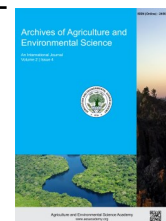




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ORIGINAL RESEARCH ARTICLE



Effects of integrated weed management practices on the performance of *boro* rice cultivars

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ABSTRACT

An experiment was conducted during the period from November 2016 through May 2017 to evaluate the effect of integrated weed management practices on weed suppression and on the performance of *boro* rice cultivars. The experiment consisted of two cultivars viz., BRR1 dhan28 and BRR1 dhan29 along with eight different weed management practices. Cultivar did not exert any significant effect on weed density and dry weight. Integrated weed management practices exerted significant effect on weed density and dry weight. The highest weed dry weight was observed in no weeding treatment and lowest one was recorded in application of pre-emergence herbicide followed by one hand weeding at 35 DAT. BRR1 dhan28 × no weeding treatment produced the highest weed dry weight and BRR1 dhan28 × application of pre-emergence herbicide followed by one HW produced the lowest weed dry weight at different DATs. BRR1 dhan28 produced higher grain and straw yields than BRR1 dhan29. The highest grain yield was obtained from application of pre-emergence herbicide followed by one hand weeding at 35 DAT. BRR1 dhan28 × application of pre-emergence herbicide followed by one HW at 35 DAT produced the highest grain yield and the lowest grain yield was resulted from BRR1 dhan28 × no weeding treatment. From the study it may be concluded that BRR1 dhan28 × application of pre-emergence herbicide followed by one HW at 35 DAT may be recommended for controlling weeds effectively and for getting the highest grain yield in *boro* rice.

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INTRODUCTION

About 71.06% of cropped area of Bangladesh is used for rice production, with annual production of 34.71 million tons from 11.62 million hectares of land (BBS, 2018). Among the three rice seasons *boro* rice occupies around 4.86 million hectares of land which is around 41.82 percent of the total rice cultivation area (BBS, 2018). The yield of *boro* rice in Bangladesh is increasing than in other rice growing countries of the world (FAO, 2004). But the prevailing climatic and edaphic conditions are favorable for luxuriant growth of numerous species of weeds which offer a keen competition with rice crop. In Bangladesh, weed infestation reduces the grain yield by 70-80% in *aus* rice (early summer), 30-40% for transplanted *aman* (autumn) rice and 22-

36% for modern *boro* (winter) rice (Mamun, 1990; BRR1, 2008). This loss is, therefore, a serious threat for the food deficit country like Bangladesh. So, proper weed management is essential for rice production in Bangladesh. Rice cultivars play an important role in crop-weed competition because of their diverse morphological traits, canopy structure and relative growth rate. Usually traditional tall cultivars of rice exert effective smothering effect on weeds (Prasad, 2011) and short stature cultivars face more weed infestation than taller one (Sarker, 1979). Further, it has been observed that early maturing rice cultivars and hybrid rice also have a suppressing effect on weeds due to improved vigour and having the tendency of early canopy cover (Mahajan and Chauhan, 2011). Weeds are the most destructive crop pest. There is no doubt

that maximum benefit from costly inputs like fertilizers and pesticides in rice can be fully derived when the crop is kept free from weed infestation. Different options are available for weed management in rice. Hand weeding is the most popular weed control method in Bangladesh. But weed control is often imperfect or delayed due to unavailability of labour during the peak period. Chemical control, on the contrary, is the most effective, economic and practical way of weed management (Hussain et al., 2008). Many researchers opined that herbicide might be considered viable alternative/ supplement to hand weeding (Mahajan et al., 2009; Chauhan and Johnson, 2011; Anwar et al., 2012a; Juraimi et al., 2013). But intensive use of herbicides may result in development of resistant weed biotypes (Rahman et al., 2010) and public health hazard (Phuong et al., 2005). The other option left is cultural weed control through adoption of different agronomic practices including tillage (Rao et al., 2007), competitive cultivar (Zhao et al., 2006; Anwar et al., 2010), seeding density (Anwar et al., 2011), water management (Rao et al., 2007), seed invigoration (Anwar et al., 2012b), stale seedbed and so on.

A single weed control approach may not be able to keep weeds below the threshold level of economic damage which demands adoption of diverse technology for weed management. Therefore, all the methods that are ecologically and economically justifiable should be integrated in a comprehensive way—known as integrated weed management (IWM). A substantial impact of IWM on rice farming has been documented by many researchers (Azmi and Baki, 2002; Sunil et al., 2010), who concluded that integration of different agronomic practices in combination with limited herbicide use managed weeds efficiently and ensured high yield. Therefore, it is necessary to use competitive rice cultivars and integration of different methods of weed management for effective weed control and obtaining higher yield. In view of the above facts this piece of work was carried out to observe the effect of rice cultivar on weed suppression, to find out the effect of different weed management techniques on the weed suppression and yield of *boro* rice, to assess the effect of interaction between cultivar and integrated weed management practices on weed suppression and the yield performance of *boro* rice.

MATERIALS AND METHODS

Description of the experimental site

Two *boro* rice cultivars BRR1 dhan28 and BRR1 dhan29 were used as experimental materials. The experiment was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from November 2016 through May 2017 to study the effect of integrated weed management practices on the performance of *Boro* rice. The experimental area is characterized by non-calcareous dark grey floodplain soil belonging to the Sonatola soil series under the old Brahmaputra Floodplain Agro-ecological zone 9. The soil of the experimental field was more or less neutral with pH value 6.8, low in organic matter content and fertility status is also low. The land type was medium high with silt loam in texture. The climate of the locality is tropical in nature and is characterized by high

temperature and heavy rainfall during *kharif* season (April to September).

Experimental treatment

The experimental treatments were as follows: Factor A: Variety (2), BRR1 dhan28 (V_1), BRR1 dhan29 (V_2), Factor B: Integrated weed management practices (8), No weeding (W_0), Application of pre-emergence herbicide Pretilachlor @ 2L ha⁻¹ (W_1), Application of early post-emergence herbicide Pediplus (Acetachlor + Bensulfuron methyl (W_2), Application of pre-emergence herbicide followed by early post-emergence herbicide (W_3), Application of pre-emergence herbicide followed by one hand weeding at 35 DAT (W_4), Application of early post-emergence herbicide followed by one hand weeding at 35 DAT (W_5), Stale seedbed (W_6), Stale seedbed followed by application of early post emergence herbicide (W_7). The experiment was laid out in a randomized complete block design with three replications. There were 16 treatment combinations. Total number of unit plots was 48.

Agronomic management

Seeds of rice variety BRR1 dhan28 and BRR1 dhan29 were collected from the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. The sprouted seeds were sown in the nursery bed on 18 November 2016. The experimental plots were fertilized with urea, triple superphosphate, muriate of potash, gypsum and zinc sulphate @ 300-100-150-110-10 kg ha⁻¹, respectively (BRR1, 2018). The entire amounts of triple superphosphate, gypsum, zinc sulphate and two thirds of muriate of potash were applied at the time of final land preparation. Urea was applied in three installments at 15, 35 and 60 days after transplanting. Rest one third muriate of potash was applied with third dose of urea. Seedlings were transplanted in the well prepared puddle field on 28 December 2016 at the rate of two seedlings hill⁻¹, maintained row and hill distance of 25 cm and 15 cm in conventional method. In case of stale seedbed, seedlings were transplanted in the plot on 7 January 2017. The crop of each plot was harvested from 1 m² of the central area with sickle at full maturity. Just before harvesting five hills excluding the border plants and the harvest area of each plot were selected at random and uprooted for collecting data on yield components. BRR1 dhan28 was harvested on 29 April and BRR1 dhan29 on 7 May 2017. Then the harvested crops of each plot was bundled separately, properly tagged and brought to threshing floor. The crops were then threshed and dry weight of grain and straw were recorded.

Data collection

The data of weed parameters were collected at 25 DAT, 50 DAT and 75 DAT of rice plants. Weed parameters such as weed density (no. m⁻²) and weed dry weight (g m⁻²) were collected. Crop characters such as plant height (cm), number of total tillers hill⁻¹, number of effective tillers hill⁻¹, tillers hill⁻¹, panicle length, number of grains panicle⁻¹, number of sterile spikelets panicle⁻¹, 1000 grain weight, grain yield, straw yield and harvest index were recorded.

Statistical analysis

All the recorded data were compiled and tabulated for statistical analysis. The collected data were analyzed following the analysis of variance (ANOVA) technique and mean differences were adjusted by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using a computer operated program namely, MSTAT-C.

RESULTS AND DISCUSSION

Effect of cultivar on weed density and weed dry weight

Weed density at 25, 50 and 75 DATs was not significantly influenced by variety. Numerically the higher weed density was found in BRRI dhan28, showing the higher values of 55.96 m⁻², and 70.33 m⁻² at 25 and 50 DATs, respectively and the lower weed density was obtained in BRRI dhan29, exhibit the lower values of 54.83 m⁻², and 69.67m⁻² at 25 and 50 DATs, respectively. At 75 DAT, the higher weed density (53.17 m⁻²) was found in BRRI dhan29 and the lower number of weed density (51.46m⁻²) was obtained in BRRI dhan28 (Table 1). Similar research findings were also reported by Islam et al. (2017) who reported that weed density at 40 and 60 DATs was not significantly affected by varieties. Weed dry weight at 25, 50 and 75 DATs was not significantly influenced by cultivar. At 25, 50 and 75 DAT numerically the higher weed dry weight of 2.51, 10.06 and 17.08 g m⁻², respectively was found in BRRI dhan29 and the lower weed dry weight of 2.38, 9.44 and 15.38 g m⁻², respectively was found in BRRI dhan28 cultivar (Table 1). This finding corroborates the findings of Islam et al. (2017) who reported that total weed dry weight was not significantly affected by the cultivars at 20, 40 and 60 DATs.

Effect of weed management practices on weed density and dry weight

Weed density (m⁻²) was significantly influenced by weed management at 25, 50 and 75 DATs. At 25 DAT, the highest weed density (109.80 m⁻²) was found in W₀ (no weeding) and the lowest one (13.33 m⁻²) was found in W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) treatment which was statistically identical to W₁ (application of pre-emergence herbicide) and W₄(application of pre-emergence herbicide followed by one hand weeding at 35

DAT). At 50 DAT, the highest weed density (166.00 m⁻²) was found in W₀ (no weeding) treatment which was statistically identical to W₆ (stale seedbed) and the lowest one (16.00 m⁻²) was found in W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) treatment (Table 2). At 75 DAT, the highest weed density (115.50 m⁻²) was found in W₀ (No weeding) and the lowest one (14.00 m⁻²) was found in W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) (Table 2). Mou et al. (2017) and Islam et al. (2017) reported in their study that no weeding treatment recorded the higher weed population than different weed control treatments. Weed management practices exerted significant effect on weed dry weight at 25, 50 and 75 DATs. At 25 DAT, the highest weed dry weight (3.35 g m⁻²) was found in W₀ (No weeding) and the lowest one (1.91 g m⁻²) was found in W₄ (application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment which was significantly different from other treatments. On the other hand, W₁ (application of pre-emergence herbicide), W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) and W₇ (stale seedbed followed by application of early post-emergence herbicide) treatments were statistically identical. At 50 DAT, the highest weed dry weight (24.15 g m⁻²) was found in W₀ (no weeding) and the lowest one (2.29 g m⁻²) was found in W₄ (application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment. Treatments W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide), W₄ (application of pre-emergence herbicide followed by one hand weeding at 35 DAT) and W₅(application of early post-emergence herbicide followed by one hand weeding at 35 DAT) were statistically identical. At 75 DAT, the highest weed dry weight (36.89 g m⁻²) was found in W₀ (no weeding) which was statistically identical to W₆ (stale seedbed) and the lowest weed dry weight (5.50 g m⁻²) was found in W₄ (application of pre-emergence herbicides followed by one hand weeding at 35 DAT) treatment which was statistically identical to W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) treatment (Table 2). Mou et al. (2017) and Islam et al. (2017) reported highest weed dry weight in no weeding treatment and the lower weed dry weight was observed in different weed management practices.

Table 1. Effect of cultivar on weed population and weed dry matter at different days after transplanting.

Cultivar	Weed density (no. m ⁻²)			Weed dry matter (g m ⁻²)		
	25DAT	50DAT	75DAT	25DAT	50DAT	75DAT
BRRI dhan28	55.96	70.33	51.46	2.38	9.45	15.38
BRRI dhan29	54.83	69.67	53.17	2.51	10.06	17.08
Level of sig.	NS	NS	NS	NS	NS	NS
CV (%)	19.65	25.94	27.49	22.58	25.49	19.26

NS = Not Significant.

Table 2. Effect of methods of weed management on weed population and weed dry weight at different days after transplanting.

Methods of weed management	Weed density (no. m ⁻²)			Weed dry matter (g m ⁻²)		
	25DAT	50DAT	75DAT	25DAT	50DAT	75DAT
W ₀	109.80a*	166.00a	115.50a	3.357a	24.15a	36.89a
W ₁	17.33e	41.33bc	34.67d	2.26cd	5.27de	9.10cd
W ₂	62.00d	64.00b	37.33d	2.31bcd	7.49d	12.40c
W ₃	13.33e	16.00c	14.00e	1.95cd	3.21e	7.65d
W ₄	14.00e	34.00bc	22.17de	1.91d	2.29e	5.500d
W ₅	79.33c	40.00bc	36.00d	2.67abc	2.42e	8.750cd
W ₆	96.67b	142.0a	97.17b	2.97ab	18.07b	33.25a
W ₇	50.67d	56.67b	61.67c	2.18cd	15.13c	16.30b
Level of sig.	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	19.65	25.94	27.49	22.58	25.49	19.26

*In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT).

Table 3. Interaction effect of cultivar and methods of weed management on weed population and weed dry weight.

Cultivar×Method of weed management	Weed population (no. m ⁻²)			Weed dry matter (g m ⁻²)		
	25DAT	50DAT	75DAT	25DAT	50DAT	75DAT
V ₁ W ₀	109.0	162.7	113.7	3.707 a*	23.09	37.53
V ₁ W ₁	20.00	40.00	25.33	2.547 bc	5.147	8.59
V ₁ W ₂	61.33	65.33	26.67	1.947 cd	8.733	9.99
V ₁ W ₃	17.33	22.67	12.00	1.240 d	2.667	4.04
V ₁ W ₄	17.33	41.33	24.33	1.200 d	2.293	5.73
V ₁ W ₅	70.67	41.33	36.00	2.853 abc	2.173	8.33
V ₁ W ₆	96.00	128.0	109.0	3.180 ab	16.57	34.40
V ₁ W ₇	56.00	61.33	64.67	2.427 bc	14.89	14.39
V ₂ W ₀	110.7	169.3	117.3	2.987 abc	25.20	36.25
V ₂ W ₁	14.67	42.67	44.00	1.973 cd	5.400	9.62
V ₂ W ₂	62.67	62.67	48.00	2.680 abc	6.240	14.80
V ₂ W ₃	9.333	9.333	16.00	2.667 abc	3.747	11.25
V ₂ W ₄	10.67	26.67	20.00	2.627 bc	2.293	5.27
V ₂ W ₅	88.00	38.67	36.00	2.480 bc	2.667	9.17
V ₂ W ₆	97.33	156.0	85.33	2.760 abc	19.57	32.11
V ₂ W ₇	45.33	52.00	58.67	1.927 cd	15.36	18.20
Level of sig.	NS	NS	NS	0.01	NS	NS
CV (%)	19.65	35.94	27.49	22.58	25.49	19.26

*In a column, figures with the same letter (s) or without letter do not differ significantly as per DMRT; NS = Not Significant; V₁=BRR1 dhan28, V₂=BRR1 dhan29; W₀= No weeding, W₁= Application of pre-emergence herbicide, W₂= Application of early post-emergence herbicide, W₃= Application of pre-emergence herbicide followed by application of early post-emergence herbicide, W₄= Application of pre-emergence herbicide followed by one hand weeding at 35 DAT, W₅= Application of early post-emergence herbicide followed by one hand weeding at 35 DAT, W₆= Stale seedbed, W₇=Stale seedbed followed by application of early post-emergence herbicide.

Interaction effect of cultivar and weed management practices on total weed population and weed dry matter

No significant variation was found in weed density due to interaction of cultivar and weed management practices at 25, 50 and 75 DATs. Similar research finding was also reported by Parvez et al. (2013). At 25 DAT, numerically the highest weed density (110.7 m⁻²) was found in V₂W₀ (BRR1 dhan29 × no weeding) and the lowest one (9.33 m⁻²) was found in V₂W₃ (BRR1 dhan29 × application of pre-emergence herbicide followed by early post-emergence herbicide). At 50 DAT, numerically the highest weed population (169.30 m⁻²) was found in V₂W₀ (BRR1 dhan29 × no weeding) and the lowest one (9.33 m⁻²) was found in V₂W₃ (BRR1 dhan29 × application of pre-emergence herbicide followed by early post-emergence herbicide). At 75 DAT, numerically the highest weed population (117.3 m⁻²) was found in V₂W₀ (BRR1 dhan29 × no weeding) and the lowest one (12.00

m⁻²) was found in V₁W₃ (BRR1 dhan28 × application of pre-emergence herbicide followed by early post-emergence herbicide) (Table 3). Significant variation was found in weed dry weight due to interaction of cultivar and weed management practices at 25 DAT. The highest weed dry matter (3.71 g m⁻²) was found in V₁W₀ (BRR1 dhan28 × no weeding) treatment, while the lowest weed dry matter (1.20 g m⁻²) was found in V₁W₄ (BRR1 dhan28 × application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment which was statistically identical to V₁W₃ (BRR1 dhan28 × application of pre-emergence herbicide followed by early post-emergence herbicide). There was no significant variation found in weed dry weight due to interaction between cultivar and weed management practices at 50 and 75 DAT (Table 3). This finding corroborates the findings of Parvez et al. (2013).

Effect of cultivar on the yield and yield contributing characters of *boro* rice

The plant height was not varied significantly by the cultivars. Numerically the taller plant (80.33 cm) was found in BRR1 dhan29 than in BRR1 dhan28 (80.13 cm) (Table 4). Total and effective tillers hill^{-1} were not significantly influenced by cultivars. Numerically the higher number of tillers hill^{-1} (10.96) and effective tillers hill^{-1} (9.12) were observed in BRR1 dhan28 than BRR1 dhan29 (Table 4). Panicle length and grains panicle $^{-1}$ were not significantly affected by different cultivars. However, numerically the longer panicle (21.06 cm) and higher number of grains panicle $^{-1}$ (85.75) were recorded in cultivar BRR1 dhan28 and shorter panicle (21.00 cm) and lower number of grains panicle $^{-1}$ (85.46) were recorded in BRR1 dhan29 (Table 4). Number of sterile spikelets panicle $^{-1}$ was not significantly affected by different cultivars. Numerically the higher number of sterile spikelets panicle $^{-1}$ (17.92) was observed in BRR1 dhan29 and the lower one (17.67) was found in BRR1 dhan28 (Table 4). Numerically the heavier thousand grain weight (21.32 g) was recorded in BRR1 dhan28 and lower one (21.16 g) was recorded in BRR1 dhan29 (Table 4). The cultivars studied differed significantly in

respect of grain yield. Higher grain yield (5.17 t ha^{-1}) was obtained in BRR1 dhan28 and the lower grain yield (4.88 t ha^{-1}) was obtained in BRR1 dhan29 cultivar. Variation in grain yield of rice due to cultivars was also reported by Parvez et al. (2013), Islam et al. (2017) and Mou et al. (2017). Straw yield was not significantly influenced by cultivar. Numerically higher straw yield (6.43 t ha^{-1}) was found in BRR1 dhan28 and lower one (6.37 t ha^{-1}) was found in BRR1 dhan29. Harvest index was significantly influenced by cultivar. Higher harvest index (43.61 %) was obtained in BRR1 dhan28 and lower harvest index (42.59 %) was obtained in BRR1 dhan29 (Table 4).

Effect of weed management practices on yield and yield contributing characters of *boro* rice

Plant height was not significantly affected by different weed management practices. Numerically the tallest plant (81.97 cm) was found in W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) treatment. The shortest plant (78.73 cm) was found in W₂ (application of early post-emergence herbicide) treatment (Table 5).

Table 4. Effect of cultivars on yield and yield contributing characters of *boro* rice.

Cultivar	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Length of panicle (cm)	Grain panicle $^{-1}$ (no.)	Sterile spikelets panicle $^{-1}$ (no.)	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
BRR1 dhan28	80.13	10.96	9.12	21.06	85.46	17.67	21.32	5.171a*	6.43	43.61a
BRR1 dhan29	80.33	10.33	8.70	21.00	85.75	17.92	21.16	4.875b	6.37	42.59b
Level of sig.	NS	NS	NS	NS	NS	NS	NS	0.01	NS	0.01
CV (%)	2.95	10.49	12.68	1.82	3.48	13.79	6.79	2.51	1.37	1.85

*In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); NS = Not Significant.

Table 5. Effect of methods of weed management on yield and yield contributing characters of *boro* rice cultivars.

Weed management practices	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Length of panicle (cm)	Grains panicle $^{-1}$ (no.)	Sterile spikelets panicle $^{-1}$ (no.)	1000- grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
W ₀	79.68	8.667c*	6.833c*	20.92	107.40e	19.83a	20.73abc	1.99f	4.28e	31.73d
W ₁	80.23	12.83ab	10.75ab	20.65	133.00c	19.33ab	21.23abc	5.59c	6.82b	45.04b
W ₂	78.73	13.00ab	11.17ab	21.25	136.90bc	19.00abc	20.13c	5.69c	6.87b	45.27ab
W ₃	81.97	13.83a	12.32a	21.18	138.90b	15.83cd	22.10ab	5.87b	7.21a	44.88b
W ₄	81.52	13.67a	12.27a	21.00	147.70a	18.00a-d	22.17ab	6.19a	7.22a	46.16a
W ₅	81.15	13.83a	12.08a	21.30	140.30b	18.17a-d	20.43bc	5.60c	6.86b	44.95b
W ₆	78.92	11.50b	9.733b	21.07	117.80d	15.67d	20.63abc	3.99e	5.42d	42.37c
W ₇	79.65	12.50ab	10.87ab	20.88	134.80bc	16.50bcd	22.47a	5.26d	6.58c	44.43b
Level of sig.	NS	0.01	0.01	NS	0.01	0.01	0.05	0.01	0.01	0.01
CV (%)	2.95	10.49	12.68	1.82	3.48	13.79	6.79	2.51	1.37	1.85

*In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), NS = Not significant; W₀= No weeding, W₁= Application of pre-emergence herbicide, W₂= Application of early post-emergence herbicide, W₃= Application of pre-emergence herbicide followed by application of early post-emergence herbicide, W₄= Application of pre-emergence herbicide followed by one hand weeding at 35 DAT, W₅= Application of early post-emergence herbicide followed by one hand weeding at 35 DAT, W₆= Stale seedbed, W₇=Stale seedbed followed by application of early post-emergence herbicide.

The highest number of total tillers hill⁻¹ (13.83) was observed in W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) treatment which was statistically identical to W₄ (application of pre-emergence herbicide followed by one hand weeding at 35 DAT) and W₅ (application of early post-emergence herbicide followed by one hand weeding at 35 DAT). The lowest number total tillers hill⁻¹ (8.67) was observed in W₀ (No weeding) treatment. In no weeding treatment weed crop competition was higher and weed suppressed the rice plant growth ultimately tiller number was reduced (Table 5). Number of effective tillers hill⁻¹ was significantly influenced by different weed management practices. The highest number of effective tillers hill⁻¹ (12.32) was observed in W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) treatment which was statistically identical to W₄ (application of pre-emergence herbicide followed by one hand weeding at 35 DAT) and W₅ (application of early post-emergence herbicides followed by one hand weeding at 35 DAT). The lowest effective tillers hill⁻¹ (6.83) was observed in W₀ (no weeding) treatment. Weeds were controlled effectively in W₃, W₄ and W₅ treatments. Therefore crop weed competition was lower and hence rice growth was vigorous in those treatments and highest number of effective tillers was observed in W₃, W₄ and W₅ treatments. Similar research finding was also repeated by Mou et al (2017). Panicle length was not significantly affected by weeding regime. Numerically the longest panicle (21.30 cm) was observed in W₅ (application of early post-emergence herbicides followed by one hand weeding at 35 DAT) treatment and the shortest one (20.65 cm) was observed in W₁ (application of pre-emergence herbicide) treatment (Table 5). Number of grains panicle⁻¹ was significantly affected by different weeding regimes. The highest number of grains panicle⁻¹ (147.70) was observed in W₄ (application of pre-emergence herbicides followed by one hand weeding at 35 DAT) treatment, while the lowest one (107.40) was observed in W₀ (no weeding) treatment. In this study, W₄ (application of pre-emergence herbicide followed by one hand weeding at 35 DAT) produced the highest number of grains panicle⁻¹ which might be attributed due to vigorous growth of rice plant because of less competition with weed. Number of sterile spikelets panicle⁻¹ was significantly affected by different weed management practices. The highest number of sterile spikelets panicle⁻¹ (19.83) was observed in W₀ (no weeding) treatment, while the lowest number of sterile spikelets panicle⁻¹ (15.67) was observed in W₆ (stale seedbed) treatment (Table 5). Weight of 1000-grain was significantly affected by different weed management practices. The heaviest thousand grain weight (22.47 g) was recorded in W₇ (stale seedbed followed by application of early post-emergence herbicide) treatment, while the lowest thousand grain weight (20.13 g) was recorded in W₂ (application of early post-emergence herbicide) treatment. Treatment W₀ (no weeding), W₁ (application of pre-emergence herbicide) and W₆ (stale seedbed) were slightly similar (Table 5). On the other hand, treatment W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) and W₄ (application of pre-emergence herbicides

followed by one hand weeding at 35 DAT) were statistically similar. Grain yield was significantly influenced by different weeding regimes. The highest grain yield (6.19 t ha⁻¹) was observed in W₄ (application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment, while the lowest grain yield (1.99 t ha⁻¹) was observed in W₀ (no weeding) treatment. Similar research finding was also reported by Parvez et al. (2013) who reported that application of pre-emergence herbicide followed by one hand weeding at 35 DAT produced the highest grain yield of rice. Treatments W₁ (application of pre-emergence herbicide), W₂ (application of early post-emergence herbicide) and W₅ (application of early post-emergence herbicide followed by one hand weeding at 35 DAT) were statistically similar. The increased yield was contributed in W₄ (application of pre-emergence herbicides followed by one hand weeding at 35 DAT) treatment due to higher number of effective tiller hill⁻¹, higher number of grains panicle⁻¹ over no weeding treatment. This might be due to the fact that in the W₄ treatment, weeds were controlled effectively and the rice field was weed free and soil was well aerated which facilitated the crop for absorption of greater amount of plant nutrients, moisture and greater reception of solar radiation for better growth. Straw yield was significantly influenced by different weeding regimes. The highest straw yield (7.22 t ha⁻¹) was observed in W₄ (application of pre-emergence herbicides followed by one hand weeding at 35 DAT) treatment which was statistically identical with W₃ (application of pre-emergence herbicide followed by early post-emergence herbicide) treatment, while the lowest straw yield (4.28 t ha⁻¹) was observed in W₀ (no weeding) treatment). Harvest index was significantly influenced by different weed management practices. The highest harvest index (46.16 %) was observed in W₄ (application of pre-emergence herbicides followed by one hand weeding at 35 DAT). The lowest harvest index (31.73 %) was observed in W₀ (no weeding) treatment (Table 5).

Interaction effect of cultivar and weed management practices on yield and yield contributing characters of boro rice

The interaction effect of cultivar and weed management practices was significant for plant height. The tallest plant (83.60 cm) was obtained from V₁W₄ (BRR1 dhan28 × application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment and the one (75.60 cm) was found in V₁W₆ (BRR1 dhan28 × stale seedbed) treatment (Table 6). Non significant variation in total and effective tillers hill⁻¹ due to interaction of cultivar and weed management was observed in the study. Numerically the highest number of total tillers hill⁻¹ (14.67) and effective tillers hill⁻¹ (13.33) were produced in V₁W₃ (BRR1 dhan28 × application of pre-emergence herbicide) and V₁W₄ (BRR1 dhan28 × application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment, respectively, while the lowest number of total tillers hill⁻¹ (8.33) and effective tillers hill⁻¹ (6.67) were produced in V₁W₀ (BRR1 dhan28 × no weeding) treatment (Table 6). Panicle length was not significantly influenced by interaction of cultivar and weed

management practices. Apparently the longest panicle (21.47 cm) was observed in V_1W_5 (BRRI dhan28 × application of early post-emergence herbicide followed by one hand weeding at 35 DAT) treatment and the shortest one (20.33 cm) was found in V_1W_1 (BRRI dhan28 × application of pre-emergence herbicide) treatment (Table 6). Number of grains panicle⁻¹ was significantly influenced by interaction of cultivar and weed management practices. The highest number of grains panicle⁻¹ (157.50) was produced by V_1W_4 (BRRI dhan28 × application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment, while the lowest one (106.30) was produced by V_2W_0 (BRRI dhan29 × no weeding) treatment which was statistically identical to V_1W_0 (BRRI dhan28 × no weeding), and V_2W_6 (BRRI dhan29 × stale seedbed) (Table 6). There was no significant variation in number of sterile spikelets panicle⁻¹ due to interaction of cultivar and different weeding regimes. Weight of 1000-grain was not significantly affected by interaction of cultivar and different weeding regimes. Numerically the heaviest 1000-grain weight (23.20 g) was obtained in V_1W_7 (BRRI dhan28 × stale seedbed) treatment, while the lowest 1000-grain weight (19.73 g) was obtained from V_2W_5 (BRRI dhan29 × application of early post-emergence herbicides followed by one hand weeding at 35 DAT) treatment (Table 6). Grain yield was significantly influenced by different cultivars and weeding regimes. The highest grain yield (6.42 t ha⁻¹) was produced in V_1W_4 (BRRI dhan28 × application of pre-emergence herbicide followed by one hand weeding at 35 DAT) treatment. This finding partially corroborates the findings of Mou et al. (2017) who reported that

application of early post-emergence herbicide followed by one hand weeding at 35 DAT produced the highest grain yield. The integrated approach like application of herbicide followed by hand weeding performed better than herbicide or hand weeding alone, such as application of pre-emergence herbicide followed by one hand weeding at 35 DAT. The lowest grain yield (1.86 t ha⁻¹) was produced in V_1W_0 (BRRI dhan28 × no weeding) condition (Table 6). The lowest grain yield ha⁻¹ in the no weeding treatment might be due to the poor performance of yield contributing characters like number of tillers hill⁻¹ and grains panicle⁻¹. Because of severe weed infestation occurred in the no weeding plots due to competition for moisture, nutrients between weed and rice plants. Straw yield was significantly influenced by different cultivars and weeding regimes. The highest straw yield (7.33 t ha⁻¹) was produced in V_1W_4 (BRRI dhan28 × application of pre-emergence herbicides followed by one hand weeding at 35 DAT) treatment. The lowest straw yield (4.04 t ha⁻¹) was obtained in V_1W_0 (BRRI dhan28 × no weeding) treatment (Table 6). Harvest index was significantly influenced by different cultivars and weed management practices. The highest harvest index (46.69 %) was recorded in V_1W_4 (BRRI dhan28 × application of pre-emergence herbicides followed by one hand weeding at 35 DAT) treatment which was statistically identical to V_1W_1 (BRRI dhan28 × application of pre-emergence herbicide) and V_1W_2 (BRRI dhan28 × application of early post-emergence herbicide). The lowest harvest index (31.48 %) was recorded in V_1W_0 (BRRI dhan28 × no weeding) which was followed by V_2W_0 (BRRI dhan29 × no weeding) (31.97%) treatment (Table 6).

Table 6. Effect of interaction between cultivars and methods of weed management on yield and yield contributing characters of *boro* rice.

Cultivar × Weed management practices	Plant height (cm)	Total tillers hill ⁻¹ (no.)	Effective tillers hill ⁻¹ (no.)	Length of panicle (cm)	Grain panicle ⁻¹ (no.)	Sterile spikelets panicle ⁻¹ (no.)	1000- grain weight (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)	Harvest index (%)
V_1W_0	80.80abc*	8.333	6.67	21.00	108.6f	21.67	20.27	1.86k	4.04k	31.48f
V_1W_1	80.17abc	13.67	11.33	20.33	141.6bc	21.00	21.20	5.88bcd	6.89de	46.06a
V_1W_2	79.13a-d	14.33	12.33	21.03	140.6bc	18.00	19.80	6.07b	6.96cd	46.58a
V_1W_3	83.00ab	14.67	13.00	21.30	144.2b	16.00	22.33	5.98bc	7.18ab	45.43abc
V_1W_4	83.60a	14.67	13.33	21.37	157.5a	17.33	21.80	6.42a	7.33a	46.69a
V_1W_5	80.63abc	14.33	12.67	21.47	141.6bc	17.67	21.13	5.67de	6.82de	45.37abc
V_1W_6	75.60d	10.67	9.133	21.20	123.9e	14.33	20.80	4.26h	5.66h	42.94de
V_1W_7	78.13cd	12.67	11.40	20.80	141.9bc	15.33	23.20	5.23g	6.56g	44.36bcd
V_2W_0	78.57bcd	9.000	7.000	20.83	106.3f	18.00	21.20	2.12j	4.51j	31.97f
V_2W_1	80.30abc	12.00	10.17	20.97	124.4e	17.67	21.27	5.30g	6.74ef	44.02cd
V_2W_2	78.33bcd	11.67	10.00	21.47	133.3cd	20.00	20.47	5.32fg	6.78e	43.96cd
V_2W_3	80.93abc	13.00	11.63	21.07	133.7cd	15.67	21.87	5.76cd	7.23ab	44.34bcd
V_2W_4	79.43a-d	12.67	11.20	20.63	137.9bc	18.67	22.53	5.96bc	7.10bc	45.63ab
V_2W_5	81.67abc	13.33	11.50	21.13	139.1bc	18.67	19.73	5.53ef	6.89de	44.52bc
V_2W_6	82.23abc	12.33	10.33	20.93	111.7f	17.00	20.47	3.72i	5.18i	41.80e
V_2W_7	81.17abc	12.33	10.33	20.97	127.6de	17.67	21.73	5.29g	6.60fg	44.49bc
Level of sig.	0.05	NS	NS	NS	0.01	NS	NS	0.01	0.01	0.05
CV (%)	2.95	10.49	12.68	1.82	3.48	13.79	6.79	2.51	1.37	1.85

*In a column, figures with the same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), NS = not significant; NS = Not Significant, V_1 = BRRI dhan 28 V_2 = BRRI dhan 29; W_0 = No weeding, W_1 = Application of pre-emergence herbicide, W_2 = Application of early post-emergence herbicide, W_3 = Application of pre-emergence herbicide followed by application of early post-emergence herbicide, W_4 = Application of pre-emergence herbicide followed by one hand weeding at 35 DAT, W_5 = Application of early post-emergence herbicide followed by one hand weeding at 35 DAT, W_6 = Stale seedbed, W_7 =Stale seedbed followed by application of early post-emergence herbicide.

Conclusion

Although cultivar did not exert any significant effect on weed density and dry weight but integrated weed management practices had significant effect on weed density and dry weight. BRR1 dhan28 produced higher grain and straw yields than BRR1 dhan29. The highest grain yield was obtained from the application of pre-emergence herbicide followed by one hand weeding at 35 DAT. BRR1 dhan28 × application of pre-emergence herbicide followed by one hand weeding at 35 DAT produced the highest grain yield. Application of pre-emergence herbicide followed by one hand weeding at 35 DAT was effective for controlling weed and obtaining highest grain yield. So, for the control of weeds in effective manner and in order to get maximum grain yield in *boro* rice, BRR1 dhan28 with the application of pre-emergence herbicide followed by one hand weeding at 35 DAT might be recommended.

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