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Effects of barley crop residues on weed management and grain yield of transplant *Aman* rice

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Abstract

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University during the period from July to December 2017 to evaluate the effect of barley crop residues on weed management and yield of transplant *aman* rice. The experiment consisted of three time of crop residue application viz. one week before transplanting, at the time of transplanting, at one week after transplanting and five doses of barley crop residues such as no crop residues, barley crop residues @ 0.5 t ha^{-1}, barley crop residues @ 1.0 t ha^{-1}, barley crop residues @ 1.5 t ha^{-1}, and barley crop residues @ 2.0 t ha^{-1}. The experiment was laid out in a split plot design with three replications. Weed population and weed dry weight were significantly affected by the dose and time of barley crop residues application. The minimum weed growth was noticed with the application of barley crop residues @ 2.0 t ha^{-1} at one week after transplanting and the maximum one was observed in no crop residues treatment at one week before transplanting. The highest values of percent weed inhibition was found with the application of barley crop residues @ 2.0 t ha^{-1} which were 48.13%, 41.39%, 39.71%, 39.88% and 38.73% for panikachu (*Monochoria vaginalis*), shama (*Echinochloa crusgalli)*, chesra (*Scirpus juncoides)*, amrul (*Oxalis corniculata*) and sabujnakful (*Cyperus difformis*), respectively. Rice grain yield and the yield contributing characters produced by the application of crop residues at one week before transplanting was the highest among different times of application and the highest reduction of rice grain yield was obtained in no crop residue treatment. The highest number of effective tillers hill^{-1}, number of grains panicle^{-1}, 1000-grain weight, rice grain and straw yields were observed when barley crop residues were applied @ 2.0 t ha^{-1} at one week before transplanting. Results of this study indicate that application of barley crop residues @ 2 t ha^{-1} at one week before transplanting showed the maximum suppression of weed growth. Therefore, barley crop residues might be used as an alternative tool for weed management in transplant *aman* rice.

Key words: Barley crop residues, weed management, percent inhibition, yield and harvest index

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Introduction

Rice (*Oryza sativa*) is one of the most extensively cultivated cereals of the world that feeds more than 50% of the world population. In Bangladesh it is the staple food and it accounts for more than 90% of total cereal production covering 75% of total cropped area of Bangladesh (BBS, 2018). Among them *aman* rice covers 5.68 million hectares of land with a production of 13.9 million metric tons and the average yield is 2.43 m ton per hectare (BBS, 2018). The average yield of rice is decreasing due to use of low yielding varieties, high weed infestation and poor crop management. Among these factors weed infestation is the most serious problem for low production of *aman* rice. Therefore, weed infestation reduces the grain yield of transplant *aman* rice cultivars by 30-40% (BRRI, 2008).

Weeds are one of the important constraints to crop production in the world including Bangladesh. It is often said that crop production is a fight against weeds (Kumar and Goh, 2000). High competitive ability of weeds exerts serious harmful effects on production resulting significant losses in crop yield. It has been estimated that 11.5% of yield of major crops of the world is lost due to weeds. Weed infestation in rice field is always subject to agro ecological condition and growing season (Moody, 1995). Without weed management, rice yield may be reduced by 16 to 88% or even 100%.

To overcome weed infestation, presently the researchers are giving more emphasis on using different crop residues for weed suppression. Crop residues are defined as crop or its parts left in the field for decomposition after it has been thrashed or harvested (Kumar and Goh, 2000). Crop allelopathy controls weeds by the release of allelochemicals from the living plants and/or through decomposition of phytotoxic plant residues (Belz, 2004; Khanh *et al.*, 2005). The incidence of growth inhibition of certain weeds and the induction of phytotoxic symptoms by many plants and their residues is well documented for many crops, including all major grain crops such as rice, rye, barley, sorghum, wheat etc (Belz, 2004). Barley (*Hordeum vulgare* L) shows a strong allelopathic activity to control weed growth. Important allelochemicals in barley may include phenolic compounds and alkaloids (e.g., hordenine, gramine). Allelopathic mulch material from barley can be applied for controlling weeds in barley and other crops. Breeding efforts can help to improve the allelopathic potential of barley cultivars for an effective and environment-friendly weed control (Jabran, 2017).

Materials and Methods

The experiment was conducted in *aman* seasons at Agronomy Field Laboratory, Bangladesh University, Mymensingh during the period from July to December 2017. The variety BRRI dhan 57 was used as test material. The experimental treatment consists of time of crop residues application viz. i) crop residues application one week before transplanting (T_1), ii) crop residues application at the time of transplanting (T_2), iii) crop residues application one week after transplanting (T_3) and crop residues viz no crop residues (C_0), barley crop residues @ 0.5 t ha^{-1}(C_1), barley crop residues @ 1.0 t ha^{-1} (C_2), barley crop residues @ 1.5 t ha^{-1} (C_3), barley crop residues @ 2.0 t ha^{-1} (C_4). The experiment was laid out in a split- plot design assigning time of crop residues application in main plot and different crop residues in split plot with three replications. Each plot size was 2m × 2.5m. Land preparation for rice cultivation was done by 3-4 times plowing and cross-plowing followed by laddering. Fertilizers and Manure were applied at the following doses: Urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate @ 164, 60, 104, 67, 10 kg ha^{-1}, respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at the time of final land preparation. Urea was applied in three installments at 15, 30 and 45 days after transplanting (DAT). Transplanting was done in 07 August 2017 at the rate of three seedlings per hill with 25 cm × 15 cm spacing. Weed population, weed dry weight and % inhibition were measured to evaluate the performance of different crop residues. The crops were harvested on 07 August 2017 at full maturity. Then the harvested crops of each plot was bundled separately, properly tagged and brought to threshing floor. The crops were then threshed and the fresh weights of grain and straw were recorded from an area of l m^2 in the middle of each plot. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were recorded and converted to t ha^{-1}. Data were statistically analyzed using the Analysis of Variance technique with the help of statistical computer package MSTAT-C. The mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez 1984).

Results and Discussion

Five weed species belonging to four families infested the experimental field. The weeds of the experimental plots were *Echinochloa crusgalli*, *Nymphaea nouchali*, *Monochoria vaginalis*, *Cyperus difformis* and *Scirpus juncoides*. There were two perennial and three annual weed species in the experimental plot (Table1).

***Effect of interaction between dose and time of application of barley crop residues on Panikachu (Monochoria vaginalis)*:** The interaction between dose and time of application of barley crop residues was found to be significant on weed density, dry weight and percent inhibition of panikachu (Table 2).

Table 1. Infested weed species found in the experimental plots of rice.

Sl. No.	Local name	Scientific name	Family	Morphological type	Life cycle
1	Panikachu	*Monochoria vaginalis*	Pontederiaceae	Broad leaved	Perennial
2	Shama	*Echinochloa crusgalli*	Poaceae	Grass	Annual
3	Chesra	*Scirpus juncoides*	Cyperaceae	Sedge	Annual
4	Amrul	*Oxalis corniculata* L.	Oxalidaceae	Slender	Perennial
5	Sabujnakful	*Cyperus difformis*	Cyperaceae	Sedge	Annual

The highest weed population (13.33) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues), second highest weed density (12.33) was found in T_1C_0 (applied crop residues one week before transplanting × no crop residues) treatment and the lowest weed density (3.33) was noticed in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment (Table 2). The highest weed dry weight (15.00 g) was found in T_3C_0 (applied crop residues one week after transplanting × No crop residues) and the lowest weed dry weight (7.163 g) was in T_1C_4 (applied crop residues one week before transplanting × 2.0 t ha^{-1}). The percent inhibition of weed was the highest in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment (52.10%) and the lowest one (0.00%) was observed in T_1C_0, T_2C_0 and T_3C_0 treatment presented in Table 2. Similar findings were reported by Sheikh (2016) who found significant weed control efficacy by different crop residues especially sorghum crop residues.

***Effect of interaction between dose and time of application of barley crop residues on Shama (Echinochloa crusgalli)*:** The interaction between dose and time of application of barley crop residues was found to be significant on weed density, dry weight and percent inhibition of shama (Table 3). The highest weed density (8.67) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues), second highest weed population (8.33) was found in T_1C_0 (applied crop residues at time of transplanting × no crop residues) treatment and the lowest weed density (3.00) was noticed in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment. The highest weed dry weight (6.97g) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues) and the lowest weed dry weight (3.36 g) was in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}).

Table 2. Interaction effect of dose and time of application of barley crop residues on *Monochoria vaginalis.*

Time x dose	Weed density (no. m^{-2})	Dry weight (g m^{-2})	% inhibition
T_1C_0	12.33b	14.97a	0.00h
T_1C_1	8.66e	11.54c	22.98f
T_1C_2	6.33g	9.26e	37.85d
T_1C_3	5.33h	8.54f	42.75c
T_1C_4	3.33j	7.163h	52.10a
T_2C_0	12.67ab	14.80a	0.00h
T_2C_1	9.67d	12.81b	13.29g
T_2C_2	7.33f	10.11d	31.55e
T_2C_3	6.33g	9.30e	37.01d
T_2C_4	4.33i	7.81gh	47.14b
T_3C_0	13.00a	15.00a	0.00h
T_3C_1	11.00c	13.32b	11.18g
T_3C_2	8.33e	11.10c	26.01f
T_3C_3	6.67g	10.07d	32.78e
T_3C_4	4.67i	8.24 fg	44.94bc
$S\bar{x}$	0.16	0.23	1.37
Level Of sig.	**	**	**

Here, in a column, figures with the same letters do not differ significantly as per DMRT, ** =Significant at 1% level of probability, T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

The percent inhibition of weed was the highest in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment (48.95%) and the lowest one (0.00%) was observed in T_1C_0, T_2C_0 and T_3C_0 treatment presented in Table 3. Similar findings were reported by Imen (2014) who found significant weed control efficacy by barley crop residues.

Table 3. Interaction effect of dose and time of application of barley crop residues on *Echinochloa crusgalli.*

Time x dose	Weed density (no. m^{-2})	Dry weight (g m^{-2})	% inhibition
T_1C_0	8.00c	6.60b	0.00i
T_1C_1	6.33f	5.80c	12.08g
T_1C_2	5.33g	5.06de	23.20e
T_1C_3	4.00j	4.00g	39.40b
T_1C_4	3.00l	3.36h	48.95a
T_2C_0	8.33b	6.70ab	0.00i
T_2C_1	6.67e	6.01c	10.38gh
T_2C_2	5.33g	5.36d	19.97ef
T_2C_3	4.67h	4.63f	30.84d
T_2C_4	3.33k	4.00g	40.36b
T_3C_0	8.67a	6.97a	0.00i
T_3C_1	7.33d	6.46b	7.19h
T_3C_2	6.33f	5.73c	17.70f
T_3C_3	5.33g	5.03e	27.71d
T_3C_4	4.33i	4.53f	34.85c
$S\bar{x}$	0.045	0.108	1.17
Level of sig.	**	*	**

Here, in a column, figures with the same letters do not differ significantly as per DMRT, * =Significant at 5% level of probability, ** =Significant at 1% level of probability T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

***Effect of interaction between dose and time of application of barley crop residues on Chesra (Scirpus juncoides)*:** The interaction between dose and time of application of barley crop residues was found to be significant on weed density, dry weight and percent inhibition of chesra (Table 4). The highest weed density (9.33) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues), second highest weed density (8.33) was found in T_2C_0 (applied crop residues at time of transplanting × no crop residues) treatment and the lowest one (3.00) was noticed in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment.

Table 4. Interaction effect of dose and time of application of barley crop residues on *Scirpus juncoides.*

Time x dose	Weed density (no. m^{-2})	Dry weight (g m^{-2})	% inhibition
T_1C_0	7.67d	3.90b	0.00j
T_1C_1	6.33g	3.47e	11.07hi
T_1C_2	5.33h	3.01g	22.81ef
T_1C_3	4.00j	2.47j	36.75bc
T_1C_4	2.67m	2.12l	45.57a
T_2C_0	8.33b	3.88bc	0.00j
T_2C_1	7.00e	3.57d	8.15i
T_2C_2	5.33h	3.14f	19.20fg
T_2C_3	3.67k	2.79h	28.17d
T_2C_4	2.67m	2.35k	39.58b
T_3C_0	9.33a	4.10a	0.00j
T_3C_1	8.00c	3.81c	7.24i
T_3C_2	6.67f	3.49e	14.90gh
T_3C_3	4.67i	2.990g	27.06de
T_3C_4	3.33l	2.70i	33.99c
$S\bar{x}$	0.055	0.026	1.68
Level of sig.	**	**	*

Here, in a column, figures with the same letters do not differ significantly as per DMRT, * = Significant at 5% level of probability, ** =Significant at 1% level of probability T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

The highest weed dry weight (4.1g) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues) and the lowest weed dry weight (2.12 g) was in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}). The percent inhibition of weed was the highest in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment (45.57%) and the lowest one (0.00%) was observed in T_1C_0, T_2C_0 and T_3C_0 treatment in Table 4. Similar findings were reported by Uddin and Pyon (2010) who found significant weed control efficacy by different crop residues.

Effect of interaction between dose and time of application of barley crop residues on Amrul (Oxalis corniculata L.): The interaction between dose and time of application of barley crop residues was found to be significant on weed density, dry weight and percent inhibition of amrul (Table 5).

Table 5. Interaction effect of dose and time of application of barley crop residues on *Oxalis corniculata L.*

Time x dose	Weed density (no. m^{-2})	Dry weight (g m^{-2})	% inhibition
T_1C_0	6.00 d	4.33d	0.00 i
T_1C_1	5.00 g	3.98 e	8.11 h
T_1C_2	4.330i	3.47 g	19.89 e
T_1C_3	3.33 k	2.93 h	32.32 c
T_1C_4	2.33m	2.50 i	42.27 a
T_2C_0	6.67 b	4.70 b	0.00 i
T_2C_1	5.67 e	4.37 d	7.038 h
T_2C_2	4.67 h	4.00 e	14.83 f
T_2C_3	3.67 j	3.45 g	26.53d
T_2C_4	2.67 l	2.86 h	39.14b
T_3C_0	7.33 a	4.81 a	0.00 i
T_3C_1	6.33 c	4.57 c	4.97 h
T_3C_2	5.33 f	4.27 d	11.22 g
T_3C_3	3.67 j	3.63 f	24.48 d
T_3C_4	2.67 l	2.97 h	38.23 b
$S\bar{x}$	0.048	0.037	1.04
Level of sig.	**	**	**

Here, in a column, figures with the same letters do not differ significantly as per DMRT, ** = Significant at 1% level of probability T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

The highest weed density (9.33) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues) and the lowest weed density (2.33) was noticed in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment. The highest weed dry weight (4.81 g) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues) and the lowest weed dry weight (2.50 g) was in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}). The percent inhibition of weed was the highest in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) (42.27%) and the lowest one (0.00%) was observed in control treatmentpresented in Table 5. Similar findings were reported by Afroz*et al.* (2018) who found significant weed control efficacy by buckwheat and pepper residues.

***Effect of interaction between dose and time of application of barley crop residues on Sabujnakphul (Cyperus difformis)*:** The interaction between dose and time of application of barley crop residues was found to be significant on weed density, dry weight and percent inhibition of sabujnakphul (Table 6). The highest weed density (6.67) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues) which same in T_2C_0 (applied crop residues at time of transplanting × no crop residues) treatment and the lowest weed density (2.33) was noticed in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment (Table 6). The highest weed dry weight (4.05 g) was found in T_3C_0 (applied crop residues one week after transplanting × no crop residues) and the lowest weed dry weight (2.27 g) was in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}). The percent inhibition of weed was the highest in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment (39.1%) and the lowest one (0.00%) was observed in control treatment presented in Table 6. Similar findings were reported by Ferdousi*et al.* (2017) who found significant weed control efficacy by different crop residues especially sorghum crop residues.

Table 6. Interaction effect of dose and time of application of barley crop residues on *Cyperus difformis.*

Time x dose	Weed density (no. m^{-2})	Dry weight (g m^{-2})	% inhibition
T_1C_0	6.33 b	3.87 b	0.00 g
T_1C_1	5.33d	3.53 e	8.83f
T_1C_2	4.00f	3.16 h	18.4 e
T_1C_3	3.33 h	2.80 j	27.6 c
T_1C_4	2.33 j	2.27 m	41.3a
T_2C_0	6.67a	4.00a	0.00g
T_2C_1	5.67 c	3.68 d	7.95 f
T_2C_2	5.33 d	3.28 g	17.9 e
T_2C_3	4.00 f	2.93 i	26. c
T_2C_4	3.00 i	2.43 l	39.1a
T_3C_0	6.67a	4.04a	0.00g
T_3C_1	5.33d	3.77c	6.67f
T_3C_2	4.33e	3.37 f	16.6e
T_3C_3	3.67 g	3.12 h	22.8 d
T_3C_4	3.33 h	2.60 k	35.6 b
$S\bar{x}$	0.037	0.018	0.775
Level of sig.	**	**	*

Here, in a column, figures with the same letters do not differ significantly as per DMRT, * =Significant at 5% level of probability, ** =Significant at 1% level of probability T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

***Effect of time of application of barley crop residues on yield and yield contributing characters of T. aman rice*:** Time of crop residues application had significant effect on yield on yield and yield contributing characters. Highest plant height (131.10cm), number of effective tillers $hill^{-1}$(5.92), Panicle length (27.19cm), number of filled grains $panicle^{-1}$(129.5) were recorded when crop residues were applied at one week before transplanting (Table 7). The highest harvest index

(47.83 %) was observed in crop residues application at the time of transplanting. The lowest plant height (128.30cm), number of effective tillers hill^{-1}(5.58), Panicle length (25.88cm), number of filled grains panicle^{-1}(127.8) were recorded when crop residues were applied at one week after transplanting.

Table 7. Effect of time of application of barley crop residues on yield and yield contributing characters of T. *aman* rice.

Time of application	Plant height (cm)	Effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	1000 grain weight (gm)	Harvest index (%)
T_1	131.10 a	5.92 a	27.19a	129.5 a	24.85	46.65b
T_2	130.40 a	5.72 b	25.99 b	128.3 b	24.59	47.83a
T_3	128.30 b	5.58 c	25.88 b	127.8 b	24.46	47.34a
$S\bar{x}$	0.703	0.032	0.348	0.284	0.169	0.204
Level of sig.	*	**	*	**	NS	**

Here, in a column, figures with the same letters do not differ significantly as per DMRT, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant, T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = Two week after transplanting.

***Effects of dose of barley crop residues on yield and yield contributing characters of T. aman rice*:** Yield and yield contributing characters were significantly influenced by barley crop residues. The highest plant height(133.40cm), number of effective tillers hill^{-1}(6.53), panicle length (28.43cm), no of filled grains panicle^{-1} (133.1), and harvest index (48.29%) were found in C_4 treatment where 2.0 t ha^{-1} barley crop residues was incorporated. The lowest plant height (126.60 cm), number of effective tillers hill^{-1}(4.84), panicle length(24.46cm), no of filled grains panicle^{-1}(123.90) were found in C_0 treatment where no barley crop residues was incorporated (Table 8).

Table 8. Effect of dose of barley crop residues on yield and yield contributing characters of T. *aman* rice.

Dose	Plant height (cm)	Effective tillers hill^{-1}	Panicle length (cm)	Filled grains panicle^{-1}	1000 grain weight (gm)	Harvest index (%)
C_0	126.60d	4.84e	24.46d	123.9e	23.98c	46.17d
C_1	128.10cd	5.40d	25.42cd	125.9d	24.29bc	46.64cd
C_2	130.00bc	5.80c	26.18bc	128.1c	24.70ab	47.28bc
C_3	131.60ab	6.14b	27.28ab	131.5b	24.95ab	47.98ab
C_4	133.40a	6.53a	28.43a	133.1a	25.26a	48.29a
$S\bar{x}$	0.909	0.041	0.450	0.367	0.217	0.263
Level of sig.	**	**	**	**	**	**

Here, in a column, figures with the same letters do not differ significantly as per DMRT, * = Significant at 5% level of probability, ** = Significant at 1% level of probability, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

Effects of interaction between dose and time of application of barley crop residues on yield and yield contributing characters of T. aman rice: nteraction effect of dose and time of application of barley crop residues showed non-significant variation in case of plant height, panicle length and 1000 grain weight. On the other hand, number of effective tillers $hill^{-1}$, number of filled grain $panicle^{-1}$, grain yield, and straw yield and were significantly affected by the combined effect of dose and time of application of barley crop residues. The highest plant height, total number of tillers $hill^{-1}$, number of effective tillers $hill^{-1}$, panicle length, number of filled grain $panicle^{-1}$, grain yield, straw yield were found in T_1C_4 (applied crop residues one week before transplanting × crop residues @ 2.0 t ha^{-1}) treatment combination (Table 9). The lowest plant height, number of effective tillers $hill^{-1}$, panicle length, number of filled grain $panicle^{-1}$, grain yield, straw yield and biological yield were found in T_3C_0 (applied crop residues one week after transplanting × no crop residues) treatment combination (Table 9).

Table 9. Effects of interaction between dose and time of application of barley crop residues on yield and yield contributing characters of T. *aman* rice.

Time x dose	Plant height (cm)	Effective tillers $hill^{-1}$	Panicle length (cm)	Filled grains $panicle^{-1}$	1000 grain weight (gm)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1C_0	127.18	4.83h	24.82	124.0h	24.01	2.88 l	3.49g	45.25
T_1C_1	128.31	5.70ef	26.18	126.8efg	24.49	3.11 i	3.69e	45.69
T_1C_2	131.41	6.06cd	26.78	128.6de	24.93	3.30 g	3.80d	46.46
T_1C_3	133.60	6.33b	28.33	132.6b	25.26	3.53 d	3.86c	47.77
T_1C_4	134.93	6.70a	29.86	135.4a	25.56	3.71 a	4.00a	48.08
T_2C_0	126.34	4.90h	24.55	123.8h	23.96	2.88 l	3.30i	46.63
T_2C_1	128.83	5.26g	25.16	124.9gh	24.27	3.09 j	3.43h	47.40
T_2C_2	130.54	5.70ef	25.89	128.0ef	24.68	3.28 h	3.55f	48.07
T_2C_3	132.21	6.20bc	26.59	131.8bc	24.84	3.48 e	3.70e	48.42
T_2C_4	133.96	6.56a	27.75	133.0b	25.20	3.70 b	3.91bc	48.65
T_3C_0	126.22	4.80h	24.01	123.9h	23.96	2.88 l	3.30i	46.64
T_3C_1	127.05	5.23g	24.91	126.2fg	24.11	3.05 k	3.46gh	46.88
T_3C_2	127.93	5.63f	25.87	127.8ef	24.50	3.27 h	3.65e	47.30
T_3C_3	129.13	5.90de	26.91	130.1cd	24.74	3.46 f	3.79d	47.75
T_3C_4	131.35	6.33b	27.68	131.0bc	25.01	3.66 c	3.94b	48.14
$S\overline{x}$	1.57	0.071	0.779	0.535	0.377	0.004	0.018	0.455
Level of sig.	NS	**	NS	*	NS	**	**	NS

Here, in a column, figures with the same letters do not differ significantly as per DMRT, ** = Significant at 1% level of probability, * = Significant at 5% level of probability, NS = Not significant, T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha-[1], C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

***Effect of time of application of barley crop residues on yield*:** The time of application of barley crop residues differed significantly in respect of grain yield. The highest grain yield (3.38 t ha^{-1}) was obtained when crop residues were applied at one week before transplanting (T_1), the increased yield might be due to the lowest number of sterile spikelet $panicle^{-1}$ and the lowest grain yield (2.83 t ha^{-1}) was obtained upon application of crop residues at one week after transplanting(T_3) treatment (Figure 1).

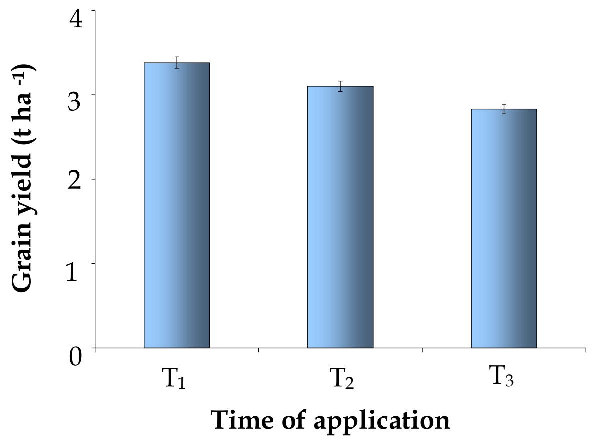

Figure 1. Grain yield of rice as influenced by time of application of barley crop residues (Bar represents standard error of means). Here, T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting.

This difference was observed due to different varietal characteristics of rice plant. BRRI (2008) also reported variation in grain yield among the varieties. Straw yield was significantly influenced by time of application of barley crop residues. The highest straw yield (3.77 t ha^{-1}) was found when crop residues were applied at one week before transplanting (T_1) and the lowest straw yield (3.57 t ha^{-1}) was found when crop residues were applied at the time of transplanting (T_2) treatment (Figure 3).

***Effect of dose of barley crop residues on grain yield*:** Grain yield was significantly influenced by dose of barley crop residues.

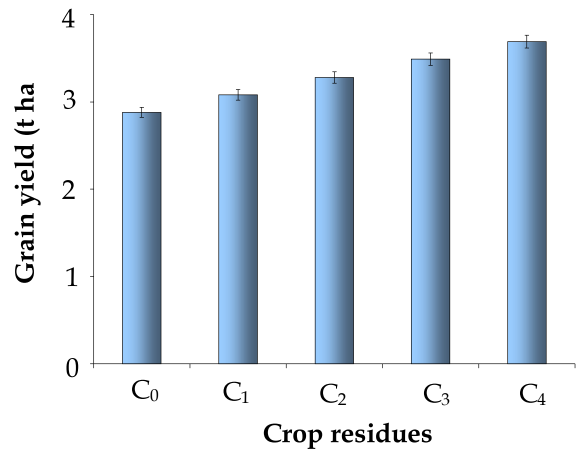

Figure 2. Grain yield of rice as influenced dose of barley crop residues (Bar represents standard error of means). Here, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

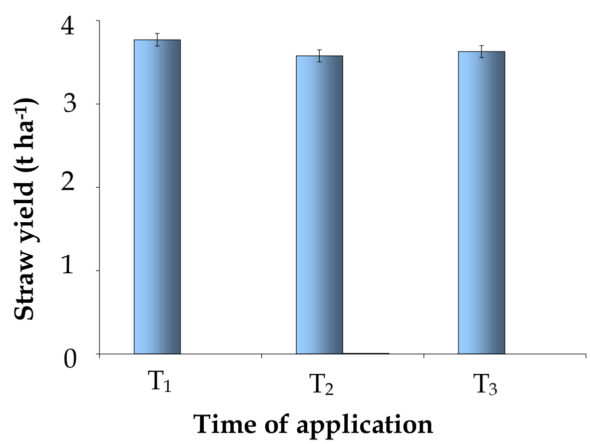

Figure 3. Straw yield of rice as influenced by time of application of barley crop residues (Bar represents standard error mean). Here, T_1 = One week before transplanting, T_2 = at the time of transplanting, T_3 = One week after transplanting.

The highest grain yield (3.69 t ha^{-1}) was produced by C_4 (crop residues @ 2.0 t ha^{-1}) treatment while the lowest grain yield (2.88 t ha^{-1}) was produced by C_0 (no crop residues) treatment (Figure 2). The weeds compete with the crop for nutrient, water, air, sunlight and space. The increased yield was contributed in weed free condition by higher number of effective tiller $hill^{-1}$, higher number of grains $panicle^{-1}$ over no weeding treatment. These might be due to the fact that the sorghum crop residues kept the rice field 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. Uddin and Pyon (2010) also reported the similar results, where crop residues influenced in crop performance. Straw yield was significantly influenced of dose of barley crop residues. The highest straw yield (3.95 t ha^{-1}) was observed in C_4 (crop residues @ 2.0 t ha^{-1}) treatment and the lowest straw yield (3.36 t ha^{-1}) was observed in C_0 (no crop residues) treatment (Figure 4).

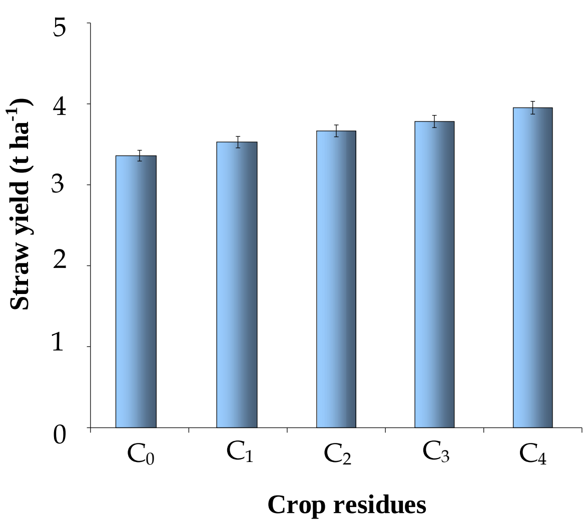

Figure 4. Straw yield of rice as influenced by dose of barley crop residues (Bar represents standard error mean). Here, C_0 = No crop residues, C_1 = Barley crop residues @ 0.5 t ha^{-1}, C_2 = Barley crop residues @ 1.0 t ha^{-1}, C_3 = Barley crop residues @ 1.5 t ha^{-1}, C_4 = Barley crop residues @ 2.0 t ha^{-1}.

Similar findings were reported by Afroz *et al.* (2018) who found significant weed control efficacy by crop residues.

Conclusion

From the above results it was found that the application of barley crop residues before transplanting @ 2.0 t ha^{-1} exhibited the superior herbicidal activity for suppressing weed growth. Therefore, the application of barley crop residues @ 2.0 t ha^{-1} at one week before transplanting could be a prospective source of efficient weed management for sustainable and ecological crop production in modern agricultural science.

Tomato is a moderately salt tolerant vegetable and the most economical and useful vegetable. The salt tolerant tomato varieties now have become very potential to help generate farmers' income within a much shortened possible period. This will increase the agricultural production which is the backbone of economy in developing countries. Herein of afterwards it can also be concluded that BARI Tomato-7 is the most suitable variety for these two regions.

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