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Integrated Weed Management in Sunflower

A.G. Tadavi, A.B. Chorey, G.S. Gaikwad and S.M. Sawadhkar*

Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India
**Corresponding author*

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A B S T R A C T

A field experiment was conducted at the Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Rabi* season of 2014-15 to study the relative performance of herbicides and cultural practices on weed control in sunflower as well as to study its effect on growth and yield of sunflower. Weed free treatment 3HW at 15, 30 and 45 DAS was found to be the most effective in controlling weeds across the crop growth period. The next best treatment among the herbicidal treatments in respect of controlling weeds was pre-emergence application of Pendimethalin @ 1 kg a.i. ha^{-1} followed by post emergence spraying of Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1}. Growth parameters and yield attributes of sunflower crop were improved under weed free treatment 3HW at 15, 30 and 45 DAS and treatment pre-emergence application of Pendimethalin @ 1 kg a.i. ha^{-1} PE followed by Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE. The effect of herbicides on microbial population was observed at initial stage, but it has not caused harmful effect on microbial population at harvesting stage. Total nutrient uptake by crop, highest gross monetary returns (34704 ha^{-1}), net monetary returns (17999 ha^{-1}) and B: C ratio (2.08) were also found highest in treatment weed free 3HW at 15, 30 and 45 DAS.

Introduction

Sunflower (*Helianthus annus* L.) is the latest addition to the list of major edible oilseed crops in importance after Soybean, Groundnut, Rapeseed and Mustard at the national and international level. It contributes 8 percent towards the total edible oil production in the country behind Soybean 21 percent, Groundnut 14 percent and Rapeseed mustard 13 percent (Hedge, 2005). As the oil and fats are important sources of energy, it is recommended as a dietary constituent for the heart patient. Presently, in India sunflower is grown over an area of 6.91 lakh hectares with a production of about 5.46 lakh tonnes and with average productivity of 791 kg per hectare. In Maharashtra sunflower is grown over an area of 0.61 lakh hectares with a production of about 0.38 lakh tonnes and average productivity of 623 kg per hectare. In Vidarbha it is grown over an area of 0.24 lakh hectares with a production of about 0.16 lakh tonnes and the productivity is 667 kg per hectare (Anonymous, 2015).

Confectionery grade for export purpose should have comparatively higher test weight, low oil content, high protein content, high oleic acid and easy hull ability. Besides taste factor is an important consideration for export purpose. One significant fact is that USA though an exporter buys sunflower seed from India for its taste. World trade in sunflower

seed is about 2 lakh tones out of which India's share is very meager and hence there is an emergent need to increase the production of sunflower. Though sunflower is recommended for cultivation in all seasons in India its performance is better in *rabi* or early summer sowings. However, success of the crop depends largely on effective weed control under weed management strategy. Chemical weed control is an alternative method that may be less expensive but more risky because of weed becoming herbicide resistant and because of concerns about unwanted side effect of herbicides. In situations where timely weeding is not feasible due to paucity and high cost of labour or unfavourable soil conditions, chemical weed control through pre or post emergence herbicides may be preferred for better weed management across the crop growth period. The present study with weed control practices comprising newer formulations and herbicide mixtures with varied application time and with integrated cultivation is a further step in the weed management strategy of sunflower crop.

Materials and Methods

A field experiment was conducted at the Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Rabi* season of 2014-15 to study the relative performance of herbicides and cultural practices on weed control in sunflower as well as to study its effect on growth and yield of sunflower and also to find out most effective and economical weed control method in sunflower.

An experiment was laid out in randomized block design with seven treatments replicated thrice. The treatments comprised of Pendimethalin @ 0.75 kg a.i. ha^{-1} as PE, Pendimethalin @ 0.75 kg a.i. ha^{-1} as PE followed by 1 IC at 30 DAS followed by HW at 40DAS, Pendimethalin @ 1 kg a.i. ha^{-1} PE followed by Quizalofop ethyl 10EC @ 75 g a.i. ha^{-1} at 15-20 DAS as PoE, Pendimethalin @ 1kg a.i. ha^{-1} PE followed by Propaquizalofop @ 75g a.i. ha^{-1} at 15-20 DAS as PoE, Pendimethalin @ 1kg a.i. ha^{-1} PE followed by Fenoxoprop ethyl @ 37.5g a.i. ha^{-1} at 15-20 DAS as PoE, Weed free 3HW at 15, 30 and 45 DAS and weedy check.

The experimental site was black and clayey in texture with slightly alkaline in reaction having pH 7.80 and EC (0.38 dsm^{-1}). It was low in nitrogen (210.27 kg ha^{-1}), and phosphorus (15.86kg ha^{-1}) and high in potash (364.25 kg ha^{-1}). Rainfall received during cropping season was 207 mm in 10 rainy days mainly in September as against the normal of 225.4mm in 11.8 rainy days. Rainfall received during the season was less than the normal.

Results and Discussion

Effect of different weed control methods on growth and yield attributes of sunflower

Data regarding the growth and yield attributes as influenced by different weed management practices is given in tables 1 and 2 respectively. Significant differences in growth parameters were noticed due to different weed control methods. Plant height (137.67cm), number of leaves (4.61), leaf area $plant^{-1}$($4.78dm^2$), total dry matter production per plant (146.33g) were significantly higher in weed free situation with 3HW at 15, 30 and 45 DAS followed by treatment pre-emergence application of Pendimethalin @ 1kg a.i. ha^{-1}*fb* post emergence spraying of Quizalofop ethyl 10EC @ 75 g a.i. ha^{-1} at 15-20 DAS which were statistically at par with each other. This might be due to favourable conditions obtained under these treatments there by less crop weed competition, facilitating luxurious crop growth resulting more vigorous growth as compared to other treatments. The

treatment weedy check recorded the lowest plant height.

Similarly, significant differences in yield parameters were observed in different weed control methods. Head diameter (11.73cm), head weight (100.67g), 100 seed weight (4.53g), number of seed plant^{-1}(406.23), seed weight plant^{-1} (18.40g) were significantly higher under weed free situation with 3HW at 15, 30 and 45 DAS followed by treatment pre-emergence application of Pendimethalin @ 1kg a.i. ha^{-1}*fb* post emergence spraying of Quizalofop ethyl 10EC @ 75 g a.i. ha^{-1} at 15-20 DAS and treatment pre-emergence application of Pendimethalin @ 1kg a.i. ha^{-1}*fb* post emergence spraying of Fenoxoprop ethyl @ 37.5g a.i. ha^{-1} at 15-20 DAS which is significantly at par with each other. 100 seed weight was not influenced significantly by various weed control treatments under study. However, numerically highest 100 seed weight was observed in treatment weed free i.e 3HW at 15, 30 and 45 DAS (4.53 g) followed by pre-emergence application of Pendimethalin @ 1kg a.i. ha^{-1}*fb* post emergence spraying of Fenoxoprop ethyl @ 37.5g a.i. ha^{-1} at 15-20DAS and application This might be due to more availability of nutrients and moisture as there was less competition between weeds and crop thereby increased the seed weight. Similar results were reported by Suresh and Reddy (1994).The lowest yield attributes was recorded in weedy check.

Effect of different weed control methods on weeds

Data given in table 3 revealed that weed free situation with 3HW at 15, 30 and 45 DAS) recorded significantly lowest weed count (26.67) and weed dry matter at every stages of crop growth followed by pre-emergence application of Pendimethalin @ 0.75 kg a.i. ha^{-1}*fb* 1 IC at 30 DAS *fb* HW at 40DAS. This might be due to weed free situation maintained by three hand weedings which was responsible in controlling the weed population and dry matter production of weeds. Weed free treatment and herbicidal treatment gave better reduction in total weeds which ultimately gave reduction in weed dry matter and increased the weed control efficiency.

Among the weed management practices, treatment pre-emergence application of Pendimethalin @1 kg a.i. ha^{-1} *fb* post emergence spraying of Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} showed minimum weed index (20.75%) followed by Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE (24.52%), Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS (30.18%), Pendimethalin @ 0.75 kg a.i. ha^{-1} PE (45.28%), T_4 (45.28%). Weedy check treatment recorded maximum weed index i.e. 62.85% indicating the reduction in sunflower seed yield due to presence of weeds throughout crop growth period.

Lower weed index in chemical treatments alone and mechanical weed control practices might be due to better weed control which provided favourable conditions for crop growth which ultimately increased the seed yield of sunflower crop as compared to Weedy check treatment.

Effect of different weed control methods on nutrient uptake of weeds and sunflower

Significant influence of different weed control methods in uptake of nutrients was observed by weeds and sunflower crop (Tables 4 and 5, respectively). In respect of weeds, significant differences in uptake of nitrogen, phosphorus and potassium by weeds and sunflower crop were recorded in different weed control methods. Weed free situations with 3HW at 15, 30 and 45DAS recorded significantly less

uptake of N (4.26 kgha^{-1}), P(0.63 kgha^{-1}), K (3.50 kgha^{-1}) by weeds followed by pre-emergence application of Pendimethalin @ 0.75kg a.i. ha^{-1} *fb* one inter cultivation at 30 DAS *fb* hand weeding at 40 DAS, pre-emergence application of Pendimethalin @ 1 kg a.i. ha^{-1}*fb* post emergence spraying of Propaquizalofop @ 75 g a.i. ha^{-1} application of pre-emergence of pendimethalin @ 1.0 kg a.i. ha^{-1}*fb* post emergence application of Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} at 15-20 DAS pre-emergence application of Pendimethalin @ 1kg a.i. ha^{-1}*fb* post emergence spraying of Quizalofop ethyl 10EC @ 75 g a.i. ha^{-1}at 15-20 DAS and pre-emergence application of Pendimethalin @ 0.75 kg a.i. ha^{-1}. The highest values of NPK uptake by weeds were recorded under the Weedy check treatment. This was mainly due to heavy infestation of weeds which took up enormous amount of NPK from soil in Weedy check as nutrient uptake and which was directly governed by dry matter production of weeds. Enormous loss of nutrients due to uncontrolled weed growth. Similar results were reported by Jaykumar *et al.,* (1988).

Effect of different weed control treatments on microbial count in the soil

Data regarding Microbial count (Bacteria, Fungi and Actinomycetes) is mentioned in table 6. Data revealed that, before spraying and at harvest number of Bacteria, Fungi and Actinomycetes were found comparable among all the weed management treatments. However, at 15 days after spraying of herbicides significant reduction in microbial count was noticed among different weed management practices. Weedy check and weed free treatments were comparable and found significantly superior in the respect of the Bacteria, Fungi and Actinomycetes population over rest of the treatments.

Table.1 Growth attributes of sunflower as influenced by different weed control treatments

Treatment	Plant height (cm)	Number of leaves plant^{-1}	Leaf area plant^{-1} (dm^2)	Dry matter accumulation (g plant^{-1})
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	106.07	2.34	2.28	115.33
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	127.17	3.17	3.09	119.17
T_3 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	132.33	4.03	3.92	138.33
T_4 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	107.00	2.35	2.29	118.33
T_5 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	130.33	4.01	3.90	123.17
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	137.67	4.91	4.78	146.33
T_7 - Weedy check	99.17	1.90	1.00	94.83
S.E(m)±	1.58	0.56	0.26	2.73
C.D. at 5%	4.89	1.75	0.80	8.43

Table.2 Yield attributes of sunflower as influenced by different weed control treatments

Treatment	Head diameter (cm)	Head weight (g)	No. of seed plant^{-1}	Seed weight plant^{-1}	100 seed weight
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	10.27	86.20	309.82	10.06	3.25
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	10.20	89.53	338.08	12.84	3.80
T_3 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	11.67	95.73	347.22	13.88	4.00
T_4 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	10.20	88.40	308.58	10.06	3.26
T_5 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	10.33	92.00	349.64	14.58	4.17
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	11.73	100.67	406.24	18.40	4.53
T_7 - Weedy check	9.33	80.20	289.35	9.02	3.12
S.E(m)±	0.43	2.65	0.61	0.61	0.31
C.D. at 5%	1.34	8.18	1.90	1.90	NS

Table.3 Effect of different weed control treatments on control of weeds

Treatment	Total weed count m^{-2}	Weed dry matter productiion (g)	Weed control efficiency (%)	Weed index (%)
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	49.93	50.33	28.57	45.28
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	31.07	31.67	56.17	30.18
T_3 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	43.20	43.67	40.00	24.52
T_4 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	47.13	47.33	34.28	45.28
T_5 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	42.53	43.00	40.00	20.75
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	26.67	27.33	62.85	0.00
T_7 - Weedy check	71.27	71.80	-	50.94
S.E(m)±	0.46	1.18	-	-
C.D. at 5%	1.43	3.64	-	-

Table.4 Nutrient uptake (N, P and K) by crop (kg ha^{-1}) as influenced by Different weed control treatments

Treatment	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	21.48	8.42	47.55
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	27.71	11.31	63.13
T_3 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	30.15	11.88	67.72
T_4 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	20.95	8.31	45.25
T_5 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	32.59	12.91	70.91
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	40.43	16.92	90.66
T_7 - Weedy check	20.18	8.42	44.97
S.E(m) ±	3.36	1.41	7.75
C.D. at 5%	10.38	4.37	23.88

Table.5 Nutrient uptake (N, P and K) by weeds (kg ha^{-1}) as influenced by Different weed control treatments

Treatment	**N (kg ha^{-1})**	**P (kg ha^{-1})**	**K (kg ha^{-1})**
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	7.95	1.16	6.39
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	5.07	0.70	4.09
T_3 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	6.86	1.05	5.59
T_4 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	7.43	1.00	6.06
T_5 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	6.62	0.90	5.46
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	4.26	0.63	3.50
T_7 - Weedy check	11.56	1.58	9.27
S.E(m) ±	0.18	0.02	0.15
C.D. at 5%	0.57	0.08	0.47

Table.6 Microbial count at periodical growth stages as influenced by Different weed control treatments (cfu g^{-1} soil $x10^7$)

Treatment	Bacteria			Fungal			Actinomycetes		
	Before sowing	After spray	At harvest	Before sowing	After spray	At harvest	Before sowing	After spray	At harvest
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	11.33	7.11	19.46	7.67	6.33	20.17	7.68	7.15	21.17
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	10.45	7.02	19.67	7.33	5.07	20.10	8.58	6.97	21.33
T_3 -Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	11.54	8.27	21.84	7.17	5.39	21.50	8.37	6.84	22.16
T_4 -Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	10.18	6.96	19.33	7.50	5.17	21.33	8.35	6.67	21.67
T_5 -Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	10.04	6.83	21.35	7.33	5.51	21.20	8.53	7.33	23.04
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	11.67	13.81	23.33	7.02	10.17	21.48	8.70	11.17	24.84
T_7 - Weedy check	13.09	14.67	23.97	7.17	11.67	21.99	8.34	14.67	25.30
S.E(m) ±	0.724	0.771	1.179	0.537	0.617	1.059	0.61	0.49	1.09
C.D. at 5%	NS	2.38	NS	NS	1.90	NS	NS	1.52	NS

Table.7 Seed yield, oil content and as influenced by different weed control Treatments

Treatment	Seed yield ($kgha^{-1}$)	Oil content (%)	Oil yield ($kgha^{-1)}$
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	559.41	35.31	197.42
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	713.73	36.99	265.00
T_3 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	771.60	37.81	291.71
T_4 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	559.41	35.71	199.35
T_5 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	810.18	37.31	302.61
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	1022.37	38.20	389.23
T_7 - Weedy check	501.54	34.77	172.97
S.E(m) ±	83.39	0.80	32.22
C.D. at 5%	256.97	NS	99.31

Table.8 Economics of the crop as influenced by different weed control treatments

Treatment	GMR (Rs ha^{-1})	NMR (Rs. ha^{-1})	B: C ratio
T_1 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE	18815	4826	1.35
T_2 - Pendimethalin @ 0.75 kg a.i. ha^{-1} PE *fb* 1 IC at 30 DAS *fb* HW at 40 DAS	24145	7856	1.48
T_3 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE	26114	9734	1.59
T_4 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75 g a.i. ha^{-1} as PoE	18815	2420	1.15
T_5 - Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE	27405	11609	1.73
T_6 - Weed free (3HW at 15, 30 and 45 DAS)	34704	17999	2.08
T_7 - Weedy check	16946	5641	1.50
S.E(m) ±	2842	2842	-
C.D. at 5%	8758	8758	-

Among the herbicidal treatments numerically minimum bacterial count was observed with treatment Pendimethalin @ 1kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} at 15-20 DAS as PoE), minimum actinomycetes count was observed in treatment with pendimethalin @ 1kg a.i. ha^{-1} PE *fb* Propaquizalofop @ 75g a.i. ha^{-1} at 15-20 DAS as PoE and minimum fungal count was observed in treatment Pendimethalin @ 1kg a.i. ha^{-1} PE *fb* 1IC at 30DAS *fb* HW at 40DAS), however, these were statistically similar.

Population of soil microorganism i.e bacteria, fungi, actinomycetes were significantly influenced After 15 days of herbicide application of as compared to their population before herbicide application. But at the time of harvest of the crop the microbial population with all the treatment attained the equal level. Hence, it was clear that the effect of herbicide on soil microbes was temporary which was in conformity with the results of Ghosh *et al.*, (2014).

Effect of different weed control methods on seed yield, oil yield and oil content

Data given in table 7 revealed that different weed management practices significantly improved the seed yield, oil content and oil yield. Treatment weed free situation with 3HW at 15, 30 and 45DAS registered highest seed yield (1022.37kgha^{-1}) followed by pre-emergence application of Pendimethalin @ 1kg a.i. ha^{-1}*fb* post emergence spraying of Fenoxoprop ethyl @ 37.5g a.i. ha^{-1} at 15-20DAS(810.18 kg ha^{-1}). Treatment weedy check) recorded lowest seed yield (501.54 kgha^{-1}).

This might be due to the better weed control associated with decrease in weed population and improvement in yield contributing characters and ultimately increased the seed yield in these treatments compare to other treatments. Similar results were reported by Tripathi and Vivek (2001) in respect of seed yield.

Similarly, the same trend was noticed in respect of oil yield and oil content. The treatment weed free 3HW at 15, 30 and 45 DAS produced significantly higher oil yield (389.23 kg ha^{-1}) over rest of the treatments except the treatment where Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE was applied (302.61 kg ha^{-1}) and Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb* Quizalofop ethyl 10 EC @ 75 g a.i. ha^{-1} as PoE was applied (291.71 kg ha^{-1}) which were statistically at par with each other. Oil content of seed was not influenced due to any weed method. Due to less crop weed competition weed free treatment and herbicidal treatments gave highest grain weight with Pendimethalin @ 1 kg a.i. ha^{-1} PE *fb*

Fenoxoprop ethyl @ 37.5 g a.i. ha^{-1} as PoE was applied which resulted in obtaining highest oil content of the seed.

Effect of different weed control methods on economics of the crop

Data given in table 8 revealed that different weed management practices significantly improved economics of sunflower crop. Treatment weed free recorded significantly higher gross monetary returns (Rs. 34,704 ha^{-1}) and NMR (Rs. 17999 ha^{-1}) over rest of the treatments except the treatment pre-emergence application of Pendimethalin @ 1kg a.i. ha^{-1} *fb* post emergence spraying of Fenoxoprop ethyl @ 37.5g a.i. ha^{-1} at 15-20 DAS and pre-emergence application of Pendimethalin @1kg a.i. ha^{-1} *fb* post emergence spraying of Quizalofop ethyl 10EC @ 75 g a.i. ha^{-1} which were statistically at par with each other. The same treatment produced highest Benefit: Cost ratio (2.08) Minimum GMR (16946 ha^{-1}) and B: C ratio (1.35) was observed in treatment weedy check.

Due to less crop weed competition weed free treatment and herbicidal treatments gave highest benefit cost ratio. Similar results were reported by Sumathi *et al.,* (2010).

The weed free treatment proved better in giving higher weed control efficiency, higher seed yield and recorded maximum GMR (34704 ha^{-1}), NMR (17999 ha^{-1}) and B: C ratio (2.08) followed by Pendimethalin @ 1kg a.i. ha^{-1} PE *fb* Fenoxoprop ethyl @ 37.5g a.i. ha^{-1} as PoE.

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