 467.34ef | 13.36 |
| Cinisulfuron+pretilachlor | 550.29fg | 5.26 | 464.19ef | 12.59 |
| Unweeded | 522.80g | - | 412.27f | - |

Means within columns with the same alphabets are not significantly different at p = 0.05 (Tukeys Test)

oxidiazon significantly reduced the number of tillers and panicles compared to hand weeding and the untreated control. Observed that the total tiller numbers and productive tillers of IR36 rice were markedly reduced with butachlor and pendimethalin compared to thiobencarb, which may have promoted tillering, although weed control efficacy was similar.

Different treatments exhibited significant variation for number of grains per panicle. The highest number of grains per panicle (119.73) was recorded in the treatment with bispyribac-sodium (Nominee) and the lowest number of grains per panicle was produced with pyrazosulfuron (Table 3). But, other treatments produced intermediate number of grains per panicle. Begum *et al.* (2003) observed significant variation on grains per panicle when plants were treated with different herbicides at different doses. However, treatments had no significant effect on % filled grains. The range of % filled grain was between 67.77 to 73.11%. The low values may be attributed to rice bug attack which occurred during milk/dough stage. The highest 1000-grain weight was recorded in the weed-free treatment which was comparable to fentrazamide+propanil, bensulfuron, cinosulfuron, bentazone, pyrazosulfuron and 2, 4-D amine (Table 3). The lowest 1000-grain weight was found in cinosulfuron+pretilachlor and pretilachlor+safener which were comparable to the unweeded control and bispyribac-sodium.

The highest straw biomass was observed in fentrazamide+propanil, bensulfuron and weed-free treatments followed by cinosulfuron, bentazon, 2, 4-D amine, pyrazosulfuron, pretilachlor+safener and bispyribac-sodium. The lowest straw biomass was recorded in the unweeded treatment which was similar to cinisulfuron+pretilachlor (Table 4). Weed competition significantly reduced straw biomass in the unweeded control (Begum *et al*., 2003). Straw biomass increased by 70% or more with fentrazamide+propanil, bensulfuron and weed-free conditions, while pretilachlor+safener, bispyribac-sodium and cinisulfuron+pretilachlor increased straw biomass by less than 15%.

The maximum grain yield was obtained in weed-free treatment which were comparable to fentrazamide+propanil and bensulfuron (Table 4). The lowest grain yield was obtained in the unweeded control. Herbicide treatments of bispyribac-sodium, pretilachlor+safener and cinisulfuron+pretilachlor produced similar grain yields as the unweeded treatment. Intermediate grain yields were obtained with herbicides cinosulfuron, bentazon, 2, 4-D amine and pyrazosulfuron. Azmi (2002) found that bensulfuron, 2, 4-D amine and manual weeding produced higher yields than other herbicides including pretilachlor treatments. Lo *et al.* (1990) observed the three locational trail in Malaysia and found that all sulfonylurea herbicides produced higher yields at Bumbong Lima, while in Telok Cengai and Besut, bensulfuron and both bensulfuron and 2, 4-D showed better performance. In this experiment the lowest yield from bispyribac-sodium, pretilachlor+safener and cinisulfuron+pretilachlor treatments and unweeded (control) may be consequence of reduced in productive tillers and 1000 grain weight. In the unweeded treatment the low productive tillers and 1000-grain weight were due to competition from *F. miliacea* with rice. While bispyribac-sodium, pretilachlor+safener and cinisulfuron+pretilachlor treatments, weed control was excellent but lower productive tiller and 1000-grain weight were probably due to some physiological injury in rice due to the herbicides. Begum *et al.* (2003) also reported reduced number of total and productive tillers in untreated controls and some herbicidal treatments. However, in this study, grain yield increased with increased number of productive tillers and 1000 grain weight. Grain yields increased by more than 80% in weed-free, fentrazamide+propanil and bensulfuron treated pots compared to the unweeded control. Application of the herbicides bispyribac-sodium, pretilachlor+safener and cinisulfuron+pretilachlor gave less than 20% yield increase compared to unweeded controls (Table 4). Ooi and Chong (1990) found that early post emergence application of Setoff®, Sofit®, or combination of Setoff® and Sofit® respectively increased grain yields by 3-8, 45 and 45-55% compared to the untreated control. However, as a whole Choubey *et al.* (1998) reported that under several weed management practices grain yields were enhanced by 43-65% relative to the unweeded control.

## CONCLUSION

All tested herbicides were effective in controlling *F. miliacea*, but the herbicides pyrazosulfuron, cinosulfuron+pretilachlor and 2, 4-D exerted some phytotoxic effects on rice. Rice yields were the resultant effects of weed competition and health of the crop after herbicide treatment. Yields (grain and straw), plant height, productive tillers $m^{-2}$, total tillers $m^{-2}$, panicle length (cm), No. of grains per panicle, 1000 grain weight and chlorophyll content of MR 220 rice were significantly influenced by the weed control treatments. Among the treatments weed-free (hand weeded), fentrazamide+propanil and bensulfuron treated rice showed significantly better performance with respect to all parameter measured except leaf chlorophyll content. Reduced performance of the rice crop was observed in treatments with cinosulfuron, pretilachlor+safener, bispyribac-sodium and the unweeded control. In general, based on overall rice yields across treatments, bensulfuron and fentrazamide gave yields comparable to the weed-free (hand-weeded) treatment, which were superior to other herbicide treatments. Grain yield increase by these herbicides was more than 80% compared to the unweeded treatment. Herbicides bensulfuron and fentrazamide are recommended for more effective control of *Fimbristylis miliacea*. However, monitoring is essential for future shifts in weed population and the need for rotation or alternate mixtures of the herbicide used.

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## REFERENCES

Allard, J.L. and A. Zoschke, 1990. A solution to the major weed problems in wet-sown rice: experiences with pretilachlor/fenclorim in South-East Asia. Proceedings of Pest Management in Rice Conference, June 4-7, Society of Chemical Industry by Elsevier Applied Science. pp: 378-388.

Azmi, M., 2002. Weed succession as affected by repeated application of the same herbicide in direct-seeded rice. J. Trop. Agric. Food Sci., 30: 151-161.

Begum, M.K., K.M. Hasan, M. Salim, M.A. Hossain and M.K. Rahman, 2003. Effect of herbicides on different crop characters used in controlling weeds of Aman rice grown under wet seeded culture. J. Agron., 2: 44-51.

Chang, S.H., 1988. Bensulfuron-methyl combinations with quinclorac for broad spectrum weed control in rice. The Malaysian National Seminar and Workshop on Rice Field Weed Management, June 7-9, Malaysian Agricultural Research Development Institute and Malaysian Agricultural Chemicals Association, Penang, Malaysia. pp: 123-130.

Choubey, N.K., R.S. Tripathi, B.C. Ghosh and S.S. Kolhe, 1998. Influence of fertilizer and weed management practices on weed growth and yield of direct-seeded upland rice. Oryza, 35: 154-158.

Fischer, A.J., C.M. Ateh, D.E. Bayer and J.E. Hill, 2000. Herbicide-resistant *Echinochloa oryzoides* and *E. phyllopogon* in california *Oryza sativa* fields. Weed Sci., 48: 225-230.

Fursch, H., 1999. Fentrazamide-new opportunities for weed control in seeded rice. Brighton Crop Protection Conference: Weeds. November 15-18, Bayer, A.G., Leverkusen, pp: 99-104.

Llewellyn, R.S., R.K. Lindner, D.J. Pannell and S.B. Powles, 2002. Resistance and the herbicide resource: Perceptions of Western Australian grain growers. Crop Prot., 21: 1067-1075.

Lo, N.P., M. Azmi and A. Xavier, 1990. Sulfonylurea herbicides for transplanted rice. Malaysian Plant Protection Society, Kuala Lumpur, Malaysia.

Moody, K, 1977. Weed control in sequential cropping in rainfed lowland rice growing areas in tropical Asia. Jakarta, Indonesia

Moody, K., 1982. The status of weed control in rice in Asia. FAO Plant Protect. Bull., 30: 119-123.

Noldin, J.A., 1977. Efficacy of the herbicide byspyribac sodium for the control of weeds in irrigated rice. Lavoura-Arrozeira, 50: 431-431.

Okafor, L.I., 1986. Predominant weeds in Nigeria. Trop. Pest Manag., 32: 261-266.

Ooi, G.T. and C. Chong, 1990. Setoff: A sulfonylurea herbicide for weed management in Direct seeded and transplanted rice in Malaysia. Malaysian Plant Protection Society Kuala Lumpur, Malaysia.

Peng, S., F.V. Garcia, R.C. Laza and K.G. Cassman, 1993. Adjustment for specific leaf weight improves chlorophyll meter's estimate of rice leaf nitrogen concentration. Agron. J., 85: 987-990.

Rao, A.N., D.E. Johnson, B. Sivaprasad, J.K. Ladha, A.M. Mortimer, 2007. Weed management in direct-seeded rice. Adv. Agron., 93: 153-255.

Retzinger, E.J. and C. Mallory-Smith, 1997. Classification of herbicides by site of action for weed resistance management strategies. Weed Tech., 11: 384-393.

Roder, W. and B. Keobulapha, 1997. Weeds in slash-and-burn rice fields in northern Laos. Weed Res., 37: 111-119.

Singh, S., L. Bhushan, J.K. Ladha, R.K. Gupta, A.N. Rao and B. Sivaprasad, 2006. Weed management in dry-seeded rice (*Oryza sativa*) cultivated on furrow irrigated raised bed planting system. Crop Prot., 25: 487-495.

Smith, J.R.J., 1988. Weed control in water and dry seeded rice, *Oryza sativa*. Weed Tech., 2: 242-250.

Valverde, B.E., C.R. Riches and J.C. Caseley, 2000. Prevention and management of herbicide resistant weeds in rice: Experiences from Central America with *Echinochloa colona*. Tropical Agricultural Centre for Research and Higher Education (CATIE), Camera de Insumes Agropecuarios. San Jose (Costa Rica).

Watanabe, H., Z. Md. Ismail and N.K. Ho, 1997. Response of 2, 4-D resistant biotype of *Fimbristylis miliacea* (L.) Vahl. to 2, 4-D dimethylamine and its distribution in Muda plain, Peninsular Malaysia. J. Weed Sci. Tech., 42: 240-249.

Yew, K.N., W. Schulze, H.N. Fang and J. Rodmanis, 2001. Lecspro ® 44.25 WP: A new herbicide for direct-sown rice in Malaysia. Pflanzenschutz-Nachrichten Bayer., 54: 113-126.