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EFFECT OF VARIETY AND WEED MANAGEMENT ON THE YIELD PERFORMANCE OF *BORO* RICE

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ABSTRACT

Zaman F, Devi S, Islam MS, Monira S, Gupta R (2022) Effect of variety and weed management on the yield performance of *Boro* rice. *Int. J. Sustain. Crop Prod.* 17(2), 06-15.

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from December 2019 to May 2020 to investigate the effect of variety and weed management on the performance of *Boro* rice. Two rice varieties (BRRI dhan50 and BRRI dhan58) and six weed management practices (no weeding, two-hand weedings at 15 & 30 DAT, Three hand weedings at 15, 30 & 45 DAT, Application of pre-emergence herbicide superheat 500 EC @ 1 L ha^{-1} followed by one hand weeding at 30 DAT, Application of post-emergence herbicide super-power 10 WP @ 150 g ha^{-1} followed by one hand weeding at 30 DAT, Application of pre-emergence herbicide + post-emergence herbicide) were used as treatment. Eight weed species belonging to five families infested the experimental field. Among the eight species of weed, three were grasses, three were broad leaves and two were sedges. The selection of an appropriate weed management strategy helps reduce rice yield loss due to weeds. BRRI dhan58 produced a higher grain yield (3.62 t ha^{-1}) than BRRI dhan50 (3.27 t ha^{-1}). The highest grain yield (4.7 t ha^{-1}) was obtained from the application of pre-emergence herbicide + post-emergence herbicide and the lowest value was obtained from no weeding (2.38 t ha^{-1}). BRRI dhan58 × application of pre-emergence & post-emergence herbicide produced the highest grain yield (4.93 t ha^{-1}) and the lowest grain yield (2.0 t ha^{-1}) resulted from BRRI dhan50 × no weeding treatment. From the result of the study, it may be concluded that BRRI dhan58 × application of pre-emergence herbicide & post-emergence herbicide followed by one-hand weeding at 30 DAT may be recommended for controlling weeds effectively and for getting the highest grain yield in *Boro* rice. However, proper weed management and time of herbicide application are very important with respect to its efficiency.

Key words: *Boro rice, herbicide, pre-emergence, post-emergence, yield*

INTRODUCTION

Rice (*Oryza sativa* L.) is the dominant food crop of more than 50% of global people (Dass *et al*. 2016). Worldwide, rice is grown on 162.06 million hectares, with an annual production of about 497.69 million tons of rice (FAO 2021). About 90% of the world's rice is produced (143 million ha of the area with a production of 612 million tons of paddy) in Asia (FAO 2009). In respect of area and production, it ranks fourth among the rice-producing countries of the world following China, India and Indonesia (FAO 2009).

Bangladesh is an agro-based country. Agriculture is the single largest producing sector of the economy in Bangladesh since it comprises about 13.29% of the country's GDP (BBS 2021). The performance of this sector has an overwhelming impact on major macro-economic objectives of the country like employment generation, poverty alleviation, human resources development and food security.

Rice has extensively grown in Bangladesh in *Aus*, *Aman* and *Boro* seasons. In the *Boro* season, 37.61 metric tons of rice (52.84% of the total annual rice production) was produced from 11.72 million hectares of land (74% of the total farm area) in 2020-2021 (BBS 2021). Though Bangladesh is the fourth largest rice producer in the world but its productivity is low compared to other Asian countries. The average yield of rice is almost less than 50% of the world's average rice grain yield. The increasing rate of population is 1.05% (BBS 2018) decreasing rate of agricultural land is by 1% per annum (Hussain *et al*. 2006) which limits the horizontal expansion of rice area. So, to meet this ever-increasing food demand, an increment of rice production per unit area is only the alternative to bring self-sufficiency in food production. The lion's share of self-sufficiency is obtained through the expansion of HYV rice cultivation in the *Boro* season. However, many of them are not known to have been studied to their yield and yield-contributing characteristics. Bangladesh Rice Research Institute (BRRI) released several cultivars to cultivate in the *Boro* season with a detailed study of their different agronomic traits to furnish worthwhile information regarding yield and possibilities for varietal improvement.

Weeds are one of the major biogenic barriers to higher rice production across the world. Usually, crop-weed competition reduces 40-60% of rice production, but it may exceed 94-96% for employing poor weed control practices (Chauhan and Johnson, 2011; Islam *et al*. 2017). In Bangladesh, weed invasions decreased seed yields by up to 22-36% in *Boro* rice (BRRI 2008). Weeds affect crop plants directly for natural resources (air, moisture, sunlight and space) and nutrients (Ashiq and Aslam, 2014), and indirectly by harbouring plant pests, obstructing irrigation systems, reducing yields and quality, and enhancing operational costs (Zimdahl 2013). There is no doubt that the maximum benefit from costly inputs like fertilizers and pesticides in rice can fully be derived when the crop is kept free from weed infestation. Therefore, weed management techniques should be employed to boost rice yield.

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The present traditional weed management system is more laborious, time-consuming, and expensive and cannot be done in time due to various reasons (Ahmed *et al*. 2005). The unavailability of labour at peak periods is one of them since landless people migrates towards the urban areas in recent years with a dream to earn more. Moreover, delaying hand weeding reduces rice yield production drastically owing to greater crop-weed competition during a critical growth period (Rashid *et al*. 2012). So, crop growers prefer herbicide-based weed management techniques to overcome this issue. Herbicides are used successfully for weed control in rice fields for rapid effect, easier to application and low-cost involvement in comparison to traditional methods of hand weeding. But, herbicide-based farming approaches cannot be a sustainable alternative in a long run due to producing herbicide-tolerant weeds and shifting of weed vegetation (Chauhan and Opeña, 2013) and showing toxicity to crop plants (Blackshaw *et al*. 2005) and it might affect the situation going forward (Bastiaans *et al*. 2000). Furthermore, herbicide usage is commonly highlighted as endangering biodiversity and raising environmental concerns (Marshall *et al*. 2003). So, Integrated Weed Management (IWM) approaches have to be given prime importance for sustainable and ecologically sound crop production systems. Herbicides (pre-emergence and post-emergence) in combination with hand weeding would help to obtain higher crop yield with less effort and cost (Sathyamoorthy *et al*. 2004). Generally, pre-emergence herbicides are employed to control the early flushes, whereas late flushes of weeds are controlled by post-emergence herbicides. Instead of traditional weeding in *Boro* rice, a sequential application of pre-emergence herbicide with early post-emergence herbicide or hand weeding would help to obtain higher crop yield and it is supported by Singh *et al*. (2016). Therefore, the best weed control method needs to be found out to reduce losses due to weed infestation and thus getting the maximum yield. Besides, cultivar and wedding regimes, therefore, have a good influence on the performance of rice crops. The present experiment was therefore undertaken to evaluate the effects of variety and weed management on the yield performance of *Boro* rice.

MATERIALS AND METHODS

Experimental site

The experiment was implemented at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from December 2019 to May 2020. The experimental field was located at $24^0 75'$ N latitude and $90^0 50'$ E longitude at an elevation of 18 m above the sea level belonging to non-calcareous dark grey floodplain soil under the Agro-ecological Zone at the Old Brahmaputra Floodplain (AEZ-9). The experimental field was a medium-high land with silty clay loam soil texture having a pH value of 6.5. The soil of the experimental field was low in organic matter content (2.02%) and the fertility level of the soil was low (0.1% total N, 3.19 ppm available P and 0.09 me exchangeable K). The climate of the locality is subtropical in nature and is characterized by high temperatures and heavy rainfall. The climatic condition i.e. monthly total rainfall, average temperature and relative humidity during the study period from December 2019 to May 2020 are shown in Fig. 1.

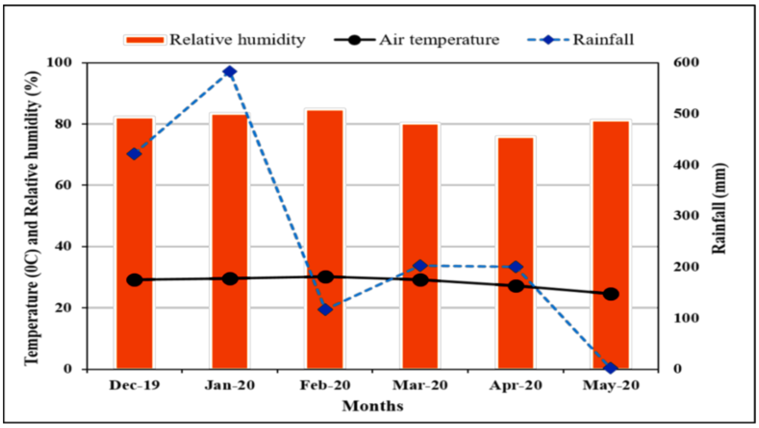

Fig. 1. Monthly total rainfall, average temperature and relative humidity during the study period

Experimental treatments and design

The experiment comprised two factors namely, variety and weed management practices. Two rice varieties included (i) BRRI dhan50 and (ii) BRRI dhan58. While six weed managements were (i) no weeding, (ii) two hand weedings at 15 and 30 DAT, (iii) three hand weedings at 15, 30 and 45 DAT, (iv) application of pre-emergence herbicide superheat 500 EC @ 1 L ha^{-1} followed by one hand weeding at 30 DAT, (v) application of post-emergence herbicide super-power 10 WP @ 150 g ha^{-1} followed by one hand weeding at 30 DAT, (vi) application of pre-emergence herbicide + post-emergence herbicide. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There were 36 plots in all with the size of 4.0 m × 2.5 m each. The details of the experimental treatment are presented in Table 1.

Table 1. Details of the weed management used in this experiment

Treatment name and abbreviation	Treatment details
No weeding (W_1)	Weeds were allowed to grow up to harvesting of the crop.
Two hand weedings at 15 DAT and 30 DAT (W_2)	In this treatment, weeds were allowed to grow with the crop for the first 14 DAT, At 15 days one hand weeding was done. Weeds were allowed to grow with the crop till 29 DAT and at 30 DAT, another hand weeding was given.
Three hand weedings at 15, 30 and 45 DAT (W_3)	In this treatment, weeds were allowed to grow with the crop for the first 14 DAT, At 15 days one hand weeding was done. Weeds were allowed to grow with the crop till 29 DAT and at 30 DAT, another hand weeding was given. Then another hand weeding was given at 45 DAT and afterwards, no weeding was done till harvesting.
Application of pre-emergence herbicide superheat 500 EC @ 1 L ha^{-1} followed by one hand weeding at 30 DAT (W_4)	In this treatment, Superheat 500EC @ 1 L ha^{-1} was applied at 5 DAT in 4-5 cm standing water by hand sprayer in the plots with one hand weeding.
Application of post-emergence herbicide super power 10 WP @ 150 g ha^{-1} followed by one hand weeding at 30 DAT (W_5)	In this treatment, herbicide super power 10 WP @ 150g ha^{-1} was applied at 15 DAT in 4-5 cm standing water by hand sprayer in the plots with one hand weeding.
Application of pre-emergence herbicide + post-emergence herbicide (W_6)	In this treatment, pre-emergence herbicide (superheat 500 EC) & post-emergence herbicide (super power 10WP) were applied in simultaneously.

Crop husbandry

Healthy and vigorous seeds of BRRI dhan50 and BRRI dhan58 were collected from Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Sprouted seeds of all the varieties were sown in the wet nursery bed. Proper care was taken to raise the seedlings in the nursery bed. Weeds were removed and irrigation was given in the seedbed as and when necessary. Transplanting of thirty days old seedlings was done on 8 January 2020 at 25 cm × 15 cm spacing with three seedling hill^{-1}. The experimental plots were fertilized with urea, triple superphosphate, gypsum, muriate of potash and zinc sulphate @ 300, 100, 110, 120, and 10 kg ha^{-1}, respectively. The entire amounts of triple superphosphate, muriate of potash, gypsum and zinc sulphate were applied at the time of final land preparation. Urea was applied in three instalments at 15, 30 and 45 days after transplantation. After a week of transplanting, certain hills' seedlings died off and were replaced by planting seedlings of the same age to fill up the gaps. Weeding was done as per experimental treatments. The experimental plots were irrigated six times.

Data recording and statistical analysis

Data on weed species grown in the experimental fields were collected at the vegetative growth stages of the rice plants by using 0.5 m × 0.5 m quadrat. The crops were harvested at full maturity when 90% of the grains became golden yellow in colour. Five hills (excluding border hills) were randomly selected in each plot and uprooted before harvesting for recording different yield contributing characters of rice. The 1000-grain weight, grain and straw yield were recorded at harvest. The grain yield was recorded at 12% moisture content and converted to t ha^{-1}. The Harvest index was calculated with the following formula:

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

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of the computer package MSTAT. The mean differences among the treatments were adjudged as per Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Weed composition

The experimental field was infested with eight weed species including three types of grasses, two sedges and three broad leaves (Table 2). The Poaceae family topped the list contributing three weeds followed by the Cyperaceae family with two weeds. Whereas, each of the following families such as Compositae, Oxaledaceae, and Pontederiaceae contributed one weed. According to the findings, the major leading weeds in the study area were *Echinochloa crusgalli*, *Paspalum scrobiculatum*, *Leersis hexandra*, *Fimbristylis miliacea*, *Scirpus juncoides, Oxalis europaea*, *Eclipta alba*, and *Monochoria vaginalis*. But, Monira *et al*. (2020) identified *Echinichloa crusgalli, Panicum repens, Leersia hexandra, Fimbristylis miliacea* and *Scirpus juncoides* as the highest dominant weeds in *Boro* rice fields in the same research area. In general, weed vegetation's existence, structure, richness, significance, and rankings shift over time and almost always depend on climatic conditions, agronomic practices, and weed seedbanks status of that particular area (Anwar *et al*. 2013). The present study also revealed that annual weeds are dominant over perennial weeds. The periodical alterations of irrigation and farm maintenance might account for such transition of weeds from perennials to annuals and vice versa which is supported by (De Datta, 1988).

Table 2. Infested weed species were found growing in the experimental plots in rice

Sl. No.	Local name	Scientific name	Family	Morphological type
1	Shama	*Echinochloa crusgalli*	Poaceae	Annual grass
2	Angta	*Paspalum scrobiculatum*	Poaceae	Perennial grass
3	Arail	*Leersia hexandra*	Poaceae	Annual grass
4	Joina	*Fimbristylis miliacea*	Cyperaceae	Annual sedge
5	Chesra	*Scirpus juncoides*	Cyperaceae	Annual sedge
6	Amrul shak	*Oxalis europaea*	Oxaledaceae	Annual broad leaf
7	Keshuti	*Eclipta alba*	Compositae	Annual broad leaf
8	Panikachu	*Monochoria vaginali*	Pontederiaceae	Perennial broad leaf

Plant height

The plant height varied significantly among the varieties. Taller plants (84.14 cm) were found in V_2 (BRRI dhan58) and shorter plants (77.60 cm) were found in V_1 (BRRI dhan50) (Table 3). Plant height is a varietal character and it is the genetic constituent of the variety, therefore, plant height was different between the two varieties. The results are consistent with the findings of Bisne *et al*. (2006) who observed plant height differed significantly among the varieties. The plant height also varied significantly among the weeding regime (Table 4). The tallest plants (85.31 cm) were found in W_6 (Application of pre-emergence herbicide + post-emergence herbicide) which was statistically similar to W_4 (Application of pre-emergence herbicide superheat 500 EC @ 1 L ha^{-1} @ followed by one hand weeding at 30 DAT) and W_5 (Application of post-emergence herbicide super-power 10 WP @ 150 g ha^{-1} followed by one hand weeding at 30 DAT). The shortest plants (77.33 cm) were found in W_3 (Three hand weedings at 15, 30 and 45 DAT) which was statistically significant to W_1 (no weeding) and W_2 (Two hand weedings at 15 and 30 DAT). Similar findings were found by Chowdhury *et al*. (1994) who reported that the highest plant height was produced due to weed-free conditions and the lowest plant height was in no weeding condition. While Afroz *et al*. (2019) reported that the tallest plant was produced by pre-emergence herbicide followed by hand weeding treatment. Plant height was significantly affected by the interaction between variety and weeding regimes (Table 5). The tallest plants (87.70 cm) were found in V_2W_6 (BRRI dhan58 × Application of pre-emergence + post-emergence herbicide) and the shortest plants (74.04 cm) were found in V_1W_3 (BRRI dhan50 × Three hand weedings at 15, 30 and 45 DAT). This result differed from the results of Salam *et al*. (2020). They observed that the tallest plant was produced from the interaction of variety with two hand weedings treatment.

Number of total tillers hill^{-1}

The number of total tillers on hill^{-1} was significantly influenced by different varieties. The highest number of total tillers hill^{-1} (9.08) was observed in V_2 (BRRI dhan58) and the lowest number of total tillers hill^{-1} (8.12) was observed in V_1 (BRRI dhan50) (Table 3). Tiller number is a varietal character and it is the genetic constituent of the variety, therefore, the number of total tillers hill^{-1} was different between the two varieties. The number of total tiller hill^{-1} varied significantly among the weeding regime. The highest number of total tillers hill^{-1} (10.14) was found in W_6 (Application of pre-emergence + post-emergence herbicide) and the lowest number of total tillers hill^{-1} (6.84) was found in W_1 (No weeding) (Table 4). In no weeding treatment weed crop competition was higher and suppressed the rice plant growth and ultimately tiller number was reduced. The interaction between variety and the weeding regime was found to be significant to the number of total tillers hill^{-1}. The highest number of total tillers hill^{-1} (10.64) was found in V_2W_6 (BRRI dhan58 × Application of pre-emergence + post-emergence herbicide) and the lowest number of total tillers hill^{-1} (5.87) was found in V_1W_1 (BRRI dhan50 × No weeding) (Table 5). It was evident that the number of total tillers hill^{-1} in all no-weeding treatments was drastically reduced.

Number of effective tillers hill^{-1}

Variety had a significant influence on the number of effective tillers hill^{-1}. Results showed that BRRI dhan58 was found more productive than BRRI dhan50 in effective tiller production (Table 3). Jones *et al*. (1996) also found a significant variation of effective tiller hill^{-1} among different varieties. The number of effective tillers hill^{-1} varied significantly among the weeding regime. The highest number of effective tillers hill^{-1} (9.03) was found in W_6 (Application of pre-emergence herbicide + post-emergence herbicide) which was statistically similar to W_5 (Application of post-emergence herbicide super-power 10 WP @150 g ha^{-1} followed by one hand weeding at 30 DAT) and the lowest one (5.89) was found in W_1 (No weeding) (Table 4). Afroz *et al.* (2019) reported that pre-emergence herbicide followed by one-hand weeding treatment produced the maximum number of total tillers hill^{-1} and that of the lowest value was from no weeding treatment. In no weeding treatment weed crop competition was higher and suppressed the rice plant growth and ultimately tiller number was reduced. De Datta (1990) observed that effective weed management increased the number of effective tillers due to more availability of water, nutrients and light. Similar results were supported by Singh *et al*. (1999). The number of effective tillers hill^{-1} was significantly affected by the interaction of variety and weed management. The highest number of effective tillers hill^{-1} (9.49) was found in V_2W_6 (BRRI dhan58 × Application of pre-emergence & post-emergence herbicide) and the lowest (4.87) was found in V_1W_1 (BRRI dhan50 × No weeding) (Table 5). A similar research finding was also reported by Mou *et al*. (2017).

Panicle length

The effect of variety on panicle length was not significant at a 1% level of probability (data not presented). There was a significant effect of weed management on panicle length (Table 4). The longest panicle (22.88 cm) was found in W_6 (Application of pre-emergence herbicide + post-emergence herbicide) and the shortest one (20.03 cm) was found in W_3 (Three-hand weedings at 15, 30 and 45 DAT) which was statistically similar to W_2 (Two-hand weedings at 15 and 30 DAT). Khan and Tarique (2011) also found the longest panicle in the weed-free plots. The interaction effect of variety and the weeding regime was significant to panicle length. The longest panicle (23.16 cm) was found in V_2W_6 (BRRI dhan58 × Application of pre-emergence & post-emergence herbicide) followed by V_1T_6, V_2T_1 and the shortest (18.59 cm) was found in V_1W_3 (BRRI dhan50 × Three hand weeding at 15, 30 and 45 DAT) (Table 5).

Number of grains panicle^{-1}

The number of grains panicle^{-1} was significantly influenced by different varieties. The highest no. of grains panicle^{-1} (99.92) was observed in V_2 (BRRI dhan58) and the lowest (93.53) was observed in V_1 (BRRI dhan50) (Table 3). Differences in the number of grains panicle^{-1} were due to varietal difference which was also reported by BRRI (1995). The number of grains panicle^{-1} varied significantly among the weed management practices. The highest number of grains panicle^{-1} (104.18) was found in W_6 (Application of pre-emergence herbicide + post-emergence herbicide) which might be due to the vigorous growth of rice plants because of minimum crop-weed competition. The lowest one (87.53) was found in W_1 (No weeding) (Table 4). Whereas, Salam *et al.* (2020) and Afroz *et al.* (2019) reported that the highest number of grains panicle^{-1} was obtained from pre-emergence herbicide followed by one-hand weeding treatment. De Datta (1990) observed that effective weed management increased the number of grains panicle^{-1} due to more availability of water, nutrients and light. Similar results were supported by Singh *et al*. (1999). The interaction between variety and the weeding regime was found to be significant to the number of grains panicle^{-1}. The highest number of grains panicle^{-1} (110.33) was found in V_2W_2 (BRRI dhan58 × Two hand weeding at 15 and 30 DAT) which was statistically similar to V_2W_6 (BRRI dhan58 × Application of pre-emergence herbicide & post-emergence herbicide) and the lowest (83.24) was found in V_1W_1 (BRRI dhan50 × No weeding) (Table 5).

Number of sterile spikelet's panicle^{-1}

The number of sterile spikelets panicle^{-1} was not significantly influenced by different varieties. The effect of weed management on the number of sterile spikelets panicle^{-1} was not significant. In addition, the interaction between variety and weed management practices was found to be non-significant to the number of sterile spikelets panicle^{-1} (data not presented).

1000-grain weight

The weight of 1000 grain was not varied significantly among the varieties (data not presented). The weight of 1000-grain varied significantly among the weed management practices. The highest weight of 1000 grain (22.53 g) was found in W_4 (Application of pre-emergence herbicide followed by one-hand weeding at 30 DAT) which is similar to the findings of Salam *et al.* (2020) and the lowest weight of 1000 grain (21.17 g) was found in W_2 (Two-hand weedings at 15 and 30 DAT) (Table 4). Nahar *et al*. (2010) also reported heavier grain weights of weed-free plots. The interaction between variety and weed management was found to be significant to the weight of 1000-grain. The highest weight of 1000 grain (23.35 g) was found in V_2W_4 (BRRI dhan58 × Application of pre-emergence herbicide superheat 500 EC @1 L ha^{-1} followed by one hand weeding at 30 DAT) and the lowest one (21.04 g) was found in V_1W_5 (BRRI dhan50 × Application of post-emergence herbicide super-power 10 WP @ 150g ha^{-1} followed by one hand weeding at 30 DAT) (Table 5).

Grain yield

Grain yield was significantly influenced by different varieties. The highest grain yield (3.62 t ha^{-1}) was observed in V_2 (BRRI dhan58) and the lowest grain yield (3.27 t ha^{-1}) was observed in V_1 (BRRI dhan50) (Fig. 2). This difference was observed due to different varietal character of rice plant. BRRI (1995) also reported variations in grain yield among the varieties. Grain yield varied significantly among the weeding regime. The highest grain yield (4.7 t ha^{-1}) was found in W_6 (Application of pre-emergence + post-emergence herbicide). The possible cause was that herbicides' impact on weeds may have led to rice plants receiving more water, air, light, space, and nutrients for optimum growth and development, which supported the development of more attributes that contribute to better yield. Additionally, the increase in foliage may have aided in photosynthesis because of less crop-weed competition, which serves as a contributing factor to the treatment's increased production. An identical result was also reported by Dhakal *et al*. (2019). The lowest grain yield (2.38 t ha^{-1}) was found in W_1 (No weeding) (Fig. 3). This happened due to severe weed infestation with various species of weeds and competition for moisture, space, air, light and nutrients between weeds and *Boro* rice plants which had an adverse influence on all the yield components and finally on grain yield (Bhuiyan *et al*. 2011; Khaliq *et al*. 2011). The interaction between variety and weed management was found to be significant to grain yield. The highest grain yield (4.93 t ha^{-1}) was found in V_2W_6 (BRRI dhan58× Application of pre-emergence & post-emergence herbicide). The second highest grain yield (4.47 t ha^{-1}) was obtained from V_1W_6 (BRRI dhan50 with the application of pre-emergence herbicide + post-emergence herbicide) which is statistically similar with grain yield (4.35 t ha^{-1}) of V_2W_5 (BRRI dhan58 with the application of post-emergence herbicide super-power 10 WP @ 150g ha^{-1} followed by one hand weeding at 30 DAT). The lowest grain yield (2.00 t ha^{-1}) was found in V_1W_1 (BRRI dhan50 × No weeding) (Table 5). It was evident that grain yield in all no-weeding treatments was drastically reduced.

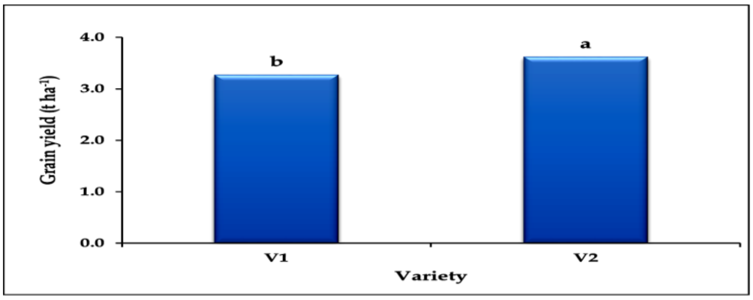

Fig. 2. Effect of variety on the grain yield of *Boro* rice. Bars with a similar letter (s) do not differ significantly whereas bars with dissimilar letters differ significantly as per DMRT. Here, V_1 = BRRI dhan50 and V_2 = BRRI dhan58

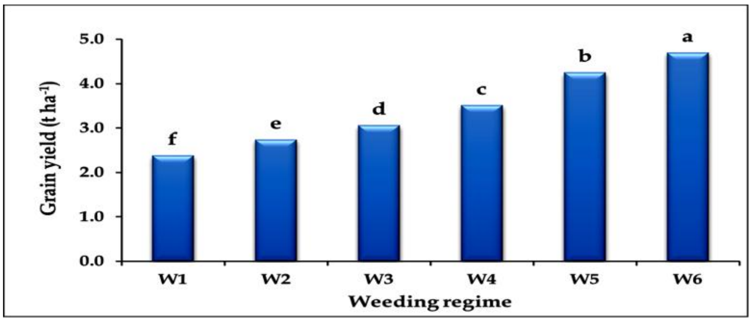

Fig. 3. Effect of weeding regime on the grain yield of *Boro* rice. Bars with similar letter (s) do not differ significantly whereas bars with dissimilar letters differ significantly as per DMRT. Here, W_1= No weeding (W_1), W_2= Two-hand weeding at 15 and 30 DAT, W_3= Three hand weeding at 15, 30 and 45 DAT, W_4= Application of pre-emergence herbicide superheat 500 EC @ 1L ha^{-1} followed by one hand weeding at 30 DAT, W_5= Application of post-emergence herbicide super-power 10 WP @ 150g ha^{-1} followed by one hand weeding at 30 DAT and W_6= Application of pre-emergence herbicide + post-emergence herbicide

Straw yield

The straw yield was not significantly influenced by different varieties (data not presented). Weed management practices had a significant influence on straw yield. The highest straw yield (5.05 t ha^{-1}) was found in W_6 (Application of pre-emergence + post-emergence herbicide) and the lowest straw yield (2.79 t ha^{-1}) was found in W_1 (No weeding) (Fig. 4). These might be because the weeding kept the rice field weed free and soil was well aerated which facilitated the crop for absorption of the greater amount of nutrients, moisture and greater reception of solar radiation for better growth. Weed competition was severe in no weeding condition so less tillering occurred which results in lower straw yield. On the other hand, in weed-free treatment throughout the crop growth period, because of high tillering ability higher straw yield was produced. The interaction between variety and weed management was found to be significant to straw yield. The highest straw yield (5.15 t ha^{-1}) was found in V_2W_6 (BRRI dhan58 × Application of pre-emergence & post-emergence herbicide) and the lowest straw yield (2.43 t ha^{-1}) was found in V_1W_1 (BRRI dhan50 × No weeding) (Table 5).

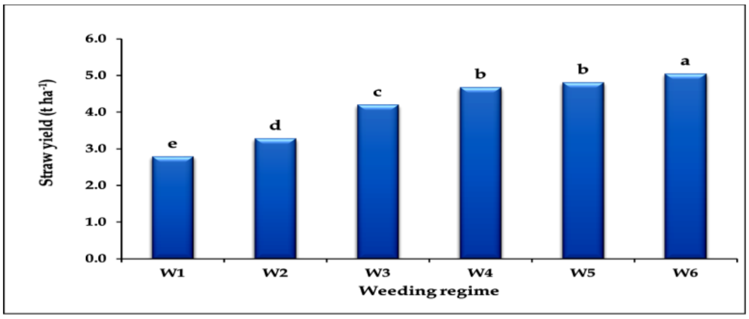

Fig. 4. Effect of weeding regime on the straw yield of *Boro* rice**.** Bars with similar letter (s) do not differ significantly whereas bars with dissimilar letters differ significantly as per DMRT. Here, W_1= No weeding (W_1), W_2= Two-hand weeding at 15 and 30 DAT, W_3= Three hand weeding at 15, 30 and 45 DAT, W_4= Application of pre-emergence herbicide superheat 500 EC @ 1L ha^{-1} followed by one hand weeding at 30 DAT, W_5= Application of post-emergence herbicide super-power 10 WP @ 150g ha^{-1} followed by one hand weeding at 30 DAT and W_6= Application of pre-emergence herbicide + post-emergence herbicide

Biological yield

The biological yield was significantly influenced by different varieties. The highest biological yield (7.97 t ha^{-1}) was observed in V_2 (BRRI dhan58) and the lowest one (7.19 t ha^{-1}) was observed in V_1 (BRRI dhan50) (Table 3). This variation might be due to the genetic constituents of the two varieties. There was a significant effect of weed management on the biological yield of rice. The highest biological yield (9.75 t ha^{-1}) was found in W_6 (Application of pre-emergence + post-emergence herbicide) and the lowest biological yield (5.17 t ha^{-1}) was found in W_1 (No weeding) (Table 4). Variations in biological yield among weedings' regimes were dependent upon the severity of weed infestation and climatic conditions. Higher weed infestation not only reduce the grain yield but also hampered the plant growth and tillering capacity and finally influenced straw yield as well as biological yield. Biological yield showed a significant effect on the interaction of variety and weed management. The highest biological yield (10.08 t ha^{-1}) was found in V_2W_6 (BRRI dhan58 × Application of pre-emergence & post-emergence herbicide) and the lowest one (4.44 t ha^{-1}) was found in V_1W_1 (BRRI dhan50 × No weeding) (Table 5).

Harvest index (%)

The harvest index was not significantly influenced by different varieties (data not presented). Weed management had a significant effect on the harvest index of *Boro* rice. The highest harvest index (48.21%) was found in W_6 (Application of pre-emergence & post-emergence herbicide and the lowest one (42.09%) was found in W_3 (Three-hand weedings) (Table 4). Similar findings were observed by Manish *et al*. (2006) who stated that weeding had a significant variation in harvest index. The harvest index showed a significant effect on the interaction of variety and weed management. The highest harvest index (48.92%) was found in V_2W_6 (BRRI dhan58 × Application of pre-emergence & post-emergence herbicide) and the lowest one (40.68%) was found in V_2W_3 (BRRI dhan58 × Three-hand weedings at 15, 30 and 45 DAT) (Table 5).

Table 3. Effect of variety on the yield contributing characters and yield of *Boro* rice

Variety	Plant height (cm)	Number of total tillers $hill^{-1}$	Number of effective tillers $hill^{-1}$	Number of grains $panicle^{-1}$	Biological yield (t ha^{-1})
V_1	77.60b	8.12b	7.18b	93.53b	7.19b
V_2	84.14a	9.08a	8.12a	99.92a	7.97a
$LSD_{(0.05)}$	2.69	0.37	0.31	5.56	0.15
Level of Sig.	**	**	**	**	**
CV%	4.81	6.27	5.83	8.32	2.91

This means with the same letters within the same column don't differs significantly.
**=Significant at 1% level of probability
V_1=BRRI dhan50
V_2=BRRI dhan58

Table 4. Effect of weeding regime on the yield contributing characters and yield of *Boro* rice

Treatment	Plant height (cm)	Number of total tillers $hill^{-1}$	Number of effective tillers $hill^{-1}$	Panicle length (cm)	Number of grains $panicle^{-1}$	1000 grain weight (g)	Biological yield (t ha^{-1})	Harvest index (%)
W_1	79.83b	6.84d	5.89d	21.24ab	87.53d	21.40ab	5.17f	46.03ab
W_2	80.09b	7.93c	7.07c	21.06b	102.83ab	21.17b	6.03e	45.44b
W_3	77.33b	8.07c	7.15c	20.03b	92.64cd	21.27ab	7.27d	42.09d
W_4	81.73ab	9.00b	8.10b	21.19ab	93.92bcd	22.53a	8.20c	42.80c
W_5	80.96ab	9.60ab	8.63a	21.05b	99.28abc	21.61ab	9.06b	46.91ab
W_6	85.31a	10.14a	9.03a	22.88a	104.18a	21.85ab	9.75a	48.21a
$LSD_{(0.05)}$	4.66	0.64	0.53	1.80	9.63	1.27	0.26	2.10
Level of Sig.	**	**	**	**	**	**	**	**
CV%	4.81	6.27	5.83	7.11	8.32	4.94	2.91	3.88

Means with the same letters within the same column don't differs significantly.
**=Significant at 1% level of probability
W_1=No Weeding
W_2=Two hand weeding at 15 and 30 DAT
W_3= Three hand weeding at 15, 30 and 45 DAT
W_4= Application of pre-emergence herbicide superheat 500 EC @ 1L ha^{-1} followed by one hand weeding at 30 DAT
W_5= Application of post-emergence herbicide super power 10 WP @ 150g ha^{-1} followed by one hand weeding at 30 DAT
W_6= Application of pre-emergence herbicide + post- emergence herbicide

Table 5. Interaction effect of variety and weeding regime on the yield contributing characters and yield of *Boro* rice

Interaction	Plant height (cm)	Number of the total tiller hill^{-1}	Number of the effective tillers hill^{-1}	Panicle length (cm)	Number of grains panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1W_1	76.40de	5.87g	4.87h	19.83cd	83.24e	21.20b	2.00i	2.43g	4.44h	45.10bcde
V_1W_2	77.05cde	7.52f	6.71g	19.90cd	95.34bcde	21.22b	2.62h	3.12f	5.74g	45.60bcd
V_1W_3	74.04e	7.64ef	6.72g	18.59d	94.29bcde	21.51b	3.00fg	3.84d	6.84e	43.85cde
V_1W_4	77.90cde	8.82cd	7.90cde	19.84cd	87.53de	21.71ab	3.34e	4.57c	7.91d	42.23ef
V_1W_5	77.31cde	9.24bcd	8.30bcd	20.00bcd	99.09abcd	21.04 b	4.16c	4.62c	8.78c	47.35ab
V_1W_6	82.92abcd	9.63bc	8.57bc	22.60a	101.70abc	21.70ab	4.47b	4.95ab	9.43b	47.46ab
V_2W_1	83.25abc	7.82ef	6.91fg	22.64a	91.83cde	21.59ab	2.77gh	3.14f	5.91g	46.85ab
V_2W_2	83.14abc	8.35def	7.43efg	22.23abc	110.33a	21.13 b	2.86gh	3.45e	6.31f	45.32bcd
V_2W_3	80.61bcde	8.51de	7.57def	21.48abc	90.98cde	21.04 b	3.13ef	4.57c	7.70d	40.68f
V_2W_4	85.55ab	9.18bcd	8.30bcd	22.54ab	100.30abcd	23.35a	3.68d	4.80bc	8.49c	43.41def
V_2W_5	84.60ab	9.95ab	8.97ab	22.09abc	99.46abcd	22.17ab	4.35bc	5.00ab	9.35b	46.48abc
V_2W_6	87.70a	10.64a	9.49a	23.16a	106.66ab	22.00ab	4.93a	5.15a	10.08a	48.92a
$LSD_{(0.05)}$	6.59	0.91	0.75	2.55	13.63	1.80	0.27	0.25	0.37	2.97
Level of Sig.	**	**	**	**	**	**	**	**	**	**
CV%	4.81	6.27	5.83	7.11	8.32	4.94	4.61	3.62	2.91	3.88

Means with the same letters within the same column don't differs significantly.
**=Significant at 1% level of probability
V_1=BRRI dhan50, V_2=BRRI dhan58
W_1=No Weeding
W_2=Two hand weeding at 15 and 30 DAT
W_3= Three hand weeding at 15, 30 and 45 DAT
W_4= Application of pre-emergence herbicide superheat 500 EC @ 1L ha^{-1} followed by one hand weeding at 30 DAT
W_5= Application of post-emergence herbicide super power 10 WP @ 150g ha^{-1} followed by one hand weeding at 30 DAT
W_6= Application of pre-emergence herbicide + post- emergence herbicide

CONCLUSION

The selection of an appropriate weed management strategy helps reduce rice yield loss due to weeds. BRRI dhan58 produced higher grain and straw yields than BRRI dhan50. The weeding regime had a significant effect on yield and yield contributing characters. The highest grain yield was found in BRRI dhan58 under the application of pre-emergence + post-emergence herbicide treatment. The lowest grain yield was obtained in BRRI dhan50 under no weeding treatment (V_1W_1). Therefore, BRRI dhan58 under application of pre-emergence + post-emergence herbicide (V_2W_6) treatment appeared to be best. Moreover, environmental issues related to herbicide use should be brought under consideration. Because, farmers sometimes ignore the instructions and do not use the correct volume of spray, dose and spray nozzle, which leads to poor weed suppression. In that case, farmers may integrate pre-emergence or post-emergence herbicide with a manual weeding considering both the environmental and labour cost issues.

REFERENCES

Afroz R, Salam MA, Begum M (2019) Effect of weeding regime on the performance of *Boro* rice cultivars. *J. Bangladesh Agric. Univ.* 17(3), 265-273.

Ahmed GJU, Bhuiyan MKA, Riches CR, Mortimer M, Jhonson D (2005) Farmer's participatory studies of integrated weed management system for intensified lowland. Proceeding of the 8th Biennial Agronomy Convention. *J. Agron.* 31-32.

Anwar MP, Juraimi AS, Mohamed MTM, Uddin MK, Samedani B, Puteh A, Man A (2013) Integration of agronomic practices with herbicides for sustainable weed management in aerobic rice. *Sci World J.* 2013: 1-12.

Ashiq M, Aslam Z (2014) Chemical control of weeds. In: weeds and weedicides. Department of Agronomy, Ayub Agricultural Research Institute, Faisalabad and University of Agriculture, Faisalabad, Pakistan. pp. 235 – 256.

Bastiaans L, Kropff MJ, Goudriaan J, Laar HH (2000) Design of weed management systems with a reduced reliance on herbicides poses new challenges and prerequisites for modelling crop-weed interactions. *Field Crop Res.* 67:161–179.

BBS (Bangladesh Bureau of Statistics) (2018) Statistical Yearbook of Bangladesh. Statistics Division, Ministry of Planning. Government of the People's Republic of Bangladesh. Dhaka. p. 143.

BBS (Bangladesh Bureau of Statistics) (2021) Yearbook of Agricultural Statistics-2021. Bangladesh Bureau of Statistics, Statistical Division, Ministry of Planning, Govt. Peoples Republic of Bangladesh, Dhaka.

Bhuiyan MR, Rashid MM, Ray D, Karmakar B, Hossain MM, Khan MAI (2011) Sound weed management option for sustainable crop production. *Bangladesh J. Weed Sci.* 1(1), 25-29.

Bisne R, Motiramani NK, Sarawgi AK (2006) Identification of high yielding hybrids in rice. *Bangladesh J. Agric. Res.* 31(1), 171-174.

Blackshaw RE, Moyer JR, Harker KN, Clayton GW (2005) Integration of agronomic practices and herbicides for sustainable weed management in a zero-till barley field pea rotation. *Weed Technol.* 19: 190-196.

BRRI (Bangladesh Rice Research Institute) (1995) Adhunik Dhaner Chash. Bangladesh Rice Res. Inst. Joydevpur, Gazipur, Bangladesh. Pub. No. 5. pp. 12, 20-21, 23.

BRRI (Bangladesh Rice Research Institute) (2008) Annual report for 2007. Bangladesh Rice Research Institute, Joydebpur, Gazipur, Bangladesh.

Chauhan BS, Johnson DE (2011) Competitive interactions between weedy rice and cultivated rice as a function of added nitrogen and the level of competition. *Weed Biol. Manage.* 11: 202-209.

Chauhan BS, Opeña J (2013) Weed management and grain yield of rice sown at low seeding rates in mechanized dry-seeded systems. *Field Crops Res.* 141: 9-15.

Chowdhury MJU, Sarker AU, Sarker MAR, Kashem MA (1994) Effect of weed infestation regime on the growth and yield of transplant *aman* rice. *Bangladesh J. Agric. Sci.* 21(1), 141-147.

Dass A, Shekhawat K, Choudhary AK, Sepat S, Rathore SS, Mahajan G, Chauhan BS (2016) Weed management in rice using crop competition. *Crop Prot*. 95, 45-52.

De Datta SK (1988) Progress in weed science and control technology in tropical rice. In the Proceedings 1988 of Tropical Weed Science Society Conference, Thailand, 14-35.

De Datta SK (1990) Weed control in rice in South and South East Asia. Ext. Bull. No. 146. FFTC. Taiwan. pp. 1-24.

Dhakal M, Sah SK, Kharel G (2019) Integrated weed management in direct-seeded rice: Dynamics and economics. *Int. J. Agric. Environ. Food Sci*. 3, 81-84.

FAO (Food and Agricultural Organization) (2021) Rice Market Monitor, Rome.

FAO (Food and Agriculture Organization) (2009) FAOSTAT Database FAO, Rome, www.faostat.fao.org, pp.26.

Gomez KA, Gomez AA (1984) Duncan's, Muitiple Range Test. Statistical Procedures for Agricultural Research 2nd Edition. A Wiley Inter-Science publication, John Wiley and Sons, New York. pp. 202-215.

Hussain MM, Alam MS, Islam MA, Rashid MM, Islam MF, Rashid MA, Razzaque MS, Mamin MSI, Islam MR, Kabir H, Parvin S, Mukul HR (2006) In: Baqui MA (eds.). In: Proc. Twenty First BRRI-DAE Joint Workshop. Bangladesh Rice Research Institute Joydebpur, Gazipur, Bangladesh, September 19 21 pp. 1-3.

Islam AKMM, Popy FS, Hasan AK, Anwar MP (2017) Efficacy and economics of herbicidal weed management in monsoon rice of Bangladesh. *J. Sci. Agric*. 1, 275.

Jones MP, Johnson D, Fofana BS, Koupeur T (1996) Selection of weed competitiveness in upland rice. *Int. Rice Res. Notes* 21(1), 32-33.

Khaliq A, Riaz MY, Matloob A (2011) Bio-economic assessment of chemical and non-chemical weed management strategies in dry seeded fine rice (*Oryza sativa* L.). *J. Plant Breed. Crop Sci.* 3(12), 302-310.

Khan TA, Tarique MH (2011) Effects of weeding regime on the yield and yield contributing characters of transplant *boro* rice. *Int. J. Sci. Adv. Technol*. 11, 11-14.

Manish C, Khajanji SN, Savu RM, Dewangan YK (2006) Effect of halosulfuron-methyl on weed control in direct seeded drilled rice under puddled condition of Chhattisgarh plains. *Plant Arch.* 6(2), 685-687.

Marshall EJP, Brown VK, Boatman ND, Lutman PJW, Squire GR, War LK (2003) The role of weeds in supporting biological diversity within crop fields. *Weed Res.* 43, 77-89.

Monira S, Begum M, Uddin MR (2020) Impact of weed control practices on weed suppression and crop performance in *Boro* rice. *Fundam. Appl. Agric.* 5(3), 372-382.

Mou MRJ, Salam MA, Hossen K, Kato-Noguchi H, Islam MS (2017) Effect of weeding regime on the performance of transplanted *aman* rice. *J. Agrofor. Environ.* 11(1&2), 261-266.

Nahar S, Islam MA, Sarkar MAR (2010) Effect of spacing and weed regime on the performance of transplant *aman* rice. *Bangladesh J. Weed Sci.* 1(1), 89-93.

Rashid MH, Alam MM, Rao AN, Ladha JK (2012) Comparative efficacy of pretilachlor and hand weeding in managing weeds and improving the productivity and net income of wet-seeded rice in Bangladesh. *Field Crops Res.* 128, 17-26.

Salam A, Sarker S, Sultana A (2020) Effect of weed management on the growth and yield performances of *Boro* rice cultivars. *J. Agric Food Environ.* 1(4), 19-26.

Sathyamoorthy NK, Mahendran S, Babu R, Ragavan T (2004) Effect of integrated weed management practices on total weed dry weight, nutrient removal of weeds in rice-rice wet seedbed system. *J. Agron.* 3(4), 263-267.

Singh G, Singh RK, Singh VP, Nayak RS (1999) Weed management in transplanted rice. *Indian J. Agron.* 44(4), 728-73.

Singh V, Jat ML, Ganie ZA, Chauhan BS, Gupta RK (2016) Herbicide options for effective weed management in dry direct-seeded rice under scented rice-wheat rotation of western Indo-Gangetic plains. *Crop Protec.* 81, 168–176.

Zimdahl RL (2013) Fundamentals of Weed Science, fourth ed. Academic Press.