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Original Article

Effect of Herbicide Dose and Water Management on Weed Control Efficiency and Yield Performance of Boro Rice

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Abstract

An experiment was conducted at the Experimental Farm of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur during November 2011 to May 2012 to determine the effect of pre-emergence herbicide Pretilachlor @ 75%, 100%, 125%, 150%, 175% and 200% of the recommended dose under two water management regime i.e. continuous flooding and field capacity on weed suppression and yield performance of Boro rice cv. BRRIdhan28. One weed free and one control (unweeded) treatment were also imposed for treatment comparison. The experiment was laid down in Split Plot design with three replications. Standard management practices for transplanted rice were followed. Continuous flooding was found to contribute better weed control efficiency than field capacity. At 60 DAT, the highest weed control efficiency of 65.75% was found in the treatment receiving Pretilachlor @ 125% of the recommended dose under continuous flooding and the least (54.76%) was found in the treatment receiving 75% of the recommended dose under field capacity. Continuous flooding contributed to more tillers than field capacity, and herbicide up to 125% of the recommended dose enhanced tillering in rice. At 75DAT the highest number of tillers (17.53 $hill^{-1}$) were found in the plots receiving Pretilachlor @ 125% of the recommended dose under good water management (W1T3), while the lowest (11.10 $hill^{-1}$) was recorded in W2T6 treatment receiving Pretilachlor @ 200% of the recommended dose under field capacity. The highest tiller mortality (27.90%) was observed in W1T3 treatment, whereas the least (8.06%) was observed in W2T5 treatment receiving the same herbicide @175% of the recommended dose under field capacity. Application of Pretilachlor at recommended dose under continuous flooding contributed to the highest crop dry matter production (1144.60g m^{-2}) thus leading to the highest grain yield of 6.31 t ha^{-1} being followed by the treatment receiving Pretilachlor @ 125% of the recommended dose under same water management yielding 5.95 t ha^{-1} along with the highest harvest index of 0.58. Results revealed that Pretilachlor at recommended dose might be considered as viable option for weed management in transplanted Boro rice cultivation for effective weed management and satisfactory grain yield provided that appropriate water management is adopted. [*Journal of Science Foundation 2014;12(2):39-46*]

Keywords: Rice; herbicide dose; water management; weed control; grain yield

Introduction

Rice is the staple food in Bangladesh. The area and production of rice in 2006 were 10.58 million hectares and 27.32 million metric tons respectively (BBS, 2007) in Bangladesh. Weeds is the most important constraint in rice crop and weed management is one the most time consuming and laborious practice in rice cultivation. Poor weed control is one of the major factors for yield reduction of rice depending on the type of weed flora and their intensity (Amarjit *et al.*, 1994). Mamun (1990) reported that weed growth reduced grain yield by 69-100% for direct seeded *aus* rice, 16-48% for *aman* rice and 22-36% for modern *Boro* rice.

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In Bangladesh, the traditional methods of weed control practices include preparatory land tillage, hand weeding by niri/khurpiand hand pulling. These methods involve a large amount of labour, time and money. Herbicidal weed control methods offer an advantage to save labor and money, as a result, is regarded as cost effective (Ahmed *et al.*, 2000). Chemical weed control has become popular in Bangladesh along with many rice growing countries in recent years. The main reason is scarcity of labor during peak growing season, and also lower weeding cost. The total use of herbicides in Bangladesh in the year 2008 was 4024.77 tons (BCPA, 2009) compared to only 108 ton in 1989 (BBS, 1991) and the growth is almost exponential.

Herbicides are poisonous chemical compounds. That's why they obviously have some detrimental effects on main crop (Begum *et al.*, 2008; Scarponi *et al.*, 2005; Islam, 2001; Rahman, 2001), surrounding ecosystems (Panda and Sahu, 2004; Bromilow, 2003; Sannino and Gianfreda 2001), and human health (Gammon, 2009). Therefore, judicious use of herbicides is essential to ensure proper weed control, crop growth and yield, and environmental safety. Information on the judicious use of herbicides are, however, scanty under Bangladesh context. The main reason is that there are no national guidelines on herbicide use and DAE has not been emphasizing training and education on herbicide use as they do in case of other pesticides (Bari, 2012). That's why field level Extension personnel as well as farmers are lacking information regarding safe and judicious use of herbicides in crop cultivation. As a result farmers rely mainly on herbicide dealers and traders for dose configuration. Bari (2012) further reported that farmers are not following dose instructions properly. Even they were found to use overdoses as well as under dose of herbicides. Again, water management is a key issue to ensure efficacy of applied herbicides. Rice herbicides, in general require adequate water in the rice fields. Farmers in Bangladesh often do not have idea or knowledge regarding proper water management to ensure efficacy of applied herbicides (Bari, 2012).

Under the above mentioned context, judicious use of appropriate herbicides for appropriate crops to be ensured to sustain crop productivity and protecting the environment. Therefore, the present study was undertaken to evaluate a commonly used rice herbicide at different doses in transplanted Boro rice under two selected water management to see the effect of herbicide at variable dose under continuous flooding and field capacity on weed infestation behavior in rice field; to determine the effect of herbicide at variable dose under continuous flooding and field capacity condition on crop growth and development and to evaluate the yield performance of Boro rice as affected by herbicide dose and continuous flooding and field capacity.

Methodology

A field experiment was conducted at the Experimental Farm of the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur under wet land condition during November 2011 to May 2012. BRRIdhan28, a modern rice variety was used as the test crop. The experiment was laid out in split plot design with three replications where two water management, i.e. continuous flooding (W1) and field capacity (W2) were put in the main plot treatment; while pre-emergence herbicide Pretilachlor was applied at 6 different doses, i.e. 75% (T1), 100% (T2), 125% (T3), 150% (T4), 175% (T5) and 200% (T6) were applied in the sub-plots. In addition, one control (T7) and weed free treatment (T8) were also imposed for comparison. A fertilizer dose of 77-80-55-5 kg of Triple Super Phosphate, Muriate of Potash, Gypsum and Zinc sulfate, respectively was applied in the experimental field. The whole amount of fertilizers was applied as basal dose during final land preparation. Urea was top-dressed in three equal installments at 20, 40 and 60 days after transplanting (DAT), respectively. One month old rice seedlings were transplanted in the main field on January 4, 2012 done with two seedlings hill^{-1} at a spacing of 20cm x 15cm on the same day. Herbicide was applied in the crop field at 6 DAT. A water height of 4-6cm was maintained during herbicide application. But under continuous flooding this water level was maintained until grain filling stage, whereas under field capacity, as the water was drained out gradually, the rice soil was kept at field capacity throughout the growing season until the crop attained grain filling stage. The crop was kept under continuous observation from transplanting till harvesting. Intercultural operations such as irrigation, pest management and other necessary cultural operations were done as and when required. The crop was harvested on 10 May, 2012 when 80% of the grains were matured. The data on weed infestation were collected from each unit plot at 30, 60, 90 DAT and at harvest. A plant quadrate (population counter) of 0.25 m^2 was placed randomly inside the plot. The infesting weeds within each quadrate were counted. The average number of three samples was then multiplied by 4 to obtain the weed density m^{-2}. The weeds inside each quadrate for density count were uprooted and cleaned. The collected weeds were first dried in the sun and then in an electrical oven for 72 hours maintaining a continuous temperature of 80°C. After drying, weight of dry weed was measured and expressed in g m^{-2}.

Weed control efficiency (WCE): WCE was calculated with the following formula:

Weed control efficiency (WCE) = {(DMC – DMT) / DMC} x 100
DMC = Weed dry matter in unweeded treatment
DMT = Weed dry matter in weed control treatment

At harvest, five plants were harvested from each plot to record data on yield components and the plants from an area of 2.4 m^2 was harvested to record data on grain and straw yields. The harvested crops were threshed; cleaned, dried weighed and necessary data were collected on various crop characters. Number of filled grains and sterile spikelets were counted from each panicle. Thousand grain weight was measured from air dried grains at 14% moisture content. The data were compiled and tabulated in proper forms for statistical analysis. Analysis of variance was done following the experimental design with the help of the computer package Statistix 10. Later the means were separated through Least Significance Difference (LSD) test.

Results and Discussion

Considerable effects of water management and herbicide dose on weed control, plant growth and yield contributing characters were observed throughout the study. In this chapter the effects of weed control treatments on individual parameters are discussed.

Table 1: Weed control efficiency as affected by herbicide dose and water management in Boro rice

Treatment	Weed control efficiency (%)			
	30 DAT	60 DAT	90 DAT	At Harvest
W1T1 (75%)	51.26	58.27	49.91	39.44
W1T2 (100%)	52.60	61.87	60.20	43.09
W1T3 (125%)	56.44	65.75	65.56	47.36
W1T4 (150%)	55.11	64.08	59.51	44.92
W1T5 (175%)	54.43	62.92	59.20	43.34
W1T6 (200%)	54.27	60.77	57.89	43.13
W1T7 (Control)	0.00	0.00	0.00	0.00
W1T8 (Weed free)	100.0	100.0	100.0	100.0
W2T1 (75%)	40.24	54.76	43.44	38.14
W2T2 (100%)	42.34	56.56	53.57	39.06
W2T3 (125%)	49.58	60.35	64.25	42.88
W2T4 (150%)	46.52	58.80	58.72	42.09
W2T5 (175%)	44.27	58.46	57.83	40.69
W2T6 (200%)	44.60	56.58	56.85	39.81
W2T7 (Control)	0.00	0.00	0.00	0.00
W2T8 (Weed free)	100.0	100.0	100.0	100.0
CV (%)	2.79	3.77	0.76	7.72
LSD (0.05)	2.308	3.614	0.7037	5.673

Note: W1= Continuous flooding; W2 = Field capacity

Weed control efficiency (WCE) as affected by herbicide dose and water management

There were significant differences among the treatments in terms of weed control efficiency. Weed control efficiency increased up to 60DAT, and then increased at slower rate irrespective of water management and weed control treatments (Table 1). It might be due to lowering of herbicidal treatments which allowed germination and infestation of weed plants at later stages.

Table 2: Tillering behavior of Boro rice as affected by herbicide dose and water management

Treatment	Tillers hill^{-1}			Average tillers hill^{-1} under water management		
	75 DAT	At Harvest	% Mortality	At 75 DAT	At harvest	% Mortality
W1T1 (75%)	14.83	11.03	25.62	14.73	10.90	26.01
W1T2 (100%)	15.72	12.18	22.52			
W1T3 (125%)	17.53	12.64	27.90			
W1T4 (150%)	15.40	11.90	22.73			
W1T5 (175%)	13.98	11.59	17.10			
W1T6 (200%)	14.53	11.24	22.64			
W1T7 (Control)	8.96	4.33	51.67			
W1T8 (Weed free)	16.87	12.27	27.27			
W2T1 (75%)	11.80	9.93	15.85	11.46	9.57	16.48
W2T2 (100%)	12.07	10.97	9.11			
W2T3 (125%)	13.65	10.80	20.88			
W2T4 (150%)	12.52	10.00	20.13			
W2T5 (175%)	11.42	10.50	8.06			
W2T6 (200%)	11.10	10.18	8.29			
W2T7 (Control)	5.68	3.06	46.13			
W2T8 (Weed free)	13.40	11.10	17.16			
CV (%)	7.55	8.91				
$LSD_{0.05}$	1.873	0.8077				

Note: W1= Continuous flooding; W2 = Field capacity

At 60 DAT (when transplanted rice plants approached towards flowering), apart from weed free and control (unweeded) situation, the highest WCE of 65.75% was found in W1T3 treatment receiving pre-emergence herbicide @125% of the recommended dose under continuous flooding, while the least (54.76%) was found in W2T1 receiving pre-emergence herbicide @75% of the recommended dose under field capacity.

Table 3: Dry matter production as affected by herbicide dose and water management in Boro rice

Treatment	TDM at harvest (g m^{-2})	% Change from weed free	% Change from control	Average TDM under water management (g m^{-2})
W1T1 (75%)	1011.34	-22.10	5.24	1088.84
W1T2 (100%)	1144.6	-11.83	19.10	
W1T3 (125%)	1106.13	-14.80	15.10	
W1T4 (150%)	1018.22	-21.57	5.95	
W1T5 (175%)	1101.71	-15.14	14.64	
W1T6 (200%)	1069.48	-17.62	11.29	
W1T7 (Control)	961.01	-25.98		
W1T8 (Weed free)	1298.23		35.09	
W2T1 (75%)	888.40	-24.67	20.40	938.77
W2T2 (100%)	980.40	-16.87	32.86	
W2T3 (125%)	952.50	-19.23	29.08	
W2T4 (150%)	900.20	-23.67	21.99	
W2T5 (175%)	941.00	-20.21	27.52	
W2T6 (200%)	930.40	-21.11	26.09	
W2T7 (Control)	737.90	-37.43		
W2T8 (Weed free)	1179.32		59.82	
CV (%)	4.71			
LSD (0.05)	79.81			

Data revealed that, water management had a significant effect on weed control efficiency, i.e. the better the water management, the higher the weed control efficiency irrespective of weed control treatments. Again, data revealed that WCE was the highest in the plots receiving pre-emergence herbicide @ 125% of the recommended dose (T3) irrespective of water management throughout the season (Table 1). Results indicated that, the existing recommended dose of herbicide might need further adjustment to combat weed problem effectively in Boro rice cultivation.

Table 4: Yield performance of Boro rice as affected by herbicide dose and water management

Treatment	Panicle hill^{-1}	Filled grain panicle	Unfilled grain panicle	1000 grain wt (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI
W1T1 (75%)	10.02	113.1	18.72	25.47	4.557	4.693	0.49
W1T2 (100%)	11.47	116.3	17.34	27.35	6.310	5.950	0.51
W1T3 (125%)	11.69	114.8	16.22	26.83	5.95	4.38	0.58
W1T4 (150%)	10.90	115.4	19.16	26.09	5.523	4.893	0.53
W1T5 (175%)	10.49	113.8	20.06	25.81	4.173	4.240	0.50
W1T6 (200%)	10.07	112.5	21.18	25.06	5.153	3.963	0.57
W1T7 (Control)	2.953	97.13	23.83	24.70	1.077	1.303	0.47
W1T8 (Weed free)	11.73	117.2	15.57	26.56	6.597	5.360	0.55
W2T1 (75%)	8.57	108.8	25.07	21.65	3.717	2.960	0.56
W2T2 (100%)	9.75	109.7	24.41	22.69	4.220	3.917	0.52
W2T3 (125%)	9.49	111.4	23.47	23.30	3.44	3.32	0.51
W2T4 (150%)	8.43	107.7	27.52	21.96	2.983	3.733	0.44
W2T5 (175%)	9.06	106.3	26.77	22.26	2.297	3.503	0.40
W2T6 (200%)	8.81	110.4	28.59	20.98	2.640	3.123	0.46
W2T7 (Control)	1.81	88.98	34.79	20.28	1.073	1.183	0.48
W2T8 (Weed free)	10.00	112.0	26.21	22.90	4.680	4.113	0.53
CV (%)	4.49	0.92	2.17	1.67	7.37	7.09	
LSD (0.05)	1.089	4.853	4.187	0.9769	2.154	1.400	

Note: W1= Continuous flooding; W2 = Field capacity

Tillering behaviour as affected by herbicide dose and water management

Water management had considerable effect on tiller production irrespective of weed control treatments (Table 2). At 75 DAT, during the period of peak tiller production, the number of tiller was 28.53% higher under continuous flooding (14.73 hill^{-1}) compared to that under field capacity (11.46 hill^{-1}). Similar trend was noticed at harvest, however, at a narrower margin (13.90%). Weed control treatments also affected tiller production significantly. At 75DAT the highest number of tillers (17.53 hill^{-1}) was found in the plots receiving Pretilachlor @ 125% of the recommended dose under continuous flooding (W1T3). The lowest number of tillers (5.68/hill) was found in the treatments of T7 (control plot) under field capacity. Apart from unweeded situation, the lowest (11.10 hill^{-1}) was recorded in W2T6 treatment receiving Pretilachlor @ 200% of the recommended dose under field capacity. Data revealed that, tiller production increased with increase in herbicide does up to 125% of the recommended dose, thereafter it declined irrespective of water management. It might be due to that, herbicide dose beyond 125% of the recommended dose put adverse effects on crop growth and development process leading to lower tiller production.

In case of tiller mortality, an opposite scenario was revealed, i.e. under continuous flooding, tiller mortality rate was higher (26.01%) compared to that (16.48%) under field capacity (Table 3), i.e. tiller mortality rate was 57.83% higher under continuous flooding when compared to field capacity. Weed control treatment, i.e. herbicide dose also put significant effect on tiller mortality. The highest tiller mortality (27.90%) was observed in W1T3 treatment receiving Pretilachlor herbicide under continuous flooding, whereas the least (8.06%) was observed in W2T5 treatment receiving the same herbicide @175% of the recommended dose under field capacity condition (Table 2).

Table 5: Comparative yield performance of Boro rice as affected by herbicide dose and water management

Treatment	Grain yield (t ha^{-1})	% Change from weed free	% Change from control	Average grain yield under water management (t ha^{-1})
W1T1 (75%)	4.557	-30.92	323.12	4.92
W1T2 (100%)	6.310	-4.35	485.89	
W1T3 (125%)	5.95	-9.81	452.46	
W1T4 (150%)	5.523	-16.28	412.81	
W1T5 (175%)	4.173	-36.74	287.47	
W1T6 (200%)	5.153	-21.89	378.46	
W1T7 (Control)	1.077	-83.67	-	
W1T8 (Weed free)	6.597	-	512.53	
W2T1 (75%)	3.717	-20.58	246.41	3.13
W2T2 (100%)	4.220	-9.83	293.29	
W2T3 (125%)	3.44	-26.50	220.60	
W2T4 (150%)	2.983	-36.26	178.01	
W2T5 (175%)	2.297	-50.92	114.07	
W2T6 (200%)	2.640	-43.59	146.04	
W2T7 (Control)	1.073	-77.07	-	
W2T8 (Weed free)	4.680	-	336.16	

Note: W1= Continuous flooding; W2 = Field capacity

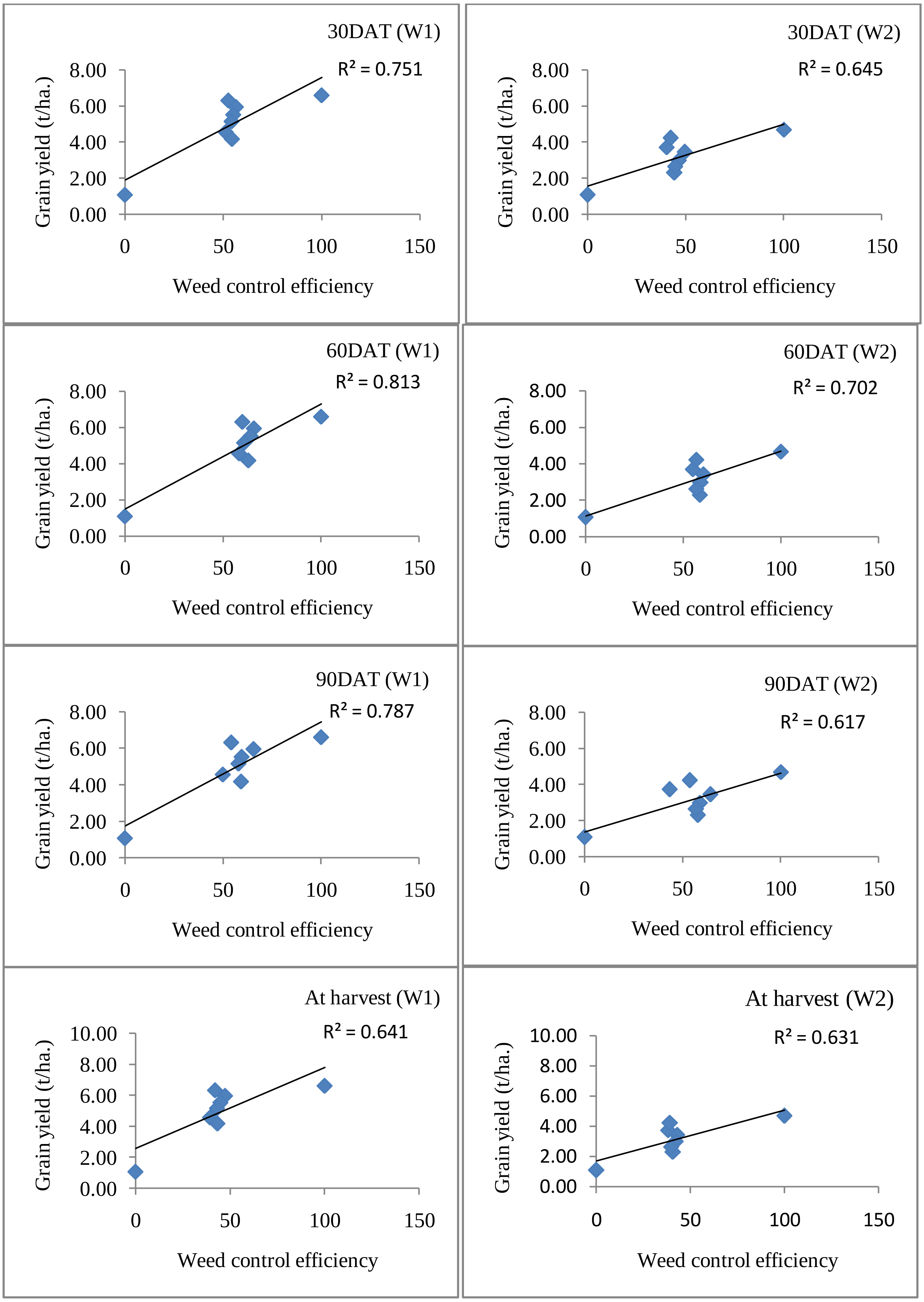
The reason behind higher tiller mortality under continuous flooding might be that, here herbicide was able to exert its toxicity fully under continuous flooding, which is also a pre-requisite for increasing efficacy of pre-emergence herbicide. Now, under continuous flooding, herbicide also exert its full toxic effect on weeds as well as rice plants adversely affecting crop growth and development thus leading to higher tiller mortality rate.

Total dry matter production (TDM) as affected by herbicide dose and water management

Total dry matter production was significantly affected by water management and herbicide dose (Table 2). Weed free treatment (T8) under continuous flooding contributed to the highest TDM production (1298.23 g m^{-2}) at harvest while unweeded treatment (T7) under field capacity showed the least (737.9 g m^{-2}) during the same period (Table 3). Among the herbicidal treatments, W1T2 treatment receiving recommended dose of herbicide under continuous flooding produced the highest TDM of 1144.6 g m^{-2}, while the least (888.40 g m^{-2}) was recorded in W2T1 treatment receiving herbicide @75% of the recommended dose under field capacity (Table 3). Data revealed that, crop dry matter production was 15.99% higher under continuous flooding (1088.85 g m^{-2}) compared to that (938.77g m^{-2}) under field capacity. Again, DM production was the highest in treatments receiving pre-emergence herbicide at recommended dose irrespective of water management. As herbicidal dose was increased above recommended dose, TDM production declined correspondingly. It might be due to that herbicide at higher dose might put adverse impacts on the growth and development of rice plants, leading to lowering in dry matter production and its distribution within the rice plants. Such phenomenon was also evident in case of tiller production as shown in Table 2.

Yield performance of Boro rice as affected by herbicide dose and water management

Both water management and herbicide dose significantly affected grain yield and its contributing characters. Data revealed that, the better the water management, the higher the grain yield irrespective of weed control treatments (Table 4). The highest yield (6.597 t ha^{-1}) was obtained from weed free (T8) treatment under continuous flooding, while the lowest (1.07 t ha^{-1}) was obtained from unweeded treatment under field capacity. Among herbicidal treatments, W1T2 treatment receiving pre-emergence herbicide @ recommended dose under continuous flooding contributed to the highest grain yield of 6.31 t ha^{-1}, which was statistically identical to that in weed free treatment (6.597 t ha^{-1}) under continuous flooding (W1T8). W2T5 treatment receiving herbicide @175% of the recommended dose under field capacity produced the lowest grain yield (2.297 t ha^{-1}).



W1= Continuous flooding; W2= Field capacity

Fig. 1 Relationship between weed control efficiency and grain yield as influenced by water management in Boro rice.

Data indicated that, rice grain yield was higher in continuous flooding compared to that in field capacity. Again, grain yield was the highest in T2 treatment (recommended dose of herbicide) irrespective of water management. As the herbicide dose was increased beyond recommended dose, yield gradually declined. Such decline in yield despite higher weed control efficiency was also reported earlier by Bari (2010), Bari *et al.*, (2008) and Mondal *et al.* (1995). Results revealed that herbicide might be used at recommended dose for satisfactory rice grain yield provided that appropriate water management is adopted. Average rice grain yield under continuous flooding was 4.92 t ha^{-1}, which was 57.05% higher than that under field capacity (Table 5). Data revealed that, T2 treatment receiving herbicide at recommended dose incurred only 4.35% and 9.83% yield loss under continuous flooding and field capacity, respectively compared to other treatments. There was a positive linear relationship between weed control efficiency and grain yield, i.e. as the WCE increased the grain yield of rice also increased (Fig. 1). The relationship was stronger at 60 DAT compared to other sampling dates. Data indicated that, weed control efficiency during flowering stage was more important compared to other crop growth stages. Data further indicated that the, relationship was much stronger under continuous flooding than under field capacity. It might be due to that, herbicide exerted its toxic effects on weed plants more efficiently under continuous flooding thus leading to favourable impact on crop and development process which finally led to higher dry matter production (Table 3) and finally grain yield (Table 4). Therefore, it might reasonably argued that, pre-emergence herbicide application at recommended dose under continuous flooding might be the best option for satisfactory grain yield performance of Boro rice as observed through this study.

Conclusion

Results of the study revealed that, application of Pretilachlor @ 125% of the recommended dose applied as pre-emergence under continuous flooding provided better weed control efficiency in transplanted Boro rice. But, application of Pretilachlor at recommended dose as pre-emergence under continuous flooding contributed to higher crop dry matter production leading to higher grain yield and harvest index. The study, thus suggested that, Pretilachlor herbicide at recommended dose might be considered ideal for use in transplanted Boro rice cultivation provided appropriate water management is ensured.

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