Advances in Environmental Biology, 6(8): 2423-2427, 2012
ISSN 1995-0756

This is a refereed journal and all articles are professionally screened and reviewed **ORIGINAL ARTICLE**

Allelopathic Inhibition by *Fimbristylis miliacea* on the Growth of the Rice Plants

B.S. Ismail and A.B. Siddique

School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia, 43600 UKM, Bangi, Selangor, Malaysia.

B.S Ismail & A.B Siddique: Allelopathic Inhibition by *Fimbristylis miliacea* on the Growth of the Rice Plants

ABSTRACT

A study on the allelopathic effects of *Fimbristylis miliacea* on four rice varieties namely MR211, MRQ74, MR220 and MR84 was carried out under laboratory and greenhouse conditions. Three concentrations of the aqueous extract of the weed (12.5, 25 and 50 g/ l) and debris (5, 10 and 20 g dry debris / kg soil) were used to test the allelopathic effect of *F, miliacea* on the growth of the four rice varieties. The weed stem extract showed comparatively higher growth inhibitory effects than that from the leaf. The weed extract caused greater reduction on the root length of the rice plant than on the shoot length. Of the 4 rice varieties tested, MRQ74 was found to be the most susceptible to the weed inhibitory effects. At full strength the *F.miliacea* extract caused root and shoot reduction of MRQ74 by 82.01 and 53.61% of the control, respectively. Plant height and seedling fresh weight of all the four varieties were reduced by the debris of *F. miliacea*. At the highest concentration MRQ74 showed a greater reduction in plant height and dry weight (57.1 and 51.3% respectively) compared to the other varieties tested. The weed root exudate caused significant reduction in plant height and dry weight of MRQ74 followed by MR220. The allelopathic effect of the weed root exudate was observed to be lower than the effect of the weed extracts and debris. The inhibitory effects of the extracts and debris of *F. miliacea* on rice growth parameters were found to be concentration dependent.

Key words: Aqueous extract, Debris, *Fimbristylis miliacea*, Inhibitory Malaysian rice

Introduction

Weeds are the cause of serious yield reduction problems in rice cultivation worldwide. Zhang [24] reported that, 10 million tons of rice are lost annually due to weed competition; this quantity of rice is sufficient to feed at least 56 million people for 1 year. Infestation by weeds is the major biotic stress in rice production and accounts for 30 to 40 percent of yield losses [1]. Weed management in rice will be improved if farmers take into consideration the ecology of major weeds and their interaction with the rice crop.

F. miliacea, a sedge is a dominant weed in rice fields, especially in South-East Asia [15]. In Malaysia, it is ranked as the fifth and third most serious weed in the rice growing areas of Muda and Besut respectively [11]. *F. miliacea* is also reported as a dominant weed species in rice fields [2,4] with emergence density of 54 - 3074 plants m^{-2} [22].

Weeds compete with cultivated species for space, light, water, nutrients and other growth requirements and are certainly the major source accounting for the adverse effects on crop growth and yield [18]. Some weeds interfere with crop plants through allelochemicals which inhibit crop growth and development [21,5,3]. Some weeds have been reported to have growth inhibitory effects on the rice plant [13,23,17]. Identification of allelochemicals in weeds will help to enhance the understanding of crop-weed competition and thereby necessitate appropriate measures for weed management [13]. In the context of research findings on other aspects, only limited information is available on the growth inhibitory effects of *F. miliacea* on the rice plants. Like certain other weeds, along with competition for nutrients, *F. miliacea* may exert allelopathic effects on the rice plants. Considering this possibility the present research work was undertaken. The objective of the study was to investigate the allelopathic effects of *F. miliacea* on four Malaysian rice varieties.

Materials and Methods

F. miliacea plants and seeds were collected from the Tanjung Karang rice growing area in Selangor, Malaysia. Weed plants were washed, separated into leaf, stem and root, air dried, ground by a commercial blender and stored until time of use. Rice seed of four varieties namely, MR211, MRQ74, MR220 and MR84 were obtained from the MARDI Research Station at Seberang Perai, Malaysia.

Corresponding Author

Ismail B.S., School of Environmental and Natural Resource Sciences, Faculty of Science and Technology, 43600 UKM Bangi, Selangor, Malaysia
E-mail: ismail@ukm.my

Effect of aqueous extracts of the leaves, stems and roots of the weed species on rice seedlings:

Ten gms each of different ground plant parts of the weed (leaf, stem and root) were placed in separate flasks each containing 200 ml of distilled water and shaken for 48 hours at room temperature (27±3°C) by an orbital shaker (160 rpm). The extracts was strained through 4 layers of cheese cloth and then through two layers of Whatman # 2 filter paper to remove solid material. The filtrate was centrifuged at 4000 rpm for 15 min. The supernatant was collected and filtered through a 0.22 µm membrane filter paper. The extract was made up to 1000 ml, to become the stock solution and stored in a refrigerator at 4°C until further use. Three of concentration levels of the aqueous extracts were used in the experiment, i.e. full strength (50 g/l), half strength (25g/l), and quarter strength (12.5g/l). Dilutions were made with distilled water prior to use. Rice seeds were surface sterilized (15% sodium hypochlorite for 15 min), ten seeds of each variety namely MR220, MRQ74, MR211 and MR84 were placed in separate Petri dishes lined with 9 cm Whatman # 2 filter paper. Five ml of either the weed extract or distilled water (for control) were used to wet each filter paper. Four replicates were done for each concentration. The covered Petri dishes were incubated at 30^0C and checked daily. The dishes were kept moist by addition of the respective extract or distilled water (for the control) when necessary. The root and shoot length of the seedlings were recorded after 7 days. Root length and shoot length of the seedlings were measured and expressed as percentage of the control.

Bioassay of weed debris:

To determine the effect of weed debris, whole dried weed plants (leaf, stem, and root) were cut into pieces and ground by a commercial blender and stored at 4^0C until time of use. Debris of four concentrations (0, 5, 10 and 20 gm dry debris) were mixed separately with 1 kg soil and placed in plastic bags (height 12 cm X diameter 10 cm). For the control, similar bags were filled with soil without the addition of weed debris. Twenty seeds of each rice variety were sown in separate bags and watered regularly. After 7 days the seedlings were thinned to ten per bag. The plants were harvested 2 weeks after sowing. Data was recorded on plant height and dry weight of the seedlings and expressed as percentage of the control.

Effect of the root exudate:

The double-pot technique [16] was used to evaluate the effect of the weed root exudate on the growth of the rice plants. For this technique, two pot sizes 20 cm and 14 cm in diameter were used. The small sized pots had a hole at the bottom but there was no hole at the bottom of the larger pots. It should be noted that, the pots were filled with soil without any organic manure. The soil of the small pots was mixed with sand in the ratio of 2:3 to ensure the allelochemicals leached from the weed root and accumulated in the bigger pots. Weed plants were grown in the small pots. One month after emergence the small pots with the weed plants were placed on the top of the bigger pots. Twenty rice seeds each of the 4 varieties were sown in the bigger pots around the base of the small pots. The small pots were watered daily with 100 ml of tap water and the weed density was maintained at 50-60 plants per pot. After 7 days the rice seedlings were thinned to ten per pot. The rice seedlings were harvested 2 weeks after sowing. Data on plant height and seedling dry weight was recorded and expressed as percentage of the control.

Statistical analysis:

All experiments were conducted using the completely randomized design with 4 replications. The experimental data was subjected to the analysis of variance and means were compared using the Duncan Multiple range Test and the LSD test (for root exudate) at the 5% level of significance. The statistical analyses were done using the SPSS/PC version 11.5 software

Results:

Aqueous extracts:

Root growth:

The weed leaf aqueous extract at full strength showed inhibitory effects on the seedling root growth for all the four rice varieties tested. It caused significant root reduction in MRQ74, MR220, and MR84 by 46, 40 and 31% of the control respectively (Table 1). The stem extracts reduced the root growth of the rice plants significantly with increase in the concentration levels. The stem extract drastically inhibited the root growth of MRQ74 by 82% compared to the control, followed by the other varieties, at full strength. The root length of MRQ74 decreased with increasing concentrations of the root extract of the weed. It caused 38% root reduction in MRQ74 compared to the control, followed by other rice varieties with the exception of MR211. The root extract of *F. miliacea* caused a significant reduction in the root length of the rice varieties tested. There was significant reduction in the root length of MRQ74 but this was less than that caused by the stem extract. The results showed that the root growth of MRQ74 was greatly reduced by the leaf, stem and root extracts of the *F. miliacea*.

Table 1: Effect of *F. miliacea* extracts (leaf, stem and root) on the seedling root length (% of the control) of four Malaysian rice varieties.

Rice varieties	Extract concentrations			
	Control	Quarter	Half	Full
Leaf extract				
MR211	100.0bc	134.1a	108.1b	89.4c
MRQ74	100.0a	92.4b	89.0c	54.2d
MR220	100.0a	89.8ab	80.1b	59.9c
MR84	100.0a	84.8b	74.1c	69.3c
Stem extract				
MR211	100.0a	83.7b	65.1c	55.7d
MRQ74	100.0a	85.4b	49.7c	18.0d
MR220	100.0a	96.3a	86.7b	37.5c
MR84	100.0a	109.5a	81.5b	64.9c
Root extract				
MR211	100.0a	98.3a	89.7b	91.1b
MRQ74	100.0a	86.1b	75.1b	61.6c
MR220	100.0a	97.5a	91.3a	67.4b
MR84	100.0a	92.1b	88.6c	80.0d

Means within rows followed by same letter are not significantly different (p>0.05, $LSD_{0.05}$)

Shoot growth:

Aqueous leaf, stem and root extracts of the weed showed inhibitory effects on the seedling shoot growth for all the rice varieties tested, at full strength. At full strength the leaf extract caused significant shoot reduction of MR211, MRQ74, MR220 and MR84 by 15, 28, 25, and 16% respectively (compared to the control) (Table 2). The decrease in shoot length of MRQ74 was the highest (54% reduction). At full strength the stem extract showed a pattern of inhibition of MRQ74 similar to that of the leaf extract. The shoot growth of most of the rice varieties tested was unaffected at quarter and half strength of the root extract, rather it showed a stimulation effect. The root extract of *F. miliacea* caused significant reduction on shoot length of all the rice varieties tested with MRQ74 showing the greatest reduction compared to the others. The results showed that the stem extract of *F. miliacea* had greater effect on the rice seedling growth than the leaf and root extract of the weed.

Table 2: Effect of *F. miliacea* extracts (leaf, stem and root) on the seedling shoot length (% of control) of four Malaysian rice varieties.

Rice varieties	Extract concentrations			
	Control	Quarter	Half	Full
Leaf extract				
MR211	100.0b	119.3a	100.5b	85.2c
MRQ74	100.0b	110.0a	109.3a	71.9c
MR220	100.0a	101.1a	94.3b	75.2c
MR84	100.0a	100.0a	96.2a	83.8b
Stem extract				
MR211	100.0a	93.0a	73.4b	78.6b
MRQ74	100.0a	95.0a	62.9b	46.4c
MR220	100.0a	85.8b	85.7b	53.8c
MR84	100.0a	101.9a	73.8b	74.1b
Root extract				
MR211	100.0a	100.7a	95.9ab	86.5b
MRQ74	100.0a	97.9a	95.7a	84.9b
MR220	100.0a	101.4a	103.5a	90.5b
MR84	100.0a	106.4a	105.5a	92.4b

Means within rows followed by same letter are not significantly different (p>0.05, $LSD_{0.05}$)

Weed debris on plant height and dry weight:

Table 3 shows the inhibitory effect of the *F .miliacea* debris (which was mixed with soil) on the plant height, and seedling dry weight. Irrespective of the rice varieties tested, the plant height decreased with increasing concentrations of the weed debris with the exception of MR220 at quarter strength. *F. miliacea* residue greatly inhibited the plant height of MRQ74 (43% of control) followed by MR220, MR211 and MR84 at full strength. Similarly weed debris reduced the dry weight of all the rice varieties tested at full strength with MRQ74 showing the highest reduction.

Root exudate:

Table 4 shows the inhibitory effect of the weed root exudate on plant height and dry weight of the rice seedlings. The weed root exudate inhibited the plant height of MRQ74, and MR220 by 18 and 16% respectively compared to the control. Similarly it caused dry weight reduction of MRQ74 (21% of control), followed by MR220. The plant height and dry weight of MRQ74 was greatly reduced by the root exudate of *F. miliacea*.

Table 3: Effect of *F. miliacea* debris on plant height and dry weight of the seedlings of four rice varieties (% of control).

	Debris concentration								
Rice varieties	Control	Quarter	Half	Full		Control	Quarter	Half	Full
	Plant height					Dry weight			
MR211	100.0a	94.3b	80.3c	75.5c		100.0a	88.5ab	77.6b	63.0c
MRQ74	100.0a	82.8b	59.1b	57.1c		100.0a	91.3b	57.4c	51.3d
MR220	100.0a	110.2a	84.1b	60.5c		100.0a	110.1a	73.0b	57.4c
MR84	100.0a	83.8b	77.5b	78.4b		100.0a	91.6ab	86.8bc	80.9c

Means within rows followed by same letter are not significantly different (p>0.05, $LSD_{0.05)}$

Table 4: Effect of *F. miliacea* root exudate on plant height and dry weight of seedlings (% of control) of four rice varieties.

Rice varieties	Plant height				Dry weight		
	Control	Treatment	LSD		Control	Treatment	LSD
MR211	100.0	110.6	NS		100.0	104.7	NS
MRQ74	100.0	81.7	4.9		100.0	78.5	2.82
MR220	100.0	83.6	1.4		100.0	85.4	3.71
MR84	100.0	99.2	NS		100.0	92.8	NS

Discussion:

The results showed that different parts of the weed (leaf, stem and root) exerted different levels of allelopathic effects on the various growth parameters. This is due to different concentrations of allelochemicals in various parts of the plant [6,9,20]. By increasing the aqueous extract concentrations, reduction in seedling root and shoot length was observed. The magnitude of allelopathic interactions was dependent on the concentration and chemical stability of the active compounds as well as the plant's tolerance to such compounds and their microbial metabolites [19]. The weed extracts (leaf, stem and root) enhanced the root and shoot growth in some cases at quarter and half strength, but the extracts reduced significantly the root and shoot growth at full strength. Many studies have shown that allelochemicals stimulate growth at lower concentrations and inhibit growth at higher concentrations [12,14,8]. The test varieties in the present study showed different responses to the weed extracts, debris and root exudate. The result showed that MRQ74 was most affected by the aqueous extract of *F. miliacea* compared to the other varieties tested. This may be due to inability of the variety to detoxify the allelochemicals released by *F. miliacea*. The results also showed that the weed debris at the highest rate caused reduction in plant height and dry weight of the rice seedlings. The allelochemicals could be released into the soil environment during decomposition of the debris. The chemicals in the soil then affect the growth of the rice seedlings. Some plants release allelochemical into the environment by the decomposition of their debris [8].

Allelochemicals are also released into the soil via leaves and roots. These allelochemicals then affect the growth of neighbouring plants. However not all varieties are affected by the chemicals as can be seen in the case of MR211. Besides the selectivity of allelochemicals, the tested varieties may also have demonstrated selectivity as reported by Ismail and Siddique [7], Kamal and Asghari [10]. The allelopathic effect of root exudates of the weeds was observed to be lower than the effect of the weed extracts and debris. This could be that the weed root tissue contained lower concentrations of chemicals which were not sufficient to produce more significant allelopathic effects.

Results from the present study showed that, in addition to its competitive ability, *F. miliacea* had some allelopathic effects on the growth parameters of the rice plants, and it should be noted that MRQ74 was the most sensitive. More work has to be done in order to verify whether there are multi dimensional inhibitory effects between *F. miliacea* and rice plants.

Acknowledgements

The second would like to thank the Centre for Graduate Management, Universiti Kebangsaan Malaysia for providing the fellowship research grant to the second author.

References

1. Abeysekera and S.K. Anuruddhika, 2001. Management of *Echinochloa* spp. in rice in Sri Lanka. Paper presented at the FAO workshop on *Echinochloa* spp. control, Beijing, China, pp: 13.
2. Azmi, M. and M. Mashhor, 1995. Weed succession from transplanting to the direct seeding method in Kemubu rice area, Malaysia. *Journal of Bioscience*, 6(2): 143-154.
3. Batish, D.R., H.P. Singh, R.K. Kohli, S. Kaur, D.B. Saxena and S. Yadav, 2007. Assessment of parthenin against some weeds. *Zeitschrift für Naturforschung*, 62c: 367-372.
4. Begum, M., A.S. Juraimi, M. Azmi, A. Rajan and S.R. Syed-Omar, 2005. Weed Diversity of Rice Fields in Four Districts of Muda Rice Granary Area, North-West peninsular Malaysia. Malaysian Applied Biology, 34(2): 31-41.
5. Bhowmik, P.C. and Inderjit, 2003. Challenges and opportunities in implementing allelopaty for weed management. *Crop Protection*, 22: 661-671.

6. Hyder, P.W., E.X. Fredrickson, R.E. Estell, M. Tellez and R.P. Gibbens, 2002. Distribution and concentration of total phenolics, condensed tannins, and nordihydroguairaretic acid (NDGA) in creosotebush (*Larrea tridentata*). *Biochemistry System Ecology*, 30: 905-912.
7. Ismail, B.S. and A.B. Siddique, 2011. The inhibitory effect of Grasshopper’s Cyperus (*Cyperus iria* L.) on the seedling growth of five Malaysian rice varieties. *Tropical Life Sciences Research*, 22(1): 81-89.
8. Ismail, B.S. and T.V. Chong, 2009. Allelopathic effects of *Dicranopteris linearis* debris on common weeds of Malaysia. *Allelopathy Journal*, 23(2): 277-286.
9. Ismail, B.S. and A. Kumar, 1996. Effects of aqueous extracts and residues decomposition of *Mikania Micrantha* H.B.K. on selected crops. *Allelopathy Journal*, 3(2): 195-206.
10. Kamal, J. and B. Asghari, 2008. Effects of sunflower (*Helianthus annuus* L.) extracts on wheat (*Triticum aestivum* L.) and physicochemical characteristics of soil. *African Journal of Biotechnology.*, 7(22): 4130-4135.
11. Karim, S.M.R., M. Azmi and B.S. Ismail, 2004. Weed problems and their management in rice fields of Malaysia: An overview. *Weed Biology and Management*, 4: 177-186.
12. Leather, G.R. and F.A. Einhellig, 1988. Bioassay of naturally occurring allelochemicals for phytotoxicity . *Journal Chemical Ecology*, 14: 1831-1827.
13. Manandhar, S., B.B. Shrestha and H.D. Lekhak, 2007. Weeds of Paddy Field at Kirtikpur, Kathmandu. *Scientific World*, 5(5): 100-106.
14. Mandal, S., 2001. Allelopathic activity of root exudates from *Leonurus sibiricus* L. (Raktodrone). *Weed Biology and Management*, 1: 170-175.
15. Moody, K., 1989. Weeds Reported to Occur In Rice in South and Southeast Asia: Weeds Reported in South and Southeast Asia, pp: 1-80.International Rice Research Institute, Los Banos, Laguna, P.O. Box933, 1099 Manila, Philippines.
16. Mridha, A.J. and S.M.R. Karim, 2008. Hidden power of rice varieties to suppress weed in Bangladesh. Asia-Pacific Weed Science Society *NEWS LETTER*, 1(1): 11-12.
17. Ohigashi, H., J. Harada, S. Tadachika, H. Nobuhiro, C. Premasthira, Y. Asakawa, F. Yoshiharu and S. Sakashita, 1997. Allelochemicals of gooseweed, *Sphenoclea zeylanica*. Abstracts of the international union of pure and applied chemistry: International Conference Biodiversity and Bioresources-Conservation and Utilization. pp: 157.
18. Patterson, D.T., 1981. Effects of allelopathic chemicals on growth and physiological responses of soybean (*Glycine max*). *Weed Science*, 29: 53-59.
19. Phillips, R.E., R.E. Blevins, G.W. Thomas, W.W. Frye and S.H. Phillips, 1980. No-tillage agriculture. *Scienc*e, 208: 1108-1113.
20. Putnam, A.R. and W.B., Duke, 1978. Allelopathy in agroecosystems. *Annual Review of Phytopathology*, 16: 431-451.
21. Qasem, J.R. and C.L. Foy, 2001. Weed allelopathy, its ecological impact and future prospects: a review. In: Allelopathy in agroecosystems. Edited by R. K. Kohli, H.P. singh and D. R. Batish. Haworth Press, New York, pp: 43-119.
22. Watanabe, H., M. Azmi and M.Z. Ismail, 1997. Emergence of major weeds and their population change in wet-seeded rice fields of the MUDA area, Peninsular Malaysia. In*:* Rajan, A. (ed.), *Proc. 16th Asian Pacific Weed Science Society Conf*. pp: 246–250. Kuala Lumpur, Malaysia.
23. Yamamoto, T., K. Yokotani-Tomita, S. Kosemura, K. Yamamura, Yamada and K. Hasegawa, 1999. Allelopathic Substance Exuded from a Serious Weed, Germinating Barnyard Grass (*Echinochloa crus-galli* L.), Roots. *Journal of Plant Growth Regulation*, 18(2): 65-67.
24. Zhang, Z.P., 2001. Weed management in rice in China. Summary presented at FAO Workshop on *Echinochloa* spp. Control, Beijing, China, 27 May.