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Research Article

# THE ALLELOPATHIC EFFECTS OF *ELEOCHARIS ATROPURPUREA* AND *FIMBRISTYLIS DICHOTOMA* ON WEED MANAGEMENT OF *AMAN* RICE

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## Abstract

The existing rice-growing system continues to search for a biological way to decrease the harmful effects of using chemicals to control weeds. One way an allelopathic plant suppresses the plants around it is by releasing compounds that are also allelopathic, a process known as plant allelopathy. The current study examined the allelopathic effects of *Eleocharis atropurpurea* and *Fimbristylis dichotoma* on weed management of *aman* rice. It was carried out from July to December 2019 at the Bangladesh Agricultural University's Agronomy Field Laboratory in Mymensingh. The field trial included five treatments such as A: Residues of E. Atropurpurea and F. Dichotoma; No crop residues ($R_1$), 1.0 t ha$^{-1}$ ($R_2$), 2.0 t ha$^{-1}$ ($R_3$), 3.0 t ha$^{-1}$ ($R_4$), Farmars practices ($R_5$) and three rice varieties such as BRRI dhan34 ($V_1$), Nizershail ($V_2$), and Kalozira ($V_3$). In field experiment, the highest shama weed density (15.98) was found in BRRI dhan34 when no reside was applied and the lowest (2.38) was found in chesra at farmer's practice. In case of dry weight, the highest value (12.35 g) was recorded at no residues for the variety of BRRI dhan34, whereas the lowest weed dry weight (1.38 g) was found in kalozira at farmer's practice. Applying residues of *Eleocharis atropurpurea* and *Fimbristylis dichotoma*, especially at higher rates (3.0 t ha$^{-1}$), is recommended for sustainable weed control in aman rice cultivation.



## Introduction

Globally, rice (*Oryza sativa* L.) is the most essential grain crop, feeds most of the world's population. Rice, wheat, and maize account for 49% of all the calories consumed by people, with 23% coming from rice, 17% from wheat, and 9% from maize (BBS, 2022). Thus, around one-fourth of all calories consumed worldwide come from rice (Farhat *et al*., 2023). Global rice production reached around 759.6 million tons in 2017 (FAO, 2018). The most significant cereal crop in Asia is rice (*Oryza sativa*), of which 90% of the yearly production is farmed and consumed. However, as compared to worldwide mean yields, Asian mean yields are low (Haider, 2018). Although Bangladesh was the world's fourth-largest producer of rice, its productivity lagged behind other Asian nations. Geographic and agronomic condition of Bangladesh are favourable for rice cultivation which occupies nearly 74.85% of the total net cropped area of the country with annual production is 34.71 million metric tons from 11.38 million hectares (BBS, 2022). It is crucial to manage fertilizers properly in order to maximize rice output (Stellacci *et al.,* 2013). The consequences of allelopathy, which can be both growth-inhibiting and growth-promoting, are widely acknowledged (Quintana *et al*., 2008; Weidenhamer and Callaway, 2010). Allelopathy, according to Kohli *et al*. (1998) and Singh *et al*. (2001), is any direct or indirect impact of plants on other plants through the release of chemicals and is crucial in a variety of agro-ecosystems. One of the biggest causes of yield reductions worldwide is weed, which is commonly referred to as the silent killer of crops (Halder *et al*., 2023). Weeds not only reduce agricultural yield and quality but also monopolize vital space, moisture in the soil, and light (Islam *et al*. 2024a). An unwanted plant called weed interferes with natural resources, causing serious problems in agriculture.

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It has been established that weed is one of the main and oldest obstacles to growing as much rice as possible (Varanasi *et al*., 2015). Weeds also increased the cost of harvesting and production.

Weeds can be eliminated using a variety of weed control strategies, such as mechanical, chemical, biological, cultural, and manual methods (Siddika *et al*., 2024). *Eleocharis atropurpurea* (Retz.) is a small tufted annual weed that is extensively widespread in tropical, subtropical, and temperate countries. It is a member of the sedge family Cyperaceae (Mishra *et al*., 2017; Sarwar and Prodhan, 2011). Biological weed control involves the use of living organisms, such as insects, fungi, bacteria, or grazing animals, to manage and suppress weed populations. These biological agents target specific weeds, reducing their growth and reproduction while minimizing harm to other plants and the environment. This method promotes ecological balance and sustainability in weed management. It serves as a natural, eco-friendly alternative to chemical and mechanical control methods (Abbas *et al*., 2018). In weed-crop competition, high capability in taking of essential light, water, nutrients, and space by weeds makes them dominant to crops. Moreover, vigorous seed producing capacity and seed dormancy, ability to adapt in any conditions also makes the weeds a strong competitor of crops (Al Harun *et al*., 2014). In Bangladesh, a number of weeds grow in crop field, which compete with crop and reduce the crop yield. Control of weed, therefore, is essential to successful production of rice. Cultural, physical, biological and chemical methods are used to control of weeds in Bangladesh. Among them, farmers mostly used chemical method to control weed but it has negative effects both on human and environment. Therefore, researchers now searching some biological methods to control weed in rice cultivation. In these circumstances, plant allelopathy would a biological solution (Soltys *et al*., 2013). *E. atropurpurea* has a long, thin, spherical stem that reaches a maximum height of 10 cm. As a wetland plant, it grows widely in marshes, river bottoms, shallow water, and irrigated canals (Cook, 1996) and is also a harmful weed in rice fields (Sarwar and Prodhan 2011). It is generally known that *Fimbristylis dichotoma*, a prominent weed of paddy rice, is found across the tropics, particularly in Asia and Africa. While aerated soil can support growth, wet soils are the primary growth medium for *F. dichotoma* (Islam *et al*., 2024b). The current study was conducted to investigate the allelopathic potential of *F. dichotoma* and *E. atropurpurea* on the growth and yield of *aman* rice in field conditions.

## Materials and Methods

***Experiment site and treatments***

The present research work was carried out at the Agronomy Field Laboratory Bangladesh Agricultural University, Mymensingh during the period from June to December, 2019. The research field, positioned at 24°25´ N latitude and 90°50´ E longitude, was 18 meters above the level of the sea and belonged to the non-calcareous dark grey flooding plain soil under the Sonatala series of the Old Brahmaputra Flood plain. It was also part of the Agro-ecological area of the Old Brahmaputra Flood plain (AEZ-9) (FAO and UNDP, 1988). Two components made up the experimental treatment. They are as follows, Factor A: Residues of *E. Atropurpurea* and *F. Dichotoma;* No crop residues ($R_1$), 1.0 t ha$^{-1}$ ($R_2$), 2.0 t ha$^{-1}$ ($R_3$), 3.0 t ha$^{-1}$ ($R_4$), Farmars practices ($R_5$). Factor B: Rice Variety (3): BRRI dhan34 ($V_1$), Nizershail ($V_2$), Kalozira ($V_3$)

***Experimental design***

The research study was developed with two factor randomized complete block design (RCBD) with three separate replications. Each plot was 2.5 m × 2.0 m in size and in total 45 plots were used for the field experiment at BAU.

***Collection and preparation of crop residues***

In this work, residues from *F. dichotoma* and *E. atropurpurea* were used. The Agronomy Field Laboratory of Bangladesh Agricultural University provided them for collection. Following gathering, the residue material was shade-dried on a covered threshing floor before being roughly chopped with a sickle. After collection, the crop residues were dried under shade in the cover threshing floor of Agronomy Field Laboratory of BAU. The studied crop residues were cut as small as possible and then sample was ground using blender to make them powder.

***Preparation of seedling nursery bed and seed sowing***

A designated area of land was chosen to cultivate seedlings. The field was first leveled with a ladder and then thoroughly puddled with a country plough. On July 7, 2019, the sprouting seeds were sown in three distinct nursery beds. The necessary attention was given to the viable seedlings on the nursery bed.

***Preparation of the experimental land***

On July 30, 2019, the field was prepared. Following surface preparation, a tractor-drawn plough was used to plough the field. Weeds and stubbles were removed and cleaned from individual followed by laddering. Following final plots, the field's layout was created.

***Fertilizer application***

Urea, triple super phosphate (TSP), muriate of potash (MoP), and gypsum were applied at the rate of 130, 55, 82, and 10 kg $ha^{-1}$ to the experimental plots for BRRI Dhan34, Nizershail, and Kalozira. All fertilizers were administered in full quantities prior to final land preparation, with the exception of urea. At 20 and 40 DAT, urea was top dressed in two installments.

***Application of crop residues***

When the final land preparation was being done, the residues of *F. dichotoma* and *E. atropurpurea* were treated seven days before to the transplanting of rice. Afterwards, a shovel was used to thoroughly mix the remains into the appropriate plots. A total of 18 kg $ha^{-1}$ of residue was used for all plots.

***Uprooting seedlings***

One day before the plants were removed, the nursery bed was moistened with water. After being uprooted on August 15, 2019, the seedlings were moved right away to the main field. To be transplanted, healthy seedlings of a similar shape were chosen.

***Weed parameters at field***

***Weed Density (no. $m^{-2}$)***

Data on weed density were collected from each plot of the rice plants by using 0.25 m x 0.25 m quadrate as per method described by Cruz *et al*. (1986). The weeds with in the quadrate were counted accordingly at 25 and 50 DAT.

***Weed dry weight (g $m^{-2}$)***

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 72 hours at a temperature of 80°C. The dry weight of each species was taken by an electric balance.

***Statistical analysis***

Following correct accumulation and tabulation, the data were statistically analyzed. The computer program MSTAT-C was used to assist with the analysis of variance. Duncan's Multiple Range Test (DMRT), as described by Gomez and Gomez (1984), was used to determine the mean differences between the treatments (significance level at the $p<0.01$ and 0.05).

## Results and Discussion

***Infested weed species in the experimental field***

Infesting the experimental field were four weed species from five families. The weed in the field study is identified by its scientific name, life cycle, morphological type, family, and local name in Table 1. *Echinochloa crusgalli*, *Monochoria vaginalis*, *Scirpus juncoides*, and *Marsilea quadrifolia* L. were the weeds in the experimental plots. One weed species resembled grass in appearance, two were broadleaf, and one was hedges. The experimental plot contained two kinds of perennial weeds and two species of annual weeds.

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

| Local Name | Scientific Name | Family | Morphological Type | Life Cycle |
|---|---|---|---|---|
| Shama | *Echinochloa crusgalli* | Gramineae | Grass | Annual |
| Chesra | *Scirpus juncoides* | Cyperaceae | Sedge | Perennial |
| Panikachu | *Monochoria Vaginalis* | Pontederiaceae | Broadleaf | Perennial |
| Shusni shak | *Marsilea Quadrifolia L* | Marsileaceae | Broadleaf | Annual |

***Weed Density (WD)***

***Effect of variety on WD***

WD of panikachu, shama, shusni, chesra were significantly affected by variety. Maximum shama WD (10.68) was seen in BRRI Dhan34 and the lowest WD (8.86) was obtained in Nizershail (Figure 1). Maximum panikachu WD (10.10) was seen in Nizershail and the lowest WD (7.03) was found in Kalozira (Figure 1). The highest Shusni WD (7.31) found in Kalozira and the lowest WD (6.51) showed in Nizershail (Figure 1). Maximum WD of chesra (5.69) was showed in Kalozira and the lowest WD (4.84) was showed in BRRI dhan34 (Figure 1). BRRI dhan34 exhibited the highest WD for shama, indicating its lower weed suppression capacity, while Kalozira and Nizershail demonstrated better weed control, with lower WD for shusni and chesra. Thes

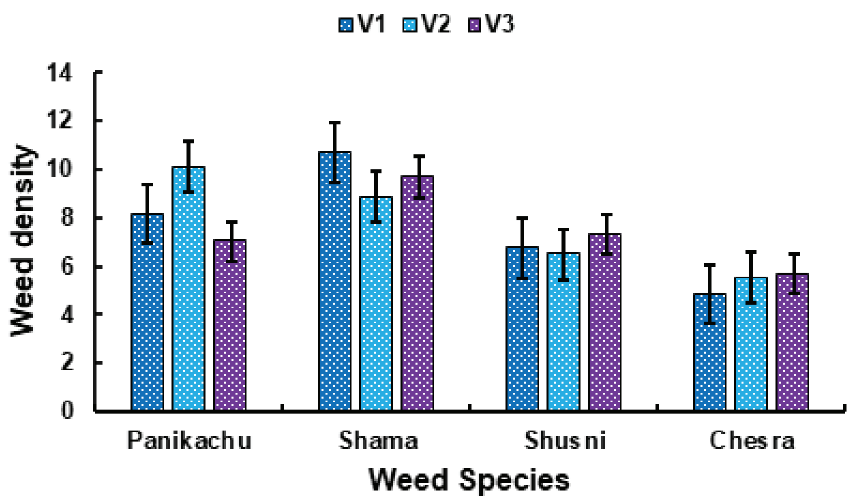


**Figure 1.** Variety's effect on weed density

$V_{1=}$ BRRI dhan34, $V_{2=}$ Nizershail, $V_3$= Kalozira

***Effect of E. atropurpurea and F. dichotoma residue on WD***

WD of shusni, chesra, panikachu, shama were significantly affected by *E. atropurpurea and F. dichotoma* residue. The highest shusni WD (11.24) was seen in $R_1$ and the lowest WD was found (2.83) in $R_5$ (Figure 2). In case of chesra the highest WD (7.95) was seen in $R_1$ and the lowest WD was observed (2.78) in $R_5$ (Figure 2). The highest panikachu WD (12.52) was seen in $R_1$ and the lowest (4.15) was seen in $R_5$ (Figure 2). In case of shama the highest WD (14.83) was seen in $R_1$ and the lowest (4.60) was seen in $R_5$ (Figure 2). The highest WD for all weed species was observed in the no-residue treatment, highlighting the greater weed competition in the absence of crop residues. The results are consistent with the findings of Islam *et al.* (2024b).

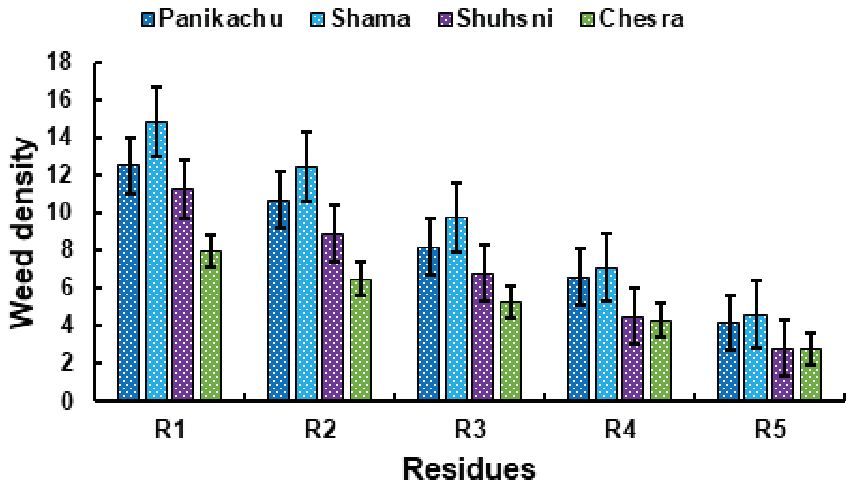


**Figure 2.** Effect of *E. atropurpurea* and *F. dichotoma* residue on weed density
$R_1$=No crop residue, $R_2$=1.0 t ha$^{-1}$, $R_3$=2.0 t ha$^{-1}$, $R_4$=3.0 t ha$^{-1}$, $R_5$=Farmers practices.

***Effect of interaction between variety and E. atropurpurea and F. dichotoma residue on WD***

The effect of combination between variety and *E. atropurpurea* and *F. dichotoma* residue was found significant on panikachu, shama, shusni and chesra WD (Table 2). The heighest WD found in $V_1R_1$ (BBRI dhan34xno crop residue) and the lowest WD found in $V_1R_5$ (BRRI dhan34 × farmers practice). The combination of BRRI dhan34 with no crop residue resulted in the highest weed density, while the farmer's practice effectively reduced weed density, indicating the importance of residue management in controlling weed growth. Similar results were supported by Mia *et al.* (2024)

**Table 2.** Effect of interaction of variety and E. atropurpurea and F. dichotoma residue on weed density

| Interaction | Weed density | | | |
|---|---|---|---|---|
| | **Panikachu** | **Shama** | **Shusni** | **Chesra** |
| $V_1R_1$ | 11.49bc | 15.98a | 10.65b | 7.33c |
| $V_1R_2$ | 10.72cd | 12.41d | 8.65d | 5.91e |
| $V_1R_3$ | 7.85ef | 10.18e | 6.59f | 4.88f |
| $V_1R_4$ | 6.70fg | 9.20f | 5.19g | 3.70g |
| $V_1R_5$ | 4.08hi | 5.62i | 2.75i | 2.38h |
| $V_2R_1$ | 15.07a | 14.36b | 11.24ab | 7.89b |
| $V_2R_2$ | 12.92b | 13.14c | 8.56d | 6.49d |
| $V_2R_3$ | 9.89d | 8.52g | 6.20f | 5.45e |
| $V_2R_4$ | 7.74ef | 4.99ij | 3.72h | 4.61f |
| $V_2R_5$ | 4.87hi | 3.30k | 2.83i | 3.29g |
| $V_3R_1$ | 10.99cd | 14.17b | 11.82a | 8.65a |
| $V_3R_2$ | 8.42e | 11.77d | 9.55c | 7.10c |
| $V_3R_3$ | 6.80fg | 10.54e | 7.61e | 5.44e |
| $V_3R_4$ | 5.46gh | 7.20h | 4.69g | 4.59f |
| $V_3R_5$ | 3.48i | 4.87j | 2.90i | 2.68h |
| **LSD (0.05)** | **1.43** | **0.65** | **0.62** | **0.55** |
| **Level of Significance** | * | ** | ** | * |
| **CV%** | **10.16** | **3.95** | **5.38** | **6.16** |

According to DMRT, values that belong to the same letter in a column do not differ appreciably. ** indicates significance at the 1% probability level, while * indicates significance at the 5% probability level, $V_1$= BRRI dhan34, $V_2$= Nizershail, $V_3$= Kalozira, $R_1$=No crop residue, $R_2$=1.0 t ha$^{-1}$, $R_3$=2.0 t ha$^{-1}$, $R_4$=3.0 t ha$^{-1}$, $R_5$=Farmers practices.

***Dry weight (DW)***

***Effect of variety on DW***

DW of shama, shusni, chesra and panikachu were significantly affected by variety. Maximum shama DW (7.88g/25cm$^2$) was seen in Nizershail and the lowest DW (6.55/25cm$^2$) was seen in Kalozira (Figure 3) and also the highest chesra DW (5.08/25cm$^2$) was seen in Nizershail and the lowest DW (3.56/25cm$^2$) was obtained in BRRI dhan34 (Figure 3). The highest shusni DW (5.02 g/25cm$^2$) was seen in Kalozira and the lowest DW (3.56/25cm$^2$) was seen in BRRI dhan34 (Figure 3). The highest panikachu DW (5.46/25cm$^2$) was seen in Nizershail and the lowest DW (4.58/25cm$^2$) was found in Kalozira (Figure 3). Nizershail had the highest DW for shama, chesra, and panikachu, according to the data, indicating a lesser level of weed-suppressive efficacy. The potential for integrated weed control was highlighted by the fact that BRRI dhan34 and Kalozira demonstrated superior weed suppression with reduced DW for the majority of weed species. Similar findings were found by Varanasi and Prasad (2015).

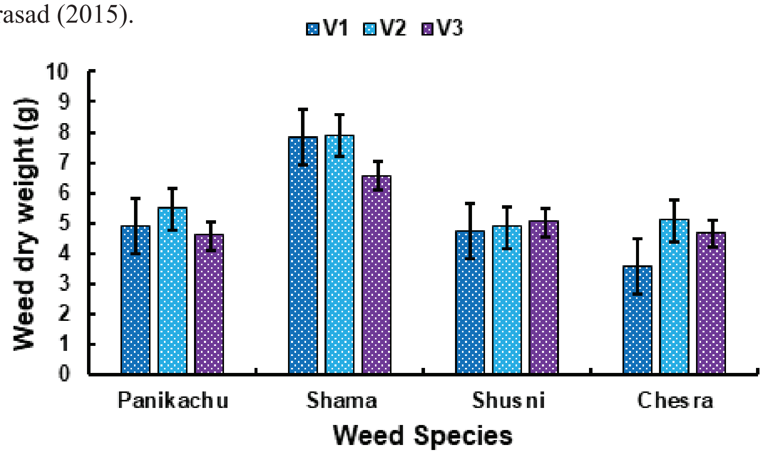


**Figure 3.** Effect of variety on dry weight

$V_{1=}$ BRRI dhan34, $V_{2=}$ Nizershail, $V_3$= Kalozira

***Effect of E. atropurpurea and F. dichotoma residue on DW***

DW of panikachu, shama, shusni and chesra were significantly affected by *E. atropurpurea* and *F. dichotoma* residue at. The highest panikachu DW (8.55g/25cm$^2$) was seen in $R_1$ and the lowest (2.01g/25cm$^2$) was found in $R_5$ (Figure 4). In case of shama the highest DW (12.00 g/25cm$^2$) was found in $R_1$ and the lowest (2.67 g/25cm$^2$) was seen in $R_5$ (Figure 4). The highest shusni DW (8.50 g/25cm$^2$) was seen in $R_1$ and the lowest (1.74gm/25cm$^2$) was found in $R_5$ and the highest chesra DW (6.71g/25cm$^2$) was found in $R_1$ and the lowest (2.02gm/cm$^2$) was found in $R_5$ (Figure 4). The results show that the no-residue treatment had the highest DW for all weed species, suggesting that more weed development was possible when agricultural residues were absent. However, the farmer's approach had the lowest DW, indicating that effective weed management techniques can greatly lower weed biomass. These results are in conformity with that obtained by Farhat *et al.* (2023).

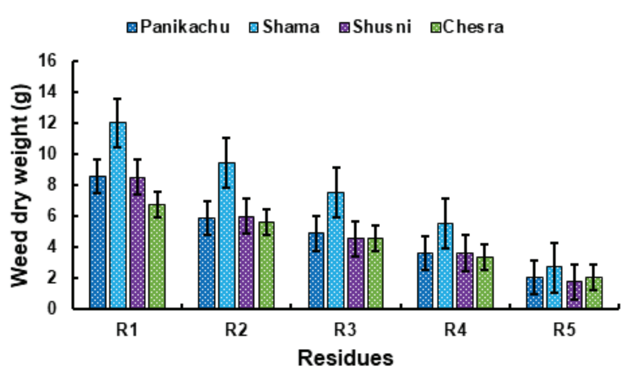


**Figure 4.** Effect of *E. atropurpurea* and *F. dichotoma* residue on dry weight

$R_1$=No crop residue, $R_2$=1.0 t ha$^{-1}$, $R_3$=2.0 t ha$^{-1}$, $R_4$=3.0 t ha$^{-1}$, $R_5$=Farmers practices.

***Effect of interaction between variety and E. atropurpurea and F. dichotoma residue on DW***

The effect of combination between variety and *E. atropurpurea* and *F. dichotoma* residue was found to be significant of panikachu, shama, susni and chesra DW (Table 3). The heighest weed DW found in $V_2R_1$ (Nizershailxno crop residue) and the lowest WD found in $V_1R_5$ (BRRI dhan34xfarmers practice). The highest weed dry weight was produced by the combination of Nizershail and no crop residue, but the farmer's method successfully reduced weed dry weight, underscoring the significance of residue management in lowering weed biomass. Similar results were supported by Mia *et al.* (2024).

**Table 3.** Effect of interaction between variety and *E. atropurpurea* and *F. dichotoma* residue on weed dry weight

| Interaction | Dry weight (g) | | | |
|---|---|---|---|---|
| | **Panikachu** | **Shama** | **Shusni** | **Chesra** |
| $V_1R_1$ | 8.72b | 12.35a | 8.11b | 5.61d |
| $V_1R_2$ | 5.84e | 9.55d | 5.69d | 4.80f |
| $V_1R_3$ | 4.31h | 7.36f | 4.73e | 3.46h |
| $V_1R_4$ | 3.58j | 6.48g | 3.64gh | 2.41i |
| $V_1R_5$ | 1.98l | 3.49j | 1.39j | 1.54k |
| $V_2R_1$ | 9.51a | 12.35a | 8.74a | 7.54a |
| $V_2R_2$ | 6.36d | 10.34c | 5.55d | 6.38c |
| $V_2R_3$ | 5.48f | 8.54e | 4.32f | 5.35e |
| $V_2R_4$ | 3.86i | 5.68h | 3.70g | 3.76g |
| $V_2R_5$ | 2.07l | 2.48k | 2.01i | 2.39i |
| $V_3R_1$ | 7.41c | 11.30b | 8.65a | 6.99b |
| $V_3R_2$ | 5.46f | 8.49e | 6.64c | 5.55d |
| $V_3R_3$ | 4.75g | 6.61g | 4.50f | 4.85f |
| $V_3R_4$ | 3.31k | 4.31i | 3.47h | 3.73g |
| $V_3R_5$ | 1.98l | 2.04l | 1.84i | 2.12j |
| **LSD (0.05)** | **0.11** | **0.13** | **0.21** | **0.15** |
| **Level of Significance** | ** | ** | ** | ** |
| **CV%** | **1.35** | **1.06** | **2.60** | **1.95** |

According to DMRT, values that belong to the same letter in a column do not differ appreciably. ** indicates significance at the 1% probability level, $V_{1=}$ BRRI dhan34, $V_{2=}$ Nizershail, $V_3$= Kalozira, $R_1$=No crop residue, $R_2$=1.0 t ha$^{-1}$, $R_3$=2.0 t ha$^{-1}$, $R_4$=3.0 t ha$^{-1}$, $R_5$=Farmers practices.

## Conclusion

Weed density, weed dry weight were significantly affected by species *E. atropurpurea and F. dichotoma* residue and their interaction. The highest weed density and dry weight for both weed species were found in no residue's treatment. The lowest weed density and dry weight for all weed species were found in *E. atropurpurea and F. dichotoma* residue at 3.0 t ha$^{-1}$ treatment. From the above results it was found that the variety Kalozira and $R_3$ (*E. atropurpurea* and *F. dichotoma* residue at 3 t ha$^{-1}$) treatment exhibited the superior effect. Therefore*, E. atropurpurea* and *F. dichotoma* residue could be a potential source of weed management tool for sustainable crop production.

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## Conflict of Interest

There is no conflict of interest, according to the authors.

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