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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 crus-galli), 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.

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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 (Secale cereale 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; Hosain 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 (V3) and factor B consist of five plant residues : No crop residues (C0), soybean crop residues @ 2 t ha⁻¹(C1), wheat crop residues @ 2 t ha⁻¹(C2), bishkatali residues @ 2 t ha⁻¹(C3), sorghum crop residues @ 2 t ha⁻¹(C4) 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 puddled 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   | Monochoria vaginalis | Pontederiaceae | Broadleaf          | Perennial  |
| 2    | Shama       | Echinochloa crusgalli | Gramineae    | Grass              | Annual     |
| 3    | Chechra     | Scirpus juncoides | Cyperaceae   | Sedge              | Annual     |
| 4    | Sabujnakphul| Cyperus diffiformis | 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) | Chechra (S. juncoides) | Sabujnakphul (C. diffiformis) | Amrul (O. corniculata) |
|---------|---------------------------|----------------------|------------------------|-------------------------------|------------------------|
|         | Weed population (no./m²) | Dry weight (g/m²)   | Inhibition (%)         | Weed population (no./m²)     | Dry weight (g/m²)   | Inhibition (%)         | Weed population (no./m²) | Dry weight (g/m²)   | Inhibition (%)         | Weed population (no./m²) | Dry weight (g/m²)   | Inhibition (%)         |
| V₁      | 11.20                     | 23.13a               | 26.40                  | 8.06                          | 15.78b               | 26.40                  | 8.06                          | 15.78b               | 26.40                  | 8.06                          | 15.78b               | 26.40                  | 8.06                         |
| V₂      | 10.80                     | 21.77b               | 26.44                  | 8.46                          | 17.32a               | 25.46a                 | 6.46ab                        | 4.59                 | 29.69                  | 5.86                          | 6.35                 | 31.17                  | 5.20                         |
| V₃      | 11.133                    | 21.53                 | 26.87                  | 8.13                          | 16.65a               | 20.53b                 | 7.00a                          | 4.81                 | 28.14                  | 6.26                          | 6.70                 | 28.94                  | 6.06                         |
| 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                         |
| Level of significance | NS | ** | NS | NS | ** | * | * | NS | NS | NS | NS | ** | ** | NS |

Crop residues (treatments)
| C₁     | 18.44a                   | 30.15a               | 0.00 e                 | 13.33a                        | 21.76a               | 0.00 e                 | 11.00a                        | 6.55a               | 0.000e                  | 9.44a                        | 9.31a               | 0.000e                  | 9.00a                        |
| C₂     | 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                        |
| C₃     | 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                         |
| C₄     | 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                         |
| C₅     | 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                         |
| 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                          |
| 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; V₁= BR11, V₂= BRRI dhan34, V₃= BRRI dhan49, C₁= No crop residues, C₂= Soybean crop residues @ 2 t ha⁻¹, C₃= Wheat crop residues @ 2 t ha⁻¹, C₄= Bishkatali residues @ 2 t ha⁻¹, C₅= 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 | Panikachu (M. vaginalis) | Shama (E. crusgalli) | Chesra (S. juncoides) | Sabujnakful (C. difformis) | Amrul (O. corniculata) |
|-------------|---------------------------|----------------------|------------------------|-----------------------------|------------------------|
| V1C1        | 18.66                     | 13.33                | 10.66                  | 9.33                        | 8.33                   |
| V1C2        | 14.00                     | 10.33                | 8.00                   | 8.33                        | 7.00                   |
| V1C3        | 11.00                     | 7.66                 | 6.33                   | 6.00                        | 5.33                   |
| V1C4        | 8.00                      | 5.66                 | 4.00                   | 3.66                        | 3.66                   |
| V1C5        | 4.33                      | 3.33                 | 2.33                   | 2.00                        | 1.66                   |
| V2C1        | 18.00                     | 14.00                | 11.00                  | 9.33                        | 9.33                   |
| V2C2        | 13.66                     | 11.00                | 9.33                   | 8.33                        | 7.66                   |
| V2C3        | 10.00                     | 8.33                 | 6.00                   | 6.66                        | 6.33                   |
| V2C4        | 7.66                      | 5.33                 | 3.66                   | 3.66                        | 4.66                   |
| V3C1        | 11.00                     | 7.66                 | 6.33                   | 6.00                        | 5.33                   |
| V3C2        | 8.00                      | 5.66                 | 4.00                   | 3.66                        | 3.66                   |
| V3C3        | 4.33                      | 3.33                 | 2.33                   | 2.00                        | 1.66                   |
| V3C4        | 4.66                      | 3.66                 | 2.33                   | 2.00                        | 1.66                   |

Sx           | 1.43                      | 1.21                 | 1.39                   | 0.88                        | NS                     |

Level of significance: NS = Not significant; V1 = BR11, V2 = BRRI dhan34, V3 = BRRI dhan49, C1 = No crop residues, C2 = Soybean crop residues, C3 = Wheat crop residues, C4 = Bishkatali residues, C5 = Sorghum crop residues.

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

| Interaction | Panikachu (M. vaginalis) | Shama (E. crusgalli) | Chesra (S. juncoides) | Sabujnakful (C. difformis) | Amrul (O. corniculata) |
|-------------|---------------------------|----------------------|------------------------|-----------------------------|------------------------|
| V1C1        | 31.43                     | 20.96                | 6.38                   | 9.23                        | 4.93                   |
| V1C2        | 29.60                     | 18.43                | 5.44                   | 8.28                        | 4.37                   |
| V1C3        | 29.43                     | 15.40                | 4.86                   | 6.63                        | 3.90                   |
| V1C4        | 28.00                     | 13.03                | 3.56                   | 4.59                        | 3.20                   |
| V1C5        | 25.90                     | 11.06                | 2.20                   | 3.05                        | 1.93                   |
| V2C1        | 25.70                     | 23.36                | 6.58                   | 9.26                        | 5.26                   |
| V2C2        | 25.03                     | 18.83                | 6.06                   | 8.28                        | 4.70                   |
| V2C3        | 24.06                     | 17.61                | 4.78                   | 6.92                        | 4.25                   |
| V2C4        | 23.18                     | 14.72                | 3.49                   | 4.60                        | 3.61                   |
| V3C1        | 18.50                     | 12.06                | 2.06                   | 2.90                        | 2.31                   |
| V3C2        | 17.73                     | 20.96                | 6.70                   | 9.43                        | 5.27                   |
| V3C3        | 15.90                     | 18.46                | 5.80                   | 8.63                        | 4.91                   |
| V3C4        | 12.70                     | 17.41                | 5.02                   | 6.73                        | 4.24                   |
| V3C5        | 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 = Not significant; V1 = BR11, V2 = BRRI dhan34, V3 = BRRI dhan49, C1 = No crop residues, C2 = Soybean crop residues, C3 = Wheat crop residues, C4 = Bishkatali residues, C5 = Sorghum crop residues.
Table 5. Combined effect of variety and different crop residues on inhibition of different weeds plants.

| Interaction | Panikachu (M. vaginalis) | Shama (E. crusgalli) | Chesra (S. juncoides) | Sabujnakful (C. difformis) | Amrul (O. corniculata) |
|-------------|--------------------------|----------------------|-----------------------|---------------------------|------------------------|
| V₁C₁        | 0.00                     | 0.00                 | 0.00                  | 0.00                      | 0.00                   |
| V₁C₂        | 10.90                    | 12.06                | 14.70                 | 10.30                     | 9.44                   |
| V₁C₃        | 20.30                    | 26.54                | 23.80                 | 28.20                     | 21.00                  |
| V₁C₄        | 41.10                    | 37.81                | 44.30                 | 50.30                     | 35.20                  |
| V₁C₅        | 59.60                    | 47.20                | 65.50                 | 66.90                     | 60.80                  |
| V₂C₁        | 0.00                     | 0.00                 | 0.00                  | 0.00                      | 0.00                   |
| V₂C₂        | 13.10                    | 18.98                | 7.88                  | 10.60                     | 10.30                  |
| V₂C₃        | 21.60                    | 24.05                | 27.40                 | 25.20                     | 19.00                  |
| V₂C₄        | 40.10                    | 36.30                | 46.90                 | 50.30                     | 31.20                  |
| V₂C₅        | 57.20                    | 47.98                | 68.40                 | 68.80                     | 55.70                  |

In a column, figures with the same letter do not differ significantly as per DMRT. NS = Not significant; V₁ = BR11, V₂ = BRRI dhan34, V₃ = BRRI dhan49, C₁ = No crop residues, C₂ = Soybean crop residues, C₃ = Wheat crop residues, C₄ = Bishkatali residues, C₅ = Sorghum crop residues.

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

| 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 (%) |
|---------|-------------------|-------------------------------|-----------------------------------|---------------------|-------------------------|----------------------|-------------------|-------------------|--------------------|
| V₁      | 117.09b           | 8.62a                         | 7.84a                             | 23.82a              | 132.25a                 | 21.08a               | 4.84a             | 5.63a             | 46.15a             |
| V₂      | 123.72a           | 7.34b                         | 6.53c                             | 19.91c              | 104.97b                 | 16.92c               | 2.88c             | 3.69c             | 43.86b             |
| V₃      | 107.60c           | 7.23c                         | 6.78b                             | 22.63b              | 98.15c                  | 19.83b               | 4.49b             | 5.14b             | 45.66a             |
| Sx      | 0.51              | 0.05                          | 0.14                              | 0.16                | 0.85                    | 0.36                 | 0.08              | 0.09              | 0.63               |

In a column, figures with the same letters do not differ significantly as per DMRT, ** = Significant at 1% level of probability, NS= Not significant, V₁ = BR11, V₂ = BRRI dhan34, V₃ = 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./m²), 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./m²), weed dry weight (17.32 g), 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./m²) 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./m²) 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 (6.20 no./m²) 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./m²) was found in control treatment where no crop residue was used and the
lowest was found in C5 where Sorghum crop residues @ 2 t ha$^{-1}$ were used. The highest weed dry weight (30.15 g) was found in C1 treatment and inhibition was found in C5 (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 C1 (no crop residues) treatment. The lowest weed population (3.33no./m$^2$) and dry weight (11.53 g) were found in C5 (Sorghum crop residues @ 2 t ha$^{-1}$) (Table 2). The inhibition (46.84%) was found in C5 (Sorghum crop residues @ 2 t ha$^{-1}$). For Chesa (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 C5 (Sorghum crop residues). The highest weed dry weight (6.55 g) was found in C1 treatment and the lowest one was observed in C3 treatment. Percent inhibition of weed was the highest (66.85%) in C5 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 C1 and the lowest (2.11) was found in C5 treatment. The highest weed dry weight (9.31 g) was found in C1 (no crop residue) treatment, the lowest weed dry weight (3.08 g) was found in C5 treatment. Percent inhibition of weed was the highest (66.94%) in C5. For Amrul (O. corniculata), the lowest weed population and dry weight of weed was in C2 treatment. Percent inhibition of weed was the highest (52.62%) in C5. 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 V1C1 (BR11 × no crop residue). The lowest weed dry weight (12.36 g) was in V2C3 (BRRI dhan49 × sorghum crop residues @ 2 t ha$^{-1}$). Percent inhibition of weed was the highest in V1C5 (Table 3-5). In case of Shama (E. crusgalli), the lowest weed population (3.00 no./m$^2$) was found in V2C5 weed and dry weight (11.06 g) was in V1C4. Percent inhibition of weed was the highest (47.98%) in V2C5 (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 V2C4 and the lowest (2.33) was found in V2C5 and the lowest weed dry weight (2.06 g) was in V2C5. Percent inhibition (68.4%) was the highest in V2C5 (Table 3, 4 and 5). The highest, Sabujnakful (C. difformis) weed population (9.66) was found in V3C1 and the lowest dry weight of weed (2.90 g) was in V3C5. Percent inhibition of weed was highest in V1C5 (68.80%). For Amrul, numerically, the lowest weed population was found in V1C5. The highest weed dry weight (5.27 g) was found in V2C1 and the lowest weed dry weight was in V1C3. Percent inhibition of weed was highest (60.80%) in V1C5 (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 (V1). For 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 VIICS (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 V1C5 (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 aman rice.

| 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                     | 20.66b                  | 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              |
| S$_x$         | 0.66             | 0.07                               | 0.19                                    | 0.21                | 1.10                        | 0.47                    | 0.10                     | 0.12                     | 0.84                |

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$^{-1}$ | 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$_1$C$_1$  | 111.75           | 7.86fg                             | 6.36h                                   | 22.16f              | 125.63d                     | 19.2                    | 4.21f                    | 5.06f                    | 45.41               |
| V$_1$C$_2$  | 113.39           | 8.23e                              | 7.33f                                   | 22.93e              | 129.93c                     | 20.33                   | 4.26f                    | 5.12d                    | 45.45               |
| V$_1$C$_3$  | 116.67           | 8.70cd                             | 8.00cd                                  | 23.88c              | 131.53c                     | 21.45                   | 4.76d                    | 5.67c                    | 45.62               |
| V$_1$C$_4$  | 120.33           | 8.96b                              | 8.46b                                   | 24.36b              | 134.23b                     | 22.01                   | 5.12b                    | 5.90b                    | 46.91               |
| V$_1$C$_5$  | 123.28           | 9.36a                              | 9.03a                                   | 25.66a              | 139.90a                     | 22.43                   | 5.76a                    | 6.39a                    | 47.38               |
| V$_2$C$_1$  | 116.43           | 6.23j                              | 5.23j                                   | 18.80k              | 99.00j                      | 15.92                   | 2.50k                    | 3.30g                    | 42.00               |
| V$_2$C$_2$  | 120.78           | 6.70i                              | 7.67i                                   | 19.26i              | 102.70hi                    | 16.44                   | 2.74j                    | 3.79f                    | 43.15               |
| V$_2$C$_3$  | 124.83           | 7.23h                              | 6.53h                                   | 19.83i              | 105.45g                     | 16.93                   | 2.95i                    | 3.83f                    | 43.54               |
| V$_2$C$_4$  | 126.27           | 7.88fg                             | 7.43ef                                  | 20.43h              | 107.48f                     | 17.34                   | 3.05h                    | 3.80f                    | 44.38               |
| V$_2$C$_5$  | 130.31           | 8.10ef                             | 7.70de                                  | 21.23g              | 110.23e                     | 17.98                   | 3.18h                    | 3.72f                    | 46.11               |
| V$_3$C$_1$  | 99.42            | 7.66g                              | 6.56h                                   | 20.96g              | 93.87l                      | 18.74                   | 3.93g                    | 4.71e                    | 45.47               |
| V$_3$C$_2$  | 104.5            | 7.86fg                             | 6.90g                                   | 22.26f              | 95.06kl                     | 18.96                   | 4.17f                    | 4.78e                    | 46.57               |
| V$_3$C$_3$  | 107.32           | 8.23e                              | 7.43ef                                  | 22.76e              | 96.15k                      | 19.35                   | 4.36e                    | 5.06d                    | 46.81               |
| V$_3$C$_4$  | 111.3            | 8.63d                              | 8.03c                                   | 23.23d              | 101.57i                     | 20.84                   | 4.89cd                   | 5.52c                    | 46.96               |
| V$_3$C$_5$  | 115.49           | 8.90bc                             | 8.50b                                   | 23.93e              | 104.10gh                    | 21.26                   | 5.00c                    | 5.63c                    | 47.02               |
| S$_x$       | 1.15             | 0.12                               | 0.35                                    | 0.36                | 1.91                        | 0.81                    | 0.17                     | 0.21                     | 1.45                |

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$_1$ = BRRI dhan34, V$_2$ = BRRI dhan49, V$_3$ = No crop residues, C$_1$ = Soybean crop residues, C$_2$ = Wheat crop residues, C$_3$ = Bishkatali residues, C$_5$ = Sorghum crop residues.

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 aman rice. Therefore, sorghum crop residues might be used as an alternative way for weed management in effective and sustainable rice production.

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