Original Research Article

Allelopathic effects of residues of *Fimbristylisdichotoma* along with manures and fertilizers on the weed growth in *boro* rice

ABSTRACT

The current agricultural system is seeking a biological solution to lessen hazardous impacts from the use of chemicals to control weeds in rice production. Plant allelopathy is one of the ways where allelopathic plant inhibits its surrounding plants by releasing allelopathic substances. The investigation was done to determine the allelopathic effects of residues of *Fimbristylisdichotoma* along with manures and fertilizers on the weed management of *boro* rice. The field experiment consisted of two rice varieties i.e BRRI dhan29 and BRRI dhan89 and six treatment such as Control (T_1), Residues @ 3 t ha^{-1} + Recommended doses of inorganic fertilizers (T_2), Residues @ 3 t ha^{-1} + Tricho-compost @5 t ha^{-1} (T_3), Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers (T_4), Residues @ 3 t ha^{-1} + Tricho-compost @2.5 t ha^{-1} + 50% less than recommended doses of inorganic fertilizers (T_5) and Residues @ 3 t ha^{-1} + Tricho-compost @3.75 t ha^{-1} + 75% less than recommended doses of inorganic fertilizers (T_6). In experiment, at 25 DAT the highest weed density (35.0) was found in BRRI dhan89 when no residue was applied and the lowest (18.00) was found in BRRI dhan29 when applied 3 t ha^{-1} *F. dichotoma* residue with Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers. At 55 DAT the highest weed density (19.66) was found in BRRI dhan89 when no residue was applied and the lowest (10.66) was found in BRRI dhan89 when applied 3 t ha^{-1} *F. dichotoma* residue with Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers. In case of dry weight, at 25 DAT the highest weed dry weight (3.76 g) was found in BRRI dhan89 when no residue was applied and the lowest (1.72 g) was found in BRRI dhan29 when applied 3 t ha^{-1} *F. dichotoma* residue with Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers. At 55 DAT the highest weed dry weight (2.29 g) was found in BRRI dhan89 when no residue was applied and the lowest (1.46 g) was found in BRRI dhan89 when applied 3 t ha^{-1} *F. dichotoma* residue with Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers. Results of this study indicate that application of *F. dichotoma* residue with the incorporation of Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers showed potentiality to inhibit weed growth.

Keywords: Allelopathy; Manures;Fertilize;,Fimbristylisdichotoma; Weed management

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important grain crop in the world and the main source of food for most people. Rice, wheat, and maize account for 49% of all the calories consumed by people; 23% of those calories come from rice, 17% from wheat, and 9% from maize. Bangladesh is an agriculture-based country, with agriculture contributing for around 13.47% of its GDP [1].

According to the World Bank, Bangladesh's value added in agriculture, forestry, and fishery in 2021 was 11.63% [2]. In 2020, the share of agriculture in Bangladesh's gross domestic product was 12.92 percent [3]. According to the World Bank, Bangladesh's total agricultural land was reported at 70.69% in 2018. According to BRRI, 75% of the total cropped area and over 80% of the total irrigated area is planted to rice. With a 19.6% GDP contribution and 63% of the people employed, agriculture continues to be the most significant sector of the Bangladeshi economy. In our country overall area is 14.86 million ha, of which 8.52 million ha are cultivable and have a 191% cropping intensity [4]. Bangladesh is the fourth-largest producer and exporter of rice in the world, behind China, India, and Indonesia [5].

While a number of variables contribute to reduced rice yields, weeds have been highlighted as a significant biological barrier to Bangladesh's pursuit of optimal rice output. Weeds are thought to be the main factor limiting rice yield among the other elements. Without keeping the soil free of weed infestation, it is impossible to get the full benefits of the rice field [6]. The current climatic and edaphic conditions in Bangladesh are particularly conducive to the rapid growth of several weed species that fiercely compete with rice plants [7]. Weeds negatively impact plant height, leaf architecture, tillering behavior, shading ability, growth pattern, and crop length, making them fierce competitors with rice plants for space, nutrients, air, water, and light [8]. In Bangladesh, the loss in rice grain yield due to weeds in farmers' fields was estimated as 43–51% [9].

Fimbristylis dichotoma as noted one of the major weeds of paddy rice is widely distributed in Asia and Africa as well as in other parts of the tropics. *Fimbristylis dichotoma* grows mainly in the moist soils but can also grow in aerated soil [10]. The present research was undertaken to explore the allelopathic potentiality of *F. dichotoma* as there are no available information on allelopathy of these weed in field conditions. Organic manures are environment friendly than inorganic fertilizers. It has been found that adding fertilizer to the soil modifies it in a variety of ways, including chemical changes that may or may not affect how productive the soil is. *Fimbristylis dichotoma* residues was included in this research to measure the combined effect residues along weed manures and fertilizers. An appropriate combination of organic and inorganic sources of nutrients is required for sustainable agriculture because an imbalanced use of inorganic fertilizers and little or no use of organic manures reduces soil fertility, and since soil fertility is the major resource for increasing rice yield.

2. MATERIAL AND METHODS

2.1 Experimental Site and Soil

Geographically the experimental field is located at 24° 75″ N latitude and 90° 50″ east longitudes in the south west part of Old Brahmaputra River at an elevation of 18 m above the sea level. This site belongs to the non-calcareous dark grey floodplain soil under Old Brahmaputra Floodplain AEZ-9 [11]. Table 1 shows the research period's physical and chemical properties of the experiment field and soil.

Table 1. Physical and chemical properties of the experiment field and soil

Physical properties of the soil	
Constituent	**Results**
Bulk density (g c^{-1})	1.42
Particle density (g/cc)	2.60
Porosity (%)	44.7
Sand (1%) (0.0-0.02 mm)	21.75

Silt (%) (.02-0.002 mm)	66.60
Clay (%) (<0.002 mm)	11.65
Soil textural class	Silt loam
Chemical composition of the initial soil (0-15 cm depth)	
Soil PH	6.5
Organic matter (%)	1.30
Total nitrogen (%)	0.10
Available phosphorous (ppm)	27
Exchangeable potassium (me %)	0.12
Available Sulphur (ppm)	22.7
Available zinc	0.52
Cation Exchange Capacity (CEC)	42.27

Source: Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

2.2 Climate and weather

The major climatic parameters viz. temperature, humidity, rainfall and daily sunshine hours that prevailed during the experimental period are shown in Fig. 1. There was a moderate cold air temperature during the month of November to May and high air temperature during the rest of the months. The average air temperature during the experimental period was 16.46° C to 24.24°C. The average relative humidity was 74.18% to 83.71% and the total sunshine ranged between 132.9 to 203.9 hours' month^{-1} from November to May.

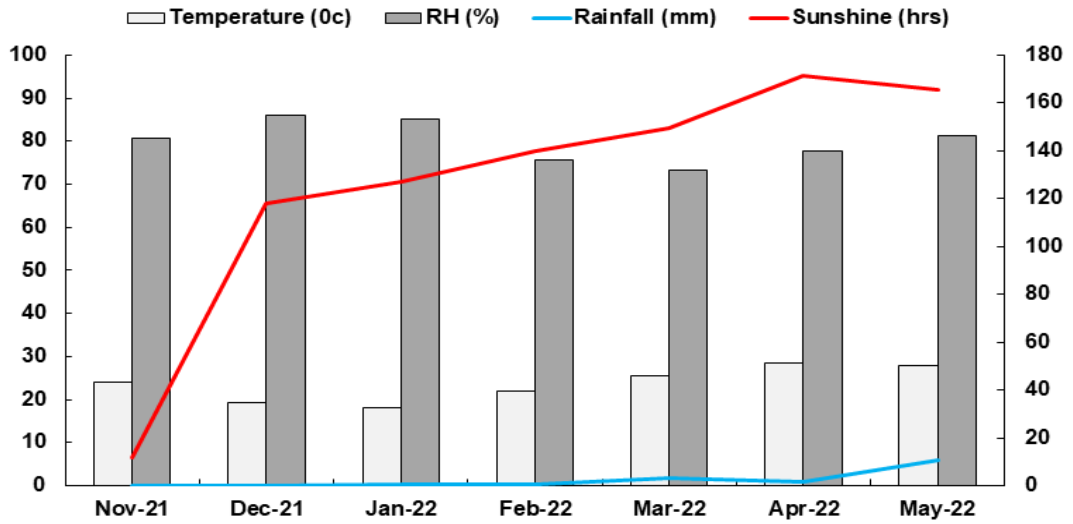

Fig. 1. Distribution of monthly average air temperature, relative humidity, rainfall and sunshine hours of the experiment site during the period from November 2021 to May 2022

2.3 Experimental Treatments

The experimental treatment consisted of two factors. They are as follows. Factor A: Rice cultivar (2): BRRI dhan29 (V_1), BRRI dhan89 (V_2). Factor B: Combination of manures and fertilizers with residues of *F. dichotoma*: Control (T_1), Residues @ 3 t ha^{-1} + Recommended doses of inorganic fertilizers (T_2), Residues @ 3 t ha^{-1} + Tricho-compost @5 t ha^{-1} (T_3),

Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers (T_4), Residues @ 3 t ha^{-1} + Tricho-compost @2.5 t ha^{-1} + 50% less than recommended doses of inorganic fertilizers (T_5), Residues @ 3 t ha^{-1} + Tricho-compost @3.75 t ha^{-1} + 75% less than recommended doses of inorganic fertilizers (T_6)

2.4 Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. There was total 36 plots for the experiment. The size of unit plot was 2.5 m × 2 m. Distance between plot to plot was 0.5 m and the distance between replication to replication was 1m. The row to row and plant to plant distances within a row were 30 cm and 15 cm, respectively.

2.5 Description of the Rice Cultivar

2.5.1 BRRI dhan29

BRRI dhan29 is a high yielding cultivar of *boro* rice developed by the Bangladesh Rice Research Institute (BRRI) Gazipur, Bangladesh. The cultivar was developed by crossing of BG 90-2 and BR 51-45-5 and was released in 1994. The cultivar BRRI dhan29 matures in 155-160 days. The plant height of BRRI dhan29 is 95 cm and medium slender and white. The grain is medium size and golden yellow in color. The harvesting period of BRRI dhan29 is mid-April to early May. The optimum yield of BRRI dhan29 is 7.5 ton/ha. BRRI dhan29 is moderately tolerant to leaf blight and sheath blight.

2.5.2 BRRI dhan89

BRRI dhan89 is a high yielding cultivar of *boro* rice developed by the Bangladesh Rice Research Institute (BRRI). The cultivar was developed by crossing of BRRI dhan29 and *Oryza rufipogon* and released in 2018. BRRI dhan89 is high yielding variety, transplanted *boro*, content of amylose is 28.5% and crop duration is 154-158 days. Protein content is 9.8%. 1000 grain weight is 24.4 gram. Plant height is 106 cm. The harvesting period of BRRI dhan89 is June-August. The optimum yield of BRRI dhan89 is 8-9.7 t ha^{-1}.

2.6 Collection and Preparation of Crop Residues

F. dichotoma residues was used in this study. These were collected from the Agronomy Field Laboratory, Bangladesh Agricultural University. After collection, the residues were dried under shade in the covered threshing floor and then residues were cut to small pieces by using a sickle.

2.7 Collection of Seed

Seeds of BRRI dhan29 and BRRI dhan89 were collected from the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh.

2.8 Seed Sprouting

Healthy seeds were selected by gravity method. Seeds were dipped in a water bucket for 24 hours. These were then taken out from water and kept thickly in a gunny bag. The seeds started sprouting after 48 hours and sown after 72 hours in the nursery bed.

2.9 Preparation of Seedling Nursery and Seed Sowing

A piece of high land was selected in the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh for raising seedlings. The land was puddled well with country plough by cleaning and leveling with ladder. Pre-germinated seeds were sown in the wet nursery bed on 20 November 2021. Proper care was taken to raise the seedling in the bed. Weeds were removed and irrigation was given in the nursery bed as and when necessary.

2.10 Land Preparation

The land was opened in 25 December 2021 with a power tiller. Then the land was puddled thoroughly by ploughing and cross ploughing four times with country plough followed by two laddering in order to level the soils. Subsequently the land was puddled with a country plough. Weeds and stubbles were removed from the field. The layout of the experimental field was done on 01 January 2022 in accordance with the experimental design.

2.11 Application of crop residues

F. dichotoma residues were applied at 7 days before transplanting of rice at the time of final land preparation. After that residues were mixed well to the respective plots by a spade.

2.12 Application of chemical fertilizers

Urea, triple super phosphate, muriate of potash, gypsum and zinc sulphate @ 248, 124, 112, 62 and 10 kg ha^{-1} were applied respectively. The whole amount of triple super phosphate, muriate of potash, gypsum and zinc sulphate were applied at the time of final land preparation and urea was applied in 3 equal splits at 15, 30, and 45 days after transplanting following experimental treatments.

2.13 Uprooting of Seedlings

40-day old seedlings were uprooted carefully. The nursery beds were made wet by application of water both in the morning and evening on the previous days of uprooting the seedlings to reduce mechanical injury and the seedlings were kept in soft mud in shade.

2.14 Transplanting of Seedlings

Seedlings were transplanted on 05 January 2022 at 25 cm x 15 cm spacing give 3 seedlings $hill^{-1}$.

2.15 Procedure of Recording Data

2.15.1 Weed population

Data on weed population were collected from each experimental plot of the rice plants at 25 and 55 DAT. The weeds within the experimental plots were counted and recorded accordingly.

2.15.2 Weed dry weight

After counting the weed all, the weeds inside each quadrate were uprooted, cleaned, separated species-wise and dried first in the sun and then in an electric oven for 96 hours at a temperature of 80°C. The dry weight of each species was taken by an electric balance.

2.16 Statistical Analysis

The data were compiled and tabulated in proper form for statistical analysis. The recorded data on various plant characters were statistically analyzed to find out the significance of variation resulting from the experimental treatments. The difference among treatment means was compared by Duncan's Multiple Range Test [12].

3. RESULTS AND DISCUSSION

3.1 Infested Weed Species in the Experimental Field

Six 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 plots have been presented in Table 2. The weeds of the experimental plots were *Eleocharis atropurpurea, Echinochloacrusgalli*, *Paspalum scrobiculatum, Monochoria Vaginalis*, *Cyperus difformis*and *Ecliptaprostrata*. Among the weed species one was broadleaf, two sedge, one herb and two were grass type morphology. There were two perennial and four annual weed species in the experimental plot. Bari et al. [13]in the experiment at Bangladesh Agricultural University reported that the three important weeds of rice fields were *Echinochloa crusgalli, Cyperus difformis* and *Scirpus juncoides*.

Table 2: Infesting weed species found growing in the experimental plots of rice

Sl. No.	Local Name	Scientific Name	Family	Morphological Type	Life Cycle
1	Panichaise	*Eleocharis atropurpurea*	Cyperaceae	Sedge	Annual
2	Shama	*Echinochloa crusgalli*	Gramineae	Grass	Annual
3	Angta	*Paspalum scrobiculatum*	Gramineae	Grass	Annual
4	Panikachu	*Monochoria Vaginalis*	Pontederiaceae	Broadleaf	Perennial
5	Sabuj Nakful	*Cyperus difformis*	Cyperaceae	Sedge	Annual
6	Keshuti	*Ecliptaprostrata*	Asteraceae	Herb	Annual/perennial

3.2 Effect of variety on different parameters

The effect of varieties on weed density was found to be non-significant. At 25 DAT, the highest weed density (29.66) was found in BRRI dhan89 (V_2) and the lowest weed density (26.94) was obtained in BRRI dhan29 (V_1). At 55 DAT, the highest weed density (15.50) was found in BRRI dhan89 (V_2) and the lowest weed density (14.27) was obtained in BRRI dhan29 (V_1) (Table 3). Varietal differences regarding the leaf area index might be due to differences in genetic constituents [14].

The effect of varieties on weed dry weight was found to be non-significant. At 25 DAT, the highest weed dry weight (2.79 g) was found in BRRI dhan89 (V_2) and the lowest weed dry weight (2.55 g) was found in BRRI dhan29 (V_1). At 55 DAT, the highest weed dry weight (1.92 g) was found in BRRI dhan89 (V_2) and the lowest weed dry weight (1.9 g) was obtained in BRRI dhan29 (V_1) (Table 3). Similar findings were reported by Jabber [15] and Hossain et al. [16], who found significant variation on weed dry weight.

Table 3: Effect of varieties on weed density and weed dry weight at the experimental plots of rice field

Variety	Weed density		Weed dry weight (g)	
	25 DAT	55 DAT	25 DAT	55 DAT
V_1	26.94	14.27	2.55	1.90
V_2	29.66	15.50	2.79	1.92
LSD $_{(0.05)}$	6.17	3.39	0.92	0.53
Level of Significance	NS	NS	NS	NS
CV%	21.54	13.03	19.89	20.17

In a column, figures with the same letter do not differ significantly as per DMRT. NS = Not significant, V_1 = BRRI dhan29, V_2= BRRI dhan89

3.3 Effect of *Fimbristylis dichotoma* residues with manures and fertilizers

The effect of different doses of manures and inorganic fertilizers with *Fimbristylis dichotoma* (L.) residues on weed density was found to be non-significant. At 25 DAT, the highest weed density (32.00) was found in T_1 (Control) and the lowest weed density (25.5) was obtained in T_4 (Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers). At 55 DAT, the highest weed density (16.66) was found in T_1 (Control) and the lowest weed density (13.5) was obtained in T_4 (Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers) (Table 4). Rahman et al. [27] also reported the similar results.

The effect of different doses of *Fimbristylis dichotoma* (L.) residues on weed dry weight was found to be non-significant. At 25 DAT, the highest weed dry weight (3.29 g) was found in Control (T_1) and the lowest weed dry weight (1.99 g) was obtained in T_4 (Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers). At 55 DAT, the highest weed dry weight (2.17 g) was found in Control (T_1) and the lowest weed dry weight (1.69 g) was obtained in T_4 (Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers) (Table 4). This result is in agreement with the findings of Akshay et al. [18].

Table 4:Effect of *Fimbristylis dichotoma* residues along with manures and fertilizers

Treatment	Weed density		Weed dry weight (g)	
	25 DAT	55 DAT	25 DAT	55 DAT
T_1	32.00	16.66	3.29	2.17
T_2	28.66	15.83	2.84	2.06
T_3	25.66	14.50	2.50	1.77
T_4	25.50	13.50	1.99	1.69
T_5	27.00	14.50	2.50	1.96
T_6	31.00	14.33	2.90	1.82
LSD $_{(0.05)}$	10.68	5.88	1.59	0.92
Level of Significance	NS	NS	NS	NS
CV%	21.54	13.03	19.89	20.17

In a column, figures with the same letter do not differ significantly as per DMRT. NS = Not significant, T_1 = Control, T_2 = Residues @ 3 t ha^{-1} + Recommended doses of inorganic fertilizers, T_3 = Residues @ 3 t ha^{-1} + Tricho-compost @5 t ha^{-1}, T_4 =Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers, T_5 = Residues @ 3 t ha^{-1} + Tricho-compost @2.5 t ha^{-1} + 50% less than recommended doses of inorganic fertilizers, T_6 = Residues @ 3 t ha^{-1} + Tricho-compost @3.75 t ha^{-1} + 75% less than recommended doses of inorganic fertilizers.

3.4 Effect of interaction of variety and residues of *Fimbristylis dichotoma* with manures and fertilizers

The interaction effect on weed density between variety and different doses of manures and inorganic fertilizers with *F. dichotoma* residue was found significant at 5% level of probability. At 25 DAT, the highest weed density (35.00) was found in V_2T_1 (BRRI dhan89 x control) and the lowest weed density (18.00) was obtained in V_1T_4 (BRRI dhan29 x Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers). At 55 DAT, the highest weed density (19.66) was found in V_2T_1 (BRRI dhan89 x control) and the lowest weed density (10.66) was obtained in V_2T_4 (BRRI dhan89 x Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers) (Table 5). Similar result was reported by Xu et al. [19].

The interaction effect on weed dry weight between variety and *F. dichotoma* residue was found non-significant at 5% level of probability. At 25 DAT, the highest weed dry weight (3.76 g) was found in V_2T_1 (BRRI dhan89 x control) and the lowest weed dry weight (1.72 g) was obtained in V_1T_4 (BRRI dhan29 x Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers). At 55 DAT, the highest weed dry weight (2.29 g) was found in V_2T_1 (BRRI dhan89 x control) and the lowest weed density (1.46 g) was obtained in V_2T_4 (BRRI dhan89 x Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers) (Table 5). Similar phenomenon was also reported byShultana et al. [20].

Table 5: Effect of interaction of variety and residues of *Fimbristylis dichotoma* along with manures and fertilizers

Interaction	Weed density		Weed dry weight (g)	
	25 DAT	55 DAT	25 DAT	55 DAT
V_1T_1	27.00ab	12.00ab	2.96	1.97
V_1T_2	28.66ab	13.66ab	3.65	2.16
V_1T_3	27.00ab	18.33ab	2.27	1.57
V_1T_4	18.00b	11.66ab	1.72	2.01
V_1T_5	28.66ab	14.00ab	1.91	1.62
V_1T_6	32.33ab	16.00ab	3.15	2.19
V_2T_1	35.00a	19.66a	3.76	2.29
V_2T_2	28.66ab	16.66ab	2.02	2.06
V_2T_3	33.00ab	17.33ab	2.05	1.97
V_2T_4	24.33ab	10.66b	2.82	1.46
V_2T_5	25.33ab	13.00ab	3.10	1.76
V_2T_6	31.66ab	15.66ab	2.66	1.91
$LSD_{(0.05)}$	15.11	8.32	2.26	1.30
Level of Significance	*	*	NS	NS
CV%	21.54	13.03	19.89	20.17

In a column, figures with the same letter do not differ significantly as per DMRT. * = Significant at 5% level of probability, NS = Not significant, V_1 = BRRI dhan29, V_2= BRRI dhan89, T_1 = Control, T_2 = Residues @ 3 t ha^{-1} + Recommended doses of inorganic fertilizers, T_3 = Residues @ 3 t ha^{-1} + Tricho-compost @5 t ha^{-1}, T_4 =Residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers, T_5 = Residues @ 3 t ha^{-1} + Tricho-compost @2.5 t ha^{-1} + 50% less than recommended doses of inorganic fertilizers, T_6 = Residues @ 3 t ha^{-1} + Tricho-compost @3.75 t ha^{-1} + 75% less than recommended doses of inorganic fertilizers.

4. CONCLUSION

From the above results it was found that the variety BRRI dhan29 along with T_4 treatment (*F. dichotoma* residues @ 3 t ha^{-1} + Tricho-compost @1.5 t ha^{-1} + 25% less than recommended doses of inorganic fertilizers) exhibited the superior effect. Therefore*, F. dichotoma* residue along with manures and inorganic fertilizers could be a potential source of weed management tool and an environment friendly package for sustainable crop production.

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