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EFFICACY OF VARIETY AND MUSTARD CROP RESIDUES ON WEED MANAGEMENT AND CROP PERFORMANCE OF TRANSPLANT AMAN RICE

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ABSTRACT

Weed infestation in rice field is always subject to agro ecological condition and growing seasons. Weeds cause major yield losses in crops and also reduce their quality. An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh to investigate the efficacy of mustard crop residues on weed management and crop performance of transplant *aman* rice. The experiment consisted of three cultivars and five different levels of mustard crop residues. The experiment was laid out in a randomized complete block design with three replications. Weed population, weed dry weight and percent inhibition of weed were significantly influenced by mustard crop residues and cultivar. The maximum weed growth was noticed with the cultivar BRRI dhan34 and the minimum was found in the cultivar BRRI dhan49. The grain yield and other yield contributing characters produced by BRRI dhan49 was the highest among the studied varieties. The highest percent inhibition of 73.36, 78.82, 71.90, 76.83 and 81.53 found in Pani kachu, Chechra, Pani shapla, Shama and Sabuj nakful, respectively with the application of mustard crop residues at 3.0 t ha⁻¹ + one hand weeding. It can be concluded that BRRI dhan49 and mustard crop residues showed potentiality to inhibit weed growth and it has a significant effect on the yield of transplant *aman* rice. Therefore, mustard crop residues could be recommended to use as an alternative tool for weed management.

KEYWORDS

mustard crop residues, weed infestation, plant height, effective tiller, grain yield, straw yield, dry weight, transplant aman rice

1. Introduction

Rice is the most extensively cultivated crop in Bangladesh and the staple food for her people. Bangladesh is an agricultural country and its agriculture is predominantly rice based. About 77.07 % of cropped area of Bangladesh is used for rice production. The people in Bangladesh depend on rice as staple food and have tremendous influence on agrarian economy of Bangladesh. Geographic and agronomic conditions of Bangladesh are favorable for rice cultivation. The average yield of rice is almost less than 50% of the world average rice grain yield. The annual production of rice is 34.71 million metric tons from 11.42 million acres of land (BBS, 2015). Transplant *aman* rice covers 5.53 million acres of land with a production of 13.19 million metric tons (BBS, 2015).

Weed is one of the major problems in rice field. Weed compete with rice plants severely for space, nutrient, air, water and light. So, it is often said that crop production is a fight against weeds (Mukhopadhay and Ghosh, 1981). In Bangladesh, weed infestation reduces the grain yield by, 70-80% in aus rice (early summer), 30-40% for transplanted *aman* rice (late summer) and 22-36% for modern boro rice cultivars (winter rice) (Mamun, 1990; BRRI, 2008). Weed also exert allelophathic effect on the growth of rice plant (Kasasian, 1971). Many investigators have reported great losses in the yield of rice due to weed infestation in different parts of

the world (Nandal and Singh, 1994). It has been estimated that 11.5% of the yield of major crops of the world is lost due to weeds. Weeds are very serious problem in transplanted rice (TP) (Walia et al., 2006). Yield losses due to weed infestation are greater than the combined losses of insect pests and diseases. Herbicides are effective in controlling weeds alone or in combination with hand weeding but it is harmful for the nature (Ahmed et al., 2005).

To overcome weed infestation presently, researchers are giving more emphasis using different crop residues to suppress weed growth. Crop residues are a tremendous natural resource not a waste. Weed suppression effects of crop residues have been explained by different mechanisms, including initial low nitrogen availability following cover crop incorporation, mulch effects, stimulation of pathogens or predators of weed seeds (Gallandt et al., 2005; Mohler, 1996). Mustard is one of the strongest allelopathic crops which has been extensively used as a cover crop or through incorporation of its residue in soil to control weed. 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).

Mustard is a successful competitor against weeds in fields as empirically known. This may be partly due to its rapid growth at the early growth

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stage. Besides this growth habit, mustard seems to have some inhibiting effects on the growth of other plants. The growth of crops cultivated at the fields where mustard was planted previously is sometimes suppressed. These suggest the allelopathic potential of mustard and it will be very useful for biological control of weeds. When mustard was amended as a crop residue, weed biomass in the transplant aman rice was found to be significantly suppressed and mustard crop residue is more eco-friendly than chemical herbicide.

Keeping the above points in views the present work was carried out with the following objectives:

- To evaluate the weed suppressing ability of mustard crop residues;
- > To estimate the efficacy of mustard crop residues on yield performance in transplant aman rice:
- To find out the optimum dose of mustard crop residues for weed management of T. aman rice; and
- > To establish an easy and sustainable method for efficient weed management and better yield of T. aman rice.

2. MATERIALS AND METHODS

The experiment was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from June 2016 to December 2016 to investigate the efficacy of mustard crop residues on weed management and crop performance of T. aman rice.

2.1 Description of the experimental location, soil and climate

The experimental field was located at 24°25' N latitude and 90°50' E longitude at an elevation of 18 m above the sea level (FAO and UNDP, 1988). The soil was more or less neutral in reaction with pH value 6.8, low in organic matter and fertility level belonging to the Sonatola series of noncalcareous dark grey floodplain soil under the Old Brahmaputra Alluvial Tract. The land type was medium high with silty loam in texture. The physical and chemical characteristics of the soil of the experimental field have been presented in Table 1. The climatic condition i.e. monthly average air temperature relative humidity (%), rainfall (mm) and sunshine (hour day-1) during the period of experiment have been presented in Table 2.

A. Morphological characteristics

Table 1: The morphological, physical and chemical properties of the experimental field					
Constituents	Characteristics				
Location	Agronomy Field Laboratory, BAU, Mymensingh				
Soil Series	Sonatola				
Soil Tract	Old Brahmaputra Alluvium				
Land type	Medium High Land				
General soil type	Non-calcareous dark grey floodplain				
Agro-ecological zone	Old Brahmaputra Floodplain(AEZ-9)				
Topography	Fairly level				
Soil type and color	Dark grey Terrace Soil				
Drainage	Moderate				
Depth of inundation	Above the flood level				
Drainage condition	Well drained				

B. Physical properties of the soil

Constituents	Results
Particle size analysis	2.57
Bulk density (g/ce)	1.42
Porosity (%)	44.7
Sand (%) (0.0-0.02 mm)	21.75
Silt (1%) (0.02-0.002 mm)	66.60
Clay (%) (<0.002 mm)	11.65
Soil textural class	Silt loam
Color	Dark grey
Consistency	Grounder

C. Chemical composition of the initial soil (0-15 cm depth)

Constituents	Results
Soil pH	6.5
Organic matter (%)	1.30
Total nitrogen (%)	0.101
Available phosphorus (ppm)	27
Exchangeable potassium (me %)	0.12
Available Sulphur (ppm)	22.7

Table 2: Distribu	Table 2: Distribution of monthly average air temperature relative humidity, rainfall and sunshine hours of the experiment site during the period from June 2016 to December 2016					
Month		** Air temperature (°C)		**Relative Humidity	*rainfall (mm)	*Sunshine (hrs)
	Maximum	Minimum	Average	(%)		
June	32.7	26.2	29.5	84.0	388.8	149.5
July	31.6	26.5	29.1	87.0	522.7	101.8
August	33.2	26.8	30.0	81.0	97.6	179.6
September	32.0	26.1	29.1	87.0	408.6	125.6
October	29.5	18.1	23.4	84.0	31.07	200.9
November	32.4	24.2	28.3	81.0	1.0	204.8
December	27.5	14.6	21.1	81.4	0.0	180.3

^{*} Monthly total ** Monthly average

Source: Weather Yard, Department of Irrigation and Water Management, Bangladesh Agricultural University, Mymensingh

2.2 Experimental treatments and design

The experimental treatment consisted of two factors. They are as follows: Factor A: Variety (3)

i. BRRI dhan34 (V1)

ii. BRRI dhan49 (V2)

iii. BRRI dhan52 (V3)

Factor B: Mustard crop residues (5)

i. No crop residues (T1)

ii. Mustard crop residues at 3.0 t ha-1 (T2)

iii. Mustard crop residues at 2.0 t ha-1 + one hand weeding (T₃)

iv. Mustard crop residues at 3.0 t ha⁻¹ + one hand weeding (T_4)

v. Three times hand weeding (T₅) (at 15, 30 and 45 DAT)

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Thus total number of plots were 45. Each plot size was $(2.0 \text{ m} \times 2.0 \text{ m})$.

2.3 Description of the rice variety

BRRI dhan34: BRRI dhan34 was developed by Bangladesh Rice Research Institute (BRRI) and released in 1997. It attains a plant height about 117

cm. Its growth duration is 135 days. These are clean, short, bold and fine aromatic rice. This variety gives an average yield of 3.5 t ha-1 (BRRI, 2015). BRRI dhan49: BRRI dhan49, a variety of aman rice, was developed by the Bangladesh Rice Research Institute (BRRI). This variety is resistant to water logging conditions. It takes about 135 days to mature. It attains a plant height of 115 cm. The grains are medium bold to medium slender with light golden husks and kernels are white in color. It gives a grain yield of 5.0-5.5 t ha-1 (BRRI, 2015).

BRRI dhan52: BRRI dhan52, is a flood tolerant rice variety for aman season, released in 2007. It takes about 155-160 days (under 13-15 days submerged condition) and 140-145 days for non-submerged condition. In submerged condition, it produces grain yield of 4.0-4.5 t ha-1 (if 10-15 days in submerged condition). This variety is capable to produce 4.5-5.0 t ha-1 in non-submerged condition. These are clean rice, grains are medium slender and kernels are white in color (BRRI, 2015).

2.4 Collection and preparation of crop residues

Mustard crop residues were used in this study. Crops were grown at the Agronomy Field Laboratory, Bangladesh Agricultural University and were harvested at the time of ripening stage to collect crop residues. After collection, the crop residues were dried under shade in the cover threshing floor of Agronomy Field Laboratory of BAU. The studied crop residues were cut as small as possible by using sickle.

2.5 Experimental details

Seeds of the test cultivar (BRRI dhan34, BRRI dhan49 and BRRI dhan52) were collected from Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. The sprouted seeds were sown uniformly in a well-prepared nursery bed on 25 June 2016. Proper care was taken to raise the healthy seedlings in the nursery bed. The field was ploughed with tractor drawn plough followed by laddering. The layout of the field was made after final land preparation. Weeds and stubbles were removed and cleaned from individual plots. The experimental plots were fertilized with 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 in equal splits at 15, 30 and 45 days after transplanting (DAT). The prepared mustard crop residues were applied at 7 days before transplanting aman rice at the time of final land preparation. After that crop residues were mixed well to the respective plots. The uprooted seedlings were immediately transferred to the main field. Healthy and similar sized seedlings were selected for transplanting. Seedlings were transplanted in the well-prepared puddle field on 26 July 2016 at the rate of three seedlings hill-1 maintaining row and hill distance of 25 cm and 15 cm, respectively. The crops were harvested at full maturity. Maturity of crops was determined when 90% of the grains became golden yellow in color. Then the harvested crops of each plot except 5 hills plot-1 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 1 m² 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.

2.6 Data collection at different growth stages

Weed data: Weed data were taken carefully.

Weed population: Data on weed population (30 days after transplanting age) were collected from each plot of the rice plants by using 0.25 m \times 0.25 m quadrate as per method described (Cruz et al., 1986). The weeds within the quadrate were counted and converted to number m⁻² multiplying by four

Weed dry weight: After counting the weed density, the weeds inside each quadrate were uprooting, cleaned, separated species-wise and dried first in the sun and then in an electric oven for 72 hours at a temperature of 80°c. The dry weight of each species was taken by an electric balance and expressed in gm⁻².

Percent inhibition: Percent inhibition of weed was calculated using the following formula:

2.7 Data collection of yield contributing characters

Data on grain and straw yields were collected from an area of l m^2 in the middle of each plot. The data on other crop characters were randomly sampled from the region outside 1 m^2 area (excluding the border hills) which was kept for taking data on grain and straw yields.

- i) Plant height (cm): Plant height was measured from the base of the ptant (ground level) to the tip of the longest panicle.
- ii) Number of total tillers hill-1: Tillers which had at least one visible leaf were counted including both panicle bearing and non-bearing tillers.
- **iii)** Number of effective tillers hill-1: The tiller which had at least one visible grain in the panicle was considered as effective tillers.
- iv) Number of non-effective tillers hill-1: The tillers without panicle were counted and considered as non-effective tillers.
- v) Length of panicle (cm): Measurement was taken from basal node of the rachis to the apex of last grains of each panicle.
- vi) Number of grains panicle-1: Presence of any food material in the spikelet was considered as grain and such spikelet present on each panicle was counted
- **vii)** Number of sterile spikelets panicle⁻¹: The spikelet that lacked any food material inside was considered as sterile spikelet and such spikelet present on each panicle was counted.
- viii) Weight of 1000 grains (g): One thousand clean dried grains were counted from the seed stock obtained from five sample hills of each plot and weighed by using an electric balance. The weight was adjusted at a seed moisture content of 14%.
- ix) Grain yield (t ha⁻¹): Grains obtained from each unit plot were sundried and weighed carefully. The dry weight of grains of central 1 m^2 areas were added to the respective unit plot yield to record the final grain yield plot⁻¹ and finally converted to t ha⁻¹.
- x) Straw yield (t ha⁻¹): Straw obtained from each unit plot including the straw of central 1 m² areas of respective unit plot was dried in the sun and weighed to record the straw yield plot⁻¹ and finally converted to t ha⁻¹.
- xi) Biological yield (t ha⁻¹): Grain yield together with straw yield was regarded as biological yield and calculated with the following formula: Biological yield = grain yield + straw yield
- xii) Harvest index (%): It indicates the ratio of economic yield (grain yield) to biological yield and was calculated by the following formula:

$$Harvest\ index\ (\%) = \frac{Grain\ yield}{Biological\ yield} \times 100$$

Statistical analysis:

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 (Gomez and Gomez, 1984).

3. RESULT AND DISCUSSION

3.1 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 3. The weeds of the experimental plots were *Monochoria vaginalis, Scirpus juncoides, Nymphaea nouchali, Echinochloa crusgalli,* and *Cyperus difformis*. A group researchers in the experiment at Bangladesh Agricultural University reported that the three important weeds of rice fields were *Echinochloa crusgalli, Cyperus difformis* and *Scirpus juncoides* (Bari et al., 1995).

	Table 3: 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	Chechra	Scirpus juncoides	Cyperaceae	Sedge	Annual	
3	Pani shapla	Nymphaea nouchali	Nymphaeaceae	Broad leaved	Annual	
4	Shama	Echinochloa crusgalli	Poaceae	Grass	Annual	
5	Sabuj nakphul	Cyperus difformis	Cyperaceae	Sedge	Annual	

3.2 Weed population, dry weight and percent inhibition

3.2.1 Monochoria vaginalis (Panikachu)

3.2.1.1 Effect of variety

Weed population, dry weight and percent inhibition of panikachu were significantly affected by variety (Table 4). The highest weed population (56.53) was found in (BRRI dhan34), and the lowest weed population (38.00) was obtained in BRRI dhan49. The highest weed dry weight (24.61 g) was found in BRRI dhan52 and the lowest weed dry weight (17.10 g) was in BRRI dhan49. Percent inhibition of weed was the highest (45.38 %) in BRRI dhan49 and the lowest one was observed in BRRI dhan34 (37.10 %).

Table 4: Effect of variety on weed population, dry weight and percent inhibition of panikachu (<i>Monochoria vaginalis</i>)			
	M	Ionochoria vaginali	s (at 30 DAT)
Variety	Weed population (no./m²)	Dry weight (g/m²)	% inhibition
V_1	56.53 a	24.61 a	37.10 с
V_2	38.00 с	17.10 с	45.38 a
V_3	45.87 b	20.25 b	38.41 b
LSD _{0.05}	1.57	1.22	1.25
Level of significance	**	**	**
CV (%)	4.51	7.96	4.18

In a column, figures with the same letters do not differ significantly as per DMRT. ** = Significant at 1% level of probability.

3.2.1.2 Effect of mustard crop residues

Weed population, dry weight and percent inhibition of panikachu were significantly affected by mustard crop residues. The highest weed population (76.44) was found in T_1 and the lowest (21.33) was found in T_4 treatment. The highest weed dry weight (34.47g) was found in T_1 (no crop residue) treatment and the lowest weed dry weight (9.25 g) was in T_4 (mustard crop residues at 3.0 t ha $^{-1}$ + one hand weeding) treatment (Table 5). Percent inhibition of weed was the highest (73.36 %) in T_4 treatment and the lowest one was observed in T_1 treatment.

Table 5: Effect of mustard crop residues on weed population, dry weight and percent inhibition of panikachu (*Monochoria vaginalis*)

Monochoria vaginalis (at 30 DAT)				
.	Weed	Weed Dry weight %		
Treatments	population (no./m²)	(g/m²)	inhibition	
T_1	76.44 a	34.47 a	00.00 e	
T ₂	58.67 b	26.13 b	24.42 d	
T ₃	43.78 c	19.00 c	45.40 c	
T_4	21.33 e	9.253 e	73.36 a	
T ₅	33.78 d	14.42 d	58.30 b	
LSD _{0.05}	2.03	1.58	1.62	
Level of Sig.	**	**	**	
CV (%)	4.51	7.96	4.18	

In a column, figures with the same letters do not differ significantly as per DMRT. ** = Significant at 1% level of probability.

3.2.2 Scirpus juncoides (Chechra)

3.2.2.1 Effect of variety

Weed population, dry weight and percent inhibition of *Scirpus juncoides* (Chechra) was significantly affected by variety. The highest weed population (69.33) was found in BRRI dhan34 and the lowest weed population (52.13) was found in BRRI dhan49 (Table 6). The highest weed dry weight (22.77 g) was found in BRRI dhan34 and the lowest weed dry weight (17.10 g) was in BRRI dhan49. Percent inhibition of weed was the highest (47.79 %) in BRRI dhan49 and the lowest one was observed in BRRI dhan34 (37.91 %).

Table 6: Effect of variety on weed population, dry weight and percent inhibition of chechra (*Scirpus juncoides*)

	Scirpus juncoides (at 30 DAT)		
Variety	Weed	Dry weight	%
	population	(g/m²)	inhibition
	(no./m²)		
V_1	69.33 a	22.77 a	37.91 c
V_2	52.13 c	17.10 c	47.79 a
V_3	60.80 b	20.82 b	42.72 b
LSD _{0.05}	2.42	1.19	1.08
Level of	**	**	**
significance			
CV (%)	5.34	7.85	3.40

In a column, figures with the same letters do not differ significantly as per DMRT. ** = Significant at 1% level of probability.

3.2.2.2 Effect of mustard crop residues

Weed population, dry weight and percent inhibition of chechra (Scirpus juncoides) were significantly affected by mustard crop residues. The highest weed population (103.1) was found in T_1 and the lowest (22.89) was found in T_4 (Table 7). The highest weed dry weight (35.27 g) was found in T_1 (no crop residues) treatment and the lowest weed dry weight (7.49 g) was in T_4 (mustard crop residues at 3.0 t ha-1 + one hand weeding) treatment (Table 6). Percent inhibition of weed was the highest (78.82 %) in T_4 treatment and the lowest one was observed in T_1 treatment (Table 7).

3.2.3 Nymphaea nouchali (Pani shapla)

3.2.3.1 Effect of variety

Weed population, dry weight and percent inhibition of *Nymphaea nouchali* (Pani shapla) was significantly affected by variety. The highest weed population (58.67) was found in BRRI dhan34 and the lowest weed population (45.80) was found in BRRI dhan49 (Table 8). The highest weed

dry weight (14.14 g) was found in BRRI dhan34 and the lowest weed dry weight (11.13 g) was in BRRI dhan49. Percent inhibition of weed was the highest (45.17 %) in BRRI dhan34 and the lowest one (38.64 %) was observed in BRRI dhan49 and BRRI dhan52.

Table 7: Effect of mustard crop residues on weed population, dry weight and percent inhibition of chechra (*Scirpus juncoides*)

weight ai	weight and percent inhibition of chechia (Sch pus juncolues)				
	Scirpus juncoides (at 30 DAT)				
Treatments	Weed population	Dry weight (g/m²)	% inhibition		
	(no./m²)	(8)	-		
T_1	103.1 a	35.27 a	00.00 e		
T_2	76.44 b	25.60 b	27.81 d		
T_3	58.67 c	19.95 c	43.72 c		
T_4	22.89 e	7.487 e	78.82 a		
T ₅	42.67 d	12.85 d	63.67 b		
LSD _{0.05}	3.13	1.53	1.40		
Level of	**	**	**		
significance					
CV (%)	5.34	7.85	3.40		

In a column, figures with the same letters do not differ significantly as per DMRT. ** = Significant at 1% level of probability.

Table 8: Effect of variety on weed population, dry weight and percent inhibition of pani shapla (*Nymphaea nouchali*)

	Nymphaea nouchali (at 30 DAT)		
Variety	Weed population (no./m²)	Dry weight (g/m²)	% inhibition
V_1	58.67 a	14.14 a	45.17 c
V_2	45.80 с	11.13 с	38.64 b
V_3	50.80 b	12.29 b	38.64 b
LSD _{0.05}	2.43	0.986	1.89
Level of	**	**	**
significance			
CV (%)	6.28	10.54	6.20

In a column, figures with the same letters do not differ significantly as per DMRT. ** =Significant at 1% level of probability.

3.2.3.2 Effect of mustard crop residues

Weed population, dry weight and percent inhibition of pani shapla (Nymphaea nouchali) were significantly affected by mustard crop residues. The highest weed population (83.56) was found in T_1 and the lowest (24.56) was found in T_4 (Table 9). The highest weed dry weight (21.33 g) was found in T_1 (no crop residues) treatment and the lowest weed dry weight (5.94 g) was in T_4 (mustard crop residues at 3.0 t ha $^{-1}$ + one hand weeding) treatment (Table 9). Percent inhibition of weed was the highest (71.90 %) in T_4 treatment and the lowest one was observed in T_1 treatment (Table 9).

Table 9: Effect of mustard crop residues on weed population, dry weight and percent inhibition of pani shapla (*Nymphaea nouchali*)

	Weight and percent immotion of pain shapia (Tymphaea nouchair)			
	Nymphaea nouchali (at 30 DAT)			
	Weed	Dry weight	%	
Treatments	population	(g/m^2)	inhibition	
	(no./m²)			
T_1	83.56 a	21.33 a	00.00 e	
T_1	60.33 b	14.66 b	30.09 d	
T_1	51.44 с	12.04 c	42.83 c	
T_1	24.56 e	5.94 e	71.90 a	
T_1	38.89 d	8.628 d	59.26 b	
LSD _{0.05}	3.14	1.27	2.44	
Level of	**	**	**	
significance				
CV (%)	6.28	10.54	6.20	

In a column, figures with the same letters do not differ significantly as per DMRT. ** = Significant at 1% level of probability.

3.2.4 Echinochloa crusgalli (Shama)

3.2.4.1 Effect of variety

Weed population, dry weight and percent inhibition of *Echinochloa crusgalli* (Shama) was significantly affected by variety. The highest weed population (61.87) was found in BRRI dhan34 and the lowest weed population (49.53) was found in BRRI dhan49 (Table 10). The highest weed dry weight (95.17 g) was found in BRRI dhan34 and the lowest weed

dry weight (71.28 g) was in BRRI dhan49. Percent inhibition of weed was the highest (48.05 %) in BRRI dhan49 and the lowest one (42.66 %) was observed in BRRI dhan34.

Table 10: Effect of variety on weed population, dry weight and percent inhibition of shama (Echinochloa crusgalli) Echinochloa crusgalli (at 30 DAT) Variety Weed Dry weight 0/6 population (g/m^2) inhibition (no./m²) V_1 61.87 a 95.17 a 45.17 c V_1 49.53 b 71.28 c 38.64 b $V_{1} \\$ 51.20 b 80.40 b 38.64 b $LSD_{0.05}$ 2.42 4.73 1.33 Level of significance

In a column, figures with the same letters do not differ significantly as per DMRT. ** =Significant at 1% level of probability.

7.69

3.93

3.2.4.2 Effect of mustard crop residues

5.97

CV (%)

Weed population, dry weight and percent inhibition of shama (*Echinochloa crusgalli*) were significantly affected by mustard crop residues. The highest weed population (95.67) was found in T_1 and the lowest (22.89) was found in T_4 (Table 11). The highest weed dry weight (149.3 g) was found in T_1 (no crop residues) treatment and the lowest weed dry weight (34.74 g) was in T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding) treatment (Table 11). Percent inhibition of weed was the highest (76.83 %) in T_4 treatment and the lowest one was observed in T_1 treatment (Table 11).

Table 11. Effect of mustard crop residues on weed population, dry

weight and percent inhibition of shama (Echinochloa crusgalli)				
	E	Echinochloa crusgalli (at 30 DAT)		
	Weed	Dry weight	%	
Treatments	population	(g/m²)	inhibition	
	(no./m²)			
T_1	95.67 a	149.3 a	00.00 e	
T_2	70.89 b	105.4 b	29.45 d	
T_3	46.42 c	69.30 c	54.13 c	
T_4	22.89 e	34.74 e	76.83 a	
T ₅	35.33 d	52.66 d	64.95 b	
LSD _{0.05}	3.12	6.11	1.71	
Level of	**	**	**	
significance				
CV (%)	5.97	7.69	3.93	

In a column, figures with the same letters do not differ significantly as per DMRT.

3.2.5 Cyperus difformis (Sabuj nakful)

3.2.5.1 Effect of variety

Weed population, dry weight and percent inhibition of *Cyperus difformis* (Sabuj nakful) was significantly affected by variety. The highest weed population (87.47) was found in BRRI dhan34 and the lowest weed population (68.0) was found in BRRI dhan49 (Table 12). The highest weed dry weight (41.68 g) was found in BRRI dhan34 and the lowest weed dry weight (20.79 g) was in BRRI dhan49. Percent inhibition of weed was the highest (57.54 %) in BRRI dhan49 and the lowest one (51.65 %) was observed in BRRI dhan52.

Table 12: Effect of variety on weed population, dry weight and percent inhibition of sabuj nakful (*Cyperus difformis*)

	Cyperus difformis (at 30 DAT)						
Variety	Weed population (no./m²)	Dry weight (g/m²)	% inhibition				
V_1	87.47 a	41.68 a	53.47 b				
V_1	68.00 c	20.79 c	57.54 a				
V_1	76.80 b	27.92 b	51.65 b				
LSD _{0.05}	4.05	1.86	2.26				
Level of Sig.	**	**	**				
CV (%)	6.99	8.27	5.58				

In a column, figures with the same letters do not differ significantly as per DMRT. ** = Significant at 1% level of probability.

3.2.5.2 Effect of mustard crop residues

Weed population, dry weight and percent inhibition of sabuj nakful (*Cyperus difformis*) were significantly affected by mustard crop residues. The highest weed population (168.4) was found in T_1 and the lowest (32.0) was found in T_4 (Table 13). The highest weed dry weight (65.39 g) was found in T_1 (no crop residues) treatment and the lowest weed dry weight (12.21 g) was in T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding) treatment (Table 13). Percent inhibition of weed was the highest (81.53 %) in T_4 treatment and the lowest one was observed in T_1 treatment (Table 13).

 Table 13: Effect of mustard crop residues on weed population, dry
weight and percent inhibition of sabuj nakful (Cyperus difformis) Cyperus difformis (at 30 DAT) Weed Dry weight **Treatments** population (g/m^2) inhibition (no./m²)168.4 a 65.39 a 00.00 e T_2 81.78 b 32.48 b 50.77 d T_3 80.44 c 23.82 c 63.82 c T_4 32.00 e 12.21 e 81.53 a T_5 44.44 d 74.97 b 16.76 d $LSD_{0.05}$ 5.22 2.40 2.92 Level of Sig. ** 6.99 8.27 CV (%) 5.58

In a column, figures with the same letters do not differ significantly as per DMRT. ** = Significant at 1% level of probability.

3.3 Yield and yield contributing characters at harvest

3.3.1 Plant height

3.3.1.1 Effect of variety

The plant height varied significantly among the varieties. The tallest plant (146.6 cm) was observed in BRRI dhan34 and the shortest plant (102.7) was observed in BRRI dhan49 (Table 14). Plant height is a varietal character and it is the genetic constituent of the cultivar, therefore, plant height was different among the three varieties. The results are consistent with the findings of Bisne *et al.* (2006) who observed plant height differed significantly among the varieties.

3.3.1.2 Effect of mustard crop residues

Plant height was not significantly affected by mustard crop residues. The tallest plant (123.9 cm) was found in T4 (mustard crop residues at 3.0 t ha¹+ one hand weeding) treatment and the shortest plant (120.7 cm) was found in T1 (no crop residue) treatment (Table 15). The results revealed that application of mustard crop residues at 3.0 t ha¹+ one hand weeding produced the highest plant height. This might be due to the availability of more nutrients from a weed free environment. Similar findings was found by Hasan (2015), who reported that the highest plant height was produced due to weed free condition and the lowest plant height was in no weeding condition.

3.3.2 Number of total tillers hill-1

3.3.2.1 Effect of variety

Number of total tillers hill- 1 was significantly influenced by variety. The highest number of total tillers hill- 1 (14.19) was found in BRRI dhan49 and the lowest number of total tillers hill- 1 (10.84) was found in BRRI dhan34 (Table 14).

3.3.2.2 Effect of mustard crop residues

Number of total tillers hill-1 was significantly influenced by mustard crop residues. The highest number of total tillers hill-1 (13.76) was produced by T_4 (mustard crop residues at 3.0 t ha-1 + one hand weeding) treatment followed by T_5 (3 times hand weeding) treatment. The lowest number of total tillers hill-1 (11.91) was produced by T_1 (no crop residue) treatment (Table 15).

3.3.3 Number of effective tillers hill-1

3.3.3.1 Effect of variety

Number of effective tillers hill-1 was significantly influenced by variety.

^{** =} Significant at 1% level of probability.

The highest number of effective tillers hill- 1 (12.80) was found in BRRI dhan49 and the lowest number of effective tillers hill- 1 (9.11) was found in BRRI dhan34 (Table 14).

3.3.3.2 Effect of mustard crop residues

Number of effective tillers hill- 1 was significantly influenced by mustard crop residues. The highest number of effective tillers hill- 1 (13.02) was produced by T_4 (mustard crop residues at 3.0 t ha- 1 + one hand weeding) treatment followed by T_5 (3 times hand weeding) treatment. The lowest number of effective tillers hill- 1 (9.42) was produced by T_1 (no crop residue) treatment (Table 15).

3.3.4 Number of non-effective tillers hill-1

3.3.4.1 Effect of variety

Number of non-effective tillers hill⁻¹ was significantly influenced by variety. The highest number of non-effective tillers hill⁻¹ (1.73) was found in BRRI dhan34 and the lowest number of effective tillers hill⁻¹ (1.38) was found in BRRI dhan49 (Table 14).

3.3.4.2 Effect of mustard crop residues

Number of non-effective tillers hill⁻¹ was significantly influenced by mustard crop residues. The highest number of non-effective tillers hill⁻¹ (2.49) was produced by T_1 (no crop residue) treatment. The lowest number of non-effective tillers hill⁻¹ (0.73) was produced by T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding) treatment (Table 15).

3.3.5 Length of panicle

3.3.5.1 Effect of variety

Panicle length was not significant by different varieties (Table 14). Numerically, the longest panicle length (23.47 cm) was recorded in variety BRRI dhan49 and the shortest panicle (23.21 cm) was recorded in BRRI dhan34.

3.3.5.2 Effect of mustard crop residues

Panicle length was significantly influenced by mustard crop residues (Table 15). The longest panicle (23.70 cm) was observed in T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding) treatment followed by (23.52 cm) T_5 (3 times hand weeding) treatment and the shortest one (22.93 cm) was observed in T_1 (no crop residue) treatment.

3.3.6 Number of grains panicle-1

3.3.6.1 Effect of variety

Number of grains panicle⁻¹ was significantly influenced by different varieties (Table 14). The highest number of grains panicle⁻¹ (150.7) was observed in BRRI dhan49 and the lowest one (132.0) was found in BRRI dhan34. A group researcher reported variable number of grains among the varieties (Singh et al., 1996). Varietal differences regarding the number of grains might be due to differences in genetic constituents.

3.3.6.2 Effect of mustard crop residues

Number of grains panicle⁻¹ was significantly influenced by mustard crop residues (Table 15). The highest number of grains panicle⁻¹ (149.7) was produced by T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding)) treatment followed by T_5 (3 times hand weeding) treatment while the lowest number of grains panicle⁻¹ (128.4) was found T_1 (no crop residue) treatment. It indicated that weed free condition encouraged the number of grains panicle⁻¹ and negative effect of weeds on plant growth resulted in decreased number of grains panicle⁻¹. De Datta observed that effective weed management increased number of grains due to more availability of water, nutrients and light (De Datta, 1990; Singh et al., 1999).

3.3.7 Number of sterile spikelets panicle-1

3.3.7.1 Effect of variety

Number of sterile spikelets panicle⁻¹ was significantly influenced by different varieties (Table 14). The highest number of sterile spikelets panicle⁻¹ (22.83) was observed in BRRI dhan34 and the lowest one (20.59) was found in BRRI dhan49.

3.3.7.2 Effect of mustard crop residues

Number of sterile spikelets panicle⁻¹ was significantly influenced by mustard crop residues (Table 15). The highest number of sterile spikelets panicle⁻¹ (30.38) was produced by T_1 (no crop residue) treatment followed by T_2 (mustard crop residues at 3.0 t ha⁻¹) treatment while the lowest number of sterile spikelets panicle⁻¹ (18.53) was found T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding) treatment.

3.3.8 1000-grain weight

3.3.8.1 Effect of variety

Weight of 1000-grain was significantly affected by different varieties of rice. The highest thousand grain weight (24.14 g) was found in BRRI dhan49 and the lowest one (11.17 g) was found in BRRI dhan34 (Table 14).

3.3.8.2 Effect of mustard crop residues

Mustard crop residues were significantly affected the weight of 1000-grains. The highest 1000-grain weight (20.17 g) was recorded in T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding) treatment followed by T_5 (3 times hand weeding) and the lowest 1000-grain weight (19.18 g) was observed in T_1 (no crop residue) treatment (Table 15).

3.3.9 Grain yield

3.3.9.1 Effect of variety

The studied variety differed significantly in respect of grain yield. The highest grain yield (4.82 t ha⁻¹) was obtained in BRRI dhan49 (Figure 1). The increased yield might be due to the lowest number of sterile spikelet panicle⁻¹. The lowest grain yield (2.85 t ha⁻¹) was obtained in BRRI dhan34. This difference was observed due to different varietal characteristics of rice plant. BRRI also reported variation in grain yield among the varieties (BRRI, 2005).

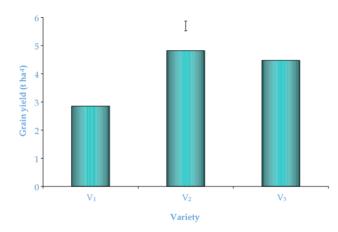


Figure 1: Grain yield as influenced by variety (Bar represents standard error mean)

3.3.9.2 Effect of mustard crop residues

Grain yield was significantly influenced by mustard crop residues. The highest grain yield $(4.50 \, t \, ha^{-1})$ was produced by T_4 (mustard crop residues at $3.0 \, t \, ha^{-1}$ + one hand weeding) treatment and the lowest grain yield $(3.12 \, t \, ha^{-1})$ was produced by T_1 (no crop residue) treatment (Figure 2).

Incorporation of mustard crop residues at 3.0 t ha $^{\text{-}1}$ + one hand weeding decrease weed emergence in the rice field and produced maximum grain yield also.

It might be due to application of crop residues added organic matter to the soil and enhance grain yield. On the other hand, control plot (no crop residue) showed maximum weed population and 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 also reported the similar results, where crop residues influenced the crop performance (Uddin and Pyon, 2010).

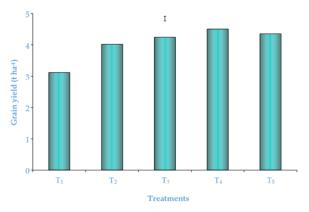


Figure 2: Grain yield as influenced by mustard crop residues (Bar represents standard error mean)

3.3.10 Straw yield

3.3.10.1 Effect of variety

Straw yield was significantly influenced by three varieties. The highest straw yield (5.74 t ha $^{-1}$) was found in BRRI dhan49 and the lowest straw yield (4.13 t ha $^{-1}$) was found in BRRI dhan34 (Figure 3). These results are in conformity with that obtained by who reported the differences in straw yield among the varieties (Chowdhury et al., 2003).

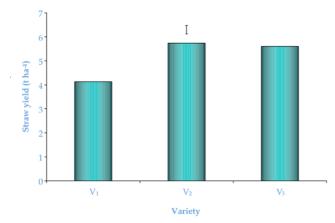


Figure 3: Straw yield as influenced by variety (Bar represents standard error mean)

3.3.10.2 Effect of mustard crop residues

Straw yield was significantly influenced by mustard crop residues. The highest straw yield (5.46 t ha^{-1}) was observed in T_4 (mustard crop residues at 3.0 t ha^{-1} + one hand weeding) treatment, and the lowest straw yield (4.81 t ha^{-1}) was observed in T_1 (no crop residue) treatment (Figure 4).

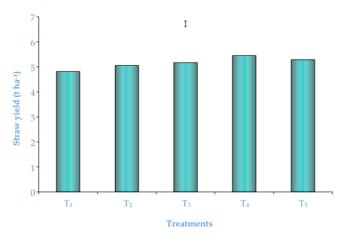


Figure 4: Straw yield as influenced by mustard crop residues (Bar represents standard error mean)

3.3.11 Biological yield

3.3.11.1 Effect of variety

Biological yield was significantly affected by variety (Table 14). The highest biological yield (10.56 t ha^{-1}) was found in BRRI dhan49 and the lowest biological yield (6.98 t ha^{-1}) was found in BRRI dhan34 variety.

3.3.11.2 Effect of mustard crop residues

Mustard crop residues had significant influence on biological yield (Table 15). The highest biological yield (9.96 t ha-1) was obtained in T_4 (mustard crop residues at 3.0 t ha-1 + one hand weeding) treatment and the lowest biological yield (7.93 t ha-1) was obtained in T_1 (no crop residue) treatment. Variations in biological yield among the weed control treatment were dependent upon the severity of weed infestation and climatic condition. Higher weed infestation not only reduced grain yield and finally influenced straw yield as well as biological yield.

3.3.12 Harvest index (%)

3.3.12.1 Effect of variety

Harvest index was significantly affected by variety (Table 14). The highest harvest index (45.48 %) was found in BRRI dhan49 rice variety followed by (44.31 %) in BRRI dhan52 and the lowest harvest index (40.58 %) was found in BRRI dhan34.

3.3.12.2 Effect of mustard crop residues

Harvest index was significantly influenced by mustard crop residues (Table 15). The highest harvest index (44.94 %) was observed in T_4 (mustard crop residues at 3.0 t ha⁻¹ + one hand weeding) treatment, and the lowest harvest index (38.70 %) was observed in T_1 (no crop residue) treatment.

Table 14: Effect of variety on yield and yield contributing characters of T. aman rice										
Variety	Plant height (cm)	No. of total tillers hill-1	No. of effective tillers hill-	No. of non- effective tillers hill-1	Panicle length (cm)	Grains panicle-1	Sterile spikelets panicle-1	1000 grain weight (g)	Biological yield (t ha ⁻¹)	Harvest index (%)
V_1	146.6a	10.84b	9.107 с	1.733 a	23.21	132.0 с	22.83 a	11.17 b	6.982 c	40.58 c
V ₂	102.7c	14.19 a	12.80 a	1.387 с	23.47	150.7 a	20.59 с	24.14 a	10.56 a	45.48 a
V ₃	118.6b	13.91 a	12.36 b	1.547 b	23.31	141.3 b	21.25 b	23.67 a	10.08 b	44.31 b
LSD _{0.05}	3.84	0.312	0.329	0.138	0.397	3.98	0.503	0.608	0.394	1.05
Level of significance	**	**	**	**	NS	**	**	**	**	**
CV (%)	4.19	3.22	3.86	11.89	2.28	3.76	3.12	4.14	5.72	3.23

^{** =} Significant at 1% level of probability. NS = Not Significant.

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per DMRT. V_1 = BRRI dhan34, V_2 = BRRI dhan49, V_3 = BRRI dhan52

In a column, figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as

per DMRT. ** = Significant at 1% level of probability. * = Significant at 5% level of probability. NS = Not Significant. T_1 = No crop residues, T_2 = Mustard crop residues at 3.0 t ha⁻¹ + one hand weeding, T_4 = Mustard crop residues at 3.0 t ha⁻¹ + one hand weeding, T_5 = 3 times Hand weeding.

Table 15: Effect of mustard crop residues on yield and yield contributing characters of T.aman rice										
Treatments	Plant height (cm)	No. of total tillers hill ⁻¹	No. of effective tillers hill-1	No. of non- effective tillers hill-1	Panicle length (cm)	Grains panicle ⁻¹	Sterile spikelets panicle-1	1000 grain weight (g)	Biological yield (t ha ⁻¹)	Harvest index (%)
T ₁	120.7	11.91d	9.42 e	2.489 a	22.93 b	128.4 d	30.38 a	19.18b	7.934 d	38.70 b
T_2	122.6	12.73 с	10.71 d	2.022 b	23.22ab	138.8 с	20.24 b	19.53ab	9.083 c	43.98 a
T ₃	122.7	13.04bc	11.53 с	1.511 c	23.27 ab	143.0bc	19.71 b	19.57 ab	9.421 bc	44.81 a
T_4	123.9	13.76a	13.02 a	0.733 e	23.70 a	149.7a	18.53 c	20.17 a	9.961 a	44.94 a
T ₅	123.3	13.44ab	12.42b	1.022 d	23.52 a	146.8ab	18.91 c	19.86ab	9.648 ab	44.87 a
LSD _{0.05}	4.96	0.402	0.425	0.178	0.513	5.13	0.649	0.786	0.509	1.35
Level of significance	NS	**	**	**	*	**	**	**	**	**
CV (%)	4.19	3.22	3.86	11.89	2.28	3.76	3.12	4.14	5.72	3.23

4. CONCLUSION

Five weed species belonging to four families were severely infested in the experimental field. The weeds of the experimental plots were Monochoria vaginalis, Scirpus juncoides, Nymphaea nouchali, Echinochloa crusgalli, and Cyperus difformis. Weed population, weed dry weight, percent inhibition was significantly affected by variety and different crop residues. The highest weed population and dry weight for all weed species were found in no crop residue treatment. The percent inhibition of all weed species were highest when mustard crop residues at 3.0 t ha-1 + one hand weeding was incorporated. Variety had significant effect on yield and yield contributing characters like number of total tillers hill-1, number of noneffective tillers hill-1, number of grains panicle-1, weight of thousand seed. The highest grain yield was found in BRRI dhan49. On the other hand, BRRI dhan34 produced the lowest grain yield due to the higher number of non-effective tillers hill-1. Crop residues had also significant effect on yield and yield contributing characters. The highest grain yield was found in T4 treatment due to the production of higher number of effective tillers hill-1, higher number of grain panicle-1 and lower number of sterile spikelets panicle-1. The lowest grain yield was produced in T1 treatment due to lower number of effective tillers hill-1, lower number of grain panicle-1 and higher number of sterile spikelets panicle-1. Yield and yield contributing characters like thousand grain weight, grain yield and straw yield were significantly affected by the interaction between variety and crop residues. BRRI dhan49 under T₄ treatment condition produced the highest grain and straw yield followed by the same variety. The lowest grain yield resulted from BRRI dhan34 variety under T1 treatment.

The study revealed that the variety BRRI dhan49 and T_4 (mustard crop residues at 3.0 t har¹ + one hand weeding) treatment exhibited the best effect followed by BRRI dhan52 and T_4 treatment for most of the studied traits. Thus, the mustard crop residues showed herbicidal activity for suppressing weed growth. Therefore, mustard crop residues could be a potential source of weed management tool for sustainable crop production.

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