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Challenges of weed management in organically grown rice: A review

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Abstract

This review examines the impact of non chemical weed management on crop growth, weed density, weed biomass, yield, and the economic aspects of organically grown transplanting aromatic rice. Effective weed control is critical for maximizing the growth and grain yield of rice and promoting sustainable agricultural practices. The non chemical weed management practice has been shown to significantly reduce weed density and biomass, which in turn enhances crop growth and increases yield potential. Economic analyses indicate that while non chemical weed management practices costs can be substantial, the benefits in yield and reduced labor can result in favorable economic outcomes. This review highlights the necessity of balancing the benefits of non chemical weed management practices future research should focus on promote non chemical weed management techniques to enhance the sustainability production of rice production system.

Keywords: Non chemical weed management, transplanted aromatic rice-tomato cropping system, crop growth, weed density and economic viability

1. Introduction

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. The organically grown rice-tomato cropping system has shown promising potential for sustainable agriculture by improving soil health, reducing dependence on chemical inputs, and enhancing overall crop productivity. This review paper aims to synthesize current research on the effects of non chemical weed management practices in organically grown rice-tomato cropping systems. We will examine how various of non chemical weed management treatments impact weed density and biomass, explore their consequences for crop growth and yield, and analyze the economic implications for farmers. Non-chemical weed management practices under organically grown rice systems play a crucial role in maintaining crop health and yield without relying on synthetic herbicides. Techniques such as manual weeding, mechanical weeding, mulching and stale seedbed effectively reduce weed pressure while enhancing soil health and microbial activity. These methods support the principles of organic farming by promoting ecological balance and sustainability. They are environmentally friendly and help in conserving biodiversity in the field. 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. Anonymous (2021) Indian agriculture is characterized by agro-ecological diversities in temperature, rainfall, soil, and cropping system. Rice is regarded as the most important staple food crop for majority of world's population. Rice (*Oryza sativa* L.) is an edible starchy cereal grain and the grass plant belonging to family poaceae. FAOSTAT (2021) ^[9] Rice-based cropping systems have been reported from different parts of India ranging from rice-rice-rice to rice followed by different cereals, pulses, oilseeds, vegetables and fiber crops (Deep *et al.*, 2018) ^[6]. 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 Rathod (2017) ^[24]. Organic farming is a production system that avoids or largely excludes the use of synthetic fertilizers, pesticides, growth regulators and livestock feed additives (Pandey and Sing, 2012) ^[20]. The yield losses due to weeds vary from 40-100 per cent in direct seeded rice (Choubey *et*

al., 2001) ^[5]. Today, the awareness on organic agricultural produce is increasing and the demand for organic food is also rising, leading to increase in land area under organic farming (Pandit *et al.*, 2013) ^[21]. About 71.5 million ha of land is under organic farming worldwide with 2.8 million producers (Willer *et al.*, 2020) ^[13].

2. Major weed flora

Gnanasoundari and Somassundaram (2014) ^[10] a field experiment was conducted at Coimbatore to identify weed management practices under organic farming and concluded that major weed flora widespread in the rice crop in weedy check were comprised of 31% of broad leaved weeds such as *Eclipta alba* and *Monochoria vaginalis*, 32% sedges *Cyperus iria* and *Cyperus difformis* and 37% grasses such as *Echinochloa colonum*, *Echinochloa crusgalli*. Hassan *et al.* (2015) an experiment was conducted during rainy season in sandy loam soils at Jharkhand and noticed that major weed flora in the rice field were *Ludwigia parviflora* and *Digitaria sanguinalis* (15.4% each), *Spilanthes acmella* (14.1%), *Echinochloa crusgalli* and *Fimbristylis miliaceae* (8.9% each), *Cyperus iria* (6.4%). Sahu *et al.* (2015) conducted an experiment on clay loams at Varanasi, *kharif* transplanted rice was infested with grassy weeds, viz. *Echinochloa colona*, *Echinochloa crusgalli*, *Cynodon dactylon*, *Panicum repens* and *Paspalum distichum*; broad-leaved weeds, viz. *Ammania baccifera*, *Eclipta alba*, *Caesulia axillaris*, *Commelina benghalensis*, *Euphorbia hirta*, *Ludwigia parviflora* and sedges like *Cyperus iria*, *Cyperus difformis* and *Fimbristylis miliaceae*. Saini and Chopra (2015) ^[27] observed *Echinochloa sp.*, *Cyperus sp.*, *Ischaemum rugosum*, *Digitaria sanguinalis*, *Caesulia axillaris* and *frimbristylis tenera* in paddy during *kharif* season. In the field experiment at Punjab on clay loam soils. Yadav *et al.* (2017) ^[32] the predominant weed flora associated with *kharif* paddy field were *Echinochloa colona*, *Echinochloa crusgalli*, *Ischaemum rugosum*, *Leptochloa chinensis* among grasses and *Ammania baccifera*, *Alternanthera sessilis*, *Caesulia axillaris* among broad leaf weeds, and *Cyperus difformis* is the only species found among the sedges. Gupta (2021) a field experiments was carried out at Jammu to study effect of different weed management practices on weed dynamics and yield of organic basmati rice and reported that the major weed flora present in control plot (weedy check) throughout the crop growth period were *Echinochloa spp.* and *Cynodon dactylon* among grassy weeds, amongst broad leaved weeds, *Cyperus spp.* amongst sedges weeds *Dactyloctenium aegyptium*, *Phyllanthus niruri*, *Physalis minima* and *Sorghum halepense* amongst other weeds found in experimental field during crop season of the study. Sharma *et al.* (2021) from Jammu conducted field experiments under organic conditions in transplanted basmati rice and reported that the major weed flora present in organic basmati rice crop comprised of 37.4% sedges such as *Cyperus spp.*, 40.5% grasses including *Cynodon dactylon* and *Echinochloa spp.* whereas 22.0% grasses including, *Commelina benghalensis*, *Phyllanthus niruri*, *Alternanthera philoxeroides*, and *Sphenocleazeylanica*. Wang *et al.* (2022) conducted field experiment under organic rice conditions in Shanghai, China and reported that major weed flora present in the organic rice comprised of 96% of dicotyledonous weeds including *Alternanthera philoxeroides*, *Ludwigia prostrata* and *Lindernia procumbens* whereas 3.9% monocotyledonous weeds like *Murdanniatricquetra*, *Cyperus difformis*, *Echinochloa crusgalli*.

3. Effect of weed management practices on weeds

Mrunalini *et al.* (2008) ^[15] reported that rotary weeder in paddy crop grown in SRI method enhanced the pace of work and doubled the productivity, saved time up to 70-76% and optimized the human effort through improved postures and reduced the muscular fatigue as compared with the hand weeding process. Mukherjee *et al.* (2008) ^[17] from W.B. reported that under season long weedy conditions in rice crop, weed competition causes rice grain yield to drop by 57 to 61% as compared to weed free situation throughout the crop growth period. However, the yield losses were reduced to 2 to 4% in case of weeding at critical period of crop weed competition i.e. 20 DAT and 31 to 38% in case of weeding up to 40 DAT. Ramamoorthy *et al.* reported that in rice stale seed bed combined with two inter cultivation (30 and 60 DAT) resulted in 91.6% higher weed control efficiency, while passing the wheel hoe at 20, 30 and 45 DAT without hand weeding resulted in an 88.7 percent higher weed control efficiency. Singh and Guru (2011) ^[28] a field experiment was conducted at Crop Research Centre, Pantnagar during the rainy season of 2008 to study the effect of rice straw incorporation into the soil on the weed flora and growth in rice and the data on weed dry weight recorded at 60 DAT revealed a significant decrease in all the plots where rice straw was incorporated and reported that 5.0 t ha⁻¹ rice straw incorporation have beneficial effect in terms of weed control. Anitha *et al.* (2012) ^[2] observed that concurrent growing of Sesbania and its incorporation at 30 DAS resulted decline in total weed count due to concurrent growing of Sesbania was 72%, while that in weed dry matter production was 57% compared to rice grown alone. The reduction in weed population and dry matter may be attributed to shading effect exerted by the canopy of Sesbania. The co-cropping system reduced the weeding cost by 59% due to saving in labor requirement by 38 man-days/ha. Reddy *et al.* (2012) ^[25] conducted an experiment and noticed that the lowest broad leaved weed population was recorded with two hand weeding on 20 and 40 DAT compared to other treatments in transplanted rice. Saini and Chopra (2015) ^[27] noted that mechanical weeding thrice with cono weeder at 15, 30, 45 DAT in *kharif* rice was significant in reducing weed density (34.2 m⁻²), weed dry weight (17.8 g m⁻²) and also recorded higher weed control efficiency (97.4%) compared to hand weeding at 15 and 30 DAT (60.5 m⁻², 31.4 g m⁻², 97.1% respectively). on clay loam soils at Punjab.

4. Effects of non-chemical weed management practices on crop growth yield and yield attributes

Gorgy (2010) recorded that chisel plowing + puddling twice was superior in dry matter, leaf area index, number of tillers m⁻², number of filled grains panicle⁻¹, panicles number m⁻², harvest index and grain yield but panicle weight and 1000-grain weight were not affected.

Akbar *et al.* (2011) ^[1] from Pakistan studied the weed management strategies in improving the yield and quality of direct seeded rice and revealed that maximum plant height, number of tillers m⁻², kernels panicle, 1000 grain weight, grain yield, straw yield and harvest index was recorded in hand pulling treatment at 30, 45 and 60 days after sowing over control (weedy check). Anitha *et al.* (2012) ^[2] observed that concurrent growing of Sesbania and its incorporation at 30 DAS resulted in a weed suppression of 70% with yield of rice enhancement to the tune of 0.840 t ha⁻¹ and increased profitability of Rs 12520 ha⁻¹. Gopinath *et al.* (2012) ^[11] conducted an field experiment for

three years during rainy (*kharif*) season of 2006-2008 at Almora, Uttarakhand to study the effect of different weed control methods on weed infestation, energy use efficiency, productivity and profitability of direct seeded rice (*Oryzasativa* L.) recorded hand weeding twice at 20 and 40 DAS in rainfed upland direct seeded rice as increase growth and grain yield of rice crop over control. Hakim *et al.* (2013) [12] from Malaysia conducted an experiment to determine the critical period of crop weed competition in rice crop and reported that lowest plant height (99.31 cm), dry matter (136.6 g m⁻²), leaf area (643.33 cm² hill⁻¹), effective tillers hill⁻¹ (2.76), grains panicle⁻¹ (66.99), 1000-grain weight (20.23 g), and grain yield hill⁻¹ (1.97) were obtained in season long weedy check treatment as compared to weed free and other treatments.

Mohtisham *et al.* a field experiment to investigate the effect of different mulches on weed infestation in aerobic rice was conducted at Agronomic Research Area, University of Agriculture, Faisalabad, during the growing year 2010 and revealed that the all agronomic parameters or traits of rice such as plant height, total number of tillers, panicle length, 1000 kernel weight, biological yield, paddy yield and harvest index was reduced significantly by application of mulches and dry weight of weeds (broad and narrow leaf) was also significantly affected by the use of mulches. Different mulching techniques/material significantly improved the agronomic traits of aerobic rice over control and improving the rice yield. Bhuiyan *et al.* (2014) [3] conducted field experiments in organic rice at Faridpur (Bangladesh) and reported that weed competition from season long weedy situations resulted in lowest plant height (98.2 cm), leaf are index (2.99), panicle m⁻² (257), grains panicle⁻¹ (83), 1000-grain weight (18.59 g) and grain yield (4.52 t ha⁻¹) as compared to weed free and other organic treatments. Gnanasoundari and Somasundaram (2014) [10] field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *Rabi* to identify the ideal weed management technique in organic rice production and revealed that the Azolla incorporated at 20 & 40 DAT produced a higher number of tillers, grains per panicle, panicle length, panicle weight, grain yield, straw yield as compared to weedy check in organic rice weed management practices under the clay loam soils of Tamil Nadu, India. Nayak *et al.* (2014) [18] observed that the highest grain yield (4275 kg ha⁻¹) was achieved with plant density 47 hills m⁻² in combination of cono weeding twice but remained at a par to hand weeding twice (4142 kg ha⁻¹). Parameswari and Shrinivas (2014) conducted an experiment during *kharif* season of Hyderabad and reported that among weed management practices, farmer's practice (hand weeding twice at 20 and 40 DAS in direct seeded rice and transplanted rice and in SRI) of weeding recorded higher grain and straw yield in direct seeded rice under puddled conditions. Teja *et al.* (2015) [30] recorded the highest number of panicles m⁻², grains panicle⁻¹ with hand weeding twice on 20 and 40 DAT. The grain yield indicated that two hand weeding for rice crop resulted in significantly higher grain yield (3.59 t ha⁻¹) due to lowest weed count. Mewada *et al.* conducted a field experiment and found that the highest grain yield (3.95 t ha⁻¹) with hand weeding twice at 20 and 40 DAS and lowest under weedy check (1.73 t ha⁻¹). Similar trend was observed in straw yield under aerobic rice system. They also recorded maximum weed control efficiency under hand weeding twice treatment at 20 and 40 DAS and minimum under weedy check. However, weed density and weed dry weight were found maximum under weedy check and minimum with hand weeding twice at 20 and 40 DAS. Sureshkumar *et al.* (2016) [26] reported that maximum values of

yield attributing characters like tillers, panicle length, grains panicle⁻¹, grain weight plant⁻¹, test weight as well as grain yield recorded under manual weeding twice.

Chanda *et al.* (2017) [4] reported that due to the incorporation of dhaincha biomass in soil, the rice grain yield increased 7.82% to 33.56% over the control and they also observed that pH value, organic matter and total nitrogen slightly increased, however, available phosphorus and potassium more or less static, and available sulfur increased due to dhaincha incorporation in post-harvest soil, compared to initial soil sample. Dubey *et al.* (2017) [8] conducted an experiment at Faizabad (U.P.) observed maximum shoot dry matter, higher number of panicles, grains per panicle, longer panicle length, test weight, grain yield and net returns in hand weeding (20 and 40 DAT) than that of other weed management practices among the rice establishment methods. Roop *et al.* (2015) [26] conducted field experiments during *kharif* seasons at Meerut to control weeds in basmati rice crop and found that the maximum length of panicle (24.67 and 26.59, respectively), number of panicles m⁻² (240.75 and 242.50, respectively), 1000 grain weight (21.05 and 21.24 g, respectively) and grain yield (30.40 and 32.60 quintal ha⁻¹, respectively) was recorded with two hand weeding as compared to control. Rathod and Somasundaram (2017) [24] conducted a field experiment at Coimbatore and study revealed that paddy straw mulch @ 3 t ha⁻¹ + hand weeding at 35 DAT gave higher dry matter production at 60 DAT, CGR, and grain yield of rice followed by 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 (3.85 g m⁻² day⁻¹) by hand weeding twice on 15 DAT and 35 DAT, Cono weeder 3 times on 20, 30, 40 DAT recorded CGR was (3.62 g m⁻² day⁻¹) and Azolla as dual crop with rice and incorporation on 35 DAT using power weeder (2.77 g m⁻² day⁻¹) between 90 to 120 DAT. Whereas lowest CGR recorded under control plot (2.17 g m⁻² day⁻¹). This might be due to better control of weeds at tillering stage of the crop resulted in higher yield of the grain.

Satapathy *et al.* observed that all the weed control treatments significantly reduced weed population, dry matter and increased grain yield of rice compared to weedy check. Hand weeding twice recorded grain yield of 5.64 t ha⁻¹ resulting in 54.5% increase over weedy check. Mechanical weeding *fb* by one hand weeding recorded reduction in grain yield of 9.2% over hand weeding twice. Dhanapal *et al.* (2018) [7] conducted a field experiment at Kathalagere Davanagere registered that the hand weeding on 25 and 45 DAT resulted in the highest grain (5.84 t ha⁻¹) and straw yield in rice (6.95 t ha⁻¹).

Yadav *et al.* (2018) [32] reported that the incorporation of *Sesbania aculeata* green manure @ 33.8 and 35.6 t ha⁻¹ prior to transplanting of Basmati rice during 2015 and 2016, respectively resulted in higher yield attributes and yield of Basmati rice compared with *Vigna umbellata*, *Leucaena leucocephala* and summer fallow during both the years. Sharma *et al.* suggested that the highest grain yield 4443 kg ha⁻¹ under hand weeding twice (25 and 45 DAT) and lowest 3291 kg ha⁻¹ recorded under weedy check plot. Jayadeva *et al.* (2019) [14] ascertained that hand weeding twice on 20 and 40 DAT/DAS recorded higher grain and straw yield in rice over weedy check. Patel and Ghosh (2019) [22] worked on an experiment at Visva-Bharati, Sriniketan, Birbhum, West Bengal to study the effect of different weed management practices on yield improvement of transplanted *kharif* rice. The higher grain yield of rice was recorded in the hand weeding done at 20 and 40 DAT. Kumar *et al.* (2022) [31] a field experiment was conducted at Meerut (U.P)

to find out effect of weed management practices on yield and economics of transplanted rice, it found that two manual hand weeding gave significantly higher grain and straw yield as compared to weedy check in transplanted rice.

5. Effects of different weed management practices on Economics

Jadhav *et al.* (2011) also found highest net return in rice with two hand weeding at 20 and 40 DAT and reported that cost of cultivation varies among different weed management treatments. Maximum cost of cultivation (Rs. 25428 ha⁻¹) was found under manual weeding twice (20 and 40 DAS) as compared to the other treatments in rice. Mukharji (2011) [16] studied the rotary paddy weeder at 20 and 40 DAT effect on controlling weeds in transplanted rice and found net return in rotary paddy weeder at 20 and 40 (Rs. 10090 and 12310 ha⁻¹) and benefit: cost ratio (0.77 and 0.92) during both years as compare to control plot. Sindhu *et al.* (2011) studied the stale seedbed and green manuring effect on controlling weeds in rice and found highest net return in stale seedbed for 14 days (Rs. 32436 ha⁻¹). They reported lowest cost of cultivation and highest B:C ratio in case of stale seedbed for 14 days compared to normal seed bed technique. Gnanasoundari and Somasundaram (2014) [10] field experiment was conducted at Coimbatore during Rabi to identify the ideal weed management technique in organic rice production and revealed that the application of rice bran at 2 t ha⁻¹ on 3 DAT followed by a hand weeding on 35 DAT increased the net returns and B:C ratio (2.45) as compared to other non-chemical weed management practices.

6. Conclusion

This review underscores the critical importance of non-chemical weed management practices in enhancing the productivity, sustainability, and economic viability of organically grown transplanted aromatic rice–tomato cropping systems. The evidence clearly indicates that timely and effective non-chemical approaches significantly reduce weed density and biomass, thereby improving key crop growth parameters such as plant height, tiller and branch numbers, and ultimately, grain and fruit yields. Moreover, these practices can contribute to cost savings by reducing the reliance on labor-intensive manual weeding, offering a favorable return on investment despite potentially high initial costs.

Non-chemical weed management aligns with the goals of sustainable agriculture by minimizing environmental impacts and promoting soil health while maintaining crop productivity. The integration of such practices presents a promising pathway for organic farmers seeking to optimize yields without compromising ecological integrity. Future research should prioritize refining these techniques, developing location-specific recommendations, and assessing their long-term impacts on soil and crop health. Strengthening the adoption of non-chemical weed control strategies will be essential to achieving resilient, productive, and environmentally sustainable rice production systems.

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