

Full Length Research Paper

Non-chemical weed management in organic rice

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Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *Rabi* 2012-2013 (October-February) to identify the ideal weed management technique in organic rice production. The experiment was laid out in randomized block design with three replications. The treatments comprised of fourteen different weed management practices. The results revealed that application of rice bran at 2 t ha⁻¹ on 3 DAT followed by a hand weeding on 35 DAT kept the total weed density (15.00 No.m²) and weed dry weight (3.38 g m²) below the economic threshold level and also increased the yield (4816 kg ha⁻¹) of organic rice production.

Key words: Organic rice, weed control, yield attributes, grain yield, straw yield.

INTRODUCTION

Organic weed control encourages weed suppression rather than elimination. This is done by promoting soil health through a combination of crop rotation, cover crops, biologically based bio-fertilizers, compost and mulch. Proper management through organic methods offer varied benefits over chemical herbicides, including increased biodiversity, improved soil nutrition and structure, and protection of ground and surface water. Surender-Rao and Sitaramayya (1997) reported that growing of *Azolla* as a dual crop with rice resulted in significantly more tillers, longer panicles and more spikelets. Solaiappan and Veerabadran (1997) have also reported that the green manure intercrops had no effect on the yield of associate *kharif* rice but the subsequent *rabi* rice yield got increased. Use of rice bran, which contributes nutrient after decomposition and suppresses weeds in rice fields (Yan et al., 2007). The higher mineral

nitrogen concentration in top soil at early growth stage of rice, which was induced by rice bran applied at 7 DAT for weed suppression, brought about higher grain yield of rice as reported by Yan et al. (2007). The present study aimed to confirm this possibility in weed control and evaluate the influence on yield performance in organic rice farming system employing non-chemical weed management practices.

MATERIALS AND METHODS

Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *Rabi* 2012- 13 (October-February) to identify the ideal weed management technique in organic rice production. The experiment was laid out in randomized block design with three replications. The treatments comprised of fourteen different weed management practices viz.,

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Abbreviations: DAT, Days after transplanting.

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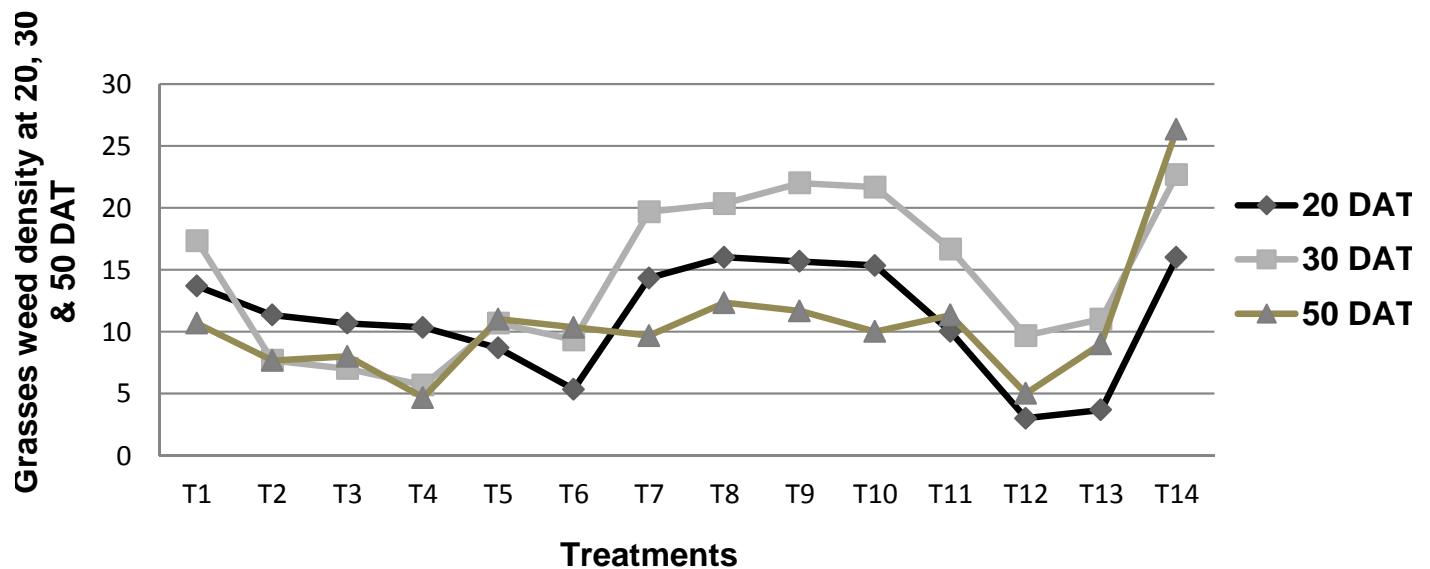


Figure 1. Effect of non-chemical weed management practices on grasses weed density.

Paired row planting of rice with daincha as intercrop + incorporation on 35 DAT (T₁), *Azolla* as dual crop and manual incorporation on 20 DAT and 40 DAT (T₂), *Azolla* as dual crop and rotary weeder incorporation on 20 DAT and 40 DAT (T₃), *Azolla* as dual crop and cono weeder incorporation on 20 DAT and 40 DAT (T₄), Rotary weeder four times on 10, 20, 30 and 40 DAT (T₅), Cono weeder four times on 10, 20, 30 and 40 DAT (T₆), Rice hull solution (50%) spray on 3 DAT + HW on 35 DAT (T₇), Rice hull solution (50%) spray on 15 DAT + HW on 35 DAT (T₈), Sunflower dried stalk solution (1:10 w/v) spray on 3 DAT + HW on 35 DAT (T₉), Sunflower dried stalk solution (1:10 w/v) spray on 15 DAT + HW on 35 DAT (T₁₀), Rice straw at 3 t ha⁻¹ on 3 DAT + HW on 35 DAT (T₁₁), Rice bran at 2 t ha⁻¹ on 3 DAT + HW on 35 DAT (T₁₂), HW on 15 DAT and 35 DAT (T₁₃) and unweeded control (T₁₄). The rice variety Co (R) 48 was used as test cultivar sown on 5th October 2012 at 30 × 10 cm. Weed observation like weed flora, weed density and dry weight taken at 20, 30 and 50 DAT. The number of total tillers, productive tillers, number of panicles per hill, panicle length and panicle weight were counted from the five tagged plants and mean value was calculated. Grain from each net plot was cleaned, sun dried and weighed at 14% moisture content and the grain yield was expressed in kg ha⁻¹. The straw obtained from each net plot area was sun dried and weighed. The straw yield was expressed in kg ha⁻¹. The data were statistically analyzed by the analysis of variance method as suggested by Gomez and Gomez (2010). Wherever the treatment differences were found significant, critical differences were worked out at 5% probability level and the values are furnished.

RESULTS AND DISCUSSION

Weed occurrence

In the experimental field, all the three groups of weeds consisted of two grasses, two sedges and three broad leaved weeds were present. *Echinochloa colonum*, and

Echinochloa crus-galli under grasses, *Cyperus difformis* and *Cyperus iria* under sedges and *Eclipta alba*, *Ammania baccifera* and *Monochoria vaginalis* under Board Leave Weed (BLW) were observed. Altogether BLW weeds comprising *E. alba* and *A. baccifera* were predominant, followed by sedges especially *C. difformis* and grasses particularly *E. colonum* in the experimental field.

Total weed density

In this field experiment, mainly 7 species of weed were growing especially, *E. colonum*, *E. crus-galli*, *C. difformis*, *C. iria*, *E. alba*, *A. baccifera* and *M. vaginalis* in rice field. As shown in Figure 1, Grasses weed density was registered lower (3.33 m⁻²) in application of rice bran 2 t ha⁻¹ fb one hand weeding at 20 DAT. At 30 and 50 DAT *Azolla* as dual crop with rice and cono weeder incorporation twice (T₄) recorded distinctly lower grass weed density (5.67 and 4.67 m⁻²). Sedge weed density (Figure 2) was distinctly lower (6.00 m⁻²) in hand weeding twice (T₁₃) at 20 DAT. *Azolla* as dual crop with rice and cono weeder incorporation twice (T₄) and *Azolla* as dual crop with rice and rotary weeder incorporation twice (T₃) recorded significantly lower (6.33 and 4.00 m⁻²) density of sedges. In respect of the sedge weed density, the result was significant at all the stages of observation. The distribution of sedges, *C. difformis* and *C. iria*, was very high in the total weed density in all the three stages (20, 30 and 50 DAT). BLW density was distinctly lower of 3.00 and 5.00 No.m⁻² (Figure 3) in application of rice bran at 2 t ha⁻¹ fb hand weeding (T₁₂) at 20 and 50 DAT. At 30 DAT, the broad leaved weed density was registered lower (5.33 No.m⁻²) in *Azolla* as

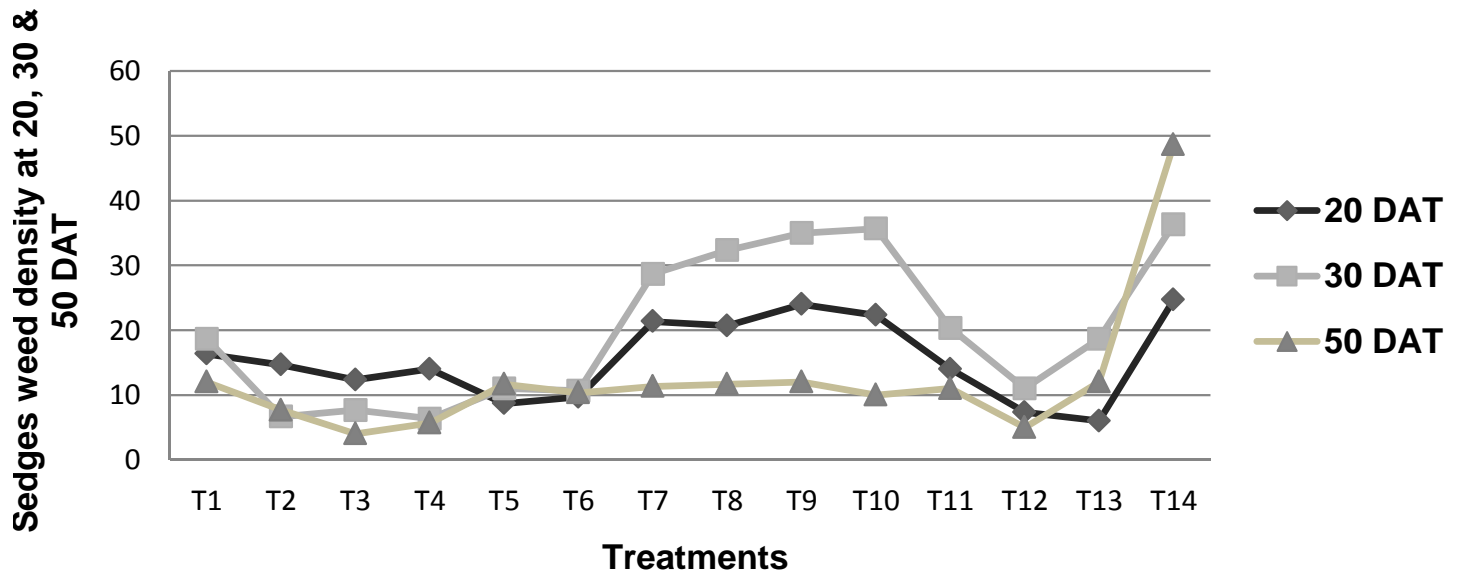


Figure 2. Effect of non-chemical weed management practices on sedges weed density.

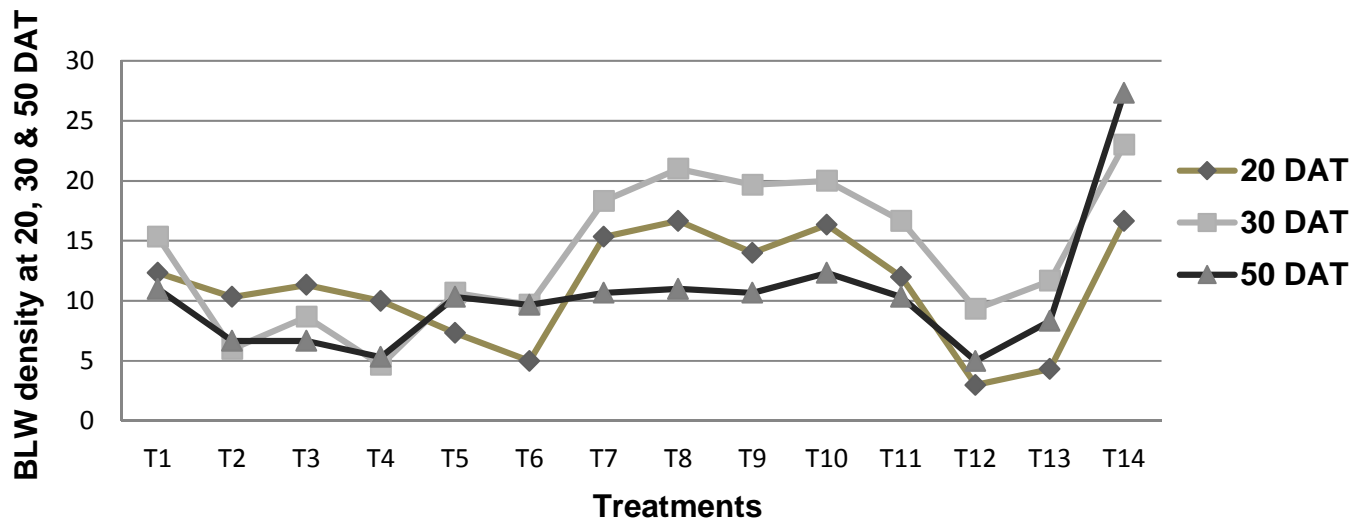


Figure 3. Effect of non-chemical weed management practices on BLW density.

dual crop with rice and cono weeder incorporation twice (T₄).

Among different weed management practices the total weed density was lower in application of rice bran at 2 t ha⁻¹ on 3 DAT followed by hand weeding on 35 DAT methods of weed control significantly (Table 2) reduced the weed density over unweeded control. Rice byproducts meal was also found to be quite suppressive to annual weed growth (Kuk et al., 2001). Grasses, sedges and BLW density was distinctly lower (4.67, 4.00 and 5.00 m⁻²) in application of rice bran

2 t ha⁻¹ fb one hand weeding at 50 DAT (T₁₂). Distinct reduction of total weed density by application of rice bran at 2 t ha⁻¹ 3 DAT + HW on 35 DAT might be due to the control of weeds at the germination phase and significant reduction at later stages as late germinating weeds were controlled by one hand weeding at 35 DAT. The suppressive effect of rice bran application to soil surface after transplanting on paddy weed was considered to be associated with a decline in redox potential and dissolved oxygen concentration was reported by Muroi et al. (2005) and

Nakayama et al. (2002). Similar observation was reported by Kim et al. (2001) who found that rice bran application had little suppression effect on *E. crus-galli*, but suppressed *M. vaginalis*, *Scirpus juncoides*, and *Cyperus* spp to a substantial degree. Total weed density was distinctly higher (57.33, 82.00 and 102.33 No. m⁻²) in unweeded control (T₁₄) at 20, 30 and 50 DAT. Obviously unweeded control (T₁₄) resulted in higher grasses, sedges and broad-leaved weeds density due to unchecked and increased weed growth at all the growth stages of the crop.

Total weed dry weight

Data pertaining to the application of rice bran at 2 t ha⁻¹ fb hand weeding (T₁₂) recorded distinctly lower grasses, sedges and BLW dry weight of 1.13, 1.12 and 1.13 g m⁻² at 50 DAT respectively. As shown in Table 3. Considerable reduction in total weed dry weight was recorded lower in application of rice bran at 2 t ha⁻¹ on 3 DAT + HW on 35 DAT (3.92, 5.34 and 3.38 g m⁻²) at 20, 30 and 50 DAT. The application of rice bran significantly decreased the total weed density and weed dry weight as compared with weedy control was reported by Khan et al. (2007). This is next to rice bran application *Azolla* as dual crop with rice and cono weeder incorporation twice 20 and 40 DAT at 30 DAT might be attributed to the minimum number of total weeds with lesser biomass in the cropping period. Weed dry weight was reduced due to the efficient weed control and lesser weed population as compared to other treatments.

Weed control efficiency

Weed control efficiency (WCE) indicates the magnitude of effective reduction of weed dry weight by weed control treatments over weedy check. This was highly influenced by different weed control treatments. Application of rice bran at 2 t ha⁻¹ 3 DAT + HW on 35 DAT recorded higher weed control efficiency of 83.0, 91.4 and 96.3%, respectively at 20, 30 and 50 DAT and it was on par with *Azolla* as dual crop with rice and cono weeder incorporation twice on 20 and 40 DAT. More reduction of weed dry weight by reducing the weed density in these treatments resulted in higher Weed Control Efficiency.

Yield parameters

Application of rice bran at 2 t ha⁻¹ 3 DAT + HW on 35 DAT recorded significantly high values of yield components viz., number of productive tillers (192.2 m⁻²), panicle length (20.3 cm), panicle weight (3.10 g) and number of filled grains (110.8) which was in conformity with Kato et al. (2010).

The possible reason might be that the weed free situation at early stage favoured the vigorous growth of seedlings without crop weed competition due to prolonged control of weeds. The competition free environment has increased the capacity of source (LAI) and sink and in turn the length of panicle, panicle weight and number of filled grain panicle⁻¹ of rice (Table 4).

Yield

Significantly higher grain yield of rice (4816 kg ha⁻¹) was recorded with the application of rice bran at 2 t ha⁻¹ on 3 DAT and hand weeding on 35 DAT which was in conformity with the findings of Yan et al. (2007) and Kato et al. (2010). The favourable conditions created through the efficient weed control resulted in lesser weed competition between crop and weeds. This favoured the crop to produce more leaf area and plant dry matter production. The increase in number of productive tillers, panicle length and number of filled grains panicle⁻¹ resulted in the higher grain yield in application of rice bran at 2 t ha⁻¹ on 3 DAT and hand weeding on 35 DAT (Table 5). Rice bran application under deep flooding significantly increased both spikelet number per panicle and panicle number, leading to substantial increase in total spikelet number per unit area and grain yield as compared to deep flooding with no rice bran reported by Yan et al. (2007). The straw yield was recorded 7108 kg ha⁻¹ with the application of rice bran at 2 t ha⁻¹ on 3 DAT + HW on 35 DAT might be due to efficient weed control, high nutrient uptake by the crop and increased dry matter production. Distinctly lower grain and straw yields were recorded in unweeded control. This was due to severe competition between crop and weed for different resources viz., light, moisture, space and nutrients (Table 1).

Economics

The mean data on cost of cultivation (Rs. ha⁻¹), gross return (Rs. ha⁻¹), net return (Rs. ha⁻¹) and benefit-cost (B:C) ratio is presented in Table 6. Lower cost of cultivation was recorded in cono weeder four times (Rs. 31,825 ha⁻¹), rotary weeder four times (Rs. 31,825 ha⁻¹). The moderate cost of cultivation was recorded in application of rice bran 2 t ha⁻¹ fb hand weeding and higher cost of cultivation was registered with *Azolla* as dual crop with rice and manual incorporation twice (Rs. 37,980 ha⁻¹) and was followed by *Azolla* as dual crop with rice and rotary weeder incorporation twice (Rs. 36,165 ha⁻¹), *Azolla* as dual crop with rice and cono weeder incorporation twice, (Rs. 36,165 ha⁻¹) and hand weeding twice (Rs. 35,455 ha⁻¹). *Azolla* as dual crop with rice and manual incorporation on 20 and 40 DAT recorded higher cost of cultivation which might be due to application of

Table 1. Properties and composition of grain.

Properties	Composition
Textural composition (% on moisture free basis)	
a. Clay (%)	47.5
b. Silt (%)	22.2
c. Coarse sand (%)	11.9
d. Fine sand (%)	18.4
e. Textural class	Clay loam
Chemical composition (Moisture free basis)	
a. Available N (kg ha ⁻¹)	213.9
b. Available P ₂ O ₅ (kg ha ⁻¹)	16.7
c. Available K ₂ O (kg ha ⁻¹)	402
d. Organic carbon (%)	0.45
Microbial population	
a. Fungi (CFU x 10 ⁴ g ⁻¹ of soil)	8.0
b. Bacteria (CFU x 10 ⁶ g ⁻¹ of soil)	13.0
c. Actinomycetes (CFU x 10 ³ g ⁻¹ of soil)	4.0

Table 2. Weed flora of the experimental field.

S/ No.	Botanical Name	Common Name	Life form	Family
I. Grasses				
1.	<i>Echinochloa colonum</i> (L.) Link *	Jungle grass	A	Poaceae
2.	<i>Echinochloa crus-galli</i> (L.) P. Beauv	Barnyard grass	A	Poaceae
II. Sedges				
1.	<i>Cyperus difformis</i> (L.) *	Umbrella plant	A	Cyperaceae
2.	<i>Cyperus iria</i> (L.)	Rice flat sedge	A	Cyperaceae
III. Broad leaved weeds				
1.	<i>Eclipta alba</i> (L.) Hassk *	False daisy	A	Asteraceae
2.	<i>Ammania baccifera</i> (L.) *	Red stem	A	Lythraceae
4.	<i>Monochoria vaginalis</i> (L.)	Heart shaped false pickerelweed	A	Pontederiaceae

* Predominant weed, A: Annual.

Azolla and high labour requirement for manual incorporation.

The net return was markedly higher in application of rice bran at 2t ha⁻¹ fb hand weeding (Rs. 49,862 ha⁻¹). Application of rice bran at 2 t ha⁻¹ on 3 DAT and hand weeding on 35 DAT increased the grain and straw yield and consequently enhanced the net income. The result is in line with the findings of Yan et al. (2007) and was lower net return was recorded in unweeded control (Rs.15, 191 ha⁻¹). The B:C ratio was higher in application of rice bran at 2 t ha⁻¹ fb hand

weeding (2.45) and lower B:C ratio was registered under unweeded control.

Conclusion

This study was concluded that organic rice responded favourably to non-chemical weed management practices. Application of rice bran at 2 t ha⁻¹ on 3 DAT followed by hand weeding on 35 DAT positively influenced the growth and yield parameters along with nutrient uptake.

Table 3. Effect of non-chemical weed management practices on total weed density (No.m⁻²) at 20, 30 and 50 DAT in organic rice production.

Treatments	20 DAT	30 DAT	50 DAT
T ₁ - <i>S. aculeata</i> as intercrop and incorpn on 35 DAT	6.65 (42.33)	7.30 (51.33)	5.96 (33.67)
T ₂ - <i>Azolla</i> + manual incorpn. on 20 and 40 DAT	6.19 (36.33)	4.72 (20.33)	4.90 (22.01)
T ₃ - <i>Azolla</i> + rotary weederincorpn. on 20 and 40 DAT	6.01 (34.33)	5.02 (23.33)	4.54 (18.67)
T ₄ - <i>Azolla</i> + conoweederincorpn. on 20 and 40 DAT	6.04 (34.48)	4.32 (16.67)	4.20 (15.67)
T ₅ - Rotary weeder four times on 10, 20, 30 and 40 DAT	5.16 (24.67)	5.94 (33.33)	5.91 (33.00)
T ₆ - Conoweeder four times on 10, 20, 30 and 40 DAT	4.68 (20.00)	5.62 (29.67)	5.68 (30.33)
T ₇ - Rice hull solution (50%) on 3 DAT + HW on 35 DAT	7.26 (50.99)	8.27 (66.67)	5.80 (31.67)
T ₈ - Rice hull solution (50%) on 15 DAT + HW on 35 DAT	7.42 (53.33)	8.67 (73.67)	6.07 (35.00)
T ₉ - Sunflower dried stalk on 3 DAT + HW on 35 DAT	7.45 (53.67)	8.86 (76.67)	6.02 (34.34)
T ₁₀ -Sunflower dried stalk on 15 DAT + HW on 35 DAT	7.47 (54.00)	8.90 (77.33)	5.85 (32.33)
T ₁₁ -Rice straw at 3 t ha ⁻¹ on 3 DAT + HW on 35 DAT	6.16 (36.00)	7.45 (53.67)	5.88 (32.66)
T ₁₂ -Rice bran at 2 t ha ⁻¹ on 3 DAT + HW on 35 DAT	3.89 (13.33)	5.63 (29.67)	4.11 (15.00)
T ₁₃ -Hand weeding on 15 DAT and on 35 DAT	3.99 (14.00)	6.58 (41.33)	5.60 (29.33)
T ₁₄ -Unweeded control	7.70 (57.33)	9.16 (82.00)	10.21 (102.33)
SEd	3.96	5.26	3.31
CD (P=0.05%)	8.15	10.87	6.81

Figures in parenthesis are original value, HW: Hand weeding.

Table 4. Effect of non-chemical weed management practices on total weed dry weight (g m⁻²) at 20, 30 and 50 DAT in organic rice production.

Treatments	20 DAT	30 DAT	50 DAT
T ₁ - <i>S. aculeata</i> as intercrop and incorpn on 35 DAT	3.63 (11.18)	3.81 (12.54)	3.49 (10.16)
T ₂ - <i>Azolla</i> + manual incorpn. on 20 and 40 DAT	3.36 (9.28)	3.21 (8.32)	3.18 (8.14)
T ₃ - <i>Azolla</i> + rotary weederincorpn. on 20 and 40 DAT	3.25 (8.58)	3.21 (8.33)	2.77 (5.67)
T ₄ - <i>Azolla</i> + conoweederincorpn. on 20 and 40 DAT	3.25 (8.59)	3.09 (7.54)	2.61 (4.81)
T ₅ - Rotary weeder four times on 10, 20, 30 and 40 DAT	3.04 (7.24)	3.14 (7.87)	3.42 (9.75)
T ₆ - Conoweeder four times on 10, 20, 30 and 40 DAT	2.90 (6.41)	3.11 (7.70)	3.37 (9.37)
T ₇ - Rice hull solution (50%) on 3 DAT + HW on 35 DAT	4.18 (15.51)	6.44 (39.51)	3.53 (10.60)
T ₈ - Rice hull solution (50%) on 15 DAT + HW on 35 DAT	4.50 (18.24)	7.23 (50.30)	3.43 (9.84)
T ₉ - Sunflower dried stalk on 3 DAT + HW on 35 DAT	4.48 (18.12)	7.24 (50.46)	3.67 (11.48)
T ₁₀ -Sunflower dried stalk on 15 DAT + HW on 35 DAT	4.49 (18.22)	7.20 (49.88)	3.63 (11.17)
T ₁₁ -Rice straw at 3 t ha ⁻¹ on 3 DAT + HW on 35 DAT	3.46 (9.96)	3.73 (11.93)	3.46 (9.98)
T ₁₂ -Rice bran at 2 t ha ⁻¹ on 3 DAT + HW on 35 DAT	2.43 (3.92)	2.71 (5.34)	2.32 (3.38)
T ₁₃ -Hand weeding on 15 DAT and on 35 DAT	2.59 (4.72)	3.18 (8.11)	2.82 (5.98)
T ₁₄ -Unweeded control	5.00 (23.06)	8.01 (62.25)	9.67 (91.59)
SEd	0.12	0.13	0.14
CD (P=0.05%)	0.25	0.28	0.29

Figures in parenthesis are original value, HW: Hand weeding.

Table 5. Effect of non- chemical weed management practices on yield parameters of organic rice production.

Treatments	Productive tillers (No. m ⁻²)	No. filled grains panicle ⁻¹	Panicle length (cm)	Panicle weight (g)	Grain yield (kg/ha)	Stalk yield (Kg ha ⁻¹)
T ₁ - <i>S. aculeata</i> as intercrop and incorpn. on 35 DAT	160.0	90.2	19.13	2.53	3856	6175
T ₂ - <i>Azolla</i> + manual incorpn. on 20 and 40 DAT	165.0	93.6	19.40	2.51	4256	6558
T ₃ - <i>Azolla</i> + rotary weeder incorpn. on 20 and 40 DAT	174.0	99.8	19.66	2.85	4321	6400
T ₄ - <i>Azolla</i> + conoweeder incorpn. on 20 and 40 DAT	188.7	104.3	20.27	2.97	4716	6905
T ₅ - Rotary weeder four times on 10, 20, 30 and 40 DAT	168.0	95.2	19.37	2.55	3874	6218
T ₆ - Conoweeder four times on 10, 20, 30 and 40 DAT	182.0	96.2	19.63	2.84	4282	6441
T ₇ - Rice hull solution (50%) on 3 DAT + HW on 35 DAT	143.0	82.7	19.30	2.36	3604	5964
T ₈ - Rice hull solution (50%) on 15 DAT + HW on 35 DAT	130.0	79.2	18.40	2.20	3423	5909
T ₉ - Sunflower dried stalk on 3 DAT + HW on 35 DAT	147.0	87.1	18.83	2.17	3550	5868
T ₁₀ -Sunflower dried stalk on 15 DAT + HW on 35 DAT	141.0	85.8	18.87	2.35	3436	5796
T ₁₁ -Rice straw at 3 t ha ⁻¹ on 3 DAT + HW on 35 DAT	154.3	86.9	19.20	2.40	3658	5993
T ₁₂ -Rice bran at 2 t ha ⁻¹ on 3 DAT + HW on 35 DAT	192.2	110.8	20.30	3.10	4816	7108
T ₁₃ -Hand weeding on 15 DAT and on 35 DAT	185.0	100.2	19.60	2.51	4512	6585
T ₁₄ -Unweeded control	105.3	65.8	18.13	1.80	2577	4471
SEd	8.09	5.49	0.40	1.40	184.8	262.6
CD (P=0.05%)	16.66	11.28	0.83	2.80	380.0	539.8

HW- Hand weeding, DAT – day after transplanting.

Table 6. Effect of weed management practices on economics of organic rice production.

Treatments	Cost of cultivation (Rs. ha ⁻¹)	Gross return (Rs. ha ⁻¹)	Net return (Rs. ha ⁻¹)	B:C ratio
T ₁ - <i>S. aculeata</i> as intercrop and incorpn on 35 DAT	34,232	67,869	33,637	1.98
T ₂ - <i>Azolla</i> + manual incorpn. on 20 and 40 DAT	37,980	74,646	36,666	1.97
T ₃ - <i>Azolla</i> + rotary weeder incorpn. on 20 and 40 DAT	36,165	75,536	39,371	2.09
T ₄ - <i>Azolla</i> + cono weeder incorpn. on 20 and 40 DAT	36,165	82,362	46,197	2.28
T ₅ - Rotary weeder four times on 10, 20, 30 and 40 DAT	31,825	68,200	36,375	2.14

Table 6. Contd.

T ₆ - Cono weeder four times on 10, 20, 30 and 40 DAT	31,825	74,953	43,128	2.36
T ₇ - Rice hull solution (50%) on 3 DAT + HW on 35 DAT	34,105	63,622	29,517	1.87
T ₈ -Rice hull solution (50%) on 15 DAT + HW on 35 DAT	34,105	60,684	26,579	1.78
T ₉ - Sunflower dried stalk on 3 DAT + HW on 35 DAT	33,540	62,661	29,121	1.87
T ₁₀ -Sunflower dried stalk on 15 DAT + HW on 35 DAT	33,540	60,773	27,233	1.81
T ₁₁ -Rice straw at 3 t ha ⁻¹ on 3 DAT + HW on 35 DAT	34,480	64,516	30,036	1.87
T ₁₂ -Rice bran at 2 t ha ⁻¹ on 3 DAT + HW on 35 DAT	34,310	84,172	49,862	2.45
T ₁₃ -Hand weeding on 15 DAT and on 35 DAT	35,455	78,772	43,317	2.22
T ₁₄ -Unweeded control	30,505	45,696	15,191	1.50

(HW- Hand weeding, DAT-day after transplanting), Data statistically not analysed, Grain: Rs.16.00 Kg⁻¹.

Rice bran application at 3 DAT for weed suppression significantly increased mineral nitrogen concentration in the top soil during tillering stage, providing much more available nitrogen for rice growth. It also increased the both spikelet number per panicle and panicle number, leading to substantial increase in total spikelet number per unit area and grain yield. Hence, the non-chemical weed management practice of application of rice bran at 2 t ha⁻¹ on 3 DAT followed by hand weeding on 35 DAT in rice has been found to be an ideal option to control weeds and also improve yield of rice besides being economically competitive and productive under organically grown situations.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

- Gomez KA, Gomez AA (2010). Statistical Procedures for Agricultural Research. 2nd Edn. John Wiley and Sons, New York. pp. 13-175.
- Kato S, Abe D, Miki T, Iwaishi S, Harakawa T, Inubushi K (2010). Effects of application methods of organic manure at transplanting time on rice yield and suppression of paddy weeds in organic rice cultivation. Hort. Res. 64:25-34.
- Khan TD, Xuan TD, Chung MI (2007). Rice allelopathy and the possibility for weed management. Annals Appl. Biol. 151:325-339. <http://dx.doi.org/10.1111/j.1744-7348.2007.00183.x>
- Kim JG, Lee SB, Lee KB, Lee DB, Kim JD (2001). Effect of applied amount and time of rice bran on the rice growth condition, Kor. J. Environ. Agric. 20:15-19.
- Kuk YI, Shin JS, Kwon OD, Guh JO (2001). Effect of aqueous extracts of rice bran on inhibition of germination and early growth of weeds, Kor. J. Environ. Agric. 20:108-111.
- Muroi Y, Kobayashi K, Takai Y (2005). Effect of powder and pellet formulation of rice bran on growth of *Echinochloa crus-galli* (L.) Beauv. Ver. *Formosensis* Ohwi, J. Weed Sci. Tech. 50:169-175. http://dx.doi.org/10.3719/weed.50.Supplement_168

- Nakayama Y, Kitano J, Ushiki J (2002). Weed control efficacy of rice bran on weed in paddy field. J. Weed Sci. Tech. 47:118-119. http://dx.doi.org/10.3719/weed.47.Supplement_118
- Solaiappan U, Veerabadrán V (1997). Effect of green manure intercropping on rice. Madras Agric. J. 84(7):369-370.
- Surender-Rao S, Sitaramayya (1997). Changes in total and available soil nitrogen status under integrated nutrient management of rice. J. Indian Soc. Soil Sci. 45(3):445-449.
- Yan YF, Fu JD, Lee BW (2007). Rice bran application under deep flooding can control weed and increase grain yield in organic rice culture. J. Crop Sci. Biotech. 10(2):79-85.