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The economics and effectiveness of weed control techniques for rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during rabi season of 2023-24 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to The Economics and Effectiveness of Weed Control Techniques for Rice (*Oryza sativa* L.). The soil was normal in pH of 7.67, electrical conductivity (EC) of 0.24 dSm^{-1}, organic carbon content of 0.40%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 215.80, 19.57, and 148.57 kg ha^{-1}, respectively. The experiment was laid out during Kharif season of 2023-24. The experiment consisted of 9 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications.

Keywords: Herbicides, rice, hand weeding

Introduction

The plant (*Oryza sativa* L.), sometimes referred to as "Asian rice," and O. glaberrima, sometimes called "African rice," Though it can also refer to primitive or uncultivated Oryza varieties, the term "wild rice" can refer to both wild and domesticated species of the genera Zizania and Por Teresia. In Asia and over half of the world's population, rice (*Oryza sativa* L.) is the staple food. It provides about 40% of India's total food grain production. It is necessary for almost every household to have both a means of subsistence and food security. It provides 43% of the daily energy needs for about 70% of Indians. Rice is grown on 169.5 million hectares globally, with an average productivity of 4601 kg ha^{-1} and a yield of 769 million tons. In nearly every state in India, rice is planted; it is the most planted crop in terms of acreage and production. With an average productivity of 2576 kg ha^{-1}, the estimated total area planted with rice in India in 2018-19 produced 116.4 million tons of goods on 38.41 million hectares. Telangana state contributes 1.02 million hectares with a production of 6.70 million tons at an average yield of 3634 kg ha^{-1}, according to the Directorate of Economics and Statistics (2023-24). To feed its rapidly growing population, the country would need to produce over 130 million tons of rice by 2025.

It is challenging to meet rice's intended demands. The establishment method is one cultural practice that influences the rice crop's growth and development. Hand transplanting is the most common method of producing rice in South and Southeast Asia.

India is a major producer of rice, a staple crop. Many factors are reducing the yield of transplanted rice. However, weed infestation poses the greatest threat to the productivity of transplanted rice, as it can reduce rice yield by 45-51%.

Weed infestation in transplanted soil conditions is a major barrier to achieving higher yields. Periodic drying and wetting of the crop leads to a significant amount of weed seed emerging and competing with it. Weed and crop seeds germinate, emerge, and grow together in unsaturated soil. Weed plants and rice compete for nutrients. air, light, and wetness. The intense competition poses a major early threat to seedling growth. As a result, the primary obstacle of weed infestation reduces grain yield by 80-100% (Jackson *et al* 2021) [10].

Controlling weeds is essential to INM for rice. When it comes to light, water, space, and nutrients, weeds and rice plants compete (Yadav 2018) [13].

Unchecked weeds deplete soil nutrients and drastically hinder rice growth and yield. Therefore, weeds need to be controlled quickly in order for INM to be effective. The importance of weed control is growing as farmers switch to directed sowing and as water becomes more limited (Pushpakumari 2015) [11]. A variety of techniques will be used in integrated weed management, such as timely and effective vegetation preparation, leveling the ground, efficient water regulation, crop growth, use of clean, hygienic seeds, and application of the right agrochemicals (Singh *et al* 2014) [14].

Hand weeding is an effective strategy, but it can be expensive, time-consuming, and difficult in the early stages because grassy weeds and rice seedlings have many physical similarities (Akbar *et al*. 2019) [3]. Due to the labor issue, weeding is postponed during the peak of crop weed competition, which reduces output. However, weeds can be effectively controlled by applying pesticides to rice that has been transplanted. (Kabdal *et al* 2014) [12]. The mechanical control of weeds is one of the conventional methods of weed management. Even though it's an antiquated method, recent advancements like the development of power-operated weeders and motorized rotary tillers have made it a useful and effective tool for weed management (Man *et al*., 2018) [5]. Mechanical weeding not only ensures soil aeration for better crop growth but also reduces labor requirements and weeding operations time.

Therefore, to address issues like repeated herbicide use, shift in weed flora, build-up of resistance, health hazards, and ground water contamination, Integrated Weed Management (IWM), which uses herbicide mixtures and mechanical weed control methods to provide economically efficient and sustainable weed management in transplanted rice cultivation, is required. Biological control is the process of managing weeds with the use of nematodes, fish, fungi, insects, or viruses. Biocontrol has proven successful in many cases, and its use is becoming more widely accepted. Several fish have been employed to control weed in submerged environments.

Materials and Methods

A field experiment was conducted during rabi season of 2023-24 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to The Economics and Effectiveness of Weed Control Techniques for Rice (*Oryza sativa* L.).The soil was normal in pH of 7.67, electrical conductivity (EC) of 0.24 dSm^{-1}, organic carbon content of 0.40%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 215.80, 19.57, and 148.57 kg ha^{-1}, respectively. The experiment was laid out during Kharif season of 2023-24. The experiment consisted of 9 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications. W1 Hand weeding (15, 30, 45 DAS), W2: Mechanical weeding, W3: Weeding with power weeder.W4: Mulching with straw. W5: Oxyfluorfen @ 0.15 kg a.i ha^{-1} + hand weeding at 15 DAS, W6: Pretilachlor @ 0.75 kg a.i ha^{-1}+ hand weeding at 15 DAS, W7: Pendimethalin 30% EC @ 1.5 L ha^{-1} as PE fb bispyribac sodium 10% SC @ 30 ml a.i. ha^{-1} as early PoE, W8Weed free check., W9:Weedy-check. data were gathered on five plants chosen from each plot.

Yield attributing characteristics efficient tillers (per square meter)

Comparable to W5 (oxyfluorfen @ 0.15 kg ai ha^{-1} + hand weeding at 15 DAS), the control group (PB-1509: hand weeding at 15, 30, and 45 DAS) recorded the highest productive tiller number per square meter (597.17). The least productive tiller number per square meter was found in W7 (weedy check) (Choudhary *et al* 2018) [8].

Grain Weight (Per Panicle)

The maximum grain weight per panicle, W5 (oxyfluorfen @ 0.15), was measured in kilograms a.i. ha^{-1}plus rved and was comparable to W1 (hand weeding 15, 30, 45 DAS). At 15 DAS, it was cohand weeding. The weedy check, W7, took a measurement of the lowest grain weight in every panicle\ (Gautam *et al* 2018) [9].

Number of spikelets (per panicle)

The highest number of spikelets per panicle was recorded by W1 (hand weeding 15, 30, and 45 DAS); this was similar to W2 (mechanical weeding with a cycle hoe), W4 (straw mulching), and W5 (oxyfluorfen @ 0.15 kg ai ha^{-1} + hand weeding at 15 DAS). A Weedy check (W7) found very few spikelets.

Grains filled (per panicle)

When hand weeding, W1 had the greatest number of filled grains per panicle (15, 30, 45). W6 (pretilachlor @ 0.75 kg a.i ha^{-1} + hand weeding at 15 DAS), W5 (oxyfluorfen @ 0.15 kg a.i ha^{-1}) and W2 (mechanical weeding with cycle hoe) matched (Bhatt *et al* 2017) [7].

Test Weight

W5 (oxyfluorfen @ 0.15 kg a.i ha^{-1} + hand weeding at 15 DAS) achieved the highest thousand grain weight, which was similar to W1 (hand weeding 15, 30, 45 DAS). The weedy check (W7) yielded the lowest value.

Grain yield (kg/ha)

The results demonstrated that the various weed control strategies had a significant effect on grain yield. The highest grain yield (3889.00 kg ha^{-1}) was achieved by W1 (hand weeding at 15, 30, and 45 DAS), while W5 (oxyfluorfen @ 0.15 kg a.i ha^{-1} + hand weeding at 15 DAS) produced the same amount of grain (Mani 2018) [5]. With a yield of 2111.00 kg ha^{-1}, the lowest yielding Unweeded check (W7) recorded significantly less than any other treatment. The grain yield for the treatments was significantly higher than the control (PB-1509) at 4944.33 kg ha^{-1} Singh (2020) [6].

Straw Yield (kg/ha)

Of all the treatments, the control treatment (PB-1509: hand weeding at 15, 30, and 45 DAS) yielded the most straw (6333.33 kg ha^{-1}). Similar to W1, this involved hand weeding at 15, 30, and 45 DAS. W5 (hand weeding at 15 DAS plus oxyfluorfen @ 0.15 kg a.i ha^{-1}) was applied next, and it performed similarly to W2 (mechanical weeding with cycle hoe) Rao (2016) [4]. In comparison to Aiswarya, the grain yield for the control (PB-1509) was significantly higher (4944.33 kg ha^{-1}) when comparing the treatments. In comparison to all the other checks, the weedy check (W7) had the lowest straw yield—by a significant margin.

Harvest Index (HI)

The highest harvest index was found in W1 (hand weeding at 15, 30, and 45 DAS) and W5 (oxyfluorfen @ 0.15 kg a.i ha^{-1} + hand weeding at 15 DAS). Weedy Check revealed the lowest harvest index (W7). The control group's harvest index (PB-1509) was significantly higher than the treatment group's.

Table 1: Grain weight per panicle, spikelets per panicle, productive tillers, and full grains per panicle

Treatment	Grain weight per panicle (g)	Spikelets per panicle (nos.)	Productive tillers m-2 (nos.)	Filled grains per panicle (nos.)
W1: Hand weeding (HW)	2.19	115.89	547.33	102.00
W2: Mechanical weeding	1.95	112.11	488.33	99.55
W3: Weeding with power weeder	1.91	91.77	466.83	76.33
W4: Mulching with straw	1.47	103.66	405.76	69.89
W5: OF @ 0.15 kg a.i ha^{-1} + HW	2.49	112.99	555.00	98.44
W6: PC @ 0.75 kg a.i ha^{-1}+ HW	1.71	104.77	505.76	92.77
W7: Weedy check	1.44	80.44	288.83	65.56
Control: PB-1509 (HW)	1.71	98.89	597.17	89.44
SE m (±)	0.169	5.356	15.968	3.509
CD (0.05)	0.514	16.249	48.439	10.638

Table 2: The impact of weed control techniques on harvest index, straw output, and grain yield

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
W1: Hand weeding (HW)	3889.00	6333.33	0.38
W2: Mechanical weeding	3333.33	5700.00	0.36
W3: Weeding with power weeder	3055.76	5500.13	0.36
W4: Mulching with straw	2944.76	5366.76	0.35
W5: OF @ 0.15 kg a.i ha^{-1} + HW	3500.00	5822.21	0.38
W6: PC @ 0.75 kg a.i ha^{-1}+ HW	3000.33	5400.00	0.35
W7: Weedy check	2111.00	4200.33	0.33
Control: PB-1509 (HW)	4944.33	6777.79	0.42
SE m (±)	136.626	179.900	0.007
CD (0.05)	414.453	546.997	0.022

Conclusion

One more efficiently than weeds, resulting in a higher final yield. The amount of grain produced by hand weeding was 3889 kg ha^{-1}, which was significantly more than the amount produced by pre-emergence oxyfluorfen spray at 0.15 kg a.i ha^{-1} and hand weeding at 15 DAS (3500 kg). Mechanical weeding with a cycle hoe and power weeder produced somewhat good yields (3333.33 kg ha^{-1} and 3055.76 kg ha^{-1}, respectively), although yields were lower than the best treatments.

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