

Effect of weed control practices on weed dry matter, production potential and nutrient uptake of sunflower (*Helianthus annuus*) in Vertisols

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ABSTRACT

Field experiments were conducted during rainy (*khariif*) season of 2006 and 2007 in Vertisols of semi-arid tropics, Hyderabad to evaluate the performance of sunflower (*Helianthus annuus* L.) for different weed control treatments. Pre-emergence application of pendimethalin (1.0 kg) in combination with interculturing at 21 days after sowing, followed by hand weeding was found as good as that of weed-free treatment in reducing weed growth and recorded higher seed yield and higher nutrient uptake of sunflower in Vertisols. On an average, weeds removed 39 kg N/ha, 8 kg P/ha and 53 kg K/ha in unweeded control. The activity of soil enzymes (urease, dehydrogenase and phosphatase) were enhanced/maintained with application of pendimethalin at lower doses followed by intercultivation.

Key words: Sunflower, Soil enzymes, Vertisols, Weed flora, Weed control efficiency, Weed index

Sunflower (*Helianthus annuus* L.), an efficient oilseed crop with high quality edible oil and wider adaptability is being cultivated in rainy (*khariif*) and post-rainy (*rabi* and summer) seasons both in Alfisols and Vertisols. Weeds cause yield losses in sunflower up to the extent of 34% (Yaduraju 2002). Due to wide row spacing and initial slow growth, it suffers due to infestation of weeds, especially during rainy season. Wet soil conditions during rainy season in Vertisols do not permit mechanical weeding to create weed-free conditions. Hence, use of herbicides has become a necessary practice to reduce the weed menace during early growth stages of sunflower. However, neither herbicides nor cultivations are adequate for consistent and acceptable weed control. Thus integrated weed management is gaining importance in management of weeds for preventing losses and higher input efficiency in sunflower. When herbicides are applied to soils, they generally disturb the natural ecosystem through their effects on soil microbial and enzymatic activities. Application of herbicides is known to have side effects on soil enzymes. Keeping these issues in view, the present experiment was conducted to find out the effect of weed control measures on weeds, nutrient uptake, yield and soil enzymatic activity of sunflower in Vertisols.

MATERIALS AND METHODS

Field experiments were conducted during *khariif* season

of 2006 to 2007 for two consecutive years at Patancheru, Hyderabad (17° 35' N latitude, 78° 15' E longitude and 545 m altitude), Andhra Pradesh on Vertisols. The experimental site was clay soil with a soil pH, organic carbon, available nitrogen, available phosphorus and potassium of 7.7, 0.51%, 228 kg/ha, 15 kg/ha and 772 kg/ha, respectively. 'KBSH 1' sunflower was grown in a randomized block design with 3 replications of 8 treatments. The plot was fertilized with 60:60:30 kg NPK through urea, single superphosphate and muriate of potash, respectively. The seeds of sunflower were hand dibbled with spacing of 60 cm×30 cm on ridges and furrows. The 8 treatments comprised pre-emergence application of pendimethalin (Stomp 30 EC) 1.5 kg/ha; imazethapyr (Pursuit 10 WP) 0.20 kg/ha as post-emergence at 15–20 days after sowing; pendimethalin 1.0 kg/ha, followed by imazethapyr 0.15 as post-emergence at 21–25 days after sowing; pendimethalin 1.0 kg/ha, followed by one intercultivation at 21–25 days after sowing; pendimethalin 1.0 kg/ha, followed by intercultivation at 21–25 days after sowing + hand weeding at 40–45 days after sowing, farmers' practice (1 hand weeding + 2 intercultivations) compared with weed-free check and unweeded control treatment. Weed population (at 45 days after sowing and at harvest) and weed drymatter (at harvest) were collected through pre-marked quadrats of 1 m² area. The weed counts were subjected to square root transformation ($\sqrt{x+1}$) to normalize the distribution. Weed control efficiency and weed index were also worked out to assess the efficiency of different weed-control treatments. Nitrogen, phosphorus and potassium

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contents were analyzed and their uptake were calculated from their respective elemental concentration and dry-matter accumulation at harvest. The soil samples were collected at 60 days after sowing synchronizing with maximum enzymatic activity for estimation of urease, dehydrogenase and phosphatase by following standard procedures. The data were analyzed according to randomized block design by standard ANOVA at $P \leq 0.05$ level of significance.

RESULTS AND DISCUSSION

Major weed flora

During the crop growth period, 15 weed species were found to be predominant that included 4 monocots, viz *Cyperus rotundus* L. (purple nut sedge), *Cyperus iria* L. (umbrella sedge), *Cynodon dactylon* (L.) Pers. (bermuda grass), *Panicum repens* L. (torpedo grass) and 11 dicot species, viz *Acalypha indica* L. (Indian Acalypha), *Alysicarpus rugosus* (Willd) DC (rough chainpea), *Abutilon indicum* L. (Sweet) (Indian Abutilon), *Cyanotis axillaris* L. (Sweet) (spreading dayflower), *Convolvulus arvensis* L. (Field bindweed), *Digera arvensis* Forssk. (Kanjero), *Euphorbia hirta* L. (hairy spurge), *Merrimeia emarginata* Burm.f. (kidney leaf morning glory), *Phyllanthus madraspatensis* L. (Madras leafglory), *Parthenium hysterophorus* L. (carrot grass) and *Xanthium strumarium* L. (Cocklebur).

Total weed population and weed dry matter

The pooled analysis showed significantly, the highest total weed population in unweeded control (138/m² at 45 days after sowing and 157/m² at harvest), while the lowest weed population (29/m² at harvest) was recorded with application

of pendimethalin 1.0 kg/ha, followed by intercultivation at 21–25 days after sowing + hand weeding at 40–45 days after sowing this was followed by pendimethalin 1.0 kg/ha, followed by imazethapyr 0.15 as post-emergence spray where in the weed population was controlled to a great extent.

Significantly higher weed dry matter (207 g/m²) was recorded in unweeded control. Application of different herbicides either in combinations or alone resulted in reduction of weed dry matter; higher weed control efficiency and lowest weed index compared to unweeded control (Table 1). Weed dry matter is a better parameter to measure the competition than the weed number. Application of pendimethalin + intercultivation + hand weeding provided higher weed control efficiency (81.6%) lower weed dry matter (38.3 g/m²) and weed Index (6.0). The weed control efficiency among different treatments varied between 47 and 100%. The pooled weed index among different treatments was found to be in the range of 6–48.2 (Table 1). Weed index is the reduction in crop yield due to presence of weeds in comparison with weed-free check, which is an ideal parameter to judge the effectiveness of herbicide. This was found to be less with application of pre-emergence application of pendimethalin, followed by intercultivation and hand weeding, indicating their effectiveness in controlling weeds. Similar observations were reported by Channappagoudar *et al.* (2008) in rainy season sunflower.

Nutrient removal by weeds

Significantly, the highest nutrient removal (N, P, and K) was recorded in unweeded control. On an average, weeds removed 39 kg N/ha, 8 kg P/ha and 53 kg K/ha in unweeded control. Application of different weed control treatments

Table 1 Total weed population, weed drymatter and nutrient removal by weeds as influenced by different weed control measures in *kharif* sunflower (pooled mean of 2 years)

Treatment	Time of application	Total weed population no./m ²		Weed drymatter (g/m ²)	Weed control efficiency (%)	Weed Index	Nutrient removal by weeds (kg/ha)		
		45 DAS	Harvest				N	P	K
Pendimethalin 1.5 kg	Pre-emergence	34.8 (5.9)	47.5 (6.7)	60.7	70.4	33.5	13.4	2.22	13.5
Imazethapyr 0.20 kg	Post-emergence	37.3 (6.2)	53.3 (7.3)	99.5	47.4	48.2	20.0	3.88	24.5
Pendimethalin 1.0 kg fb Imazethapyr 0.15	Pre-emergence, followed by post-emergence	22.3 (4.8)	39.5 (6.2)	72.0	64.6	31.1	13.3	2.68	16.2
Pendimethalin 1.0 kg fb IC	Pre-emergence	28.7 (5.2)	43.3 (6.5)	63.8	68.9	16.4	13.6	2.14	13.7
Pendimethalin 1.0 kg fb IC + HW at 45 DAS	Pre-emergence	16.3 (3.9)	29.2 (5.4)	38.3	81.6	6.0	7.7	1.30	8.56
Farmers' practice		30.7 (5.7)	47.1 (6.9)	85.0	59.5	31.0	19.4	3.0	20.0
Weed free		0 (1.0)		5.05	100		0.0	0.0	0
Unweeded control		138 (11.8)	156.9 (12.5)	207			39.2	8.0	53.0
CD ($P=0.05$)		22.8 (2.1)	25.6 (1.5)	27.4				1.04	6.5

Figures in the parentheses are square root ($\sqrt{x+1}$) transformed values

Fb, followed by; IC, intercultivation at 21–25 days; H W, hand weeding at 40–45 days

significantly reduced the uptake of these nutrients tilting the balance in favour of sunflower crop. Application of pendimethalin, followed by intercultivation + hand weeding removed lowest quantities of nutrients (7.7 kg N/ha, 1.3 kg P/ha and 8.6 kg K/ha) and offered least competition for nutrients (Table 1).

Performance of sunflower as influenced by different weed control measures

The pooled analysis showed plant height was significantly more (181 cm) when sunflower crop was grown under weed-free environment this was at par with application of pendimethalin 1.0 kg, followed by intercultivation (176 cm). Significantly shorter plants (160 cm) were produced when the crop was grown under unweeded conditions. The head

diameter was found to be significant due to different weed control treatments and it was found to be larger when sunflower was grown under weed-free treatment (15.7 cm), followed by application of pendimethalin as pre-emergence spray.

The seed and stalk yield of sunflower was significantly influenced due to different weed control treatments. The pooled analysis showed highest seed yield was recorded in weed-free check (2 451 kg/ha), which was at par (2 308 kg/ha) with application of pendimethalin 1.0 kg/ha, followed by intercultivation + hand weeding treatment. The lowest seed yield (1 079 kg/ha) was found with unweeded control. The stalk yield and 1000-seed weight also followed similar trend as that of seed yield (Table 2). These treatments resulted in better control of weeds and provided weed-free condition

Table 2 Performance of sunflower as influenced by different weed control measures (pooled mean of 2 years)

Treatment	Time of application	Plant height (cm)	Head diameter (cm)	Seed yield (kg/ha)	Stalk yield (kg/ha)	1 000-seed weight (g)
Pendimethalin 1.5 kg	Pre-emergence	175	15.3	1 628	3 137	49.7
Imazethapyr 0.20 kg	Post-emergence	168	12.7	1 263	2 171	40.8
Pendimethalin 1.0 kg fb	Pre-emergence,	172	14.6	1 677	2 999	50.7
Imazethapyr 0.15	followed by post-emergence					
Pendimethalin 1.0 kg fb I.C	Pre-emergence	176	15.0	2 051	3 590	50.4
Pendimethalin 1.0 kg fb I.C + HW at 45 DAS	Pre-emergence	176	15.2	2 308	4 066	51.6
Farmers' practice		176	14.9	1 781	3 205	48.2
Weed free		181	15.7	2 451	4 118	52.9
Unweeded control		160	13.0	1 079	1 954	35.9
CD ($P=0.05$)		7.4	1.8	347	442	4.1

Fb, Followed by IC, intercultivation at 21–25 days; H W, hand weeding at 40–45 days

Table 3 Nutrient uptake (kg/ha) by sunflower as influenced by different weed control measures (pooled mean of 2 years)

Treatment	Time of application	N uptake			P uptake			K uptake		
		Stalk (kg/ha)	Seed (kg/ha)	Total (kg/ha)	Stalk (kg/ha)	Seed (kg/ha)	Total (kg/ha)	Stalk (kg/ha)	Seed (kg/ha)	Total (kg/ha)
Pendimethalin 1.5 kg	Pre-emergence	24.9	33.5	58.4	3.6	9.16	12.8	127.4	22.5	149.8
Imazethapyr 0.20 kg	Post-emergence	16.6	24.8	41.4	2.59	6.94	9.5	85.4	16.9	102.3
Pendimethalin 1.0 kg fb	Pre-emergence,	22.6	35.9	58.4	3.65	9.69	13.4	116.5	21.9	138.5
Imazethapyr 0.15	followed by post-emergence									
Pendimethalin 1.0 kg fb IC	Pre-emergence	27.7	44.2	71.9	4.45	11.6	16.2	141.5	26.6	168.4
Pendimethalin 1.0 kg fb IC + HW at 45 DAS	Pre-emergence	32.9	51.1	84	5.18	13.2	18.4	161	30.9	192.7
Farmers' practice		22.3	38.3	60.6	3.88	10.0	13.9	114	24.5	138.5
Weed free		34.6	56.8	91.4	5.27	13.8	19.0	163	32.9	195.6
Unweeded control		12.2	20.2	32.3	2.06	5.26	7.32	74.2	14.1	88.3
CD ($P=0.05$)		3.9	7.3		0.59	1.9		19.2	3.32	

Fb, Followed by; IC, intercultivation at 21–25 days; HW, hand weeding at 45 days

for longer period of crop growth and resulted in increased plant height, yield attributing characters and yield. The performance of sunflower was affected due to application of post-emergence application of imazethapyr leading to smaller head diameter, lower seed yield, stalk weight and 1000-seed weight among different weed control treatments. In unweeded control, the crop was adversely affected by weeds due to heavy competition with crop for moisture, nutrients, space and light which can be attributed for suppressed crop growth. This confirms the result of Channappagoudar *et al.* (2008). In sunflower keeping the plots weed-free up to 40

days had shown beneficial effect on seed yield of sunflower (Wanjari *et al.* 2001).

Nutrient uptake by crop

The pooled data on nutrient uptake (N, P and K) by stalks, seed of sunflower was significantly influenced due to different weed control measures. The total (stalk + seed) N uptake was found to be the highest (91.4 kg/ha) in weed-free check and application of pendimethalin, followed by intercultivation + hand weeding (84 kg/ha), pendimethalin + intercultivation (71.9 kg/ha). The lowest total N uptake

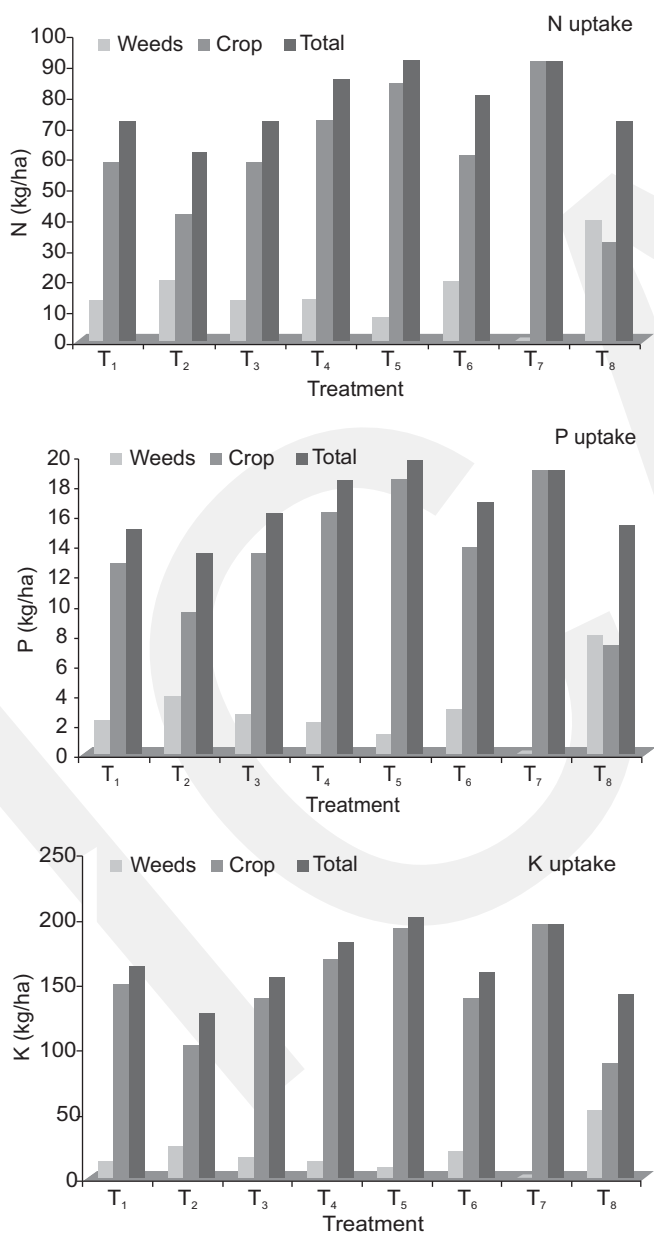


Fig 1 Nutrient uptake by sunflower and associated weeds as influenced by different weed control treatments (mean of 2 years)

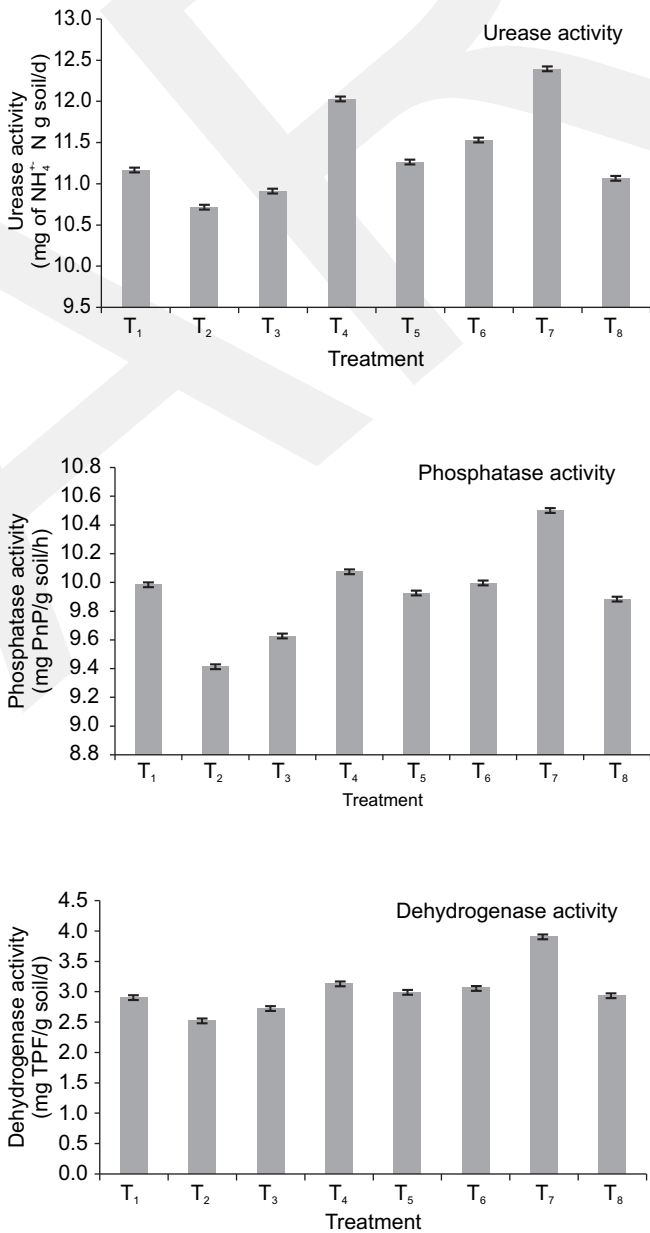


Fig 2 Soil enzymatic activity as influenced by weed control treatments in sunflower under vertisols

(32.3 kg/ha) was found in unweeded control, followed by post-emergence application of imazethapyr (41.4 kg/ha). The nutrient uptake of P and K nutrients by stalk, seed and total followed similar pattern as that of total N uptake (Table 3).

The summary of nutrient uptake by crop and weeds are presented in Fig 1. The worst scenario of crop-weed competition for nutrients was noticed in unweeded control (T₈) where in the weeds were successful in competing with sunflower in removing higher quantities (32 kg N/ha; 7.3 kg P/ha) of nutrients depriving the sunflower crop its due share of nutrients resulting in lower test weight and yield of sunflower. The ideal situation was found with weed-free (T₇) situation where in the nutrient uptake by weeds was nil and the sunflower crop utilized full share of nutrients (91 kg N/ha; 19 kg P/ha and 196 kg k/ha). Similarly, the nutrient uptake by weeds was bare minimum in T₅ (pendimethalin 1.0 kg fb intercultivation + hand weeding) and T₄ (pendimethalin 1.0 kg fb one intercultivation) providing congenial conditions for the crop to grow. Application of pendimethalin 1.0 kg, followed by intercultivation + hand weeding (T₅ 84 kg N/ha; 18.4 kg P/ha and 193 kg k/ha) recorded similar trends of higher nutrient uptake as that of most ideal situation. In general, the nutrient uptake of sunflower was low in treatments where imazethapyr was applied as post-emergent spray due to lower dry matter production of crop in this treatment. During the present study, unchecked weed growth reduced the sunflower yield to the tune of 56% compared to weed-free check. Higher yield in weed-free check, pendimethalin treatments may be attributed to their low weed population, lesser weed dry matter, low weed index high weed control efficiency and higher nutrient uptake. Weed index is the reduction in crop yield due to presence of weeds in comparison with weed-free check, which is an ideal parameter to judge the effectiveness herbicide. This is less in pendimethalin treatments, indicating their effectiveness in controlling weeds. Similar observations were reported by Channappagoudar *et al.* (2008). The lower yields in imazethapyr treatments could be due to its phytotoxic effect

on crop to some extent resulting in reduced plant height, head diameter and reduced yields.

Herbicides vs soil enzymes

Urease enzyme is involved in hydrolytic cleavage of urea to nitrogen and hence is one of the most important soil enzymes. Dehydrogenase activity is an indication microbial activity in soils. In the present investigation, there was marked inhibition of three soil enzymes (urease, phosphatase and dehydrogenase) with the application of pre and post-emergence herbicides, viz pendimethalin and imazethapyr at higher doses alone (T₁, T₂) and in combination (T₃) compared to control (T₇ and T₈). Application of lower doses of pendimethalin 1.0 kg, followed either by intercultivation (T₄) and hand weeding (T₅) maintained favourably higher activity of soil enzymes similar to that of weed-free situation (T₇). A lower dose of pre-emergence application of herbicides, followed by soil working was found to enhance the porosity of soils leading to improved aeration and higher microbial activity. Intensive use of herbicides without adequate knowledge on its effects on soil enzymes may have adverse impact on soil-bio-chemical processes and nutrient cycling. Similar observations were reported by Ramesh *et al.* (2000) in soybean (Fig 2).

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