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Impact of various weed control methods on nutrient uptake and quality of dibbled rice (*Oryza sativa* L.)

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Abstract
The study conducted at the ASPEE Agricultural Research and Development Foundation Farm in Nare, Thane during the Kharif season of 2013 utilized a randomized block design to evaluate various weed management methods. Treatments included single herbicides, pre and post-emergence herbicide combinations, and herbicide mixtures. Rice was sown using the dibbling method with a spacing of 15 cm between plants and 20 cm between rows, using 30 kg of seeds per hectare. Results indicated that Oxyfluorfen pre-emergence followed by 2,4-D post-emergence, and two hand weeding's at 20 and 40 days after sowing (DAS), significantly enhanced nitrogen, phosphorus, and potassium uptake in rice grains and straw compared to other treatments. Conversely, the weedy check exhibited the lowest nutrient uptake. In terms of quality, protein content in rice grains varied significantly among weed control treatments compared to the weedy check.

Keywords: Dibbled rice, herbicides, nutrient uptake, protein

Introduction
Rice (*Oryza sativa* L.) serves as a staple food for over 60% of the global population and more than 65% of India's populace. It plays a vital role in both global food grain and cereal production. Rice cultivation typically employs either direct seeding or transplanting methods. In coastal regions, the predominant method is puddled transplanting, although drilling and dibbling techniques are also utilized in certain areas for paddy cultivation. Direct sowing or drilling techniques for rice cultivation are characterized by their efficiency, simplicity, and cost-effectiveness. However, they are often challenged by weed proliferation. Direct seeding of rice involves establishing the crop directly from seeds in the field, bypassing the traditional method of transplanting seedlings from a nursery, as described by Farooq *et al*. (2011) [3]. The primary challenge encountered in direct-seeded rice cultivation, particularly under dry field conditions, is the significant weed infestation. Transitioning to direct-seeded rice cultivation may lead to shifts in weed flora, often favoring the emergence of highly competitive grasses and sedges that are more challenging to manage, as highlighted by Azmi *et al*. (2005) [1]. Weeds that emerge concurrently with rice plants tend to absorb significant quantities of essential nutrients from the soil, leading to a potential reduction in yield. The impact of weeds on yield varies depending on the cultivation method. Ravichandran (1991) [6] reported yield losses of 36 percent in transplanted rice, whereas direct-seeded rice experiences substantially higher losses, reaching up to 84 percent. In direct-seeded rice cultivation, it is crucial to maintain weed-free fields during the initial 30 to 40 days to prevent early competition between the crop and weeds. Early competition from weeds can lead to a substantial reduction in rice yield, underscoring the importance of employing pre-emergence herbicides, which are commonly utilized by farmers. However, some weed seeds may continue to germinate over time, and pre-emergence herbicides, with their relatively limited residual effectiveness, may not effectively control all weed species.

As a result, solely relying on pre-emergence herbicides may not suffice to optimize rice yields. To ensure effective weed management, it is essential to consider the use of post-emergence herbicides in conjunction with other weed control methods. To ensure effective weed management, it's crucial to consider the use of post-emergence herbicides in conjunction with other weed control methods. As a result, we've decided to undertake a systematic research study to investigate how pre-emergence and post-emergence herbicides, both individually and in combination or as herbicide mixtures, impact the nutrient uptake and quality of dibbled rice.

Materials and Methods

During the Kharif season of 2013, a field trial was conducted at the ASPEE Agricultural Research and Development Foundation Experimental Farm located in Nare, Thane District. The purpose of this trial was to investigate the influence of various weed control methods on the nutrient uptake and quality of transplanted rice. The experimental plot soil exhibited a clay texture and was characterized by moderate levels of available nitrogen (282.00 kg ha^{-1}) and phosphorus (13.80 kg ha^{-1}). Additionally, it showed moderately high availability of potassium (276.22 kg ha^{-1}), medium organic carbon content (9.7 g ha^{-1}), and an alkaline pH level of 7.81.

In the experimental setup, a total of 16 treatments were administered, each designated as follows: T_1 involved Pyrazosulfuron application at 25 g ha^{-1} between 3-7 days after sowing (DAS), T_2 applied Pretilachlor-s at 750 g ha^{-1} within 0-3 DAS, T_3 utilized Cyhalofop butyl at 90 g ha^{-1} at 25 DAS, T_4 utilized Fenoxaprop p-ethyl at 60 g ha^{-1} at 30 DAS, T_5 involved Cyhalofop butyl in combination with Chlorimuron ethyl and Metasulfuron methyl at 90+4 g ha^{-1} between 25-30 DAS, T_6 combined Fenoxaprop p-ethyl with Chlorimuron ethyl and Metasulfuron methyl at 60+4 g ha^{-1} between 25-30 DAS, T_7 combined Pyrazosulfuron with Cyhalofop butyl and Chlorimuron ethyl plus Metasulfuron methyl at 25+90+4 g ha^{-1} at 3-7 DAS followed by 25-30 DAS, T_8 combined Pyrazosulfuron with Fenoxaprop p-ethyl and Chlorimuron ethyl plus Metasulfuron methyl at 25+60+4 g ha^{-1} at 3-7 DAS followed by 25-30 DAS, T_9 combined Pretilachlor-s with Cyhalofop butyl and Chlorimuron ethyl plus Metasulfuron methyl at 750+90+4 g ha^{-1} at 0-3 DAS followed by 25-30 DAS, T_{10} combined Pretilachlor-s with Fenoxaprop p-ethyl and Chlorimuron ethyl plus Metasulfuron methyl at 750+60+4 g ha^{-1} at 0-3 DAS followed by 25-30 DAS, T_{11} utilized Azimsulfuron at 35 g ha^{-1} at 20 DAS, T_{12} applied Bispyribac-Na at 25 g ha^{-1} at 20 DAS, T_{13} involved Fenoxaprop p-ethyl in combination with Ethoxysulfuron at 60+15 g ha^{-1} between 25-30 DAS, T_{14} utilized Oxyfluorfen followed by 2,4-D at 300+500 g ha^{-1} at 0-4 DAS followed by 30 DAS, T_{15} included two hand weeding's at 20 and 40 DAS, and T_{16} served as the weedy check. These treatments were distributed in a randomized block design with three replications. Seeds were sown in the experimental plot using dibbling method, with a spacing of 15 cm between individual plants and 20 cm between rows. On June 6th, 2013, rice seeds were manually sown to a depth of approximately 3 to 4 cm at a rate of 30 kg per hectare and subsequently covered with soil. Regular package of practices were implemented according to standard guidelines, and growth observations were recorded periodically. The nitrogen (N), phosphorus (P), and potassium (K) levels in both plant and weed samples were analyzed using the alkaline permanganate method (Subbaih and Asija, 1956) [9] for N, Bray's method (Bray and Kurtz, 1945) [2] for P, and Flame photometer (Jackson, 1973) [4] for K.

Results and Discussion

Impact of various weed control methods on the nutrient uptake of rice

The findings from Table 1 indicate that treatment T_{14}, involving oxyfluorfen pre-emergence followed by 2,4-D post-emergence, demonstrated notably increased nitrogen (N), phosphorus (P), and potassium (K) uptake in both grain and straw compared to other treatments. This performance was comparable to treatment T_{15}, which involved two manual weedings at 20 and 40 days after sowing (DAS). These outcomes align with previous studies conducted by Mandal *et al*. (2011) [5] and Singh *et al*. (2013) [8]. Conversely, Treatment T_{16}, which involved allowing weeds to grow unchecked (weedy check), demonstrated significantly lower uptake of essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K) compared to other weed management strategies. This was attributed to the uncontrolled proliferation of weeds under Treatment T_{16}. These findings closely mirror those reported by Singh *et al*. (2013) [8] and Verma *et al*. (2013) [11].

Impact of various weed control methods on the nutrient uptake of weeds

In contrast, Treatment T_{16}, designated as the weedy check, witnessed intense competition between the rice crop and weeds, as indicated by the substantially higher uptake of nitrogen (N), phosphorus (P), and potassium (K) by the weeds, as shown in Table 2. This phenomenon was more pronounced in Treatment T_{16} compared to other treatments. Similar findings were reported by Singh *et al*. (2013) [8].

Impact of different weed control methods on quality of rice

Regarding quality considerations, the protein content in rice grain (as depicted in Table 3) was notably influenced by various weed management practices. Treatment T_{14}, involving oxyfluorfen pre-emergence followed by 2,4-D post-emergence, demonstrated a significant increase in rice grain protein content compared to most other treatments, except for treatments T_{15}, T_{10}, T_9, T_8, and T_7. This rise in protein content could be attributed to higher nitrogen concentration in the rice grain resulting from these particular weed management practices. Conversely, Treatment T_{16}, the weedy check, exhibited the lowest protein content in rice grain among all treatments. These findings are consistent with prior studies conducted by Sawant (2003) [7] and Tendulkar (2004) [10]. In summary, our investigation indicates that treatment T_{14}, involving oxyfluorfen pre-emergence followed by 2,4-D post-emergence, and treatment T15, comprising two manual weedings at 20 and 40 days after sowing (DAS), emerged as the most efficacious weed management strategies for enhancing both nutrient absorption and rice quality.

Table 1: Representation and description of treatment method

Symbol	Treatment details
T_1	Pyrazosulfuron @ 25 g/ha at 3-7 DAS
T_2	Pretilachlor-s @ 750 g/ha at 0-3 DAS
T_3	Cyhalofop butyl @ 90 g/ha at 25 DAS
T_4	Fenoxaprop p-ethyl @ 60 g/ha at 30 DAS
T_5	Cyhalofop butyl + (Chlorimuron ethyl + Metasulfuron methyl) @ 90+ 4 g/ha at 25-30 DAS
T_6	Fenoxaprop p-ethyl + (Chlorimuron ethyl + Metasulfuron methyl) @ 60 + 4 g/ha at 25-30 DAS
T_7	Pyrazosulfuron @ 25 g/ha + [Cyhalofop butyl + (Chlorimuron ethyl + Metasulfuron methyl)] @ 90+ 4 g/ha at 3-7 DAS fb 25-30 DAS
T_8	Pyrazosulfuron @ 25 g/ha + [Fenoxyprop p-ethyl + (Chlorimuron ethyl + Metasulfuron methyl)] @ 60+ 4 g/ha at 3-7 DAS fb 25 30 DAS
T_9	Pretilachlor-s @ 750 g/ha + [Cyhalofop butyl + (Chlorimuron ethyl + Metasulfuron methyl)] @ 90+ 4 g/ha at 0-3 DAS fb 25-30 DAS
T_{10}	Pretilachlor-s @ 750 g/ha + [Fenoxyprop p-ethyl + (Chlorimuron ethyl + Metasulfuron methyl)] @ 60+ 4 g/ha at 0-3 DAS fb 25-30 DAS
T_{11}	Azimsulfuron @ 35 g/ha at 20 DAS
T_{12}	Bispyribac- Na @ 25 g/ha at 20 DAS
T_{13}	Fenoxaprop p-ethyl + Ethoxysulfuron @ 60 +15 g/ha at 25-30 DAS
T_{14}	Oxyfluorfen fb 2,4- D @ 300 + 500 g/ha at 0-4 DAS fb 30 DAS
T_{15}	Two hand weeding at 20 and 40 DAS
T_{16}	Weedy check

Table 2: Impact of various weed control methods on the nutrient uptake of rice

Symbols	N uptake in grain kg ha^{-1}	N uptake in straw kg ha^{-1}	Total uptake of N Kg ha^{-1}	P uptake in grain kg ha^{-1}	P uptake in straw kg ha^{-1}	Total uptake of P kg ha^{-1}	K uptake in grain kg ha^{-1}	K uptake in straw kg ha^{-1}	Total uptake of K kg ha^{-1}
T_1	45.52	20.02	65.54	7.94	5.15	13.09	8.63	33.32	41.94
T_2	45.52	19.87	65.39	8.46	5.75	14.21	9.35	34.86	44.22
T_3	44.59	20.10	64.69	8.06	5.35	13.41	8.81	33.64	42.45
T_4	43.80	20.02	63.82	8.08	5.19	13.26	9.22	34.61	43.83
T_5	50.01	24.95	74.96	9.54	7.00	16.54	10.69	40.74	51.43
T_6	50.68	25.58	76.26	10.06	7.55	17.61	11.01	40.05	51.05
T_7	56.30	26.83	83.13	11.45	7.96	19.41	13.55	42.21	55.75
T_8	56.44	27.48	83.92	10.99	8.24	19.23	12.49	43.82	56.32
T_9	57.13	27.91	85.04	11.33	7.95	19.28	13.13	44.63	57.76
T_{10}	58.32	28.65	86.98	11.66	8.14	19.81	13.52	45.28	58.80
T_{11}	49.57	24.23	73.80	9.11	6.06	15.18	9.54	38.89	48.43
T_{12}	50.43	24.65	75.08	9.35	6.19	15.54	10.77	39.00	49.77
T_{13}	53.81	26.28	80.09	10.66	7.43	18.08	11.98	41.83	53.81
T_{14}	64.56	32.50	97.06	13.67	9.71	23.39	17.32	51.55	68.87
T_{15}	59.99	29.32	89.30	12.27	8.56	20.84	14.62	46.70	61.31
T_{16}	21.88	9.15	31.03	3.34	2.14	5.48	3.46	16.51	19.98
S.Em ±	2.27	1.28	3.32	0.66	0.64	1.22	0.70	1.92	2.35
C.D. at 5%	6.55	3.68	9.69	1.92	1.84	3.52	2.02	5.53	6.79

Table 3: Impact of various weed control methods on the nutrient uptake of weeds and quality of rice

Symbols	Nutrient uptake by weed (Kg ha^{-1})			Protein content in Grain (%)
	N	P	K	
T_1	15.99	8.77	15.99	7.50
T_2	14.63	8.15	15.59	7.40
T_3	11.89	6.56	13.12	7.38
T_4	12.88	6.66	13.74	7.44
T_5	8.42	4.68	9.67	7.58
T_6	7.31	3.99	7.97	7.67
T_7	5.27	3.01	5.81	7.79
T_8	3.91	2.03	4.06	7.81
T_9	3.91	2.08	4.31	7.90
T_{10}	3.16	1.65	3.56	7.92
T_{11}	12.62	7.15	13.04	7.48
T_{12}	9.79	5.40	10.13	7.52
T_{13}	7.17	3.86	9.38	7.69
T_{14}	2.35	1.17	2.94	8.06
T_{15}	2.98	1.63	3.52	7.96
T_{16}	34.49	18.97	34.49	6.94
S.Em ±	0.75	0.41	0.80	0.10
C.D. at 5%	2.16	2.18	2.31	0.28

Conclusion
The study elucidated the significant influence of various weed control methods on both the nutrient uptake of rice and weeds, as well as the quality of rice. Notably, treatments involving oxyfluorfen pre-emergence followed by 2,4-D post-emergence (Treatment T_{14}) and two manual weeding's at 20 and 40 days after sowing (DAS) (Treatment T_{15}) exhibited superior performance in enhancing nutrient uptake by rice, particularly nitrogen (N), phosphorus (P), and potassium (K), while concurrently suppressing weed growth. These findings align with previous research and underscore the importance of effective weed management strategies in optimizing rice production and quality. Moreover, Treatment T_{14} showed a significant increase in rice grain protein content, further emphasizing its potential to enhance the nutritional quality of rice. Thus, the study provides valuable insights into the selection and implementation of weed control methods to maximize both yield and quality in dibbled rice cultivation.

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