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Influence of herbicides on yield and economics of *Kharif* sunflower

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ABTRACT

A field experiment was conducted during 2012 and 2013 at Oilseeds Research Station, Latur (M.S.) to study the effect of different pre (PE) and post-emergence (POE) herbicides on yield and economics of sunflower in vertisols. Though the highest head diameter (17.5 and 15.9 cm), seed yield per plant (35.23 and 25.08 g), 100 seed weight (5.69 and 5.53 g) and seed yield (1710 kg ha^{-1}) were observed in weed free situation, but these parameters were found statistically at par with the application of Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS and application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} or Propaquizofop 10% EC @ 62 g a.i. ha^{-1} or Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i. ha^{-1} at 20 DAS (POE). The highest Net Monetary Return (' 38262 ha^{-1}) and BC ratio (2.89) were recorded with the application Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE). Among different chemical weed control methods lowest dry weed weight (12 and 83 g/m^2), Weed Index (2.1 and 0.8) and highest Weed Control Efficiency (90 and 87 %) and Crop Resistance Index (10.2) were observed with the application Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE). The application of Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} + Chlorimuron Ethyl 25 % wp @ 9 g a.i. ha^{-1} at 20 DAS (POE) has shown phytotoxicity effect on sunflower crop resulting stunted and reduced growth. In 0-10 scale phytotoxicity of this treatment was rated as 2-3 (20-30%).

Keywords: Pre-emergence herbicides, post-emergence herbicides, sunflower, weed management

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops in India and ranks third after soybean and groundnut as a source of edible oil. Sunflower with its versatile nature is expected to play a crucial role in the oilseed economy of the country. Sunflower is principally a rainy season crop and keeping in view the production potential, improved suitable agro techniques should be made available to increase the productivity of sunflower and to improve economic status of the sunflower grower. Among various factors responsible for low seed yield of sunflower, judicious weed management is the major aspect for limiting seed production in sunflower. The losses caused by weeds exceed the losses from any other category agricultural pests. Weed competition is one of the major biotic constraints in realizing higher sunflower productivity due to wider spacing and application of higher dose of fertilizers. Heavy weed infestation is the dominant reason for low yield of sunflower. Weeds are salient competitors of natural and manmade resources like nutrients, water and light which could have been otherwise for boosting up crop productivity.

Uncontrolled weed growth reduced the seed yield of sunflower up to an extent of 55% (Wanjari *et al*., 2000). Further, non-availability of labour and high rate of wages during peak periods of agricultural operations, increased hiring charges of bullock-drawn intercultural implements, pre- and post-emergence herbicides may be viable option to control the weeds right from the sowing to harvesting of sunflower crop.

Since application of single herbicide may not be effective in providing broad spectrum weed control, hence, application of pre and post emergence herbicides either in combination or sequence and integration with manual weeding may be more beneficial. In order to increase the productivity of sunflower and reduce the cost of cultivation, the use of sequential application of pre and post-emergence herbicides may be the useful option rather than pre or post-emergence herbicide application alone. The sequential application of pre- and post-emergence herbicides in sunflower has not been investigated adequately.

Keeping in view these facts, the present investigation was undertaken to test the performance of various post emergence herbicides along with one pre-emergence and hand weeding for providing weed control during critical period of crop-weed interference in *kharif* sunflower

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* season of 2012 and 2013 at Oilseeds Research Station, Latur (VNMKV, Parbhani). Geographically Latur is situated between 18^0 05' to 18^0 75' North latitude and between 76^{0}25' to 77^{0}25' East longitude. It's height from

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Mean Sea Level is about 540.63 m and has sub-tropical climate. Nine weed control treatments *viz.*, T_1- Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE), T_2- Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS, T_3-Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE), T_4- Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Propaquizofop 10% EC @ 62 g a.i. ha^{-1} at 20 DAS (POE), T_5- Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i. ha^{-1} at 20 DAS (POE), T_6- Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} + Chlorimuron Ethyl 25 % wp @ 9 g a.i. ha^{-1} at 20 DAS (POE), T_7- Farmers practice (Two hoeing operations at 20 and 40 DAS + one hand weeding at 30 DAS), T_8- Weed free (Three hand weeding at 15, 30 and 45 DAS) and T_9- Unweeded were evaluated in randomized block design with three replications. The experimental soil was clayey in texture with slightly alkaline in nature (pH7.65 and 7.42) containing low organic carbon (0.41% and 0.39%), available nitrogen (133 and 128 kg ha^{-1}), available phosphorus (9.52 and 9.10 kg ha^{-1}) and high in available potassium (422 and 410 kg ha^{-1}). The individual plot size was 4.8 x 4.5m. All the quantitative data were recorded in net plot (3.6 x 3.9m) avoiding any possible border effects.The recommended dose of fertilizer was 90:45:45 NPK kg ha^{-1}. Half dose of nitrogen and full dose of phosphorus and potassium was applied at planting and remaining half dose of nitrogen was applied one month after sowing. The sources of nutrient were diammonium phosphate (DAP), urea and muriate of potash. The sunflower hybrid LSFH-35 was sown on 19 July, 2012 and 6, August 2013 at spacing of 60 x 30 cm and was harvested on 22 October, 2012 and 31October, 2013. Standard package of practices were adopted for raising the crop. Pre-emergence application of pendimethalin was done on next day of sowing and post-emergence application of other herbicides was done 20 DAS. Weeds at harvest were collected using 1m^2 quadrate in all treatments and dried in oven till a constant weight was observed (g m^{-2}). The dry weed weight was subjected to square root transformation ("x+.05) to normalize their distribution (Gomez and Gomez, 1984). Weed control efficiency (Mani *et al*., 1973) and different indices (Devasenapathy *et al*., 2008) worked out by the formula as below.

$$WCE = \frac{WDC - WDT}{WDC} \times 100$$

Where WCE: Weed control efficiency; WDC: Weed dry matter in control; WDT: Weed dry matter in treatment

$$CRI = \frac{\text{Crop dry matter in treatment plot}}{\text{Crop dry matter in control plot}} \times \frac{\text{Weed dry matter in control plot}}{\text{Weed dry matter in treatment plot}}$$

Where CRI: Crop Resistance Index

Data on various variables were analyzed by analysis of variance (Panse and Sukhatme, 1967) and pooled analysis for two years were carried out as per procedure outlined by Cochran and Cox (1957). Total rainfall received during experimental period was 827.5 and 927.9 mm during 2012-13 and 2013-14, distributed over 39 and 66 rainy days, respectively

RESULTS AND DISCUSSION

Effect on weeds

The experimental field was infested with *Cynodon dactylon, Brachairia eruciformis, Dinebra retroflexa, Digitaria sanguinallies, Cyprus rotundus, Parthenium hysterophorus, Digera arvensis, Acalypha indica, Euphorbia geniculata, Amaranthaus viridis, Phylanthus niruri etc.* species of weed in both the years.

The weed free treatment recorded lowest weed dry weight over all the treatments. Among chemical weed control methods application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE) recorded lowest weed dry weight which was closely followed by Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS (Table 1). Weed dry weight was significantly reduced in both the years in all the herbicidal treatments compared to unweeded check. It might be due to broad spectrum activity of sequential application of pre and post emergence herbicides on weed and their greater efficiency to retard cell division of meristems as a result of which weeds died rapidly. Unweeded check recorded highest weed dry weight. The results are in concordance with the findings of Balyan (1993) and Channappagoudar *et al*. (2008).

Weed control efficiency and Weed Index

Though the highest weed control efficiency was in weed free treatment, but it was closely followed by application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE). Among chemical weed control methods highest weed control efficiency was observed with the application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1}

Table 1: Dry weed weight, weed control efficiency and weed index at harvest as influenced by different treatments

Treatment	Dry weed weight (g m^{-2})		WCE (%)		WI (%)	
	2012	2013	2012	2013	2012	2013
T_1	4.423* (19)	17.81* (317)	85	52	12.2	17.4
T_2	3.89* (15)	8.68* (75)	88	81	3.1	1.6
T_3	3.58* (12)	9.13* (83)	90	87	2.1	0.8
T_4	4.21* (17)	11.93* (142)	86	79	2.8	1.1
T_5	4.61* (21)	13.72* (188)	84	72	6.6	5.2
T_6	4.07* (16.)	11.64* (135)	87	80	26.5	46.3
T_7	5.32* (28)	14.05* (197)	78	70	15.3	17.2
T_8	2.51* (6)	3.53* (12)	95	98	—	—
T_9	11.26* (127)	25.79* (665)	—	—	24.3	35.6
SEm(±)	**0.18***	**4.18***	—	—	—	—
LSD(0.05)	**0.53***	**7.17***	—	—	—	—
General Mean	**4.87***	**14.38***	—	—	—	—

Table 2: Head diameter, test weight and seed yield plant^{-1} of sunflower as influenced by various treatments

Treatments	Head diameter		Test weight(g)		Seed yield (g plant^{-1})	
	2012	2013	2012	2013	2012	2013
T_1	15.8	14.63	5.84	5.60	30.13	20.93
T_2	16.6	15.80	5.98	5.83	34.40	23.34
T_3	17.1	15.83	6.11	6.12	34.70	24.67
T_4	17.0	15.57	6.02	5.77	34.50	23.33
T_5	16.9	15.35	6.00	5.40	32.90	23.06
T_6	16.1	11.87	5.69	5.53	25.83	18.79
T_7	16.4	14.60	6.01	5.50	29.83	19.99
T_8	17.5	15.90	6.18	6.13	35.23	25.08
T_9	15.3	12.80	5.58	4.00	26.61	13.58
SEm(±)	**0.3**	**0.36**	**0.25**	**0.14**	**0.69**	**0.70**
LSD(0.05)	**0.9**	**1.08**	**NS**	**0.44**	**2.08**	**2.10**
General Mean	**16.5**	**14.71**	**6.7**	**5.54**	**31.57**	**21.42**

Table 3: Seed yield and economics of sunflower as influenced by various treatments

Treatment	Seed yield (kg ha^{1})		Pooled values			
	2012	2013	Seed yield (kg ha^{-1})	GMR (‘ha^{-1})	NMR (‘ha^{-1})	B:C ratio
T_1	1651	1223	1437	50295	31092	2.66
T_2	1877	1458	1668	58357	34563	2.48
T_3	1896	1470	1683	58899	38262	2.89
T_4	1883	1435	1659	58071	37584	2.87
T_5	1810	1405	1608	56269	36074	2.82
T_6	1424	795	1110	38839	18791	1.97
T_7	1640	1227	1434	50179	28331	2.33
T_8	1937	1482	1710	59827	30864	2.08
T_9	1467	954	1211	42368	25700	2.60
SEm (±)	**69**	**67**	**48**	**1674**	**1674**	**0.08**
LSD(0.05)	**206**	**199**	**133**	**4639**	**4639**	**0.22**
General Mean	**1732**	**1273**	**1505**	**52664**	**31348**	**2.52**

Note: *T_1:Pendimethalin 38.7 CS @ 0.75 kg a.i.ha^{-1} PE; T_2:Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} PE + hoeing at 30 DAS + HW at 40 DAS; T_3:Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} PE + Quizalofop Ethyl 5 % EC @ 37.5 g a.i. ha^{-1} POE; T_4:Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} PE + Propaquizofop 10 EC @ 62 g a.i. ha^{-1} POE; T_5:Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} PE + Fenoxoprop-p- Ethyl 9.3 EC @ 37.5 g a.i. ha^{-1} POE; T_6:Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} + Chlorimuron Ethyl 25 % WP @ 9 g a.i. ha^{-1} POE; T_7:Farmers practice; T_8:Weed free; T_9:Unweeded; Figures in parentheses are original values. *Square root transformed (“X +0.5) values.*

(PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE), followed by Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS (Table 1) during both the years. These results are in agreement with those of Barui *et al*. (2006) and Pannacci *et al.* (2007). The lowest weed index was observed with the application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE), followed by Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Propaquizofop 10% EC @ 62 g a.i. ha^{-1} at 20 DAS (POE) and Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS (Table 1) during both the years. It might be due to efficient weed control by the herbicidal treatments, which enhanced growth and yield of sunflower crop.

Phytotoxicity rating

The application of Quizalofop Ethyl 5 EC @ 37.5 g a.i. ha^{-1} + Chlorimuron Ethyl 25 % wp @ 9 g a.i. ha^{-1} at 20 DAS (POE) as directed post-emergence spray on weeds has shown phytotoxic effect on sunflower crop resulting stunted and reduced growth. In 0-10 scale phytotoxicity of this treatment was rated as 2-3 (20-30 per cent).

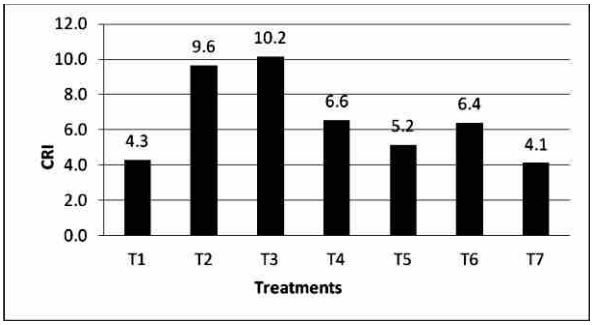

Fig.1 Effect of different weed management treatments on Crop Resistance Index (CRI) in sunflower (Pooled values)

Yield attributes and yield

Different weed management practices had significant impact on yield attributes and yield of sunflower. The weed free treatment showed highest value of all yield attributes and yield of sunflower during both the year. These results are in conformity with the findings of Kumar *et al*.(2013). Among chemical weed control methods application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE) recorded significantly higher head diameter and seed yield per plant of sunflower over unweeded check, farmers practice, application of Quizalofop Ethyl 5 EC @ 37.5 g a.i. ha^{-1} + Chlorimuron Ethyl 25 % wp @ 9 g a.i. ha^{-1} at 20 DAS (POE) and Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) and closely followed by application of Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS and Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Propaquizofop 10% EC @ 62 g a.i. ha^{-1} at 20 DAS (POE). Test weight of sunflower was not influenced significantly due to different weed control methods during first year. During second year, though the weed free treatment recorded highest test weight of sunflower but it was statistically *at par* with the application of Pendimethalin 38.7 CS @ 0.75 kg a.i ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS and application of Pendimethalin 38.7 CS @ 1.0 kg a.i ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i ha^{-1} or Propaquizofop 10% EC @ 62 g a.i ha^{-1} or Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i ha^{-1} at 20 DAS (POE).

In pooled results, the weed free treatment recorded significantly higher seed yield of sunflower over unweeded check, farmers practice, application of Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} + Chlorimuron Ethyl 25 % wp @ 9 g a.i. ha^{-1} at 20 DAS (POE) and Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE).

The application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE)+ Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE) was next best treatment followed by Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS and Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Propaquizofop 10% EC @ 62 g a.i. ha^{-1} or Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i. ha^{-1} at 20 DAS (POE) in producing seed yield of sunflower as that of weed free treatment. It might be due to efficient weed control which lowered weed flora and enhanced the growth of crop in herbicidal treatments.

Highest value (10.2) of crop resistance index (CRI) was obtained with the application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE)+ Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE), which was followed by Pendimethalin 38.7 CS @ 0.75 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS + one hand weeding at 40 DAS (Fig.1)

Economics

Gross monetary return, net monetary return and benefit cost ratio were influenced significantly due to different methods of weed control. The weed free treatment recorded significantly higher GMR but found

statistically at par with the application of Pendimethalin 38.7 CS @ 0.75 kg a.i ha^{-1} (PE)+ one hoeing at 30 DAS followed by hand weeding at 40 DAS and application of Pendimethalin 38.7 CS @ 1.0 kg a.i ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i ha^{-1} or Propaquizofop 10% EC @ 62 g a.i ha^{-1} or Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i ha^{-1} at 20 DAS (POE). The results are in concordance with the findings of Narkhede *et al.,* (2000).

An application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE)+ Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE) recorded significantly higher NMR, which was statistically *at par* with Pendimethalin 38.7 CS @ 0.75 kg a.i ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 DAS and application of Pendimethalin 38.7 CS @ 1.0 kg a.i ha^{-1} (PE) + Propaquizofop 10% EC @ 62 g a.i ha^{-1} or Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i ha^{-1} at 20 DAS (POE). The present findings corroborate with earlier reporter of Sumathi *et. al.* (2010)

Among different weed control methods an application Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE) + Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} at 20 DAS (POE) recorded significantly higher B:C ratio of sunflower which was closely followed by application of Pendimethalin 38.7 CS @ 1.0 kg a.i ha^{-1} (PE) + Propaquizofop 10% EC @ 62 g a.i ha^{-1} or Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i ha^{-1} at 20 DAS (POE).

From the results it may be inferred that application of Pendimethalin 38.7 CS @ 1.0 kg a.i. ha^{-1} (PE)+ Quizalofop Ethyl 5% EC @ 37.5 g a.i. ha^{-1} or Propaquizofop 10% EC @ 62 g a.i ha^{-1} or Fenoxoprop Ethyl 9.3% w/w@ 37.5 g a.i ha^{-1}at 20 DAS (POE) was more effective for getting higher returns and better weed control in *kharif* sunflower

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