

## Presumption of Herbicide Resistant Weeds and Yield of *Boro* Rice as Influenced by Pre- and Post-emergence Herbicides

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**Abstract:** In Bangladesh, weed infestation is a leading problem in rice cultivation and the sole dependency on post-emergence herbicides is ineffective. Therefore, a field experiment was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh from December 2021 to May 2022. The study was done to determine the relative effectiveness of different pre-emergence herbicides and to presume the herbicide-resistant weeds and yield of boro rice as influenced by pre- and post-emergence herbicides. Four rice varieties: BAU dhan3 (V<sub>1</sub>), BRRRI dhan28 (V<sub>2</sub>), BRRRI dhan81 (V<sub>3</sub>), BRRRI dhan96 (V<sub>4</sub>) and six herbicide managements: Control (H<sub>1</sub>), Hand Weeding at 30 DAT (H<sub>2</sub>), Bensulfuron methyl @ 980 g ha<sup>-1</sup> (H<sub>3</sub>), Pretilachlor @ 2 L ha<sup>-1</sup> (H<sub>4</sub>), Carfentrazone ethyl @ 208 mL ha<sup>-1</sup> (H<sub>5</sub>), Ethoxisulfuron @ 200 g ha<sup>-1</sup> (H<sub>6</sub>) were used in a randomized complete block design (RCBD) with three replications. The most dominant weed species in the experimental plots were *Echinochloa crusgalli*, *Scirpus mucronatus*, *Monochoria hastata*, *Enhydra fluctuans* and *Oxalis europaea*. This study found Ethoxisulfuron (H<sub>6</sub>) and Carfentrazone ethyl (H<sub>5</sub>) were the most effective weed management treatments for weed suppression and grain yield at twice the recommended doses. In this study, the highest grain yield (5.40 t ha<sup>-1</sup>), straw yield (6.80 t ha<sup>-1</sup>) and biological yield (12.20 t ha<sup>-1</sup>) were obtained from BRRRI dhan81 (V<sub>3</sub>) with hand weeding (H<sub>2</sub>) and highest harvest index (45.60%) were obtained from BAU dhan3 (V<sub>1</sub>) with Pretilachlor (H<sub>4</sub>). Therefore, this result is useful for farmers at field level cultivation of *boro* rice.

**Keywords:** Ethoxisulfuron; Carfentrazone; Grain yield; Phytotoxicity; Rice varieties.

### INTRODUCTION

In Bangladesh, rice (*Oryza sativa* L.) is the most important crop and one of the most delicate agricultural goods for local and international markets. The most important product's raw material is rice, which is also used to make some food items in the entire country. Rice is the staple food, with an average annual consumption rate per capita of 144.5 kg year<sup>-1</sup> (Yunus *et al.* 2019). Bangladesh earns about 11.20% of its gross domestic product (GDP) from agriculture (BBS, 2023). Rice is a tropical crop cultivated in almost all parts of Bangladesh. There are three primary growing seasons for rice. Among the rice groups grown in our country, boro rice, in particular, covers 4852.29 thousand hectares of land with a production of 2076.76 thousand MT year<sup>-1</sup> (BBS, 2023). Due to low-yielding varieties, heavy weed infestations, and inadequate

crop management, the average rice production is declining. Weed infestation is the most prominent problem causing poor rice output among these issues. Weeds, including in Bangladesh, are among the most critical constraints to crop production worldwide. According to the ISWS conference (2020), approximately 11.5% of the global production of essential crops is lost as a result of weed infestation. Without weed control, rice production can be decreased by 16 to 88% or even 100% (Khanh *et al.* 2013). The massive loss in yield presupposes weeds are seriously detrimental to crop production and must be prevented from growing or eliminated. It is a severe limitation of crop production for an overpopulated small country such as Bangladesh.

Proper weed management is crucial for optimizing rice yields in Bangladesh, where various weeds, typically classified as grasses, sedges, and broadleaf weeds,

commonly infest fields. Traditional weed control methods include preparatory land tillage, hand weeding with hoes, and hand pulling, with hand weeding being the most prevalent. Typically, two to three hand weedings are conducted per rice crop cycle, depending on the type and severity of weed infestation. However, heavy rainfall, flooding, high temperatures, or labor shortages can impede these traditional methods during critical periods (Chauhan *et al.* 2015). The current reliance on post-emergence herbicides alone by rice growers has proven ineffective, highlighting the need for an integrated weed management strategy incorporating pre-emergence herbicides. Such strategies offer initial benefits by reducing weed pressure, enhancing crop competitiveness, and yielding economic benefits. A lot of research has shown that pre-emergence herbicides like pendimethalin, oxadiazon, butachlor, and pretilachlor work to get rid of weeds (Stickler *et al.* 1969; Yang & Holmen, 2007; He *et al.* 2013).

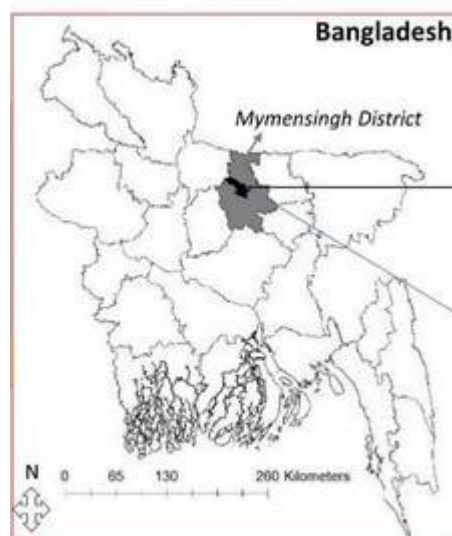
Pendimethalin is a dinitroaniline herbicide that breaks down microtubules needed to make microfibrils in the cell wall. This stops cells from growing and chromosomes from moving during mitosis in germinating seeds and young weed shoots (Appleby & Valverde, 1989). Oxadiazon stops protoporphyrinogen oxidase, an important enzyme for plant growth, which breaks down plant tissues (Dayan *et al.* 2001). Butachlor and other chloroacetanilide herbicides, like pretilachlor, hinder enzymes from synthesizing chlorophyll and fatty acids (Gotz & Boger, 2004). Despite their proven efficacy, detailed information on the performance of pre-emergence and pre-emergence herbicides still needs to be provided. Recent studies have reported significant increases in GY and effective weed control with these herbicides. For instance, a study found a 22% increase in GY with an 80 kg ha<sup>-1</sup> seeding rate using pretilachlor (Onwuchekwa-Henry *et al.* 2022). Awan *et al.* (2016) reported complete control of *E. colona*, *E. crus-galli*, and *Leptochloa chinensis* with oxadiazon. However, instances of phytotoxicity in rice from oxadiazon and pendimethalin have been noted, particularly in smallholder fields, which could adversely affect rice plant metabolism, morphology, and physiology (Awan *et al.* 2016; Ryu *et al.* 2020; Onwuchekwa-Henry *et al.* 2023).

Given these concerns, there is a compelling need to explore further and compare the effectiveness of pre-emergence herbicides with traditional farmer practices of omitting them. This study hypothesizes that pre-emergence herbicides reduce weed biomass and enhance GY compared to fields where no pre-emergence herbicides are applied under various post-emergence herbicide applications and seeding rates. The aim is to determine the relative effectiveness of different pre-emergence herbicide options on weed biomass, rice growth, and yield, providing crucial insights for optimizing weed management in rice cultivation.

## MATERIALS AND METHODS

### Experimental site

The experiment was conducted at the Agronomy Field Laboratory (AFL), Bangladesh Agricultural University (BAU), Mymensingh, from December 2019 to June 2020. The study location is situated at 90°50' E longitude, 24°25' N latitude, and an elevation of 18 meters above sea level. It is part of the Old Brahmaputra floodplain (AEZ-9) (FAO & UNDP, 1988) (Figure. 1). The soil of the experimental field was nearly neutral with a pH value of 6.8, moderate in organic matter, and had a moderate fertility level. The land type was medium high, with a silty loam texture. The climate of the locality is sub-tropical, characterized by high temperatures and heavy rainfall during the Kharif season (April to September) and minimal rainfall with moderately low temperatures during the Rabi season (October to March). Detailed information on the monthly mean values of daily maximum, minimum, and average temperatures, relative humidity, monthly total rainfall, and sunshine hours received at the experimental station during the study period was recorded.



**Figure 1.** Map of the study area

### Experimental treatments and design

The experiment was meticulously designed, consisting of two components. Factor A contains four varieties, such as BAU dhan3 (V<sub>1</sub>), BRR1 dhan28 (V<sub>2</sub>), BRR1 dhan81 (V<sub>3</sub>), BRR1 dhan96 (V<sub>4</sub>). Factor B formed, viz., Control (H<sub>1</sub>), Hand Weeding at 30 DAT (H<sub>2</sub>), Bensulfuron methyl @ 980 g ha<sup>-1</sup> (H<sub>3</sub>), Pretilachlor @ 2 L ha<sup>-1</sup> (H<sub>4</sub>), Carfentrazone ethyl @ 208 mL ha<sup>-1</sup> (H<sub>5</sub>), Ethoxisulfuron @ 200 g ha<sup>-1</sup> (H<sub>6</sub>). The experiment was laid out in a randomized complete block design (RCBD) with three replications, ensuring the reliability of the results. The doses were assigned to the main plot, and the herbicides were randomly allocated to the subplot. The unit plot size was 10.0 m<sup>2</sup> (4.0 m × 2.5 m). The distance between the two plots was 0.5 m. The total number of plots were 6×4×3=72.

### Phytotoxicity of Herbicides to Rice Plants

The phytotoxicity of herbicides to rice plants was assessed through visual observation, noting symptoms such as leaf yellowing, leaf-tip burning, and stunted growth, following the IRRI (1965) guidelines. The observed toxicity levels were categorized as no, slight, moderate, severe, and toxic.

### Preparation of plots and Crop husbandry

A designated plot was meticulously prepared for seedling cultivation. Initially, the soil was thoroughly puddled using a traditional country plough and levelled using a ladder. The plot was partitioned into two symmetrical sections for the sowing of sprouted seeds in a wet nursery bed on 5 December 2021. Measures were implemented to promote the healthy development of seedlings, including regular weeding and necessary irrigation. Preparation of the experimental land commenced with a tractor-drawn disc plough, followed by intensive puddling achieved through multiple rounds of ploughing and cross ploughing with a power tiller. Subsequent levelling was performed using a ladder. The experimental setup was finalized on December 28, 2019, with precise adherence to the experimental design, which included removing all weeds and stubbles from each plot. Fertilization of the experimental plots involved the application of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulphate at rates of 220, 120, 150, 85, and 10 kg ha<sup>-1</sup>, respectively. The total quantities of TSP, MoP, gypsum, and zinc sulphate were incorporated during the final land preparation phase. According to BRRI (2013), urea was strategically top-dressed in three equal installments at three crucial growth stages: 15 days after transplanting (DAT), during tillering, and at panicle initiation. To ensure minimal disruption during transplantation, the nursery bed was irrigated one day before the uprooting of the seedlings, which facilitated their easy extraction with minimal mechanical damage to the roots. The seedlings, aged forty days, were transplanted

into the well-prepared, puddled field on 20 January 2022. Planting was executed at a density of three seedlings hill<sup>-1</sup>, with rows spaced 25 cm apart and hills spaced 15 cm apart, ensuring optimal growth conditions.

### Harvesting and data collection

Data regarding WP at 30 DAT were systematically gathered from each experimental plot utilizing a 0.50 m × 0.50 m quadrat in accordance with the methodology outlined by Cruz *et al.* (1986). Weeds within each quadrat were enumerated and subsequently converted to a density per square meter by multiplying by a factor of four. Following the WP assessment, the weeds from each quadrat were meticulously uprooted, cleaned, and classified by species. The collected weed samples were then subjected to sun drying followed by dehydration in an electric oven maintained at 80°C for a duration of 72 hours. The DW of each species was determined using an electronic balance and recorded in grams per square meter, ensuring the accuracy and reliability of the data.

The harvesting process was carried out when the crops reached the appropriate level of maturity for harvesting and 1 m<sup>2</sup> area was chosen in the central section of each plot to measure the GY and SY. The GY was converted to a moisture content of 14% and translated to metric tons hectare<sup>-1</sup>. No. of total tiller hill<sup>-1</sup>, and total DW hill<sup>-1</sup> were recorded for each plot, with five hills being tagged. The data was collected 30 DAT. During the harvest, many measurements were taken, including PH, NET hill<sup>-1</sup>, panicle length (PL), number of grains panicle<sup>-1</sup> (NG), 1000-grain weight (TGW), GY, and SY. Subsequently, the BY and HI were computed.

### Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package, MSTAT-C. The mean differences among the treatments were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

## RESULT AND DISCUSSION

Nine weed species from five different families infested the experimental field. Of these, four species were grasses, three were broadleaves, and two were sedges. The local names, scientific names, families, morphological types, and life cycles of the weeds present in the experimental plot are

detailed in Table 1. The predominant weeds in the experimental plots included *Echinochloa crusgalli*, *Monochoria hastata*, *Leersia hexandra*, *Scirpus mucronatus*, *Scirpus articulatus*, *Panicum repens*, *Digitaria ischaemum*, *Enhydra fluctuans* and *Oxalis europaea*.

**Table 1.** Infested weed species were found in the experimental rice plots

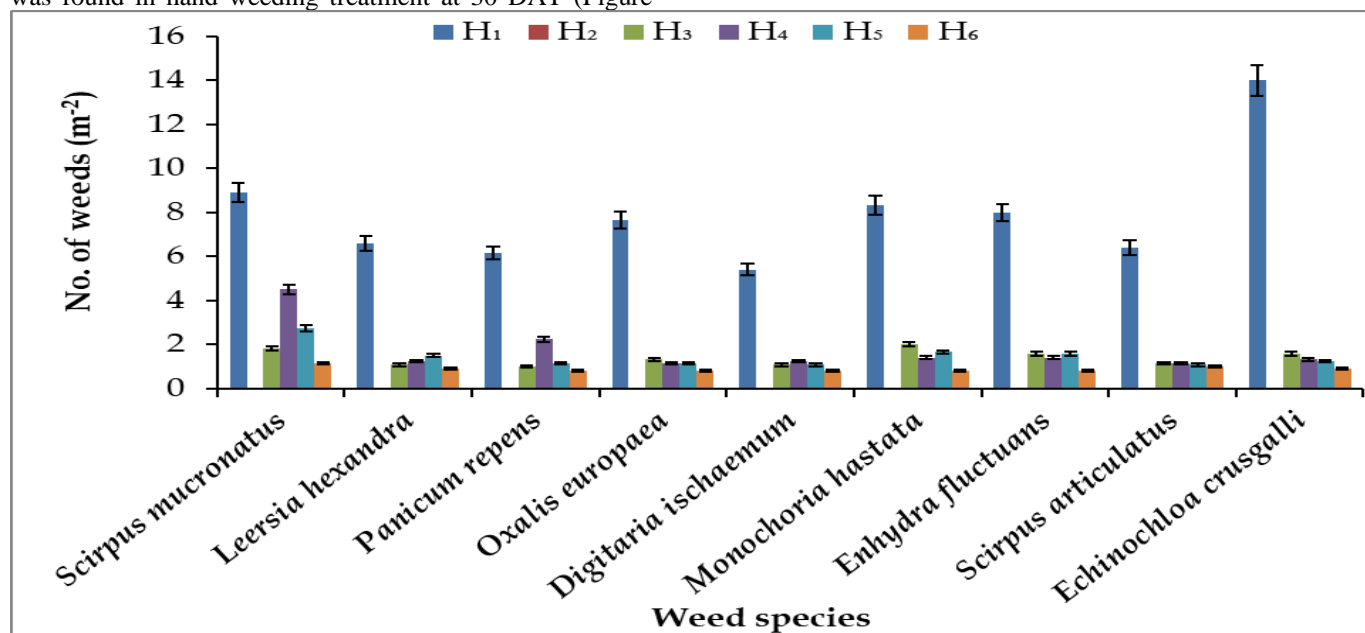
| Local name   | Scientific name      | Family         | Morphological type | Life cycle |
|--------------|----------------------|----------------|--------------------|------------|
| Shama        | <i>E. crus-galli</i> | Poaceae        | Grass              | Annual     |
| Chotoangulee | <i>D. ischaemum</i>  | Poaceae        | Grass              | Annual     |
| Arail        | <i>L. hexandra</i>   | Poaceae        | Grass              | Perennial  |
| Angta        | <i>P. repens</i>     | Poaceae        | Grass              | Perennial  |
| Panikachu    | <i>M. hastata</i>    | Pontederiaceae | Broad leaved       | Perennial  |
| Helencha     | <i>E. fluctuans</i>  | Onagraceae     | Broad leaves       | Annual     |
| Chechra      | <i>S. mucronatus</i> | Cyperaceae     | Sedge              | Perennial  |

|        |                       |             |        |           |
|--------|-----------------------|-------------|--------|-----------|
| Noldug | <i>S. articulatus</i> | Cyperaceae  | Sedge  | Annual    |
| Noldog | <i>S. articulatus</i> | Cyperaceae  | Sedge  | Annual    |
| Motka  | <i>O. europaea</i>    | Oxalidaceae | Leaves | Perennial |

**Effect of herbicides on density of weed species**

WP were significantly influenced by weed management practices. The highest WP (14.00 no. m<sup>-2</sup>) was found in control treatment at 30 DAT and the lowest WP (m<sup>-2</sup>) (0.00) was found in hand weeding treatment at 30 DAT (Figure

2). Similar findings were reported by Zahan *et al.* (2017), who found significant variation in weed species under different herbicide applications.



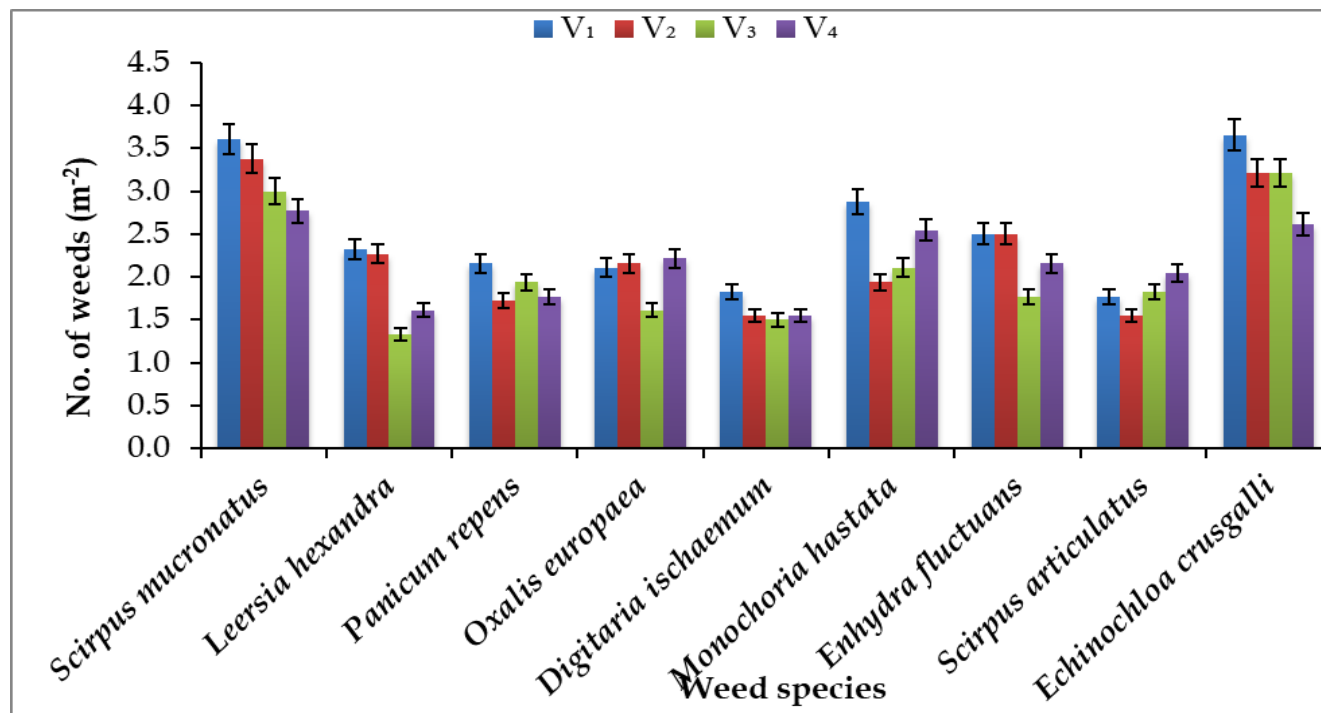
**Figure 2.** Effect of herbicides on density of weed species at 30 DAT

H<sub>1</sub>=Control, H<sub>2</sub>=Hand weeding, H<sub>3</sub>=Bensulfuron methyl, H<sub>4</sub>=Pretilachlor, H<sub>5</sub>=Carfentrazon ethyl, H<sub>6</sub>=Ethoxisulfuron

**Effect of variety on density of weed species**

Weed population and species m<sup>-2</sup> were significantly influenced by weed management practices (Figure. 2). The highest weed population (m<sup>-2</sup>) (3.61) was found in BAU dhan3 (V<sub>1</sub>) at 30 DAT and the lowest weed population (m<sup>-2</sup>)

was found in BRR dhan81 (V<sub>3</sub>) (1.33) at 30 DAT (Figure. 3). Similar findings were reported by Mostofa *et al.* (2024) who found significant variation on weed species in case of different rice variety.



**Figure 3.** Effect of variety on density of weed species at 30 DAT  
 Here, V<sub>1</sub>=BAU dhan3, V<sub>2</sub>=BRRRI dhan28, V<sub>3</sub>=BRRRI dhan81, V<sub>4</sub>= BRRRI dhan96

**Interaction effect between herbicides and variety on density of weed species**

WP (m<sup>-2</sup>) were significantly influenced by weed management practices. The highest weed population was found in control (H<sub>1</sub>V<sub>1</sub>) treatment at 30 DAT and the lowest

weed population was found in hand weeding (H<sub>2</sub>V<sub>1</sub>) followed by (H<sub>2</sub>V<sub>2</sub>), (H<sub>2</sub>V<sub>3</sub>) and (H<sub>2</sub>V<sub>4</sub>) treatment at 30 DAT (Table 2). Similar findings were reported by Rahman et al. (2024) who found significant variation on weed species under herbicide and variety.

**Table 2.** Interaction effect between herbicide and variety on weed population and species

| Interaction                   | <i>S. mucronatus</i> | <i>L. hexandra</i> | <i>P. repens</i> | <i>O. europaea</i> | <i>D. ischaemum</i> | <i>M. hastata</i> | <i>E. fluctuans</i> | <i>S. articulatus</i> | <i>E. crusgalli</i> |
|-------------------------------|----------------------|--------------------|------------------|--------------------|---------------------|-------------------|---------------------|-----------------------|---------------------|
| H <sub>1</sub> V <sub>1</sub> | 10.33a               | 8.00b              | 7.33a            | 7.66b              | 6.00a               | 10.00b            | 8.66b               | 6.66b                 | 13.00c              |
| H <sub>2</sub> V <sub>1</sub> | 0.00j                | 0.00h              | 0.00g            | 0.00f              | 0.00e               | 0.00g             | 0.00g               | 0.00e                 | 0.00i               |
| H <sub>3</sub> V <sub>1</sub> | 3.33fg               | 1.00fg             | 1.00ef           | 1.33de             | 1.00cd              | 2.00de            | 1.00f               | 1.00d                 | 2.33e               |
| H <sub>4</sub> V <sub>1</sub> | 5.66cd               | 1.33fg             | 2.33d            | 1.33de             | 1.66c               | 2.33d             | 2.00de              | 1.00d                 | 1.66ef              |
| H <sub>5</sub> V <sub>1</sub> | 1.33hi               | 2.33e              | 1.33ef           | 1.33de             | 1.33cd              | 2.00de            | 2.33d               | 1.00d                 | 1.33fg              |
| H <sub>6</sub> V <sub>1</sub> | 1.00ij               | 1.33fg             | 1.00ef           | 1.00e              | 1.00cd              | 1.00f             | 1.00f               | 1.00d                 | 1.00fgh             |
| H <sub>1</sub> V <sub>2</sub> | 10.33a               | 9.00a              | 5.33b            | 8.00b              | 5.33ab              | 6.333c            | 9.66a               | 5.00c                 | 15.00b              |
| H <sub>2</sub> V <sub>2</sub> | 0.00j                | 0.00h              | 0.00g            | 0.00f              | 0.00e               | 0.00g             | 0.00g               | 0.00e                 | 0.00i               |
| H <sub>3</sub> V <sub>2</sub> | 1.66hi               | 1.33fg             | 1.00ef           | 2.00d              | 1.00cd              | 2.66d             | 2.33d               | 1.33d                 | 1.66ef              |
| H <sub>4</sub> V <sub>2</sub> | 6.66c                | 1.00fg             | 2.33d            | 1.33de             | 1.33cd              | 1.00f             | 1.33ef              | 1.33d                 | 1.33fg              |
| H <sub>5</sub> V <sub>2</sub> | 1.00ij               | 1.66ef             | 1.00ef           | 1.00e              | 1.00cd              | 1.00f             | 1.00f               | 1.00d                 | 2.33e               |
| H <sub>6</sub> V <sub>2</sub> | 0.66ij               | 0.66gh             | 0.66fg           | 0.66ef             | 0.66de              | 0.66fg            | 0.66fg              | 0.66de                | 1.66ef              |
| H <sub>1</sub> V <sub>3</sub> | 8.33b                | 3.33d              | 4.66b            | 5.33c              | 5.00b               | 6.000c            | 4.66c               | 6.00b                 | 16.00a              |
| H <sub>2</sub> V <sub>3</sub> | 0.00j                | 0.00h              | 0.00g            | 0.00f              | 0.00e               | 0.00g             | 0.00g               | 0.00e                 | 0.00i               |
| H <sub>3</sub> V <sub>3</sub> | 1.33hi               | 1.00fg             | 1.00ef           | 1.00e              | 1.33cd              | 2.33d             | 2.00de              | 1.00d                 | 1.00fgh             |
| H <sub>4</sub> V <sub>3</sub> | 2.33gh               | 1.66ef             | 3.33c            | 1.00e              | 1.00cd              | 1.00f             | 1.00f               | 1.33d                 | 1.33fg              |
| H <sub>5</sub> V <sub>3</sub> | 4.66de               | 1.00fg             | 1.66de           | 1.33de             | 1.00cd              | 2.33d             | 2.00de              | 1.33d                 | 0.66ghi             |
| H <sub>6</sub> V <sub>3</sub> | 1.33hi               | 1.00fg             | 1.00ef           | 1.00e              | 0.66de              | 1.00f             | 1.00f               | 1.33d                 | 0.33hi              |
| H <sub>1</sub> V <sub>4</sub> | 6.66c                | 6.00c              | 7.33a            | 9.66a              | 5.33ab              | 11.00a            | 9.00ab              | 8.00a                 | 12.00d              |
| H <sub>2</sub> V <sub>4</sub> | 0.00j                | 0.00h              | 0.00g            | 0.00f              | 0.00e               | 0.00g             | 0.00g               | 0.00e                 | 0.00i               |
| H <sub>3</sub> V <sub>4</sub> | 1.00ij               | 1.00fg             | 1.00ef           | 1.00e              | 1.00cd              | 1.00f             | 1.00f               | 1.33d                 | 1.33fg              |

|                               |        |        |        |        |        |        |        |       |         |
|-------------------------------|--------|--------|--------|--------|--------|--------|--------|-------|---------|
| H <sub>4</sub> V <sub>4</sub> | 3.33fg | 1.00fg | 1.00ef | 1.00e  | 1.00cd | 1.33ef | 1.33ef | 1.00d | 1.00fgh |
| H <sub>5</sub> V <sub>4</sub> | 4.00ef | 1.00fg | 0.66fg | 1.00e  | 1.00cd | 1.33ef | 1.00f  | 1.00d | 0.66ghi |
| H <sub>6</sub> V <sub>4</sub> | 1.66hi | 0.66gh | 0.66fg | 0.66ef | 1.00cd | 0.66fg | 0.66fg | 1.00d | 0.66ghi |
| Level of significance         | **     | **     | **     | **     | **     | **     | **     | **    | **      |
| CV%                           | 21.88  | 26.25  | 21.76  | 24.98  | 27.41  | 22.74  | 24.65  | 28.84 | 18.72   |

Here, means with the same letters or without letters within the same column do not differ significantly, \*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability, NS = Not significant H<sub>1</sub>=Control, H<sub>2</sub>=Hand weeding, H<sub>3</sub>=Bensulfuron methyl, H<sub>4</sub>=Pretilachlor, H<sub>5</sub>=Carfentrazon ethyl, H<sub>6</sub>=Ethoxisulfuron, V<sub>1</sub>=BAU dhan3, V<sub>2</sub>=BRRI dhan28, V<sub>3</sub>=BRRI dhan81, V<sub>4</sub>=BRRI dhan96

**Effect of herbicide on dry weight of different weed species**

Weed control strategies at 30 DAT had a substantial impact on total dry weight (g m<sup>-2</sup>). Table 3 shows that at 30 days after treatment (DAT), the hand weeding (H<sub>2</sub>) treatment had the lowest weed dry weight (0.00 g) while

the control (H<sub>1</sub>) treatment had the greatest weed dry weight (21.26 g). Mostofa *et al.* (2024) reported comparable results, observing a significant fluctuation in weed dry weight following herbicide application.

**Table 3.** Effect of different herbicide on number of weeds and weed dry weight

| Herbicide             | Number of weeds | Weed dry weight (g) |
|-----------------------|-----------------|---------------------|
| H <sub>1</sub>        | 71.75a          | 21.26a              |
| H <sub>2</sub>        | 0.000e          | 0.000f              |
| H <sub>3</sub>        | 12.91c          | 5.389d              |
| H <sub>4</sub>        | 16.25b          | 9.540b              |
| H <sub>5</sub>        | 13.41c          | 6.743c              |
| H <sub>6</sub>        | 8.750d          | 4.010e              |
| Level of Significance | **              | **                  |
| CV%                   | 7.01            | 16.73               |

Means with the same letters or without letters within the same column do not differ significantly, \*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability, NS = Not significant, H<sub>1</sub>=Control, H<sub>2</sub>=Hand weeding, H<sub>3</sub>=Bensulfuron methyl, H<sub>4</sub>=Pretilachlor, H<sub>5</sub>=Carfentrazon ethyl, H<sub>6</sub>=Ethoxisulfuron

**Effect of variety on dry weight of different weed species**

Weed control strategies at 30 DAT had a substantial impact on total dry weight (g m<sup>-2</sup>). Table 4 shows that at 30 DAT, BRRI dhan96 (V<sub>4</sub>) had the lowest weed dry weight (6.99 g) while BAU dhan3 (V<sub>1</sub>) had the highest (8.50 g). Nur-A-Alam *et al.* (2024) published similar results, noting a considerable variance in weed dry weight under various varieties.

**Table 4.** Effect of variety on number of weeds and weed dry weight

| Variety               | Number of weeds | Weed dry weight (g) |
|-----------------------|-----------------|---------------------|
| V <sub>1</sub>        | 22.44a          | 8.50a               |
| V <sub>2</sub>        | 21.27b          | 8.00a               |
| V <sub>3</sub>        | 18.61d          | 7.79ab              |
| V <sub>4</sub>        | 19.72c          | 6.99b               |
| Level of Significance | **              | **                  |
| CV%                   | 7.01            | 16.73               |

In a column, figures with the same letter do not differ significantly as per DMRT, \*\* = Significant at 1% level of probability, V<sub>1</sub>=BAU dhan3, V<sub>2</sub>=BRRI dhan28, V<sub>3</sub>=BRRI dhan81, V<sub>4</sub>=BRRI dhan96

**Effect of interaction of variety and herbicides on dry weight of different weed species**

Weed control techniques at 30 DAT had a considerable impact on total dry weight (gm<sup>-2</sup>). Table 5 shows that the highest weed dry weight (23.19 g) was found in the control condition at 30 DAT. The lowest weed dry weight (0.00 g) was found in the hand weeding condition. Pramanik *et al.* (2020) showed a substantial difference in the dry weight of weeds under varying herbicide and variety conditions.

**Table 5.** Interaction effect between different herbicide and variety on number of weeds and weed dry weight

| Interaction                   | Number of weeds | Weed dry weight (g) |
|-------------------------------|-----------------|---------------------|
| H <sub>1</sub> V <sub>1</sub> | 77.66a          | 21.66a              |
| H <sub>2</sub> V <sub>1</sub> | 0.000l          | 0.00j               |
| H <sub>3</sub> V <sub>1</sub> | 14.00gh         | 7.76ef              |
| H <sub>4</sub> V <sub>1</sub> | 19.33d          | 11.03c              |
| H <sub>5</sub> V <sub>1</sub> | 14.33fg         | 5.63fgh             |
| H <sub>6</sub> V <sub>1</sub> | 9.333ijk        | 4.91gh              |
| H <sub>1</sub> V <sub>2</sub> | 75.00b          | 23.19a              |
| H <sub>2</sub> V <sub>2</sub> | 0.000l          | 0.00j               |
| H <sub>3</sub> V <sub>2</sub> | 16.66ef         | 5.84fg              |

|                               |          |         |
|-------------------------------|----------|---------|
| H <sub>4</sub> V <sub>2</sub> | 17.66de  | 8.57de  |
| H <sub>5</sub> V <sub>2</sub> | 11.33i   | 6.05fg  |
| H <sub>6</sub> V <sub>2</sub> | 7.000k   | 4.38ghi |
| H <sub>1</sub> V <sub>3</sub> | 59.00c   | 21.08ab |
| H <sub>2</sub> V <sub>3</sub> | 0.000l   | 0.00j   |
| H <sub>3</sub> V <sub>3</sub> | 11.33i   | 4.42ghi |
| H <sub>4</sub> V <sub>3</sub> | 14.00gh  | 9.91cd  |
| H <sub>5</sub> V <sub>3</sub> | 16.33efg | 8.96cde |
| H <sub>6</sub> V <sub>3</sub> | 11.00i   | 2.35i   |
| H <sub>1</sub> V <sub>4</sub> | 75.33ab  | 19.10b  |
| H <sub>2</sub> V <sub>4</sub> | 0.000l   | 0.00j   |
| H <sub>3</sub> V <sub>4</sub> | 9.666ij  | 3.53hi  |
| H <sub>4</sub> V <sub>4</sub> | 14.00gh  | 8.66de  |
| H <sub>5</sub> V <sub>4</sub> | 11.66hi  | 6.32fg  |
| H <sub>6</sub> V <sub>4</sub> | 7.666jk  | 4.38ghi |
| Level of Significance         | **       | **      |
| CV%                           | 7.01     | 16.73   |

In a column, figures with the same letter do not differ significantly as per DMRT, \*\* = Significant at 1% level of probability, H<sub>1</sub>=Control, H<sub>2</sub>=Hand weeding, H<sub>3</sub>=Bensulfuron methyl, H<sub>4</sub>=Pretilachlor, H<sub>5</sub>=Carfentrazone ethyl, H<sub>6</sub>=Ethoxisulfuron, V<sub>1</sub>=BAU dhan3, V<sub>2</sub>=BRRI dhan28, V<sub>3</sub>=BRRI dhan81, V<sub>4</sub>=BRRI dhan96

**Prediction of Herbicide Resistant Weeds Based on Weed Density**

Current research on weed density showed that some weed species, including *Scirpus mucronatus*, *Echinochloa crusgalli*, *Panicum repens*, and *Leersia hexandra*, were able to survive even when given a double dose of specific herbicides (Figure. 2). In the plots treated with specific herbicides (Bensulfuron methyl, Pretilachlor, Carfentrazone ethyl and Ethoxisulfuron), weeds such as *Monochoria hastata*, *Enhydra fluctuans* and *Digitaria ischaemum* also managed to survive (Table 2).

It was observed that *Scirpus mucronatus* and *Echinochloa crusgalli* were found to be successfully survived even with the double of recommended dose of herbicides in BAU dhan3, BRRI dhan28 and BRRI dhan81.

Our findings coincide with those of Cai *et al.* (2022) who discovered two putative resistant and one susceptible *Echinochloa crusgalli* population in Jiangsu Province rice fields. The two populations that were resistant to mefenacet had higher pre-emergence resistance than the susceptible population by 2.8 and 4.1 times, and higher early post-emergence resistance by 10 and 6.8 times, respectively. Additionally, to show cross or multiple resistance to mefenacet, these *E. crusgalli* populations also showed resistance to acetochlor, pyraclonil, imazamox, and quinclorac. Another study by Liu *et al.* (2022) found that *Echinochloa colona*, *Echinochloa crusgalli*, and *Echinochloa muricata* were the only species to significantly respond to commonly used pre-emergence (clomazone, quinclorac) and post-emergence herbicides (propanil, quinclorac, imazethapyr, and fenoxaprop-ethyl).

**Phytotoxicity of Herbicides to Rice Plants**

Following the application of herbicides, rice plants require eight to ten days to return to normal growth and color. The degree of toxicity of various herbicides to rice plants has been observed, and the symptoms produced have been found to be slightly toxic, with yellowing of the leaves and burning of the growth caused by Bensulfuron methyl, Pretilachlor, Carfentrazone ethyl, and Ethoxisulfuron.

**Effect of herbicides on yield and yield contributing characters of Boro rice**

Different weed management treatments significantly influenced the yield contributing characters of boro rice. The highest PH, NTT hill<sup>-1</sup>, NET hill<sup>-1</sup>, PL, NGP, TGW, GY, SY and BY (107.50 cm, 13.41, 11.75, 22.75, 81.75, 28.55g, 5.14 t ha<sup>-1</sup>, 6.53 t ha<sup>-1</sup> and 11.67 t ha<sup>-1</sup>) were produced when weeds were controlled by hand weeding. All the above-mentioned characters contained their lowest values for control treatment. (Table 6).

**Table 6.** Effect of different herbicide on yield and yield contributing characters of *boro* rice

| Herbicide             | PH (cm)  | NTT hill <sup>-1</sup> | NET hill <sup>-1</sup> | NNET hill <sup>-1</sup> | PL (cm) | NGP    | NSS    | TGW (g) | GY (t ha <sup>-1</sup> ) | SY (t ha <sup>-1</sup> ) | BY (t ha <sup>-1</sup> ) | HI (%)  |
|-----------------------|----------|------------------------|------------------------|-------------------------|---------|--------|--------|---------|--------------------------|--------------------------|--------------------------|---------|
| H <sub>1</sub>        | 88.75d   | 8.25c                  | 5.33c                  | 2.91a                   | 13.83d  | 65.91e | 15.25a | 22.49c  | 2.28e                    | 3.46d                    | 5.75e                    | 39.54d  |
| H <sub>2</sub>        | 107.50a  | 13.41a                 | 11.75a                 | 1.66b                   | 22.75a  | 81.75a | 8.00c  | 28.55a  | 5.14a                    | 6.53a                    | 11.67a                   | 44.01bc |
| H <sub>3</sub>        | 102.58bc | 11.16b                 | 9.58b                  | 1.58b                   | 19.58c  | 76.50c | 11.08b | 25.69b  | 4.41d                    | 5.70c                    | 10.12d                   | 43.60c  |
| H <sub>4</sub>        | 102.17c  | 11.25b                 | 9.75b                  | 1.50b                   | 19.66c  | 75.33d | 10.91b | 25.45b  | 4.48d                    | 5.61c                    | 10.10d                   | 44.44ab |
| H <sub>5</sub>        | 103.25b  | 11.08b                 | 9.75b                  | 1.33b                   | 20.58b  | 78.58b | 11.33b | 25.70b  | 4.84b                    | 6.00b                    | 10.85b                   | 44.60a  |
| H <sub>6</sub>        | 102.33c  | 11.50b                 | 9.83b                  | 1.66b                   | 21.25b  | 78.91b | 11.08b | 25.84b  | 4.65c                    | 6.00b                    | 10.66c                   | 43.67c  |
| Level of significance | **       | **                     | **                     | *                       | **      | **     | *      | **      | **                       | **                       | **                       | *       |
| CV%                   | 2.00     | 8.23                   | 9.02                   | 19.29                   | 4.74    | 2.40   | 6.51   | 2.81    | 2.72                     | 2.32                     | 2.25                     | 3.37    |

In a column, figures with the same letter do not differ significantly as per DMRT, \* = Significant at 5% level of probability, \*\* = Significant at 1% level of probability, H<sub>1</sub>=Control, H<sub>2</sub>=Hand weeding, H<sub>3</sub>=Bensulfuron methyl, H<sub>4</sub>=Pretilachlor, H<sub>5</sub>=Carfentrazone ethyl, H<sub>6</sub>=Ethoxisulfuron

### Effect of variety on yield and yield contributing characters of *Boro* rice

The effects of varieties were found to be non-significant TGW. Numerically, the highest TGW (25.84 g) were found in BRRRI dhan96 and the lowest TGW (25.39 g) were found in BRRRI dhan28. Different varieties had a significant impact on PH, NTT hill<sup>-1</sup>, NET hill<sup>-1</sup>, PL, NGP, GY, SY, BY, and HI. The highest PH, NTT hill<sup>-1</sup>, PL (103.61 cm, 11.55 and 20.33 cm respectively) were produced in case of BAU dhan3, and GP, GY, SY, BY, and HI (76.72, 4.55 t

ha<sup>-1</sup>, 5.75 t ha<sup>-1</sup>, 10.30 t ha<sup>-1</sup>, 43.99%) were produced for BRRRI dhan28. While the lowest NTT hill<sup>-1</sup>, NET hill<sup>-1</sup> (10.61, 9.00) was found in BRRRI dhan96 and lowest GY, SY and BY (3.84, 5.05, 8.90 t ha<sup>-1</sup>) was obtained in BAU dhan3 (Table 7). Similar findings were reported by Akondo *et al.* (2024), who found significant variation in the NET hill<sup>-1</sup> under different herbicide applications.

**Table 7.** Effect of variety on yield and yield contributing characters of *boro* rice

| Variety               | PH (cm) | NTT hill <sup>-1</sup> | NET hill <sup>-1</sup> | NNET hill <sup>-1</sup> | PL (cm) | NGP    | NSS     | TGW (g) | GY (t ha <sup>-1</sup> ) | SY (t ha <sup>-1</sup> ) | BY (t ha <sup>-1</sup> ) | HI (%)  |
|-----------------------|---------|------------------------|------------------------|-------------------------|---------|--------|---------|---------|--------------------------|--------------------------|--------------------------|---------|
| V <sub>1</sub>        | 103.61a | 11.55a                 | 9.50ab                 | 2.05a                   | 20.33a  | 75.38b | 10.88c  | 25.72   | 3.84d                    | 5.05c                    | 8.90c                    | 42.77c  |
| V <sub>2</sub>        | 95.67c  | 10.77b                 | 9.11b                  | 1.66b                   | 19.22b  | 76.72a | 11.50ab | 25.39   | 4.55a                    | 5.75a                    | 10.30a                   | 43.99a  |
| V <sub>3</sub>        | 103.83a | 11.50a                 | 9.72a                  | 1.77ab                  | 19.22b  | 75.72b | 11.05bc | 25.53   | 4.36c                    | 5.65b                    | 10.01b                   | 43.15bc |
| V <sub>4</sub>        | 101.28b | 10.61b                 | 9.00b                  | 1.61b                   | 19.66b  | 76.83a | 11.66a  | 25.84   | 4.45b                    | 5.76a                    | 10.22a                   | 43.33b  |
| Level of significance | **      | **                     | **                     | *                       | **      | **     | *       | NS      | **                       | **                       | **                       | *       |
| CV%                   | 2.00    | 8.23                   | 9.02                   | 19.29                   | 4.74    | 2.40   | 6.51    | 2.81    | 2.72                     | 2.32                     | 2.25                     | 3.37    |

In a column, figures with the same letter do not differ significantly as per DMRT, \* = Significant at 5% level of probability, \*\* = Significant at 1% level of probability, NS= non-significant, V<sub>1</sub>=BAU dhan3, V<sub>2</sub>=BRRRI dhan28, V<sub>3</sub>=BRRRI dhan81, V<sub>4</sub>=BRRRI dhan96

### Combined effect of herbicide and variety on yield and yield contributing characters of *Boro* rice

The interaction effect between herbicide treatments and varieties on yield contributing characters of *boro* rice was found to be significant. The tallest plant, measuring 110.00 cm, was observed in BAU dhan3 while weed was controlled by hand weeding. The highest NTT hill<sup>-1</sup> (14.00), NET hill<sup>-1</sup> (12.66) and PL (24.00 cm) was also observed in the same combination. Whereas the shortest plant (84.00 cm), NET hill<sup>-1</sup> (4.66) was recorded under control condition in BRRRI dhan28 while lowest NTT hill<sup>-1</sup> was found in control with BRRRI dhan96 and lowest PL (13.00 cm) was observed in control condition both for BRRRI dhan81 and BRRRI dhan96 (Table 8). These findings align with those reported by Mim *et al.* (2024) and Nur-A-Alam *et al.* (2024), who also observed significant variations in the NET hill<sup>-1</sup>.

Significant effects were observed for herbicide and variety on the NGP of *boro* rice. The highest NGP (83.00) was obtained in combination of BRRRI dhan28 and hand weeding, while the control treatment for BRRRI dhan81 resulted in the lowest NGP (63.00).

TGW, GY, SY and BY of *boro* rice was significantly influenced by weed management practices. The highest TGW (29.12), GY (5.40 t ha<sup>-1</sup>), SY (6.80 t ha<sup>-1</sup>) and BY (12.20) was achieved with BRRRI dhan 81 controlled by hand weeding, while the lowest TGW (22.30) was obtained for Control and BRRRI dhan96 combination whereas the lowest GY (1.80 t ha<sup>-1</sup>), SY (3.00 t ha<sup>-1</sup>) and BY (4.80 t ha<sup>-1</sup>) was observed under control conditions with BAU dhan3 (Table 08). The competition between weeds and crops for nutrients, water, air, sunlight, and space contributed to these variations in yield. Increased GY in low weedy conditions was attributed to a higher NET hill<sup>-1</sup> and a greater NGP compared to weedy conditions. Similar results were reported by Dola *et al.* (2024), who found significant variations in GY. Mostofa *et al.* (2024) reported similar findings, noting significant variations in straw yield and BY. The HI was significantly influenced by weed management practices. The highest HI (45.60%) was observed in BAU dhan3 while treated with pretilachlor. On the other hand, the lowest HI (37.48%) was recorded under control conditions with the same variety (Table 08). These results corroborate the findings of Kundu *et al.* (2020), who reported significant variations in the HI.

**Table 8.** Combined effect of herbicide and variety on yield and yield contributing characters of *boro* rice

| Interaction                   | PH<br>(cm) | NTT<br>hill <sup>-1</sup> | NET<br>hill <sup>-1</sup> | NNET<br>hill <sup>-1</sup> | PL<br>(cm) | NGP      | NSS       | TGW<br>(g) | GY<br>(t ha <sup>-1</sup> ) | SY<br>(t ha <sup>-1</sup> ) | BY<br>(t ha <sup>-1</sup> ) | HI<br>(%)   |
|-------------------------------|------------|---------------------------|---------------------------|----------------------------|------------|----------|-----------|------------|-----------------------------|-----------------------------|-----------------------------|-------------|
| H <sub>1</sub> V <sub>1</sub> | 94.00k     | 9.00ef                    | 5.33ef                    | 3.66a                      | 15.33j     | 69.66k   | 14.00b    | 22.96g     | 1.80l                       | 3.00j                       | 4.80j                       | 37.48m      |
| H <sub>2</sub> V <sub>1</sub> | 110.00a    | 14.00a                    | 12.66a                    | 1.33de                     | 24.00a     | 81.00bc  | 9.00hi    | 27.78bc    | 4.66efg                     | 6.23c                       | 10.90cd                     | 42.81i      |
| H <sub>3</sub> V <sub>1</sub> | 104.67efg  | 11.33cd                   | 9.33cd                    | 2.00cd                     | 20.00efgh  | 75.00i   | 10.33fg   | 25.65de    | 4.16h                       | 5.53f                       | 9.70f                       | 42.96hi     |
| H <sub>4</sub> V <sub>1</sub> | 107.00cd   | 12.00bc                   | 10.66bc                   | 1.33de                     | 20.33efgh  | 73.00j   | 9.66gh    | 25.71de    | 3.80i                       | 4.53g                       | 8.33g                       | 45.60a      |
| H <sub>5</sub> V <sub>1</sub> | 104.00efg  | 11.00cd                   | 9.00d                     | 2.00cd                     | 21.33bcde  | 76.66ghi | 11.33cdef | 26.11de    | 4.33h                       | 5.53f                       | 9.86f                       | 43.91cdefgh |
| H <sub>6</sub> V <sub>1</sub> | 102.00hi   | 12.00bc                   | 10.00cd                   | 2.00cd                     | 21.00cdef  | 77.00fgh | 11.00def  | 26.10de    | 4.30h                       | 5.50f                       | 9.80f                       | 43.88cdefgh |
| H <sub>1</sub> V <sub>2</sub> | 84.00n     | 8.00fg                    | 4.66f                     | 3.33ab                     | 14.00jk    | 65.00l   | 16.00a    | 22.56g     | 2.63j                       | 3.73h                       | 6.36h                       | 41.33j      |
| H <sub>2</sub> V <sub>2</sub> | 103.00gh   | 13.33ab                   | 11.66ab                   | 1.66de                     | 22.00bcd   | 83.00a   | 8.00ij    | 28.58ab    | 5.30ab                      | 6.60ab                      | 11.90ab                     | 44.54bcde   |
| H <sub>3</sub> V <sub>2</sub> | 94.00k     | 11.00cd                   | 10.00cd                   | 1.00e                      | 19.00hi    | 77.00fgh | 10.66efg  | 25.59def   | 4.60fg                      | 5.80e                       | 10.40e                      | 44.22bcdef  |
| H <sub>4</sub> V <sub>2</sub> | 93.00k     | 10.33de                   | 9.00d                     | 1.33de                     | 18.00i     | 75.33hi  | 12.00cd   | 25.49def   | 5.00d                       | 6.20c                       | 11.20c                      | 44.64abcd   |
| H <sub>5</sub> V <sub>2</sub> | 101.00i    | 11.00cd                   | 10.00cd                   | 1.00e                      | 20.33efgh  | 79.00de  | 11.33cdef | 24.42f     | 5.00d                       | 6.06cd                      | 11.06cd                     | 45.18ab     |
| H <sub>6</sub> V <sub>2</sub> | 99.00j     | 11.00cd                   | 9.33cd                    | 1.66de                     | 22.00bcd   | 81.00bc  | 11.00def  | 25.69de    | 4.80e                       | 6.10cd                      | 10.90cd                     | 44.03cdefg  |
| H <sub>1</sub> V <sub>3</sub> | 91.00l     | 9.00ef                    | 6.33e                     | 2.66bc                     | 13.00k     | 63.00m   | 15.00ab   | 22.13g     | 2.20k                       | 3.43i                       | 5.63i                       | 39.04l      |
| H <sub>2</sub> V <sub>3</sub> | 109.00ab   | 14.00a                    | 12.00ab                   | 2.00cd                     | 22.66ab    | 81.00bc  | 7.00j     | 29.12a     | 5.40a                       | 6.80a                       | 12.20a                      | 44.26bcdef  |
| H <sub>3</sub> V <sub>3</sub> | 108.00bc   | 11.00cd                   | 9.33cd                    | 1.66de                     | 19.33ghi   | 76.00hi  | 11.00def  | 25.74de    | 4.20h                       | 5.46f                       | 9.66f                       | 43.44fghi   |
| H <sub>4</sub> V <sub>3</sub> | 105.67de   | 11.66cd                   | 10.00cd                   | 1.66de                     | 19.66fgh   | 77.00fgh | 11.00def  | 25.08ef    | 4.60fg                      | 5.80e                       | 10.40e                      | 44.22bcdef  |
| H <sub>5</sub> V <sub>3</sub> | 104.00efg  | 11.33cd                   | 10.00cd                   | 1.33de                     | 20.00efgh  | 78.66def | 11.66cde  | 25.64de    | 5.03cd                      | 6.20c                       | 11.23c                      | 44.80abc    |
| H <sub>6</sub> V <sub>3</sub> | 105.33def  | 12.00bc                   | 10.66bc                   | 1.33de                     | 20.66defg  | 78.66def | 10.66efg  | 25.45ef    | 4.73ef                      | 6.23c                       | 10.96cd                     | 43.15ghi    |
| H <sub>1</sub> V <sub>4</sub> | 86.00m     | 7.00g                     | 5.00ef                    | 2.00cd                     | 13.00k     | 66.00l   | 16.00a    | 22.30g     | 2.50j                       | 3.70h                       | 6.20h                       | 40.31k      |
| H <sub>2</sub> V <sub>4</sub> | 108.00bc   | 12.33bc                   | 10.66bc                   | 1.66de                     | 22.33bc    | 82.00ab  | 8.00ij    | 28.71ab    | 5.20bc                      | 6.50b                       | 11.70b                      | 44.44bcde   |
| H <sub>3</sub> V <sub>4</sub> | 103.67fgh  | 11.33cd                   | 9.66cd                    | 1.66de                     | 20.00efgh  | 78.00efg | 12.33c    | 25.77de    | 4.70efg                     | 6.03cd                      | 10.73de                     | 43.79defgh  |
| H <sub>4</sub> V <sub>4</sub> | 103.00gh   | 11.00cd                   | 9.33cd                    | 1.66de                     | 20.66defg  | 76.00hi  | 11.00def  | 25.51def   | 4.53g                       | 5.93de                      | 10.46e                      | 43.30fghi   |
| H <sub>5</sub> V <sub>4</sub> | 104.00efg  | 11.00cd                   | 10.00cd                   | 1.00e                      | 20.66defg  | 80.00cd  | 11.00def  | 26.65cd    | 5.00d                       | 6.23c                       | 11.23c                      | 44.51bcde   |
| H <sub>6</sub> V <sub>4</sub> | 103.00gh   | 11.00cd                   | 9.33cd                    | 1.66de                     | 21.33bcde  | 79.00de  | 11.66cde  | 26.12de    | 4.80e                       | 6.20c                       | 11.00cd                     | 43.63efghi  |
| Level of significance         | **         | **                        | **                        | *                          | **         | **       | *         | **         | **                          | **                          | **                          | *           |
| CV%                           | 2.00       | 8.23                      | 9.02                      | 19.29                      | 4.74       | 2.40     | 6.51      | 2.81       | 2.72                        | 2.32                        | 2.25                        | 3.37        |

In a column, figures with the same letter do not differ significantly as per DMRT, \* = Significant at 5% level of probability, \*\* = Significant at 1% level of probability, H<sub>1</sub>=Control, H<sub>2</sub>=Hand weeding, H<sub>3</sub>=Bensulfuron methyl, H<sub>4</sub>=Pretilachlor, H<sub>5</sub>=Carfentrazone ethyl, H<sub>6</sub>=Ethoxisulfuron, V<sub>1</sub>=BAU dhan3, V<sub>2</sub>=BRRI dhan28, V<sub>3</sub>=BRRI dhan81, V<sub>4</sub>=BRRI dhan96

## CONCLUSION

The experiment revealed that Ethoxisulfuron and Carfentrazone ethyl were the most efficient among the weed management treatments for suppressing weeds and delivered the maximum grain production when applied in double of the recommended doses. Despite the fact that using double doses of herbicides enhanced yield, the difference was not very noticeable when compared to the doses that are recommended. Even all the treatments with double doses of herbicides resulted in brief, mild phytotoxic effects. According to the results of the weed density study it was clear that some weeds in particular *Echinochloa crusgalli*, *Scirpus mucronatus*, *panicum repens* and *Leersia hexandra* were able to survive despite being treated with twice as much herbicide as was suggested. It is predicted that using herbicides in the specified amounts will effectively control all weeds. However, if these weeds are not controlled by using recommended or even higher than recommended doses of herbicides, it is possible that these types of weeds may appear to be herbicide resistant in this situation. Therefore, additional molecular research is required to confirm whether the anticipated herbicides are resistant against these particular weeds.

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## Conflict of Interest

The authors have declared no conflicts of interest.

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