Plant Archives Vol. 26, Supplement 2, 2026 pp. 3388-3402 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.430

TOWARDS SUSTAINABLE WEED MANAGEMENT IN DIRECT-SEEDED RICE: EFFECTS OF WEED MANAGEMENT STRATEGIES UNDER DIFFERENT WEED PRESSURE LEVELS

Koya Madhuri Mani[1], Ananda N.[2], Nagender G.[3], Umesh M. R.[2], Gireesh C.[4], Mahender Kumar R.[5], Ramesh Y.M.[2] and Mukesh Kumar Meena[6]

[1]Acharya N.G. Ranga Agricultural University, Bapatla, India
[2]Department of Agronomy, University of Agricultural Sciences, Raichur, India
[3]Department of Agronomy, Professor Jayshankar Telangana State Agricultural University, Hyderabad, India
[4]Department of Genetics and Plant breeding, ICAR- Indian Institute of Seed Science, Regional Station, Bengaluru, Karnataka, India
[5]Department of Agronomy, ICAR- Indian Institute of Rice Research, Hyderabad, India
[6]Department of Crop Physiology, University of Agricultural Sciences, Raichur, India
*Corresponding author E-mail: madhurikoya1238@gmail.com

(Date of Receiving : 09-05-2026; Date of Revision : 06-07-2026; Date of Acceptance : 25-07-2026)

ABSTRACT

The experiment was conducted to evaluate the competitive capacity of various rice genotypes against weed infestation under different management regimes. Utilizing a split-plot design with three replications and twelve treatment combinations, the study investigated four weeding regimes: weed-free, weeding at 15 and 30 days after sowing (DAS), weeding at 45 DAS and a weedy check across ten rice cultivars, including DRR H-4, DRR Dhan 44 and Sahbhagidhan. The results demonstrated that weed pressure exerts a significant influence on the growth, physiological development and yield of all tested rice genotypes. Weed-free conditions and early weeding at 15–30 DAS consistently facilitated superior growth metrics, including increased plant height, leaf area index (LAI) and tiller density. Specifically, under weed-free conditions, the genotype DRR H-4 reached a plant height of 75.53 cm at 60 DAS and 113.6 cm at harvest. Conversely, the weedy check condition severely restricted dry matter accumulation and negatively impacted essential physiological markers, including SPAD readings, NDVI and photosynthetic rates. Under weedy conditions, these metrics showed marked declines across all cultivars, confirming that unchecked weed proliferation directly disrupts the photosynthetic capacity and metabolic efficiency required for grain development.

Among the evaluated cultivars, DRR H-4 emerged as a high-performing genotype, achieving a grain yield of 5893 kg ha^{-1} under weed-free conditions, thereby demonstrating superior competitive potential. In contrast, the weedy check resulted in substantial yield losses, with grain yields declining to approximately 1500–1521 kg ha^{-1} for the tested varieties. Critical yield components such as panicle length, panicle weight, filled grains per panicle and overall harvest index were significantly diminished in the presence of high weed pressure, with Sahbhagidhan, for example, experiencing a reduction in panicle length to 16.83 cm and filled grains to 47 per panicle under weedy conditions.

Furthermore, the study highlights the efficacy of timely weed management. Weeding at 45 DAS achieved a high weed control efficiency (WCE), ranging from 93.06% to 93.95% among the cultivars, demonstrating that even delayed intervention can significantly alter the competitive landscape. The weedy check, characterized by the highest total weed density and weed dry matter (WDM), serves to underscore the extent of competition-induced impairment. Conclusively, these findings indicate that mitigating early weed competition is essential to realizing the full genetic yield potential of these rice varieties. The study establishes that proactive, early-stage weed management is imperative for optimizing biomass and grain production, with DRR H-4 exhibiting a distinct advantage in competitive performance under the varying pressures evaluated. This research provides a robust framework for selecting competitive rice cultivars to improve overall system productivity.

***Keywords*:** Direct seeded rice, weed management regimes, genotypic competitiveness, physiological attributes and yield components.

Introduction

Rice (*Oryza sativa* L.) is the cornerstone of food security and agricultural sustainability in India, where nearly 60% of the population relies on it as a primary staple food (FAO, 2024). Globally, Asian nations account for over 90% of rice cultivation and consumption, spanning approximately 147 million hectares and yielding around 688 million tonnes of paddy rice annually (Grover and Chauhan, 2022). In India, rice occupies nearly 46 million hectares with an annual production of approximately 136.7 million tonnes, contributing nearly 40% of the nation's total food grain output (Government of India, 2024). Despite these historic milestones achieved since the Green Revolution, the challenge of feeding the world's most populous nation persists amid changing climates and resource constraints (Pathak *et al*., 2022). Consequently, agricultural research must pivot toward maximizing crop productivity while minimizing labor, water and energy footprints (Ladha *et al*., 2020).

Traditionally, rice is cultivated via transplanting seedlings into puddled, flooded fields. Although this method has historically suppressed weed growth, intensive wet tillage creates an impermeable plow pan that degrades soil structure, reduces permeability and drives enormous water losses through evaporation and deep percolation (Farooq *et al*., 2011). Amidst declining water tables, acute agricultural labor shortages and escalating production costs, the conventional puddled transplanted system is becoming increasingly unsustainable (Kumar and Ladha, 2011). Furthermore, continuously flooded fields represent a major anthropogenic source of greenhouse gases, particularly methane (CH_4) (Pathak *et al*., 2013).

Direct Seeded Rice (DSR) has emerged as a resource-efficient paradigm shift, offering a viable route to sustain rice production in water-scarce regions (Chauhan, 2012). By eliminating puddling, transplanting and the requirement for continuous standing water, DSR reduces irrigation water demands by 30% to 35%, lowers labor requirements by 15% to 20% and curtails the global warming potential of rice ecosystems by up to 33% (Kakumanu *et al*., 2024; Fanish, 2016). Consequently, the adoption of DSR is expanding steadily across key rice-growing zones in India (Mahajan *et al*., 2023).

Despite its profound resource-saving benefits, the structural transition from flooded to aerobic soil environments in DSR creates an ecological niche for rapid, aggressive weed proliferation (Chauhan and Johnson, 2010). Without the suppressive blanket of standing water, weeds emerge simultaneously with rice seedlings, engaging in fierce interspecific competition for light, space, moisture and nutrients (Rao *et al*., 2017). Unmanaged weed infestation in DSR represents its single largest biotic constraint, precipitating catastrophic grain yield losses ranging from 20% to 50%, and in severe cases, causing total crop failure (Maity and Mukherjee, 2021).

While synthetic chemical herbicides offer rapid and effective weed control, exclusive reliance on chemical crop protection induces severe ecological backlashes (Kumar *et al*., 2017). These include the rapid evolution of herbicide-resistant weed biotypes, undesirable shifts in weed flora communities, risks to non-target organisms and broader environmental contamination (Qi *et al*., 2020). On the other hand, traditional manual weeding is highly effective but remains severely limited by cost, time and low labor availability during critical operational windows (Dhillon *et al*., 2021). To overcome these barriers, modern Integrated Weed Management (IWM) frameworks emphasize ecological, non-monetary interventions (Chauhan, 2013). Exploiting the innate weed-suppressing capability of competitive rice genotypes represents a highly sustainable mechanism (Dass *et al*., 2017). Cultivars characterized by superior early vigor, rapid seedling emergence, quick ground canopy coverage, high leaf area index (LAI) and rapid tillering can naturally suppress weed growth by reducing solar radiation penetration to the understory (Zhao *et al*., 2006).

However, the efficacy of these morpho-physiological traits is strongly modulated by the level of weed pressure and the timing of weed management interventions (Sunil *et al*., 2022). There is a critical need to evaluate how modern high-yielding hybrids and stress-tolerant cultivars perform under diverse, controlled gradients of weed pressure (Raj *et al*., 2023). Understanding these interactions is essential to optimize both physiological efficiency and economic returns.

Addressing these core mandates, this investigation was executed over two consecutive years to evaluate the agronomic performance and bio-physiological weed-suppressing mechanisms of distinct rice genotypes under varying degrees of weed pressure.

Material and Methods

Experimental Site and Environmental Baseline

Field experiments were conducted during the *Kharif* seasons of 2023 and 2024 at the Agronomy Unit Farm of the ICAR-Indian Institute of Rice Research (IIRR), Rajendranagar, Hyderabad, India (17.19°N latitude, 78.23°E longitude, 542.3 m above sea level).

The site belongs to the semi-arid tropical agro-climatic zone. The soil was a clay loam (50.70% clay) with a pH of 7.6, medium organic carbon (0.43%), low available nitrogen (205.50 kg ha^{-1}), medium available P_2O_5 (37.40 kg ha^{-1}), and high available K (372.53 kg ha^{-1}). Total rainfall received during the 2024 crop season was 805.9 mm, with a peak of 409.2 mm in September.

Experimental Design and Treatments

The study was arranged in a Split-Plot Design with three replications. The treatment configurations comprised four main-plot weeding regimes (weed pressures) and three sub-plot rice cultivars:

- **Main-plot: Weeding Regimes / Weed Pressure Grahams**

1. W_1: Weed-free condition throughout the crop season (Low pressure).
2. W_2: Manual weeding at 15 and 30 Days After Sowing (DAS) (Medium pressure).
3. W_3: Manual weeding at 45 DAS (High pressure).
4. W_4: Weedy check with uncontrolled weed growth (Very high pressure).

- **Sub-plot: Rice Cultivars (3)**

1. C_1: DRR H-Dhan 4 (High-yielding hybrid; 120–125 days duration).
2. C_2: DRR Dhan 44 (High-yielding variety; 115–120 days duration).
3. C_3: Sahbhagidhan (Drought/stress-tolerant variety; 105–110 days duration).

The gross and net plot dimensions were 16.2 m^2 (3.6m x 4.5 m) and 9.36 m^2 (2.4 m x 3.9 m), respectively.

Crop Husbandry and Management

Dry seeds were manually dibbled at a seed rate of 50 kg ha^{-1} into freshly prepared raised beds (80 cm wide) separated by 20 cm furrows. Sowing was executed at a spacing of 20 cm × 10 cm during both years. The recommended dose of fertilizer applied was 120: 30: 30 kg N:P_2O_5 : K_2O ha^{-1} for the inbred varieties (C_2C_3) and 150: 60: 60 kg N:P_2O_5 : K_2O ha^{-1} for the hybrid (C_1). Phosphorus was entirely basal; nitrogen was split-applied at basal, active tillering, and panicle initiation (PI) stages, while potassium was split between basal and PI stages. Standard irrigation (6–7 events of 40–50 mm each) and pest control measures (Carbofuran 3G at 10 kg ha^{-1} at 45 DAS against stem borer) were uniformly managed.

Biometric and Physiological Measurements

Growth and Physiological Markers

Five randomly tagged plants per net plot area were used to track developmental metrics:

- Plant Height: Measured from the stem base to the tip of the topmost leaf/panicle at 60 DAS and at harvest.
- Tiller Density (m^{-2}): Total tillers were counted within a 1m^2 quadrate placed in each net plot.
- Leaf Area Index (LAI): Calculated based on the maximum length (L) and width (W) of the third leaf from the top using a standard scaling constant, divided by the land area occupied.
- Dry Matter Accumulation: Biomass samples were harvested, oven-dried at 70±5ºC to a constant weight, and expressed in g plant^{-1}.
- SPAD Readings: Relative chlorophyll content was quantified from 10 random leaves using a Minolta SPAD-502 meter.
- NDVI Values: Canopy greenness and vegetative index were evaluated on 10 leaves using a handheld GreenSeeker crop sensor.
- Photosynthetic Rate: Net leaf assimilation rates were measured on clear days using a portable Infrared Gas Analyzer (IRGA) running at a reference CO_2 concentration of 400 µmol mol^{-1}.

Weed Parameters

Weed density (plants m^{-2}) and weed dry matter (WDM, gm^{-2}) were recorded at specified growth intervals using a 25 cm x 25 cm iron quadrate randomly cast at two spots per net plot. Weeds were counted, oven-dried at 60±5ºC to a constant mass, and weighed. Weed Control Efficiency (WCE) was calculated using the formula (Mani *et al*., 1973)

$$\mathrm{WCE}\ (\%) = \frac{\mathrm{DWC} - \mathrm{DWT}}{\mathrm{DWC}} \times 100$$

Where DWC and DWT represent the weed dry weights (gm^{-2}) in the weedy check and treated plots, respectively.

Yield and Yield Components

At physiological maturity, the net plot area was harvested to record Grain Yield (adjusted to a 13% moisture baseline and expressed in kg ha^{-1}). Yield components including panicle length (cm), panicle weight (g), and filled grains per panicle were measured from five representative sample plants. The Harvest Index (HI) was calculated using the standard formulation:

$$\mathrm{HI} = \frac{\text{Grain Yield}}{\text{Grain Yield} + \text{Straw Yield}}$$

Statistical Analysis

All data were subjected to Analysis of Variance (ANOVA) using split-plot design logic (Panse and Sukhatme, 1978). Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a 5% level of significance (P = 0.05). Regression analysis was deployed in MS Excel to determine the strength of relationships (R^2) between physiological traits and yield metrics. Advanced data distributions and component clusters were plotted via Violin Plots and Principal Component Analysis (PCA) biplots in R Studio utilizing the ggplot2 package.

Results and Discussion

The timing and intensity of weed management significantly influenced weed establishment, proliferation and biomass accumulation. Crop growth metrics, including plant height, leaf area index (LAI), tiller density, and dry matter accumulation, were significantly altered by weed pressure, cultivar selections, and their interactions from early vegetative growth to final harvest. Completely weed-free regimes (W_1) and early manual weeding at 15–30 DAS (W_2) consistently facilitated superior growth performance across all tested rice genotypes (Table 1a-1c) as minimizing weed competition during sensitive growth stages optimizes cell division and elongation (Nelapati *et al*., 2025). Under weed-free conditions, the high-performing genotype *DRR H-4* reached a plant height of 75.53 cm at 60 DAS and 113.6 cm at harvest (Table 1b and 1c). In contrast, prolonged weed pressure in the weedy check severely restricted vertical elongation and restricted dry matter accumulation, reducing average heights across cultivars down to 68.96 cm at 90 DAS and 74.08 cm at harvest. Both leaf canopy size and tillering structures responded strongly to resource availability, with the weed-free condition maintaining a statistically superior peak LAI of 1.85 at 60 DAS and 3.87 at 90 DAS (Table 2b and 2c), which was statistically on par with early weeding at 15 and 30 DAS since early weed removal ensures that rice establishes a dense canopy to shade out later-emerging weeds (Chakraborti *et al*., 2018). The unmanaged weedy check forced catastrophic declines in LAI down to a minimal value of 1.43 at 90 DAS. Similarly, at harvest, maximum tiller counts were securely anchored under weed-free plots at 356.11 tillers m^{-2}, followed by early weeding at 15–30 DAS at 336.50 tillers m^{-2} (Table 3b and 3c) with *DRR H-4* leading total tiller production with a mean of 297.04 tillers m^{-2} due to its high nutrient-use efficiency and robust vegetative growth characteristics (Kumar *et al*., 2023). In contrast, the weedy check limited counts to a minor fraction of 164.89 tillers m^{-2}. This pattern was mirrored in biomass production at 60 DAS, where the complete weed-free treatment maximized dry matter production at 5.02 g $plant^{-1}$, while uncontrolled weed flora in the weedy check plot dragged accumulation down to an average low of 1.86 g $plant^{-1}$ (Table 4) across all three cultivars demonstrating that the absence of weed competition enhances available light, nutrients, and moisture to support biomass accumulation (Premnath *et al*., 2024).

Across all evaluated cultivars, the unmanaged weedy check (W_4) consistently generated the highest total weed population and biomass accumulation throughout the cropping season (Anwar *et al*., 2012; Nelapati *et al*., 2025). At 45 days after sowing (DAS), the unmanaged weedy check registered a total weed density of up to 69.8 plants m^{-2} (Table 5) and a mean weed dry matter (WDM) of 10.3 g m^{-2} (Table 6). By 60 DAS, the unchecked weed communities accumulated peak biomass values, reaching up to 26.6 g m^{-2} under the weedy check condition (Dhage and Srivastav, 2020). Conversely, timely manual interventions significantly restricted weed development, and a delayed tactical manual intervention specifically weeding at 45 DAS (W_3) demonstrated a remarkably high weed control efficiency (WCE) at 60 DAS (Table 7). The peak WCE values under this delayed management regime ranged between 93.06% and 93.95% across the tested varieties, with *Sahbhagidhan* achieving the highest structural efficiency of 93.95%, followed closely by *DRR H-4* at 93.43% and *DRR Dhan 44* at 93.06%. This underscores the observation that removing weeds at 45 DAS coincides with the crop's most active growth phase, drastically lowering the residual space and opportunity for subsequent weed re-emergence by allowing the plants to recover rapidly (Choudhary *et al*., 2021), whereas the unmanaged weedy check recorded the lowest WCE of down to 5.02%.

The presence of continuous weed pressure triggered marked physiological declines across all cultivars, confirming that unchecked weed proliferation directly disrupts the photosynthetic capacity and metabolic efficiency required for grain development. Weed-free management optimized relative leaf chlorophyll density, generating high SPAD values of 39.66 at both panicle initiation (PI) and flowering (Fig. 1) as a weed-free condition provides an unrestricted opportunity to utilize maximum available soil nitrogen for chlorophyll formation (Anwar *et al*., 2020). Conversely, intense nutrient competition under the weedy check inhibited normal chlorophyll synthesis, causing readings to fall dramatically to 18.73 at PI and 23.02 at flowering. Crop vegetation health, monitored via GreenSeeker sensors, recorded peak NDVI values under weed-free environments of 0.70 at PI and 0.93 at flowering (Fig. 2), which collapsed to 0.36 at PI and 0.55 at flowering across varieties in the weedy check reflecting severe canopy reduction and nutrient deficiencies under competitive stress (Kumar *et al*., 2023). Most notably, high weed pressure directly throttled net leaf carbon assimilation rates measured via an infrared gas analyzer, forcing photosynthetic rates to plummet to 11.14 µmol $CO_2m^{-2}s^{-1}$ at PI and 13.32 µmol $CO_2m^{-2}s^{-1}$ at flowering under weedy check conditions, compared to the optimized rates of 21.91 at PI and 26.65 at flowering seen in the absence of weeds (Fig. 3), validating that severe resource competition directly suppresses cellular development and leaf-level gas exchange (Wang *et al*., 2023).

Final grain yield and its reproductive components were heavily governed by the interaction between crop genotype and weed pressure, as sustained weed-free conditions allowed the cultivars to express their full genetic yield potential (Sandhu *et al*., 2019). Among the evaluated cultivars, *DRR H-4* emerged as an elite, high-performing genotype, achieving a superior grain yield of 5393 kg ha^{-1} (Table 8) under weed-free conditions, thereby demonstrating its superior competitive potential and hybrid vigor (Senguttuvel *et al*., 2021). In contrast, the weedy check condition resulted in substantial yield losses, with grain yields declining to approximately 1500–1521 kg ha^{-1} for the general tested varieties, and specifically falling below 1000 kg ha^{-1} for *DRR Dhan 44* and *Sahbhagidhan* under full-season weed strain illustrating how intense resource depletion impairs source-sink relations during grain development (Hossain *et al*., 2020). Critical yield components such as panicle length, panicle weight, filled grains per panicle, and overall harvest index were significantly diminished in the presence of high weed pressure. Average panicle lengths dropped from a weed-free high of 25.38 cm down to 17.52 cm in the weedy check (Table 9), with *Sahbhagidhan* experiencing a reduction in panicle length to 16.83 cm under weedy conditions. Furthermore, the mean number of filled grains per panicle reached up to 186.0 under weed-free environments, led by *DRR H-4* at 200.17 (Table 8), because optimal photosynthetic activity supports spikelet fertility and carbohydrate translocation (Kavya and Vasudevan, 2022). Under weedy check conditions, Sahbhagidhan suffered extreme drops in grain setting under weedy check conditions, declining to just 47 filled grains per panicle due to limited assimilate supply (Barla *et al*., 2021). Mean panicle weights declined from a clean control high of 4.11 g to an unmanaged low of 1.06 g (Table 9), and the overall harvest index fell from an efficient 0.47 in weed-free systems down to an uncoordinated 0.29 in the weedy check plots (Fig. 4), underscoring the severe competition-induced impairment of source-to-sink translocation during the reproductive phase (Anwar *et al*., 2012; Saito *et al*., 2010).

Table 1a : Effect of weed pressure and cultivars on plant height (cm) of *kharif* direct seeded rice at 15 and 30 DAS

Treatment	15 DAS			30 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	17.17	17.53	17.35	25.50 ^{a}	26.17 ^{a}	25.83 ^{a}
W_2: Medium	17.24	17.86	17.55	24.86 ^{a}	25.29 ^{a}	25.07 ^{a}
W_3: High	17.30	17.67	17.48	22.36 ^{b}	22.41 ^{b}	22.38 ^{b}
W_4: Very high	16.98	17.46	17.22	21.69 ^{b}	22.36 ^{b}	22.02 ^{b}
S.Em. ±	0.19	0.16	0.14	0.30	0.22	0.23
C.D at 5 %	NS	NS	NS	1.05	0.75	0.79
Cultivars (C)						
C_1- DRR H4	16.37 ^{b}	16.92 ^{b}	16.64 ^{b}	24.25 ^{a}	24.53 ^{a}	24.39 ^{a}
C_2-DRR Dhan 44	17.62 ^{a}	18.22 ^{a}	17.92 ^{a}	23.84 ^{a}	24.30 ^{a}	24.07 ^{a}
C_3-Sahbagidhan	17.53 ^{a}	17.75 ^{a}	17.64 ^{a}	22.71 ^{b}	23.34 ^{b}	23.03 ^{b}
S.Em. ±	0.14	0.14	0.10	0.21	0.21	0.18
C.D at 5 %	0.43	0.41	0.31	0.62	0.62	0.53
Interaction (W x C)						
W_1C_1	16.60^{b-d}	16.80^{d}	16.70^{bc}	26.57^{a}	27.23^{a}	26.90^{a}
W_1C_2	17.40^{a-c}	18.07^{ab}	17.73^{a}	25.67^{ab}	26.33^{ab}	26.00^{ab}
W_1C_3	17.50^{a-c}	17.73^{a-d}	17.62^{ab}	24.27^{a-c}	24.93^{a-c}	24.60^{a-d}
W_2C_1	16.13^{d}	16.80^{d}	16.47^{c}	26.67^{a}	26.77^{ab}	26.72^{ab}
W_2C_2	17.73^{ab}	18.57^{a}	18.15^{a}	24.47^{a-c}	25.13^{a-c}	24.80^{a-c}
W_2C_3	17.87^{a}	18.20^{ab}	18.03^{a}	23.43^{bc}	23.97^{bc}	23.70^{b-d}
W_3C_1	16.37^{cd}	17.03^{cd}	16.70^{bc}	22.37^{c}	22.03^{c}	22.20^{cd}
W_3C_2	18.17^{a}	18.40^{ab}	18.28^{a}	23.00^{bc}	22.83^{c}	22.92^{cd}
W_3C_3	17.37^{a-c}	17.57^{b-d}	17.47^{a-c}	21.70^{c}	22.37^{c}	22.03^{cd}
W_4C_1	16.37^{cd}	17.03^{cd}	16.70^{bc}	21.40^{c}	22.07^{c}	21.73^{d}
W_4C_2	17.17^{a-d}	17.83^{a-c}	17.50^{ab}	22.23^{c}	22.90^{c}	22.57^{cd}
W_4C_3	17.40^{a-c}	17.50^{b-d}	17.45^{a-c}	21.43^{c}	22.10^{c}	21.77^{cd}
S.Em. ±	0.29	0.27	0.20	0.41	0.41	0.36
C.D at 5 %	0.86	0.82	0.61	1.24	1.24	1.07

Table 1b : Effect of weed pressure and cultivars on plant height (cm) of *kharif* direct seeded rice at 45 and 60 DAS

Treatment	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	51.72 ^{a}	52.84 ^{a}	52.28 ^{a}	73.06 ^{a}	74.19 ^{a}	73.62 ^{a}
W_2: Medium	47.04 ^{b}	48.38 ^{b}	47.71 ^{b}	70.91 ^{a}	72.02 ^{a}	71.47 ^{a}
W_3: High	34.23 ^{c}	35.46 ^{c}	34.84 ^{c}	59.16 ^{b}	60.12 ^{b}	59.64 ^{b}
W_4: Very high	34.08 ^{c}	35.08 ^{c}	34.58 ^{c}	49.73 ^{c}	51.84 ^{c}	50.79 ^{c}
S.Em. ±	0.55	0.66	0.58	0.83	0.85	0.80
C.D at 5 %	1.89	2.30	2.02	2.86	2.93	2.76
Cultivars (C)						
C_1- DRR H4	42.75 ^{a}	43.83 ^{a}	43.29 ^{a}	63.88	65.22	64.55
C_2-DRR Dhan 44	40.13 ^{b}	41.72 ^{b}	40.93 ^{b}	62.44	64.08	63.26
C_3-Sahbagidhan	42.43 ^{a}	43.27 ^{a}	42.85 ^{a}	63.32	64.34	63.83
S.Em. ±	0.39	0.24	0.26	0.48	0.56	0.41
C.D at 5 %	1.16	0.71	0.79	NS	NS	NS
Interaction (W x C)						
W_1C_1	53.93^a	55.27^a	54.60^a	74.87^a	76.20^a	75.53^a
W_1C_2	49.07^{ab}	50.40^{ab}	49.73^{ab}	71.20^b	72.27^{ab}	71.73^b
W_1C_3	52.17^{ab}	52.87^{ab}	52.52^{ab}	73.10^{ab}	74.10^{ab}	73.60^{ab}
W_2C_1	49.90^{ab}	50.90^{ab}	50.40^{ab}	71.87^{ab}	73.20^{ab}	72.53^{ab}
W_2C_2	46.03^b	47.70^b	46.87^b	70.77^b	71.77^b	71.27^b
W_2C_3	45.20^b	46.53^b	45.87^b	70.10^b	71.10^b	70.60^b
W_3C_1	33.73^c	34.73^c	34.23^c	59.33^c	60.33^c	59.83^c
W_3C_2	32.43^c	34.10^c	33.27^c	58.70^c	59.83^c	59.27^c
W_3C_3	36.53^c	37.53^c	37.03^c	59.43^c	60.20^c	59.82^c
W_4C_1	33.43^c	34.43^c	33.93^c	49.47^d	51.13^d	50.30^d
W_4C_2	33.00^c	34.67^c	33.83^c	49.10^d	52.43^d	50.77^d
W_4C_3	35.80^c	36.13^c	35.97^c	50.63^d	51.97^d	51.30^d
S.Em. ±	0.77	0.47	0.53	0.97	1.12	0.82
C.D at 5 %	2.31	1.42	1.58	2.89	3.36	2.45

Table 1c : Effect of weed pressure and cultivars on plant height (cm) of *kharif* direct seeded rice at 90 DAS and at maturity

Treatment	90 DAS			Maturity		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	102.81 ^{a}	105.14 ^{a}	103.98 ^{a}	110.44 ^{a}	112.00 ^{a}	111.22 ^{a}
W_2: Medium	93.58 ^{b}	95.80 ^{b}	94.69 ^{b}	100.72 ^{b}	102.50 ^{b}	101.61 ^{b}
W_3: High	71.78 ^{c}	73.11 ^{c}	72.44 ^{c}	77.93 ^{c}	79.71 ^{c}	78.82 ^{c}
W_4: Very high	68.01 ^{c}	69.90 ^{c}	68.96 ^{c}	73.63 ^{d}	74.52 ^{d}	74.08 ^{d}
S.Em. ±	1.32	0.84	1.01	1.37	1.05	1.14
C.D at 5 %	4.56	2.92	3.49	4.73	3.64	3.94
Cultivars (C)						
C_1- DRR H4	86.06 ^{a}	87.56 ^{a}	86.81 ^{a}	91.50 ^{a}	93.00 ^{a}	92.25 ^{a}
C_2-DRR Dhan 44	83.93 ^{a}	85.68 ^{a}	84.80 ^{a}	90.98 ^{a}	92.82 ^{a}	91.90 ^{a}
C_3-Sahbagidhan	82.15 ^{b}	84.73 ^{b}	83.44 ^{b}	89.57 ^{b}	90.73 ^{b}	90.15 ^{b}
S.Em. ±	1.21	1.01	1.00	0.88	0.87	0.81
C.D at 5 %	3.61	3.02	3.01	2.64	2.60	2.42
Interaction (W x C)						
W_1C_1	105.53^a	107.20^a	106.37^a	113.27^a	113.93^a	113.60^a
W_1C_2	105.03^a	107.03^a	106.03^a	110.90^a	113.23^a	112.07^a
W_1C_3	97.87^{ab}	101.20^{ab}	99.53^{ab}	107.17^{ab}	108.83^{ab}	108.00^{ab}
W_2C_1	94.97^b	96.30^b	95.63^b	102.13^{bc}	104.80^{bc}	103.47^{bc}
W_2C_2	93.03^b	95.37^b	94.20^b	100.37^{bc}	102.37^{bc}	101.37^{bc}
W_2C_3	92.73^b	95.73^b	94.23^b	99.67^c	100.33^c	100.00^c
W_3C_1	75.13^c	76.80^c	75.97^c	79.20^d	81.20^d	80.20^d
W_3C_2	69.47^c	70.47^c	69.97^c	77.90^{de}	79.90^d	78.90^{de}
W_3C_3	70.73^c	72.07^c	71.40^c	76.70^{de}	78.03^{de}	77.37^{de}
W_4C_1	68.60^c	69.93^c	69.27^c	71.40^e	72.07^e	71.73^e
W_4C_2	68.17^c	69.83^c	69.00^c	74.77^{de}	75.77^{de}	75.27^{de}
W_4C_3	67.27^c	69.93^c	68.60^c	74.73^{de}	75.73^{de}	75.23^{de}
S.Em. ±	2.41	2.02	2.01	1.76	1.73	1.61
C.D at 5 %	7.23	6.05	6.01	5.27	5.20	4.83

Table 2a : Effect of weed pressure and cultivars on leaf area index at 14 and 29 DAS of *kharif* direct seeded rice

Treatment	14 DAS			29 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	0.028	0.032	0.030	0.23^{b}	0.24^{a}	0.24^{a}
W_2: Medium	0.030	0.030	0.030	0.25^{a}	0.24^{a}	0.25^{a}
W_3: High	0.030	0.030	0.030	0.20^{c}	0.20^{b}	0.20^{b}
W_4: Very high	0.029	0.033	0.031	0.21^{c}	0.21^{b}	0.21^{b}
S.Em. ±	0.002	0.003	0.001	0.002	0.003	0.002
C.D at 5 %	NS	NS	NS	0.01	0.01	0.01
Cultivars (C)						
C_1- DRR H4	0.030	0.031	0.031	0.23	0.23	0.23
C_2-DRR Dhan 44	0.029	0.032	0.030	0.22	0.22	0.22
C_3-Sahbagidhan	0.028	0.031	0.030	0.23	0.22	0.22
S.Em. ±	0.002	0.001	0.001	0.01	0.005	0.005
C.D at 5 %	NS	NS	NS	NS	NS	NS
Interaction (W x C)						
W_1C_1	0.027	0.033	0.030	0.25^{a}	0.25^{a}	0.25^{a}
W_1C_2	0.027	0.033	0.030	0.22^{b-d}	0.24^{a}	0.23^{ab}
W_1C_3	0.030	0.030	0.030	0.24^{a-c}	0.24^{a}	0.24^{a}
W_2C_1	0.030	0.027	0.028	0.25^{a}	0.24^{a}	0.25^{a}
W_2C_2	0.033	0.033	0.033	0.24^{ab}	0.24^{a}	0.24^{a}
W_2C_3	0.027	0.030	0.028	0.25^{a}	0.25^{a}	0.25^{a}
W_3C_1	0.030	0.033	0.032	0.21^{d}	0.21^{b}	0.21^{bc}
W_3C_2	0.030	0.027	0.028	0.20^{d}	0.20^{b}	0.20^{c}
W_3C_3	0.030	0.030	0.030	0.20^{d}	0.20^{b}	0.20^{c}
W_4C_1	0.033	0.031	0.032	0.21^{d}	0.21^{b}	0.21^{bc}
W_4C_2	0.027	0.033	0.030	0.20^{d}	0.20^{b}	0.20^{c}
W_4C_3	0.027	0.033	0.030	0.21^{d}	0.21^{b}	0.21^{bc}
S.Em. ±	0.004	0.003	0.002	0.01	0.02	0.01
C.D at 5 %	NS	NS	NS	0.04	0.06	0.03

Table 2b : Effect of weed pressure and cultivars on leaf area index at 45 and 60 DAS of *kharif* direct seeded rice

Treatment	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	1.07^{a}	1.13^{a}	1.10^{a}	1.83^{a}	1.88^{a}	1.86^{a}
W_2: Medium	1.11^{a}	1.16^{a}	1.14^{a}	1.41^{b}	1.43^{b}	1.42^{b}
W_3: High	0.73^{b}	0.78^{b}	0.76^{b}	1.19^{c}	1.23^{c}	1.21^{c}
W_4: Very high	0.73^{b}	0.77^{b}	0.75^{b}	0.91^{d}	0.94^{d}	0.92^{d}
S.Em. ±	0.05	0.03	0.04	0.05	0.03	0.04
C.D at 5 %	0.17	0.11	0.16	0.16	0.11	0.13
Cultivars (C)						
C_1- DRR H4	0.90	0.96	0.93	1.34	1.38	1.36
C_2-DRR Dhan 44	0.92	0.97	0.94	1.33	1.36	1.34
C_3-Sahbagidhan	0.91	0.96	0.93	1.34	1.37	1.35
S.Em. ±	0.04	0.02	0.03	0.04	0.03	0.05
C.D at 5 %	NS	NS	NS	NS	NS	NS
Interaction (W x C)						
W_1C_1	1.10^{a}	1.18^{a}	1.14^{a}	1.85^{a}	1.88^{a}	1.86^{a}
W_1C_2	1.07^{a}	1.13^{a}	1.10^{a}	1.83^{a}	1.87^{a}	1.85^{a}
W_1C_3	1.02^{a}	1.09^{a}	1.05^{a}	1.82^{a}	1.89^{a}	1.86^{a}
W_2C_1	1.11^{a}	1.15^{a}	1.13^{a}	1.45^{b}	1.46^{b}	1.46^{b}
W_2C_2	1.11^{a}	1.16^{a}	1.14^{a}	1.39^{b}	1.41^{b}	1.40^{b}
W_2C_3	1.11^{a}	1.18^{a}	1.15^{a}	1.40^{b}	1.43^{b}	1.41^{b}
W_3C_1	0.74^{b}	0.80^{b}	0.77^{b}	1.16^{c}	1.22^{c}	1.19^{c}
W_3C_2	0.72^{b}	0.76^{b}	0.74^{b}	1.21^{c}	1.24^{c}	1.22^{c}
W_3C_3	0.74^{b}	0.78^{b}	0.76^{b}	1.20^{c}	1.23^{c}	1.22^{c}
W_4C_1	0.66^{b}	0.71^{b}	0.69^{b}	0.92^{d}	0.95^{d}	0.94^{d}
W_4C_2	0.77^{b}	0.81^{b}	0.79^{b}	0.89^{d}	0.92^{d}	0.91^{d}
W_4C_3	0.76^{b}	0.79^{b}	0.77^{b}	0.92^{d}	0.94^{d}	0.93^{d}
S.Em. ±	0.09	0.07	0.08	0.08	0.10	0.08
C.D at 5 %	0.28	0.22	0.23	0.24	0.30	0.23

Table 2c : Effect of weed pressure and cultivars on leaf area index at 90 DAS and at maturity of *kharif* direct seeded rice

Treatment	90 DAS			Maturity		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	3.86 ^{a}	3.87 ^{a}	3.87 ^{a}	2.34 ^{a}	2.33 ^{a}	2.33 ^{a}
W_2: Medium	3.10 ^{b}	3.13 ^{b}	3.12 ^{b}	2.11 ^{a}	2.13 ^{a}	2.12 ^{a}
W_3: High	2.47 ^{c}	2.53 ^{c}	2.50 ^{c}	1.50 ^{b}	1.56 ^{b}	1.53 ^{b}
W_4: Very high	1.42 ^{d}	1.44 ^{d}	1.43 ^{d}	0.90 ^{c}	0.95 ^{c}	0.92 ^{c}
S.Em. ±	0.16	0.13	0.15	0.10	0.07	0.08
C.D at 5 %	0.57	0.42	0.52	0.35	0.25	0.28
Cultivars (C)						
C_1- DRR H4	2.71	2.73	2.72	1.69	1.73	1.71
C_2-DRR Dhan 44	2.73	2.76	2.74	1.73	1.74	1.73
C_3-Sahbagidhan	2.70	2.75	2.72	1.71	1.76	1.74
S.Em. ±	0.05	0.04	0.06	0.05	0.04	0.06
C.D at 5 %	NS	NS	NS	NS	NS	NS
Interaction (W x C)						
W_1C_1	3.87^a	3.89^a	3.88^a	2.23^{bc}	2.26^{ab}	2.25^{ab}
W_1C_2	3.86^a	3.87^a	3.86^a	2.44^a	2.3^{ab}	2.37^a
W_1C_3	3.85^a	3.87^a	3.86^a	2.36^{ab}	2.41^a	2.39^a
W_2C_1	3.06^b	3.09^b	3.07^b	2.12^c	2.15^b	2.13^b
W_2C_2	3.15^b	3.17^b	3.16^b	2.10^c	2.13^b	2.11^b
W_2C_3	3.1^b	3.15^b	3.13^b	2.10^c	2.12^b	2.11^b
W_3C_1	2.51^c	2.56^c	2.54^c	1.52^d	1.57^c	1.55^c
W_3C_2	2.46^c	2.51^c	2.49^c	1.51^d	1.57^c	1.54^c
W_3C_3	2.43^c	2.52^c	2.48^c	1.49^d	1.54^c	1.52^c
W_4C_1	1.38^d	1.4^d	1.39^d	0.90^e	0.93^d	0.92^d
W_4C_2	1.46^d	1.48^d	1.47^d	0.89^e	0.94^d	0.92^d
W_4C_3	1.42^d	1.45^d	1.44^d	0.90^e	0.97^d	0.93^d
S.Em. ±	0.11	0.13	0.12	0.11	0.13	0.12
C.D at 5 %	0.31	0.39	0.35	0.33	0.39	0.35

Table 3a : Effect of weed pressure and cultivars on tiller number (m^{-2}) of *kharif* direct seeded rice at 15 and 30 DAS

Treatment	15 DAS			30 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	48.98	47.33	48.16	118.22 ^{a}	121.44 ^{a}	119.83 ^{a}
W_2: Medium	49.13	47.67	48.40	118.22 ^{a}	120.89 ^{a}	119.56 ^{a}
W_3: High	47.47	48.22	47.85	85.89 ^{b}	88.78 ^{b}	87.33 ^{b}
W_4: Very high	47.78	46.89	47.33	85.00 ^{b}	87.22 ^{b}	86.11 ^{b}
S.Em. ±	1.07	0.64	0.53	3.99	3.38	3.66
C.D at 5 %	NS	NS	NS	13.81	11.71	12.67
Cultivars (C)						
C_1- DRR H4	48.57	47.58	48.07	106.17 ^{a}	108.58 ^{a}	107.38 ^{a}
C_2-DRR Dhan 44	48.69	47.42	48.05	100.58 ^{a}	103.58 ^{a}	102.08 ^{a}
C_3-Sahbagidhan	47.77	47.58	47.68	98.75 ^{b}	101.58 ^{b}	100.17 ^{b}
S.Em. ±	0.71	0.49	0.45	2.35	2.23	2.28
C.D at 5 %	NS	NS	NS	7.06	6.67	6.83
Interaction (W x C)						
W_1C_1	48.33^{ab}	47.00^a	47.67 ^{a}	129.00^a	131.67^a	130.33^a
W_1C_2	49.54^a	46.33^a	47.94 ^{a}	115.00^a	118.67^a	116.83^a
W_1C_3	49.07^{ab}	48.67^a	48.87 ^{a}	110.67^a	114.00^a	112.33^a
W_2C_1	49.51^a	47.33^a	48.42 ^{a}	126.00^a	128.67^a	127.33^a
W_2C_2	48.54^{ab}	48.33^a	48.44 ^{a}	116.00^a	119.00^a	117.50^a
W_2C_3	49.33^a	47.33^a	48.33 ^{a}	112.67^a	115.00^a	113.83^a
W_3C_1	48.42^{ab}	49.67^a	49.05 ^{a}	85.00^b	87.00^b	86.00^b
W_3C_2	48.67^{ab}	48.00^a	48.33 ^{a}	86.00^b	89.33^b	87.67^b
W_3C_3	45.33^b	47.00^a	46.17^b	86.67^b	90.00^b	88.33^b
W_4C_1	48.00^{ab}	46.33^a	47.17 ^{a}	84.67^b	87.00^b	85.83^b
W_4C_2	48.00^{ab}	47.00^a	47.50 ^{a}	85.33^b	87.33^b	86.33^b
W_4C_3	47.33^{ab}	47.33^a	47.33 ^{a}	85.00^b	87.33^b	86.17^b
S.Em. ±	1.41	0.99	0.89	4.71	4.45	4.56
C.D at 5 %	4.23	NS	2.68	14.12	13.35	13.67

Table 3b : Effect of weed pressure and cultivars on tiller number (m^{-2}) of *kharif* direct seeded rice at 45 and 60 DAS

Treatment	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	211.00^{a}	218.22^{a}	214.61^{a}	321.67^{a}	326.11^{a}	323.89^{a}
W_2: Medium	205.67^{a}	210.89^{a}	208.28^{a}	310.44^{a}	315.11^{a}	312.78^{a}
W_3: High	126.44^{b}	128.89^{b}	127.67^{b}	232.00^{b}	234.78^{b}	233.39^{b}
W_4: Very high	122.78^{b}	125.67^{b}	124.22^{b}	138.56^{c}	142.33^{c}	140.44^{c}
S.Em. ±	8.59	8.86	8.69	4.59	5.62	4.87
C.D at 5 %	29.71	30.64	30.07	15.90	19.46	16.87
Cultivars (C)						
C_1- DRR H4	172.67	177.00	174.83	257.00^{a}	261.17^{a}	259.08^{a}
C_2-DRR Dhan 44	159.75	164.17	161.96	245.83^{b}	249.58^{b}	247.71^{b}
C_3-Sahbagidhan	167.00	171.58	169.29	249.17^{a}	253.00^{a}	251.08^{a}
S.Em. ±	5.68	5.70	5.66	3.22	4.00	3.57
C.D at 5 %	NS	NS	NS	9.65	11.00	10.70
Interaction (W x C)						
W_1C_1	226.33^{a}	233.67^{a}	230.00^{a}	330.00^{a}	333.33^{a}	331.67^{a}
W_1C_2	196.33^{a}	202.67^{ab}	199.50^{ab}	314.00^{bc}	318.67^{bc}	316.33^{bc}
W_1C_3	210.33^{a}	218.33^{ab}	214.33^{ab}	321.00^{ab}	326.33^{ab}	323.67^{ab}
W_2C_1	219.67^{a}	224.33^{ab}	222.00^{ab}	313.67^{bc}	319.00^{bc}	316.33^{bc}
W_2C_2	193.33^{a}	199.33^{b}	196.33^{b}	306.33^{c}	310.67^{c}	308.50^{c}
W_2C_3	204.00^{a}	209.00^{ab}	206.50^{ab}	311.33^{bc}	315.67^{bc}	313.50^{bc}
W_3C_1	123.67^{b}	125.67^{c}	124.67^{c}	238.00^{d}	242.00^{d}	240.00^{d}
W_3C_2	127.00^{b}	129.67^{c}	128.33^{c}	227.00^{e}	228.67^{e}	227.83^{e}
W_3C_3	128.67^{b}	131.33^{c}	130.00^{c}	231.00^{de}	233.67^{de}	232.33^{de}
W_4C_1	121.00^{b}	124.33^{c}	122.67^{c}	146.33^{f}	150.33^{f}	148.33^{f}
W_4C_2	122.33^{b}	125.00^{c}	123.67^{c}	136.00^{g}	140.33^{fg}	138.17^{g}
W_4C_3	125.00^{b}	127.67^{c}	126.33^{c}	133.33^{g}	136.33^{g}	134.83^{g}
S.Em. ±	11.37	11.40	11.31	6.44	8.00	7.14
C.D at 5 %	34.08	34.17	33.91	19.31	23.99	21.41

Table 3c : Effect of weed pressure and cultivars on tiller number (m^{-2}) of *kharif* direct seeded rice at 90 DAS and at maturity

Treatment	90 DAS			Maturity		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	350.56^{a}	352.56^{a}	351.56^{a}	354.78^{a}	357.44^{a}	356.11^{a}
W_2: Medium	330.33^{b}	334.56^{b}	332.44^{b}	334.33^{b}	338.67^{b}	336.50^{b}
W_3: High	260.78^{c}	263.78^{c}	262.28^{c}	267.22^{c}	268.11^{c}	267.67^{c}
W_4: Very high	160.78^{d}	161.78^{d}	161.28^{d}	164.00^{d}	165.78^{d}	164.89^{d}
S.Em. ±	5.06	4.68	4.83	4.88	4.01	4.41
C.D at 5 %	17.50	16.20	16.70	16.90	13.88	15.28
Cultivars (C)						
C_1- DRR H4	291.08^{a}	293.42^{a}	292.25^{a}	296.25^{a}	297.83^{a}	297.04^{a}
C_2-DRR Dhan 44	273.17^{b}	275.33^{b}	274.25^{b}	277.50^{b}	279.50^{b}	278.50^{b}
C_3-Sahbagidhan	262.58^{b}	265.75^{b}	264.17^{b}	266.50^{b}	270.17^{b}	268.33^{b}
S.Em. ±	4.98	5.56	5.15	4.57	5.48	4.86
C.D at 5 %	14.93	16.66	15.45	13.71	16.41	14.56
Interaction (W x C)						
W_1C_1	368.67^{a}	367.00^{a}	367.83^{a}	371.67^{a}	372.00^{a}	371.83^{a}
W_1C_2	340.33^{ab}	346.00^{ab}	343.17^{ab}	346.33^{ab}	351.67^{ab}	349.00^{ab}
W_1C_3	342.67^{ab}	344.67^{ab}	343.67^{ab}	346.33^{ab}	348.67^{ab}	347.50^{ab}
W_2C_1	339.00^{ab}	343.67^{ab}	341.33^{ab}	344.67^{ab}	348.00^{ab}	346.33^{ab}
W_2C_2	328.00^{b}	332.00^{b}	330.00^{b}	332.00^{b}	335.67^{b}	333.83^{b}
W_2C_3	324.00^{b}	328.00^{b}	326.00^{b}	326.33^{b}	332.33^{b}	329.33^{b}
W_3C_1	285.00^{c}	289.33^{c}	287.17^{c}	292.67^{c}	293.00^{c}	292.83^{c}
W_3C_2	255.67^{cd}	257.67^{d}	256.67^{d}	260.67^{d}	262.00^{d}	261.33^{d}
W_3C_3	241.67^{d}	244.33^{d}	243.00^{d}	248.33^{d}	249.33^{d}	248.83^{d}
W_4C_1	171.67^{e}	173.67^{e}	172.67^{e}	176.00^{e}	178.33^{e}	177.17^{e}
W_4C_2	168.67^{e}	165.67^{e}	167.17^{e}	171.00^{ef}	168.67^{ef}	169.83^{ef}
W_4C_3	142.00^{e}	146.00^{e}	144.00^{e}	145.00^{f}	150.33^{f}	147.67^{f}
S.Em. ±	9.96	11.11	10.31	9.14	10.95	9.71
C.D at 5 %	29.87	33.32	30.90	27.41	32.83	29.12

Table 4 : Effect of weed pressure and cultivars on dry matter production (g plant^{-1}) of *kharif* direct seeded rice at 45 and 60 DAS

Treatment	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	3.05^a	3.23^a	3.14^a	4.85^a	5.19^a	5.02^a
W_2: Medium	2.99^a	3.28^a	3.13^a	4.42^b	4.42^b	4.42^b
W_3: High	0.98^b	1.02^b	1.00^b	3.26^c	3.21^c	3.24^c
W_4: Very high	0.92^b	0.96^b	0.94^b	1.89^d	1.82^d	1.86^d
S.Em. ±	0.10	0.13	0.05	0.14	0.20	0.11
C.D at 5 %	0.35	0.44	0.17	0.48	0.68	0.36
Cultivars (C)						
C_1- DRR H4	1.93	2.15	2.04	3.49	3.67	3.58
C_2-DRR Dhan 44	2.01	2.11	2.06	3.59	3.68	3.64
C_3-Sahbagidhan	2.01	2.11	2.06	3.73	3.62	3.68
S.Em. ±	0.10	0.06	0.06	0.12	0.06	0.08
C.D at 5 %	NS	NS	NS	NS	NS	NS
Interaction (W x C)						
W_1C_1	2.99^a	3.20^a	3.10^a	4.83^a	5.24^a	5.04^a
W_1C_2	3.07^a	3.17^a	3.12^a	4.80^a	5.12^a	4.96^a
W_1C_3	3.09^a	3.33^a	3.21^a	4.91^a	5.20^a	5.05^a
W_2C_1	2.89^a	3.34^a	3.11^a	4.26^c	4.39^b	4.33^b
W_2C_2	3.09^a	3.28^a	3.19^a	4.34^{bc}	4.56^b	4.45^b
W_2C_3	2.98^a	3.21^a	3.09^a	4.66^{ab}	4.30^b	4.48^b
W_3C_1	1.01^b	1.11^b	1.06^b	3.22^d	3.30^c	3.26^c
W_3C_2	0.93^b	1.05^b	0.99^b	3.25^d	3.24^c	3.24^c
W_3C_3	0.99^b	0.90^b	0.95^b	3.31^d	3.10^c	3.21^c
W_4C_1	0.85^b	0.95^b	0.90^b	1.66^f	1.74^d	1.70^d
W_4C_2	0.94^b	0.94^b	0.94^b	1.97^{ef}	1.81^d	1.89^d
W_4C_3	0.98^b	1.00^b	0.99^b	2.06^e	1.90^d	1.98^d
S.Em. ±	0.21	0.12	0.13	0.24	0.13	0.16
C.D at 5 %	0.62	0.35	0.36	0.73	0.38	0.47

Table 5 : Effect of weed pressure and cultivars on total number of weeds (no. m^{-2}) at 45 and 60 DAS of *kharif* direct seeded rice

Treatment	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
W_2: Medium	4.61(20.7)	5.94(34.8)	5.27(27.8)	8.82(77.5)	9.70(93.7)	9.26(85.6)
W_3: High	7.57(56.8)	8.83(77.4)	8.20(67.1)	4.70(21.6)	4.86(23.2)	4.78(22.4)
W_4: Very high	7.78(60.2)	8.94(79.4)	8.36(69.8)	11.00(120)	12.02(144)	11.51(132)
S.Em. ±	0.09	0.05	0.03	0.08	0.08	0.05
C.D at 5 %	0.30	0.17	0.11	0.28	0.26	0.16
Cultivars (C)						
C_1- DRR H4	5.10(33.6)	6.14(48.6)	5.62(41.1)	6.20(53.1)	6.71(63.2)	6.46(58.2)
C_2-DRR Dhan 44	5.12(33.8)	6.07(47.4)	5.60(40.6)	6.36(55.9)	6.85(66.0)	6.60(60.9)
C_3-Sahbagidhan	5.28(35.9)	6.10(47.7)	5.69(41.8)	6.36(55.7)	6.90(66.5)	6.63(61.1)
S.Em. ±	0.11	0.10	0.07	0.14	0.15	0.10
C.D at 5 %	NS	NS	NS	NS	NS	NS
Interaction (W x C)						
W_1C_1	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
W_1C_2	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
W_1C_3	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)
W_2C_1	4.49(19.6)	5.84(33.6)	5.16(26.6)	8.66(75.0)	9.51(90.3)	9.08(82.6)
W_2C_2	4.59(20.6)	5.91(34.6)	5.25(27.6)	8.81(77.3)	9.61(92.0)	9.21(84.6)
W_2C_3	4.74(22.0)	6.05(36.3)	5.40(29.1)	8.99(80.3)	9.97(99.0)	9.48(89.6)
W_3C_1	7.37(54.0)	8.82(77.3)	8.10(65.6)	4.59(20.6)	4.78(22.6)	4.69(21.6)
W_3C_2	7.51(56.0)	8.88(78.3)	8.19(67.1)	4.74(22.0)	4.87(23.3)	4.81(22.6)
W_3C_3	7.82(60.6)	8.78(76.6)	8.30(68.6)	4.78(22.3)	4.91(23.6)	4.84(23.0)
W_4C_1	7.82(61.0)	9.17(83.6)	8.50(72.3)	10.84(117)	11.84(140)	11.34(128)
W_4C_2	7.69(58.6)	8.78(76.6)	8.24(67.6)	11.17(124)	12.21(148)	11.69(136)
W_4C_3	7.83(61.0)	8.85(78.0)	8.34(69.5)	10.98(120)	12.00(143)	11.49(132)
S.Em. ±	0.21	0.20	0.14	0.28	0.29	0.20
C.D at 5 %	0.64	0.62	0.42	0.85	0.87	0.60

*Weed count figures are transformed to √x+0.5 and original figures are given in parenthesis

Table 6 : Effect of weed pressure and cultivars on weed dry matter (g m^{-2}) at 45 and 60 DAS of *kharif* direct seeded rice

Treatment	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)
W_2: Medium	0.84(4.93)	0.86(5.29)	0.85(5.41)	1.03(8.72)	1.07(9.72)	1.05(9.22)
W_3: High	1.08(10.1)	1.10(10.7)	1.09(11.0)	0.59(1.95)	0.57(1.75)	0.58(1.85)
W_4: Very high	1.10(10.7)	1.12(11.2)	1.11(10.3)	1.42(24.3)	1.49(28.9)	1.45(26.6)
S.Em. ±	0.02	0.03	0.01	0.02	0.04	0.04
C.D at 5 %	0.07	0.09	0.04	0.08	0.07	0.06
Cultivars (C)						
C_1- DRR H4	0.84(6.59)	0.84(6.59)	0.84(6.55)	0.83(8.68)	0.85(10.0)	0.84(9.38)
C_2-DRR Dhan 44	0.82(6.24)	0.86(7.30)	0.84(6.36)	0.84(8.94)	0.87(10.3)	0.85(9.63)
C_3-Sahbagidhan	0.83(6.52)	0.83(6.56)	0.83(7.19)	0.83(8.65)	0.85(9.90)	0.84(9.27)
S.Em. ±	0.02	0.03	0.01	0.01	0.02	0.01
C.D at 5 %	NS	NS	NS	NS	NS	NS
Interaction (W x C)						
W_1C_1	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)
W_1C_2	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)
W_1C_3	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)	0.30(0.0)
W_2C_1	0.84(1.80)	0.88(5.58)	0.86(5.31)	1.01(8.35)	1.06(9.44)	1.04(8.90)
W_2C_2	0.83(1.77)	0.87(5.40)	0.85(5.15)	1.03(8.80)	1.07(9.84)	1.05(9.32)
W_2C_3	0.83(1.85)	0.84(4.90)	0.84(4.88)	1.04(8.99)	1.07(9.88)	1.06(9.44)
W_3C_1	1.10(1.95)	1.08(10.2)	1.09(10.4)	0.60(1.98)	0.57(1.74)	0.58(1.86)
W_3C_2	1.05(1.83)	1.13(11.6)	1.09(10.5)	0.60(2.00)	0.60(1.95)	0.60(1.98)
W_3C_3	1.08(1.86)	1.09(10.3)	1.08(10.2)	0.58(1.86)	0.55(1.57)	0.57(1.71)
W_4C_1	1.09(1.84)	1.10(10.5)	1.10(10.5)	1.42(24.3)	1.48(29.1)	1.45(26.7)
W_4C_2	1.10(2.04)	1.15(12.2)	1.12(11.3)	1.43(24.9)	1.50(29.4)	1.46(27.2)
W_4C_3	1.12(1.93)	1.11(11.0)	1.11(11.0)	1.41(23.7)	1.48(28.1)	1.44(25.9)
S.Em. ±	0.03	0.02	0.03	0.02	0.03	0.02
C.D at 5 %	0.10	0.05	0.06	0.05	0.10	0.06

*Dry matter figures are transformed to log(x+2) and original figures are given in parenthesis

Table 7 : Effect of weed pressure and cultivars on weed control efficiency (%) at 45 and 60 DAS of *kharif* direct seeded rice

Treatment	45 DAS			60 DAS		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	100.00	100.00	100.00	100.00	100.00	100.00
W_2: Medium	60.69	58.84	59.76	67.37	68.14	67.76
W_3: High	19.34	16.65	18.00	92.70	94.26	93.48
W_4: Very high	14.31	12.44	13.38	8.84	5.25	7.04
Cultivars (C)						
C_1- DRR H4	47.49	48.77	48.13	67.52	66.96	67.24
C_2-DRR Dhan 44	50.25	43.21	46.73	66.54	66.20	66.37
C_3-Sahbagidhan	48.01	48.97	48.49	67.63	67.57	67.60
Interaction (W x C)						
W_1C_1	100.00	100.00	100.00	100.00	100.00	100.00
W_1C_2	100.00	100.00	100.00	100.00	100.00	100.00
W_1C_3	100.00	100.00	100.00	100.00	100.00	100.00
W_2C_1	59.81	56.61	58.21	68.74	69.06	68.90
W_2C_2	60.93	58.01	59.47	67.04	67.76	67.40
W_2C_3	61.32	61.90	61.61	66.33	67.62	66.97
W_3C_1	14.09	20.61	17.35	92.56	94.30	93.43
W_3C_2	24.40	9.62	17.01	92.51	93.61	93.06
W_3C_3	19.54	19.73	19.63	93.04	94.87	93.95
W_4C_1	16.06	17.86	16.96	8.76	4.49	6.62
W_4C_2	15.68	5.21	10.45	6.60	3.44	5.02
W_4C_3	11.19	14.26	12.72	11.14	7.81	9.48

Table 8 : Effect of weed pressure and cultivars on number of filled grains per panicle and grain yield of *kharif* direct seeded rice

Treatment	No. of filled grains per panicle			Grain yield		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	182.67 ^{a}	189.33 ^{a}	186.00 ^{a}	5481 ^{a}	5612 ^{a}	5547 ^{a}
W_2: Medium	141.00 ^{b}	146.11 ^{b}	143.56 ^{b}	4666 ^{b}	4819 ^{b}	4742 ^{b}
W_3: High	105.22 ^{c}	106.33 ^{c}	105.78 ^{c}	3238 ^{c}	3266 ^{c}	3252 ^{c}
W_4: Very high	42.33 ^{d}	54.44 ^{d}	48.39 ^{d}	1355 ^{d}	1646 ^{d}	1501 ^{d}
S.Em. ±	4.85	3.64	3.28	200	172	135
C.D at 5 %	16.78	12.60	11.34	695	596	468
Cultivars (C)						
C_1- DRR H4	129.50 ^{a}	135.33 ^{a}	132.42 ^{a}	3905 ^{a}	4117 ^{a}	4011 ^{a}
C_2-DRR Dhan 44	112.33 ^{b}	116.17 ^{b}	114.25 ^{b}	3665 ^{a}	3730 ^{b}	3698 ^{b}
C_3-Sahbagidhan	111.58 ^{b}	120.67 ^{b}	116.13 ^{b}	3486 ^{b}	3661 ^{b}	3573 ^{b}
S.Em. ±	5.15	5.46	3.20	80	96	73
C.D at 5 %	15.45	16.36	9.59	241	278	221
Interaction (W x C)						
W_1C_1	198.67^{a}	201.67^{a}	200.17^{a}	5789^{a}	5996^{a}	5893^{a}
W_1C_2	175.33^{b}	182.67^{b}	179.00^{b}	5493^{ab}	5539^{ab}	5516^{ab}
W_1C_3	174.00^{b}	183.67^{b}	178.83^{b}	5162^{b}	5302^{ab}	5232^{b}
W_2C_1	154.67^{c}	159.00^{c}	156.83^{c}	5047^{bc}	5336^{ab}	5192^{b}
W_2C_2	138.00^{d}	138.00^{d}	138.00^{d}	4585^{cd}	4508^{bc}	4547^{c}
W_2C_3	130.33^{d}	141.33^{d}	135.83^{d}	4366^{d}	4612^{b}	4489^{c}
W_3C_1	113.00^{e}	117.67^{e}	115.33^{e}	3444^{e}	3517^{cd}	3480^{d}
W_3C_2	101.67^{e}	96.67^{g}	99.17^{f}	3194^{e}	3221^{d}	3208^{d}
W_3C_3	101.00^{e}	104.67^{f}	102.83^{f}	3078^{e}	3061^{d}	3069^{d}
W_4C_1	51.67^{f}	63.00^{h}	57.33^{g}	1340^{f}	1618^{e}	1479^{e}
W_4C_2	34.33^{g}	47.33^{i}	40.83^{h}	1389^{f}	1653^{e}	1521^{e}
W_4C_3	41.00^{fg}	53.00^{i}	47.00^{h}	1337^{f}	1669^{e}	1503^{e}
S.Em. ±	10.31	10.91	6.40	161	196	147
C.D at 5 %	30.90	32.72	19.18	482	526	442

Table 9 : Effect of weed pressure and cultivars on panicle length (cm) and panicle weight (g) of *kharif* direct seeded rice at harvest

Treatment	Panicle length (cm)			Panicle weight (g)		
	2023	2024	Pooled	2023	2024	Pooled
Weed pressure (W)						
W_1: No/ Low	25.27 ^{a}	25.50 ^{a}	25.38 ^{a}	3.96 ^{a}	4.26 ^{a}	4.11 ^{a}
W_2: Medium	23.58 ^{a}	23.27 ^{a}	23.42 ^{a}	3.44 ^{a}	3.62 ^{a}	3.53 ^{a}
W_3: High	19.39 ^{b}	20.58 ^{b}	19.98 ^{b}	2.05 ^{b}	2.26 ^{b}	2.15 ^{b}
W_4: Very high	17.01 ^{b}	18.03 ^{b}	17.52 ^{b}	1.05 ^{c}	1.07 ^{c}	1.06 ^{c}
S.Em. ±	0.52	0.78	0.60	0.17	0.13	0.07
C.D at 5 %	1.81	2.69	2.08	0.60	0.45	0.24
Cultivars (C)						
C_1- DRR H4	21.63	22.43	22.03	2.75	2.86	2.80
C_2-DRR Dhan 44	21.08	21.22	21.15	2.50	2.79	2.64
C_3-Sahbagidhan	21.24	21.89	21.56	2.62	2.76	2.69
S.Em. ±	0.47	0.48	0.45	0.17	0.15	0.10
C.D at 5 %	NS	NS	NS	NS	NS	NS
Interaction (W x C)						
W_1C_1	25.37^{a}	26.03^{a}	25.70^{a}	4.10^{a}	4.36^{a}	4.23^{a}
W_1C_2	25.80^{a}	24.60^{abc}	25.20^{ab}	3.82^{ab}	4.14^{ab}	3.98^{ab}
W_1C_3	24.63^{a}	25.87^{ab}	25.25^{ab}	3.97^{ab}	4.28^{a}	4.12^{ab}
W_2C_1	24.03^{a}	24.50^{abc}	24.27^{ab}	3.72^{ab}	3.80^{bc}	3.76^{bc}
W_2C_2	23.27^{a}	22.47^{cde}	22.87^{bc}	3.17^{c}	3.60^{c}	3.39^{c}
W_2C_3	23.44^{a}	22.84^{bcd}	23.14^{bc}	3.42^{bc}	3.47^{c}	3.45^{c}
W_3C_1	19.53^{bc}	20.53^{def}	20.03^{de}	2.01^{d}	2.26^{d}	2.14^{d}
W_3C_2	18.27^{bcd}	19.50^{efg}	18.88^{def}	1.93^{d}	2.24^{d}	2.09^{d}
W_3C_3	20.37^{b}	21.70^{cde}	21.03^{cd}	2.21^{d}	2.28^{d}	2.24^{d}
W_4C_1	17.57^{cd}	18.63^{fg}	18.10^{ef}	1.17^{e}	1.01^{e}	1.09^{e}
W_4C_2	16.97^{cd}	18.30^{fg}	17.63^{ef}	1.08^{e}	1.18^{e}	1.13^{e}
W_4C_3	16.50^{d}	17.17^{g}	16.83^{f}	0.90^{e}	1.02^{e}	0.96^{e}
S.Em. ±	0.94	0.95	0.90	0.34	0.29	0.19
C.D at 5 %	2.81	2.86	2.69	1.01	0.88	0.58

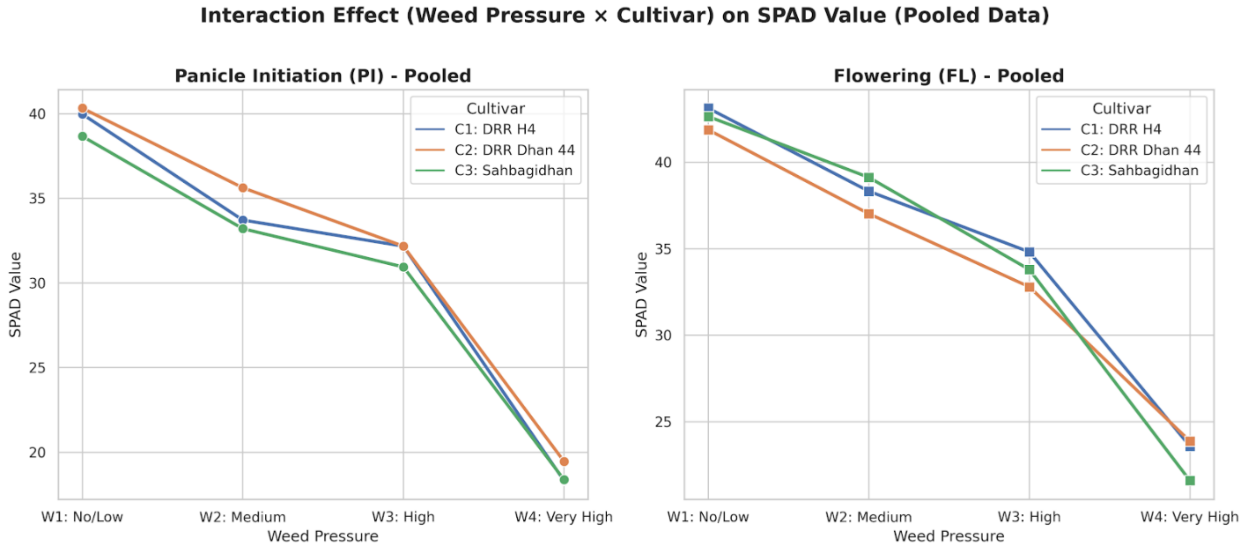

Fig. 1 : Differential Response of Rice Cultivars to Varying Weed Pressure on SPAD value at Panicle Initiation and Flowering

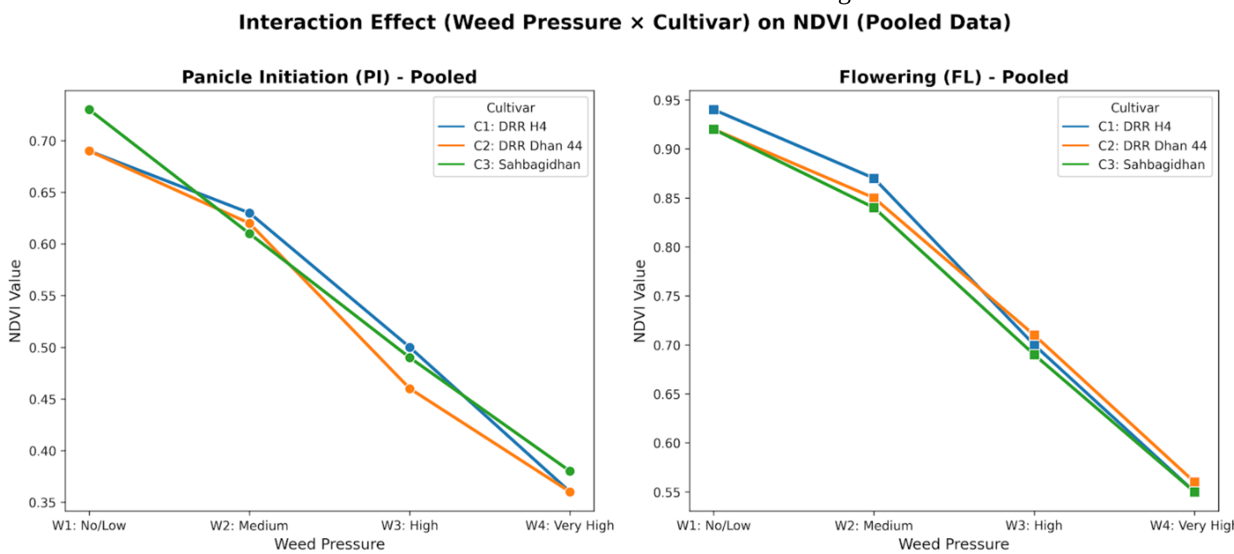

Fig. 2 : Differential Response of Rice Cultivars to Varying Weed Pressure on NDVI at Panicle Initiation and Flowering

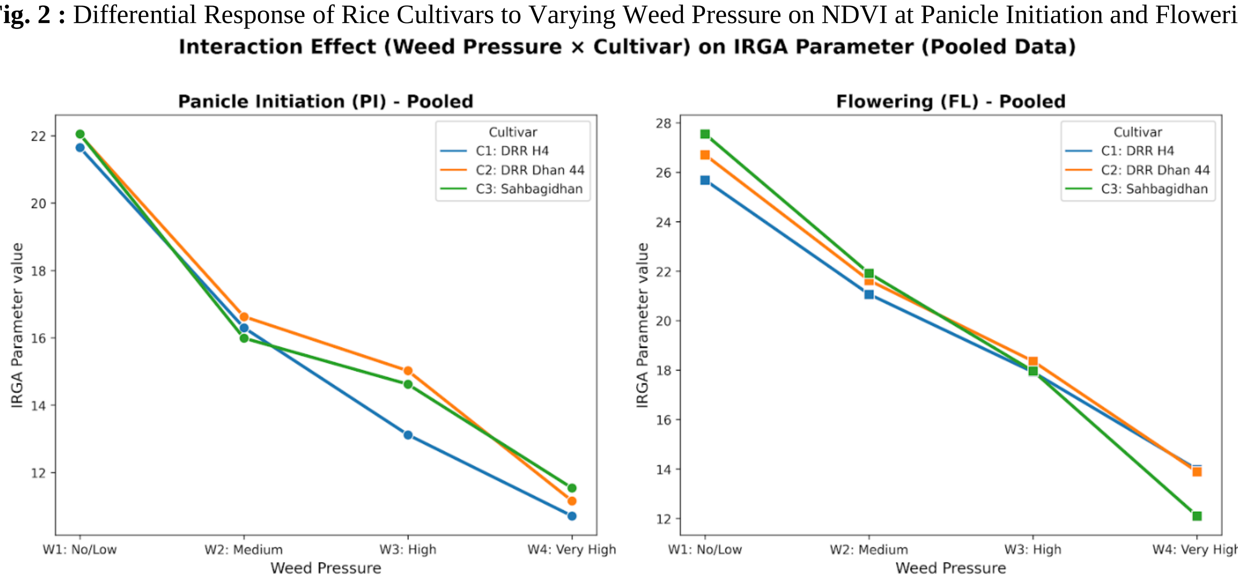

Fig. 3 : Differential Response of Rice Cultivars to Varying Weed Pressure on IRGA µmol $CO_2 m^{-2} s^{-1}$ at Panicle Initiation and Flowering

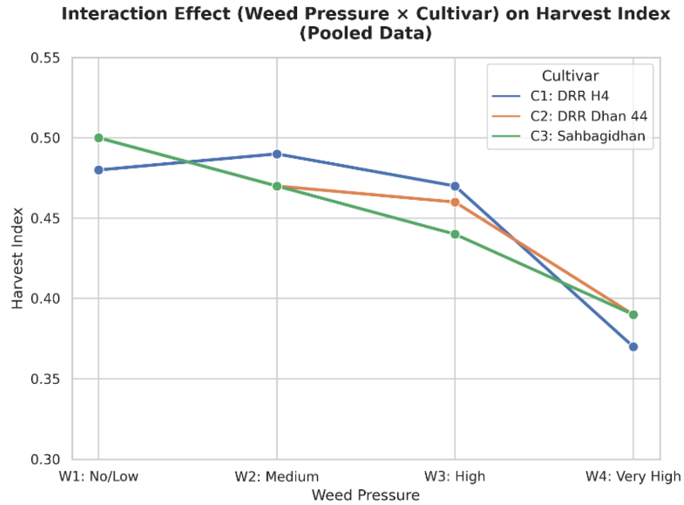

Fig. 4 : Differential Response of Rice Cultivars to Varying Weed Pressure on harvest index

Acknowledgement: The authors highly acknowledge the ICAR-Indian Institute of Rice Research (IIRR) for providing the necessary field and laboratory facilities to conduct this research. We are also grateful to the Department of Agronomy, University of Agricultural Sciences, Raichur for providing the technical support to carry out this investigation.

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