Project ID 369

Competitive Research Grant

Sub-Project Completion Report

on

Development of sustainable biological weed management techniques through allelochemicals from crop residues

Project Duration

May 2017 to September 2018

Department of Agronomy
Bangladesh Agricultural University
Mymensingh-2202

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acronyms

BAU	Bangladesh Agricultural University
DAT	Days After Transplanting
CV	Co-efficient of Variation
P-level	Probability level
/	Per
w/v	weight by volume

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Executive Summary

Recent agriculture in Bangladesh is productivity-oriented and relies principally on synthetic inputs to tackle weeds and other pest problems. Exhaustive herbicide apply to control weeds over the last few decades is posing severe ecological and environmental threats to the globe and its inhabitants. Herbicide residues in crop produce, soil and ground water, shifts in weed populations, evolution of resistant weed biotypes, and associated health hazards have diverted the attention of researchers to discover and launch alternative weed management strategies. There is an increasing force for using organically produced pesticide worldwide.

Crop residues are defined as crop or its parts left in field for decomposition after it has been harvested. Crop residues can interfere with weed development and growth through alteration of soil physical, chemical, and biological characteristics. The presence of crop residues on the soil surface as mulch suppresses weeds through allelopathic effect and thus reduces a greater reliance on herbicides. Research on crop residues for weed suppression is very limited. In the present study, phytotoxic crop residues has been screened out for allelochemicals. Bioassays test of crop residues for both of weeds and crops has been done in the laboratory. Moreover, field experiments using boro rice and wheat as test crops was done to determine optimum dose and time of application of crop residues according to the plan.Finally aqueous extract of crop residues has been applied in the field to control weed and crop performance were studied. Observation was made to study the growth of selected weeds under the treatments (different crop residues) and growth and yield of rice and wheat. Aaqueous extract of sorghum in the laboratory with 100 % concentration mostly inhibited the germination and suppressed the growth of selected weed species. Highest grain yield of boro rice (4.53 t ha^{-1}) was observed in sorghum residues application when applied before transplanting while the lowest grain yield (1.02 t ha^{-1}) was observed in applied crop residues at one week after transplanting and no crop residues application. The production of wheat responded similarly as of boro rice when treated with sorghum crop residue, highest yield (3.97 t/ha) observed from hand weeding followed by 3.88 t/ha by aqueous residue of sorghum @ 1:20 ration (w/v) and this due to the production of higher number of effective tillers $hill^{-1}$, higher number of grain $spike^{-1}$, higher number of filled grain $spike^{-1}$.Aqueous extract of sorghum crop residues had also significant effect on yield and yield contributing characters.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: Development of sustainable biological weed management techniques through allelochemicals from crop residues

2. Implementing organization: Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202.

3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

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4. Sub-project budget (Tk):

a. Total: 15,99,850.00 Tk
b. Revised (if any):

5. Duration of the sub-project: May-2017 to September-2018

a. Start date (based on LoA signed): 08 May, 2017
b. End date: 30 September 2018

6. Justification of undertaking the sub-project:

Recent agriculture is productivity-oriented and relies principally on artificial inputs to tackle weeds and other pest problems. Exhaustive herbicide apply to control weeds over the last few decades is posing severe ecological and environmental threats to the globe and its inhabitants. Herbicide residues in produce, soil and ground water, shifts in weed populations, evolution of resistant weed biotypes, and associated health hazards have diverted the attention of researchers to discover and launch alternative weed management strategies. There is an increasing force for organically produced products worldwide. Allelopathy, a vital natural phenomenon that clarifies interference among species through biochemical pathways is a tool that can be manipulated to control weeds in agro ecosystems (Khanh *et al*., 2005). Use of allelopathic properties of native plant/crop species proposes promising opportunities for this purpose. Allelopathy can adjust plant biodiversity through its impact on plant adaptation, survival, and community organization.

Crop residues are defined as crop or its parts left in field for decomposition after it has been thrashed or harvested (Kumar and Goh, 2000). Earlier these were regarded merely as waste, but now because of their usefulness they are considered as chief resource that can bring significant physical, chemical, and biological changes in the agricultural soil after amendment. Crop allelopathy controls weeds by the release of allelo-chemicals from intact roots of living plants and/or through decomposition of phytotoxic plant residues (Belz, 2004; Khanh et al. 2005; Qasem and Hill,1989; Weston 1996). 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 (*Hordeum vulgare*), sorghum (*Sorghum bicolor* L.) and wheat (Belz, 2004). Crop residues can interfere with weed development and growth through alteration of soil physical, chemical, and biological characteristics. In the case of crop residues, there are two possible sources of allelo-chemicals; the compounds can be released directly from crop litter or they can be produced by microorganisms that use plant residues as a substrate (Kruidhof, 2008). The presence of crop residues on the soil surface as mulch suppresses weeds through allelopathy and thus reduces a greater reliance on herbicides (White *et al.,* 1989; Worsham, 1991; Batish *et al.,* 2001). However, additional management practices are required (Yenish *et al.,* 1996). Some residues are also known to enhance the efficiency of herbicides (Teasdale *et al.,* 1991); however, much depends on crop residues, its placement, environmental conditions, and cropping patterns.

Because of environmental and human health distress, worldwide efforts are being made to reduce the heavy reliance on synthetic herbicides that are used to control weeds. The phenomenon of allelopathy, which is expressed through the release of chemicals by plant or crop residues, has been suggested to be one of the probable alternatives for achieving sustainable weed management. Research regarding crop residues for weed suppression is very limited and or new in Bangladesh. Therefore, the aim of our work is to develop effective weed management technique that can help in the field of sustainable weed management.

7. **Sub-project goal:** Development of environmental friendly weed management technique for sustainable weed management along with organic matter enrichment in soil

8. Sub-project objective (s):

a) To select out potential crop residues for allelochemicals

b) To explore the possibility of using allelo-chemicals properties of crop residues for weed suppression
c) To find out the optimum dose and time of application of selected crop residues for weed suppression and crop performance
d) To study the effect of aqueous extract of crop residues on weed management and crop performance

9. Implementing location (s):

[a] Net house, Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202.

[b] Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh-2202.

10. Methodology in brief:

a) Growing of Crops for Crop Residue

Barley, sorghum, wheat, lentil, mustard, soybean, rice, maize and grasspea, acacia, pea and marsh pepper crop residues were used in this study. The crops were grown at the Agronomy Field Laboratory, Bangladesh Agricultural University and were harvested at the time of ripening stage to collect crop residues.

b) Preparation and extraction of samples

After collection, the crop residues were dried under shade in the cover threshing floor of Agronomy Field Laboratory of BAU. The well dried crop residues were brought to the laboratory and chaffed with fodder cutter (2~3 cm pieces). Chaffed crop residues were soaked in water in the ratio of 1:10 (w/v) for 24 hours at ambient room temperature. After 24 hours of soaking the water extract was filtered using a coarse mesh to remove the plant residue. The filtered extract was considered as 100% concentration and then they were diluted into 75% and 50% for all the crop residues.

Experiment 1: Bioassay of extract of different crop residues in the laboratory

The herbicidal activity of 12 different crop residues was tested on weed species of *Echinochloa crus-galli* (shama) in Petri dishes. Ten seeds of *Echinochloa crus-galli* were allowed to germinate in sterile Petri dishes (100×40 mm) on the surface of sterile Whatman #1 filter paper at concentrations of 0, 100%, 75% and 50% concentrated crop residues extracts for 2 weeks. A 10-ml solution of each concentration was added to individual Petri dishes. Afterwards, for a 2 weeks period, the Petri dishes were placed in the laboratory under room temperature. Each treatment was replicated 3 times. Efficacy of different crop residues was measured based on germination of weed seed, shoot and root length of weeds and shoot and root dry weight of weeds. Percent inhibition was measured by comparing the data with control (without crop residue).

Experiment 2: Effect of time of application of selected crop residues on weed suppression and yield of Rice

The experiment was conducted in Rabi seasons at Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during the period from December 2017 to May 2018. The variety BRRI dhan29 was used as test crop. The experimental treatment consists of time of crop residues application viz. applied crop residues before transplanting (T_1), applied crop residues one week after transplanting (T_2), applied crop residues two week after transplanting (T_3) and Crop residues viz. control (no weeding) (C_1), sorghum @ 2.0 t ha^{-1} (C_2), maize @ 2.0 t ha^{-1}(C_3), mustard @ 2.0 t ha^{-1} (C_4), rice @ 2.0 t ha^{-1} (C_5). The experiment was laid out in a split- plot design assigning time of crop residues application in main plot and different crop residues in split plot with three replications. Each plot size was 2m × 2m. The spacing between plots to plot was 0.5 m. The distance between blocks was maintained 1m. Land preparation for rice cultivation was done by 3-4 times plowing and cross-plowing followed by laddering. Fertilizers and Manure were applied at the following doses: Urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate @ 240, 100, 120, 110, 10 kg ha^{-1}, respectively. The entire amounts of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at the time of final land preparation. Urea was applied in three installments at 15, 30 and 45 days after transplanting (DAT). Transplanting was done in 18 January @ three seedlings per hill with 25 cm × 15 cm row and hill spacing. The crops were harvested on 6 May, 2018 at full maturity. Then the harvested crops of each plot was bundled separately, properly tagged and brought to threshing floor. The crops were then threshed and the fresh weights of grain and straw were recorded from an area of l m^2 in the middle of each plot. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw $plot^{-1}$ were recorded and converted to t ha^{-1}.Data were statistically analyzed using the Analysis of Variance technique with the help of statistical computer package MSTAT. The mean differences were adjudged by Duncan's Multiple Range Test (*Gomez and Gomez* 1984).

c) Experiment 3: Effect of aqueous extract of sorghum and mustard crop residues on wheat

Two experiment were carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh located at $24^0$75' N latitude and 90^o50' E longitude at an elevation of 18 m above the mean sea level characterized by non-calcareous dark grey floodplain soil belonging to the Old Brahmaputra Floodplain, (AEZ-9). The soil of the experimental field was more or less neutral in reaction with pH value 6.8, low in organic matter and fertility level. The land type was medium high with silty loam in texture. The experiment consists of two factors including crop residues (5) i) No use of extract (control), ii) Aqueous extract of sorghum crop residues @ 1:20 ratio (w/v), iii) Aqueous extract of sorghum crop residues @ 1:30 ratio (w/v), iv) Aqueous extract of sorghum crop residues @ 1:40 ratio (w/v) and v)Hand weeding and variety (3): i) BARI Gom19 (Sourav) ii) BARI Gom21 (Shatabdi) iii) BARI Gom24 (Prodip).The same variety were used for another experiment with i) No use of extract (control), ii) Aqueous extract of mustard crop residues @ 1:20 ratio (w/v), iii) Aqueous extract of mustard crop residues @ 1:30 ratio (w/v), iv) Aqueous extract of mustard crop residues @ 1:40 ratio (w/v) and v)Hand weeding. The experiments were laid out in a randomized complete block design with three replications. Thus total numbers of plots were 45. Each plot size was (2 m × 2.5 m). The distance maintained between the individual plots was 0.5 m and the distance between the replication was 1.0 m.

After collection, the crop residues were dried under shade in the covered threshing floor of Agronomy Field Laboratory of BAU. The studied crop residues were cut as small as possible by using sickle. The small pieces of sorghum crop residues were dipped into water for 24 hours and then collected the aqueous extract from residues. The prepared sorghum aqueous extract was applied two times (20 days and 40 days) after seed sowing by a hand sprayer. Data were collected on the basis of different parameters of wheat and weeds. Among them percent inhibition shows the suppressing ability of aqueous extract of sorghum residues on weed.

$$\text{Inhibition (\%)} = \frac{\text{Dry weight of weed at control - Dry weight of weed from treatment}}{\text{Dry weight of weed at control}} \times 100$$

Data were also collected from wheat on yield basis such as grain yield, straw yield, harvest index etc which showed the yield performance of wheat. The recorded data were compiled and tabulated for statistical analysis. 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.

11.Results and Discussion

Experiment I

a) Effect of leaf extract on seed germination, soot and root length of shama weed

The germination, shoot length and root length were significantly influenced by crop residues and their concentration (Table 1). The highest germination (85.00%) was obtained from pea leaf extract whereas lowest (74.17%) was in sorghum leaf extract. This indicates that sorghum leaf extract inhibit germination mostly. Aqueous leaf extracts of weeds were highly phytotoxic to shama seed. All the applied concentrations of leaf extract significantly suppressed the germination of shama weed (Table 2). The inhibition of germination was highest in 100 % aqueous extract. Similar trend was obtained in case of shoot and root length. In case of interaction, aqueous extract of sorghum with 100 % concentration inhibit the germination most compared to other treatments.

Table 1. Effect of crop residues on percent germination, shoot length and root length of shama seed

Cultivars	Germination (%)	Shoot length (cm)	Root length (cm)
C_1	75.83 de	3.533 e	1.242 f
C_2	80.00 bc	4.335 bc	2.200 b
C_3	85.00 a	4.777 a	1.908 c
C_4	77.50 cde	4.310 bc	1.983 c
C_5	81.67 b	4.093 d	1.958 c
C_6	80.00 bc	3.493 e	1.533 e
C_7	74.17 e	3.377 e	1.508 e
C_8	81.67 b	4.443 bc	2.000 c
C_9	77.50 cde	4.427 bc	1.800 d
C_{10}	78.33 bcd	4.277 c	2.242 b
C_{11}	80.00 bc	4.485 b	2.358 a
C_{12}	80.83 bc	4.435 bc	2.158 b
Sx	1.10	0.059	0.037
Significance	**	**	**
CV (%)	4.81	4.93	6.64

C_1 = Crop residues of Grasspea, C_2 = Crop residues of Mustard, C_3 = Crop residues of Pea, C_4 = Crop residues of Barley, C_5 = Crop residues of Sunflower, C_6 = Crop residues of Lentil, C_7 = Crop residues of Sorghum, C_8 = Crop residues of Wheat, C_9 = Crop residues of Soybean, C_{10} = Crop residues of Marsh pepper, C_{11} = Crop residues of Acacia, C_{12} = Crop residues of Rice

Table 2. Effect of concentration on percent germination, shoot length and root length of shama seed

Conc.	Germination (%)	Shoot length (cm)	Root length (cm)
Control	96.67 a	5.440 a	2.967 a
100%	66.67 d	3.138 d	1.292 d
75%	74.44 c	3.681 c	1.497 c
50%	79.72 b	4.403 b	1.875 b
Sx	0.636	0.034	0.021
Significance	**	**	**
CV (%)	4.81	4.93	6.64

Table 3. Combined effect of crop residues and concentration on percent germination, shoot length and root length of shama seed

Cult.	Conc.	Germination (%)	Shoot length (cm)	Root length (cm)
C_1	Control	96.67 a	5.440 a	2.967 a
	100%	60.00 gh	2.150 qr	0.3333 r
	75%	70.00 def	2.373 q	0.5667 q
	50%	76.67 bcd	4.167 fghij	1.100 lmno
C_2	Control	96.67 a	5.440 a	2.967 a
	100%	66.67 efg	3.300 no	1.833 fgh
	75%	76.67 bcd	4.133 ghij	1.900 efg
	50%	80.00 bc	4.467 cdefg	2.100 de
C_3	Control	96.67 a	5.440 a	2.967 a
	100%	76.67 bcd	3.967 hijk	1.333 jk
	75%	83.33 b	4.833 bc	1.567 ij
	50%	83.33 b	4.867 b	1.767 ghi
C_4	Control	96.67 a	5.440 a	2.967 a
	100%	66.67 efg	3.567 lmn	1.367 jk
	75%	70.00 def	3.967 hijk	1.567 ij
	50%	76.67 bcd	4.267 efgh	2.033 def
C_5	Control	96.67 a	5.440 a	2.967 a
	100%	73.33 cde	2.900 p	1.333 jk
	75%	76.67 bcd	3.700 klm	1.533 ij
	50%	80.00 bc	4.333 defgh	2.000 defg
C_6	Control	96.67 a	5.440 a	2.967 a
	100%	66.67 efg	2.033 qr	0.9333 op
	75%	76.67 bcd	2.367 q	1.000 nop
	50%	80.00 bc	4.133 ghij	1.233 klm
C_7	Control	96.67 a	5.440 a	2.967 a
	100%	56.67 h	1.900 r	0.8667 p
	75%	66.67 efg	2.333 q	1.033 mnop
	50%	76.67 bcd	3.833 jklm	1.167 klmn
C_8	Control	96.67 a	5.440 a	2.967 a
	100%	70.00 def	3.800 jklm	1.367 jk
	75%	76.67 bcd	3.967 hijk	1.567 ij
	50%	83.33 b	4.567 bcde	2.100 de
C_9	Control	96.67 a	5.440 a	2.967 a
	100%	63.33 fgh	3.467 mno	1.000 nop
	75%	73.33 cde	4.233 efghi	1.267 kl
	50%	76.67 bcd	4.567 bcde	1.967 defg
C_{10}	Control	96.67 a	5.440 a	2.967 a
	100%	66.67 efg	3.167 op	1.633 hi

Cult.	Conc.	Germination (%)	Shoot length (cm)	Root length (cm)
	75%	73.33 cde	3.867 ijkl	2.000 defg
	50%	76.67 bcd	4.633 bcd	2.367 bc
C11	Control	96.67 a	5.440 a	2.967 a
	100%	63.33 fgh	3.800 jklm	1.833 fgh
	75%	76.67 bcd	4.167 fghij	2.133 de
	50%	83.33 b	4.533 bcdef	2.500 b
C12	Control	96.67 a	5.440 a	2.967 a
	100%	70.00 def	3.600 klmn	1.667 hi
	75%	73.33 cde	4.233 efghi	1.833 fgh
	50%	83.33 b	4.467 cdefg	2.167 cd
Sx		2.20	0.118	0.073
Significance		*	**	*
CV (%)		4.81	4.93	6.64

b) Effect of leaf extract on % inhibition for germination, soot and root length of shama weed seed

Crop residues and their concentration had significantly influence on % inhibition for germination, shoot length and root length (Table 4). The highest % inhibition for germination and shoot length (23.06%, 37.94%) was obtained from sorghum leaf extract. Aqueous leaf extracts of weeds were highly phytotoxic to shama seed. All the applied concentrations of leaf extract significantly suppressed the % inhibition of shama weed (Table 5). The inhibition of germination was highest in 100 % aqueous extract. Similar trend was obtained in case of % inhibition for shoot and root length. In case of interaction, aqueous extract of sorghum with 100 % concentration inhibit the germination most compared to other treatments (Table 6).

Table 4. Effect of crop residues on percent inhibition of germination, shoot length and root length of shama seed

Cultivars	% inhibition of Germination	% inhibition of Shoot length	% inhibition of root length
C1	21.30 b	34.98 a	58.15 a
C2	17.13 d	20.27 cd	25.71 e
C3	11.85 f	12.11 e	35.62 d
C4	19.72 c	20.69 c	33.05 d
C5	15.37 e	24.64 b	34.01 d
C6	17.13 d	35.70 a	48.24 b
C7	23.06 a	37.94 a	49.15 b
C8	15.46 e	18.24 cd	32.45 d
C9	19.81 c	18.46 cd	39.26 c
C10	18.89 c	21.32 c	24.38 e
C11	17.13 d	17.45 d	20.49 f
C12	16.20 de	18.39 cd	27.16 e
Sx	0.476	1.01	1.14
Significance	**	**	**
CV (%)	9.29	14.90	11.12

C_1 = Crop residues of Grasspea, C_2 = Crop residues of Mustard, C_3 = Crop residues of Pea, C_4 = Crop residues of Barley, C_5 = Crop residues of Sunflower, C_6 = Crop residues of Lentil, C_7 = Crop residues of Sorghum, C_8 = Crop residues of Wheat, C_9 = Crop residues of Soybean, C_{10} = Crop residues of Marsh pepper, C_{11} = Crop residues of Acacia, C_{12} = Crop residues of Rice

Table 5. Effect of concentration on percent inhibition of germination, shoot length and root length of shama seed

Conc.	% inhibition of Germination	% inhibition of Shoot length	% inhibition of root length
Control	0.0000 d	0.0000 d	0.0000 d
100%	30.89 a	42.22 a	56.38 a
75%	22.75 b	32.20 b	49.46 b
50%	17.38 c	18.98 c	36.72 c
Sx	0.274	0.580	0.660
Significance	**	**	**
CV (%)	9.29	14.90	11.12

Table: 6. Combined effect of crop residues and concentration on percent inhibition of germination, shoot length and root length of shama seed

Cult.	Conc.	% inhibition of Germination	% inhibition of Shoot length	% inhibition of root length
C_1	Control	0.0000 j	0.0000 q	0.0000 s
	100%	37.41 b	60.42 ab	88.80 a
	75%	27.41 e	56.25 b	80.81 b
	50%	20.37 g	23.26 jklm	62.97 defg
C_2	Control	0.0000 j	0.0000 q	0.0000 s
	100%	31.11 d	39.31 de	37.99 mno
	75%	20.37 g	23.95 ijkl	35.87 nop
	50%	17.04 h	17.81 lmno	28.97 pq
C_3	Control	0.0000 j	0.0000 q	0.0000 s
	100%	20.37 g	27.00 hijk	54.87 hi
	75%	13.33 i	11.07 p	47.08 jkl
	50%	13.70 i	10.36 p	40.52 lmn
C_4	Control	0.0000 j	0.0000 q	0.0000 s
	100%	30.74 d	34.33 efg	53.68 hij
	75%	27.41 e	26.94 hijk	47.12 jkl
	50%	20.74 g	21.48 klmn	31.39 opq
C_5	Control	0.0000 j	0.0000 q	0.0000 s
	100%	24.07 f	46.59 c	55.14 hi
	75%	20.37 g	31.79 fgh	48.39 ijk
	50%	17.04 h	20.17 lmno	32.50 opq
C_6	Control	0.0000 j	0.0000 q	0.0000 s
	100%	31.11 d	62.41 ab	68.30 cd
	75%	20.37 g	56.48 b	66.31 cde
	50%	17.04 h	23.91 ijkl	58.37 gh
C_7	Control	0.0000 j	0.0000 q	0.0000 s
	100%	41.11 a	65.06 a	70.83 c
	75%	30.74 d	57.12 b	65.16 cdef
	50%	20.37 g	29.60 fghij	60.59 efgh
C_8	Control	0.0000 j	0.0000 q	0.0000 s
	100%	27.41 e	30.00 fghi	53.88 hij
	75%	20.74 g	26.95 hijk	46.93 jkl
	50%	13.70 i	16.02 nop	29.01 pq
C_9	Control	0.0000 j	0.0000 q	0.0000 s
	100%	34.44 c	36.05 def	66.27 cde
	75%	24.07 f	21.89 klmn	57.21 gh
	50%	20.74 g	15.91 nop	33.57 nopq
C_{10}	Control	0.0000 j	0.0000 q	0.0000 s
	100%	31.11 d	41.68 cd	44.90 klm

Cult.	Conc.	% inhibition of Germination	% inhibition of Shoot length	% inhibition of root length
	75%	24.07 f	28.85 ghij	32.38 opq
	50%	20.37 g	14.76 op	20.23 r
C_{11}	Control	0.0000 j	0.0000 q	0.0000 s
	100%	34.44 c	30.02 fghi	38.26 mno
	75%	20.37 g	23.15 jklm	28.05 q
	50%	13.70 i	16.64 mnop	15.66 r
C_{12}	Control	0.0000 j	0.0000 q	0.0000 s
	100%	27.41 e	33.74 efg	43.62 klm
	75%	23.70 f	22.01 klmn	38.19 mno
	50%	13.70 i	17.81 lmno	26.83 q
Sx		0.952	2.01	2.29
Significance.		**	**	**
CV (%)		9.29	14.90	11.12

c) Effect of leaf extract on dry shoot weight, % inhibition for dry shoot weight, dry root weight, % inhibition for dry root weight of shama weed seed

The dry shoot weight,% inhibition for dry shoot weight, dry root weight,% inhibition for dry root weight were significantly influenced by crop residues and their concentration (Table 7). The highest % inhibition for shoot dry weight and root dry weight (40.48%, 39.60%) was obtained from sorghum leaf extract. All the applied concentrations of leaf extract significantly suppressed the dry shoot weight, % inhibition for dry shoot weight, dry root weight,% inhibition for dry root weight of shama weed (Table 8). The inhibition for shoot dry weight and root dry weight was highest in 100 % aqueous extract. In case of interaction, aqueous extract of sorghum with 100 % concentration had highest % inhibition for dry shoot weight and % inhibition for dry root weight compared to other treatments (Table 9).

Table 7. Effect of crop residues leaf extract on dry shoot weight, percent inhibition of dry shoot weight, dry root weight and percent inhibition of dry root weight of shama seed

Cultivars	Dry shoot weight (mg)	% Inhibition of dry shoot weight	Dry root weight (mg)	% Inhibition of dry root weight
C_1	0.5833 d	41.62 a	0.2975 de	28.49 c
C_2	0.6225 cd	37.70 bc	0.3358 bc	19.26 e
C_3	0.6750 b	32.10 f	0.3733 a	10.42 g
C_4	0.6608 bc	33.79 ef	0.3375 bc	19.00 e
C_5	0.6208 cd	37.64 bc	0.3167 cd	23.95 d
C_6	0.6000 d	39.70 ab	0.2800 e	32.77 b
C_7	0.5900 d	40.48 a	0.2517 f	39.60 a
C_8	0.6525 bc	34.36 ef	0.3558 ab	14.56 f
C_9	0.6633 bc	33.42 ef	0.3350 bc	19.52 e
C_{10}	0.6292 bcd	36.72 cd	0.3217 cd	22.78 d
C_{11}	0.7200 a	27.45 g	0.3533 ab	15.09 f
C_{12}	0.6517 bc	34.56 de	0.3683 a	11.60 g
Sx	0.016	0.769	0.009	0.813
Level of significance	**	**	**	**
CV (%)	8.71	7.45	11.08	13.16

C_1 = Crop residues of Grasspea, C_2 = Crop residues of Mustard, C_3 = Crop residues of Pea, C_4 = Crop residues of Barley, C_5 = Crop residues of Sunflower, C_6 = Crop residues of Lentil, C_7 = Crop residues of Sorghum, C_8 = Crop residues of Wheat, C_9 = Crop residues of Soybean, C_{10} = Crop residues of Marsh pepper, C_{11} = Crop residues of Acacia, C_{12} = Crop residues of Rice

Table 8. Effect of concentration on dry shoot weight, percent inhibition of dry shoot weight, dry root weight and percent inhibition of dry root weight of shama seed

Conc.	Dry shoot weight (mg)	% Inhibition of dry shoot weight	Dry root weight (mg)	% Inhibition of dry root weight
Control	1.000 a	0.0000 d	0.4167 a	0.0000 d
100%	0.3486 d	64.93 a	0.2539 d	39.00 a
75%	0.5144 c	48.08 b	0.2989 c	28.22 b
50%	0.6933 b	30.16 c	0.3394 b	18.46 c
Sx	0.009	0.444	0.005	0.469
Level of significance	**	**	**	**
CV (%)	8.71	7.45	11.08	13.16

Table 9. Combined effect of leaf extract and concentration on dry shoot weight, percent inhibition of dry shoot weight, dry root weight and percent inhibition of dry root weight of shama seed

Cult.	Conc.	Dry shoot weight (mg)	% Inhibition of dry shoot weight	Dry root weight (mg)	% Inhibition of dry root weight
C_1	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.3000 qrs	70.17 ab	0.1833 mn	56.00 c
	75%	0.4333 klmno	56.40 ghi	0.2700 hijk	35.01 fg
	50%	0.6000 efgh	39.90 op	0.3200 bcdefgh	22.96 klmno
C_2	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.3500 opqrs	64.95 cde	0.2833 fghijk	31.73 ghi
	75%	0.4700 jklmn	53.00 ijk	0.3033 cdefghij	27.04 ijkl
	50%	0.6700 bcdef	32.86 qr	0.3400 bcdef	18.25 opqrs
C_3	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.4200 lmno	57.44 ghi	0.3467 bcde	16.78 pqrst
	75%	0.5500 ghij	44.78 lmn	0.3567 abcd	14.49 rstuv
	50%	0.7300 bcd	26.19 st	0.3733 ab	10.42 uv
C_4	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.4100 lmnop	58.71 fgh	0.2833 fghijk	32.06 ghi
	75%	0.5800 fghi	42.05 no	0.3100 cdefghi	25.54 klm
	50%	0.6533 cdef	34.42 q	0.3400 bcdef	18.41 opqrs
C_5	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.3167 pqrs	68.32 bc	0.2467 jkl	40.66 e
	75%	0.5000 hijkl	49.36 kl	0.2800 fghijk	32.78 gh
	50%	0.6667 bcdef	32.86 qr	0.3233 bcdefgh	22.38 lmno
C_6	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.2700 rs	73.20 a	0.1433 no	65.65 b
	75%	0.4300 klmno	56.40 ghi	0.2400 kl	42.38 e
	50%	0.7000 bcde	29.22 rs	0.3200 bcdefgh	23.04 klmno
C_7	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.2500 s	74.65 a	0.1067 o	74.33 a
	75%	0.4800 ijklm	51.03 jk	0.2067 lm	50.43 d
	50%	0.6300 defg	36.23 pq	0.2767 ghijk	33.65 fg
C_8	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.3500 opqrs	64.43 cde	0.3167 bcdefghi	23.94 klmn
	75%	0.5100 hijkl	48.85 klm	0.3367 bcdefg	19.20 nopqr
	50%	0.7500 bc	24.16 t	0.3533 bcd	15.09 qrstu
C_9	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.3700 nopqr	63.25 def	0.2567 ijkl	38.26 ef
	75%	0.5500 ghij	44.29 mno	0.3067 cdefghij	26.27 jklm
	50%	0.7333 bcd	26.13 st	0.3600 abcd	13.56 stuv
C_{10}	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w

Cult.	Conc.	Dry shoot weight (mg)	% Inhibition of dry shoot weight	Dry root weight (mg)	% Inhibition of dry root weight
	100%	0.3167 pqrs	67.76 bcd	0.2567 ijkl	38.41 ef
	75%	0.5333 ghijk	45.59 lmn	0.2867 efghijk	31.21 ghij
	50%	0.6667 bcdef	33.53 qr	0.3267 bcdefgh	21.49 mnop
C_{11}	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.4400 klmno	55.42 hij	0.3000 defghijk	27.80 hijk
	75%	0.6700 bcdef	32.26 qr	0.3333 bcdefg	19.92 nopq
	50%	0.7700 b	22.12 t	0.3633 abc	12.65 tuv
C_{12}	Control	1.000 a	0.0000 u	0.4167 a	0.0000 w
	100%	0.3900 mnopq	60.92 efg	0.3233 bcdefgh	22.39 lmno
	75%	0.4667 jklmn	53.00 ijk	0.3567 abcd	14.37 rstuv
	50%	0.7500 bc	24.34 t	0.3767 ab	9.630 v
Sx		0.031	1.54	0.018	1.63
Significance		*	**	**	**
CV (%)		8.71	7.45	11.08	13.16

Plate 1. Preparation of crop residues concentration

Plate 2. Weed seed in different conc. of crop residues

Plate 3. Germination of weed seed under different conc. Plate 4. Observation on weed germination

Plate 5. Data collection

Experiment 2

a) Infested weed species in the experimental field

Four major weed species belonging to three families infested the experimental field. The weeds of the experimental plots were *Echinochloa crusgalli* (Shama), *Scirpus juncoides* (Chesra), *Monochoria vaginalis* (Panikachu) and *Cyperus difformis* (Sabujnakful). Bari et al. (1995) in the experimental at BAU reported that the three important weeds of rice fields were *Echinochloa crusgalli, Scirpus juncoides* and *Cyperus difformis.* Other minor weed species are not mentioned here.

b) Time of application and different crop residues interaction influence on Shama *(Echinochloa crusgalli)*

The interaction on weed population, dry weight and growth inhibition of shama were significant .The highest weed population (28.33 m^{-2}) was found in T_1C_1 (applied crop residues before transplanting x no crop residues), second highest weed population (19.67 m^{-2}) was found in T_1C_5 (applied crop residues before transplanting x rice crop residues) and the lowest was found in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) treatment (Table 10). The highest weed dry weight (11.3g) was found in T_3C_1 (applied at two weeks after transplanting x no crop residues) and the lowest weed dry weight was found in T_1C_2 (applied crop residues before transplanting x sorghum crop residues). The growth inhibition of weed was the highest in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) (59.15 %) and the lowest inhibition (0.00 %) was observed in T_1C_1, T_2C_1 and T_3C_1 presented in Table 10.

Table 10. Combined effects time of application and crop residues on Shama (*Echinochloa crusgalli)* weed control

Treatment combination	Shama *(Echinochloa crusgalli)*		
	Number	Dry weight (g)	% growth inhibition
T_1C_1	28.33 a	10.8	0.00
T_1C_2	12.00 g	4.40	59.15
T_1C_3	18.33 bc	6.90	36.29
T_1C_4	15.00 defg	5.36	50.25
T_1C_5	19.67 b	6.00	44.23
T_2C_1	27.33 a	10.8	0.00
T_2C_2	16.00 cdef	4.90	54.48
T_2C_3	13.67 fg	7.60	29.21
T_2C_4	14.00 fg	5.97	44.55
T_2C_5	17.33 bcde	6.50	39.98
T_3C_1	25.33 a	11.3	0.00
T_3C_2	14.33 efg	5.86	48.16
T_3C_3	25.33 a	8.33	26.49
T_3C_4	15.33 cdef	7.03	37.31
T_3C_5	18.00 bcd	7.60	32.57
Level of significance	**	NS	NS
CV (%)	9.14	6.07	17.50

In a column, figures with the same letters do not differ significantly as per DMRT, ** =Significant at 1% level of probability, NS = Not significant, Here, T_1 = Applied crop residues before transplanting, T_2 =Applied crop residues one week after transplanting, T_3 = Applied crop residues two week after transplanting, C_1 – Control (No weeding), C_2 – Sorghum, C_3 – Maize, C_4 – Mustard, C_5 – Rice.

c) Time of application and different crop residues interaction influence on Chesra *(Scirpus juncoides)*

Combined effect of time of application and crop residues was significant for inhibition. The interaction on weed population, dry weight and growth inhibition of Chesra were significant. The highest weed population (28.33 m^{-2}) was found in T_1C_1 (applied crop residues before transplanting x no crop residues) and the lowest was found in T_3C_4 (applied crop residues at two weeks after transplanting x mustard crop residues) treatment (Table 11). The highest weed dry weight (15.70g) was found in T_1C_1 (applied crop residues x no crop residues) which is statistically similar to T_2C_1 (applied crop residues at one week after transplanting x no crop residues) treatment (Table 11) and the lowest weed dry weight was found in T_3C_2 (applied crop residues at two weeks after transplanting x sorghum crop residues).

Table 11: Combined effects time of application and crop residues on Chesra *(Scirpus juncoides)* weed control

Treatment combination	Chesra *(Scirpus juncoides)*		
	Number	Dry weight (g)	% growth inhibition
T_1C_1	44.00 a	15.70 a	0.00 i
T_1C_2	33.00 bc	6.63 gh	57.75 a
T_1C_3	26.67 cde	10.20 bc	35.03 f
T_1C_4	29.67 cd	8.23 ef	47.56 c
T_1C_5	25.00 de	8.80 de	43.95 d
T_2C_1	38.00 ab	14.83 a	0.00 i
T_2C_2	44.00 a	6.70 gh	54.83 b
T_2C_3	33.00 bc	10.73 b	27.64 g
T_2C_4	26.67 cde	8.70 de	41.35 e
T_2C_5	29.67 cd	9.50 cd	35.96 f
T_3C_1	25.00 de	9.46 cd	0.00 i
T_3C_2	41.00 a	4.90 i	48.24 c
T_3C_3	28.00 cde	7.30 fg	22.89 h
T_3C_4	22.33 e	6.13 h	35.21 f
T_3C_5	33.00 bc	6.66 gh	29.58 g
Level of significance	**	**	**
CV (%)	11.64	6.85	3.69

In a column, figures with the same letters do not differ significantly as per DMRT, ** =Significant at 1% level of probability, Here, T_1 = Applied crop residues before transplanting, T_2 = Applied crop residues one week after transplanting, T_3 = Applied crop residues two weeks after transplanting, C_1 = Control (No weeding), C_2 = Sorghum, C_3 = Maize, C_4 = Mustard, C_5 = Rice.

The percent growth inhibition of chesra weed was the highest (57.75%) in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) and the lowest inhibition (0.00 %) was observed in T_1C_1, T_2C_1 and T_3C_1 presented in (Table 11).

d) Time of application and different crop residues interaction influence on Panikachu (*Monochoria vaginalis*)

The highest weed population (2.33 m^{-2}) was found in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) and the lowest was found in T_1C_1, which was statistically identical to T_1C_5, T_2C_2, T_3C_1, T_3C_2 and T_3C_3 (Table 12). The highest weed dry weight (0.41g) was found in T_1C_1 (applied crop residues before transplanting x no crop residues) (Table 12) and the lowest weed dry weight was found in T_3C_2 (applied crop residues at two weeks after transplanting x sorghum crop residues). Apparently, the percent growth inhibition of panikachu weed was the highest (64.50%) in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) and the lowest inhibition (0.00 %) was observed in T_1C_1, T_2C_1 and T_3C_1 presented in (Table 12).

Table 12: Combined effects time of application and crop residues on Panikachu (*Monochoria vaginalis*) weed control

Treatment combination	Panikachu (*Monochoria vaginalis*)		
	Number	Dry weight (g)	% growth inhibition
T_1C_1	1.00 c	0.41	0.00
T_1C_2	2.33 a	0.14	64.50
T_1C_3	1.67 b	0.25	37.70
T_1C_4	2.00 ab	0.19	54.10
T_1C_5	1.00 c	0.22	45.08
T_2C_1	1.67 b	0.37	0.00
T_2C_2	1.00 c	0.15	59.63
T_2C_3	2.33 a	0.24	35.08
T_2C_4	1.67 b	0.19	49.86
T_2C_5	2.00 ab	0.22	41.07
T_3C_1	1.00 c	0.25	0.00
T_3C_2	1.00 c	0.11	54.67
T_3C_3	1.00 c	0.17	30.67
T_3C_4	1.67 b	0.14	45.33
T_3C_5	1.67 b	0.16	37.33
Level of significance	**	NS	NS
CV (%)	13.75	16.38	12.50

In a column, figures with the same letters do not differ significantly as per DMRT, ** =Significant at 1% level of probability, Here, T_1 = Applied crop residues before transplanting, T_2 =Applied crop residues one week after transplanting, T_3 = Applied crop residues two week after transplanting, C_1 = Control (No weeding), C_2 = Sorghum, C_3 = Maize, C_4 = Mustard, C_5 = Rice

e) Time of application and different crop residues interaction influence on Sabuj nakful *(Cyperus difformis)*

The highest weed population (32.67 m^{-2}) was found in T_1C_1 (applied crop residues before transplanting x no crop residues) and the lowest weed population (11.33 m^{-2}) was found in T_1C_4, (Table 13). The highest weed dry weight (11.07g) was found in T_3C_1 (applied crop residues at two weeks after transplanting x no crop residues) and the lowest weed dry weight (4.40g) was found in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) (Table 13).

Table 13: Combined effects time of application and crop residues on sabujnakful *(Cyperus difformis)* weed control

Treatment combination	Sabuj nakful *(Cyperus difformis)*		
	Number	Dry weight (g)	% growth inhibition
T_1C_1	32.67 a	10.93	0.00
T_1C_2	16.33 e	4.40	59.53
T_1C_3	14.00 efg	6.47	40.14
T_1C_4	11.33 g	5.40	50.19
T_1C_5	26.33 bc	5.80	46.50
T_2C_1	26.67 bc	10.43	0.00
T_2C_2	32.00 a	4.63	55.36
T_2C_3	22.00 d	6.77	34.75
T_2C_4	13.00 fg	5.73	44.95
T_2C_5	13.67 efg	6.30	39.15
T_3C_1	25.67 bc	11.07	0.00
T_3C_2	24.67 cd	5.57	49.59

Treatment combination	Sabuj nakful *(Cyperus difformis)*		
	Number	Dry weight (g)	% growth inhibition
T_3C_3	28.33 b	8.10	26.66
T_3C_4	15.67 ef	6.47	41.44
T_3C_5	14.33 efg	7.17	35.00
Level of significance	**	NS	NS
CV (%)	8.21	7.47	10.39

In a column, figures with the same letters do not differ significantly as per DMRT, ** =Significant at 1% level of probability, Here, T_1 = Applied crop residues before transplanting, T_2 =Applied crop residues one week after transplanting, T_3 = Applied crop residues two week after transplanting, C_1 = Control (No weeding), C_2 = Sorghum, C_3 = Maize, C_4 = Mustard, C_5 = Rice

The percent growth inhibition of sabujnakful weed was the highest (59.53%) in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) and the lowest inhibition (0.00 %) was observed in T_1C_1, T_2C_1 and T_3C_1 presented in (Table 13). In case interaction effect, it was non-significant for crop residues and its application time.

f) Time of application and different crop residues interaction influence on plant height

Combined effect of application time and crop residues showed non-significant effect on plant height .The highest plant height (34.63, 61.58 and 78.27 cm) was found in T_1C_2 (applied crop residues before transplanting x sorghum crop residues) at all days of sampling and the lowest plant height (28.25, 41.50 and 58.07 cm) was found in T_3C_1 (applied crop residues at two weeks after transplanting x no crop residues) at all days of sampling.

Table 14: Combined effects of time of application and crop residues on plant height at different days after transplanting (DAT)

Treatment combination	Plant height (cm)		
	25 DAT	50 DAT	75 DAT
T_1C_1	30.50	49.50	73.90
T_1C_2	34.63	61.58	78.27
T_1C_3	31.17	49.75	75.68
T_1C_4	31.50	53.75	77.11
T_1C_5	31.83	50.58	75.78
T_2C_1	28.33	44.33	61.50
T_2C_2	33.82	60.92	73.07
T_2C_3	28.80	48.08	63.46
T_2C_4	32.75	52.50	68.28
T_2C_5	32.65	50.25	67.02
T_3C_1	28.25	41.50	58.07
T_3C_2	33.00	58.25	72.95
T_3C_3	29.50	48.03	60.38
T_3C_4	31.98	52.25	67.25
T_3C_5	32.20	49.75	66.96
Level of significance	NS	NS	NS
CV (%)	7.57	4.04	4.69

In a column, figures with the same letters do not differ significantly as per DMRT, NS = Not significant, Here, T_1 = Applied crop residues before transplanting, T_2 =Applied crop residues one week after transplanting, T_3 = Applied crop residues two weeks after transplanting, C_1 = Control (No weeding), C_2 = Sorghum, C_3 = Maize, C_4 = Mustard, C_5 = Rice

g) Time of application and different crop residues interaction influence on yield attributes and yield

Combined effect of time of application and crop residues showed significant variation in case of effective tillers hill^{-1} (Table 15). The highest number of effective tillers hill^{-1} (7.97) was obtained from T_1C_2 (applied crop residues before transplanting and sorghum residues application) treatment, while the lowest number of effective tillers hill^{-1} (6.10) was obtained from T_3C_3 (applied crop residues at two weeks after transplanting and maize crop residues application) treatment. Panicle length was non-significant for both times of application and crop residues. The highest panicle length (22.33 cm) was observed in T_1C_2 (applied crop residues before transplanting and sorghum residues application) treatment, while the shortest panicle length (20.04 cm) was observed in T_3C_1 (applied crop residues at two weeks after transplanting and no crop residues application) treatment (Table 15). Interaction effect of time of application and crop residues showed non-significant variation in case of grains panicle^{-1}. The highest grains panicle^{-1} (115.0) was produced in T_1C_2 (applied crop residues before transplanting and sorghum residues application) treatment, while the lowest grains panicle^{-1} (99.45) was produced in T_3C_1 (applied crop residues at two weeks after transplanting and no crop residues application) treatment (Table 15). Interaction effect was also non-significant for 1000-grain weight. The highest weight of 1000 grains (22.77g) was recorded in T_3C_2 (applied crop residues at two weeks after transplanting and sorghum crop residues application) treatment (Table 15). Combined effect of time of application and crop residues showed non-significant variation in grain yield. However highest grain yield (4.53 t ha^{-1}) was observed in sorghum residues application when applied before transplanting while the lowest grain yield (1.02 t ha^{-1}) was observed in T_2C_1 (applied crop residues at one week after transplanting and no crop residues application) treatment (Fig. 1). The lowest grain yield (1.02 t ha^{-1}) in the no weed management practices might be due to the poor performance of yield characters like higher number of effective tillers hill^{-1} and higher number of grains/spikelets panicle^{-1}. Because severe weed infestation occurred in the plots due to competition for nutrient, water, air, sunlight and space between weed and rice plants. Similar results were also observed by Gogoi et al. 2001; Attalla and Kholosy 2002. Interaction effect of time of application and crop residues showed significant variation in straw yield. The highest straw yield (4.93 t ha^{-1}) was observed in sorghum residues application when applied before transplanting and the lowest straw yield (1.27 t ha^{-1}) was produced by T_3C_1 (applied crop residues at two weeks after transplanting and no crop residues application) treatment (Fig. 2).

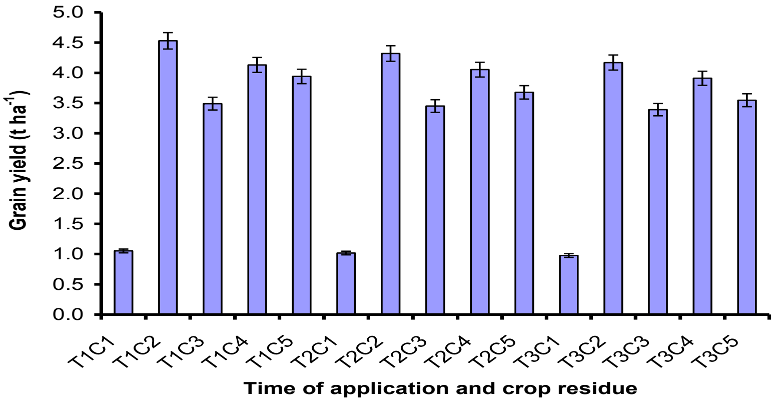
Table 15. Combined effects of time of application and crop residues on yield contributing characters of rice

Treatments combination	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000 grain weight (gm)	Harvest index (%)
T_1C_1	73.51	7.33	6.77	20.36	105.3	21.29	40.94
T_1C_2	79.38	9.87	7.97	22.33	115.0	21.38	47.92
T_1C_3	74.92	7.80	7.40	21.40	107.9	21.50	48.17
T_1C_4	76.49	8.20	7.73	22.08	112.5	21.77	48.20
T_1C_5	74.93	8.00	7.47	21.73	110.1	21.49	48.52
T_2C_1	72.63	6.70	6.20	20.09	101.9	21.73	42.54
T_2C_2	79.98	8.96	7.20	21.90	112.7	21.37	48.57
T_2C_3	76.18	7.66	6.67	21.35	105.9	21.83	48.74
T_2C_4	78.66	8.10	7.07	21.70	110.4	21.81	49.35

Treatments combination	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000 grain weight (gm)	Harvest index (%)
T_2C_5	78.34	7.86	7.03	21.65	107.4	21.30	48.73
T_3C_1	73.01	6.53	6.13	20.04	99.45	22.03	43.65
T_3C_2	77.30	8.43	6.83	21.45	109.7	22.77	49.33
T_3C_3	75.80	7.50	6.10	20.84	104.0	21.81	49.17
T_3C_4	76.25	7.93	6.93	21.31	106.3	22.47	48.69
T_3C_5	76.78	7.80	6.67	21.25	105.2	22.44	49.48
Level of significance	NS	NS	NS	NS	NS	NS	NS
CV (%)	3.08	7.59	5.63	2.30	3.18	3.95	3.82

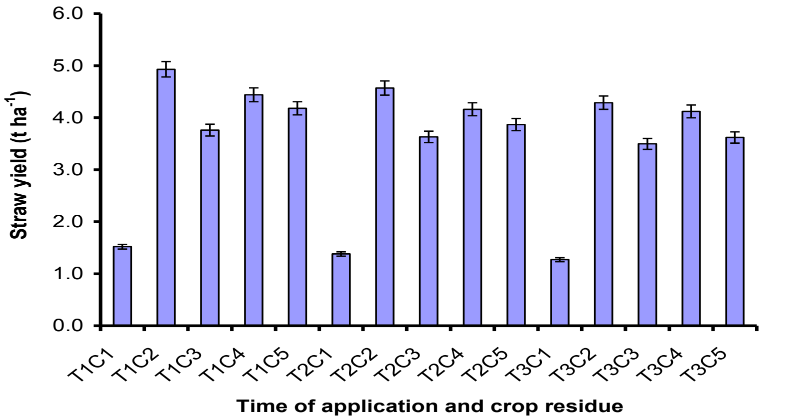
In a column, values having the same letters do not differ significantly whereas values with dissimilar letter differ significantly as per DMRT.

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant
T_1 = Applied crop residues before transplanting, T_2 =Applied crop residues one week after transplanting, T_3 = Applied crop residues two weeks after transplanting, C_1 = Control (No weeding), C_2 = Sorghum, C_3 = Maize, C_4 = Mustard, C_5 = Rice



T_1 = Applied crop residues before transplanting, T_2 =Applied crop residues one week after transplanting, T_3 = Applied crop residues two weeks after transplanting.C_1 = Control (No weeding), C_2 = Sorghum, C_3 = Maize, C_4 = Mustard, C_5 = Rice

Fig 1: Effect of interaction between the time of application and different crop residues on grain yield



T_1 = Applied crop residues before transplanting, T_2 =Applied crop residues one week after transplanting, T_3 = Applied crop residues two weeks after transplanting, C_1 = Control (No weeding), C_2 = Sorghum, C_3 = Maize, C_4 = Mustard, C_5 = Rice

Fig 2: Effect of interaction between the time of application and different crop residues on straw yield

Interaction effect of time of application and crop residues showed non- significant variation in harvest index. The highest harvest index (49.48%) was observed in T_3C_5 (applied crop residues at two weeks after transplanting and rice crop residues application) and the lowest harvest index (40.94%) was produced by T_1C_1 (applied crop residues before transplanting and no crop residues application) treatment (Table 15).

Experiment 3

a) Effect of aqueous extract of crop residues on weed management Infested weed species in the experimental field for sorghum crop residues

Seven weed species belonging to five 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 16.

Table 16. Infested weed species found growing in the experimental plots in Wheat

Sl. No.	Local name	Scientific name	Family	Morphological type	Life cycle
1	Mutha	*Cyperus rotundus*	Cyperaceae	Sedge	Perennial
2	Durba	*Cynodon dactylon*	Gramineae	Grass	Perennial
3	Bathua	*Chenopodium album*	Chenopodiaceae	Broad leaved	Annual
4	Shama	*Echinochloa crusgalli*	Gramineae	Grass	Annual
5	Angta	*Paspalum scrobiculatum*	Gramineae	Grass	Annual
6	Tit begun	*Solanum torvum*	Solanaceae	Broad leaved	Perennial
7	Biskatali	*Polygonum hydropiper*	Polygonaceae	Broad leaved	Annual

b) Effect of variety on number and percent inhibition on different weeds

Variety shows the significant effect on number of weed population for biskatali, tit begun, shama and angta and others are not significantly affected. The lowest number of weeds was found in different varieties for different weeds (Table 17). On the other hand only shama and durba are not significant and rest of them are significantly affected in terms of percent inhibition. Bathua (38.97), tit begun (54.15), biskatali (39.62) and angta (58.19) shows highest percent inhibition for V_2 and mutha (40.06) is found in V_1 variety. (Table 17)

Table 17: Effect of variety on number and percent inhibition on different weeds

	Number of weed per quadrate (25×25) cm^2							% Inhibition						
Weed name	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta
variety														
V_1	6.11	5.86	7.33b	6.13	0.80b	6.80a	1.00a	36.78c	40.06a	38.45b	39.40	47.51b	37.38	53.91b
V_2	5.86	5.53	7.53a	6.07	1.00a	6.26b	0.80b	38.97a	38.40b	39.62a	40.56	54.15a	39.29	58.19a
V_3	6.13	5.80	7.53a	6.27	1.00a	6.60ab	1.00a	37.80b	37.42b	38.49b	40.60	52.53a	38.09	54.25b
$S\bar{x}$	0.10	0.12	0.05	0.08	0.02	0.13	0.03	0.27	0.36	0.33	0.38	1.31	0.89	0.72
Level of significance	NS	NS	**	NS	**	*	**	**	**	*	NS	**	NS	**
CV (%)	6.72	6.88	2.67	5.16	5.70	7.87	9.32	2.81	3.57	3.29	3.66	9.80	8.94	5.01

** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Non significant
V_1 = BRRI GOM19 (Sourav), V_2 = BARI GOM21 (Shatabdi), V_3 = BARI GOM24 (Prodip)

c) Effect of aqueous extract of sorghum on number and percent inhibition on different weeds

Numbers of weed populations are significantly affected by the treatments for all weed species. Lowest weed population was found in C_4 treatments (Hand weeding) followed by C_1 treatment (Table 18). Highest percent inhibition was also found in C_4 treatment which is followed by C_1 treatment where the concentration of aqueous extract of sorghum was high (1:20). Numerically 51.81, 51.10, 55.58, 52.90, 73.83, 53.85 and 75.26 percent inhibition were found in bathua, mutha, biskatali, durba, tit begun, shama and angta respectively for C_1 treatment. (Table 18)

Table 18: Effect of aqueous extract of sorghum on number and percent inhibition on different weeds

	Number of weed per quadrate (25×25) cm^2							% Inhibition						
Weed name	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta
Treatments														
C_O	8.78a	8.33a	11.00a	8.77a	1.99a	9.55a	2.00a	0.00e	0.00e	0.00e	0.00e	0.00e	0.00e	0.00e
C_1	5.11d	4.66d	6.44c	5.66d	0.67c	5.33d	0.55d	51.81b	51.10b	55.58b	52.90b	73.83b	53.85b	75.26b
C_2	6.66 c	5.99c	7.66b	6.44c	0.67c	7.33c	0.89c	35.56c	41.11c	40.50c	40.20c	56.12c	38.26c	62.73c
C_3	7.55b	7.55b	7.66b	7.22b	1.22b	8.00b	1.22b	23.32d	22.67d	31.96d	30.48d	32.54d	24.42d	39.25d
C_4	2.07 e	2.11e	4.55d	2.66e	0.11d	2.55e	0.00e	78.57a	78.19a	66.21a	77.32a	94.48a	76.01a	100.0a
$S\bar{x}$	0.13	0.13	0.07	0.11	0.02	0.17	0.03	0.35	0.46	0.43	0.49	1.68	1.14	0.93
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CV (%)	6.72	6.88	2.67	5.16	5.70	7.87	9.32	2.81	3.57	3.29	3.66	9.80	8.94	5.01

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

C_0 = No use of extract, C_1 = Aqueous extract of sorghum crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of sorghum crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of sorghum crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

** =Significant at 1% level of probability.

d) Combined effect of variety and aqueous extract of sorghum on number and percent inhibition on different weeds

For all the weed species V_2C_4 combination found the lowest number of weed population. On the other hand highest percent inhibition was also found in the same combination. (Table 19)

Table 19: Combined effect of variety and aqueous extract of sorghum on number and percent inhibition on different weeds

	Number of weed per quadrate (25×25) cm^2							% Inhibition						
Weed name	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta
Treatments														
V_1C_0	8.66ab	8.00abc	11.00b	8.33b	1.33b	10.33	2.00a	0.00	0.00g	0.00f	0.00h	0.00	0.00	0.00g
V_1C_1	4.66g	4.667f	6.66g	6.33e	0.67d	5.33	0.67d	50.13	51.49b	54.61c	51.40d	71.85	53.09	72.43c
V_1C_2	7.33d	6.66d	6.67g	6.33e	0.67d	7.33	1.00c	34.16	45.79c	40.23d	40.45ef	50.32	37.77	60.32d
V_1C_3	7.66cd	7.66bc	8.00 e	7.00cd	1.00c	8.33	1.33b	23.08	25.68e	32.10e	30.13g	31.93	22.65	36.78f
V_1C_4	2.23h	2.33g	4.33j	2.66gh	0.33e	2.66	0.00f	76.54	77.31a	65.32b	74.91b	83.44	74.66	100.0a
V_2C_0	8.33bc	8.33ab	11.67a	9.00a	2.33a	9.00	2.00a	0.00	0.00g	0.00f	0.00h	0.00	0.00	0.00g
V_2C_1	5.00fg	4.67f	6.67g	5.33f	0.67d	5.33	0.33e	53.29	51.76b	56.58c	55.14c	75.04	55.18	80.52b
V_2C_2	6.33e	5.33f	7.67ef	6.33e	0.67d	7.00	0.67d	37.18	39.81d	40.62d	38.39f	60.30	39.05	64.17d
V_2C_3	7.66cd	7.33c	7.67ef	7.33c	1.33b	7.66	1.00c	23.68	21.20f	31.44e	29.47g	35.41	25.75	46.26e
V_2C_4	2.00h	2.00g	4.00j	2.33h	0.00f	2.33	0.00f	80.72	79.20a	69.44a	79.78a	100.0	77.84	100.0a
V_3C_0	9.33a	8.66a	10.33c	9.00a	2.33a	9.33	2.00a	0.00	0.00g	0.00f	0.00h	0.00	0.00	0.00g
V_3C_1	5.66ef	4.66f	6.00h	5.33f	0.67d	5.33	0.67d	52.01	50.19b	55.56c	52.07d	74.61	53.28	72.83c
V_3C_2	6.33e	6.00e	8.66d	6.66de	0.67d	7.66	1.00c	35.33	37.74d	40.66d	41.80e	57.75	37.97	63.71d
V_3C_3	7.33d	7.66bc	7.33f	7.33c	1.33b	8.00	1.33b	23.21	21.09f	32.35e	31.83g	30.29	24.85	34.72f
V_3C_4	2.00h	2.00g	5.33i	3.00g	0.00f	2.66	0.00f	78.45	78.06a	63.88b	77.28b	100.0	75.53	100.0a
$S\bar{x}$	0.25	0.29	0.12	0.18	0.03	0.29	0.05	0.61	0.79	0.74	0.85	2.90	1.99	1.60
Level of significance	**	*	**	**	**	NS	**	NS	**	**	**	NS	NS	**
CV (%)	6.72	6.88	2.67	5.16	5.70	7.87	9.32	2.81	3.57	3.29	3.66	9.80	8.94	5.01

In a column, figures with the same letter do not differ significantly as per DMRT.
** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Non significant

V_1 = BRRI GOM19 (Sourav), V_2 = BARI GOM21 (Shatabdi), V_3 = BARI GOM24 (Prodip)
C_0 = No use of extract, C_1 = Aqueous extract of sorghum crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of sorghum crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of sorghum crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

e) Effect of variety on yield and yield contributing characters of wheat

Varietal effect on yield and yield contributing characters of wheat showed the significant effect. Highest plant height, higher number of total tillers and effective tillers $hill^{-1}$, higher number of grain $spike^{-1}$, higher number of filled grain $spike^{-1}$, highest straw yield and highest harvest index was found in V_2 (BARI GOM21) variety (Table 20). The highest grain yield (3.84 tha^{-1}) was obtained in BARI GOM21 followed by BARI GOM24 (3.69 tha^{-1}). (Fig. 3)

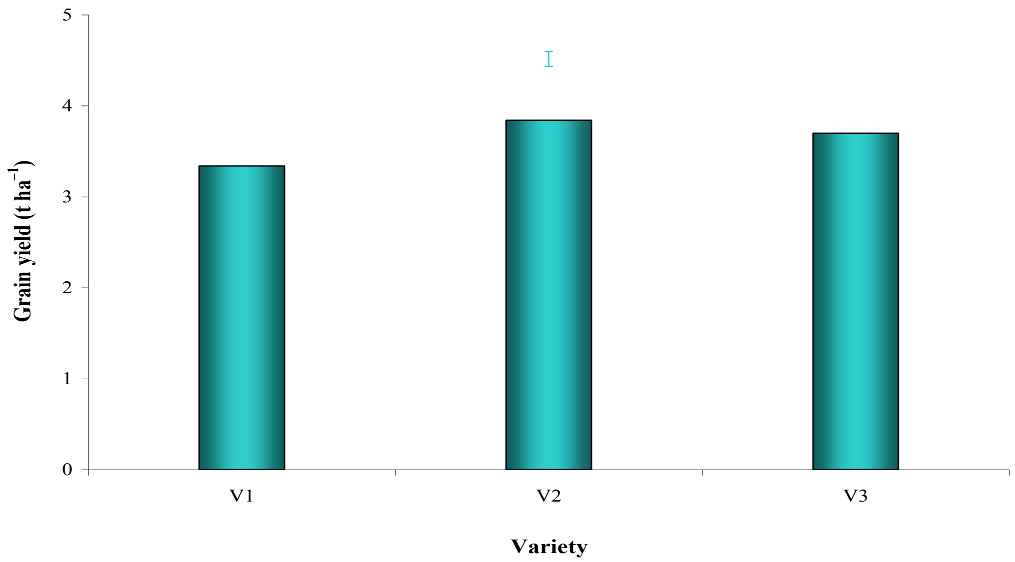


Fig3. Grain yield as influenced by variety (Bar represents standard error mean)
Here, V_1 = BRRI GOM19 (Sourav), V_2 = BARI GOM21 (Shatabdi), V_3 = BARI GOM24 (Prodip)

Table 20. Effect of variety on yield and yield contributing characters of wheat

Varieties	Plant height (cm)	No. of total tillers hill^{-1}	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of grains spike^{-1}	Filled grain spike^{-1}	1000 grain weight (gm)	Straw yield (t ha^{-1})	Harvest index (%)
V_1	88.71c	4.02b	3.16b	10.29	42.23	15.22b	55.18a	4.01b	45.14b
V_2	95.51a	4.13a	3.35a	10.46	43.36	15.75a	53.60ab	4.36a	46.75a
V_3	91.24b	4.07ab	3.25b	10.36	42.76	15.42ab	52.39b	4.35a	45.57b
$S\bar{x}$	0.761	0.023	0.032	0.105	0.385	0.141	0.606	0.037	0.348
Level of significance	**	**	**	NS	NS	*	**	**	**
CV (%)	3.21	2.14	3.85	3.92	3.48	3.53	4.37	3.40	2.94

V_1 = BRRI GOM19 (Sourav), V_2 = BARI GOM21 (Shatabdi), V_3= BARI GOM24 (Prodip)
** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Non significant

f) Effect of aqueous extract of sorghum crop residues on yield and yield contributing characters of wheat

Aqueous extract of sorghum crop residues had also significant effect on yield and yield contributing characters. The highest grain yield (3.97tha^{-1}) was produced by C_4 treatment, followed by C_1 (3.88 tha^{-1}) and lowest one (2.61 tha^{-1}) was produced by C_0 (no use of extract) treatment due to the production of higher number of effective tillers hill^{-1}, higher number of grain spike^{-1}, higher number of filled grain spike^{-1}. The lowest grain yield was produced in C_0 treatment. **(**Table 21 and Fig. 4***).*** Uddin and Pyon (2010) also reported the similar results, where crop residues influenced in crop performance.

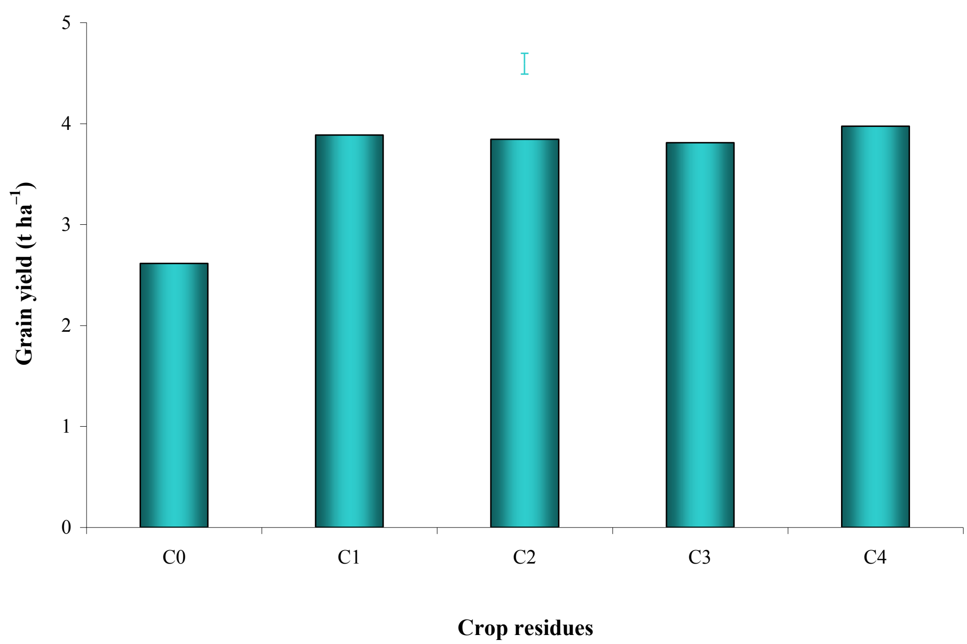


Fig 4. Grain yield as influenced by aqueous extract of sorghum crop residues (Bar represents standard error mean)

C_0 = No use of extract, C_1 = Aqueous extract of sorghum crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of sorghum crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of sorghum crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

g) Infested weed species in the experimental field for mustard crop residues

Seven weed species belonging to 5 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 23. The weeds of the experimental plots were *Cyperus rotundus*, *Cynodon dactylon, Chenopodium album*, *Echinochloa crusgalli, Paspalum scrobiculatum, Solanum torvum* and *Polygonum hydropiper*. There were three perennial and four annual weed species in the experimental plot

Table 23: Infested weed species found growing in the experimental plots in Wheat

Sl. No.	Local name	Scientific name	Family	Morphological type	Life cycle
1	Bathua	*Chenopodium album*	Chenopodiaceae	Broad leaved	Annual
2	Mutha	*Cyperus rotundus*	Cyperaceae	Sedge	Perennial
3	Durba	*Cynodon dactylon*	Gramineae	Grass	Perennial
4	Shama	*Echinochloa crusgalli*	Gramineae	Grass	Annual
5	Tit begun	*Solanum torvum*	Solanaceae	Broad leaved	Perennial
6	Biskatali	*Polygonum hydropiper*	Polygonaceae	Broad leaved	Annual
7	Angta	*Paspalum scrobiculatum*	Gramineae	Grass	Annual

h) Effect of variety on number and percent inhibition on different weeds

Variety shows the significant effect on number of weed population for all of the weeds. The lowest number of weeds was found in different varieties for different weeds (Table 24). On the other hand all of the weeds are significantly affected in terms of percent inhibition. Bathua (53.02), mutha (49.29), biskatali (52.90), durba (53.00), shama (52.77) and angta (56.46) shows highest percent inhibition for V_2 and tit begun (57.11) is found in V_3 variety. (Table 24)

Table 24: Effect of variety on number and percent inhibition on different weeds

	Number of weed per quadrate (25×25) cm^2							% Inhibition						
Weed name	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta
variety														
v_1	3.00a	4.33a	7.60a	4.40a	3.60a	4.27a	3.72a	46.37b	39.07b	42.94c	41.30b	50.83b	48.82b	52.74c
v_2	2.53b	2.93c	4.27c	2.534c	2.65b	3.60b	2.07c	53.02a	49.29a	52.90a	53.00a	52.85ab	52.77ab	56.46a
v_3	3.00a	3.47b	5.94b	3.20b	2.10c	3.13c	2.74b	51.49a	46.26a	48.41b	50.95a	57.11a	55.03a	54.14b
$S\bar{x}$	0.047	0.107	0.083	0.14	0.077	0.049	0.113	1.29	1.58	0.967	1.34	1.57	1.45	0.429
Level of significance	**	**	**	**	**	**	**	**	**	**	**	*	**	**
CV (%)	6.49	11.64	5.45	17.08	10.69	5.08	15.42	9.86	13.68	7.79	10.71	11.33	10.72	3.05

** =Significant at 1% level of probability, * =Significant at 5% level of probability

V_1 = BRRI GOM19 (Sourav), V_2 = BARI GOM21 (Shatabdi), V_3 = BARI GOM24 (Prodip)

i) Effect of aqueous extract of mustard on number and percent inhibition on different weeds

Numbers of weed populations are significantly affected by the treatments for all weed species. Lowest weed population was found in C_4 treatments (Hand weeding) followed by C_1 treatment (Table 25). Highest percent inhibition was also found in C_4 treatment which is followed by C_1 treatment where the concentration of aqueous extract of mustard was high (1:20). Numerically 66.32, 60.98, 67.52, 73.90, 67.65, 66.40 and 67.36 percent inhibition were found in bathua, mutha, biskatali, durba, tit begun, shama and angta respectively for C_1 treatment. (Table 25)

Table 25: Effect of aqueous extract of mustard on number and percent inhibition on different weeds

	Number of weed per quadrate (25×25) cm^2							% Inhibition						
Weed name	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta
Treatments														
C_O	4.78a	5.67a	9.11a	5.56a	4.94a	6.33a	5.52a	0.00d	0.00e	0.00e	0.00d	0.00d	0.00d	0.00e
C_1	1.99d	2.78d	4.89d	2.22d	1.53d	2.66d	1.46d	66.32b	60.98b	67.52b	73.90a	67.65b	66.40b	67.36b
C_2	2.66c	3.22c	5.56c	3.33c	3.11c	3.22c	2.86c	62.15b	54.91c	53.38c	61.46b	64.47b	63.43b	64.68c
C_3	3.33b	4.11b	6.78b	4.11b	3.67b	4.66b	3.87b	49.12c	34.62d	40.75d	28.30c	56.53c	55.81c	62.84d
C_4	1.44 e	2.11e	3.33e	1.67d	0.68e	1.44e	0.51e	74.94a	73.86a	78.75a	78.41a	79.33a	75.41a	77.36a
$S\bar{x}$	0.061	0.139	0.108	0.192	0.099	0.062	0.146	1.66	2.04	1.25	1.73	2.03	1.87	0.553
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CV (%)	6.49	11.64	5.45	17.08	10.69	5.08	15.42	9.86	13.68	7.79	10.71	11.33	10.72	3.05

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

C_0 = No use of extract, C_1 = Aqueous extract of mustard crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of mustard crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of mustard crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

** =Significant at 1% level of probability.

j) Combined effect of variety and aqueous extract of mustard on number and percent inhibition on different weeds

For all the weed species V_2C_4 combination found the lowest number of weed population. On the other hand highest percent inhibition was also found in the same combination. (Table 26)

Table 26: Combined effect of variety and aqueous extract of mustard on number and percent inhibition on different weeds

	Number of weed per quadrate (25×25) cm^2							% Inhibition						
Weed name	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta	Bathua	Mutha	Biskatali	Durba	Tit begun	Shama	Angta
Treatments														
V_1C_0	5.00a	7.00a	11.67a	7.00	6.67a	7.33a	7.33a	0.00	0.00	0.00g	0.00e	0.00	0.00	0.00
V_1C_1	2.33f	3.33cde	6.00e	3.00	2.67e	3.33h	2.00fg	61.91	53.25	66.52b	66.25b	63.73	62.48	65.00
V_1C_2	3.00d	3.67cd	7.67c	4.00	3.67cd	4.00g	3.33cd	56.61	44.13	38.75e	58.45b	60.86	59.41	63.00
V_1C_3	3.67c	5.33b	8.67b	5.33	4.00bc	5.00d	4.93b	40.43	28.37	31.69f	4.89e	49.59	48.57	60.90
V_1C_4	1.33i	2.33fg	4.00h	2.67	1.00fg	1.67j	1.00hi	72.91	69.63	77.74a	76.90a	79.96	72.98	74.80
V_2C_0	4.33b	4.00c	7.00d	4.00	4.33b	6.00b	3.90c	0.00	0.00	0.00g	0.00e	0.00	0.00	0.00
V_2C_1	1.67gh	2.33fg	3.67h	1.67	1.27f	2.33i	0.73ij	68.47	66.99	68.86b	77.58a	67.00	66.58	70.00
V_2C_2	2.33f	3.00def	3.67h	2.67	3.33d	3.33h	2.44ef	65.21	62.98	63.09bc	63.97b	62.00	63.85	67.00
V_2C_3	2.67e	3.33cde	4.67 g	3.33	3.67cd	4.67e	3.10de	53.91	39.04	52.56d	44.40c	56.67	58.77	65.38
V_2C_4	1.67h	2.00g	2.33i	1.00	0.67gh	1.67j	0.20j	77.47	77.47	79.99a	79.05a	78.60	74.66	79.92
V_3C_0	5.00a	6.00b	8.67b	5.67	3.83bcd	5.66c	5.33b	0.00	0.00	0.00g	0.00e	0.00	0.00	0.00
V_3C_1	2.00g	2.67efg	5.00fg	2.00	0.65gh	2.33i	1.67gh	66.63	62.70	67.19b	77.86a	72.22	69.66	67.09
V_3C_2	2.67e	3.00def	5.33f	3.33	2.33e	2.33i	2.80de	62.72	57.64	58.30cd	61.97b	70.55	66.84	64.03
V_3C_3	3.67c	3.67cd	7.00d	3.67	3.33d	4.33f	3.57cd	50.26	36.45	38.01e	35.61d	63.33	60.13	62.24
V_3C_4	1.67h	2.00g	3.67h	1.33	0.37h	1.00k	0.33ij	74.45	74.49	78.54a	79.29a	79.44	78.58	77.35
$S\bar{x}$	0.107	0.240	0.187	0.333	0.172	0.108	0.253	2.88	3.55	2.16	2.99	0.350	3.23	0.961
Level of significance	**	**	**	NS	**	**	**	NS	NS	**	**	NS	NS	NS
CV (%)	6.49	11.64	5.45	17.08	10.69	5.08	15.42	9.86	13.68	7.79	10.71	11.33	10.72	3.05

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

** =Significant at 1% level of probability, NS = Non significant

V_1 = BRRI GOM19 (Sourav), V_2 = BARI GOM21 (Shatabdi), V_3 = BARI GOM24 (Prodip)

C_0 = No use of extract, C_1 = Aqueous extract of mustard crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of mustard crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of mustard crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

k) Effect of variety on yield and yield contributing characters of wheat

Varietal effect on yield and yield contributing characters of wheat showed the significant effect. No. of total tillers per hill, No of spikelet per spike, Unfilled grain per spike and Harvest index shows the significant effect. Highest harvest index (45.77) was obtained in BARI Gom24 followed by BARI Gom19 (45.41). (Table 27)

Table 27. Effect of variety on yield and yield contributing characters of wheat

Cultivars	No. of total tillers $hill^{-1}$	No. of non effective tillers $hill^{-}$	Spike length (cm)	No of spikelet $spike^{-1}$	Unfilled grain $spike^{-1}$	Harvest index (%)
V_1	4.05b	0.59	10.30	14.54b	2.84a	45.41a
V_2	4.30a	0.58	10.71	15.35a	2.61b	44.78b
V_3	4.15b	0.57	10.48	15.16a	2.72b	45.77a
Sx	0.042	0.026	0.157	0.117	0.038	0.178
Level of significance	**	NS	NS	**	**	**
CV (%)	3.84	17.52	5.80	3.01	5.51	1.52

V_1 = BRRI Gom19 (Sourav), V_2 = BARI Gom 21 (Shatabdi), V_3 = BARI Gom 24 (Prodip)
** =Significant at 1% level of probability
NS = Not significant

a) Effect of aqueous extract of mustard crop residues on yield and yield contributing characters of wheat

Aqueous extract of sorghum crop residues had also significant effect on yield and yield contributing characters. The highest harvest index (45.88) was produced by C_3 treatment, followed by C_1 (45.44) and lowest one (45.04) was produced by C_4 treatment. (Table 28)

Table 28. Effect of aqueous extract of mustard crop residues on yield and yield contributing characters of wheat

Residues	No. of total tillers $hill^{-1}$	No. of non-effective tillers $hill^{-}$	Spike length (cm)	No of spikelet $spike^{-1}$	Unfilled grain $spike^{-1}$	Harvest index (%)
C_0	3.78e	0.56	10.11b	13.97d	2.92a	45.07
C_1	4.39b	0.59	10.59ab	15.39ab	2.69c	45.44
C_2	4.13c	0.59	10.43ab	15.15bc	2.74bc	45.18
C_3	3.97d	0.60	10.31b	14.86c	2.86ab	45.88
C_4	4.55a	0.55	11.04a	15.70a	2.39d	45.04
Sx	0.054	0.033	0.203	0.150	0.049	0.230
Level of significance	**	NS	*	**	**	NS
CV (%)	3.84	17.52	5.80	3.01	5.51	1.52

** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant

C_0 = No use of extract, C_1 = Aqueous extract of mustard crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of mustard crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of mustard crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

Table 28. Effect of aqueous extract of mustard crop residues on yield and yield contributing characters of wheat

Residues	No. of total tillers hill^{-1}	No. of non-effective tillers hill^{-}	Spike length (cm)	No of spikelet spike^{-1}	Unfilled grain spike^{-1}	Harvest index (%)
C_0	3.78e	0.56	10.11b	13.97d	2.92a	45.07
C_1	4.39b	0.59	10.59ab	15.39ab	2.69c	45.44
C_2	4.13c	0.59	10.43ab	15.15bc	2.74bc	45.18
C_3	3.97d	0.60	10.31b	14.86c	2.86ab	45.88
C_4	4.55a	0.55	11.04a	15.70a	2.39d	45.04
Sx	0.054	0.033	0.203	0.150	0.049	0.230
Level of significance	**	NS	*	**	**	NS
CV (%)	3.84	17.52	5.80	3.01	5.51	1.52

** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant

C_0 = No use of extract, C_1 = Aqueous extract of mustard crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of mustard crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of mustard crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

b) Combined effects of variety and aqueous extract of mustard crop residues on yield and yield contributing characters of wheat

Yield and yield contributing characters like straw yield, grain yield and harvest index were significantly affected by the interaction between variety and crop residues. V_2C_4 combination showed the maximum result which was followed by $V_3C_{1.}$ (Table 29)

Table 29. Combined effects of variety and aqueous extract of mustard crop residues on yield and yield contributing characters of wheat

Variety x Residues	Plant height (cm)	No. of effective tillers hill^{-1}	Spike length (cm)	No. of grains spike^{-1}	1000 grain weight (gm)	Grain yield t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1C_0	90.07	3.07	9.92	37.98	54.50	3.02i	3.67j	45.20abc
V_1C_1	95.80	3.73	10.40	44.01	55.03	3.67ef	4.35gh	45.76ab
V_1C_2	94.87	3.37	10.22	43.49	54.73	3.50g	4.25gh	45.16abc
V_1C_3	90.67	3.27	10.19	42.87	54.57	3.35h	4.00i	45.60ab
V_1C_4	96.53	3.87	10.80	44.71	55.50	3.89d	4.69e	45.34abc
V_2C_0	92.53	3.33	10.28	42.13	55.03	3.62f	4.39fg	45.20abc
V_2C_1	100.10	3.87	10.82	45.30	55.90	4.23b	5.35b	44.17cd
V_2C_2	97.07	3.67	10.66	44.39	55.73	4.15c	5.10c	44.87bcd
V_2C_3	93.87	3.53	10.38	43.81	55.33	3.90d	4.60ef	45.91ab
V_2C_4	102.07	4.22	11.39	46.82	56.07	4.51a	5.79a	43.77d
V_3C_0	90.33	3.27	10.13	40.46	54.67	3.33h	4.10hi	44.82bcd
V_3C_1	98.53	3.80	10.56	44.51	55.60	4.15c	4.80de	46.37a
V_3C_2	95.73	3.60	10.41	43.71	55.60	3.89d	4.65e	45.51ab
V_3C_3	93.47	3.33	10.35	43.41	55.07	3.71e	4.33gh	46.14ab

Variety x Residues	Plant height (cm)	No. of effective tillers $hill^{-1}$	Spike length (cm)	No. of grains $spike^{-1}$	1000 grain weight (gm)	Grain yield t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_3C_4	101.33	3.93	10.93	45.89	55.77	4.26b	5.00cd	46.01ab
Sx	2.18	0.066	0.351	0.877	0.639	0.026	0.080	0.397
Level of sig.	NS	NS	NS	NS	NS	**	*	*
CV (%)	3.95	3.20	5.80	3.49	2.01	1.16	3.02	1.52

** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant

V_1 = BRRI GOM19 (Sourav), V_2 = BARI Gom 21 (Shatabdi), V_3 = BARI Gom 24 (Prodip)

C_0 = No use of extract, C_1 = Aqueous extract of mustard crop residues @ 1:20 ratio (w/v), C_2 = Aqueous extract of mustard crop residues @ 1:30 ratio (w/v), C_3 = Aqueous extract of mustard crop residues @ 1:40 ratio (w/v), C_4 = Hand weeding

12. Research highlight/findings (Bullet point – max 10 nos.):

- Among the 12 tested crop residues sorghum extract followed by grass pea extract suppressed weed growth shama
- 100% aqueous extract of sorghum followed by grass pea performed better as weed suppression agent
- Application of sorghum residues before transplanting of boro rice suppressed weed growth (shama, panikachu, and sabuj nakful) and gave maximum yield of rice
- Aqueous extract of sorghum residues @1;20 ratio (w/v) may be used for weed growh growth suppression in wheat

Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Laptop computer, Laser printer, UPS, Digital Camera, Scanner	101500.00	Laptop computer, Laser printer, UPS, Digital Camera, Scanner	101500.00	
(b) Lab &field equipment	FX-i series Precision balance, Electric Top Balance, Electric balance	209212.00	FX-i series Precision balance, Electric Top Balance, Top balance	209212.00	
(c) Other capital items	Steel Almirah	20000.00	Steel Almirah	20000.00	

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Repair and renovation of Lab.			30000.00	30000.00	

3. Training/study tour/ seminar/workshop/conference organized: Not applicable

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

4. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	412888	408533	408533	0	100	
B. Field research/lab expenses and supplies	628750	622890	622495	395	about 100	
C. Operating expenses	127500	122742	122500	242	about 100	
D. Vehicle hire and fuel, oil & maintenance	--	--	--	--	--	
E. Training/workshop/seminar etc.	--	--	--	--	--	
F. Publications and printing	85000	6500	6500	0	100	
G. Miscellaneous	15000	15000	15000	0	100	
H. Capital expenses	330712	330712	330712	637	100	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
1. To screen out potential crop residues for allelochemicals	1. 12 sample plants were grown and residues collected, preserved, chapped, and water soaked for 24 hours. Collected plant extracts for using in the experiment	1. Sorghum leaf extract suppressed weed growth by 74%.	1. Crop residue extract has allelopathic suppression effect to weed growth
2. To explore the possibility of using allelopathic properties of crop residues for weed suppression	2. Analyzed the crop residue samples for identifying the allelo-chemicals available.	2. Aqueous extract of sorghum with 100 % concentration inhibit the weed growth of Shama	2. Crop residues and their concentration has influence on inhibition of weed growth
3. To study the dose response and time of application of selected crop residues for crop performance	3. The crop residues used in different times of crop growth to measure its efficacy as suppressor of weed growth and yield improvement of test crop	3. The highest growth inhibition (59%) observed when crop residue applied before transplanting	3. Grain yield of test crops did not affected by use of crop residue extract
4. To study the aqueous extract of crop residues on crop	4. Variable doses and concentration of aqueous extract of sorghum and mustard crop residues were used on boro rice and wheat to observe the growth and yield performance	4. More than 60% growth inhibition were found in bathua, mutha, biskatali, durba, tit begun, shama and angta	4. Application of aqueous extract of sorghum and mustard crop residues has positive effect on yield of test crops

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	--	--	
Journal publication	03	--	**Proposed title:** 1.Efficasy of different crop residues extract on weed

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
			control in laboratory condition 2.Effect of variety and time of application of crop residues on weed control and crop performance of rice 3. Evaluation of variety and aqueous extract of crop residues on weed control and crop performance of wheat
Information development	--	--	Crop residues can be used in the field level to suppress weed successfully.
Other publications, if any	--	--	--

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

ii. **Generation of new knowledge that help in developing more technology in future**

Application of aqueous extract of sorghum crop residues @ 1:20 ratio (w/v) might be the potential source for alternate weed management technique in the field of wheat.

iii. Technology transferred that help increased agricultural productivity and farmers' income

iv. Policy Support

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

(a) A desk monitoring was done by PIU-BARC-NATP-2 team on 07.03.2018 that was leaded by Dr. Mian Sayeed Hassan, director, project implementation unit (PIU), BARC. According to the comments of monitoring team, the project was going on rightly and scheduled based.

(b) Research progress was presented in the six month progress workshop (15-16 May, 2018) that was presented on 15 May, 2018 at BARC auditorium.

(c) One year research progress was presented in the Annual Workshop (10-13, September) on 12 September, 2018 at BARC auditorium.

ii) Field Monitoring (time& No. of visit, Team visit and output):

(a) Two internal field monitoring was done by Bangladesh Agricultural University Research System (BAURES) team on March 03, 2018 and 17 May, 2018. Members of the monitoring team expressed their opinion as – highly satisfied.

(b)

<u>I. Lesson Learned/Challenges (if any)</u>

i) Large-scale research studies provided the best means of evaluating practical, replicable approaches to improving laboratory and field research knowledge.

ii) Learnt about data collection, preparation and presentation in scientific meeting.

iii) Learnt about management and proper expenditure of financial budget.

iii) Learnt about preparation and submission of scientific report.

<u>J. Challenges (if any)</u>

Signature of the Principal Investigator
Date: 27.01.2019
Seal

Counter signature of the Head of the organization/authorized representative
Date: 27.01.2019
Seal