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Effect of *Fimbristylis miliacea* Competition with MR220 Rice in Relation to Different Nitrogen Levels and Weed Density

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ABSTRACT

The study was conducted to investigate the severity of competition between rice and *Fimbristylis miliacea* with application of different levels of nitrogen and different density of *F. miliacea*. Sixty 25 cm diameter by 30 cm deep clay pots were filled with 6 kg of Bakau series with clay texture ricifields soil. Treatments consisted of a factorial combination of three nitrogen (N) levels and five weed densities and laid out in a RCBD with four replications. The interaction between weed density and nitrogen fertilization had a pronounced influence on rice yield contributing characters and rice yield. At low weed densities (500 plants m^{-2}), rice yields increased with higher N fertilization. On the other hand, at the higher weed density (1000 plants m^{-2}), increasing N fertilization to 170 kg ha^{-1} had no significant effect on yield. However, rice yield at this level of N fertilization with the lowest weed density of 250 plants m^{-2}, was similar to the weed-free treatment. With an efficient weed control program it is possible to increase the fertilizer use efficiency of the crop. When less fertilizer is applied, the productivity per unit of applied fertilizer can be maximized by good weeding practice.

Key Words: Competition; Nitrogen levels; Weed density; *Fimbristylis miliacea*; Rice yield

INTRODUCTION

Fimbristylis miliacea (L.) Vahl family Cyperaceae is a competitive rice weed occurring worldwide and among ten most common species in all type of rice cultures in South Asia (Moody, 1989). Weeds compete with cultivated species for space, light, water, nutrients and other growth requirements are certainly major resources accounting for the adverse effect of weeds on crop growth and yield (Sharma *et al.*, 1986; Patterson, 1987). The effect of weed density on rice yields has been established for several weed species including barnyardgrass (*Echinochloa crus-galli*) (Smith, 1974; Azmi, 1994), bearded sprangletop (*Leptochloa fascicularis*) (Smith, 1983), hemp sesbania (*Sesbania exaltata*) Cory northern jointvetch (*Aeschynomene virginica*) (Smith, 1968) and *Leptochloa chinensis* (Pane, 1997). Radosevich and Roush (1990) reported that crop plants under competitive stress produced fewer tillers and fewer panicle bearing tillers with smaller panicles. However, for short stature weeds higher weed density is accountable to reduce rice yields compared to tall and aggressive species. But, no information is available on the competition effect of short stature weed *F. miliacea* on rice although it is a densely dominant species in ricefields (Azmi & Mashhor, 1995; Begum *et al.*, 2005) with emergence density of 54- 3074 plants m^{-2} (Watanabe *et al.*, 1997).

Generally nitrogen affects plant development, competition and community structure. Modern rice varieties require more nitrogen than the traditional varieties. In tropical areas, nitrogen fertilizer accounts for about 67% of the total amount of fertilizers applied to the rice crop (De Datta & Nantasomsaran, 1991). In that case, nitrogen responsive crop species are more competitive under high N-fertilization, but if the associated weed is also responsive to N it utilizes more of the applied N and no advantage in crop yield may be obtained (Ehsanullah *et al.*, 2001). *F. miliacea* is a competitive weed, especially at high population densities with rapid root spreading capability surrounding rice root in short stature rice varieties (Holm *et al.*, 1977; Pons & Utomo, 1985). To achieve high rice yields, both nitrogen fertilization and weed management are essential. Knowledge of the relationship between fertility and weed competition and critical threshold density at specific nitrogen levels can help farmers to manipulate fertilizers to favor the crop and suppress weed growth. Information on

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yield loss by different weed densities and response to applied nitrogen has not been reported for *F. miliacea*. Present study was undertaken to determine the competitive relationship of *F. miliacea* at different densities and at different levels of nitrogen, when grown season-long with rice.

MATERIALS AND METHODS

The experiment was carried out in the glasshouse at the Faculty of Agriculture Universiti Putra Malaysia during October 2004 to April 2005. Sixty clay pots, size 25 cm diameter by 30 cm were filled with 6 kg of paddy soil collected from Tanjung Karang ricefield. The soil was Bakau series (Typic Hydraquents) with clay texture (68.59% clay, 28.83% silt & 0.28% sand). Analysis showed that soil pH value was 4.90 and was rated as deficient in the main elements like N, P and K, etc.

Ten gram m^{-2} of rice (*Oryza sativa* var. MR220) seeds were pre-germinated and sown on the soil surface of the pot. Treatments consisted of a factorial combination of three nitrogen (N) levels and five weed densities. Nitrogen as urea (46% N) was applied at 100 and 170 kg ha^{-1}. No nitrogen was applied in the control pots. Nitrogen fertilizer was applied in three splits at 20, 35 and 55 days after sowing. Triple super phosphate at the rate of 0.82 g per pot (167 kg ha^{-1}) and Muriate of potash at 1.23 g per pot (250 kg ha^{-1}) were applied as basal fertilizer. The *F. miliacea* density treatments were 0, 250, 500, 1000 and 2000 plants m^{-2}. *F. miliacea* seeds were sown on the surface of saturated soil. The control pots were maintained weed-free. *F. miliacea* plants were established at the desired densities (0, 12, 24, 48 & 96 plants per pot) within one week after emergence, while the rice was at the 1 to 2 leaf stages. The weed densities were maintained throughout the growing season by hand weeding. Water was applied as necessary to maintain a 2-3 cm water depth. The 3 × 5 factorial experiment was laid out in a RCBD with four replications. The pots were placed close together with a border row of extra pots around the entire perimeter to minimize border effects.

At rice harvest, data on plant height, total tiller number, productive tiller number, grains per panicle, filled grains per panicle, 1000 grain weight, rice straw biomass and grain yield were recorded following standard procedures. For weed, shoot biomass was recorded at harvest. Biomass was determined by drying the rice/weed plants at 65^{o}C for 48 h. The grain was threshed and grain yields were based on weight adjusted to 14% moisture. Weed and crop measurements were transformed to units m^{-2}. All yield and yield component data were analyzed using the SAS statistical software and mean differences were tested using Tukey's studentized range test at $P<0.05$.

RESULTS AND DISCUSSION

Rice plant height. Treatment without N fertilization produced the tallest plants in weed-free condition and the lowest rice plant height was recorded for higher weed densities (Fig. 1). When N was applied at 100 kg ha^{-1}, increasing weed density did not reduce plant height. In treatments with N at 170 kg ha^{-1}, the highest plant height was observed in weed-free pots, which were similar to rice with a weed density of 250 m^{-2}. But, lower rice plant heights were observed with higher weed densities from 500 to 2000 m^{-2}. Azmi (1990) observed that rice plant height was significantly reduced when common weeds were allowed to compete compared to weed free.

Number of total tillers of rice. Highest number of total tillers m^{-2} was observed from the weed-free pots, which was similar to those recorded in pots with weed density of 250 m^{-2}. Tiller production was reduced with increased weed density (Table I). Sultana (2000) observed about 52% reduction in tillers due to competition from *E. crus-galli*. Fazlul *et al.* (2003) also observed significantly highest number of total tillers produced in weed-free treatments.

Table I. Vegetative growth and yield contributing characters of rice influenced by weed density

Weed density m^{-2}	Total tillers m^{-2}	Fertile grains per panicle (%)	1000-grain weight (g)
0	440.49a	69.67a	22.23a
250	377.55ab	64.83a	22.01a
500	319.60b	54.14b	20.62b
1000	295.42b	48.06b	20.37b
2000	294.22b	52.50b	21.25ab

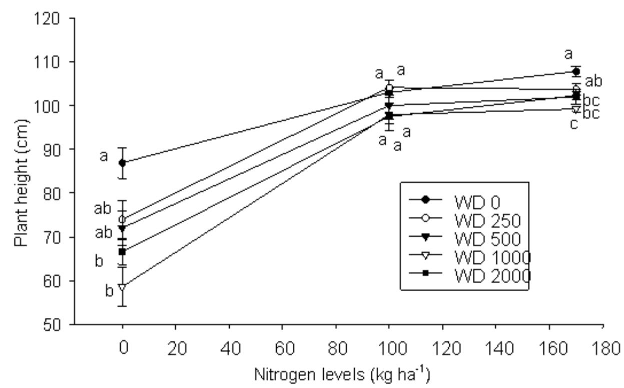
Means within columns with same alphabets are not significantly different at $P \geq 0.05$ for each treatment (Tukeys Test)

Table II. Vegetative growth and yield contributing characters of rice influenced by N levels

Nitrogen(kg ha^{-1})	Total tillers m^{-2}	Fertile grains per panicle (%)	1000-grain weight (g)
0	258.81c	47.77b	20.09b
100	346.92b	63.28a	21.86a
170	430.63a	62.47a	21.94a

Means within columns with same alphabets are not significantly different at $P \geq 0.05$ for each treatment (Tukeys Test)

Fig. 1. Rice plant height response to N treatment for all weed density levels [Means within N levels with same alphabets are not significantly different at P ≥ 0.05 (Tukeys Test)]



The number of tillers m^{-2} increased with increasing rates of nitrogen (Table II). The increase in number of fertile tillers with the increase in nitrogen levels can be attributed to the reduction in mortality of tillers and enabling the production of more tillers from the main stem (Martin *et al*., 1992; Ersin *et al*., 2006). Trails at IRRI have also demonstrated increasing number of culms in rice with high levels of N fertilizer (IRRI, 1967; Akbar *et al*., 2006).

Number of productive tillers. Reproductive growth is a reflection of vegetative growth. Varying weed density had no influence on productive tillers m^{-2}, where nitrogen was not applied. But, with nitrogen at 100 kg ha^{-1}, productive tiller gradually decreased with increase in weed density from 250 to 1000 m^{-2}. A similar trend was observed with N-fertilization at 170 kg ha^{-1} (Fig. 2). There was a clear trend with higher nitrogen level producing more productive tillers when weed-free and weed density treatments with 250 m^{-2}. Kleinig and Noble (1968) also reported increase in number of productive tillers with higher N application at low and *vice versa* for high *Echinochloa* densities.

Fertile grains per panicle. Significantly higher percentage of fertile grains per panicle was found in weed free pots and weed density of 250 m^{-2} compared with rest of weed density treatments (Table I). Similar result was observed for other species e.g., red rice density of 5 plants m^{-2} were not effective to reduce fertile grain of rice but weed densities to 108 and 215 plants m^{-2} reduced fertile grain of rice (Diarra *et al*., 1985). N applied at 170 and 100 kg ha^{-1} gave higher %fertile grains per panicle compared to the treatment without nitrogen (Table II). Dingkuhn *et al*. (1990) reported that the higher filled spikelet number was promoted due to positive response to N application.

1000-grain weight. Thousand-grain weight is a genetic character widely used in yield estimation and varietal selection in rice, and environmental factors have minimum influence (Iqbal *et al*., 2008). Higher 1000-grain weight was obtained in weed-free and with weed density of 250 m^{-2}, while 1000-grain weights were significantly lowered with other three higher weed densities (Table I). Islam *et al*. (1980) also reported variation in 1000- grain weight due to weed infestation but in contrast Rao and Moody (1992) reported that weed competition did not affect seed weight of the rice. Significantly higher 1000-grain weight was found in both 100 and 170 kg ha^{-1} N treatments compared to without nitrogen (Table II). According to Kausar *et al.* (1993) the nitrogen application increased protein percentage, this in turn increased the grain weight. Similarly Maqsood *et al.* (2000) and Warraich *et al.* (2002) also observed that application of nitrogen improves 1000–grain weight of cereal.

Rice straw biomass. At 0 and 100 kg ha^{-1} N as weed density increased from 0 to 500 m^{-2}, rice straw biomass gradually decreased, but leveled off at weed densities of 1000 and 2000 m^{-2} (Fig. 3). Highest straw biomass was observed with 170 kg ha^{-1} N in weed-free treatments and weed density treatment of 250 m^{-2}. Lowest straw biomass

Fig. 2. Rice productive tillers variation to N treatment for all weed density levels [Means within N levels with same alphabets are not significantly different at P ≥ 0.05 (Tukeys Test)]

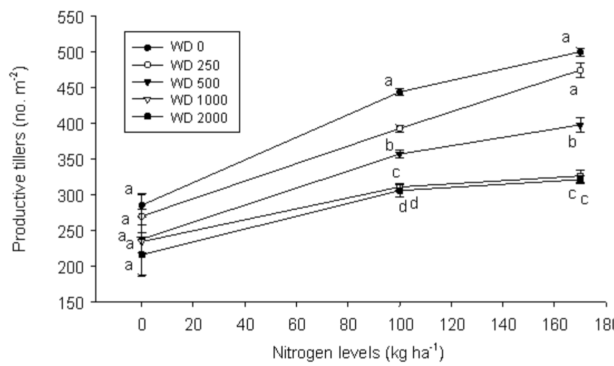
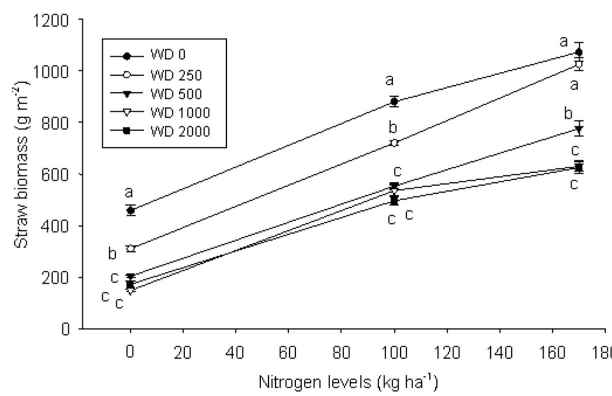


Fig. 3. Rice straw biomass in response to N treatment for all weed density levels [Means within N levels with same alphabets are not significantly different at P ≥ 0.05 (Tukeys Test)]



was recorded with higher weed densities. Evidently, irrespective of weed density higher N fertilization produced more rice straw biomass than without N (Fig. 3). Probably increased N rates enhanced more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation (Mandal *et al*., 1992). Similar responses have been reported with other weed species (Pane, 1997; Iqbal & Wright, 1999).

Weed dry matter. Dry matter production of a weed infestation reflects its ability to compete. When N was applied at 100 and 170 kg ha^{-1}, weeds dry matter was significantly increased as weed density increased (Fig. 4). Without N application, highest weed biomass was recorded at weed density of 2000 m^{-2} and was followed by 1000 m^{-2}. Weed biomass at weed densities 500 m^{-2} and 250 m^{-2} were similar. These results showed that N fertilization increased weed dry matter compare to treatments without N-fertilization. In general different weeds had different growth response in respect of fertilizer management. Blackshaw *et al*. (2003) found that growth of 23 weeds increased with added nitrogen, but response varied greatly amongst species.

Fig. 4. Weed dry matter content in response to N treatment for all weed density levels [Means within N levels with same alphabets are not significantly different at P ≥ 0.05 (Tukeys Test)]

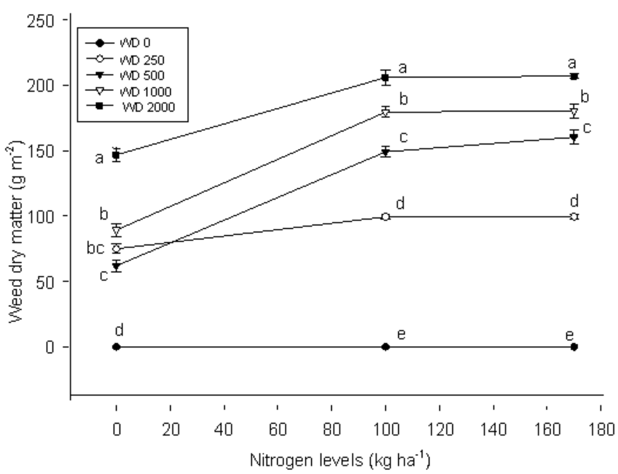
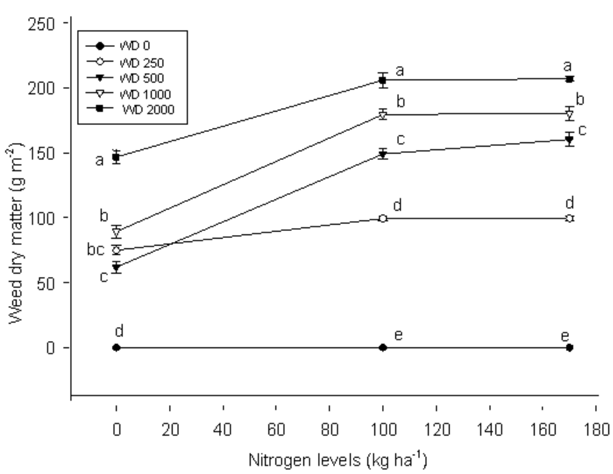


Fig. 5. Grain yield variation due to N treatment for all weed density levels [Means within N levels with same alphabets are not significantly different at P ≥ 0.05 (Tukeys Test)]



Grain yield. Rice grain yield significantly increased with increasing N level especially in weed-free treatments and with low weed densities (Fig. 5). With N fertilization at 100 and 170 kg ha^{-1} grain yields were similar at higher weed density levels (1000 & 2000 m^{-2}). Nitrogen level increasing from 100 to 170 kg ha^{-1} did not give a corresponding increase in yield at these high densities. Higher N levels did compensate for competition at low weed densities with yields similar to the weed-free treatment. Sharma (1997) reported that higher N increased weed biomass and proved to be of no benefit in both unweeded and densely infested crop; but gave significant increase in yield following the higher application of N when weed growth was reduced by either cultural or chemical method. De Datta (1974) suggested that applying less fertilizer than is needed to produce maximum yield is better when weed control is inadequate. However, Pande and Bhan (1966) reported that rice yields almost doubled when nitrogen application was increased from 60 to 80 kg ha^{-1}, indicating that rice was more competitive with more available nitrogen. This study also suggests that rice was more competitive than *F. miliacea* when N supply was adequate and that low infestations could be tolerated with N applications of 100 kg ha^{-1} or higher.

In this study, grain yield was significantly negatively correlated with weed dry matter at N levels 100 and 170 kg N ha^{-1} (R^2=0.88 & 0.78 for weed dry matter at 100 & 170 kg N ha^{-1}, respectively). De Datta (1974) reported a significant negative correlation between *C. rotundas* dry weight and rice grain yield as influenced by nitrogen application. Similar findings for other weed species have been reported by Florez *et al.* (1999) and the effects of weeds competition were predicted with weed biomass. There is competition between weed and crop for N absorption, which can be associated with a reduction in crop yield (Nam-il *et al*. (2001).

CONCLUSION

Managing rice fertilization is an important component of integrated weed management systems to compensate for competition from weeds and maintain grain yields. Grain yields with nitrogen fertilization at all weed densities out weighed grain yields without N. Rice grain yield increased with increase in N from 100 to 170 kg ha^{-1} for weed densities up to 500 m^{-2}. Rice yield leveled off and increasing N had no significant effect on yield at a weed density of 1000 m^{-2} or higher. At the low weed density level (250 m^{-2}) applying N at 170 kg ha^{-1} produced similar yields as the weed-free treatments.

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