IMPACT OF WEEDING REGIME ON THE PERFORMANCE OF AUS RICE

A THESIS

BY

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EXAMINATION ROLL NO. MS-050806

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ABSTRACT

A field experiment was conducted at the Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna, during aus season, 2007 to study the impact of weeding regime on the performance of aus rice. A factorial randomized complete block design with three replications was followed for this experiment. The experimental treatment included four weeding regime *viz*., no weeding, one hand weeding at 35 days after sowing (DAS), two hand weedings at 20 and 35 DAS and three hand weedings at 20, 35 and 50 DAS and three rice varieties *viz*., BRRI dhan28, Bera Ratna and Kajol Lata. Eleven weed species belonging to five families infested the experimental plots; *Cyperus esculentus* and *Imperata cylindrica* were the most dominant. The effect of weeding regime on weed density (except at 20 DAS) and weed dry weight showed significant difference. The plant height increased gradually with increasing weeding regime. The results indicated that three hand weedings at 20, 35 and 50 DAS produced the highest number of effective tillers hill^{-1}, number of filled grains panicle^{-1}, 1000-grain weight and grain yield. The results also showed that grain yield was higher in Bera Ratna than that of other two varieties.

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CHAPTER I

INTRODUCTION

Rice (*Oryza sativa* L.) is the leading cereal crop in the world and staple food crop in Bangladesh. About 80% of the total population depends on agriculture, specially on rice cultivation. Rice covers 76% of total cropped area with an average yield of 2.39 t ha^{-1} (Anonymous, 2004). It is extensively grown in aus, aman and boro seasons. Aus rice is an important cereal crop of Bangladesh. Direct-seeded aus rice covers about 1.53 million hectares of land (Anonymous, 1997) and contributes greatly to the national cereal production (Nasiruddin, 1993).

Weeds always grow in all crop fields throughout the world. It is often said that, "crop production is a fight against weeds" (Mukhopadhyay and Ghose, 1981). The infestation of weeds is one of the most constraints in the cultivation of crop (Gaffer, 1983; Mamun, 1988a). The prevailing climate and edaphic factors of Bangladesh are highly favorable for luxuriant growth of numerous species of weeds, which offer a keen competition with rice crop (Mamun, 1988b). Many investigators have reported a great loss in the rice yield due to weed infestation from different parts of the world (Nandal and Singh, 1994). Weed growth reduced the grain yield by 68-100% in direct-seeded aus rice, 16-48% in aman rice and 22-36% of modern boro rice (Mamun, 1990). The yield loss due to weed competition in direct-seeded aus rice is 60-90% in Bangladesh. This loss is, therefore, a serious threat to an agro-based country like Bangladesh. Therefore, proper weed management is essential for successful rice production in Bangladesh.

Subsistence farmers of the tropics spend more time and energy on weed control than any aspects of rice cultivation. Thus the best weeding regime

need to be adopted by the farmer with a view to reducing weed infestation and maximizing rice yield. Increasing the frequency of hand weeding one or two times at 20 and 40 days after sowing (DAS) was found to reduce the weed density and weed dry matter resulting in double grain yield (Anonymous, 1976).

Weed free period during the critical period of competition is essential for optimum rice yield. Three to six weeks weed free period from seeding is needed for better growth and yield of aus rice (Anonymous, 1977). In Bangladesh, weeds are traditionally controlled by hand weeding but it is time consuming, costly and becoming more difficult day-by-day due to scarcity of labours (Mamun *et al.*, 1986). So, the appropriate weeding regime should be found out.

Therefore, the present study was undertaken to achieve the following objectives:

- To find out the effect of weeding regime on the yield and yield components of aus rice;
- To optimize the time of weeding for obtaining higher yield of rice.

CHAPTER II

REVIEW OF LITERATURE

Weed is one of the major problems in the production of rice. In Bangladesh, weeds are traditionally controlled by hand weeding. Selection of appropriate weeding regime that can suppress the weed growth and consequently render better performance with regard to the quality and quantity of rice grains is, therefore, an important area of investigation. Reports on the effect of weeding regime on the yield of rice pertinent to this study are reviewed here.

Effect of weed density on rice

Domingues and coworkers (1982) observed that weed competition reduced the fresh and dry biomass, productive panicles and grain weight of rice cv. IC25. Iwata and colleagues (1983) reported that weed reduced growth and yield of rice. The authors further reported that the competition of light and nitrogen was a major factor in crop-weed competition. Rice yield decreased as the density of *Echinochloa crusgalli* increased.

Karim and Mamun (1988) reviewed the research work on the crop weed competition and reported that the main cause of losses was the competition of weed. Most of the plant parameters including plant height, number of tillers, number of panicles and grain weight are affected by weed competition. The competitive ability of weed was governed by plant growth characteristics, rate and time of emergence, density and duration of association with the crops.

Shad and Khan (1988) reported that competition between rice (cv. Basmati370) and the weed *E. crusgalli, F. littoralis* and *Sagittaria guayanensis* caused significant yield reduction. The authors reported that when the weeds were not controlled within six weeks or until harvest rice yield significantly declined. They also observed that among the infesting species of weed the biomass production m^{-2} was the greatest in *E. crusgalli* and this weed exerted the most harmful effect on rice yield.

Fischer and colleagues (1992) studied the critical period of rice-weed competition for the rice cultivar Oryzica I and CICA8. They found the weed species *E. crusgalli, E. colonum, E. indica, C. difformis, C. iria, C. esculentus* and *Eclipta alba* as the major weeds. The authors found that competitive effects from these weeds were similar for the both the cultivars. Weed emerging simultaneously with the crop seedling were the most damaging ones. Rice yield increased as the duration of weed free period extended.

Effect of weeds on plant characters of rice

Wayan and coworkers (1982) reported that rice plant parameters such as plant height, number of effective tillers $hill^{-1}$, panicle length, number of grains and sterile spikelets $panicle^{-1}$ and grain weight were affected by weed competition resulting in loss of crop yield.

Ghobrial (1983) found that unrestricted weed growth decreased the number of tillers and panicles m^{-2} and the number of filled grains $panicle^{-1}$. Shelka and colleagues (1985) observed that weed free condition up to harvest gave the highest yield which was similar to the yield obtained in the plots kept free of weeds up to 30 and 45 DAS.

Biswas and colleagues (1991) reported that plant height was the shortest in control treatment than other treatments, but two hand weedings resulted the tallest plant. Singh and Ram (1991) found that mechanical weeding at 20 and 40 DAS in rice cv. Akashi increased the number of panicles m^{-2}, number of grains $panicle^{-1}$, 1000-grain weight and grain yield of rice.

Azmi and Mashhor (1992) observed that *E. crusgalli* at density of 15 and 25 plants m^{-2} significantly reduced the number of tillers of rice (cv. MR71) at maturity. Only 10 plants m^{-2} were required to cause yield reduction of about 18.7%. The number of *E. crusgalli* m^{-2} was also negatively correlated with the number of rice panicle m^{-2}. Weed competition during the first 15 DAS had no significant effect on rice yield, whereas competition beyond 15 DAS caused drastic reduction in rice grain yield. Grain yield of rice increased significantly with an increase in the duration of the weed free period.

Singh and Singh (1998) found that more than 60% reduction in grain yield of rice occurred in weedy plots when compared with weed free plots. Ahmed and coresearchers (2000) reported that the tallest plant was found on weed free treatment (107.89 cm) and shortest plant was found in weedy plots (78.58 cm) in aus rice.

Effect of hand weedings on weed infestation and performance of rice

BRRI (1976) reported that increasing the frequency of hand weeding one or two times at 20 and 40 DAS reduced the weed density and weed dry weight remarkably and doubled the grain yield. Legaspi and coworkers (1989) reported that unweeded crop produced highest weed dry weight and the lowest grain yield. The crop hand weeded twice (at 21 and 42 DAS) produced the lowest weed density and weed dry weight and the highest grain yield.

Kulmi (1990) concluded from field experiment that hand weeding methods resulted in lower weed density and dry weight and higher grain yield in comparison to herbicide treated plots. Biswas and colleagues (1991) conducted an evaluation trial of herbicides in direct seeded rice in Bangladesh. Effect of herbicides was compared with that of hand weeding at three locations. They found that hand weeding was superior to chemicals.

Abdel-Samie and El-Bially (1996) found that the most effective weed control treatment was 3 hand weedings. Rafiquddaulla (1999) observed that weed dry weight at 20, 40 and 60 DAS was significantly affected by the weeding regimes. No weeding regimes produced the highest weed density and weed dry weight. Maximum number of effective tillers, panicle length, filled grains panicle^{-1}, grain yield and straw yield were obtained from the weed free condition which was similar to three weedings. Maximum non-effective tillers and unfilled grains panicle^{-1} were found from no weeding.

Sharma and Bhunia (1999) observed that two hand weedings significantly reduced the weed biomass and improved the grain yield of aus rice. Hossain (2000) studied the effect of different weed control treatments in rice as one hand weeding, two hand weedings, three hand weedings, Ronstar, Ronstar + hand weeding. He observed that yield and yield contributing characters increased with the increase in frequency of hand weeding.

Effect of weeding regime on the yield of rice

Smith (1977) conducted an experiment in Bihar Agricultural College Farm to find out the mechanical weed control in direct seeded upland rice. He added that unweeded weed population obtain 102.99 g dry matter of weed m^{-2} and grain yield was 1917 kg ha^{-1} and two hand weedings at 20 DAS and 40 DAS obtained 19.42 g dry matter of weed m^{-2} and grain yield was 2999

kg ha^{-1}. He concluded that two hand weedings were the best obtaining maximum yield.

Dexit and colleagues (1981) carried out an experiment comprising 8 weed control treatments and stated that hand weeding twice gave the highest rice yield of 4.51 t ha^{-1} followed by propanil + 1 hand weeding (3.1 t ha^{-1}). Manipon and coworkers (1981) conducted an experiment on rice cv. IR36 and IR40 to evaluate the weed control treatments. Results showed that grain yield of IR36 were the highest (2.23 t ha^{-1}) with 3 hand weedings compared with hand weeding once (1.37 t ha^{-1}). The authors suggested that 3 weedings were better for obtaining maximum yield.

Ali (1985) revealed that in direct seeded upland rice, weed free condition from 0 to 20 DAS gave similar results to the unweeded condition. He also observed that critical crop-weed competition period was between 20 to 60 DAS. The recommended three weedings were at 20, 40 and 60 DAS. Bhan and coworkers (1985) reported that manual removal of weeds twice at 15 and 30 DAS, at 15 and 45 DAS and at 30 and 45 DAS and thrice at 15, 30 and 45 DAS resulted in significant decrease in population and dry matter of weeds at subsequent stages of rice growth. Maximum reduction in weed infestation was recorded from weedings at 15 and 45, 30 and 45, and 15, 30 and 45 DAS.

Shelka and colleagues (1985) observed that weed free condition up to harvest gave the highest yield which was similar to the yields obtained in the plots kept free of weeds up to 30 and 45 DAS. These treatments gave significantly higher yield than the weed free condition upto 15 DAS. The authors concluded that critical period for crop weed competition in upland rice was between 15 to 30 DAS. Senthong (1986) stated that in direct

seeded rice cv. R. D. 7 hand weeding once at 25 DAS and hand weeding twice at 25 and 45 DAS and control treatments gave grain yield of 4.61, 5.65 and 3.69 t ha^{-1}, respectively. Plant height was 78.2, 78.4 and 74.5 cm, respectively and number of weeds, 0.25 m^{-2} was 42.5, 20.0 and 47.7, respectively.

Mishra and colleagues (1987) conducted an experiment at different weeding regimes (20, 40 and 60 DAS, weed free and no weeding) in direct seeded rice. They reported that hand weeding twice at 20 and 40 DAS, weed free and weedy control, grain yield was 1.86, 1.96 and 0.96 t ha^{-1}, respectively and weed dry weight was 93.8, 10.8 and 217.5 g m^{-2}, respectively. Nayak and Lenka (1989) stated that in direct seeded rice crop, weed control by hand weeding (25 and 45 DAS) gave slightly higher yield than weed control with beshan (cross cultivation in the young crop once or twice in standing water and ladder) + 1 hand weeding.

Singh and Ram (1991) reported that mechanical weeding (20 and 40 DAS) for the control of weeds (mostly *Echinochloa colonum, Cyperus rotundus, Agenatum conyzoides* and *Eclipta alba*) in rice cv. Akashi, increased the number of panicle m^{-2} (from 153 to 199-221), number of grains $panicle^{-1}$ (from 90.9 to 98.4-107.7), the 1000-grain weight (from 19.4 to 20.13- 21.23 g) and the grain yield (from 725 to 1383- 1580 kg ha^{-1}) of rice. Dwivedi and colleagues (1991) conducted an experiment to evaluate the manual weed control once 30 DAS or twice 30 and 60 DAS and pre-emergence Benthiocarb at 1.5 kg ha^{-1} in rice cv. IET. 7564. Manual weeding twice and Benthiocarb + manual weeding once resulted in the greatest weed control. The greatest grain yield (1.35-1.37 t ha^{-1}) was obtained when manual weeding was conducted twice.

Saxena and Vaishya (1993) reported that hand weeding once 20 or 40 DAS and twice at 20 and 40 DAS for weed control in rice cv. Saket-4 resulted in decreased weed dry weight and increased grain yield compared with untreated control values of 17.699 g m^{-2} and 121 kg ha^{-1} to 7.46- 11.45 g and 2433- 3611 kg, respectively. Hand weeding twice resulted in the highest weed control and grain yield. Rajsakhar and coworkers (1994) stated that hand weeding at 15, 25 and 35 DAS resulted in a significantly lower weed population (10.3 weeds m^{-2}) and dry weight (6.39 g m^{-2}). Use of the twin wheeled hoe, peg type dry land weeded and bindha + hand weeding reduced weed dry weight and increased rice grain yield.

Alam and colleagues (1995) studied that in direct seeded upland rice cv. BR14 the first 25-55 DAS were found to be critical crop-weed competition period. They reported that the highest grain yield (3.39 t ha^{-1}) was obtained when the crop was kept weed free for the first 65 DAS, whereas the grain yield (0.19 t ha^{-1}) was obtained in the absence of any weeding. Naseem and colleagues (1995) studied BR 21 which was hand weeded at 20 and 40 DAS or 20, 40 and 60 DAS. Grain yield increased due to 2 or 3 hand weedings (2.21 t ha^{-1}) compared with control (0.96 t ha^{-1}).

Singh and Pillai (1996) conducted an experiment by using seven short duration rice cultivars, which were grown in the wet season of 1988-89 in Rajendranagar, Andra Pradesh. They stated that crops were hand weeded at 20 and 40 DAS. Compared with unweeded controls, weed control treatment decreased weed dry weight of 65.3-68.7%, and mean grain yield was 1.04 t ha^{-1} without weed control and 2.17-2.25 t ha^{-1} with weed control treatments. Among the cultivars yield ranged from 1.61 t ha^{-1} in cv. IET 9975 to 2.18 t ha^{-1} in IET 9830.

Patel and colleagues (1998) reported that when the weeds were allowed to grow with the crop, grain yield was reduced by about 48.6%. The highest weed population (192 m^{-2}) and dry weight of weed (246.5 g m^{-2}) were observed in the unweeded check at 45 DAS. Maximum grain yield of rice (4909 kg ha^{-1}) was recorded with two hand weedings at 25 and 45 DAS.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna during the period from May to September, 2007. The details of materials used and methods followed in the investigation are described in this chapter.

The experimental site was selected on the eastern side of the university campus. The field was medium high land with clay soil. The physical and chemical characteristics of the soil of the experimental field have been presented in Appendix 1. The weather conditions during the study period (May - September, 2007) have been presented in Appendix 2.

The experiment was laid out in a Factorial Randomized Complete Block Design (RCBD) with three replications. The experimental treatment consisted of three varieties of rice and four weeding regime.

Factor A. Variety

1. BRRI dhan28 (V_1)
2. Bera Ratna (V_2)
3. Kajol Lata (V_3)

Factor B. Weeding regime

1. No weeding (W_1)
2. One hand weeding at 35 DAS (W_2)
3. Two hand weedings at 20 and 35 DAS (W_3)
4. Three hand weedings at 20, 35 and 50 DAS (W_4)

There were 36 plots in the experiment and the size of unit plot was 4.0 m × 2.5 m. Distance between two blocks was 1.0 m and between plots was 0.5 m.

The land was prepared thoroughly by tilling twice with power tiller and subsequently ploughing one time with country plough followed by laddering. All weeds, stubble and crop residues were removed and the field was divided into unit plot according to the design. Then the field was made ready for sowing.

According to the BRRI recommendation urea, triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate were applied at the rate of 150, 50, 75, 35 and 5 kg ha^{-1}. The whole amount of TSP, MP, gypsum and zinc sulphate were applied as basal dose in the unit plot at the time of final land preparation and they were thoroughly incorporated to soil with the help of spade. Urea was top dressed in two equal splits at 25 and 45 DAS.

Seeds were sown at the rate of 5-6 seeds $hill^{-1}$ maintaining a spacing of 20 cm from hill to hill and 25 cm from row to row. After germination, seedling(s) was thinned maintaining 3 seedlings $hill^{-1}$. Gap filling was done where it was required.

The experimental plots were irrigated as and when necessary and excess water was drained out at the time of heavy rainfall. Weeding was done as per the experimental treatments. Pest control practices were carried out as and when necessary.

Different varieties matured at different dates. The experimental crops were harvested plot-wise at full maturity stage by cutting the whole plants at the

ground level with sickle. It was then threshed, cleaned and processed to record the relevant data in respect of the experimental requirement.

Data collection

Data were collected on the following heads at different dates as per experimental requirement:

A. Weed parameters

1. Weed density

Weed density was collected from each plot at 20, 35 and 50 DAS by using 1m × 1m quadrate. The quadrate was placed in two spots at random keeping $1m^2$ area in the middle of each plot for taking yield data. It was calculated as no. m^{-2}.

2. Weed dry weight

After counting the weed density, the collected weeds were dried in an electric oven for 72 hours at a temperature of 70°C. It was calculated as g m^{-2}.

B. Crop parameters

For convenience of observation on the crop characters except the grain and straw yields with harvest index, data were collected from 5 randomly selected hills from each of the plots. The sample hills were uprooted prior to harvest and then sun dried. Data on crop characters were then collected as follows.

1. Plant height (cm)

Plant height was measured with the help of a meter scale from the ground level to the tip of the uppermost leaf. Plant height had taken at 15 days interval starting from 14 DAE.

2. Number of tillers $hill^{-1}$

Both ear bearing and non-bearing tillers $hill^{-1}$ were counted.

3. Number of effective tillers hill^{-1}

The tillers bearing even a single spikelet were considered.

4. Panicle length (cm)

Panicle length was measured from the neck-node of the rachis to the tip of the upper most spikelet.

5. Number of grains panicle^{-1}

Number of filled grains panicle^{-1} and unfilled grains panicle^{-1} were recorded separately.

6. Thousand-grain weight (g)

One thousand grains were randomly counted from 5 sample hills of each plot and their weight was taken by an electric balance at 14% moisture level.

7. Grain yield and straw yield (t ha^{-1})

Grain yield and straw yield were determined by harvesting an area of m^{-2} pre-fixed at the centre of each unit plot.

8. Biological yield (t ha^{-1})

Biological yield was calculated by the following formula:

Biological yield = Grain yield + Straw yield

9. Harvest index (%)

Harvest index was calculated using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

Data were statistically analyzed using the "Analysis of variance" technique with the help of statistical computer package MSTAT-C. The mean differences were compared by Duncan's Multiple Range Test (Gomez and Gomez, 1984). Functional relationships between yield and yield components were done using simple regression analysis.

CHAPTER IV

RESULTS AND DISCUSSION

This chapter presents results of this study along with discussion. The results include effect of three rice varieties and four weeding regime and their interaction on crop characteristics including yield and yield components of aus rice.

Weed species

Weeds found in aus rice field are sedges, grasses and semi-aquatic which can withstand waterlogging and usually enough to depress crop yield very significantly if not timely controlled. Conditions favorable for growing aus rice are also favorable for the prolific growth of a number of weed species that compete with crop plants. The results on weed infestation in this study are presented below:

The experimental plots were infested with eleven weed species belonging to five families (Table 1). Four weed species were of the family Gramineae, three of the family Cyperaceae, two of the family Euphorbiaceae and one each of the family Scrophulariaceae and Tiliaceae. The most important weed infesting species were holde mutha (*Cyperus esculentus*), ulu (*Imperata cylindrica*), durba (*Cynodon dactylon*), khude shama (*Echinochloa colonum*), joina (*Fimbristylis miliacea*) and dadkuri (*Paspalum conjugatum*).

Table 1. Infesting species of weed in the experimental field of aus rice

Sl. no.	Local name	Botanical name	Family
1	Durba	*Cynodon dactylon*	Gramineae
2	Khude shama	*Echinochloa colonum*	Gramineae
3	Joina	*Fimbristylis miliacea*	Cyperaceae
4	Holde mutha	*Cyperus esculentus*	Cyperaceae
5	Boro chucha	*Cyperus iria*	Cyperaceae
6	Ulu	*Imperata cylindrica*	Gramineae
7	Bon morich	*Croton sparsiflorus*	Euphorbiaceae
8	Chhoto dudhia	*Euphorbia parviflora*	Euphorbiaceae
9	Sada panighas	*Lindernia antipoda*	Scrophulariaceae
10	Dadkuri	*Paspalum conjugatum*	Gramineae
11	Bonpat	*Corchorus acutangulus*	Tiliaceae

Weed density

Weed density was significantly influenced by weeding regime except at 20 DAS (Table 2). At 20 DAS, numerically the highest weed density (152.61) was found in W_1 treatment and the lowest (145.28) in W_3 treatment. At 35 DAS, the maximum weed density (84.28) was obtained in W_1 treatment which was statistically similar to W_2 treatment. At 50 DAS, the highest weed density (80.56) was produced by W_1 treatment which was statistically different from the weed density obtained from other weeding regime. This finding was similar to that of Rafiquddaulla (1999). He observed that unweeded crop was found to produce the highest weed density. This might be maximum competition thrust from the weeds to the rice plants.

Weed dry weight (g)

Weed dry weight was significantly affected by weeding regime (Table 2). At 20 DAS, the highest weed dry weight (28.54 g) was obtained in W_1 treatment which was statistically identical to W_2 treatment. At 35 DAS, the maximum weed dry weight (15.99 g) was obtained in W_1 treatment which was statistically similar to W_2 treatment. At 50 DAS, the highest weed dry weight (8.72 g) was produced by W_1 treatment and the lowest (3.58 g) was produced by W_4 treatment which was statistically similar to W_3 treatment. Rafiquddaulla (1999) observed similar results. He observed that unweeded crop was found to produce the highest weed dry weight.

Plant height (cm)

The effect of weeding regime on plant height of aus rice was significant in different sampling dates except at 24 DAS. Plant height increased

Table 2. Effect of weeding regime on weed density and weed dry weight of aus rice

Weeding regime	Weed density (no. m^{-2}) at			Weed dry weight (g) at		
	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS
W_1	152.61	84.28a	80.56a	28.54a	15.99a	8.72a
W_2	147.06	80.39a	68.89b	27.90a	15.14a	4.95b
W_3	145.28	65.44b	57.17c	26.72b	12.13b	3.88c
W_4	149.94	62.78b	53.00d	26.01b	11.33b	3.58c
Level of significance	NS	**	**	**	**	**
CV (%)	8.60	4.17	3.49	2.21	4.45	6.84

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly.
NS : Not significant and ** Significant at 1% level of probability

W_1 : No weeding

W_2 : One hand weeding at 35 DAS

W_3 : Two hand weedings at 20 and 35 DAS

W_4 : Three hand weedings at 20, 35 and 50 DAS

gradually over time reaching the maximum at maturity. However, at harvest the tallest plant (101.20 cm) was found in W_4 treatment, which was statistically similar to W_3 treatment and the shortest plant (72.44 cm) was obtained from W_1 treatment (Fig. 1). Results disclosed that weed competition was severe in no weeding condition and hence plant height was reduced. On the other hand, weed density was less in three hand weedings at 20, 35 and 50 DAS and thus the plant height was increased.

Plant height differed significantly among the varieties at 84 DAS and harvest. Plant height was greater in V_3 (93.20 cm) treatment than that of other two varieties (Fig. 2). The results revealed that variety had a great influence on plant height and it was due to their genetic make up.

The interaction effect of variety and weeding regime was not significant on plant height except at harvest. Overall, the tallest plant (106.00 cm) was found in the combination of V_3W_4 and the shortest plant (71.23 cm) was obtained from the combination of V_2W_1 (Table 3).

Number of total tillers hill^{-1}

Total tillers hill^{-1} increased markedly due to three hand weedings at 20, 35 and 50 DAS. Results showed that tillers produced at W_2 and W_3 treatments were statistically similar. More number of tillers hill^{-1} (13.53) was obtained from W_4 treatment which was statistically different from other weeding regime (Table 4). Results revealed that effective weed management enhanced tiller production.

From the study it was found that the varietal differences on number of tillers hill^{-1} were significant. The number of tillers hill^{-1} in V_1 (10.33) treatment

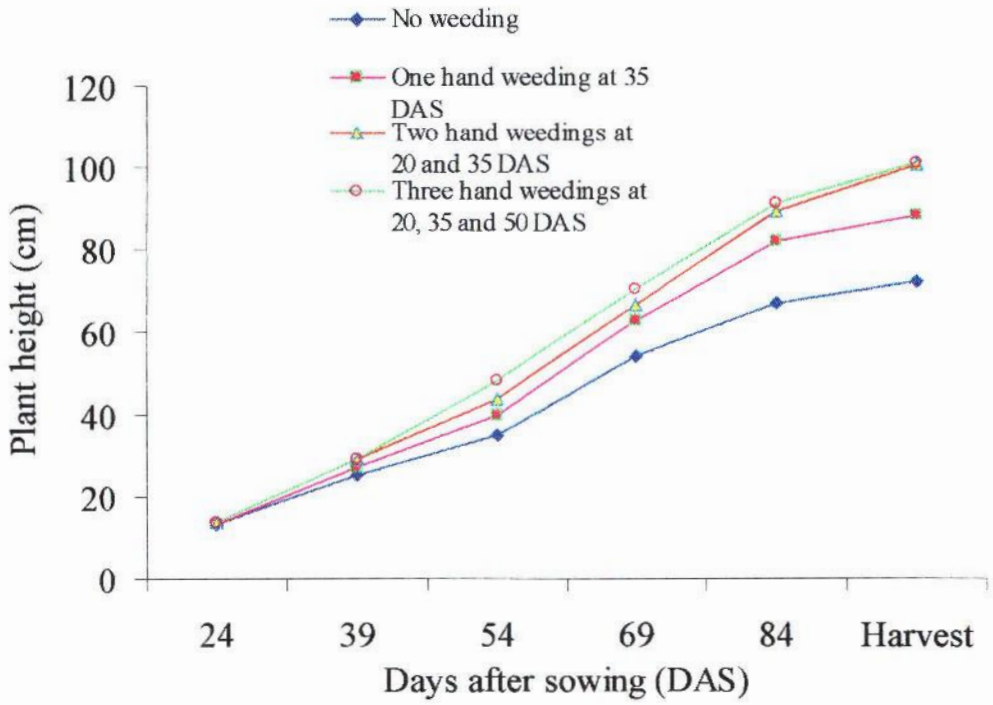

Fig. 1. Effect of weeding regime on plant height of aus rice

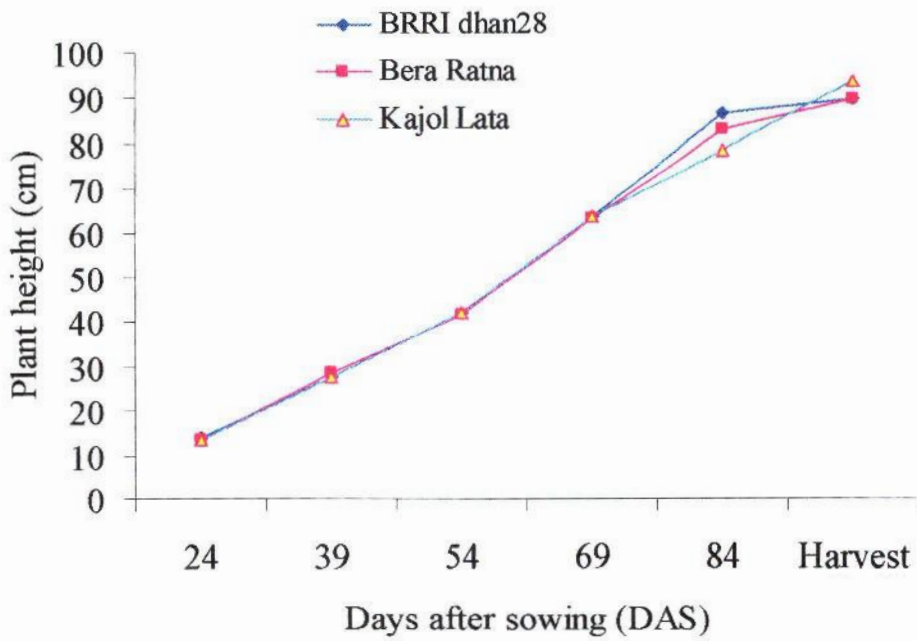

Fig. 2. Varietal differences in plant height of aus rice

was lower than those of other varieties (Table 5). These differences might be due to genetic make up of the variety.

Number of tillers hill^{-1} was significantly affected by the interaction between variety and weeding regime. The more number of tillers hill^{-1} (13.73) was found in the combination of V_2W_4 which was statistically different from other combinations (Table 6).

Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} was significantly affected by weeding regime. The highest number of effective tillers hill^{-1} (12.53) was obtained from W_4 treatment and the lowest number (3.76) was found in W_1 treatment (Table 4). Similar results were reported by Hossain (2000). He found that increasing weeding regime increased the number of effective tillers hill^{-1}. In respect of producing effective tillers hill^{-1}, no weeding was significantly inferior to rest of the treatments. This was due to the fact that in the control treatment, the crop failed to produce more tillers due to severe competition from weeds for growth resources.

The varietal differences in number of effective tillers hill^{-1} were significant. Numerically the number of effective tillers hill^{-1} in V_3 (9.55) was higher than that of other varieties (Table 5). The probable reason of variation in producing effective tillers hill^{-1} might be primarily due to genetic make up of the variety which was influenced by environment.

The combined effect of variety and weeding regime was significant for number of effective tillers hill^{-1}. The highest (12.67) and lowest (3.47)

Table 4. Effect of weeding regime on the yield and yield components of aus rice

Weeding regime	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
W_1	5.42c	3.76d	16.33c	45.23c	18.18ab	20.34d	1.05c	2.13c	49.22b
W_2	12.00b	9.80c	19.43b	65.67b	19.29a	20.99c	2.60b	5.18b	50.10b
W_3	12.40b	11.53b	21.85a	92.66a	18.01ab	21.39b	4.26a	7.36a	57.95a
W_4	13.53a	12.53a	21.72a	94.67a	17.65b	21.69a	4.38a	7.53a	58.20a
Level of significance	**	**	**	**	**	**	**	**	**
CV (%)	2.98	3.04	1.63	2.63	4.16	0.51	2.68	2.29	1.89

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly.

** Significant at 1% level of probability

W_1 : No weeding

W_2 : One hand weeding at 35 DAS

W_3 : Two hand weedings at 20 and 35 DAS

W_4 : Three hand weedings at 20, 35 and 50 DAS

Table 5. Varietal differences in the yield and yield components of aus rice

Variety	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BRRI dhan28	10.33b	9.20	20.69a	80.65a	17.15b	22.61b	3.06b	5.52b	54.12ab
Bera Ratna	11.13a	9.47	18.69c	67.79c	17.93b	23.23a	3.20a	5.93a	52.51b
Kajol Lata	11.05a	9.55	20.12b	75.24b	19.77a	17.47c	2.94b	5.20c	54.98a
Level of significance	**	*	**	**	**	**	**	**	**
CV (%)	2.98	3.04	1.63	2.63	4.16	0.51	2.68	2.29	1.89

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly.
** Significant at 1% level of probability and * Significant at 5% level of probability

Table 6. Interaction effect of variety and weeding regime on yield and yield components of aus rice

Variety × weeding regime	Total tillers hill^{-1}	Effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1W_1	5.27g	3.47f	15.40h	44.84h	16.93	21.96f	1.05f	2.10g	49.81
V_1W_2	10.40e	9.07e	20.99c	73.92f	18.73	22.53e	2.70d	5.29e	50.91
V_1W_3	12.47cd	11.67c	22.99a	98.66b	16.79	22.84d	4.18bc	7.24bc	57.77
V_1W_4	13.20ab	12.60a	23.37a	105.20a	16.13	23.09c	4.32b	7.44b	57.98
V_2W_1	5.87f	3.87f	16.11g	44.87h	17.81	22.75d	1.06f	2.24g	47.59
V_2W_2	12.13d	9.40e	17.99f	60.39g	18.98	23.04c	2.67d	5.39e	49.49
V_2W_3	12.80bc	11.93bc	20.54cd	85.29d	17.67	23.43b	4.50a	7.98a	56.33
V_2W_4	13.73a	12.67a	20.13d	80.63e	17.26	23.71a	4.58a	8.09a	56.63
V_3W_1	5.13g	3.93f	17.48f	45.99h	19.79	16.31j	1.03f	2.05g	50.25
V_3W_2	13.47a	10.93d	19.32e	62.71g	20.17	17.40i	2.42e	4.85f	49.91
V_3W_3	11.93d	11.00d	22.02b	94.03c	19.57	17.91h	4.09c	6.85d	59.76
V_3W_4	13.67a	12.33ab	21.66b	98.23b	19.54	18.28g	4.23bc	7.05cd	60.00
Level of significance	**	**	**	**	NS	**	**	**	NS
CV (%)	2.98	3.04	1.63	2.63	4.16	0.51	2.68	2.29	1.89

In a column figures having similar letter (s) do not differ significantly whereas figures with dissimilar letter (s) differ significantly.

** Significant at 1% level of probability and NS : Not significant

V_1: BRRI dhan28

V_2: Bera Ratna

V_3: Kajol Lata

W_1: No weeding

W_2: One hand weeding at 35 DAS

W_3: Two hand weedings at 20 and 35 DAS

W_4: Three hand weedings at 20, 35 and 50 DAS

number of effective tillers hill^{-1} were found in V_2W_4 and V_1W_1 treatments, respectively (Table 6).

Regression analysis taking effective tillers hill^{-1} as dependent variable and weeding regime as independent variable showed a linear and positive relationship in all the three rice varieties (Fig. 3). The three regression models obtained are -

Effective tillers hill^{-1} (V_1) = 4.704 + 2.999 × weeding regime (R^2 = 0.8903)

Effective tillers hill^{-1} (V_2) = 5.128 + 2.893 × weeding regime (R^2 = 0.8781)

Effective tillers hill^{-1} (V_3) = 5.757 + 2.527 × weeding regime (R^2 = 0.737)

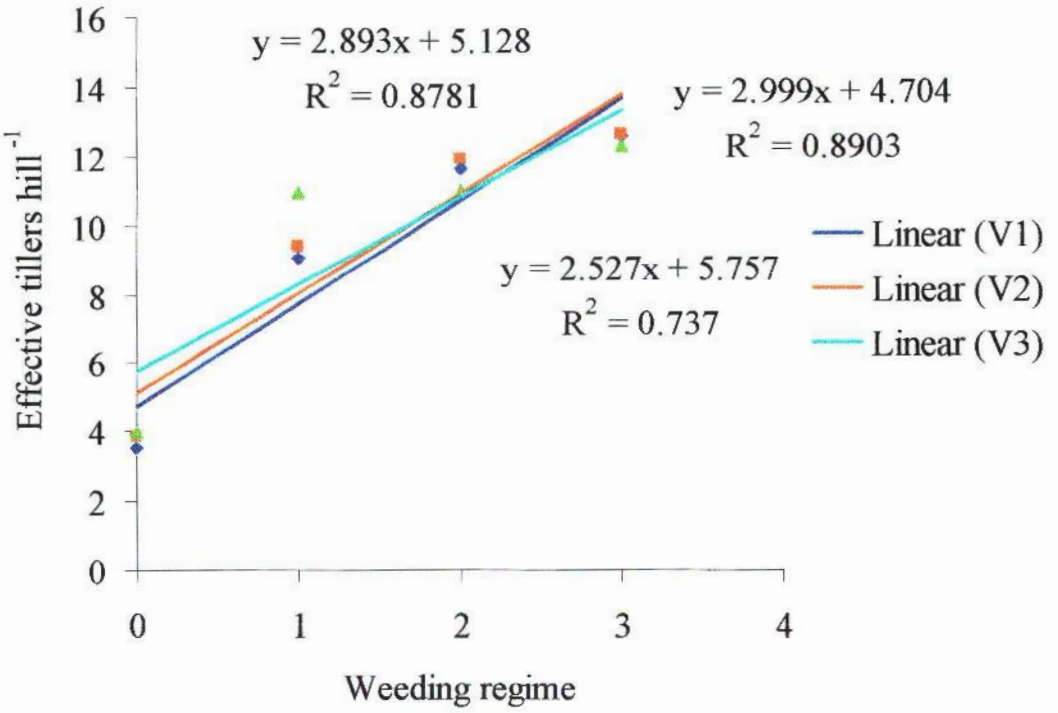

Fig. 3. Functional relationship between weeding regime and effective tillers hill^{-1} in rice varieties

V_1: BRRI dhan28
V_2: Bera Ratna
V_3: Kajol Lata

0 : No weeding
1 : One hand weeding at 35 DAS
2 : Two hand weedings at 20 and 35 DAS
3 : Three hand weedings at 20, 35 and 50 DAS

Regression analysis between effective tillers hill^{-1} and grain yield revealed that grain yield is highly dependent on effective tillers hill^{-1} and about 90% (R^2 = 0.8967) of the variation in grain yield could be explained by the variation in effective tillers hill^{-1} (Fig. 4).

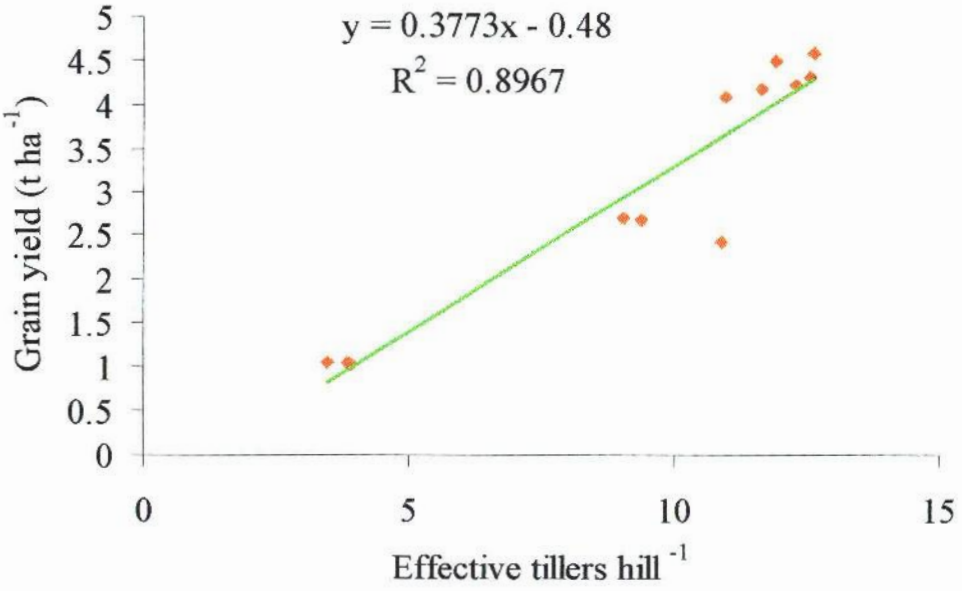

Fig. 4. Functional relationship between effective tillers hill^{-1} and grain yield (t ha^{-1}) in aus rice

Panicle length (cm)

Panicle length was significantly influenced due to weeding regime. Results indicated that W_3 and W_4 treatments were statistically similar. The shortest panicle (16.33 cm) was obtained from W_1 treatment which was statistically different from the panicle length obtained at other weeding regime (Table 4). Results revealed that better weed management increased panicle length.

Significant differences in panicle length were found among the varieties. The panicles were longer in V_1 (20.69 cm) than the other varieties (Table 5). This difference might be due to genetic make up of the variety.

Interaction effect of variety and weeding regime was significant on panicle length. However, the longest panicle (23.37 cm) was obtained from V_1W_4 treatment which was significantly different from the panicle length obtained from other combinations (Table 6).

Number of filled grains panicle^{-1}

From the study it was found that the effect of weeding regime on number of filled grains panicle^{-1} was significant. Results showed that grains produced at W_3 and W_4 treatments were statistically identical. The highest number of filled grains panicle^{-1} (94.67) was found from W_4 treatment and the lowest number (45.23) was recorded in W_1 treatment (Table 4). Similar results were reported by Hossain (2000) and Rafiquddaulla (1999). They found that filled grains panicle^{-1} increased with increasing weeding regime. These results indicated that high weed infestation in control treatment hampered the production of filled grains panicle^{-1}. The reason might be high weed density competed for nutrients and other growth enhancing requirements along with rice plants and their impact resulted in fewer filled grains panicle^{-1}.

The varietal differences on number of filled grains panicle^{-1} was found significant. The number of filled grains panicle^{-1} in V_1 (80.65) was higher than that of other varieties (Table 5). Results revealed that number of filled grains panicle^{-1} differed due to their genetic differences.

Number of filled grains panicle^{-1} was significantly affected by interaction between variety and weeding regime. The highest number of filled grains panicle^{-1} (105.20) was found in the combination of V_1W_4 and the lowest number (44.84) in the combination of V_1W_1 (Table 6).

Filled grains panicle^{-1} showed a linear and positive relationship with weeding regime for all the three varieties (Fig. 5). The regression models can be developed for the three varieties as

Filled grains panicle^{-1} (V_1) = 49.782 + 20.582 × weeding regime (R^2= 0.93)

Filled grains panicle^{-1} (V_2) = 47.968 + 13.218 × weeding regime (R^2= 0.83)

Filled grains panicle^{-1} (V_3) = 47.034 + 18.804 × weeding regime (R^2= 0.93)

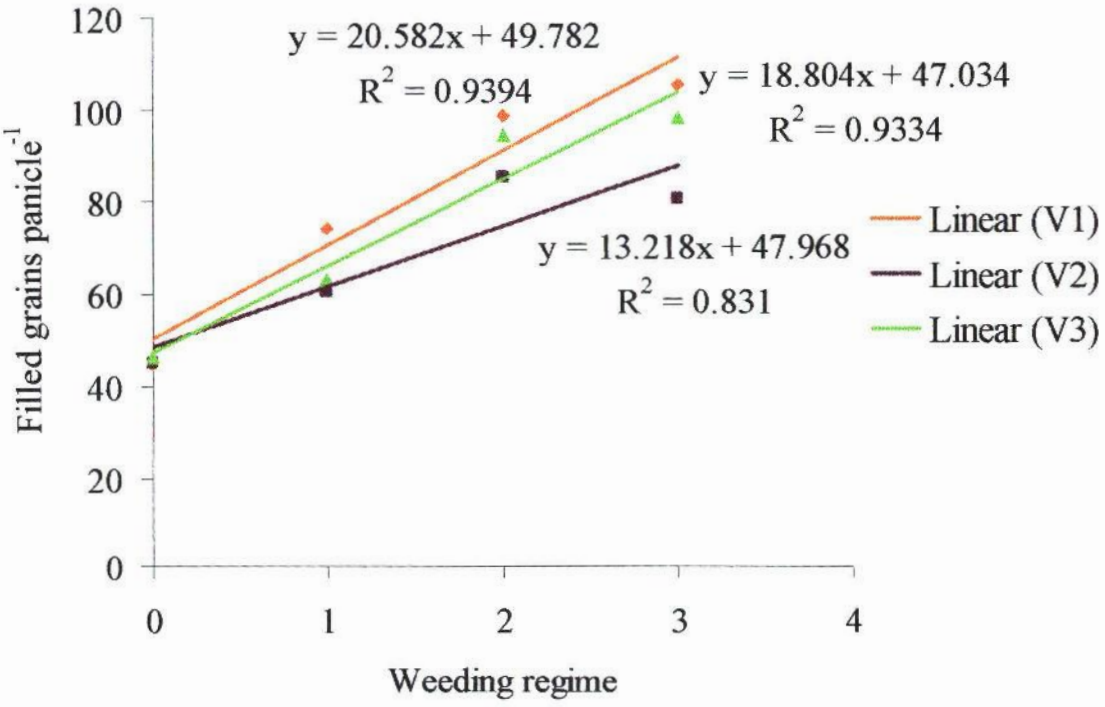

Fig. 5. Functional relationship between weeding regime and filled grains panicle^{-1} in rice varieties

V_1: BRRI dhan28 — 0 : No weeding

V_2: Bera Ratna — 1 : One hand weeding at 35 DAS

V_3: Kajol Lata — 2 : Two hand weedings at 20 and 35 DAS

3 : Three hand weedings at 20, 35 and 50 DAS

Plotting grain yield against number of filled grains panicle^{-1} yielded straight lines. This indicates that grain yield increased with the increment of filled grains panicle^{-1}. The value of R^2 (0.8663) revealed that over 85% of the

variation in grain yield could be explained by the variation in number of filled grains panicle^{-1}(Fig. 6).

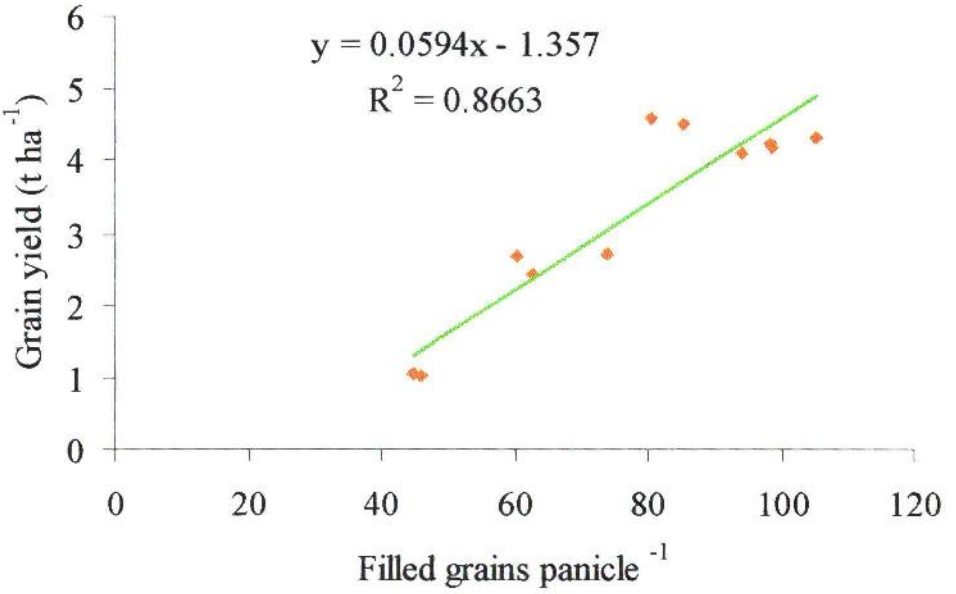

Fig. 6. Functional relationship between filled grains panicle^{-1} and grain yield (t ha^{-1}) in aus rice

Number of unfilled grains panicle^{-1}

Number of unfilled grains panicle^{-1} varied significantly by weeding regime. The highest number of unfilled grains panicle^{-1} (19.29) was produced from W_2 treatment and the lowest number (17.65) from W_4 treatment (Table 4).

The varietal differences on number of unfilled grains panicle^{-1} were significant. In V_3 number of unfilled grains panicle^{-1} (19.77) was higher than that of other treatments (Table 5).

Number of unfilled grains panicle^{-1} did not vary significantly due to interaction between variety and weeding regime. Numerically the highest number of unfilled grains panicle^{-1} (20.17) was produced from V_3W_2

treatment combination and the lowest number (17.65) from V_1W_4 treatment combination (Table 6).

Thousand-grain weight (g)

Thousand-grain weight was significantly affected by weeding regime. The heaviest grain (21.69 g) was found from W_4 treatment which was statistically different from the grain weight obtained at other weeding regime. The lowest grain weight (20.34 g) was found in W_1 treatment (Table 4). Similar findings were reported by Rafiquddaulla (1999). Results revealed that thousand-grain weight decreased as the frequency of weeding regime decreased. This might be due to severe competition from the uncontrolled weeds with the crop plants for nutrient, air, space, light, water and other growth requirements as a result size of rice grain became smaller.

Significant differences in thousand-grain weight were found among the varieties. Thousand-grain weight in V_2 (23.23 g) was greater than that of other varieties (Table 5). This variation was due to grain size of the individual variety.

Interaction effect between variety and weeding regime was significant on thousand-grain weight. The heaviest grain (23.71 g) was found from V_2W_4 treatment combination which was statistically different from the grain weight obtained at other treatment combinations (Table 6).

Grain yield (t ha^{-1})

From the study it was found that grain yield was significantly influenced by weeding regime. The highest grain yield (4.38 t ha^{-1}) was obtained from W_4 treatment, which was statistically identical to W_3 treatment. The lowest grain yield (1.05 t ha^{-1}) was found in W_1 treatment (Table 4). These findings were similar to that of Naseem and colleagues (1995), Hossain (2000), Manipon and coworkers (1981) and Rafiquddaulla (1999). They found that grain yield increased with the increment of weeding regime. The weeds competed with the crop for growth factors thus reducing yield. This might be due to the fact that the weeding kept the land clean and soil was well aerated which facilitated the crop for better absorption of nutrients, moisture and solar radiation for higher yield. Effective weed management enhanced number of effective tillers hill^{-1}, number of filled grains panicle^{-1} and 1000-grain weight which ultimately increased grain yield of rice. On the other hand, reduction of effective tillers hill^{-1}, filled grains panicle^{-1} and 1000-grain weight due to severe weed competition in the control treatment caused a reduction in the grain yield of rice. Therefore, direct seeded rice should be kept weed free till 50 DAS to obtain better yield.

Significant differences in grain yield were found among the varieties. However, the grain yield in V_2 (3.20 t ha^{-1}) was higher than that of other two varieties (Table 5). These yield differences were mainly due to differences of varieties in their genetic make up.

Grain yield was significantly influenced by interaction between variety and weeding regime. The highest (4.58 t ha^{-1}) and lowest (1.03 t ha^{-1}) grain yield was found in V_2W_4 and V_2W_3 treatment combinations, respectively (Table 6).

Simple linear regressions showed that grain yield was highly dependent on weeding regime in all the three rice varieties. Results indicated that yield of rice varieties increased with increment of weeding regime (Fig. 7). The regression equations obtained are -

Grain yield (V_1) = 1.369 + 1.129 × weeding regime (R^2 = 0.9089)

Grain yield (V_2) = 1.344 + 1.239 × weeding regime (R^2 = 0.9078)

Grain yield (V_3) = 1.252 + 1.127 × weeding regime (R^2 = 0.9197)

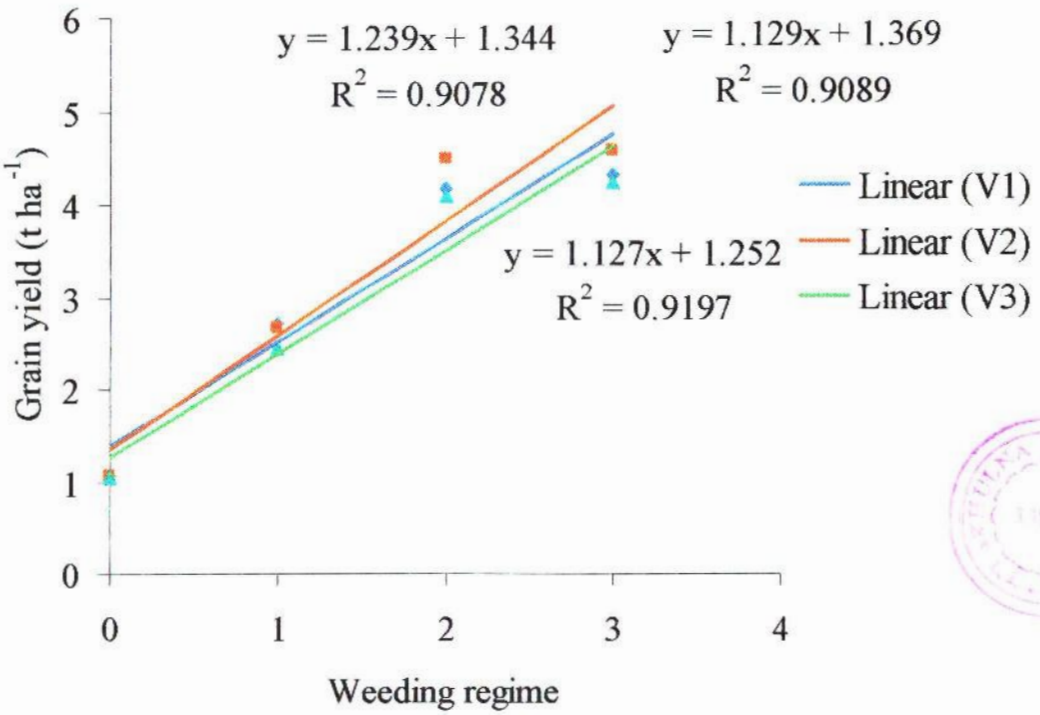

Fig. 7. Functional relationship between weeding regime and grain yield (t ha^{-1}) in rice varieties

V_1: BRRI dhan28

V_2: Bera Ratna

V_3: Kajol Lata

0 : No weeding

1 : One hand weeding at 35 DAS

2 : Two hand weedings at 20 and 35 DAS

3 : Three hand weedings at 20, 35 and 50 DAS

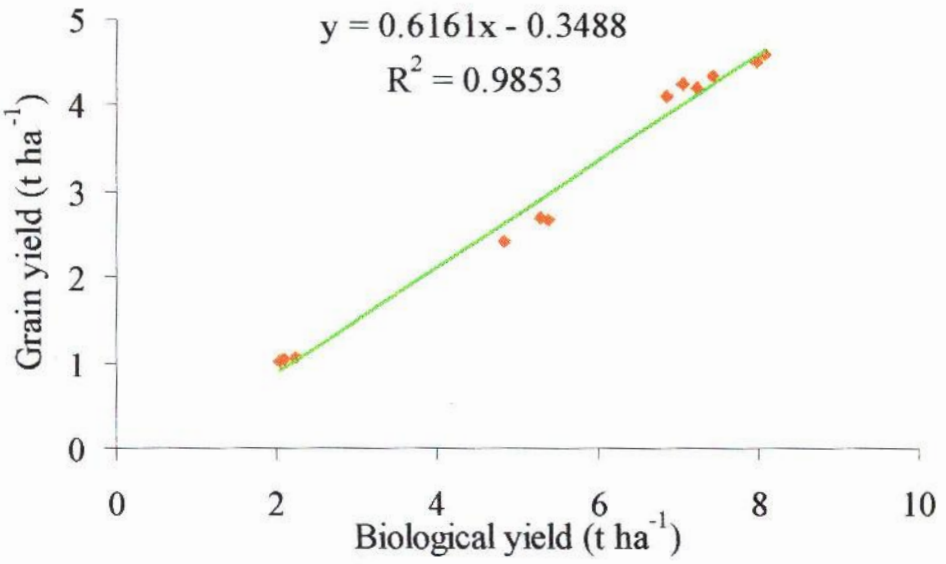

Fig. 8. Functional relationship between biological yield (t ha^{-1}) and grain yield (t ha^{-1}) in aus rice

Harvest index (%)

Harvest index was significantly influenced by weeding regime. The results of the present study showed that W_3 and W_4 treatments were statistically similar in respect of harvest index. However, the maximum harvest index (58.20%) was recorded from W_4 treatment and the minimum (49.22%) in W_1 treatment (Table 4).

The varietal differences on harvest index were also found significant. Harvest index in V_3 (54.98%) was higher than those of other varieties (Table 5).

The interaction effect between variety and weeding regime on harvest index was not significant. However, numerically the maximum harvest index (60.00%) was recorded from V_3W_4 treatment whereas the minimum harvest index (47.49%) was found in V_2W_1 treatment (Table 6).

CHAPTER V

SUMMARY AND CONCLUSION

A field trial was conducted at the Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna, during aus season, 2007 to find out the impact of weeding regime on the performance of aus rice. The experiment was laid out in a Factorial Randomized Complete Block Design (RCBD) with three replications. The experiment included four weeding regime and three rice varieties. The four weeding regime were no weeding (control), one hand weeding at 35 DAS, two hand weedings at 20 and 35 DAS and three hand weedings at 20, 35 and 50 DAS and three varieties were BRRI dhan28, Bera Ratna and Kajol Lata.

The land was well prepared and fertilized with urea, triple superphosphate (TSP), muriate of potash (MP), gypsum and zinc sulphate as per BRRI recommendations. The whole amount of TSP, MP, gypsum and zinc sulphate were applied as basal dose in the unit plot at the time of final land preparation and urea was top dressed in two equal splits at 25 and 45 DAS. Seeds were sown at the rate of 5-6 seeds $hill^{-1}$ maintaining a spacing of 20 cm from hill to hill and 25 cm from row to row. After germination, seedling(s) was thinned maintaining 3 seedlings $hill^{-1}$.

The experimental plots were infested with eleven weed species belonging to five families. *Cyperus esculentus* and *Imperata cylindrica* were the most dominant species recorded in the plots. The effect of weeding regime on weed density (except at 20 DAS) and weed dry weight was significant. The highest weed density and weed dry weight were observed in the control treatment and the lowest weed density (except at 20 DAS) and weed dry weight were found in three hand weedings at 20, 35 and 50 DAS.

The tallest plant was obtained from three hand weedings at 20, 35 and 50 DAS and the shortest plant was found in the control treatment. The plant height increased gradually with increasing weeding regime. The plant height was longer in Kajol Lata than that of other two varieties.

Weeding regime and variety had significant effect on yield and yield contributing characters. Three hand weedings at 20, 35 and 50 DAS produced the highest number of effective tillers hill^{-1}, number of filled grains panicle^{-1}, 1000-grain weight, grain yield, biological yield and harvest index whereas control treatment produced the lowest number of effective tillers hill^{-1}, number of filled grains panicle^{-1}, 1000-grain weight and grain yield. The results showed that grain yield was higher in Bera Ratna than that of other two varieties.

From the present study it was concluded that three hand weedings at 20, 35 and 50 DAS produced the highest number of effective tillers hill^{-1}, number of filled grains panicle^{-1}, 1000-grain weight and grain yield of aus rice. Bera Ratna showed better performance than that of other two varieties. To obtain better performance of aus rice, three hand weedings at 20, 35 and 50 DAS might be recommended.

CHAPTER VI
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APPENDICES

Appendix 1. Physical and chemical characteristics of soil (0 -15 cm depth) of the experimental site

Sl. no.	Name of the elements	Average amount of nutrients
1.	P^H	7.6
2.	Salinity (ds m^{-1})	4.6
3.	Organic matter (%)	2.23
4.	Potassium (m.e./100 g soil)	0.42
5.	Total Nitrogen (%)	0.208
6.	Phosphorus (µg/g soil)	4.01
7.	Sulphur (µg/g soil)	458.55
8.	Textural class	Clay

Source: Soil Resources Development Institute, Regional Research Centre, Doulatpur, Khulna.