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Weed Management Practices for Improving Productivity and Nutrient Uptake of Sunflower (*Helianthus annuus* L.) in Alfisols

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Abstract A field experiment was conducted to study the integration of pre and post-emergence herbicides and cultural practices for weed management in sunflower (*Helianthus annuus* L.)on red sandy loam soil during *kharif* 2014 at AICRP on sunflower, ZARS, UAS, GKVK, Bengaluru with combination of 9 weed management treatments in three replications. In this experiment one pre-emergence, four post-emergence herbicides and farmers practice i.e., two IC at 20 and 40 DAS + one HW at 30 DAS, which was compared with weed free (Three hand weedings at 15, 30 and 45 DAS) and unweeded check. Among the different weed management practices, the nutrient uptake (N, P_2O_5 and K_2O) by crop was significantly higher with pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a. i. ha^{-1} at 17 DAS as directed POE on weeds (75.63, 26.91 and 69.48 kg ha^{-1}, respectively) and farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (83.15, 31.63 and 75.68 kg ha^{-1}, respectively) which was on par with weed free (Three HW at 15, 30 and 45 DAS) (78.67, 28.98 and 71.49 kg ha^{-1}, respectively)whereas uptake was lower in unweeded control (38.52, 10.36 and 30.43 kg ha^{-1}, respectively). The nutrient uptake by weeds was in reverse trend.

Keywords Sunflower, Weed management, Nutrient uptake.

Introduction

Sunflower (*Helianthus annuus* L.) is the important oil seed crop of the India. Presently, it is cultivated in an area of 0.69 m ha with a production of about 0.54 mt and productivity of 791 kg ha^{-1}. The sunflower crop was accepted by the farming community due to its desirable characters like short duration, photo and thermo insensitivity, low seed rate and high seed multiplication rate (1:50) along with best quality edible oil. The productivity has been often deflated due to heavy weed menace. Uncontrolled weed growth caused enormous loss of nutrients which in turn reduced the yield of sunflower crop. Heavy weed infestation in sunflower crop is mainly due to wider spacing, slower crop growth during early stages, highly responsive to fertilizers and irrigation.The increased growth of weeds offers severe competition for rowth

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resources generally more competition for nutrients and water. To reduce the loss of nutrients due to weeds and increase the yield of sunflower, weed management is an important aspect. The conventional method of weed control is laborious, inefficient and highly costly. Sometimes wet conditions due to frequent raining during *kharif* do not permit weeding when the crop requires weed free conditions. These conditions have led to herbicide use as necessary economic practice. However, neither herbicide nor cultivations are adequate for consistent and acceptable weed control. Therefore integrated weed management is the best for higher production, using pre-emergence herbicide in combination with hand weeding or intercultivation with implements or post-emergent herbicide. Therefore, the present investigation was carried out to know the effect of different weed management practices on nutrient uptake and yield of sunflower.

Materials and Methods

An experiment was conducted during *kharif* season of 2014, at AICRP on sunflower, ZARS, UAS, GKVK, Bengaluru. The soil was red sandy loam in texture and slightly acidic in reaction (6.70) with available nitrogen 250 kg ha^{-1}, available phosphorus 59 kg ha^{-1} and available potassium 218 kg ha^{-1} and organic carbon content of 0.43%. .KBSH-53, sunflower hybrid was directly sown on 11th August with a spacing of 60 cm × 30 cm.Experiment included nine treatments consisting of T_1 : Pendimethalin 38.7 CS at 0.75 kg a.i. ha^{-1} as PE, T_2 : Pendimethalin 38.7 CS at 0.75 kg a.i. ha^{-1} as PE + one IC at 30 DAS + HW at 40 DAS, T_3 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds T_4 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + propaquizafop 62 EC at 62 g a.i. ha^{-1} at 17 DAS as directed POE on weeds, T_5 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + fenoxoprop-ethyl 9 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds, T_6 : Quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} + chlorimuron-ethyl 25 WP at 9 g a.i. ha^{-1} at 17 DAS as directed POE on weeds, T_7 : Farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS), T_8 : Weed free (Three HW at 15, 30 and 45 DAS), T_9 : Unweeded control. Farm yard manure at 7.5 t ha^{-1} was applied two weeks before planting. The fertilizer nitrogen, phosphorus and potassium were applied as per recommended dose 90:90:60 N, P_2O_5 and K_2O kg ha^{-1} through urea, SSP and MOP. 50% of fertilizer nitrogen and entire dose of P and K were applied at the time of planting. Remaining 50% nitrogen was top-dressed at the time of earthing up and $ZnSO_4$ (36% Zn) and borax (11% B) as source of micronutrients and applied to soil before sowing. Pre-emergence herbicides were applied by using knapsack sprayer fitted with Aspee WFN 78 nozzle with a spray volume of 750 liters ha^{-1}. Post-emergence herbicides were applied by using knapsack sprayer fitted with Aspee WFN 40 nozzle by using 375 liters of spray volume ha^{-1}. The post-emergence herbicides were sprayed when they were in active stage without being wilted to ensure good action by the herbicides.

Then the experimental data were subjected to analysis by using Fisher's method of Analysis of Variance (ANOVA) [1]. The levels of significance used in *F* and *t* test was at $p = 0.05$. The formulae for calculating nutrient uptake by crops, weeds and harvesting index are detailed below.

Nutrient uptake

$$\text{Nutrient uptake by plant} = \frac{\text{Nutrient content (\%)} \times \text{biological yield}}{100}$$

$$\text{Nutrient uptake by weed} = \frac{\text{Nutrient content (\%)} \times \text{weed dry weight}}{100}$$

Harvest index (HI)

$$\text{Harvest index} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

Results and Discussion

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

Among the different weed management practices, nitrogen, phosphorus and potassium uptake by seed and stalk of sunflower at harvest was significantly higher in pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds (40.42, 17.92 and 17.99 and

Table 1. Nutrient uptake in sunflower at harvest as influenced by different weed management practices. CS : Aqueous capsule suspension, PE : Pre-emergence spray, POE : Post-emergence spray, DAS: Days after sowing, fb: followed by, HW : Hand weeding, IC : Inter cultivation.

Treatments	Nutrient uptake (kg ha^{-1})								
	Nitrogen			Phosphorus			Potassium		
	Stalk	Seed	Total	Stalk	Seed	Total	Stalk	Seed	Total
T_1 : Pendimethalin 38.7 CS at 0.75 kg a.i. ha^{-1} as PE	24.96	27.95	52.91	5.89	10.64	16.53	31.09	10.13	41.22
T_2 : Pendimethalin 38.7 CS at 0.75 kg a.i. ha^{-1} as PE+ one IC at 30 DAS +HW at 40 DAS	30.19	34.02	64.21	7.34	13.91	21.25	41.86	14.63	56.49
T_3 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE+ Quizalofop ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds	35.21	40.42	75.63	8.99	17.92	26.91	51.49	17.99	69.48
T_4 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE+ Propaquizafop 62 EC a t62 g a.i. ha^{-1} at 17 DAS as directed POE on weeds	28.25	29.97	58.22	6.23	12.40	18.63	37.06	12.77	49.83
T_5 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + Fenoxoprop-ethyl 9 EC at 37.5g a.i. ha^{-1} at 17 DAS as directed POE on weeds	25.77	29.48	55.25	6.50	12.02	18.52	35.45	12.77	48.22
T_6 : Quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} + Chlorimuron ethyl 25 WP at 9 g a.i ha^{-1} at 17 DAS as directed POE on weeds	23.46	27.78	51.24	5.62	10.65	16.27	29.97	11.59	41.56
T_7 : Farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS)	39.61	45.54	83.15	10.16	21.47	31.63	55.91	19.77	75.68
T_8 : Weed free (Three HW at 15, 30 and 45 DAS)	37.65	41.02	78.67	9.42	19.56	28.98	52.27	19.22	71.49
T_9 : Unweeded control	17.53	20.99	38.52	3.63	6.73	10.36	23.39	7.04	30.43
SEm ±	2.09	1.86	3.18	0.65	2.17	2.25	2.96	0.97	2.94
CD (p = 0.05)	6.23	5.56	9.52	1.94	6.55	6.72	8.82	2.86	8.79

35.21, 8.99 and 51.49 kg ha^{-1}, respectively) and farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (43.54, 21.47 and 19.77 and 39.61, 10.16 and 55.91 kg ha^{-1}, respectively) which was on par with weed free (Three HW at 15, 30 and 45 DAS) (41.02, 19.56 and 19.22 and 37.65, 9.42 and 52.22 kg ha^{-1}, respectively) whereas, the lowest uptake of nitrogen, phosphorus and potassium by seed and stalk of sunflower crop was recorded in unweeded control (20.99, 6.73 and 7.04 and 17.53, 3.63 and 23.39 kg ha^{-1}, respectively).

Among the different weed management practices, total nitrogen, phosphorus and potassium uptake by sunflower crop at harvest was significantly higher in pendimethalin 38.7 CS at 1.0 kg a.i ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds (75.63, 26.91 and 69.48 kg ha^{-1}, respectively) and farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (83.15, 31.63 and 75.68 kg ha^{-1}, respectively) which was on par with weed free (Three HW at 15, 30 and 45 DAS) (78.67, 28.98 and 71.49 kg ha^{-1}, respectively) as a result of higher dry matter production as discussed earlier owing to better weed control and less weed competition. Whereas, the lowest uptake of nitrogen, phosphorus and potassium by sunflower crop was recorded in unweeded control (38.52, 10.36 and 30.43 kg ha^{-1}, respectively) as a result of weed competition resulting in lower dry matter production [2, 3].

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

The nitrogen, phosphorus and potassium uptake by weeds at harvest was significantly influenced by different weed management practices. Significantly the lowest uptake of nutrients through weeds was recorded in pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds (18.23, 4.39 and 14.92 kg ha^{-1}, respectively) and farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (15.35, 3.24 and 11.97 kg ha^{-1}, respectively) which was on par weed free (Three HW at 15, 30 and 45 DAS) (17.56, 3.63 and

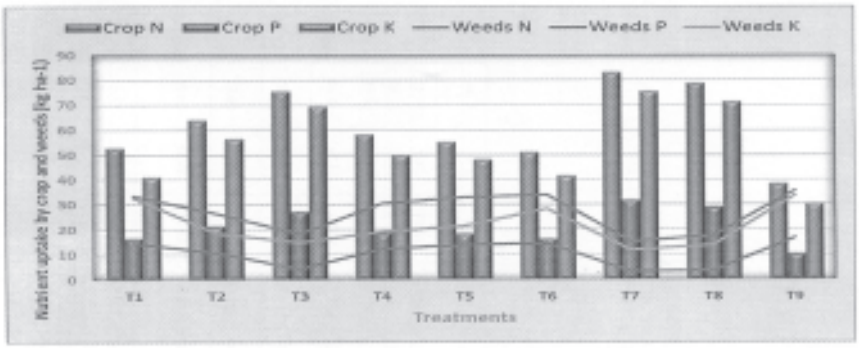

Fig. 1. Uptake of nitrogen, phosphorus and potassium by sunflower and weeds as influenced by different weed management practices.

13.78 kg ha^{-1}, respectively) with as consequence of effective removal of weeds. Significantly higher uptake of nitrogen, phosphorus and potassium was observed in unweeded control (35.48, 16.88 and 33.59 kg ha^{-1}, respectively) due to absence of effective weed management practice, the weeds grew luxuriantly utilizing the available growth resources to the fullest extent.

Yield

Weed management practices significantly influenced the seed yield,stalk yield and harvest index of sunflower (Table 1). Significantly the highest seed and stalk yield including harvest index were recorded with pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as

Table 2. Nutrient removal by weeds, seed yield, stalk yield and harvest index in sunflower as influenced by different weed management practices. **CS** : Aqueous capsule suspension, **PE** : Pre-emergence spray, **POE** : Post -emergence spray, **DAS** : Days after sowing, **fb** : followed by, **HW** : Hand weeding, **IC** : Inter cultivation.

Treatments	Nutrient removal by weeds (kg ha^{-1}) N	P	K	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})	HI
T_1 : Pendimethalin 38.7 CS at 0.75 kg a.i. ha^{-1}as PE	33.41	14.51	32.61	1396	3106	0.31
T_2 : Pendimethalin 38.7 CS at 0.75 kg a.i.ha^{-1} as PE + one IC at 30 DAS + HW at 40 DAS	26.32	10.75	18.57	1653	3324	0.33
T_3 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE+Quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds	18.23	4.39	14.92	1795	3420	0.34
T_4 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE+Propaquizafop 62 EC at 62 g a.i. ha^{-1} at 15-20 DAS as directed POE on weeds	30.55	12.34	19.25	1573	3231	0.33
T_5 : Pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE+Fenoxoprop-ethyl 9 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds	32.84	13.93	21.46	1475	3199	0.32
T_6 :Quizalofop-ethyl 10 RC at 37.5 g a.i. ha^{-1} + Chlorimuron-ethyl 25 WP at 9 g a.i. ha^{-1} at 17 DAS as directed POE on weeds	33.92	14.67	28.26	1260	3014	0.30
T_7 : Farmers practice (Two IC at 20 and 40 DAS+one HW at 30 DAS)	15.35	3.24	11.97	1888	3437	0.36
T_8 : Weed free (Three HW at 15, 30 and 45 DAS)	17.56	3.63	13.78	1824	3431	0.35
T_9 Unweeded control	35.4816.88		33.59	1021	2761	0.28
SEm ±	1.05	0.43	1.03	76.64	22.74	0.01
CD (p = 0.05)	3.12	1.21	3.07	229.7	68.23	0.03

directed POE on weeds (1795, 3420 kg ha^{-1} and 0.34 respectively) and farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (1888, 3437 kg ha^{-1} and 0.36 respectively) which was on par with weed free (Three HW at 15, 30 and 45 DAS) (1824, 3431 kg ha^{-1} and 0.35 respectively). This was mainly due to increased nutrient uptake by the crop resulting from lesser weed competition. Enhancement of nitrogen uptake by sunflower was mainly due to maintenance of weed free period during crop growth period. The better performance of crop in famers practice, herbicide treated plot and weed free plots was mainly due to increased nutrient uptake and very low dry matter accumulation of weeds. All the above said parameters were the lowest with the unweeded check due to heavy weed infestation [4].

Harvest index of sunflower was also significantly influenced by different weed management practices (Table 2). Among different treatments, farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (0.36) and pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds (0.34) recorded significantly higher harvest index which was on par with weed free (Three HW at 15, 30 and 45 DAS) (0.35). The increase in harvest index may be attributed to adequate suppression of weed growth which favored better utilization of photo-assimilates for seed formation. Similar results have also been discussed by Sylvestre et al. [5]

Conclusion

The present study concluded that pendimethalin 38.7 CS at 1.0 kg a.i. ha^{-1} as PE + quizalofop-ethyl 10 EC at 37.5 g a.i. ha^{-1} at 17 DAS as directed POE on weeds is very effective in reducing the nutrient removal by weeds, which results in increased seed yield. This method not only helps in overcoming of labor problem, but also curtailing the nutrient drained by weeds.

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