Indian Journal of Weed Science (2026) **58**(2): 228–231
http://dx.doi.org/10.5958/0974-8164.2026.00034.4

RESEARCH NOTE

Non-chemical weed management options for enhancing transplanted rice productivity and profitability

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Received: 15 October 2025 | Revised: 27 December 2025 | Accepted: 30 December 2025

ABSTRACT

A field experiment was conducted during *Navarai* season (Jan–April 2024) at Annamalai University to evaluate the efficacy and identify non-chemical weed management options for enhancing the productivity of transplanted rice (*Oryza sativa* L.). The experiment was laid out in a Randomized Block Design (RBD) with twelve treatments and three replications. The tested treatments include: hand weeding; cono-weeding; and incorporation of: rice residues (straw, husk, husk ash, bran), *Azolla*, and tree leaves (neem, pongamia, mango, sapota) in different combinations. Hand weeding twice at 15 and 35 days after transplanting (DAT) recorded the higher weed control efficiency (87.86%) and highest rice grain yield. *Azolla* 250 kg/ha applied 3 DAT followed by cono-weeding on 35 DAT was on par with hand weeding twice, in recording higher gross return, net return and B: C ratio.

Keywords: *Azolla*, Non-chemical weed management, Rice residues, Weed control efficiency

India ranks first in area (43.9 million ha), second in production (150 million tons) with a productivity of 4.38 t/ha (USDA 2025). The relentless proliferation of weeds presents a formidable challenge to rice cultivation, frequently leading to considerable reductions in rice yield and necessitating the adoption of efficacious management strategies (Rao and Chandrasena 2024). This pervasive agricultural issue significantly impacts global food security, especially given that rice serves as a staple for more than half of the world's population (Camacho *et al*. 2024). Conventional weed control methods, predominantly relying on herbicides, have raised environmental and health concerns, prompting an urgent need for sustainable and non-chemical alternatives (Rao and Chandrasena 2024). This imperative for eco-friendly practices has spurred extensive research into alternative weed management approaches, emphasizing integrated strategies that minimize ecological footprints while maintaining agricultural productivity (Rao and Korres 2024). Furthermore, the escalating cost of synthetic herbicides, coupled with the development of herbicide-resistant weed biotypes, accentuates the necessity for viable non-chemical interventions (Abhinandan *et al.* 2020). Consequently, exploring and optimizing non-chemical weed management strategies, such as mechanical weeding, mulching, and the application of allelopathic plant materials, becomes critical for augmenting rice productivity in an environmentally sustainable manner (Singh and Singh 2023). This study was specifically aimed at assessing the efficacy of a range of non-chemical weed management options, including manual weeding, cono-weeding, and various organic amendments like rice straw, rice husk, Azolla, and different leaves mulches, and identify best option for managing weeds and consequently improving transplanted rice productivity.

A field study was conducted during the *Navarai* season of 2024 (Jan to April 2024) in Department of Agronomy, Annamalai University, Chidambaram, Tamil Nadu. The experimental soil was characterized by low organic carbon (0.47%), low in available nitrogen (230 kg/ha), medium in available phosphorus (17.85 kg/ha) and high in available potassium (353 kg/ha). The rice variety ADT 43 was used in the field trial.

The experiment was laid out in a randomized block design (RBD) with three replications. The weed management treatments tested include: unweeded control, hand weeding on 15 and 35 days after transplanting (DAT), cono-weeding on 15 and 35 DAT, application of rice straw as organic mulch (rice straw) at 2 t/ha on 3 DAT followed by (*fb*) cono-weeding on 35 DAT, application of rice husk as

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organic mulch (rice husk) at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT, application of rice husk ash as organic mulch (rice husk ash) at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT, application of rice bran as organic mulch (rice bran) at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT, application of *Azolla* at 250 kg/ha on 3 DAT *fb* cono-weeding on 35 DAT, application of neem leaves as organic mulch (neem leaves) at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT, application of *Pongamia* leaves as organic mulch (*Pongamia* leaves) at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT, application of mango leaves as organic mulch (mango leaves) at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT, application of sapota leaves as organic mulch (sapota leaves) at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT. Organic mulches (rice straw, rice husk, rice husk ash, rice bran, neem leaves, pongamia leaves, mango leaves, and sapota leaves) were air-dried, chopped into small pieces (5–7 cm) where applicable, and uniformly broadcast on the soil surface between rice rows at 3 DAT under shallow standing water conditions (2–3 cm). Organic mulch rates of 2–3 t/ha were used to ensure uniform coverage without affecting rice seedling establishment.

The field was thoroughly puddled and evenly levelled using a wooden plank. Rice seedlings were grown separately in a nursery. Twenty-one-day old rice seedlings were transplanted at a spacing of 20 × 10 cm. Data on weed density and dry weight (biomass) were recorded at 30 and 60 DAT using four quadrats of size 0.5 x 0.5 m and the weed control efficiency (WCE) and weed index were calculated using standard procedure (Saravanane 2020). The existing market prices of rice (₹21/kg) and straw (₹1/kg) were considered, to workout economics returns. Data on weed density and biomass were transformed with square root transformation $\sqrt{(x+0.5)}$) before analysis. The relationship between grain yield and weed biomass at harvest was evaluated through linear regression analysis. The data were analysed statistically following the standard procedures outlined by Panse and Sukhatme (1967).

Effect on weeds

Weed flora of the experimental field during the cropping period primarily comprised of grasses, sedges and broad-leaved weeds. The major weeds in the experimental plots were: *Echinochola colonum, Echinochola crus-galli* and *Leptochloa chinensis* amongst grasses, *Cyperus iria, Cyperu difformis, Cyperus rotundus, Fimbristylis littoralis* amongst sedges and *Eclipta alba*, *Bergia capensis* and *Sphenoclea zeylanica* amongst broad-leaved weeds. The sedges dominated the experimental field followed by grasses as observed earlier by Vikram *et al.* (2023) in the *Navarai* season.

All the weed control treatments significantly influenced the weed flora at 30 and 60 DAT (**Table 1**). The lowest weed density, biomass and highest WCE were recorded with hand weeding on 15 and 35 DAT, which was on par with *Azolla* 250 kg/ha on 3 DAT followed by (*fb*) cono-weeding on 35 DAT, as the rapid proliferation of Azolla, forming a thick mat over the water surface that blocks sunlight and suppresses the germination of photosensitive weeds, and subsequent cono-weeding at 35 DAT simultaneously improved soil aeration and weed control, thereby enhancing root growth and nutrient uptake in rice, falling in line with the earlier findings (Gnanasoundari and Somasundaram 2014, Pazhanisamy *et al.* 2020). The highest weed density and lowest WCE were recorded in unweeded control.

Azolla 250 kg/ha on 3 DAT *fb* cono-weeding on 35 DAT recorded the lowest weed index (1.21%), followed by cono-weeding on 15 and 35 DAT with 5.21%, and rice bran at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT with 9.16% (**Table 1**), confirming findings of Fernando and Alawathugoda (2024) with *Azolla pinnata*.

Effect on transplanted rice growth and yield

Among different treatments, hand weeding twice at 15 and 35 DAT being on par with *Azolla* at 250 kg/ha on 3 DAT *fb* cono-weeding on 35 DAT recorded significantly higher, *viz.* transplanted rice plant height and dry matter production, number of productive tillers, filled grains and grain yield (**Table 2**). Rathod and Somasundaram (2017) and Bhargavi *et al.* (2023) noted that effective weed management practices directly improve crop growth and biomass production in transplanted rice by reducing weed interference. Effective weed control at the earlier stages of crop growth due to better suppression of weeds by the wide coverage of the field with *Azolla* and the late emerging weeds during the critical stage of crop growth by cono weeding jointly resulted in better weed control, thus finally resulting in better crop growth and yield (Pandey *et al.* 2008 and Marzouk *et al.* 2023). A negative linear relationship between grain yield of transplanted rice and weed biomass at the critical growth stage (**Figure 1**) was observed confirming findings of Pooja and Saravanane (2021).

Table 1. Effect of different non-chemical weed management treatments on total weed density, total weed biomass, weed control efficiency (WCE) and weed index in transplanted rice

Treatment	Total weed density (no./m^2)		Total weed biomass (g/m^2)		WCE (%)		Weed index
	30 DAT	60 DAT	30 DAT	60 DAT	30 DAT	60 DAT	
Unweeded control	10.75 (115.00)	11.75 (137.67)	12.43 (154.09)	13.80 (189.98)	0.00	0.00	58.98
Hand weeding twice on 15 and 35 DAT	4.25 (17.67)	5.61 (31.00)	4.34 (18.60)	5.97 (35.19)	87.86	81.44	0.00
Cono-weeding on 15 and 35 DAT	5.11 (25.67)	6.10 (36.67)	5.31 (27.74)	6.50 (41.73)	81.95	77.99	5.21
Mulching with rice straw at 2 t/ha on 3 DAT followed by (*fb*) cono-weeding on 35 DAT	6.33 (39.67)	7.45 (55.00)	6.96 (48.00)	8.20 (66.72)	68.80	64.85	18.28
Mulching with rice husk at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	6.72 (44.67)	7.69 (58.67)	7.39 (54.18)	8.59 (73.33)	64.85	61.41	21.99
Mulching with rice husk ash at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	7.52 (56.00)	8.44 (70.67)	8.53 (72.24)	9.65 (92.57)	53.12	51.17	36.40
Mulching with rice bran at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	5.72 (32.33)	6.76 (45.33)	6.13 (37.27)	7.23 (51.95)	75.73	72.73	9.16
Azolla 250 kg/ha on 3 DAT *fb* cono-weeding on 35 DAT	4.59 (20.67)	5.79 (33.00)	4.54 (20.27)	6.15 (37.29)	86.79	80.31	1.21
Mulching with neem leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	7.08 (49.67)	8.03 (64.00)	7.87 (61.56)	9.08 (81.92)	60.03	56.83	27.41
Mulching with *Pongamia* leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	7.33 (53.33)	8.26 (67.67)	8.31 (68.62)	9.37 (87.29)	55.42	53.98	31.00
Mulching with mango leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	5.87 (34.33)	7.08 (49.67)	6.37 (40.12)	7.62 (57.61)	73.92	69.59	12.61
Mulching with sapota leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	7.58 (57.00)	8.57 (73.00)	8.68 (75.04)	9.84 (96.36)	51.23	49.17	39.34
LSD (p=0.05)	0.46	0.32	0.49	0.35	-	-	-

DAT: Days after transplanting, Values in parenthesis are original and outside are transformed $\sqrt{(x+0.5)}$)

Table 2. Effect of different non-chemical weed management practices on transplanted rice growth, yield parameters, yield and economics of transplanted rice

Treatment	Plant height (cm)	DMP (t/ha)	Productive tiller/m^2	No. of filled grains/ panicle	Grain yield (t/ha)	Total cost of cultivation (x10^3 ₹/ha)	Gross income (x10^3 ₹/ha)	Net income (x10^3 ₹/ha)	B:C
Unweeded control	74.13	6.83	185.2	94.14	2.57	49.36	58.86	9.50	1.19
Hand weeding twice on 15 and 35 DAT	103.87	11.73	347.2	113.29	6.28	65.20	140.35	75.14	2.15
Cono-weeding on 15 and 35 DAT	96.11	10.96	318.2	109.84	5.95	58.24	133.20	74.96	2.29
Mulching with rice straw at 2 t/ha on 3 DAT followed by (*fb*) cono-weeding on 35 DAT	83.83	9.61	271.6	104.69	5.13	55.50	114.98	59.48	2.07
Mulching with rice husk at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	82.93	9.07	264.3	104.22	4.90	55.50	109.91	54.40	1.98
Mulching with rice husk ash at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	74.97	7.26	201.8	98.35	3.99	55.50	90.24	34.73	1.63
Mulching with rice bran at 2 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	89.80	10.37	298.4	108.82	5.70	63.50	127.68	64.17	2.01
Azolla 250 kg/ha on 3 DAT *fb* cono-weeding on 35 DAT	99.73	11.46	330.4	115.10	6.20	59.75	138.65	78.89	2.32
Mulching with neem leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	77.37	8.44	231.4	102.43	4.56	53.50	102.32	48.82	1.91
Mulching with *Pongamia* leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	76.00	7.73	228.1	101.12	4.33	53.50	97.47	43.96	1.82
Mulching with mango leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	88.47	9.99	294.7	107.68	5.49	53.50	122.66	69.15	2.29
Mulching with sapota leaves at 3 t/ha on 3 DAT *fb* cono-weeding on 35 DAT	74.53	6.94	197.8	96.52	3.81	53.50	86.33	32.82	1.61
LSD (p=0.05)	6.18	0.51	16.73	4.03	0.25	-	-	-	-

DAT: Days after transplanting

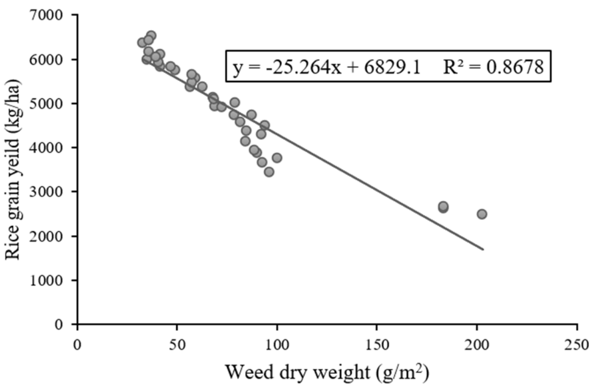

Figure 1. The relationship between transplanted rice grain yield and total weed biomass at harvest

Economics

The highest gross return, net return and B:C ratio was recorded with *Azolla* 250 kg/ha on 3 DAT *fb* cono-weeding on 35 DAT. The cono-weeding on 15 and 35 DAT recorded next highest net returns and B:C ratio which was higher than that recorded with hand weeding on 15 and 35 DAT as labour usage in hand weeding increased the cost of cultivation and reduced the returns. The lowest transplanted rice grain yield resulted in least gross return, net returns and B: C ratio in unweeded control confirming findings of Yadav *et al.* (2023).

Conclusion

Effective and economical weed management in transplanted rice can be achieved with application of *Azolla* at 250 kg/ha on 3 DAT followed by cono-weeding on 35 DAT as it recorded rice grain yield comparable to hand weeding twice at 15 and 35 DAT, with higher economic returns, especially in regions facing labour scarcity.

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