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Assessment of different crop residues and herbicide on weed control efficiency in Transplanted *Aman* rice

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ABSTRACT

To investigate the performance of different crop residues and pre-emergence herbicide in terms of weed control efficiency in transplanted *Aman* rice, an experiment was taken in the net house of Agronomy division, BRRI, Joydebpur, Gazipur-1701 during T. *Aman* in 2016. The experiment comprised of five weed control treatment viz. chopped (2-3 cm) crop residues of sorghum (T_1), Chopped (2-3 cm) crop residues of soybean (T_2), chopped (2-3 cm) crop residues of mungbean (T_3), chopped (2-3 cm) crop residues of rice (T_4), pre-emergence herbicide (Butachlor) (T_5) and control (no weed management method) (T_6) and it was laid out in complete randomized design with three replications. The result revealed that application of pre-emergence herbicide (Butachlor) showed lowest weed density (25.0 m^{-2}), weed dry matter weight (6.5 gm^{-2}) and highest weed control efficiency (75.0%) followed by application of sorghum and rice straw residues. The lowest weed control efficiency (58%) was obtained from control treatment. Overall, herbicide treatments provided better weed control than the crop residues treatments. Herbicide-treated plots showed greater rice yield (5.11 t ha^{-1}) that was similar with sorghum and rice straw residues treated plot. So, to reduce herbicide use in the present situation of Bangladesh, natural herbicide or crop residues application may alternative option of synthetic herbicides to suppress weeds in rice cultivation. However, more studies are required to fully explore the possibility of environment-friendly weed management in rice. Such studies may decrease total use of herbicides.

Introduction

Weeds are one of the important constraints to crop production in the world including Bangladesh. It causes a great yield reduction in rice production globally. The estimated that rice yield losses due to insect pest is be 40% while weeds cause about 32% yield loss (Oerke & Dehne, 2004). Kashem et al. (2009) also stated that weeds cause more than $ 40 billion in annual global losses through reduction in agricultural and silvicultural productivity. Losses caused by weeds vary from one country to another, depending on the predominant weed flora and on the control methods practiced by farmers. Researchers stated that manual, chemical, mechanical weeding and/ or combination of them can be used for successful control of weed (Abdollahi & Ghadiri, 2004; Anaya, 2003).

In Bangladesh, manual hand weeding is still significantly practiced by farmers all over. Availability of rural labor decrease progressively as workers migrates to cities or abroad to engage in more remunerative employment (Zhang et al., 2014). As a result peasant has to face problem of labor scarcity and rising wages. Hand weeding method is not economical due to its costly weeding, difficulty of performance and limitation of labor at the proper time. As a result, due to labor scarcity and pro-poor technology, chemical weed control is becoming popular than hand weeding (Ahmed et al., 2011; Hasanuzzaman et al., 2008). But due to continuous use of herbicide risks may be developed of genetic resistance of weed. Further, use of single one herbicide does not control all kinds of weeds. Labrada (2002) stated that Butachlor is being used for weed control in transplant rice that effectively control annual grasses but not of sedges and non-grass weed species (Katherisan, 2001). As a result resistant weed species compete with the crop and cause heavy yield losses (Singh et al., 2004). It was also found that, even after the application of pre- and post-emergence herbicides, it was not enough to achieve adequate weed control in direct seeded rice (Chauhan et al., 2015).

Use of synthetic herbicides is very common due to their prompt response and availability (Jamil et al., 2009). A haphazard use of herbicides is irritating various hazards related to health, ecosystem, and contamination of soil, water and aerial environment. Further, mechanical weed control requires extra soil turn-over, which can disturb soil structure and deplete soil fertility (Smith et al., 2011). Bond and Grundy (2001) also opined that mechanical weed control is not always effective and can be expensive and lack durability. These issues call for exploration of some eco-friendly alternate strategies that may provide effective weed management while being benign to our environment. In this case, plant derived materials can provide an environment friendly weed control strategies in field corps.

Suppressing weeds by harnessing the allelopathic phenomenon can be incorporated among the important innovative weed control methods (Jabran & Farooq, 2013; Zeng, 2014). Matloob et al., (2010) opined that utilization of allelopathic properties of native plant/crop species offers promising opportunities and can be helpful in controlling weeds infestation (Weston & Duke, 2003). Earlier research on, Phytotoxicity effect of dried sunflower residues and leaf powder revealed by Batish et al., (2002), Incorporation of whole sorghum plant or its various parts alone or mixed with each other by Cheema and Khaliq, (2000) and wheat straw mulch by Muminovic, (1991) on weed that significantly inhibited emergence, seedling growth and dry matter accumulation weed species.

However, in Bangladesh, little information is available or not on application of different crop residues in weed suppression in transplanted rice ecosystem during *Aman* season. Therefore the present study was undertaken to evaluate the performance of different crop residues against various weed species in transplanted rice ecosystem.

Materials and methods

Experimental site

The research study was conducted at Net house of Agronomy Division of Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur-1701 belongs to Agro ecological Zone (AEZ-15) during T. *Aman* season 2016 to evaluate weed control efficiency (WCE) of different crop residues and pre-emergence herbicide (Butachlor). The geographic coordinates of the research studied area was located between 90̊ 33' E longitude and 23̊ 77' N latitude.

Experimental design and crop residues incorporation

The experiment was conducted complete randomized designed with three replications with five weed control treatments *viz*. chopped (2-3 cm) crop residues of sorghum (T_1), Chopped (2-3 cm) crop residues of soybean (T_2), chopped (2-3 cm) crop residues of mungbean (T_3), chopped (2-3 cm) crop residues of rice (T_4), pre-emergence herbicide (Butachlor) (T_5) and control (no weed management method) (T_6) was imposed in this experiment for comparison. The pot size was one square meter.

Collection and application of crop residues and herbicide

Before going to initiate net house research, field grown harvested disease and insect attack free mature plants of sorghum, soybean, mungbean (except consumed part) were collected from the Bangladesh Agricultural Research Institute's (BARI) research plot. The crop residues were chopped about 2 to 3 cm pieces with a fodder cutter. Crop residues were incorporated @ 5.0 t ha^{-1}. As per treatment schedule whole plant residues were mixed in soil three days after transplanting. In the same day pre-emergence herbicide (Butachlor) was applied @ 25 g ha^{-1}**.**

Selection of cultivar and planting methods

Planting crop was BRRI dhan72. Thirty- days-old seedling was transplanted to maintain row to row and hill to hill distances of 20 cm on 15th June 2016.

Fertilizer Application rate and methods

The experimental plots were fertilized @ of 69-11-41 and 10 kg ha^{-1} N-P-K and S respectively according to BRRI recommended dose. The whole amount of TSP, MoP and Gypsum and one third of urea was applied during the final pot preparation. Remaining urea was top dressed at 15 and 30 days after transplanting.

Observation of weed flora in net house experiment

To account the general weed flora of the net house experiment, species wise observations were carried out at 30 days after transplanting from randomly selected quadrates (0.5 m × 0.5 m) from each experimental pot.

Weed density

Weed density (m^{-2}) was counted by using 0.5 m × 0.5 m quadrant from randomly fixed places in each pot and the weeds falling within the frames of the quadrant were counted and the mean values of different weed species were expressed in number m^{-2}.

Weed dry weight

Weeds are falling within the 0.5 m × 0.5 m quadrant were collected at 30 days after transplanting (DAT) and these were firstly dried in shade and then an oven at 70 °C for 48 h. The collected weight was expressed as g^{-2}.

Weed control efficiency

Weed control efficiency (%) was measured as per procedure of Mani et al., (1973)

Weed control efficiency (%) =

$$\frac{\text{Weed dry matter wt. (g) in weedy check plot} - \text{Weed dry matter wt.(g) in treated plot}}{\text{Weed dry matter wt.(g) in weedy check plot}} \times 100$$

Biological yield

Biological yield was calculated by using following formula. Biological yield= Grain yield + straw yield.

Harvest index

Harvest was calculated by using following formula. HI (%) = (Grain yield ÷ Biological yield) × 100.

Weed index

Weed index (WI) was calculated as per Gill et al., (1969). Weed index = $\frac{X-Y}{X} \times 100$

Where, X = Yield (t ha^{-1}) from minimum weed competition plot, Y=Yield (t ha^{-1}) from the treatment plot for which WI is to be worked out.

Harvesting and data collection

Prior to harvesting of crops five hills from each pot were selected randomly to determine the yield contributing yield contributing characters. To determine the yield data (t ha^{-1}) crop was harvested whole plot basis, tied into bundles in respective plots and was manually threshed to determine grain yield and is reported on t ha^{-1} basis. Grain weight of five hills also added with whole plot yield.

Statistical Analysis

The collected yield and yield contributing data were analyzed using "MSTATC" statistical software and least significance difference (LSD) at 0.05 probability was employed to compare the differences among treatments means. To determine weed parameter mean values of different weed species were incorporated under this experiment.

Results and Discussion

Effect of different crop residues and herbicides on weed growth

Weed density

Maximum weed number (87.0) at m^{-2} was found in no weeding plot followed by mungbean crop residues treated plot produced second highest number of weed (55.0) at m^{-2}. Pre-emergence herbicide (Butachlor) treated plot produced lowest number (25.0) of weed at m^{-2} followed by rice straw and sorghum treated plot (Table 1).

Weed dry matter weight

Minimum weed biomass was found from T_5 (6.5 g m^{-2}) while maximum from T_6 (25.9 g m^{-2}) at 30 DAT (Table 1). Similar findings were reported by Bhuiyan et al., (2010) who reported that pre emergence application of Oxadiargyl 400 SC @ 75 g a.i. ha^{-1} had minimum dry weight of weeds which resulted satisfactory weed control than other treatments.

Weed control efficiency

Weed control efficiency of different weed management ranged from 58% to 75%. The maximum WCE (75%) was found in pre-emergence herbicide treatment followed by application of crop residues of rice. Similarly, Arif et al., (2015) opined that herbicide was most effective treatment than other allelopathic extract which showed 78-90% weed control efficiency. Weed control by of mungbean residues showed the minimum (58%) weed control efficiency.

Weed index

Application of herbicides showed its superiority among the different weed control treatments and recorded lower weed index followed by application of sorghum crop residues (2.54) and rice straw (5.09). The highest weed index (39.3) was found from control treatments. Similarly, Priya et al., (2017) found highest weed index value in control plot. The higher weed index registered in non-treated plot might be due to increased weed growth and reduced nutrient availability to the crop.

Table 1. Weed density, total dry matter; weed control efficiency, weed index and harvest index as influenced by different weed control methods during T. *Aman* season, 2016, BRRI, Gazipur

Treatment	Weed density (m^{-2})	Total weed dry matter (g m^{-2})	Weed control efficiency (%)	Weed Index
T_1	34.0	7.9	70.0	2.54
T_2	51.0	9.5	63.0	9.59
T_3	55.0	10.9	58.0	18.98
T_4	27.0	7.2	72.0	5.09
T_5	25.0	6.5	75.0	0.00
T_6	87.0	25.9	-	39.33
CV (%)	-	-	-	-
$LSD_{0.05}$	-	-	-	-
F-test	-	-	-	-

Note: T_1 = chopped crop residue of sorghum @ 5.0 t ha^{-1}, T_2 = chopped crop residue of soybean @ 5.0 t ha^{-1}, T_3 = chopped crop residue of mungbean @ 5.0 t ha^{-1}, T_4 = chopped crop residue of rice straw @ 5.0 t ha^{-1}, T_5 = pre emergence Herbicide (Butachlor), T_6 = control

Effect of different crop residues and herbicides on rice yield and yield components

Plant height

Different weed management practices on plant height of rice showed non-significant variation at harvest (Table 2). In this study non-significantly, tallest plant (139.0 cm) was found from T_5 treatment while shortest (133.0 cm) was found from T_6 (control). It might be due to abundant of growth promoting factors in weed free plot that allowed the plants to attain their maximum height. Similarly Amare et al., (2016) found non-significant plant height under different weed control regime but Sultana et al., (2012) concluded that the plant height was significantly affected by weeding regime.

Number of tiller hill^{-1}

Number of tiller hill^{-1} differed significantly among different weeding regime in rice crop (Table 2). In this study highest number of tillers hill^{-1} (6.13) was recorded where weeds were controlled by pre emergence herbicide (Butachlor) (T_5) treatment which was statistically similar with T_1, T_2, T_3 and T_4 treatment. Lowest number (4.0) of effective tiller hill^{-1} was found in that plot where no weeding was done at whole crop growing period (Table 2). Similarly, Sultana et al., (2012) and Sujoy et al., (2006) found higher number of effective tiller in wheat under weeded plot than control.

Number of panicle hill^{-1}

Number of panicle hill^{-1} differed significantly among different weeding regime (Table 2). Highest number of panicle (5.0) hill^{-1} was found in T_2 treatment which was followed by sorghum (T_1), rice straw (T_4) and pre-emergence herbicide (Butachlor) (T_5) application treatments. Similarly, Mahajan and Chauhan (2008) found highest number of panicle (m^{-2}) from Butachlor application plot. Lowest number of panicle hill^{-1} (4.0) was found in control plot.

Number of filled grain panicle^{-1}

Analysis of variance showed that the filled grain number panicle^{-1} significantly affected by different weed control methods (Table 2). The maximum filled grain (106.0) panicle^{-1} was obtained from pre-emergence herbicide (Butachlor) (T_5) application plot which were statistically similar with treatments of T_1, T_2, T_3 and T_4 treatments. But Singh et al., (2016) opined that grains panicle^{-1} were more in case of sequential applications of PRE + POST herbicide compared to single PRE or POST. The control (T_6) treatment produced the lowest (80) number of filled grain panicle^{-1} which was also statistically similar with T_3 treatment.

Filled grain weight

Filled grain weight (g) did not show significant variation among different weed control treatments. The highest value (27.0 g) was found in T_5 treatment and lowest (21.0 g) was found in T_6 treatment (Table 2).

1000-grain weight

Comparison of data showed that the weed control treatments significantly affect the 1000-grain weight (Table 2). The highest 1000-grain weight (27.3 g) was recorded from plots where pre-emergence herbicide butachlor was applied which was supported by Begum et al., (2003) who found more 1000-grain weight in herbicides treated plots than untreated control. The highest value was also statistically similar to treatment of T_4, T_1 and T_2. Significantly lowest 1000-grain weight (24.0 g) was recorded in weedy check (T_6) treatment. More 1000-grain weight in herbicidal and crop residues treatments than weedy check was the result of improved growth of rice plants due to less weed competition.

Grain yield

Significant variation was observed in grain yield at 1% level due to different weed control treatments (Figure 1). The maximum grain yield (5.11 t ha^{-1}) was obtained from pre-emergence herbicide Butachlor application (T_5) treatment. On the contrary, the lowest grain yield (3.10 t ha^{-1}) was found in control (T_6) treatment. The lowest grain yield in control might be due to resultant effects of the lowest performance of yield contributing characters.

Straw yield

Different weed control treatments in regard to straw yield manifested significant difference at 1% level of significance. The highest straw yield (6.60 t ha^{-1}) was observed in T_5 treatment while the lowest straw yield (3.10 t ha^{-1}) was found in control (Table 2). The lowest straw yield was recorded in control might be due to heavy weed infestation and competition with crop plants and finally depressed the effective tillers $plant^{-1}$ and grain $panicle^{-1}$.

Biological yield

Biological yield (t ha^{-1}) showed significant variation among different weed control treatments. Highest biological yield (11.7 t ha^{-1}) was found in T_5 treatment which was statistically similar with T_1 and T_4 treatment. Lowest biological yield (7.70 t ha^{-1}) was found in control (T_6) treatment (Table 2). Zahoor et al., (2012) concluded that weed control methods increased biological yield of wheat reducing the weed infestation.

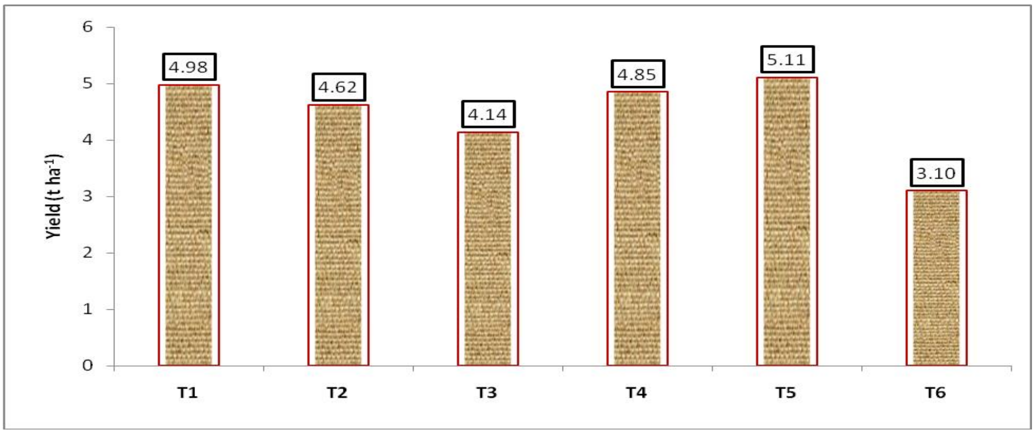

Figure 1. Grain yield (t ha^{-1}) of T. Aman rice as Influenced by different weed control methods during 2016, BRRI, Gazipur-1701. T_1 = Chopped (2-3 cm) crop residues of sorghum, T_2 = Chopped (2-3 cm) crop residues of soyabean, T_3 = Chopped (2-3 cm) crop residues of mungbean, T_4 = Chopped (2-3 cm) crop residues of rice and T_5 = Pre-emergence herbicide (Butachlor)

Table 2. Yield and yield contributing character as Influenced by different weed control strategies on BRRI dhan72 during Aman season 2016, BRRI, Gazipur-1701

Treatment	Pant height (cm)	No. of tiller $hill^{-1}$	Number of panicle $hill^{-1}$	Number of filled grain $panicle^{-1}$	Filled grain weight (g)	1000-grain weight (g)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest Index
T_1	137.0	6.0	5.0 ab	104.0 a	23.0	27.2 a	5.96 ab	10.9 ab	46.0
T_2	136.0	6.0	5.0 a	101.0 a	24.0	26.6 ab	5.90 ab	10.5 b	44.0
T_3	135.0	5.0	4.0bc	92.0 ab	23.0	25.0 bc	5.30 bc	9.4 c	44.0
T_4	138.0	6.0	5.0 ab	102.0 a	22.0	27.2 a	6.20 a	11.0 ab	44.0
T_5	139.0	6.1	5.0 ab	106.0 a	27.0	27.3 a	6.60 a	11.7 a	44.0
T_6	133.0	4.0	4.0 c	80.0 b	21.0	24.0 c	4.63 c	7.7 d	40.0
CV (%)	2.08	10.3	7.84	8.62	10.4	4.42	8.15	5.23	5.65
$LSD_{0.05}$	-	1.02	1.13	15.3	-	2.10	0.855	0.97	-
F-test	NS	*	*	*	NS	*	**	**	NS

Note: T_1 = chopped (2-3 cm) crop residue of sorghum @ 5.0 t ha^{-1}, T_2 = chopped (2-3 cm) crop residue of soybean @ 5.0 t ha^{-1}, T_3 = chopped (2-3 cm) crop residue of mungbean @ 5.0 t ha^{-1}, T_4 = chopped (2-3 cm) crop residue of rice straw @ 5.0 t ha^{-1}, T_5 = pre emergence Herbicide (butachlor), T_6 = control

Harvest index

Harvest index did not differ significantly among the different weed management practices. Maximum harvest index was found from T_1 treatment (46.0) while minimum from T_6 treatment (40.0) (Table 2). But Sujoy et al., (2006) found significant variation in harvest index of wheat due to weed control treatments.

Conclusion

The result of the study revealed that use of herbicide was efficient method for weed control in transplanted Aman rice followed by application of residues of rice straw and sorghum. The use of crop residues was an environmentally benign approach, but the level of weed suppression could not confirm its viability. So, further to draw a better conclusion combination of crop resides and new herbicide molecules need to be carried out.

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