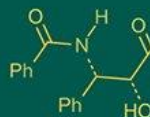


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Nutrient removal by weeds in organically grown transplanted rice

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Abstract

A field experiment was conducted at Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *kharif* season 2022 and 2023. The soil of experimental field was neutral in reaction, medium in organic carbon and low in available nitrogen, low in available phosphorus and high in available potassium. Experiment was laid out in randomized block design with three replications. The weeds of the experimental site were dominated with grasses like *Echinochloa colona* broad leaves like *Alternanthera sessilis*, *Celosia argentea*, *Cyanotis axillaris* sedge like *Cyperus iria*, *Fimbristylis miliacea* and other weeds. Results revealed that nutrient removal by weeds in Hand weeding (HW) twice at 20 and 40 DAT which was at par with Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT. Similarly, total weed density and biomass at harvest was also significantly reduced in these treatments to others. However, lowest nutrient removal by weeds at harvest was noticed in this treatment than weedy check. Highest nutrient removal by weeds recorded under weedy check.

Keywords: Rice, weed, nutrient, removal

1. Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops in the world and serves as the staple food for more than one-third of the global population, particularly in Asia and the Pacific region, where it contributes nearly 39% of the daily caloric intake (Yaduraju, 2013) [14]. The increasing concern over environmental sustainability, food safety, and human health has led to a growing interest in organic farming systems worldwide. Organic farming has emerged as a promising approach for sustainable agricultural production and rural livelihood enhancement. According to Bhattacharyya and Chakraborty (2005), organic farming is gaining momentum globally and in India due to increasing awareness regarding health and environmental issues associated with conventional agriculture. Weeds are among the most serious biological constraints affecting rice productivity, especially under organic production systems where the use of synthetic herbicides is prohibited. They compete vigorously with crop plants for essential growth resources such as nutrients, moisture, light and space, thereby reducing crop growth and yield. Delayed or ineffective weed management results in increased weed biomass, higher nutrient depletion, and substantial yield losses. Furthermore, weed competition may adversely affect grain quality, which is influenced by nutritional, physiological, and biochemical factors. Although grain quality is largely governed by genetic makeup, environmental conditions and crop management practices can significantly influence the biochemical composition of rice grains. Non-chemical weed management practices play a vital role in organic rice cultivation. Mechanical weeding tools such as long-handled khurpi and wheel hoe have been reported to improve operational efficiency and reduce labor requirements for weed control (Melander *et al.*, 2005) [6]. While inter-row weeds can be effectively controlled through mechanical cultivation, management of intra-row weeds remains a major challenge in organic rice production systems. Several researchers have reported the effectiveness of cultural and mechanical weed management practices in reducing weed infestation and nutrient removal by weeds. Gopinath *et al.* (2012) [3], during a three-year field study conducted at Almora, Uttarakhand, observed that hand weeding twice at 20 and 40 days after sowing (DAS) significantly reduced nutrient removal by weeds, recording only 8.6 kg N, 2.2 kg P, and 5.8 kg K ha⁻¹ compared to the maximum nutrient

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depletion under weedy check conditions. Gowda *et al.* (2009) ^[4] the weed control treatments brought down uptake of these nutrients by weeds. The nutrient losses by weeds was reduced to (1.67, 1.16 and 1.01 Kg N, P and K ha⁻¹, respectively) in hand weeding at 20 and 45 DAS among various treatments. Organic farming is an eco-friendly agricultural system that sustains soil health and biodiversity by completely avoiding synthetic fertilizers, pesticides, and genetically modified seeds. Instead, it relies on biological processes, natural inputs, and crop rotation to produce crops and livestock. Organic farming reduces carbon emissions, improves soil health, and reloads natural ecosystems for cleaner water and air, all while avoiding hazardous pesticide residues. Organic farming plays the main role in the sustainability of agricultural systems. Sustainable agriculture is a broad term for growing food using methods that will nurture society, the environment, and the economy.

2. Materials and Methods

The study was carried out at instructional cum research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during *kharif* crop 2022 and 2023. The soil of experimental field was *Vertisols*. Experiment was conducted in randomized block design with three replications, consisted of T₁-hand weeding (HW) twice at 20 and 40 DAT, T₂-motorized weeder twice (single row type) at 20 and 40 DAT, T₃-motorized weeder twice (single row type) at 20 and

40 DAT + one intra row HW at 20 DAT, T₄-mechanical weeding through Ambika paddy weeder at 20 and 40 DAT, T₅-mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT, T₆-green leaf manuring (incorporation at puddling) + one HW at 20DAT, T₇-10 days delayed planting with incorporation of emerged weeds, T₈-dense planting (closer spacing of 15 × 10 cm) and T₉-Weedy check. The rice variety “CG Devbhog” was transplanted on 2nd August 2022 and 27th July 2023. The cropping system was Rice-tomato and all nutrients were supplied through farm yard manure (12 tonne) and vermicompost (3 tonne). All the recommended agronomic practices were adopted to raise the crop.

Nutrient removal by weeds (kg ha⁻¹)

Weed samples of all species collected at harvest stage were also used to estimate N, P and K removal. Weeds samples were first oven dried at 60 °C for 36-48 hours. Samples were then powdered and used for chemical analysis to determine N, P and K in weeds. N, P and K were determined by Micro-Kjeldahl (Jackson, 1967) ^[5], Spectrophotometer (Chapman and Pratt, 1961) ^[2] and Flame photometer (Chapman and Pratt, 1961) ^[2] methods, respectively.

The N, P, K removal by weeds was also worked out multiplying concentration with respective dry weight of weeds on oven dry basis i.e.

$$\text{Nutrient removal (Kg ha}^{-1}\text{)} = \frac{\text{Concentration(\%)} \times \text{Dry matter weeds (Kg ha}^{-1}\text{)}}{100}$$

3. Results and Discussion

3.1 Nutrient content (%) of different weeds

The nutrient content (%) of different weeds showed in table 1. Among the different weed species studied, the highest nitrogen content was recorded in *Alternanthera sessilis*, whereas the lowest nitrogen content was observed in *Cyanotis axillaris*. In contrast, the highest phosphorus and potassium contents were recorded in *Cyanotis axillaris*, while the lowest phosphorus content was recorded in *Alternanthera sessilis*. Whereas, the lowest Potassium content was recorded in other weeds.

3.2 Nutrient removal (kg ha⁻¹)

Nutrient removal (kg ha⁻¹) data showed table 2, 3 and 4 (N,P and K). The nutrient removal by weeds species wise and total was found to be lowest under hand weeding (HW) twice at 20 and 40 DAT treatment, with nitrogen removal of only 2.48 and 2.45 kg ha⁻¹, phosphorus 1.83 and 1.64 kg ha⁻¹, and potassium 3.39 and 3.18 kg ha⁻¹ during 2022 and 2023, respectively, due to efficient weed suppression. Treatments like motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT recorded nutrient removal values at par with hand weeding (HW) twice at 20 and 40 DAT, reflecting good weedy check as well. In contrast, the highest nutrient removal by weeds occurred under the weedy check, highlighting heavy nutrient loss through weeds because of no control measures. Effective weed management improves plant height and crop growth by minimizing nutrient depletion by weeds, ensuring more nutrients remain available for the crop. These results align with earlier studies by Gowda *et al.* (2009) ^[4] who reported that the nutrient losses by weeds was reduced in

hand weeding at 20 and 45 DAS. Similarly, Rathod and Somasundaram (2017) ^[10] reported that unweeded plots recorded the highest nutrient removal by weeds, whereas paddy straw mulch @ 3 t ha⁻¹ combined with hand weeding at 30 DAT significantly reduced the removal of N, P, and K by weeds and performed on par with Azolla-based weed management practices. Sharma *et al.* (2019) ^[12] also reported that hand weeding twice at 25 and 45 DAT resulted in the lowest nutrient removal by weeds (1.07 kg N, 0.77 kg P, and 1.63 kg K ha⁻¹), while the weedy check treatment recorded the highest nutrient removal (7.12 kg N, 1.21 kg P, and 17.29 kg K ha⁻¹). In contrast, the use of a rotary paddy weeder at 20 and 40 DAT significantly reduced nutrient removal by weeds to 9.2-9.8 kg N, 1.1-1.4 kg P, and 11.7-12.4 kg K ha⁻¹. Reddy *et al.* (2021) ^[11] Weedy check plot resulted in highest nutrient removal of 43.05, 3.08 and 48.28 kg ha⁻¹ N, P and K respectively due to unrestricted weed proliferation in direct seeded rice. Manhas *et al.* (2012) reported nutrient removal of 53 kg N, 15.5 kg P and 58 kg K ha⁻¹ compared to weed free plot.

Table 1: Nutrient content (%) of rice by weeds as influenced by weed management practices in organically grown transplanted aromatic rice

Major weed species at harvest	Nutrient content weed (%)					
	N		P		K	
	2022	2023	2022	2023	2022	2023
<i>Alternanthera sessilis</i>	1.21	1.35	0.74	0.85	1.81	1.77
<i>Cyanotis axillaris</i>	1.05	1.12	0.90	0.81	1.87	1.73
<i>Celosia argentea</i>	1.12	1.28	0.86	0.84	1.79	1.72
<i>Fimbristylis miliacea</i> Other weeds	1.23	1.05	0.81	0.78	1.74	1.77

Table 2: Species wise nitrogen removal by weeds under different weed management practices on organically grown aromatic transplanted rice.

Treatment	Nitrogen removal by weeds (kg ha ⁻¹)									
	<i>Alternanthera sessilis</i>		<i>Cyanotis axillaris</i>		<i>Celosia argentea</i>		<i>Fimbristylis miliacea</i>		Other weeds	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	0.71	0.67	0.61	0.53	0.50	0.54	0.22	0.24	0.44	0.48
Motorized weeder twice (single row type) at 20 and 40 DAT	1.79	1.80	1.57	1.64	1.13	1.19	0.44	0.47	1.17	1.17
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	0.76	0.69	0.94	0.82	0.73	0.56	0.25	0.40	0.85	0.85
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	1.27	1.21	1.00	1.23	1.00	0.79	0.31	0.43	0.97	0.97
Mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT	2.02	2.07	1.63	1.81	1.33	1.42	0.51	0.54	1.47	1.47
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	1.80	1.81	1.60	1.66	1.19	1.20	0.48	0.52	1.19	1.19
10 days delayed planting with incorporation of emerged weeds	2.08	2.36	2.08	1.81	1.36	1.58	0.54	0.59	1.70	1.70
Dense planting (closer spacing of 15x10 cm)	2.20	2.48	2.15	2.54	2.58	2.57	0.82	0.72	2.38	2.38
Weedy check	2.57	3.05	3.13	4.07	2.29	2.60	0.83	0.75	3.28	3.28
SEm $\pm$	0.09	0.14	0.11	0.12	0.15	0.04	0.03	0.06	0.14	0.16
CD (P = 0.05)	0.27	0.41	0.33	0.36	0.45	0.13	0.09	0.17	0.41	0.47

Table 3: Species wise Phosphorus removal by weeds under different weed management practices on organically grown aromatic transplanted rice

Treatment	Phosphorus removal by different weeds (kg ha ⁻¹)									
	<i>Alternanthera sessilis</i>		<i>Cyanotis axillaris</i>		<i>Celosia argentea</i>		<i>Fimbristylis miliacea</i>		Other weeds	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	0.41	0.44	0.50	0.32	0.45	0.45	0.15	0.17	0.32	0.25
Motorized weeder twice (single row type) at 20 and 40 DAT	1.04	0.98	1.29	1.01	1.02	1.39	0.29	0.34	0.78	0.80
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	0.44	0.46	0.77	0.51	0.65	0.70	0.17	0.29	0.56	0.42
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	0.74	0.64	0.82	0.76	0.90	1.04	0.20	0.31	0.65	0.67
Mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT	1.18	1.16	1.34	1.12	1.19	1.53	0.34	0.39	0.98	0.82
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	1.05	0.98	1.31	1.02	1.07	1.41	0.32	0.38	0.79	0.81
10 days delayed planting with incorporation of emerged weeds	1.21	1.30	1.70	1.12	1.22	1.54	0.36	0.43	1.13	1.22
Dense planting (closer spacing of 15x10 cm)	1.28	2.10	1.76	1.56	2.32	2.15	0.54	0.52	1.59	1.58
Weedy check	1.50	2.13	2.56	2.51	2.06	3.45	0.56	0.55	2.18	2.08
SEm $\pm$	0.10	0.05	0.09	0.08	0.07	0.10	0.01	0.04	0.08	0.06
CD (P = 0.05)	0.30	0.16	0.27	0.23	0.20	0.29	0.02	0.12	0.25	0.17

Table 4: Species wise Potassium removal by weeds under different weed management practices on organically grown aromatic transplanted rice

Treatment	Potassium removal by different weeds (kg ha ⁻¹)									
	<i>Alternanthera sessilis</i>		<i>Cyanotis axillaris</i>		<i>Celosia argentea</i>		<i>Fimbristylis miliacea</i>		Other weeds	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	0.91	0.88	1.00	0.69	0.45	0.69	0.31	0.39	0.72	0.54
Motorized weeder twice (single row type) at 20 and 40 DAT	2.04	1.95	2.58	2.15	1.02	2.15	0.62	0.78	1.76	1.69
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	1.31	0.92	1.54	1.08	0.65	1.08	0.35	0.66	1.27	0.90
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	1.80	1.29	1.63	1.61	0.90	1.61	0.44	0.70	1.46	1.42
Mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT	2.39	2.33	2.67	2.37	1.19	2.37	0.72	0.89	2.20	1.74
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	2.13	1.96	2.62	2.17	1.07	2.17	0.68	0.86	1.78	1.72
10 days delayed planting with incorporation of emerged weeds	2.44	2.59	3.40	2.37	1.22	2.37	0.76	0.96	2.55	2.60
Dense planting (closer spacing of 15x10 cm)	4.65	4.20	3.52	3.32	2.32	3.32	1.16	1.17	3.58	3.35
Weedy check	4.13	4.26	5.11	5.32	2.06	5.32	1.18	1.23	4.92	4.41
SEm $\pm$	0.13	0.01	0.18	0.13	0.07	0.13	0.01	0.09	0.18	0.12
CD (P = 0.05)	0.40	0.04	0.54	0.39	0.20	0.39	0.04	0.27	0.55	0.36

Table 5: Total nutrient (NPK) removal by weeds under different weed management practices on organically grown aromatic transplanted rice

Treatment	Total nutrient removal by weeds (kg ha ⁻¹)					
	Nitrogen		Phosphorus		Potassium	
	2022	2023	2022	2023	2022	2023
Hand weeding (HW) twice at 20 and 40 DAT	2.48	2.45	1.83	1.64	3.39	3.18
Motorized weeder twice (single row type) at 20 and 40 DAT	6.10	6.28	4.42	4.52	8.01	8.72
Motorized weeder twice (single row type) at 20 and 40 DAT + one intra row HW at 20 DAT	3.52	3.33	2.59	2.38	5.12	4.64
Mechanical weeding through Ambika paddy weeder at 20 and 40 DAT	4.54	4.63	3.30	3.42	6.22	6.62
Mechanical weeding through Ambika paddy weeder + one intra row HW at 20 DAT	6.96	7.32	5.03	5.02	9.17	9.69
Green leaf manuring (incorporation at puddling) + one HW at 20 DAT	6.25	6.38	4.53	4.60	8.27	8.89
10 days delayed planting with incorporation of emerged weeds	7.75	8.04	5.63	5.60	10.38	10.90
Dense planting (closer spacing of 15x10 cm)	10.13	10.68	7.50	7.91	15.22	15.36
Weedy check	11.01	12.66	8.86	10.71	17.40	20.55
SEm±	0.34	0.29	0.28	0.25	0.59	0.48
CD (P = 0.05)	1.03	0.88	0.84	0.75	1.76	1.45

4. Conclusion

The findings of the present study demonstrated that non-chemical weed management practices significantly reduced weed growth and nutrient removal by weeds in organically grown transplanted aromatic rice. Among the different treatments evaluated, hand weeding twice at 20 and 40 DAT proved to be the most effective, recording the lowest nutrient removal by weeds and significantly reducing weed density and weed biomass at harvest. The treatment involving motorized weeding twice (single row type) at 20 and 40 DAT along with one intra-row hand weeding at 20 DAT performed statistically at par with hand weeding, indicating its effectiveness as a suitable labor-saving alternative for organic rice cultivation. In contrast, the weedy check treatment recorded the highest nutrient removal by weeds, resulting in greater nutrient losses and increased weed competition. The study clearly indicates that timely and efficient weed management is essential for minimizing nutrient depletion by weeds and improving nutrient availability to the rice crop. Motorized weeding combined with one intra-row hand weeding are alternate option of hand weeding twice at 20 and 40 DAT under organic farming which were cost effective and less labour expensive. Therefore, hand weeding twice at 20 and 40 DAT or motorized weeding combined with one intra-row hand weeding can be recommended as effective and sustainable weed management practices for organically grown transplanted aromatic rice under the agro-climatic conditions of Chhattisgarh.

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