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Research article

Impacts of different competition duration of *Echinochloa crusgalli* on transplanted *aman* rice

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Abstract

We conducted an experiment at Bangladesh Rice Research Institute, Gazipur during the year 2012 to study the growth behavior of transplanted *aman* rice under different competition durations with *Echinochloa crusgalli*. Different durations of weed interference such as 20, 40, 60 days after transplanting, weeded and weed free period were. The results revealed that all the growth characters leaf area index, leaf area duration, dry matter accumulation, crop growth rate and net assimilation rate were reduced with prolonged weed competition. However, panicle m^{-2}, grains $panicle^{-1}$ and grain yield were also reduced with increasing period of rice-weed competition. *Echinochloa crusgalli* is a severe competitor of rice even at early growth stage because all the growth parameters of the rice crop were significantly suppressed by the increasing trend of rice-weed competition durations. It might be suggested that *Echinochloa crusgalli* should be controlled as early as possible for good vegetative growth of rice. It could be concluded that in case of short duration *aman* variety like BRRI dhan56 weed competition can be allowed not more than 20 days after transplanting.

Key words: Competition period, *Echinochloa crusgalli*, *aman* rice, growth parameter.

Introduction

Weed infestation and interference is a serious problem in rice fields that significantly decreases yield. In Bangladesh weed infestation reduces rice grain yield by 70-80% in Aus rice, 30-40% in tranaplnted aman rice and 22-36% for

modern boro rice cultivars (BRRI, 2006; Mamun, 1990). Production cost of rice increased due to increase in weed control cost. The prevailing climate and edaphic conditions are highly favorable for luxuriant growth of numerous weed species that strongly compete with rice crop. Among the species *Echinochloa crusgalli* is most devastating and serious competitor as well as commonly associated with rice crop. It is an annual plant and ecologically similar to rice. It is an erect and annual plant of height 100-200 cm. The stem is stout and spongy with thick root. Leaves are 40 cm long and 5.15 mm wide. It is propagated by seed and adapted to wet soils of having 80% water holding capacity. However, its seed can germinate in standing water and tillers profusely (Auld and Kim, 1996). *Echinochloa crusgalli* can grow and flower in a photoperiod ranging from 8 to 16 hours. During the early vegetative growth it is too difficult to distinguish from rice plant, however ligules and auricles are absent in it. Due to its vigorous growth, it competes heavily with rice crop for essential growth factors like water, light and nutrients.

The ecological relationships in weed-crop competition are complicated ones. Undoubtedly, weed and crop plants compete with one another and interfere in growth activities to a varying degree. To alleviate weed crop competition, there is need to explore the critical weed-crop competition period which seriously limits crop yields. An understanding of the critical period of weed control (CPWC) and the factors affecting it are essential for making proper decision on appropriate timing of weed control and efficient use of herbicide (Knezevic et al. 2002). The critical period of weed control is a period in the crop growth cycle, in which weeds must be controlled to prevent economic crop yield loss due to weed competition (Knezevic et al. 2002). Thus, the CPWC is an important consideration in the development of appropriate weed management strategies (Swanton and Weise, 1991). The CPWC is determined by calculation of the time interval between two separately measured competition components. The critical duration of weed interference and the maximum length of time before early emerging weeds can grow and interfere with the crop before unacceptable yield loss is incurred. The critical weed-free period, the minimum length of time required for the crop to be maintained weed free before yield loss caused by subsequent emerging weeds is no longer of concern (Knezevic et al. 2002). Consequently, the interference from weeds before or after the CPWC will not result in unacceptable yield reduction. Juraimi et al. (2009) reported that the critical periods of weed competition in rice ranges between 5 and 52 days after sowing. The present study was planned to study the growth behavior of transplanted aman rice under different competition durations with *Echinochloa crusgalli*.

Materials and methods

The study was conducted at Bangladesh Rice Research Institute, Gazipur during the year 2012. The soil was clay in texture having pH of 7.85 and organic matter content is 0.70%. The treatments consisted of competition durations by 0, 20, 40, 60 days after transplanting and throughout the growing period. Weeds were removed by hand to maintain the expected duration of *Echinochloa crusgalli* association. The experiments were laid out in RCBD with three replications. The crop was fertilized at 120-60-60 kg NPK ha^{-1}. Total amount of P and K were applied at the time of transplanting the rice nursery. Nitrogen was applied in two equal splits. The plot size was 3 × 2 m. Drought tolerant rice variety BRRI dhan56 was used as a test crop. About thirty days old seedlings were transplanted at 20 × 20 cm

spacing. Seed of *Echinochloa crusgalli* was broadcast in the experimental plots and weed density was maintained as 25 plants $m^{-2.}$ The other weed plants were eradicated manually after germination. The following observations were recorded to analyze the growth behavior of rice crop.

Leaf area index (LAI)

The LAI was calculated by the following formula (Watson, 1947).

$$\text{LAI} = \frac{\text{LA}}{\text{A}}$$

Where, LA is the total one sided leaf area of a crop sample covering a land area of A.

Leaf area duration (LAD)

LAD was estimated in m^2 days according to Hunt (1978) in days.

$$\text{LAD} = \frac{(\text{LAI1} + \text{LAI2}) \times (\text{t2 - t1})}{2}$$

Where, LAI1 and LAI2 are the leaf area index at times t1and t2, respectively.

Crop growth rate (CGR)

CGR was calculated in g m^{-2} day^{-1} by using the following formula as proposed by Hunt (1978)

$$\text{CGR} = \frac{\text{W2 - W1}}{\text{t2 - t1}} \times \frac{1}{\text{A}}$$

Where, W1 and W2 are total dry weights of crops over a sampling area of A at times t1 and t2 days after transplanting, respectively.

Net Assimilation rate (NAR)

The net assimilation rate (NAR) was estimated in g m^{-2} day^{-1} by using the following formula:

$$\text{NAR} = \frac{\text{W2 - W1}}{\text{t2 - t1}} \times \frac{\text{Ln LAI2 - Ln LAI1}}{\text{LAI2 - LAI1}}$$

Where, W1 and W2 are total dry weight, LAI1 and LAI2 are leaf area index of crops at times t1 and t2 days after transplanting, respectively.

Dry matter accumulation

To determine dry matter (DM) accumulation, five plants from the central row were harvested starting from 30 DAT each at an interval of 20 days. DM accumulation was determined three times in a season and was calculated after oven drying at 70°C till constant weight on m^{-2} basis in grams.

Estimation yield loss

The percentage of yield loss of each infested plot was calculated as per Gill and Vijayakumar (1969), which is as follows:

$$Y_L\ (\%) = \frac{Ywf\ -\ Y}{Ywf} \times 100$$

Where, Y_L is the observed yield loss, Y_{wf} is the grain yield in weed-free plots and Y is the grain yield from each infested plot. The data collected were analyzed statistically using MSTATC statistical package on computer (Anonymous, 1986). Duncan's New multiple range test was applied for treatment comparison.

Results and Discussion

Dry matter accumulation

Dry matter accumulation was recorded at 30 and 50 days after transplanting (DAT). No significant difference was observed among the treatments at 30 DAT. However, significant difference was recorded at 50 DAT. At 50 DAT significantly highest dry matter accumulation was recorded in weed free plot (584.1 g m^{-2}) while lowest dry matter accumulation was found in 40 days weed competition (341.9 g m^{-2}) which is statistically similar with 60 days weed competition (358.5 g m^{-2}). These results supported the findings of Chavez and Moody (1988) who reported significant reduction in DM of rice with an increase in competition duration.

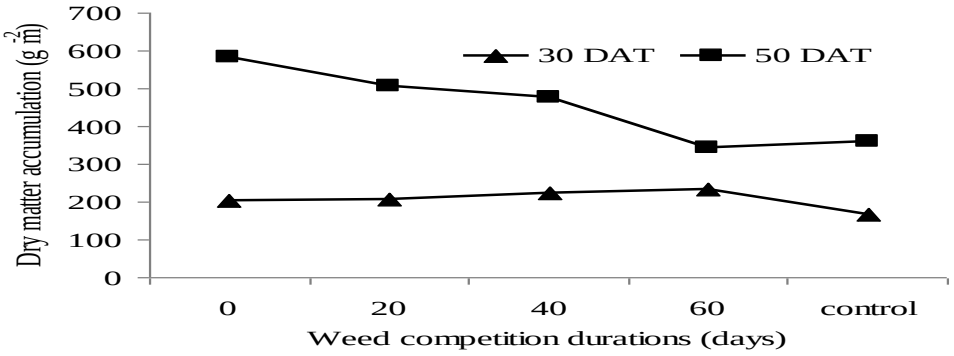

Figure 1: Effect of weed competition period on dry matter accumulation of transplanted aman rice

Leaf area index

Leaf area index was recorded at 30 and 50 days after transplanting (DAT). Significant difference was observed both at 30 and 50 DAT. At 30 DAT significantly highest LAI was found with out weed competition (3.23) which is statistically identical with 20 days weed competition (3.27) and similar with 60 days weed competition (2.95). On the other hand lowest LAI was found in 40 days rice weed competition (2.55) which is statistically similar with 60 days and throughout rice weed competition. At 50 DAT, the highest LAI was observed with no weed competition (5.48) which is statistically identical with 20 days weed competition (5.00). In contrast lowest LAI was recorded at throughout weed competition (2.94). Reduction in LAI due to the weed competition has also been reported by Okafor and Dedatta (1974) and also by Yamagishi et al. (1976).

Leaf area durations

The Highest leaf area duration was found with no weed competition (87.13) which is statistically identical with 20 days weed competition (82.67). In contrast lowest leaf area duration was found when it was allowed for throughout

(control) rice weed competition (55.50). The influence of weed competition on the leaf area durations was similar to LAI because it was derived from the LAI data. These results are in agreement with those of Tanveer (1995) who reported that weed-crop competition decreased significantly with the leaf area duration of the crop.

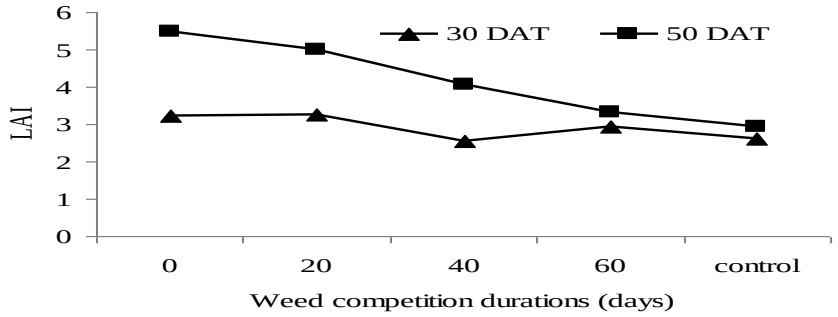

Figure 2: Effect of weed competition durations on Leaf Area Index of of transplanted aman rice

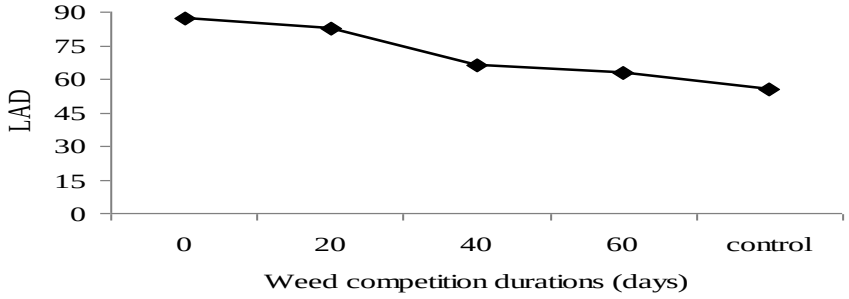

Figure 3: Effect of weed competition on Leaf Area Duration

Crop growth rate

The highest crop growth rate was observed in 20 days weed competition which is statistically identical with no weed competition. Besides, lowest crop growth rate was found in 60 days weed competition (7.62) which is statistically identical with throughout growing period (8.06). These results indicated that due to the prolonged competition, the availability of essential plant growth elements became limited and thus growth was negatively affected. Similar results were reported by Akhtar (1991).

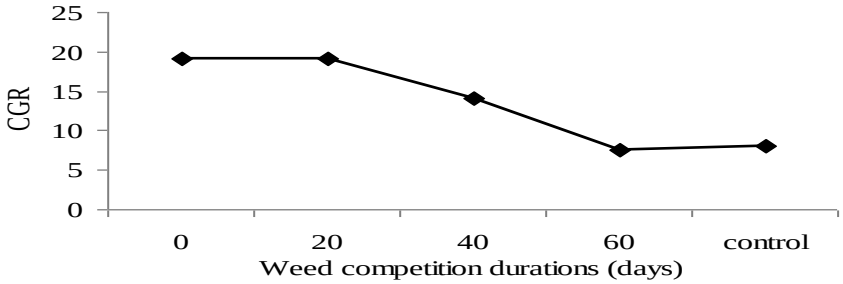

Figure 4: Effect of weed competition on crop growth rate (g m^{-2} day^{-1})

Net assimilation rate

The highest net assimilation rate (NAR) was found with no weed competition (3.50). On the other hand, the lowest net assimilation rate was observed in 60 days weed competition (0.73) which is statistically identical with throughout growing period of rice weed competition (0.90). These results showed that increase in competition period decreased the NAR probably due to less leaf area and shortage of other growth factors (nutrient, space, water etc). Another reason might be the phytotoxic effect of the toxins produced by *Echinochloa crusgalli*. Similarly, Maqsood (1998) reported that mostly cereals such as rice had NAR up to 6 g m^{-2} day^{-1} and that LAI was positively associated with NAR.

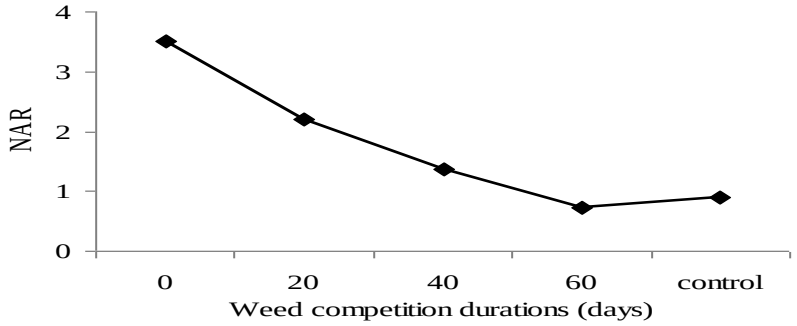

Figure 5: Effect of weed competition on net assimilation rate (g m^{-2} day^{-1})

Effect of weed competition on panicle production

The number of panicle m^{-2} was significantly reduced by the effect of weed competition period. The results revealed that the number of panicle m^{-2} was significantly higher in weed free plot than weedy treatments. The highest number of panicle m^{-2} was found with no weed competition (250) which is statistically similar with 20 days weed competition (240). On the other hand lowest numbers were recorded in season long weedy treatments (191). Figure showing gradual decrease of panicle m^{-2} with increase of weed competition period. The results are in accordance with the findings of Azmi (1990), who argued significant decrease in tiller numbers with weed competition period during 45 DAS to harvest. Jurami et al. (2009) pointed out that the tillers number of rice were significantly affected by the weeding competition period both in saturated and flooded conditions.

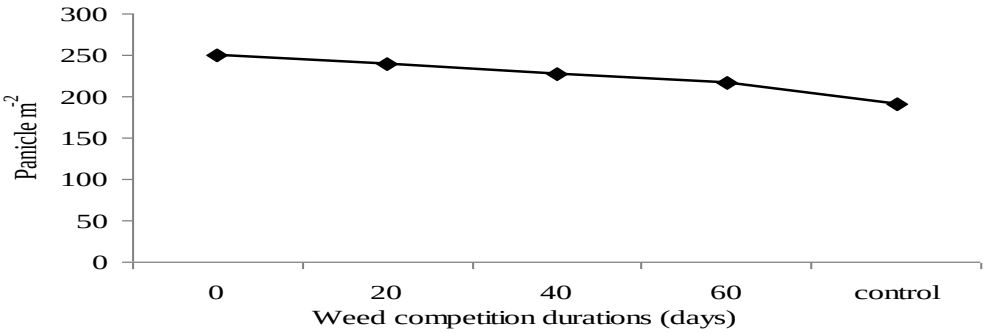

Figure 6: Effect of weed competition period on panicle/m2

Effect of weed competition on grains panicle^{-1}

The filled grains of rice were significantly influenced by weed competition period. The maximum grains panicle^{-1} was observed in weed free conditions and less number was noted under weedy conditions. Significantly highest number of grains/panicle was found in season long weed free condition (124) which is statistically similar with 20 days weed competition. However the lowest value was found in season long weedy treatments (83). Figure showing gradual decrease of grains/panicle with increase of weed competition period. Najib, (2009) observed that the filled grains/panicle of rice affected by weed competition period both in saturated and flooded conditions. Similarly, the reductions in the filled grains/panicle have been widely reported by different authors due to weeding duration and season long weed competition (Ekeleme et al. 2007; Begum et al. 2008)

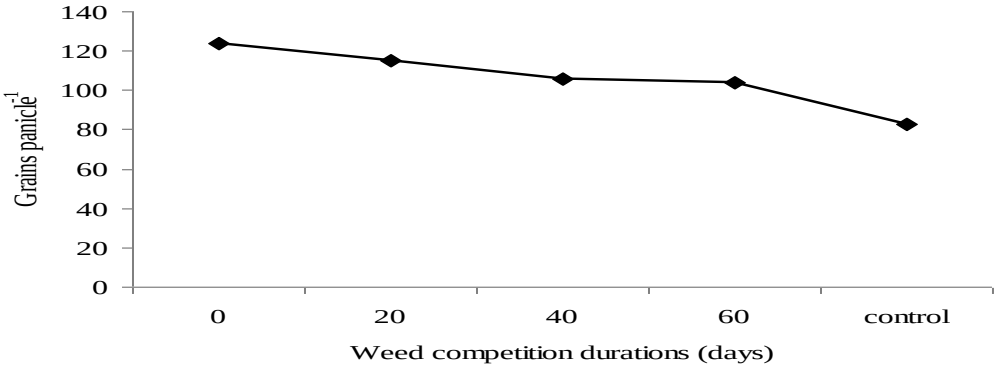

Figure 7: Effect of weed competition period on grains/panicle

Effect of weed competition on 1000- grain weight

No significant difference was found in case of 1000 grain weight. However highest1000 grain weight was found in 20 days weed competition (21.21) and lowest value was recorded in control treatments (19.97)

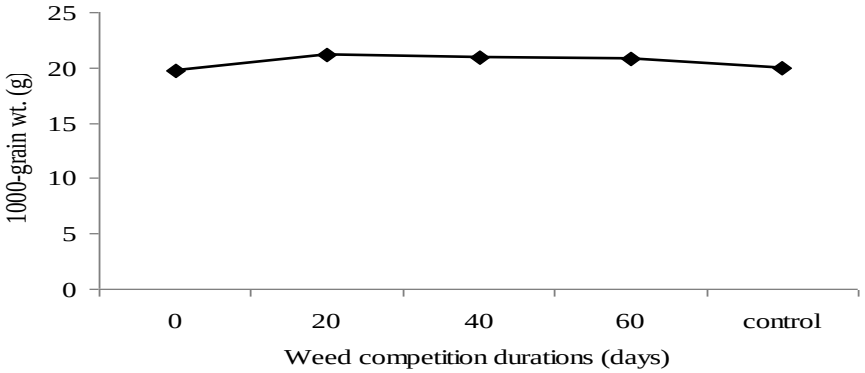

Figure 8: Effect of weed competition period on 1000- grain weight

Effect of weed competition on grain yield:

The yield was significantly decrease with the increasing span of weed interference but higher yield was recorded in season long weed free treatment (4.16 t ha^{-1}) which is statistically similar with 20 days weed competition (3.85 t ha^{-}

[1]). In contrary, the lowest yield was found in season long weedy treatments (3.12 t ha^{-1}). This result is supported by Hakim et al. (2013) who reported that the rice grain yield was reduced by the weed infestation and the scale of reduction was found according the duration of weed infestation. Prolonged weed competition resulted in lower number of panicles m^{-2}, filled grains $panicle^{-1}$ and 1000-grain weight which finally affected the grain yield.

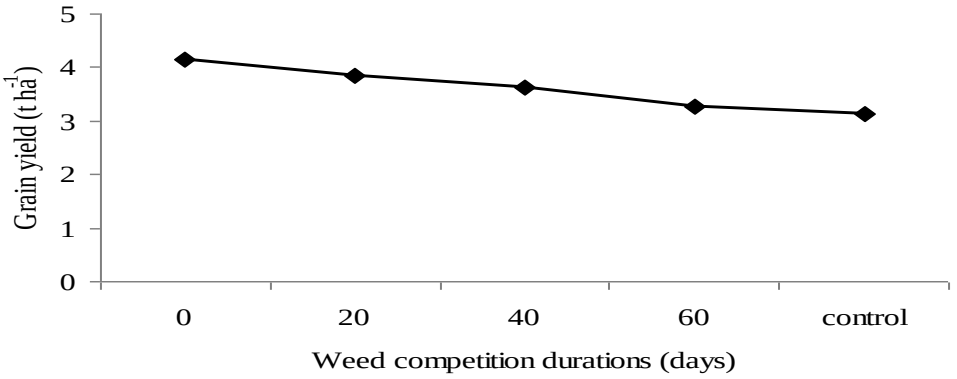

Figure 9: Effect of weed competition period on grain yield

Effect of weed competition period on grain yield reduction

Significant reduction of grain yield was found according the duration of weed infestation. It was found that 25% yield reduction occurred due to season long rice weed competition. Rice grain yield was drastically decreased in saturated condition as a consequence of increasing the weed infestations (Ekeleme et al. 2007). Chauhan and Johnson,92011) reported as high as 95%yield reduction in rice due to weed competition throughout the rice growing season. These findings might be due to differences in rice variety, agro-climatic zone, soil moisture regimes and prevalent weed flora density among the experimental sites.

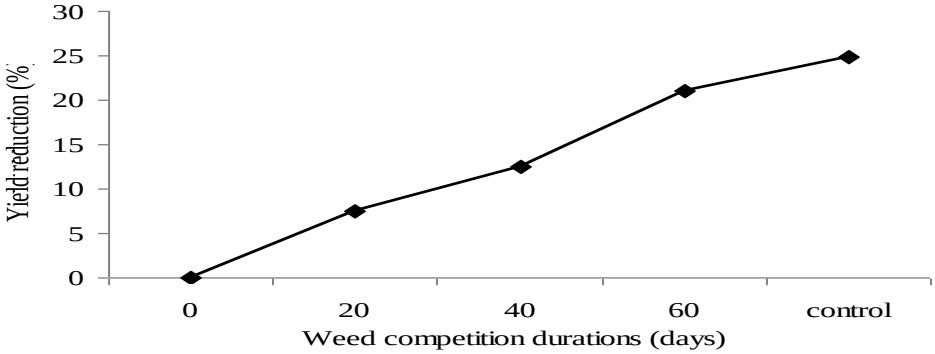

Figure 10: Effect of weed competition period on grain yield reduction

Conclusion

Echinochloa crusgalli should be controlled at early stage of rice for better vegetative growth and development of the crop. It might be suggested that weed competition should not be allowed more than 20 days after transplanting of *aman* rice.

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