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Effect of weed management practices on growth, nutrient uptake and economics of direct seeded rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted during *Kharif* 2022 at ARS, Dhadesugur to study the effect of weed management practices on growth, nutrient uptake and economics of direct seeded rice. There were eight treatments consisting of five different post emergent herbicides sprayed at 25 DAS, hand weeding at 20 and 40 DAS, weed free check and weedy check. Results revealed that, application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} at 25 DAS recorded significantly higher plant height, number of leaves, leaf area, leaf area index and dry matter accumulation. It has also resulted in enhanced nutrient uptake. It was profitable too in terms of higher net returns (Rs. 97,920 ha^{-1}) and B C ratio (2.62) of direct seeded rice production. Results confirmed that application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} at 25 DAS (weeds at 2-3 leaf stage) was most effective in managing the weeds with higher growth components with enhanced nutrient uptake resulting in higher yield of direct seeded rice.

Keywords: Post emergent herbicides, direct seeded rice, growth, nutrient uptake, economics

1. Introduction
Rice (*Oryza sativa* L.) is the most important cereal crop and a staple food for one third of the world population. It is necessary to increase its production and productivity in order to meet the growing demand of increasing population. In the world, rice is being grown in an area of 165.25 m ha with a production of 787 m t and the productivity of 4762 kg ha^{-1} (Anon., 2021) [1]. The total area of rice in India is 46.27 m ha, with a production and productivity of 129.5 m t and 2789 kg ha^{-1}, respectively (Anon., 2022) [2].

Weed infestation in direct seeded rice remains the largest constraint limiting its productivity. Weeds in direct seeded rice germinate along with rice seeds and compete from initial stage itself. In India, presence of weeds in general reduces crop yields by 31.5 per cent in winter season and 36.5 per cent in summer and *Kharif* seasons and in some cases can cause complete devastation of the crop (Anon., 2007) [3]. Traditional method of weed management practices are tedious, time consuming, labour intensive, costly and not possible to practice over an extensive area due to labour scarcity and high labour input costs. Chemical weed control is more economical, less time consuming, less expensive and when advocated at the right time, establishes a weed free environment. Various pre emergence and post emergence herbicides are presently accessible in the market to control weeds in paddy. The efficacy of these herbicides is to be worked out as effects of herbicides depends on the type of crop, soil, season, weed flora type and intensity of rainfall and so forth.

Pre emergent herbicides are ineffective in controlling the late emerged weeds. Due to rain during the sowing of *Kharif* paddy the application of pre emergent herbicide becomes difficult. The lately emerging weeds offer severe competition to the crop and infest the land with weed seeds making it less productive in successive seasons. Hence, post emergent herbicide become a possible alternative for wide range of weed control. Applications made after emergence of crops and weeds, allow for identification of the weed species present, as well as the severity of infestation. So, herbicide selection can be tailored to a particular field. Keeping the above facts in view, an investigation was undertaken to study the "Effect of weed management practices on growth, nutrient uptake and economics of direct seeded rice".

2. Materials and Methods

A field experiment was conducted during *kharif* 2022 at Agricultural Research Station, Dhadesugur, UAS, Raichur Karnataka (15º 6´ N, 76º 8´ E, altitude 358 m). The soil of the experimental site belongs to Vertisols (medium black soil). Regarding chemical properties, the soil was alkaline in reaction (pH-8.05), low in EC (0.45 dS m^{-1}) and low in organic carbon content (0.43%). The soil was low in available nitrogen (279.8 kg ha^{-1}), high in available phosphorus (28.2 kg ha^{-1}) and high in available potassium (377.4 kg ha^{-1}).

The experiment was laid out in randomized complete block design (RCBD) with three replications. There were eight treatments consisting of five different post emergent herbicides sprayed at 25 DAS, hand weeding at 20 and 40 DAS, weed free check and weedy check (Table 1). The rice variety RNR 15048 was selected for the study. Seeds were sown by adopting line sowing method at inter row spacing of 20 cm on 19th July 2022 and harvested on 25th November 2022.

From randomly selected five plants, selecting main shoot and recording plant height from ground level to the tip of the fully opened leaf and number of leaves per plant were counted at 30 days interval. Five plants were randomly selected and uprooted from destructive rows of plot at 30 days interval. The samples were separated into leaf, stem and reproductive parts and were oven dried at 70 °C to a constant dry weight to determine the total dry matter production. The plant samples were collected harvest and dried at 70 °C in a hot air oven, powdered using a grinder, fitted with stainless steel bladders and preserved in polythene bags for further analysis of uptake of N, P and K as suggested by Jackson (1973) [4]. During the field experiment, a composite soil sample was collected from experimental plot before sowing. After harvest of the crop, soils from each treated plot were taken separately. The collected soil samples were dried under shade, powdered using pestle and mortar and passed through 2 mm sieve and preserved for analysis. For organic carbon analysis, the 2 mm sieved soil samples were subjected for further grinding and passed through 0.2 mm sieve. Samples were analyzed for organic carbon, available nitrogen, phosphorus, potassium. The economics was worked out based on the prevailing market price for the existing year. Data analysis and interpretation was done using Fisher's method of analysis of variance (ANOVA) technique as given by Panse and Sukhatme (1967) [5].

3. Result and discussion

3.1 Effect of weed management practices on growth attributes

3.1.1 Plant height and number of tillers per square meter

Plant height and number of tillers per square meter of direct seeded rice was significantly influenced by weed management practices (Table 2). Among different weed management practices, weed free check recorded significantly taller plants and higher number of tillers per square meter which was on par with the application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1}. Whereas, weedy check recorded significantly lower plant height and number of tillers per square meter. Significantly higher plant height was observed under these treatments due to reduced competition for various growth factors between the crop and weeds, resulting in a favourable crop environment for better germination and establishment of the entire crop stand. Similar results were observed by Ramesha *et al*. (2019) [6]. Effective weed management and higher plant height and leaf area resulted in obtaining higher tillers. Sharma (2007) [7] also reported similar results.

3.1.2 Number of leaves per plant, leaf area and leaf area index

Different weed management practices significantly influenced the number of leaves per plant, leaf area and leaf area index (Table 3). Among different weed management practices, significantly higher number of leaves per plant, leaf area and leaf area index were noticed under weed free check during all the crop growth stages which was on par with the application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1}. While weedy check recorded significantly lower number of leaves per plant, leaf area and leaf area index. The increased number of leaves per plant, leaf area and leaf area index might be due to higher plant height, optimum plant population and good weed management practices. These results are similar to the findings of Singh *et al.* (2007) [8].

3.1.3 Dry matter production

Dry matter production and its accumulation at various growth stages was significantly affected by different weed management practices (Fig. 1). Significantly higher total dry matter production was recorded in weed free check followed by application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} compared to other weed management practices. However, it was found on par with weed free check. Whereas, significantly lower total dry matter production was recorded in weedy check. The higher total dry matter production and accumulation in different plant parts and total dry matter production in herbicide treated plots might be attributed to luxuriant growth, taller plants with more number of tillers, increased number of green leaves and leaf area of plants. The plants utilized the resources efficiently resulting in higher dry matter accumulation. Indeed, there was minimum competition of weeds with the crop for nutrients, moisture and light. These results are in conformity with the findings of Walia *et al.* (2012) [9] who observed more dry matter production in minimum weed competition plots.

3.2 Effect of weed management practices on nutrient uptake and available nutrients in soil at harvest

Results revealed that, weed free check recorded significantly higher uptake of nitrogen (133.1 kg ha^{-1}), phosphorus (41.6 kg ha^{-1}) and potassium (118.3 kg ha^{-1}) which was on par with the application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} in terms of uptake of nitrogen (129.7 kg ha^{-1}), phosphorus (41.1 kg ha^{-1}) and potassium (116.2 kg ha^{-1}) (Fig. 2). Higher nutrient uptake of crop in herbicide treated plots was primarily due to lower weed population and weed dry weight, which allowed the crop to develop well and absorb more nutrients from the soil while giving fewer possibilities for weed-induced nutrient loss. The results are similar with the findings of Hussain *et al.* (2008) [10].

Soil available nutrients *viz*., nitrogen, phosphorus and potassium were significantly influenced by weed management practices (Fig. 3). Available soil nitrogen, phosphorus and potassium were significantly higher (256.3, 29.4 and 327.8 kg ha^{-1}, respectively) in weed free check and it was found on par with the application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} (251.9, 29.1 and 322.9 kg ha^{-1},

respectively). Whereas, significantly lower soil available nitrogen, phosphorus and potassium (214.8, 21.4 and 271.4 kg ha^{-1}) was observed in weedy check.

3.3 Effect of weed management practices on economics

Among the various weed management practices, weed free check recorded significantly higher grain yield (6162 kg ha^{-1}) and it was found on par with the application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} (6058 kg ha^{-1}) Whereas significantly lower grain yield (2789 kg ha^{-1}) was recorded in weedy check. The higher cost of cultivation (Rs. 74,794 ha^{-1}) was incurred in the weed free check as compared to rest of the treatments. This might be due to higher cost of labour incurred in hand weeding to control weeds for the production of yield. Lower cost of cultivation (Rs. 52,519 ha^{-1}) was recorded in weedy check (Table 4). This might be due to no weeding and any weed control practices. significantly higher gross returns (Rs. 1,60,999 ha^{-1}) was recorded in weed free check and which was on par with the application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} (Rs. 1,58,385 ha^{-1}). However, significantly lower gross returns (Rs. 73,267 ha^{-1}) was recorded in weedy check. Application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} provided significantly higher net returns and benefit cost ratio (Rs. 97,920 ha^{-1} and 2.62). However, lower net returns and benefit cost ratio (Rs. 20,748 ha^{-1} and 1.40) was shown by weedy check. Weed free check though gave higher grain yield, but cost of cultivation was more. So, the net returns was reduced compared to application of herbicides treatments.

Herbicide technology offers an alternative method of selective and economical management of weeds right from the beginning, giving crop an advantage of good start and competitive superiority and found to be cheaper than hand weeding for effective management of weeds and economic returns in direct seeded rice. These results are in harmony with the findings of Yogananda *et al*. (2017) [11].

Table 1: Details of the treatments

Treatment No.	Treatment details
T_1	Bispyribac sodium 10% SC @ 250 ml ha^{-1}
T_2	Chlorimuron ethyl 10% WP + Metsulfuron methyl 20% WP @ 20 g ha^{-1}
T_3	Cyhalofop butyl 5.1% + Penoxsulam 1.02% OD @ 2000 ml ha^{-1}
T_4	Triafamone 20% + Ethoxysulfuron 10% WG @ 100 g ha^{-1}
T_5	Bispyribac sodium 20% + Pyrazosulfuron ethyl 15% WDG @1.5 kg ha^{-1}
T_6	Hand weeding at 20 and 40 DAS
T_7	Weed free check
T_8	Weedy check

Note: SC: Soluble concentrate, WP: Wettable powder, OD: Oil dispersion, WG: Water dispersible granules, WDG: Water dispersible granules, DAS: Days after sowing

Table 2: Plant height and Number of tillers per square meter of direct seeded rice as influenced by weed management practices

Treatment	Plant height (cm)				Number of tillers (m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	16.3	46.1	81.1	84.6	101.7	311.4	360.3	378.6
T_2	16.5	47.5	82.2	87.1	105.5	323.2	371.5	381.2
T_3	24.9	54.2	88.4	93.2	130.7	349.6	400.7	415.3
T_4	18.6	51.4	82.4	87.9	119.8	327.5	372.4	391.6
T_5	16.1	46.3	81.8	85.4	102.3	320.7	364.2	379.4
T_6	21.2	50.6	83.1	88.1	123.5	331.5	379.2	394.2
T_7	25.5	55.8	89.5	95.6	134.9	354.7	412.2	421.4
T_8	15.4	45.7	78.5	84.2	89.4	256.3	273.9	287.2
S.Em (±)	0.3	0.8	1.4	1.5	1.9	5.5	6.3	6.5
C.D. at 5%	1.0	2.5	4.3	4.5	5.7	16.7	19.1	19.8

Note: SC: Soluble concentrate, WP: Wettable powder, OD: Oil dispersion, WG: Water dispersible granules WDG: Water dispersible granules, DAS: Days after sowing

Table 3: Number of leaves per plant, leaf area per plant and leaf area index in direct seeded rice as influenced by weed management practices

Treatment	Number of leaves				Leaf area and leaf area index ( )			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1	4.0	6.6	7.9	6.8	56.0 (0.28)	207.9 (1.04)	500.7 (2.50)	236.0 (1.18)
T_2	4.6	7.5	9.3	7.8	67.3 (0.34)	243.0 (1.22)	589.4 (2.95)	270.7 (1.35)
T_3	6.8	9.2	11.9	9.6	113.0 (0.56)	306.4 (1.53)	754.2 (3.77)	333.2 (1.67)
T_4	5.0	8.1	10.2	7.7	72.0 (0.36)	262.4 (1.31)	646.4 (3.23)	267.2 (1.34)
T_5	4.2	7.1	8.2	7.4	60.3 (0.30)	230.0 (1.15)	519.7 (2.60)	256.8 (1.28)
T_6	5.3	8.5	10.6	8.7	88.4 (0.44)	283.1 (1.42)	671.8 (3.36)	301.9 (1.51)
T_7	6.9	9.5	12.3	9.8	114.0 (0.57)	316.4 (1.58)	779.5 (3.90)	340.1 (1.70)
T_8	3.1	5.7	6.5	5.3	43.2 (0.22)	179.6 (0.90)	411.9 (2.06)	183.9 (0.92)
S.Em (±)	0.1	0.1	0.2	0.1	1.3 (0.01)	4.3 (0.02)	10.4 (0.05)	4.7 (0.02)
C.D. at 5%	0.3	0.4	0.5	0.4	4.0 (0.02)	13.0 (0.06)	31.5 (0.16)	14.2 (0.07)

( ) – values in bracket indicate leaf area index, **Note:** SC; Soluble concentrate, WP: Wettable powder, OD: Oil dispersion, WG: Water dispersible granules, WDG: Water dispersible granules, DAS: Days after sowing

Table 4: Economics of direct seeded rice at harvest as influenced by weed management practices

Treatment	Grain yield (kg ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	BC ratio
T_1	4612	59469	120936	61467	2.03
T_2	5019	57987	131609	73623	2.27
T_3	6058	60465	158385	97920	2.62
T_4	5321	59136	139528	80392	2.36
T_5	4899	59719	128452	68733	2.15
T_6	5629	67369	147254	79885	2.19
T_7	6162	74794	160999	86205	2.15
T_8	2789	52519	73267	20748	1.40
S.Em (±)	88	-	2300	2300	0.04
C.D. at 5%	266	-	6977	6977	0.11

Note: SC: Soluble concentrate, WP: Wettable powder, OD: Oil dispersion, WG: Water dispersible granules, WDG: Water dispersible granules, DAS: Days after sowing

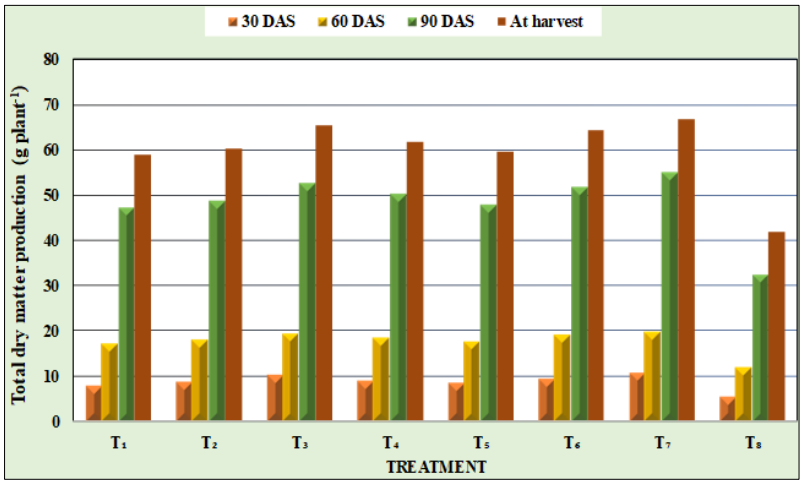

Fig 1: Total dry matter production (g plant^{-1}) at different growth stages of direct seeded rice as influenced by weed management practices

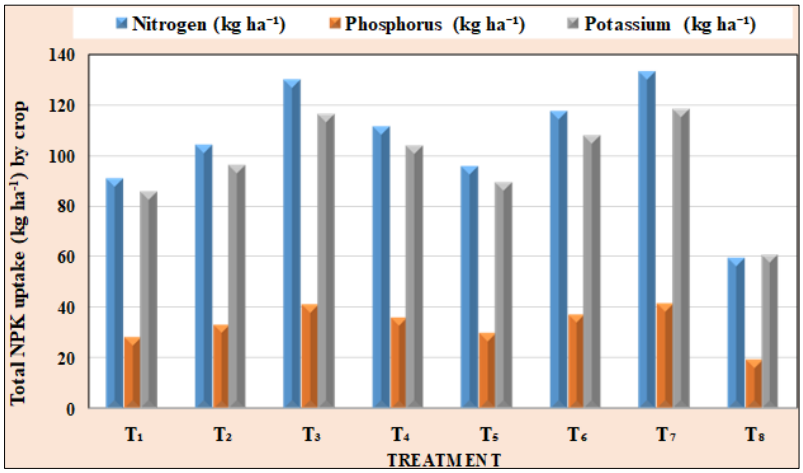

Fig 2: Total nutrient uptake (kg ha^{-1}) by direct seeded rice at harvest as influenced by weed management practices

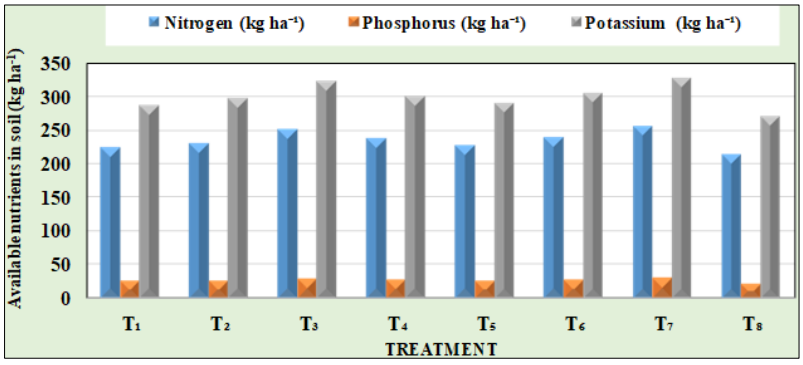

Fig 3: Available nutrients in soil after harvest of direct seeded rice as influenced by weed management practices

4. Conclusion

It was concluded that Application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1} at 25 DAS (weeds at 2-3 leaf stage) was most effective in managing the weeds resulting in higher growth with enhanced nutrient uptake leading to higher yield of direct seeded rice. Economic analysis also revealed that, higher net returns and benefit cost ratio were obtained with the application of cyhalofop butyl 5.1% + penoxsulam 1.02% OD @ 2000 ml ha^{-1}. Lowest was noticed under weedy check.

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