Archives of Agriculture and Environmental Science 5(3): 275-282 (2020)
https://doi.org/10.26832/24566632.2020.050307

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

Weed management and crop performance of rice as influenced by different crop residues

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ARTICLE HISTORY

Received: 17 June 2020
Revised received: 16 August 2020
Accepted: 16 September 2020

Keywords

Crop residues
Grain yield
Harvest index
Percent inhibition

ABSTRACT

To investigate the effect of different plant residues on weed inhibition and yield of transplant aman rice, an experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during June 2017 to December, 2017. The experiment comprised of three rice cultivars i.e. BR11, BRRI dhan34 and BRRI dhan49 and five different plant residues treatment viz., no crop residues (control), soybean, wheat, bishkatali and sorghum crop residues @ 2.0 t ha^{-1} of each. The experiment was laid out following randomized complete block design with three replications. Weed population and weed dry weight were significantly affected by cultivars and crop residues treatment. The highest percent inhibition of 58.31%, 46.84%, 66.85%, 66.94% and 57.6% was in Panikachu (*Monochoria vaginalis*), Shama (*Echinochloa crusgalli*), Chesra (*Scirpus juncoides*), Sabujnakful (*Cyperus difformis*) and Amrul (*Oxalis corniculata*), respectively caused by sorghum crop residues. The grain yield, as well as the yield contributing characters produced by BR11,was the highest among the studied varieties. The highest number of effective tillers hill^{-1} (8.41), number of grains panicle^{-1} (118.08) and 1000-grain weight (20.54 g) were observed in sorghum crop residues. BR11 under sorghum crop residues @ 2.0 t ha^{-1} produced the highest grain (5.76 t ha^{-1}) and straw yield (6.39 t ha^{-1}). So, to reduce herbicide use in the present situation of Bangladesh, natural herbicide or crop residues like sorghum might be used as an alternative way for weed management for effective and sustainable rice production.

Citation of this article: Rahman, S.H., Uddin, M.R., Salam, M.A., Sarker, U.K., Rasul, S. and Hasan, M. (2020). Weed management and crop performance of rice as influenced by different crop residues. *Archives of Agriculture and Environmental Science*, 5(3): 275-282, https://dx.doi.org/10.26832/24566632.2020.050307

INTRODUCTION

Rice is the world's most important cereal crop and the main food source for more than one-third of the world's population. Bangladesh is an agro-based country which geographical and climatic conditions are favorable for rice (*Oryza sativa* L.) cultivation: the staple food of the people of Bangladesh. About 77.07% of cropped area of Bangladesh is used for rice production. It provides nearly 48% of rural employment, about two-third of total calorie supply and one-half of the total protein intakes of an average person in the country. Rice is also the staple food for more than two billion people in Asia and four hundred millions of people in Africa and Latin America (IRRI, 2010). Weeds are one of the major constraints to crop production in the world. It is estimated that 40% yield losses are caused by insect and pest while, weed causes 32% yield loss (Oerke and Dehne, 2004). In Bangladesh, weed infestation reduces the grain yield by 70-80% in aus rice, 30-40% for transplanted aman rice and 22-36% for modern boro rice (Mamun, 1990; BRRI, 2008). There is no way to get the maximum benefit from the rice field without keeping the land free from weed infestation. So the subsistence farmers of Bangladesh spend more time and energy on weed control than any other aspects of rice cultivation. Hand weeding is generally practiced in a major area of rice cultivation in Bangladesh which is not economic also. It was also found that it was not enough to achieve adequate weed control in direct-seeded rice, even after the application of pre and post-emergence herbicides (Chauhan *et al.*, 2015).

To reduce the cost of rice production, it has been urgently needed to adopt an alternative method of weed control. Besides hand weeding there are different modern method of weed management. Such like as mechanical weed control, biological weed control, chemical or herbicidal weed control, allelopathic weed management etc. By harnessing the allelopathic phenomenon, to suppressing weeds, can be incorporated among the important innovative weed control methods (Jabran and Farooq, 2013; Zeng, 2014). Crop allelopathy controls weeds by the release of allelochemicals from the living plants and/or through the 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 plants and their residues is well documented for many crops, including all major grain crops such as rice, rye, barley, sorghum and wheat (Belz, 2004). The incidence of growth inhibition of certain weeds and the induction of phytotoxic symptoms by plants and their residues is well documented for many crops, including all major grain crops such as rice (*Oryza sativa* L.), rye (*Secalecereale* L.), barley, sorghum (*Sorghum bicolor* L.) Moench], wheat, mustard, marshpepper, hairy vetch, buckwheat and other crop residues (Belz, 2004; Uddin and Pyon, 2010; Uddin *et al.*, 2010; Won *et al.*, 2011; Uddin *et al.*, 2012; Uddin *et al.*, 2014; Ferdousi *et al.*, 2017; Hossain *et al.*, 2017; Afroz *et al.*, 2018; Ahmed *et al.*, 2018; Pramanik *et al.*, 2019; Sarker *et al.*, 2020). Crop residues can interfere with weed development and growth through alteration of soil physical, chemical, and biological characteristics. The present work was carried out to investigate the weed suppressing ability of different crop residues and estimate the efficacy of these different plant residues on yield performance of *T. aman* rice.

MATERIALS AND METHODS

Experimental site

The research study was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from June 2017 to December 2017 to investigate the efficacy of sorghum, bishkatali, wheat, soybean plant residues on weed management and crop performance of *T. aman* rice. The geographic coordinates of the research studied area was located at 24°25' N latitude and 90°50' E longitude at an elevation of 18 m above the sea level belonging to non-calcareous dark grey floodplain soil (AEZ-9) (FAO, 1988).

Soil and climate

The soil of the experimental site was more or less neutral in reaction with pH value 6.8, low in organic matter and fertility level. The climate of the locality is tropical in nature and is characterized by high temperature and heavy rainfall during Kharif season (April to September) and scanty of rainfall associated with moderately low temperature during Rabi season (October to March).

Experimental design

The experimental treatment consisted of two factors. Factor A consists of three variety viz., BR 11 , BRRI dhan34, iii) BRRI dhan49 (V_3) and factor B consist of five plant residues : No crop residues (C_1), soybean crop residues @ 2 t ha^{-1}(C_2), wheat crop residues @ 2 t ha^{-1}(C_3), bishkatali residues @ 2 t ha^{-1}(C_4), sorghum crop residues @ 2 t ha^{-1}(C_5) The experiment was laid out in a randomized complete block design (RCBD) with three replications. Thus the total numbers of plots were 45.

Land preparation and crop management

The field was ploughed with tractor drawn plough followed by laddering. The experimental plots were fertilized with urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate @ 195, 50, 70, 75, 2.8 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 two equal splits at 20 and 50 days after transplanting. Thirty days old seedlings were uprooted carefully from the nursery bed on 26 July 2017. Seedlings were transplanted in the well prepared puddle field on 7 August 2017 at the rate of three seedlings hill^{-1} maintaining row and hill distance of 25 cm and 15 cm, respectively.

Data collection and analysis

Data on weed population (30 DAT) were collected from each plot of the rice plants by using 0.25 m × 0.25 m quadrate as per method described by Cruz *et al.* (1986). The dry weight of each species was taken by an electric balance and expressed in gm^{-2} and then Percent inhibition of weed was calculated. Data of yield and yield contributing characters were recorded from five randomly selected sample plants from each plot. Data recorded for different parameters were compiled and tabulated in proper form and subjected to statistical analysis. The Analysis of variance was done with the help of computer package MSTAT-C program. The mean differences among the treatments were adjudged by Duncan's Multiple Range Test (DMRT) as laid out by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Infested weed species in the experimental field

Five weed species belonging to four families infested the experimental field. Local name, scientific name, family, morphological type and life cycle of the weed in the experimental plot have been presented in (Table 1). The weeds of the experimental plots were *M. vaginalis*, *E. crusgalli*, *S. juncoides*, *C. difformis*, *O. corniculata*.

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

S.N.	Local name	Scientific name	Family	Morphological type	Life cycle
1	Panikachu	Monochoriavaginalis	Pontederiaceae	Broadleaf	Perennial
2	Shama	Echinochloacrusgalli	Gramineae	Grass	Annual
3	Chechra	Scirpusjuncoides	Cyperaceae	Sedge	Annual
4	Sabujnakphul	Cyperusdifformis	Cyperaceae	Sedge	Annual
5	Amrul	Oxalis corniculata	Oxalidaceae	Herb	Perennial

Table 2. Effect of variety and crop residues on weed population, dry weight and percent inhibition of different weeds.

Variety	Panikachu (*M. vaginalis*)			Shama (*E. crusgalli*)			Chesra (*S. juncoides*)			Sabujnakful (*C. difformis*)			Amrul (*O. corniculata*)		
	Weed population (no./m^2)	Dry weight (g/m^2)	Inhibition (%)	Weed population (no./m^2)	Dry weight (g/m^2)	Inhibition (%)	Weed population (no./m^2)	Dry weight (g/m^2)	Inhibition (%)	Weed population (no./m^2)	Dry weight (g/m^2)	Inhibition (%)	Weed population (no./m^2)	Dry weight (g/m^2)	Inhibition (%)
V_1	11.20	23.13a	26.40	8.06	15.78b	24.72ab	6.26b	4.39	29.69	5.86	6.35	31.17	5.20b	3.68b	25.30
V_2	10.80	21.77b	26.44	8.46	17.32a	25.46a	6.46ab	4.59	30.15	6.00	6.39	31.03	6.06a	4.03a	23.26
V_3	11.133	21.53b	26.87	8.13	16.65a	20.53b	7.00a	4.81	28.14	6.26	6.70	28.94	6.20a	4.07a	22.77
Sx	0.64	0.73	2.28	0.54	0.81	4.23	0.62	0.38	4.87	0.49	0.43	3.66	0.40	0.19	3.89
Level of significance	NS	**	NS	NS	**	*	*	NS	NS	NS	NS	NS	**	**	NS
Crop residues (treatments)															
C_1	18.44a	30.15a	0.00 e	13.33a	21.76a	0.00e	11.00a	6.55a	0.000e	9.44a	9.31a	0.000e	9.00a	5.16a	0.000e
C_2	14.11b	26.53b	11.99d	10.66b	18.57b	14.31d	9.00b	5.77b	12.00d	8.44b	8.40b	9.877d	7.66b	4.69b	8.872d
C_3	10.66c	24.09c	20.09c	8.11c	16.80c	22.51c	6.44c	4.89c	25.38c	6.33c	6.76c	27.35c	6.00c	4.13c	19.84c
C_4	7.55d	17.37d	42.46b	5.66d	14.24d	34.19b	4.11d	3.78d	42.41b	3.88d	4.87d	47.74b	4.33d	3.47d	32.57b
C_5	4.34e	12.57e	58.31a	3.33e	11.53e	46.84a	2.33e	2.16e	66.85a	2.11e	3.08e	66.94a	2.11e	2.19e	57.62a
Sx	0.82	0.95	2.93	0.70	1.04	5.46	0.80	0.49	6.29	0.63	0.56	4.72	0.52	0.25	5.02
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

In a column, figures with the same letter do not differ significantly as per DMRT.** = Significant at 1% level of probability, NS= Not Significant; V_1= BR11, V_2= BRRI dhan34, V_3= BRRI dhan49, C_1= No crop residues, C_2= Soybean crop residues @ 2 t ha^{-1}, C_3=Wheat crop residues @ 2 t ha^{-1}, C_4= Bishkatali residues @ 2 t ha^{-1}, C_5=Sorghum crop residues @ 2 t ha^{-1}.

Table 3. Combined effect of variety and different crop residues on weed population of different weeds plants.

Interaction	Weed population (no./m2)				
	Panikachu (*M. vaginalis*)	Shama (*E. crusgalli*)	Chesra (*S. juncoides*)	Sabujnakful (*C. difformis*)	Amrul (*O. corniculata*)
V_1C_1	18.66	13.33	10.66	9.33	8.33
V_1C_2	14.00	10.33	8.00	8.33	7.00
V_1C_3	11.00	7.66	6.33	6.00	5.33
V_1C_4	8.00	5.66	4.00	3.66	3.66
V_1C_5	4.33	3.33	2.33	2.00	1.66
V_2C_1	18.00	14.00	11.00	9.33	9.33
V_2C_2	13.66	11.00	9.33	8.33	7.66
V_2C_3	10.00	8.33	6.00	6.66	6.33
V_2C_4	7.66	5.33	3.66	3.66	4.66
V_2C_5	4.66	3.66	2.33	2.00	2.33
V_3C_1	18.66	12.66	11.33	9.66	9.33
V_3C_2	14.66	10.66	9.66	8.66	8.33
V_3C_3	11.00	8.33	7.00	6.33	6.33
V_3C_4	7.00	6.00	4.66	4.33	4.66
V_3C_5	4.33	3.00	2.33	2.33	2.33
Sx	1.43	1.21	1.39	1.09	0.88
Level of significance	NS	NS	NS	NS	NS

In a column, figures with the same letter do not differ significantly as per DMRT. NS = Not significant; V_1= BR11, V_2= BRRI dhan34, V_3= BRRI dhan49, C_1= No crop residues, C_2= Soybean crop residues, C_3= Wheat crop residues, C_4= Bishkatali residues, C_5= Sorghum crop residues.

Table 4. Combined effect of variety and different crop residues on weed dry weight of different weeds plants.

Interaction	Dry weight (g/m^2)				
	Panikachu (*M. vaginalis*)	Shama (*E. crusgalli*)	Chesra (*S. juncoides*)	Sabujnakful (*C. difformis*)	Amrul (*O. corniculata*)
V_1C_1	31.43	20.96	6.38	9.23	4.93
V_1C_2	29.60	18.43	5.44	8.28	4.37
V_1C_3	29.43	15.40	4.86	6.63	3.90
V_1C_4	28.00	13.03	3.56	4.59	3.20
V_1C_5	25.90	11.06	2.20	3.05	1.93
V_2C_1	25.70	23.36	6.58	9.26	5.26
V_2C_2	25.03	18.83	6.06	8.28	4.70
V_2C_3	24.06	17.61	4.78	6.92	4.25
V_2C_4	23.18	14.72	3.49	4.60	3.61
V_2C_5	18.50	12.06	2.06	2.90	2.31
V_3C_1	17.73	20.96	6.70	9.43	5.27
V_3C_2	15.90	18.46	5.80	8.63	4.91
V_3C_3	12.70	17.41	5.02	6.73	4.24
V_3C_4	12.65	14.96	4.29	5.42	3.62
V_3C_5	12.36	11.46	2.23	3.3	2.32
Sx	1.64	1.80	0.84	0.97	0.43
Level of significance	NS	NS	NS	NS	NS

In a column, figures with the same letter do not differ significantly as per DMRT. NS = Not significant; V_1= BR11, V_2= BRRI dhan34, V_3= BRRI dhan49, C_1= No crop residues, C_2= Soybean crop residues, C_3= Wheat crop residues, C_4= Bishkatali residues, C_5= Sorghum crop residues.

Table 5. Combined effect of variety and different crop residues on inhibition of different weeds plants.

Interaction	Inhibition (%)				
	Panikachu (*M. vaginalis*)	Shama (*E. crusgalli*)	Chesra (*S. juncoides*)	Sabujnakful (*C. difformis*)	Amrul (*O. corniculata*)
V_1C_1	0.00	0.00	0.00	0.00	0.00
V_1C_2	10.90	12.06	14.70	10.30	9.44
V_1C_3	20.30	26.54	23.80	28.20	21.00
V_1C_4	41.10	37.81	44.30	50.30	35.20
V_1C_5	59.60	47.20	65.50	66.90	60.80
V_2C_1	0.00	0.00	0.00	0.00	0.00
V_2C_2	13.10	18.98	7.88	10.60	10.30
V_2C_3	21.60	24.05	27.40	25.20	19.00
V_2C_4	40.10	36.30	46.90	50.30	31.20
V_2C_5	57.20	47.98	68.40	68.80	55.70
V_3C_1	0.00	0.00	0.00	0.00	0.00
V_3C_2	11.90	11.88	13.40	8.56	6.82
V_3C_3	18.20	16.94	24.80	28.5	19.50
V_3C_4	46.00	28.46	35.80	42.5	31.30
V_3C_5	58.00	45.34	66.50	65	56.20
Sx	5.09	9.47	10.89	8.17	8.69
Level of significance	NS	NS	NS	NS	NS

In a column, figures with the same letter do not differ significantly as per DMRT. NS = Not significant; V_1= BR11, V_2= BRRI dhan34, V_3= BRRI dhan49, C_1= No crop residues, C_2= Soybean crop residues, C_3= Wheat crop residues, C_4= Bishkatali residues, C_5= Sorghum crop residues.

Table 6. Effects of variety on yield and yield contributing characters of transplant amanrice.

Variety	Plant height (cm)	Number of total tillers hill^{-1}	Number of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	1000 grain weight (g)	Grain yield t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1	117.09b	8.62a	7.84a	23.82a	132.25a	21.08a	4.84a	5.63a	46.15a
V_2	123.72a	7.34b	6.53c	19.91c	104.97b	16.92c	2.88c	3.69c	43.86b
V_3	107.60c	7.23c	6.78b	22.63b	98.15c	19.83b	4.49b	5.14b	46.56a
Sx	0.51	0.05	0.14	0.16	0.85	0.36	0.08	0.09	0.63
Level of significance	**	**	**	**	**	**	**	**	**

In a column, figures with the same letters do not differ significantly as per DMRT, ** = Significant at 1% level of probability, NS= Not significant, V_1= BR11, V_2=BRRI dhan34, V_3= BRRI dhan49.

Effect of variety on weed population, dry weight and percent inhibition

For, Panikachu (*M. vaginalis*), numerically, the highest weed population (11.20 no./m^2), weed dry weight (23.13 g) was found in BR11, percent inhibition of weed was highest (26.87%) in BRRI dhan49. Dry weight and percent inhibition of Shama (*E. crusgalli*) were significantly affected by variety (Table 2). The highest weed population (8.46 no./m^2) , weed dry weight (17.32g), percent inhibition of weed was the highest (25.46%) in BRRI dhan34. In case of Chesra (*S. juncoides*), the highest weed population (7.0 no./m^2) was found in BRRI dhan49, weed dry weight (4.81 g) was found in BRRI dhan49,percent inhibition of weed was the highest (30.15%) in BRRI dhan34. Weed population, dry weight and percent inhibition of Sabujnakful (*C. difformis*) were not significantly affected by variety. Numerically, the highest weed population (6.26 no./m^2) was found in BRRI dhan49 , weed dry weight (6.70 g) was found in BRRI dhan49, percent inhibition of the weed was highest (31.17%) in BR11. For Amrul (*O. corniculata*), the highest weed population (6.20no./m^2) and weed dry weight (4.07 g) was found in BRRI dhan49, percent inhibition of weed was the highest (25.30%) in BR11 (Table 2).

Effect of different crop residues on weed population, dry weight and percent inhibition

Weed population, dry weight and percent inhibition of Panikachu (*M. vaginalis*) were significantly affected by different crop residues .The highest weed population (18.11 no./m^2) was found in control treatment where no crop residue was used and the lowest was found in C_5 where Sorghum crop residues @ 2 t ha^{-1} were used. The highest weed dry weight (30.15 g) was found in C_1 treatment and inhibition was found in C_5 (58.31%) where sorghum residue applied. For Shama (*E. crusgalli*), the highest weed population (13.33no./m^2) and dry weight (21.76 g) were found in C_1 (no crop residues) treatment. The lowest weed population (3.33no./m^2) and dry weight (11.53 g) were found in C_5 (Sorghum crop residues @ 2 t ha^{-1}) (Table 2). The inhibition (46.84%) was found in C_5 (Sorghum crop residues @ 2 t ha^{-1}). For Chesra (*S. juncoides*), the highest weed population (11.00no./m^2) was found in no crop residue treatment and the lowest (2.33no./m^2) was found in C_5 (Sorghum crop residues). The highest weed dry weight (6.55 g) was found in C_1 treatment and the lowest one was observed in C_5 treatment. Percent inhibition of weed was the highest (66.85%) in C_5 treatment. Similar findings were reported by Uddin and Pyon (2010) who found significant weed control efficacy by different crop residues. For sabujnakful, the highest weed population (9.44no./m^2) was found in C_1 and the lowest (2.11) was found in C_5 treatment. The highest weed dry weight (9.31 g) was found in C_1 (no crop residue) treatment, the lowest weed dry weight (3.08 g) was found in C_5 treatment. Percent inhibition of weed was the highest (66.94%) in C_5 (Table 2). For Amrul (*O. corniculata*), the lowest weed population and dry weight of weed was in C_5 treatment. Percent inhibition of weed was the highest (52.62%) in C_5 treatment. Similar findings were reported by Hossain *et al.* (2017) who found significant weed control efficacy by mustard crop residues.

Effect of interaction between variety and different crop residues on weed population, dry weight and percent inhibition

For Panikachu (*M. vaginalis*), numerically, the highest weed population (18.66 no./m^2) was found in V_1C_1 (BR11 × no crop residue. The lowest weed dry weight (12.36 g) was in V_3C_5 (BRRI dhan49 × sorghum crop residues @ 2 t ha^{-1}). Percent inhibition of weed was the highest in V_1C_5 (Tables 3-5). In case of Shama (*E. crusgalli*), the lowest- weed population (3.00 no./m^2) was found in V_3C_5 weed and dry weight (11.06 g) was in V_1C_5. Percent inhibition of weed was highest (47.98%) in V_2C_5 (BRRI dhan34 × sorghum crop residues). Similar findings were reported by Ferdousi *et al.* (2017) who evaluate the combined effect of variety and wheat crop residues on weed population (14 no./m^2), dry weight (20.67 g/m^2) and percent inhibition (76.76%) of Shama (*E. crusgalli*). The highest chesra weed population (11.33) was found in V_3C_1 and the lowest (2.33) was found in V_2C_5 and the lowest weed dry weight (2.06 g) was in V_2C_5. Percent inhibition (68.4%) was the highest in V_2C_5 (Table 3, 4 and 5).The highest, Sabujnakful (*C. difformis*) weed population (9.66) was found in V_3C_1 and the lowest dry weight of weed (2.90 g) was in V_2C_5 Percent inhibition of weed was highest in V_2C_5 (68.80%). For Amrul, numerically, the lowest weed population was found in V_3C_5. The highest weed dry weight (5.27 g) was found in V_3C_1 and the lowest weed dry weight was in V_1C_5. Percent inhibition of weed was highest (60.80%) in V_1C_5 (BR11 × sorghum crop residues @ 2 t ha^{-1}) combination.

Effect of variety on yield and yield contributing characters at harvest

The highest number of total tillers hill^{-1} (8.62), number of effective tillers hill^{-1} (7.84), Panicle length (23.82 cm), no. of grains panicle-^{1} (132.25), 1000 grain weight (21.08), grain yield (4.84 t ha^{-1}) and straw yield (5.63 t ha^{-1}) were recorded from BR11 (V_1). The highest plant height (123.72 cm) was recorded from variety BRRI dhan34. For harvest index, the highest percentage 46.56 was obtained from BRRI dhan49 (Table 6). Singh *et al.* (1996) reported variable number of grains among the varieties. Varietal differences regarding the number of grains might be due to differences in genetic constituents.

Effect of different crop residues yield and yield contributing characters at harvest

The highest plant height (123.03 cm), number of total tillers hill^{-1} (8.78), number of effective tillers hill^{-1} (8.41), panicle length (23.61 cm), no. of grains panicle^{-1} (118.08), 1000 grain weight (20.56 g), grain yield (4.64 t ha^{-1}), straw yield (5.25 t ha^{-1}) and harvest index (46.84 %) were obtained from sorghum crop residues (Table 7). Control plot (no crop residue) showed maximum weed population and the highest dry weight of weed. The weeds compete with the crop for nutrient, water, air, sunlight and space and so, grain yield decreased. Uddin and Pyon (2010) also reported the similar results, where crop residues influenced crop performance.

Effect of interaction between variety and different crop residues on yield and yield contributing characters at harvest

Significant variation was found in the number of total tillers hill^{-1}, effective tillers hill^{-1}, Panicle length (cm), grains panicle^{-1}, grain yield and straw yield due to interaction between variety and different crop residues. The highest number of total tillers hill-1 (9.36), effective tillers hill^{-1} (9.03), panicle length (25.66 cm), grains panicle^{-1} (139.9), grain yield (5.76 t ha^{-1}) and straw yield (6.39 t ha^{-1}) were obtained from V1C5 (BR11 × sorghum crop residues @ 2 t ha^{-1}) combination (Table 8). Harvest index was not significantly influenced by the interaction between variety and crop residues. Numerically, the highest harvest index (47.38%) was observed in V_1C_5 (BR11 × Sorghum crop residues @ 2 t ha^{-1}) treatment (Table 8). The lowest grain yield in the control treatment occurred mainly due to poor performance of yield contributing characters like number of tillers hill^{-1} and grain panicle^{-1}, because of severe weed infestation in the plots due to competition for moisture, nutrients between weed and rice plants. Gogoi *et al.* (2000), Islam *et al.* (2001) and Attalla and Kholosy (2002) found strong relationship between number of tiller and yield. Results of the study proved that no weeding treatment did not encourage the rice plant to produce more number of effective tillers hill^{-1}. Chowdhury *et al.* (1993) stated that no weeding treatment have lower number of effective tillers hill^{-1}.

Table 7. Effect of different crop residues on yield and yield contributing characters of transplant amanrice.

Crop residues	Plant height (cm)	Number of total tillers hill^{-1}	Number of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	1000 grain weight (g)	Grain yield t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
C_1	109.20e	7.25e	6.05e	20.64e	106.17e	17.95e	3.55e	4.35e	44.67c
C_2	112.89d	7.60d	6.66d	21.48d	109.23d	18.58d	3.72d	4.56d	44.68c
C_3	116.27c	8.05c	7.32c	22.16c	111.04c	19.24c	4.05c	4.85c	45.32bc
C_4	119.30b	8.49b	7.97b	22.71b	114.33b	20.06b	4.38b	5.07b	46.12ab
C_5	123.03a	8.78a	8.41a	23.61a	118.08a	20.56a	4.64a	5.25a	46.84a
Sx	0.66	0.07	0.19	0.21	1.10	0.47	0.10	0.12	0.84
Level of significance	**	**	**	**	**	**	**	**	**

In a column, figures with the same letter do not differ significantly as per DMRT; ** = Significant at 1% level of probability; C_1= No crop residues, C_2= Soybean crop residues, C_3=Wheat crop residues, C_4= Bishkatali residues, C_5=Sorghum crop residues.

Table 8. Interaction effect of variety and crop residues on yield and yield contributing characters of transplant aman rice.

Interaction	Plant height (cm)	Number of total tillers hill^{-1}	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1C_1	111.75	7.86fg	6.36h	22.16f	125.63d	19.2	4.21f	5.06d	45.41
V_1C_2	113.39	8.23e	7.33f	22.93de	129.93c	20.33	4.26f	5.12d	45.45
V_1C_3	116.67	8.70cd	8.00cd	23.88c	131.53c	21.45	4.76d	5.67c	45.62
V_1C_4	120.33	8.96b	8.46b	24.36b	134.23b	22.01	5.21b	5.90b	46.91
V_1C_5	123.28	9.36a	9.03a	25.66a	139.90a	22.43	5.76a	6.39a	47.38
V_2C_1	116.43	6.23j	5.23j	18.80k	99.00j	15.92	2.50k	3.30g	42.00
V_2C_2	120.78	6.70i	5.76i	19.26j	102.70hi	16.44	2.74j	3.79f	43.15
V_2C_3	124.83	7.23h	6.53h	19.83i	105.45g	16.93	2.95i	3.83f	43.54
V_2C_4	126.27	7.88fg	7.43ef	20.43h	107.48f	17.34	3.05hi	3.80f	44.38
V_2C_5	130.31	8.10ef	7.70de	21.23g	110.23e	17.98	3.18h	3.72f	46.11
V_3C_1	99.42	7.66g	6.56h	20.96g	93.87l	18.74	3.93g	4.71e	45.47
V_3C_2	104.5	7.86fg	6.90g	22.26f	95.06kl	18.96	4.17f	4.78e	46.57
V_3C_3	107.32	8.23e	7.43ef	22.76e	96.15k	19.35	4.36e	5.06d	46.81
V_3C_4	111.3	8.63d	8.03c	23.23d	101.57i	20.84	4.89cd	5.52c	46.96
V_3C_5	115.49	8.90bc	8.50b	23.93c	104.10gh	21.26	5.00c	5.63c	47.02
Sx	1.15	0.12	0.35	0.36	1.91	0.81	0.17	0.21	1.45
Level of significance	NS	**	**	**	**	NS	**	**	NS

In a column, figures with the same letter do not differ significantly as per DMRT.** = Significant at 1% level of probability, NS = Not significant; V_1= BR11, V_2= BRRI dhan34, V_3= BRRI dhan49, C_1= No crop residues, C_2= Soybean crop residues @ 2 t ha^{-1}, C_3=Wheat crop residues @ 2 t ha^{-1}, C_4= Bishkatali residues @ 2 t ha^{-1}, C_5=Sorghum crop residues @ 2 t ha^{-1}.

Conclusion

Results of this study indicate that among these crop residues, sorghum crop residues showed the best potentiality to inhibit weed growth and it has a significant effect on the yield of transplant amanrice. Therefore, sorghum crop residues might be used as an alternative way for weed management in effective and sustainable rice production.

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