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Effect of Non-Chemical Weed Management Practices on Weed Control Efficiency and Grain Yield in Organic Rice Production

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ABSTRACT

A field experiment was conducted during rabi 2014 at wetland farms of Tamil Nadu Agricultural University, Coimbatore to find out the effect of non-chemical weed management practices on efficacy and grain yield in organic rice production. Among the weed management practices application of rice bran 2 t ha^{-1}fb hand weeding had resulted in significantly higher (83.8, 91.0 and 95.9 per cent at 20, 30 and 50 DAT) weed control efficiency. Mulching with biodegradable polyethelene sheet registered higher DMP of 5984 kg ha^{-1} at 60 DAT, crop growth rate (4.08 g m^{-2} day^{-1} at 90 – 120 DAT) and higher grain (5557 kg ha^{-1}) yield which was at par with application of rice bran at 2 t ha^{-1} on 3 DAT followed by hand weeding on 35 DAT. Panicle length and harvest index were not influenced significantly due to adoption of different weed management practices. Mulching with biodegradable polyethelene sheet resulted in minimum competition to application of rice bran at 2 t ha^{-1}fb hand weeding of 3.24 per cent compared to unweeded check. Among all the treatments, unweeded check resulted in lower DMP (3654 kg ha^{-1}), CGR (2.17 g m^{-2} day^{-1}), grain yield (2774 kg ha^{-1}) and higher (50.08 per cent) weed index. But taking into consideration of economics, hand weeding on 15 DAT followed by azolla inoculation on the same day recorded the highest net returns and B:C ratio compared with all other treatments.

Key words: *Weed control efficiency, weed index, organic rice, grain yield*

INTRODUCTION

In agriculture, continuous use of the herbicides over a period of time on a same piece of land, leads to ecological imbalances in terms of weed shift and environmental pollution. At present the concept of organic farming and health of food is gaining momentum and there exists a greater demand for residue free organic products.

Rice (*Oryza sativa* L.) is a major crop in the world, provides food for over half of the world's population, where 90 per cent of the world's rice is grown and consumed.

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Rice provides about 29.4 per cent of total calories per capita per day in Asian countries[4]. Among the rice growing countries, India stands first in area (43.9 million ha), second in production (106.3 million tonnes) next to China with a productivity (2419 kg ha^{-1})[3]. In organic farming weed management is a highly complicated and it would be appropriate to adopt various methods in combination rather than in isolation to manage these weeds from organic sources depending upon the nature and intensity of weeds. The complexity of these situations has resulted in a need to develop a wholistic sustainable eco-friendly weed management programme throughout the cropping period. To meet the present requirement a field experiment was conducted in rice at wetlands farm, Tamil Nadu Agricultural University, Coimbatore to find out the effect of non-chemical weed management practices on efficacy and grain yield in organic rice production.

MATERIALS AND METHODS

Field investigation was carried out during *rabi* 2014 (October 2014 to February 2015) at wetland farm, Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in a randomized block design (RBD) with three replications. The soil of the experimental field was clay loam with pH of 8.3, low in available nitrogen (216 kg ha^{-1}), medium in available phosphorus (16.9 kg ha^{-1}), high in available potassium (410 kg ha^{-1}) and medium in organic carbon content (0.60%). The variety used for the experiment was CO (R) 50. The treatments comprised of ten different weed management practices (Table 2). Field was puddled thoroughly and levelled properly with wooden plank. Rice seedlings were raised separately in nursery and the 21 days old seedlings were transplanted with a spacing of 22.5 X 22.5 cm. All other agronomic and plant protection measures were adopted as per recommendation of CPG[2].

Weed observation

Weed flora

Weed species present in the experimental plot were identified at flowering stage of crop from unweeded check plot and grouped as grasses, sedges and broad leaved weeds (BLW).

Weed control efficiency (WCE)

Weed control efficiency was worked out on the basis of weed dry matter recorded in each treatment at 20, 30, 50 DAT and at maturity using the formula suggested by Sankaran and Mani[10].

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

where,

WCE - Weed control efficiency in percentage
DWC - Dry weight of weeds in unweeded check (g m^{-2})
DWT - Dry weight of weed control treatments (g m^{-2})

Weed Index (WI)

Weed Index was worked out on the basis of economic produce recorded in each treatment as outlined by Gill and Vijayakumar[5].

$$WI = \frac{X - Y}{X} \times 100$$

Where,

WI - Weed index
X - Yield from minimum competition plot
Y - Yield from treatment for which WI is to be worked out.

Statistical Analysis

The data recorded on various parameters recorded during the course of investigation was statistically analyzed as per the procedures suggested by Gomez and Gomez[7] for randomized block design. Wherever the treatmental difference were found significant ('F' test), critical difference was worked out at 0.05 probability level. Treatmental differences that were non-significant were denoted by 'NS'.

RESULTS AND DISCUSSION

Weed flora

Weed flora of the experimental field during the cropping period primarily composed of grasses, sedges and broad leaved weeds. The weeds in the experimental area were *Echinochola colonum, E. crus-galli* under grasses, *Cyperus iria, C. difform is* under sedges and *Ammania baccifera* and *Eclipta alba* under broad leaved weeds. *Rabi* season was characterized by incessant rain and inclement weather which resulted in higher sedge weed density especially *Cyperus difformis* (L.) This might be due to weeds with higher growth vigour under submerged condition at initial stage of rice cultivation. Similar observations was reported by Madhu and Nanjappa[8] in grasses *Echinochola crus-galli,* and in sedges *Cyperus difformis* and *Ammania baccifera* in broad leaved weeds posing major problem in early stage of rice cultivation.

Weed control efficiency (WCE)

The efficiency of treatments on control of weeds in terms of dry weight in comparation to control plot was worked out (Table 2). Adoption of different weed management practices controlled the weed efficiency as evident from the weed control efficiency, which range from 7.6 to 83.8 per cent at 20 DAT, 20.9 to 91.0 per cent at 30 DAT, 24.5 to 95.9 per cent at 50 DAT.

Weed control efficiency (WCE) indicates the magnitude of effective reduction of weed dry weight by weed control treatments over unweeded check. WCE was highly influenced by different weed control treatments. Application of rice bran at 2 t ha^{-1} 3 DAT followed by hand weeding on 35 DAT recorded higher weed control efficiency of 83.8, 91.0 and 95.9 respectively at 20, 30 and 50 DAT and it was at par with hand weeding on 15 DAT followed by azolla inoculation on the same day on 20 DAT, followed by conoweeder in corporation thrice on 30 DAT and hand weeding twice on 50 DAT. These results are in accordance with the findings of Gnanasoundari[6] who reported that more reduction of weed dry weight by reducing the weed density in the treatments resulted in higher Weed Control Efficiency.

Dry matter production (DMP)

Mulching with biodegradable polyethelene sheet (T_5) registered higher DMP of 5984 kg ha^{-1} at 60 DAT (Table 3) and was at par with application of rice bran at 2 t ha^{-1} fb hand weeding (T_8) and it was comparable with application of rice bran at 2 t ha^{-1} fb hand weeding (T_8), hand weeding on 15 DAT fb azolla inoculation (T_9) and hand weeding twice (T_3) at 60 DAT. Unweeded check (T_{10}) produced significantly lower (3654 kg ha^{-1}) DMP at 60 DAT.

The higher dry matter production was recorded in mulching with biodegradable polyethelene sheet. More amount of dry matter production might be due to increase in plant height, LAI, number of tillers and favourable environmental conditions. The reduction in lower number of tillers and dry matter production was recorded in unweeded check. This might be due to the competition between the weeds and crop during the crop growth period.

Crop growth rate (CGR)

Generally there was a significant improvement in CGR due to various weed management practices between 90-120 DAT and are presented in the Table 3.

Crop growth rate of the crop was influenced by the weed management practices. Significant improvement in CGR was observed among the different treatments employed. The crop growth rate was significantly higher (4.08 g m^{-2} day^{-1}) by mulching with biodegradable polyethelene sheet (T_5) between 90 – 120 DAT, it was comparable with application of rice bran at 2 t ha^{-1} fb hand weeding (T_8). It was followed by hand weeding on 15 DAT fb azolla inoculation (T_9) and hand weeding twice (T_3). Unweeded check (T_{10}) recorded significantly lower (2.17 g m^{-2} day^{-1}) CGR between all the stages of observation.

Panicle length

It was noticed that panicle length was not influenced significantly due to adoption of different weed management practices (Table 3).

Grain yield

Mulching with biodegradable polyethelene sheet (T_5) recorded significantly higher grain yield of 5557 kg ha^{-1} and it was at par with application of rice bran at 2 t ha^{-1}fb hand weeding (T_8), hand weeding on 15 DAT fb azolla inoculation (T_9) and hand weeding twice (T_3). Drastically lower grain yield of 2774 kg ha^{-1} was obtained from the unweeded check (T_{10}). All other treatments recorded significantly higher yield than unweeded check (T_{10}). This might be due to better control of weeds at tillering stage of the crop resulted in higher yield of the crop.

Higher grain (5557 kg ha^{-1}) observed in mulching with biodegradable polyethelene sheet (Table 4) and at par with application of rice bran at 2 t ha^{-1} on 3 DAT followed by hand weeding on 35 DAT due to timely and effective control of weeds which resulted in increased growth and yield components. The variation in grain yield under different treatments was the result of variation in weed density and weed biomass. These results are in conformity with the findings of Ali *et al.*,[1] who reported that plastic sheet mulching resulted in maximum paddy yield (4.18 t ha^{-1}) due to improvement in plant height (97.56 cm), number of panicles (25.73 cm) and 1000-grain weight (18.43 g).

Distinctly lower grain yields were recorded in unweeded check. This was due to severe competition between crop and weed for different resources *viz.*, light, moisture, space and nutrients which was in conformity with the findings of Gnanasoundari[6]. Reduction in grain yield was caused by decrease in growth and yield components of rice under increased resource of weed competition for space, light, nutrients etc.[9]

Harvest index

Method of non chemical weed management practices in organic rice had no significant influence on harvest index. Similarly weed management practices also failed to show any significant influence on harvest index (Table 4).

Weed index

Weed index at different crop growth stages under different weed management practices are furnished in Table 4.

Mulching with biodegradable polyethelene sheet (T_5) was taken as base to work out the weed index, as maximum grain yield was obtained under this treatment. Mulching with biodegradable polyethelene sheet (T_5) resulted in minimum competition to application of rice bran at 2 t ha^{-1}fb hand weeding (T_8) of 3.24 per cent and hand weeding on 15 DAT fb azolla inoculation (T_9) on par with hand weeding twice (T_3) of 9.66 percentage. Unweeded check (T_{10}) resulted in higher (50.08 per cent) weed index.

Table 1: Weed flora of the experimental field

Sl. No.	Botanical Name	Common Name	Habit	Family
A.	**Grasses**			
1.	*Echinochloa colonum* (L.) Link*	Jungle grass	Annual	Poaceae
2.	*Echinochloa crus-galli* (L.) P. Beauv	Barnyard grass	Annual	Poaceae
B.	**Sedges**			
1.	*Cyperus difformis**	Umbrella plant	Annual	Cyperaceae
2.	*Cyperus iria* (L.)	Rice flat sedge	Annual	Cyperaceae
C.	**Broad Leaved Weed**			
1.	*Ammania baccifera* (L.)*	Red stem	Annual	Lythraceae
2.	*Eclipta alba* (L.) Hassk	False daisy	Annual	Asteraceae

*Predominant weeds in experimental plots

Table 2: Effect of different non-chemical weed management practices on weed control efficiency in organic rice production

	Treatments	20 DAT	30 DAT	50 DAT
T_1 -	Application of paddy straw @ 3t ha^{-1} on 3 DAT + Hand weeding on 35 DAT	65.0	81.0	89.3
T_2 -	*Azolla* as dual crop with rice and incorporation on 35 DAT using power weeder	60.2	80.0	48.8
T_3 -	Hand weeding twice on 15 DAT and 35 DAT	80.2	85.5	93.0
T_4 -	Conoweeder 3 times on 20, 30, 40 DAT	7.6	86.0	89.3
T_5 -	Mulching with biodegradable polyethelene sheet	63.8	82.9	87.0
T_6 -	Intercropping mesta (*Hibiscus cannabinus*) with rice as paired row and harvested as greens	19.3	20.9	24.5
T_7 -	Intercropping daincha (*Sesbania aculeata*) with rice as paired row cropping and incorporation on 35 DAT	51.1	31.7	87.1
T_8 -	Application of rice bran @ 2t ha^{-1} on 3 DAT + Hand weeding on 35 DAT	83.8	91.0	95.9
T_9 -	Hand weeding on 15 DAT followed by azolla inoculation	82.2	85.6	87.2
T_{10} -	Unweeded check	-	-	-

Table 3: Effect of different non-chemical weed management practices on Dry matter production (Kg ha^{-1}), Crop growth rate (g m^{-2} day^{-1}), panicle length (cm), in organic rice production

	Treatments	DMP 60 DAT	CGR 90-120 DAT	Panicle length (cm)
T_1 -	Application of paddy straw @ 3t ha^{-1} on 3 DAT + Hand weeding on 35 DAT	4996	3.75	19.54
T_2 -	*Azolla* as dual crop with rice and incorporation on 35 DAT using power weeder	4253	2.77	19.43
T_3 -	Hand weeding twice on 15 DAT and 35 DAT	5354	3.85	19.29
T_4 -	Conoweeder 3 times on 20, 30, 40 DAT	4756	3.62	19.10
T_5 -	Mulching with biodegradable polyethelene sheet	5984	4.08	19.91
T_6 -	Intercropping mesta (*Hibiscus cannabinus*) with rice as paired row and harvested as greens	3810	2.64	18.91
T_7 -	Intercropping daincha (*Sesbania aculeata*) with rice as paired row cropping and incorporation on 35 DAT	4449	3.16	19.02
T_8 -	Application of rice bran @ 2t ha^{-1} on 3 DAT + Hand weeding on 35 DAT	5767	3.95	19.85
T_9 -	Hand weeding on 15 DAT followed by azolla inoculation	5570	3.95	19.74
T_{10} -	Unweeded check	3654	2.17	17.90
	SEd	**451**	**0.30**	**1.80**
	CD (P=0.05)	**948**	**0.62**	**NS**

Table 4: Effect of different non-chemical weed management practices on grain yield (Kg ha^{-1}), harvest index and weed index in organic rice production

		Treatments	Grain yield	Harvest index	Weed index
T_1	-	Application of paddy straw @ 3t ha^{-1} on 3 DAT + Hand weeding on 35 DAT	4610	0.43	17.04
T_2	-	*Azolla* as dual crop with rice and incorporation on 35 DAT using power weeder	3898	0.40	29.85
T_3	-	Hand weeding twice on 15 DAT and 35 DAT	5020	0.44	9.66
T_4	-	Conoweeder 3 times on 20, 30, 40 DAT	4557	0.44	18.00
T_5	-	Mulching with biodegradable polyethelene sheet	5557	0.44	0.00
T_6	-	Intercropping mesta (*Hibiscus cannabinus*) with rice as paired row and harvested as greens	3642	0.39	34.46
T_7	-	Intercropping daincha (*Sesbania aculeata*) with rice as paired row cropping and incorporation on 35 DAT	4241	0.42	23.68
T_8	-	Application of rice bran @ 2t ha^{-1} on 3 DAT + Hand weeding on 35 DAT	5377	0.44	3.24
T_9	-	Hand weeding on 15 DAT followed by azolla inoculation	5020	0.43	9.66
T_{10}	-	Unweeded check	2774	0.37	50.08
		SEd	**371.2**	**0.04**	**-**
		CD (P=0.05)	**779.9**	**NS**	**-**

CONCLUSION

Among the weeding methods, rice bran applied on flood water early after rice transplanting is easier to practice and adds little extra costs as it is a by product of rice farming. Rice bran application effectively suppressed major paddy weeds without herbicide use and also increased the grain yield of rice. Higher growth and yield parameters were obtained through mulching with biodegradable polyethelene sheet due to its suppressive effect on weeds but cost. But taking into consideration of economics, net returns and B:C ratio were higher under hand weeding on 15 DAT followed by azolla inoculation on the same day.

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