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# Competitive ability of rice cultivars against *Echinochloa* species under varied nitrogen regimes

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## Abstract
A surprising fact about *Echinochloa* crus-galli the world's worst rice weed is that it can absorb nitrogen faster than many rice cultivars, turning a farmer's fertiliser investment into a weed problem. This research evaluated the competitive ability of four rice cultivars (Swarna, MTU 7029, IR 36, Jaya) against *Echinochloa* under two nitrogen regimes (60 and 120 kg N ha$^{-1}$) at Rani Lakshmi Bai Central Agricultural University, Jhansi, during kharif 2022. MTU 7029 showed the strongest weed suppression (72.1% at high N) through rapid canopy closure and early vigour. High nitrogen consistently favoured rice over *Echinochloa*, with weed suppression 22-27 percentage points higher at 120 kg N than at 60 kg N. Rice cultivars with faster early leaf area expansion were better competitors regardless of nitrogen level. These findings suggest that combining competitive cultivars with optimised nitrogen timing can reduce herbicide dependency in rice.

**Keywords:** Competitive ability, rice cultivars, *Echinochloa*, nitrogen regimes, crop-weed competition, weed suppression, canopy closure, early vigour, integrated weed management, leaf area index

## Introduction
Here is a surprising fact: *Echinochloa* crus-galli can produce up to 40,000 seeds per plant and complete its life cycle in as little as 42 days, making it one of the most formidable competitors rice farmers face [1]. In transplanted rice systems across the Indo-Gangetic Plains, *Echinochloa* species cause yield losses of 30-70% when left uncontrolled [2]. While herbicides remain the primary management tool, rising concerns about resistance, residues, and cost have renewed interest in cultural weed management approaches, particularly the use of inherently competitive rice cultivars [3].
Cultivar competitiveness against weeds depends on traits like early vigour, rapid leaf area expansion, tall stature, and high tiller production [4]. Nitrogen availability modifies this competition: both rice and *Echinochloa* respond strongly to applied nitrogen, but the relative benefit depends on which species captures the nutrient first [5]. This research tested whether cultivar choice and nitrogen rate interact to determine competitive outcomes, and which plant traits best predict weed suppression [6].

## Performance evaluation criteria
Cultivar competitive ability was assessed using three metrics: weed suppression ability (WSA = (weed biomass in pure stand − weed biomass in mixture) / weed biomass in pure stand × 100), competitive ratio (CR = relative yield of rice / relative yield of weed), and tolerance index (TI = yield in weedy condition / yield in weed-free condition). WSA reflects the crop's ability to suppress the weed, CR compares competitive balance, and TI measures the crop's ability to maintain yield despite weed pressure [4, 6]. All three were calculated at 60 DAS and at harvest.

## Material and Methods
### Material
Four rice cultivars (Swarna, MTU 7029, IR 36, Jaya) representing a range of growth durations and vigour levels were selected. *Echinochloa* crus-galli seeds were collected from natural infestations at the RLBCAU research farm, Jhansi (25°27′N, 78°34′E), air-dried, and stored at 4°C until use. The research site has Vertisol soil (clay loam), pH 7.4, organic carbon 0.58%, available N 178 kg ha$^{-1}$ [5, 7].

**Methods**
A split-plot design with four replications was used: nitrogen regime (60 and 120 kg N ha⁻¹) as main plot and cultivar (four levels) as sub-plot. Each sub-plot had three weed conditions: weed-free, natural *Echinochloa* infestation, and *Echinochloa*-seeded (supplemental sowing at 200 seeds m⁻²). Plot size: 4 m × 3 m. Rice was transplanted on 12 July 2022 and harvested in October-November. Leaf area, tiller count, and plant height were measured at 15-day intervals. Weed biomass was recorded at 30 and 60 DAS. Rice grain yield was recorded from net plot area. Data analysed by split-plot ANOVA in SAS 9.4 [7, 8].

**Results**

**Table 1:** Weed suppression ability (%) and grain yield of rice cultivars under two nitrogen regimes

| Cultivar | WSA (%) High N | WSA (%) Low N | CR High N | CR Low N | Yield weedy High N (t ha⁻¹) | Yield weed-free High N (t ha⁻¹) |
|---|---|---|---|---|---|---|
| Swarna | 68.4 ± 3.2b | 41.2 ± 4.1b | 1.84 | 1.23 | 4.12 ± 0.24b | 5.68 ± 0.21a |
| MTU 7029 | 72.1 ± 2.8a | 46.8 ± 3.7a | 2.12 | 1.38 | 4.47 ± 0.22a | 5.82 ± 0.19a |
| IR 36 | 58.3 ± 3.8c | 33.7 ± 4.4c | 1.52 | 1.08 | 3.64 ± 0.28c | 5.41 ± 0.24a |
| Jaya | 54.7 ± 4.1c | 29.4 ± 4.8c | 1.41 | 0.94 | 3.38 ± 0.31c | 5.23 ± 0.26a |

Different letters within columns differ at $p<0.05$. WSA = weed suppression ability; CR = competitive ratio

MTU 7029 was the most competitive cultivar at both nitrogen levels (Table 1). High nitrogen improved WSA by 22-27 percentage points across cultivars. Jaya had the weakest competitive ability, with a CR below 1.0 at low N meaning *Echinochloa* actually outcompeted it under nitrogen-limited conditions.

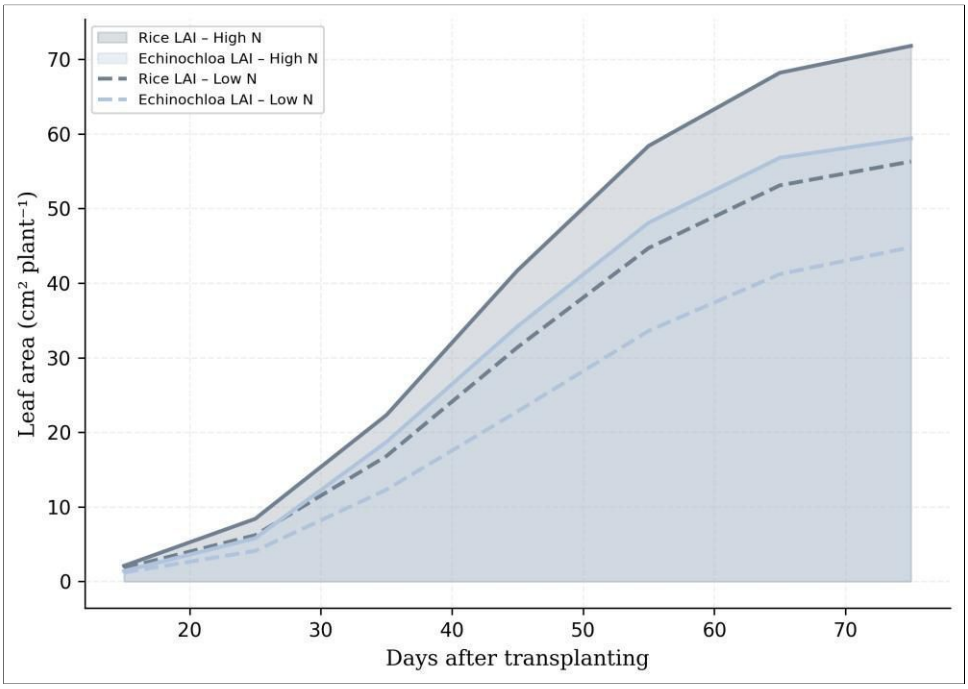


**Fig 1:** Leaf area development of rice and *Echinochloa* under high and low nitrogen regimes

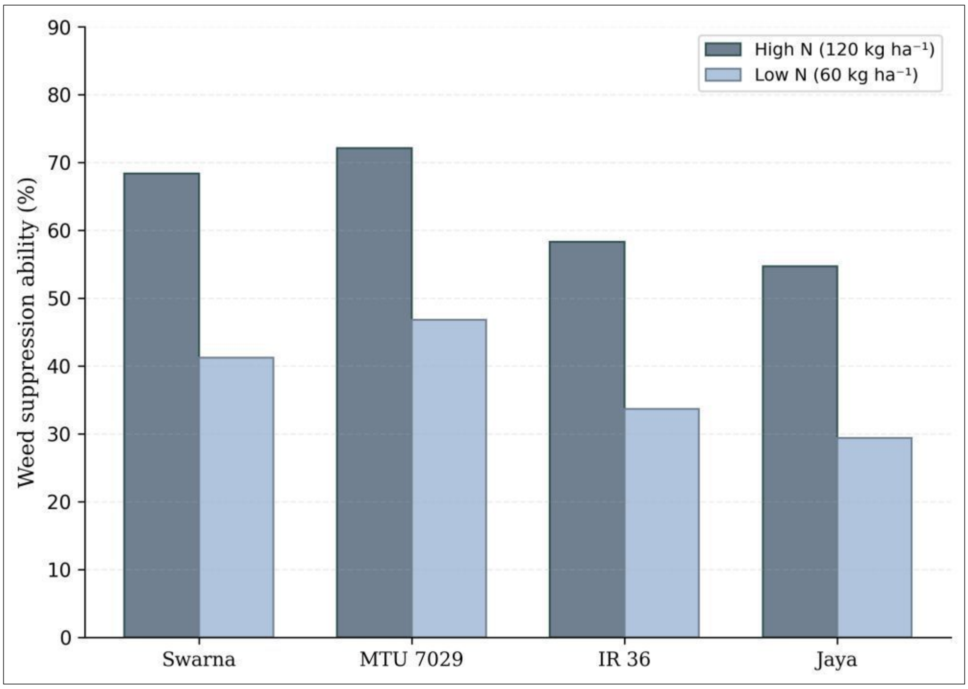


**Fig 2:** Weed suppression ability of four rice cultivars at high (120 kg) and low (60 kg) nitrogen

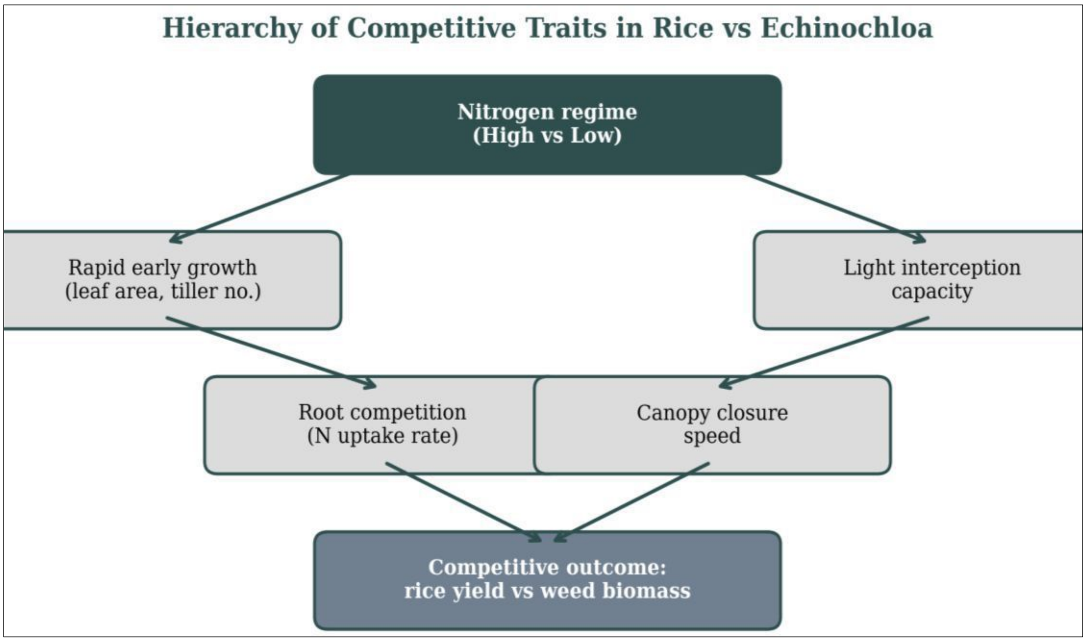


**Fig 3:** Hierarchy of competitive traits determining rice-*Echinochloa* competition outcomes

## Discussion

The strong cultivar × nitrogen interaction confirms that competitive ability is not a fixed trait but depends on the nutrient environment [3, 5]. MTU 7029's superiority is attributable to its rapid early leaf area expansion it achieved 50% canopy closure 8 days earlier than Jaya, capturing light before *Echinochloa* could establish. The finding that high nitrogen favoured rice more than *Echinochloa* may seem counterintuitive, since both species are nitrogen-responsive. But rice, as the transplanted species, has a head start in establishing its root system and can intercept applied nitrogen before the later-germinating *Echinochloa* seedlings [4, 6]. The practical implication is that split nitrogen application with a heavy basal dose to boost early rice vigour could work synergistically with competitive cultivars to reduce weed pressure without herbicides.

## Conclusion

MTU 7029 was the most competitive rice cultivar against *Echinochloa*, achieving 72.1% weed suppression at 120 kg N ha$^{-1}$. High nitrogen consistently improved competitive outcomes for all cultivars. Integrating competitive cultivars with strategic nitrogen management offers a viable approach to reducing herbicide dependency in rice systems of the Indo-Gangetic Plains.


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