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PRODUCTIVITY, NUTRIENT UPTAKE AND ECONOMICS OF *RABI* MUSTARD (*BRASSICA JUNCEA* L.) AS INFLUENCED BY DIFFERENT INTEGRATED WEED MANAGEMENT PRACTICES

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ABSTRACT

Field experiment was conducted at the Agriculture Research Station, Karimnagar, Telangana, India during Rabi season of 2023-24 to study the effect of integrated weed management practices on weeds and yield of Mustard. Different weed management practices had a significant impact on both seed yield and stover yield in mustard. Significantly higher seed and stover yields were recorded in weed-free treatment (hand weeding at 20 and 40 DAS). However, it was comparable with Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* power weeding at 25-30DAS and Oxyfluorfen 23.5% EC @ 0.1 kg a.i/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS. While, significantly lowest seed and stover yield was recorded in the weedy check. The uptake of nitrogen, phosphorus, and potassium by mustard at 25, 50, 75 DAS and harvest was notably higher with weed free treatment (hand weeding at 20 and 40 DAS) over all other treatments. Among different integrated weed management treatments, Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS had higher nitrogen, phosphorus and potassium uptake and it was being at par with Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS. The weedy check exhibited a significantly lower uptake of nitrogen, phosphorus, and potassium.

The removal of nitrogen, phosphorus, and potassium by weeds in mustard at 25, 50,75 DAS and harvest, was notably lower with hand weeding at 20 and 40 DAS over all other treatments. Among different integrated weed management treatments, Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30DAS had lower nitrogen, phosphorus and potassium removal and it was being at par with Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS. The weedy check exhibited a significantly higher removal of nitrogen, phosphorus, and potassium. The availability of nitrogen, phosphorus, and potassium in soil remained relatively unchanged after the harvest of mustard, regardless of the weed management practices applied. Higher benefit cost ratio was achieved by application of, Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS followed by Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS.

Key words : Mustard, Oxyfluorfen, Propaquizafop, Paddy straw mulch, Power weeding, Nutrient uptake, Benefit cost ratio.

Introduction

Mustard [*Brassica juncea* (L.)] is considered to be one of the most valuable oil-seed crops. It belongs to Brassicaceae (*Cruciferae*) family, with around 338 genera and 3709 species scattered worldwide. Mustard seeds are known by several names in different parts of the world, such as sarson, rai or raya, toria or lahi. While sarson and toria (lahi) are commonly referred to as rapeseed, rai, raya, or laha.

In India, Rajasthan has 46.06 percent mustard farming, followed by Haryana (12.60 percent), Madhya Pradesh (11.38 percent), Uttar Pradesh (10.49 percent),

and West Bengal (7.81 percent). The area under cultivation has gone up from 6.70 million hectares (m ha) in 2020-21 to 8.8 m ha in 2022-23. While, in Telangana it is grown in an area of 3000 ha with a production of 4.78 million tonnes and productivity of 1594 kg ha^{-1} (India stat, 2023).

For attaining the maximum yield, timely and effective weed control during the critical period of weed competition becomes necessary (Adhikary *et al*., 2016). Controlling weeds during early phase of crop growth is essential to obtain high yields and marketable produce. As conventional method of weed control, hand weeding is laborious, time consuming and expensive. Sole application of herbicides does not give an effective weed control. Options are limited for chemical weed management in mustard while assuring quality of crop produce and ensuring higher benefit – cost ratio. Hence, it was felt necessary to assess different weed management practices applied alone and in combination for improving growth and yield of Mustard. Keeping this in view, the present experiment was carried out with the objective to study the weed management practices influenced on productivity, nutrient uptake and economics in mustard.

Materials and Methods

Field experiment was conducted in the semiarid tropics at the Northern Telangana zone of Telangana during *Rabi* season of 2023-24. The experimental site was situated at 79^0 51E longitude and 18^0 301 latitude with an elevation of 259.15 meters above mean sea level.The local cultivar of mustard 'Avani' was used in the study. The experiment was laid out in a randomized complete block design with ten treatments and three replications. The treatments were T_1 -Pendimethalin 30% EC @ 1.0 kg *a.i*/ha PE, T_2 - Oxyfluorfen 23.5% EC @ 0.1 kg *a.i*/ha PE, T_3 - Pendimethalin 30% EC @ 1.0 kg *a.i*/ha PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE, T_4 - Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha^{-1} PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE, T_5 - Pendimethalin 30% EC @ 1.0 kg *a.i*./ha PE *fb* Power weeding at 25-30DAS , T_6 - Oxyfluorfen 23.5% EC @ 0.1 kg *a.i*/ha PE *fb* Power weeding at 25-30DAS , T_7 - Pendimethalin 30% EC @ 1.0 kg *a.i*./ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS , T_8 - Oxyfluorfen 23.5% EC @ 0.1 kg *a.i*./ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS , T_9 - Weed free (HW at 20 and 40 DAS), T_{10} - Weedy check. As per treatment schedule, pre-emergence herbicides were applied within in 24 hours after sowing. Post-emergence herbicide (Propaquizafop) was sprayed at 2-3 leaf stage of weeds with knapsack sprayer by using flat fan nozzle. Straw mulch was laid at 20 DAS. Intercultivation was done with power weeder at 25 DAS. Hand weeding was done at 20 and 340 DAS. Whereas, weedy check was kept undisturbed for entire cropping period. The observations were -recorded on yield, nutrient uptake by crop and economics.

Nitrogen content in weed and plant samples was estimated using the modified Kjeldhal's method (Jackson, 1967) using Automatic kelplus distillation unit after digesting the plant sample in concentrated sulphuric acid and hydrogen peroxide (Piper, 1966). The nitrogen content was expressed in percentage. N uptake was determined by multiplying dry matter production at different stages by respective a percentage of N content in plant samples and transformed into kg ha^{-1}.

$$\text{N uptake (kg ha}^{-1}) = \frac{\text{N content (\%)} \times \text{dry matter (kg ha}^{-1})}{100}$$

Phosphorus uptake

Phosphorus content at different growth stages was estimated after digesting the weed and plant samples with a diacid mixture consisting of nitric acid and perchloric acid in 9:4 ratio. The extract thus obtained was diluted with distilled water and the volume was made up to 50 ml. The phosphorus content in the extract was determined using spectrophotometer (Shimadzu UV-1800 double beam spectrophotometer) at 420 nm by Vanado-Molybdo phosphate yellow colour method as described by Piper (1966) and the phosphorus content is expressed in percentage.

Subsequently, P uptake was calculated by multiplying the dry matter of respective treatment with P content in weed, plant and grain samples and transformed into kg ha^{-1}.

$$\text{P uptake (kg ha}^{-1}) = \frac{\text{P content (\%)} \times \text{dry matter (kg ha}^{-1})}{100}$$

Potassium uptake

Potassium content at different growth stages was estimated after digesting the weed and plant with a diacid mixture consisting of nitric acid and perchloric acid in 9:4 ratio. The extract thus obtained was diluted with distilled water and the volume was made up to 50 ml. The potassium content in the extract was determined by using a Flame photometer (Elico CL 378) as described by Jackson (1967) and it was expressed in terms of percentage. The respective K uptake was calculated from weed and plant samples using the following formula and converted into kg ha^{-1}

$$\text{K uptake (kg ha}^{-1}) = \frac{\text{K content (\%)} \times \text{dry matter (kg ha}^{-1})}{100}$$

Gross returns

It is the sum of entire monetary value of the economic produce (seed) and by-product (straw) obtained from the crop. It is calculated by multiplying the yield with the current market price and is revealed as ` ha^{-1}.

Net returns (` ha^{-1})

Net return (` ha$^{-1}$) = Gross return (` ha^{-1}) – Cost of cultivation (` ha^{-1})

Benefit: Cost ratio

The benefit cost ratio was worked out by using the following formula.

$$\text{B: C ratio} = \frac{\text{Gross return (` ha}^{-1})}{\text{Cost of cultivation (` ha}^{-1})}$$

Data were subjected to statistical analyses following analysis of variance (ANOVA) technique and mean differences were adjusted by the multiple comparison tests (Gomez and Gomez, 1984).

Results and Discussion

Effect on Seed yield (kg ha^{-1})

Significantly higher seed yield was recorded with hand weeding twice at 20 and 40 DAS (1318 kg ha^{-1}), which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30 DAS (1258 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS (1242 kg ha^{-1}) over other integrated weed management practices. Due to improved aeration and increased access to space, water, light and nutrients provided by the removal of weeds in between and within rows, the weed free plots showed significant growth. Application of pre and emergence herbicides reduced competition for moisture, space, light and nutrients between the crop and weeds. This might be due to the abatement of weed competition and the knockdown effect of weeds due to the precise and accurate application of the herbicide in integration with power weeding and paddy straw mulch application. These methods provided an optimum condition for the vigorous vegetative growth and the photosynthesis rate of the crop which in case improved yield attributes. This effective suppression of weeds contributed to achieving higher yields. Significantly less seed yield was recorded with weedy check (558 kg ha^{-1}). The high levels of weed density in the unweeded control caused a decrease in grain yield due to severe competition from weeds. These observations are consistent with findings from several studies by Kalita *et al*. (2017), Chishi *et al*. (2021) and Yernaidu *et al.* (2021).

Effect on Stalk yield (kg ha^{-1})

Significantly higher stalk yield was recorded with hand weeding twice at 20 and 40 DAS (3712 kg ha^{-1}), which was onpar with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (3632 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (3502 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i* ha PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (3473 kg ha^{-1}),Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS(3376 kg ha^{-1}) and Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE fb Power weeding at 25-30 DAS (3361 kg ha^{-1}). Significantly less stalk yield was recorded with weedy check (2009 kg ha^{-1}). This outcome might be due to maintaining a weed free environment throughout the critical stages of crop growth, which allows high uptake of nutrients by crop. Similar kind of results are confirmed by the findings of Chishi *et al.* (2021), Yernaidu *et al.* (2021). Effective weed management significantly boosts stover yield by reducing competition for resources between the crop and weeds. In treatments like weedy check (hand weeding at 20 and 40 DAS), removing weeds during critical early growth stages allows crops to access more water, nutrients. Similar results were reported by Kalita *et al.* (2017) and Sharma *et al.* (2023).

Nutrient uptake by mustard crop

The data on nutrient uptake by the crop at 25, 50 and 75 days after sowing (DAS) and harvest, revealed that nutrient uptake was significantly affected by various weed control treatments presented in Table 2.

Nitrogen uptake by crop (kg ha^{-1})

At 25 DAS, significantly higher nitrogen uptake was recorded with hand weeding at 20 and 40 DAS (7.1 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (6.5 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (5.9 kg ha^{-1}). Significantly lower nitrogen uptake was recorded with weedy check (2.5 kg ha^{-1}).

At 50 DAS, Significantly higher nitrogen uptake was recorded with hand weeding at 20 and 40 DAS (37.5 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (35.2 kg ha^{-1}). Significantly lower nitrogen uptake was recorded with weedy check (12.8kg ha^{-1}).

At 75 DAS, significantly higher nitrogen uptake was recorded with hand weeding at 20 and 40 DAS (62.0 kg

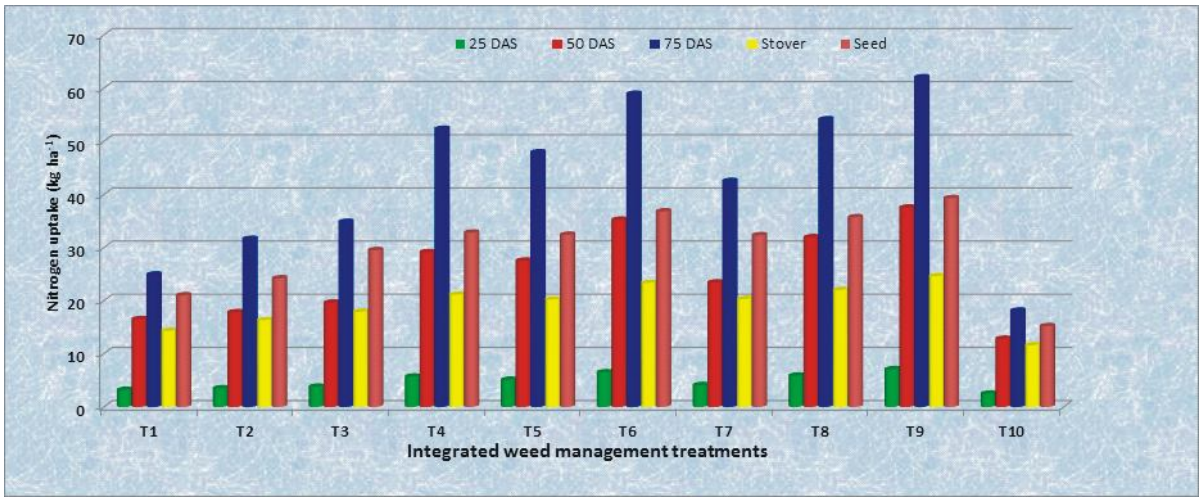

Fig. 1 : Effect of different integrated weed management treatments on nitrogen uptake (kg ha^{-1}) in mustard at 25, 50, 75 DAS and harvest.

Table 1 : Seed, Stover yield and economics (¹ ha^{-1}) as influenced by integrated weed management Practices in mustard.

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Gross returns	Net returns	B:C Ratio
T_1: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE	743	2445	41986	15331	1.57
T_2: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE	873	2774	49364	23104	1.88
T_3: Pendimethalin 30% EC @ 1.0 kg a.i/ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	1045	3015	59022	30117	2.04
T_4: Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	1139	3473	64656	36146	2.28
T_5: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE fb Power weeding at 25-30 DAS	1130	3361	63851	34696	2.20
T_6: Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE fb Power weeding at 25-30DAS	1258	3632	71094	42334	2.47
T_7: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	1135	3376	64119	34464	2.16
T_8: Oxyfluorfen 23.5% EC @ 0.1 kg*a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS	1242	3502	69753	40493	2.38
T_9: Weed free	1318	3712	74448	44663	2.50
T_{10}: Weedy check	582	2009	31640	7855	1.33
SE(m) ±	59	163	4397	4370	
C.D (P=0.05)	178	487	9235	9178	
C.V (%)	10	9	9	17	

ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (58.9 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (54.1 kg ha^{-1}). Significantly lower nitrogen uptake was recorded with weedy check (18.1 kg ha^{-1}).

At harvest, the significantly higher nitrogen uptake by seed and stalk was recorded in weed free treatment (HW at 20 and 40 DAS) (39.3 and 24.6 kg ha^{-1}, respectively) ,which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (36.8 and 23.3 kg ha-1, respectively), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (35.7 and 22.0 kg ha^{-1}, respectively).

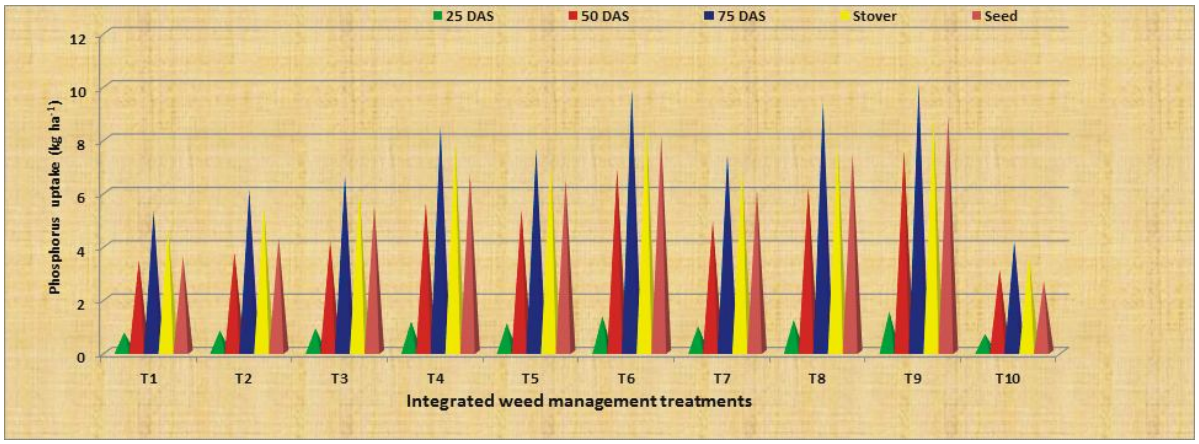

Fig. 2 : Effect of different integrated weed management treatments on phosphorus uptake (kg ha^{-1}) in mustard at 25, 50, 75 DAS and harvest.

Table 2 : Nitrogen (kg ha^{-1}) uptake by crop at 25, 50, 75 DAS and harvest as influenced by integrated weed management practices in mustard.

Treatments	Nitrogen uptake (kg ha^{-1})					
	25 DAS	50 DAS	75 DAS	At harvest		
				Stover	Seed	Total
T_1: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE	3.2	16.5	24.9	14.3	21.0	35.2
T_2: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE	3.5	17.8	31.6	16.3	24.2	40.5
T_3: Pendimethalin 30% EC @ 1.0 kg *a.i*/ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	3.8	19.6	34.8	17.9	29.5	47.4
T_4: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i* ha^{-1} PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	5.7	29.1	52.3	21.1	32.8	54.0
T_5: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	5.1	27.5	47.9	20.2	32.4	52.6
T_6: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	6.5	35.2	58.9	23.3	36.8	60.1
T_7: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	4.1	23.4	42.5	20.3	32.3	52.6
T_8: Oxyfluorfen 23.5% EC@ 0.1 kg*a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	5.9	31.9	54.1	22.0	35.7	57.7
T_9: Weed free	7.1	37.5	62.0	24.6	39.3	63.9
T_{10}: Weedy check	2.5	12.8	18.1	11.6	15.2	26.9
SE(m) ±	0.5	1.6	3.0	1.2	1.7	
CD(p=0.05)	1.5	4.7	9.0	3.7	5.0	
C.V (%)	18.0	10.9	12.2	11.2	9.6	

Significantly lower nitrogen uptake was recorded with weedy check (15.2 and 11.6 kg ha^{-1}, respectively). Weed free environment favoured higher plant height and dry matter production which resulted in higher nutrient uptake by the crop (Kour *et al*., 2013 and Mukherjee, 2014).

Phosphorus uptake by crop (kg ha^{-1})

Phosphorus uptake recorded by mustard at 25, 50, 75 DAS and at harvest in seed and stalk was significantly influenced by integrated weed management treatments (Table 3).

At 25 DAS significantly higher Phosphorus uptake

Table 3 : Phosphorus (kg ha^{-1}) uptake by crop at 25, 50,75 DAS and harvest as influenced by integrated weed management practices in mustard.

Treatments	Phosphorus (kg ha^{-1})					
	25 DAS	50 DAS	75 DAS	At harvest		
				Stover	Seed	Total
T_1: Pendimethalin 30% EC @ 1.0 kg a.i./ha PE	0.74	3.44	5.30	4.61	3.59	8.20
T_2: Oxyfluorfen 23.5% EC@ 0.1 kg a.i./ha PE	0.81	3.73	6.11	5.45	4.30	9.75
T_3: Pendimethalin 30% EC @ 1.0 kg a.i/ha PE fb Propaquizafop 10% EC @ 0.0625 kg a.i/ha PoE	0.90	4.16	6.66	5.98	5.50	11.48
T_4: Oxyfluorfen 23.5% EC@ 0.1 kg a.i ha-1 PE fb Propaquizafop 10% EC @ 0.0625 kg a.i/ha PoE	1.16	5.60	8.47	7.91	6.73	14.64
T_5: Pendimethalin30% EC @ 1.0 kg a.i./ha PE fb Power weeding at 25-30 DAS	1.08	5.33	7.65	7.03	6.51	13.54
T_6: Oxyfluorfen 23.5% EC@ 0.1 kg a.i./ha PE fb Power weeding at 25-30 DAS	1.35	6.87	9.88	8.58	8.13	16.71
T_7: Pendimethalin30% EC @ 1.0 kg a.i./ha PE fb Paddy straw mulch@ 5 t/ha at 20 DAS	0.98	4.93	7.43	6.78	6.11	12.90
T_8: Oxyfluorfen 23.5% EC@ 0.1 kg a.i./ha PE fb Paddy straw mulch@ 5 t/ha at 20 DAS	1.22	6.16	9.39	7.80	7.47	15.26
T_9: Weed free	1.53	7.53	10.08	8.82	8.90	17.72
T_{10}: Weedy check	0.68	3.09	4.17	3.57	2.67	6.24
SE(m) ±	0.11	0.42	0.45	0.68	0.75	
CD(p=0.05)	0.33	1.26	1.33	2.04	2.23	
C.V (%)	18.19	14.29	10.27	17.70	21.57	

was recorded with hand weeding at 20 and 40 DAS (1.53kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (1.35kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (1.22 kg ha^{-1}). Significantly lower Phosphorus uptake was recorded with weedy check (0.68kg ha^{-1}).

At 50 DAS significantly higher Phosphorus uptake was recorded with hand weeding at 20 and 40 DAS (7.53kg ha^{-1}) which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (6.87kg ha^{-1}. Significantly lower Phosphorus uptake was recorded with weedy check (3.09kg ha^{-1}).

At 75 DAS significantly higher Phosphorus uptake was recorded with hand weeding at 20 and 40 DAS (10.08kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (9.88 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS (9.39 kg ha^{-1}). Significantly lower Phosphorus uptake was recorded with weedy check (4.17 kg ha^{-1}).

At harvest, the significantly higher phosphorus uptake by seed and stalk was recorded in weed free treatment (HW at 20 and 40 DAS) (8.90 and 8.82 kg ha^{-1}, respectively), which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (8.13 and 8.58 kg ha^{-1}, respectively), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (7.47 and 7.80 kg ha^{-1}, respectively), Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (7.91 and 6.73 kg ha^{-1}, respectively). Significantly lower phosphorus uptake was recorded with weedy check (2.67 and 3.57 kg ha^{-1}, respectively).

Potassium uptake by crop (kg ha^{-1})

Potassium uptake recorded by mustard at 25, 50,75 DAS and at harvest in seed and stalk was significantly influenced by integrated weed management treatments (Table 4).

Table 4 : Potassium (kg ha^{-1}) uptake by crop at 25,50,75 DAS and harvest as influenced by integrated weed management practices in mustard.

Treatments	Potassium (kg ha^{-1})					
	25 DAS	50 DAS	75 DAS	At harvest		
				Stover	Seed	Total
T_1: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE	5.0	18.1	22.5	22.7	4.6	27.2
T_2: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE	5.4	19.5	27.8	26.1	6.1	32.1
T_3: Pendimethalin 30% EC @ 1.0 kg *a.i*/ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	5.8	23.0	31.6	28.1	7.2	35.2
T_4: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i* ha^{-1} PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	7.5	29.6	45.6	46.6	8.4	55.0
T_5: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	6.6	28.0	43.2	42.1	8.2	50.3
T_6: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	8.8	33.7	49.5	58.1	9.6	67.7
T_7: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	6.2	25.4	40.9	40.2	8.1	48.3
T_8: Oxyfluorfen 23.5% EC@ 0.1 kg*a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	8.0	32.4	47.7	53.0	9.4	62.4
T_9: Weed free	9.6	43.5	62.3	64.6	10.8	75.4
T_{10}: Weedy check	4.7	16.4	17.8	17.7	3.4	21.1
SE(m) ±	1.0	3.3	4.4	2.3	0.7	
CD(p=0.05)	2.9	9.9	13.1	6.9	2.1	
C.V (%)	24.6	21.3	19.5	10.0	16.3	

At 25 DAS significantly higher potassium uptake was recorded with hand weeding at 20 and 40 DAS (9.6kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (8.8kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (8.0 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (7.5 kg ha^{-1}). Significantly lower potassium uptake was recorded with weedy check (4.7kg ha^{-1}).

At 50 DAS significantly higher potassium uptake was recorded with hand weeding at 20 and 40 DAS (43.5kg ha^{-1}) which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (33.7kg ha^{-1}. Significantly lower potassium uptake was recorded with weedy check (16.4kg ha^{-1}).

At 75 DAS significantly higher potassium uptake was recorded with hand weeding at 20 and 40 DAS (62.3kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (49.5kg ha^{-1}). Significantly lower potassium uptake was recorded with weedy check (17.8kg ha^{-1}).

At harvest, the significantly higher potassium uptake by seed and stalk was recorded in weed free treatment (HW at 20 and 40 DAS) (10.8 and 64.6 kg ha^{-1}, respectively), which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (9.6 and 58.1 kg ha^{-1}, respectively). Significantly lower potassium uptake was recorded with weedy check (3.4 and 17.7 kg ha^{-1}, respectively).

The significantly highest N, P and K uptake was found in seeds and straw from the treatment of integration of Oxyfluorfen as pre-emergence application followed by power weeding and paddy straw mulch. This may be due to the lower weed density and weed dry matter which reduced the uptake and dilution of nutrients by weeds. The lower weed competition provided better growth environment for the crop which improved the moisture and nutrient uptake by the crop. The crop had competitively upper hand over the weeds in nutrient uptake. Since the crop weed interference and competition was under control, the N, P and K uptake was higher in

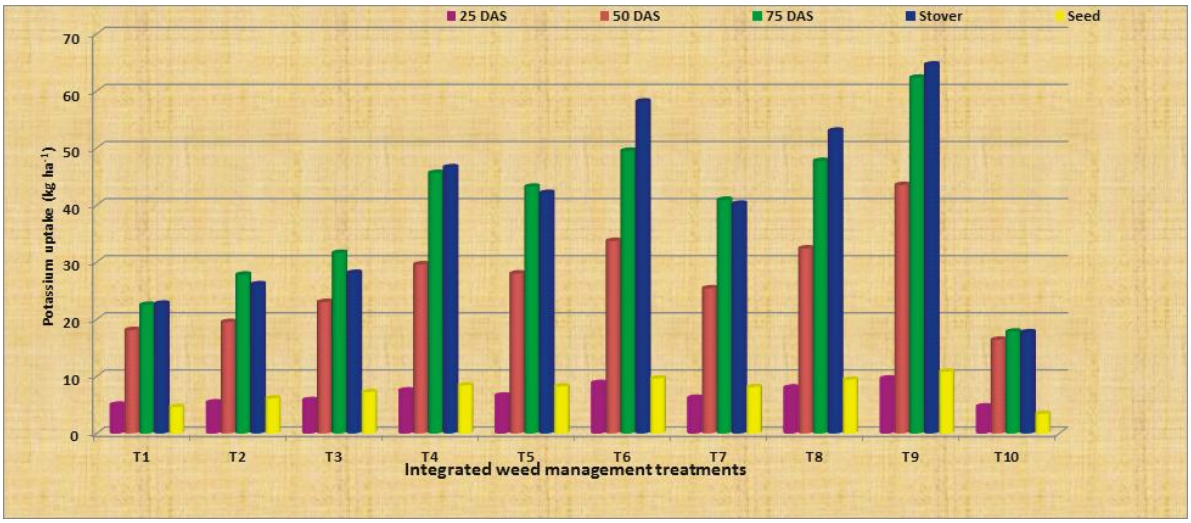

Fig. 3 : Effect of different integrated weed management treatments on Potassium uptake (kg ha^{-1}) in mustard at 25, 50, 75 DAS and harvest.

the plants which produced healthy seeds and more yield. The more uptake of N, P and K was caused by less competition from weeds for light, moisture, nutrients and space for growth and development. This in turn increased the availability of nutrients and produced more crop dry matter with higher nutrient content. Similar results were also reported by Raj *et al*. (2020) and Yernaidu *et al*. (2022).

Nutrient removal by weeds

Nutrient removal by the weeds at 25, 50,75 days after sowing (DAS) and harvest significantly influenced by different integrated weed management treatments presented in Tables 5, 6 and 7.

Nitrogen removal by weeds (kg ha^{-1})

At 25 DAS, significantly lower nitrogen removal was recorded with hand weeding at 20 and 40 DAS (0.14 kg ha^{-1}) which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25DAS (0.19 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (0.26 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (0.35 kg ha^{-1}). Significantly higher nitrogen removal was recorded with weedy check (4.68kg ha^{-1}).

At 50 DAS, significantly lower nitrogen removal was recorded with hand weeding at 20 and 40 DAS (0.43 kg ha^{-1}), which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (1.30 kg ha^{-1}, Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS (1.66 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (2.0 kg ha^{-1}).Significantly higher nitrogen removal was recorded with weedy check (13.50kg ha^{-1}).

At 75 DAS, significantly lower nitrogen removal was recorded with hand weeding at 20 and 40 DAS (1.98 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (3.26 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (3.28 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (3.84 kg ha^{-1}). Significantly higher nitrogen removal was recorded with weedy check (28.86kg ha^{-1}).

At harvest, the significantly lower nitrogen removal was recorded in weed free treatment (HW at 20 and 40 DAS) (2.45 kg ha^{-1}), which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (3.59 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS (3.94 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (4.75 kg ha^{-1}). Significantly higher nitrogen removal was recorded with weedy check (36.77 kg ha^{-1}).

Phosphorus removal by weeds (kg ha^{-1})

At 25 DAS, significantly lower phosphorus removal was recorded with hand weeding at 20 and 40 DAS (0.03 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (0.04 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (0.05 kg ha^{-1}), Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (0.07 kg ha^{-1}) and Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE fb Power weeding at 25DAS (0.09 kg ha^{-1}). Significantly

Table 5 : Nitrogen (kg ha^{-1}) removal by weeds at 25,50,75 and harvest as influenced by integrated weed management practices in mustard.

Treatments	Nitrogen (kg ha^{-1})			
	25DAS	50DAS	75DAS	Harvest
T_1: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE	2.19	7.07	12.29	16.18
T_2: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE	1.87	6.33	8.87	14.91
T_3: Pendimethalin 30% EC @ 1.0 kg *a.i*/ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	1.20	4.61	7.10	10.96
T_4: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i* ha^{-1} PE *fb*Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	0.35	2.00	3.84	4.75
T_5: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	0.45	2.75	5.10	6.76
T_6: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	0.19	1.30	3.26	3.59
T_7: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS	0.86	3.68	5.65	8.26
T_8: Oxyfluorfen 23.5% EC@ 0.1 kg*a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS	0.26	1.66	3.28	3.94
T_9: Weed free	0.14	0.43	1.98	2.45
T_{10}: Weedy check	4.68	13.50	28.86	36.77
SE(m) ±	0.17	0.66	0.99	1.02
CD(p=0.05)	0.50	1.98	2.96	3.05
C.V (%)	24.0	26.5	21.4	16.2

Table 6 : Phosphorus (kg ha^{-1}) removal by weeds at 25,50,75 and harvest as influenced by integrated weed management practices in mustard.

Treatments	Phosphorus (kg ha^{-1})			
	25DAS	50DAS	75DAS	Harvest
T_1: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE	0.33	1.22	2.26	2.71
T_2: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE	0.29	1.09	1.63	2.54
T_3: Pendimethalin 30% EC @ 1.0 kg *a.i*/ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	0.21	0.90	1.47	2.08
T_4: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i* ha^{-1} PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	0.07	0.49	0.99	1.11
T_5: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	0.09	0.60	1.18	1.43
T_6: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	0.04	0.30	0.80	0.80
T_7: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	0.16	0.79	1.30	1.74
T_8: Oxyfluorfen 23.5% EC@ 0.1 kg*a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	0.05	0.38	0.82	0.86
T_9: Weed free	0.03	0.11	0.55	0.61
T_{10}: Weedy check	0.73	2.38	5.38	6.26
SE(m) ±	0.03	0.11	0.20	0.20
CD(p=0.05)	0.09	0.34	0.61	0.60
C.V (%)	26.6	23.8	21.4	17.2

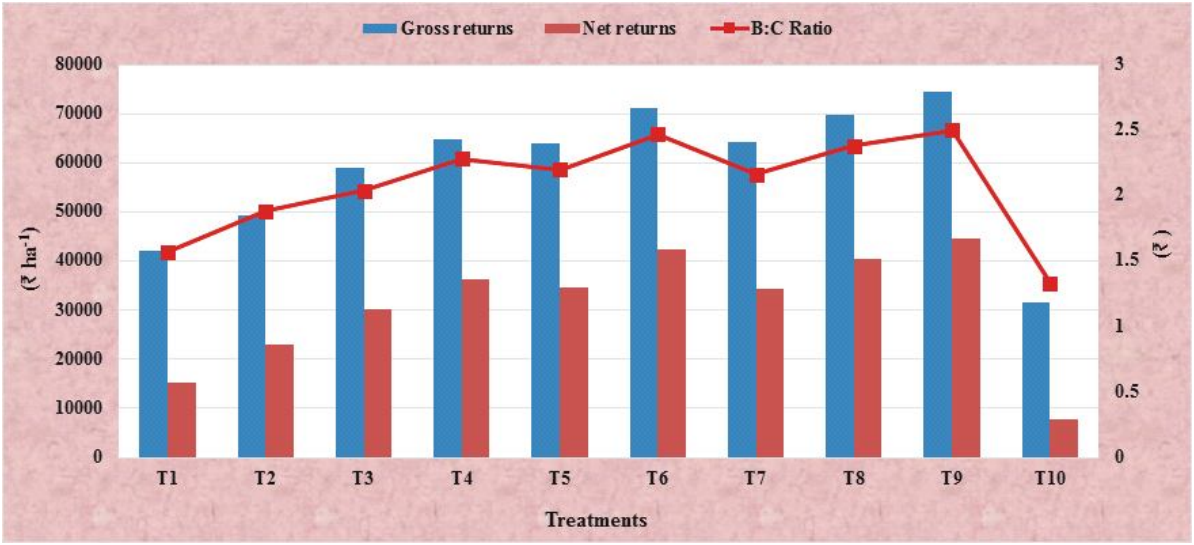

Fig. 4 : Effect of different integrated weed management treatments on gross returns, net returns, B:C Ratio in mustard.

higher phosphorus removal was recorded with weedy check (0.73kg ha^{-1}).

At 50 DAS, significantly lower phosphorus removal was recorded with hand weeding at 20 and 40 DAS (0.11 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25DAS (0.30 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (0.38 kg ha^{-1}). Significantly higher phosphorus removal was recorded with weedy check (2.38kg ha^{-1}).

At 75 DAS, significantly lower phosphorus removal was recorded with hand weeding at 20 and 40 DAS (0.55 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (0.80 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (0.82 kg ha^{-1}). Significantly higher phosphorus removal was recorded with weedy check (5.38 kg ha^{-1}).

At harvest, the significantly lower phosphorus removal was recorded in weed free treatment (HW at 20 and 40 DAS) (0.61 kg ha^{-1}), which was onpar with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (0.80 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (0.86 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (0.07 kg ha^{-1}). Significantly higher phosphorus removal was recorded with weedy check (6.26 kg ha^{-1}).

Potassium removal by weeds (kg ha^{-1})

At 25 DAS, significantly lower potassium removal was recorded with hand weeding at 20 and 40 DAS (0.13 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (0.16 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch @ 5 t/ha at 20 DAS (0.25 kg ha^{-1}), Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (0.36 kg ha^{-1}) and Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE fb Power weeding at 25DAS (0.53 kg ha^{-1}). Significantly higher potassium removal was recorded with weedy check (4.48kg ha^{-1}).

At 50 DAS, significantly potassium lower removal was recorded with hand weeding at 20 and 40 DAS (0.42 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (1.12 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (1.67 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (2.10 kgha^{-1}). Significantly higher potassium removal was recorded with weedy check (13.13 kg ha^{-1}).

At 75 DAS, significantly lower potassium removal was recorded with hand weeding at 20 and 40 DAS (1.90 kg ha^{-1}), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30DAS (2.80 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch@ 5 t/ha at 20 DAS (3.38 kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (3.96 kgha^{-1}). Significantly lower potassium removal was recorded with weedy check (28.04 kg ha^{-1}).

At harvest, the significantly lower potassium removal was recorded in weed free treatment (HW at 20 and 40 DAS) (2.47 kg ha^{-1}), which was comparable with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power

Table 7 : Potassium (kg ha^{-1}) removal by weeds at 25, 50,75 and harvest as influenced by integrated weed management practices in mustard.

Treatments	Potassium (kg ha^{-1})			
	25DAS	50DAS	75DAS	Harvest
T_1: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE	2.08	6.80	11.88	16.01
T_2: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE	1.73	5.91	8.36	14.38
T_3: Pendimethalin 30% EC @ 1.0 kg *a.i*/ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	1.21	4.77	7.28	11.57
T_4: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i* ha^{-1} PE *fb*Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	0.36	2.10	3.96	5.10
T_5: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	0.53	3.25	5.58	8.24
T_6: Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS	0.16	1.12	2.80	3.26
T_7: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	0.96	4.19	6.46	9.88
T_8: Oxyfluorfen 23.5% EC@ 0.1 kg*a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS	0.25	1.67	3.38	4.13
T_9: Weed free	0.13	0.42	1.90	2.47
T_{10}: Weedy check	4.48	13.13	28.04	36.38
SE(m) ±	0.18	0.67	1.03	1.03
CD(p=0.05)	0.52	1.99	3.07	3.10
C.V (%)	25.51	26.59	22.31	16.07

weeding at 30DAS (3.26 kg ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE*fb* Paddy straw mulch @ 5 t/ha at 20 DAS (4.13kg ha^{-1}) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (5.10 kg ha^{-1}).Significantly higher potassium removal was recorded with weedy check (36.38 kg ha^{-1}).

The highest nutrient removal by weeds was observed under weedy check treatment (T_{10}). The lower nutrient removal by weeds under different integrated weed management treatments might be due to effective control of weeds during critical period of crop growth. These findings are consistent with the results reported by Raj *et al.* (2020) and Yernaidu *et al.* (2021).

Post harvest soil analysis

The available nutrient status of the soil after the mustard harvest is presented in Table 8. The various weed management practices did not have a significant effect on Soil pH, EC, organic carbon, available nitrogen, phosphorus and potassium in the soil after the harvest of mustard.

Economics

Gross return (` ha^{-1})

Higher gross return recorded with weed free treatment (HW at 20 and 40 DAS) (` 74,448 ha$^{-1}$), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30 DAS (` 71,094 ha^{-1}) and Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS (` 69,753 ha$^{-1}$). Lower gross return was recorded with weedy check (` 31,6401 ha^{-1}).

Net return (` ha^{-1})

Higher net return recorded with hand weeding at 20 and 40 DAS (` 44,663 ha$^{-1}$), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 30 DAS (` 42,334 ha^{-1}), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS (` 40,493 ha$^{-1}$) and Oxyfluorfen 23.5% EC @ 0.1 kg *a.i* ha PE *fb* Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE (` 36,146 ha^{-1}). Lower net return was recorded with weedy check treatment (` 7,855 ha^{-1}).

B:C ratio

Higher B:C ratio was recorded with weed free treatment (HW at 20 and 40 DAS) (2.50), which was on par with Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25DAS (2.47), Oxyfluorfen 23.5% EC@ 0.1 kg *a.i.*/ha PE *fb* Paddy straw mulch@ 5 t/ha at 20 DAS (2.38). Lower B:C ratio was recorded with weedy check (1.33). Although, the hand weeding at 20

Table 8 : Soil pH, EC (dsm^{-1}) and OC (%), available nutrients N, P and K ($kg\ ha^{-1}$ as influenced by integrated weed management practices in mustard after harvest.

Treatments	pH	EC (dsm^{-1})	OC (%)	Nitrogen	Phosphorus	Potassium
T_1: Pendimethalin 30% EC @ 1.0 kg *a.i.*/ha PE	7.2	0.31	0.52	261.7	36.4	296.3
T_2: Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE	7.4	0.33	0.54	266.0	37.6	299.5
T_3: Pendimethalin 30% EC @ 1.0 kg a.i/ha PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	7.1	0.32	0.53	263.7	35.5	292.8
T_4: Oxyfluorfen 23.5% EC @ 0.1 kg *a.i*ha^{-1} PE fb Propaquizafop 10% EC @ 0.0625 kg *a.i*/ha PoE	7.1	0.32	0.51	263.3	35.9	301.0
T_5: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE fb Power weeding at 25-30 DAS	7.3	0.30	0.50	264.5	36.5	304.6
T_6: Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE fb Power weeding at 25-30 DAS	7.2	0.33	0.53	267.8	35.7	302.5
T_7: Pendimethalin30% EC @ 1.0 kg *a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS	7.1	0.32	0.54	265.8	37.2	305.5
T_8: Oxyfluorfen 23.5% EC@ 0.1 kg*a.i.*/ha PE *fb* Paddy straw mulch @ 5 t/ha at 20 DAS	7.3	0.33	0.55	266.3	36.0	310.7
T_9: Weed free	7.2	0.32	0.52	262.4	35.5	307.4
T_{10}: Weedy check	7.3	0.33	0.51	261.0	37.0	298.2
SE(m)±	0.09	0.012	0.01	12.5	1.4	13.7
C.D (p=0.05)	**NS**	**NS**	**NS**	NS	NS	NS
C.V (%)	1.67	6.49	3.75	5.8	4.9	5.5

and 40 DAS achieved the highest gross returns, the increased labour wages led to a higher cost of cultivation, timely unavailability of skilled labour and high time requirement.

Similar results were observed by Kalita *et al*. (2017), Raj *et al.* (2020), Chisi *et al.* (2021) and Sharma *et al.* (2023).

Conclusion

Based on the results, it is concluded that hand weeding at 20 and 40 DAS was found to be beneficial for higher productivity and profitability of mustard however under labour scarce situations application of Oxyfluorfen 23.5% EC @ 0.1 kg *a.i.*/ha PE *fb* Power weeding at 25-30 DAS found to be economical.

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