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EFFECT OF WEED MANAGEMENT PRACTICES ON GROWTH AND DEVELOPMENTAL INDICES OF SUNFLOWER (*Helianthus annuus* L.)

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ABSTRACT
A field experiment was conducted during *Kharif* 2014 at AICRP on sunflower, ZARS, UAS, GKVK, Bengaluru to evaluate the integration of pre and post-emergence herbicides and cultural practices for weed management in sunflower (*Helianthus annuus* L.)" in red sandy loam soil. The experiment consisted of nine treatments laid out in randomized block design replicated thrice. 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. The study revealed that significantly higher growth and developmental indices and also higher yield were observed in farmers practice 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 when compared to weed free.

KEY WORDS: Growth, Growth indices, Yield, Sunflower.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crop. It is considered as an economic and nutritious crop containing oil which is very essential in human diet. Weeds are considered serious problem because compete for water, nutrients, light and space that reduce crop growth and yield (Lehoczky and Reisinger, 2006). The reduction in sunflower yield due to weed competition ranges from 18.6 to 36.3% (Saudy and Ei-Metwally, 2009). Weed management is an important component of successful sunflower production. Sunflower is usually planted at low densities and grows slowly during the first several weeks. Therefore, maintaining a weed-free condition for the first 4 to 6 weeks will minimize weed competition and maximize yields (Krishnegowda *et al*., 1985).The conventional method of weed control is laborious, inefficient and costly. Hence, neither herbicide nor cultivation practices are adequate for consistent and acceptable weed control. Therefore integrated weed management is the best for higher productivity, using pre and post-emergence herbicides in combination with hand weeding or inter-cultivation with implements.

MATERIALS & 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 58 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 X 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.

The data on weed density and weed dry weight were subjected to log (x+2) transformation. Then the experimental data on weed growth and yield were subjected to analysis by using Fisher's method of Analysis of Variance (ANOVA) Gomez and Gomez (1984). The levels of significance used in *F* and *t* test was at $p = 0.05$.The formulae for calculating leaf area index, leaf area duration, absolute growth rate and crop growth rate are detailed below.

Leaf Area Index (LAI)

$$LAI = \frac{\text{Leaf area (cm}^2\text{ plant}^{-1})}{\text{Spacing (cm}^2\text{ plant}^{-1})}$$

Leaf Area Duration (LAD) (days)

$$LAD = \frac{Li+(Li+1)}{2} \times t_2 - t_1$$

Where,

Li= LAI at ith stage

Li+1 = LAI at (i+1)th stage

$t_2 - t_1$ = time interval between Li+1 and Li stage

Absolute Growth Rate (AGR) (g plant^{-1} day^{-1})

$$AGR = \frac{(W_2-W_1)}{(t_2-t_1)}$$

Where, W_2 and W_1 are the plant dry weight (g) recorded at the time t_2 and t_1 (days), respectively.

Crop Growth Rate (CGR) (g dm^{-2} day^{-1})

$$CGR = \frac{(W_2-W_1)}{(t_2-t_1) \text{ x spacing}}$$

Where, W_2 and W_1 are the plant dry weight (g) recorded at the time t_2 and t_1 (days), respectively.

RESULTS & DISCUSSION

Growth and developmental indices

Among different treatments, significantly higher plant height at 60 DAS was recorded with farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (93.22cm) 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 (86.86 cm) which was on par with weed free (Three HW at 15, 30 and 45 DAS) (90.68 cm) as a result of effective control and suppression of weeds as compared to other treatments and unweeded control (Table 1). The difference in plant height in the present study was attributed to weed competition in sunflower plant as reported by Krishnagowda *et al*. (1985) and Smita Prachand *et al*. (2014).

The total dry matter production is a result of cumulative and complementary effect of plant height and leaf area. The total dry matter production by sunflower plant at 30 and 60 DAS (Table-1) (Fig. 2) was significantly higher in farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (8.67 and 61.67 g plant^{-1}, respectively) followed by 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 (7.82 and 58.51 g plant^{-1}, respectively) and weed free (Three HW at 15, 30 and 45 DAS) (7.88 and 60.81 g plant^{-1}, respectively). The increased dry matter production might be due to better control of weeds resulting in higher leaf area and better photosynthesis. The total dry matter production of crop during the growth period is important for determining the economic yield. Whereas, the lowest total plant dry weight was recorded in unweeded control (2.59 and 41.31 g plant^{-1}, respectively) this might be attributed to severe competition of weeds with crop for growth factors especially shading of crop by weeds lead to lower photosynthates production and consequently restricted the development of the crop. These results are in line with Kushwah and Vyas (2006).

The leaf area at 30 and 60 DAS was significantly higher in farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) (771.8 and 3708 cm^2, respectively) followed by pendimethalin 38.7CS 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 (700.5 and 3442 cm^2, respectively) and weed free check(Three HW at 15, 30 and 45 DAS)(752.4 and 3560 cm^2, respectively) (Table 1) (Fig. 1) and this may be due to effective control of weeds from initial stages of sunflower crop growth leading to lower weed competition ultimately leading to significantly higher leaf area plant^{-1}. Whereas the lowest leaf area plant^{-1} was observed in unweeded control (407.2 and 2069 cm^2, respectively) due to uncontrolled weed growth offering severe competition as also reported by Sankpal and Mahalle (1991) and Poonguzhalan (1993).

Different weed management practices did not influenced the days for 50 % flowering. Among different treatments, significantly higher number of days taken for 50% flowering was observed in unweeded control (70.33) when compared to all other treatments. Among different treatments, significantly higher number of days taken for physiological maturity was observed in unweeded control (94.67 days) when compared to all other treatments.

Yield

Among different treatments, farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS) recorded significantly higher seed yield (1888 kg ha^{-1}). Among herbicides treatments, significantly higher seed yield was 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 directed POE on weeds (1795 kg ha^{-1}) which was on par with weed free check (Three HW at 15, 30 and 45 DAS) (1824 kg ha^{-1}) (Table 2) (Fig 1).

The higher yield was due to improvement in growth attributes (Table 1) and indices (Table 2) such as LAI (0.429, 2.060) , LAD (37.33 days), AGR (1.77 g day^{-1}) and CGR (9.81 g m^{-2} day^{-1}) at 30 and 60 DAS owing to minimum crop-weed competition throughout the crop growth period. As a result of this, sunflower showed maximum utilization of nutrients, moisture, light and space which had influenced the growth and yield. The improvement in yield components was inturn due to improved growth attributes such as higher total dry matter production, leaf area index, leaf area duration and better nutrient uptake by the crop.

TABLE 1: Total dry weight, Leaf Area and Leaf Area Index, Leaf Area Duration (days), Absolute Growth Rate (g plant $^{-1}$ day^{-1}) and Crop Growth Rate (g m^{-2} day^{-1}) of sunflower as influenced by different weed management practices.

Treatments	Total dry weight (g plant^{-1})		Leaf area (cm^2 plant^{-1})		Leaf area index		LAD	AGR	CGR
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30-60 DAS		
T_1	4.08	49.02	565.8	2182	0.314	1.212	22.90	1.50	8.32
T_2	6.70	52.13	693.9	2772	0.385	1.540	28.88	1.51	8.41
T_3	7.82	58.51	700.5	3442	0.389	1.912	34.52	1.69	9.39
T_4	5.90	51.45	586.0	2236	0.326	1.242	23.52	1.52	8.44
T_5	5.65	49.74	572.3	2236	0.318	1.242	23.41	1.47	8.16
T_6	3.32	45.72	511.1	2182	0.284	1.212	22.45	1.41	7.85
T_7	8.67	61.67	771.8	3708	0.429	2.060	37.33	1.77	9.81
T_8	7.88	60.81	752.4	3560	0.418	1.978	35.94	1.76	9.80
T_9	2.59	41.31	407.2	2069	0.226	1.149	20.63	1.29	7.17
S.Em±	0.28	1.79	25.83	113.8	0.01	0.06	1.02	0.06	0.34
CD (p=0.05)	0.85	5.37	77.44	341.2	0.04	0.19	3.05	0.19	1.03

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.
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

TABLE 2: Days taken to 50 % flowering, physiological maturity and seed yield (kg ha^{-1}) of sunflower as influenced by different weed management practices

Treatments	50 % flowering	Physiological maturity	Seed yield
T_1: Pendimethalin 38.7 CS at 0.75 kg a.i. ha^{-1} as PE	68.33	94.66	1396
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	68.00	90.33	1653
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	69.33	90.00	1795
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	69.33	91.67	1573
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	68.00	91.67	1475
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	68.00	94.33	1260
T_7: Farmers practice (Two IC at 20 and 40 DAS + one HW at 30 DAS)	69.33	89.67	1888
T_8: Weed free (Three HW at 15, 30 and 45 DAS)	69.00	90.00	1824
T_9: Unweeded control	70.33	94.67	1021
S.Em±	0.11	0.12	76.64
CD (p=0.05)	NS	0.35	229.7

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

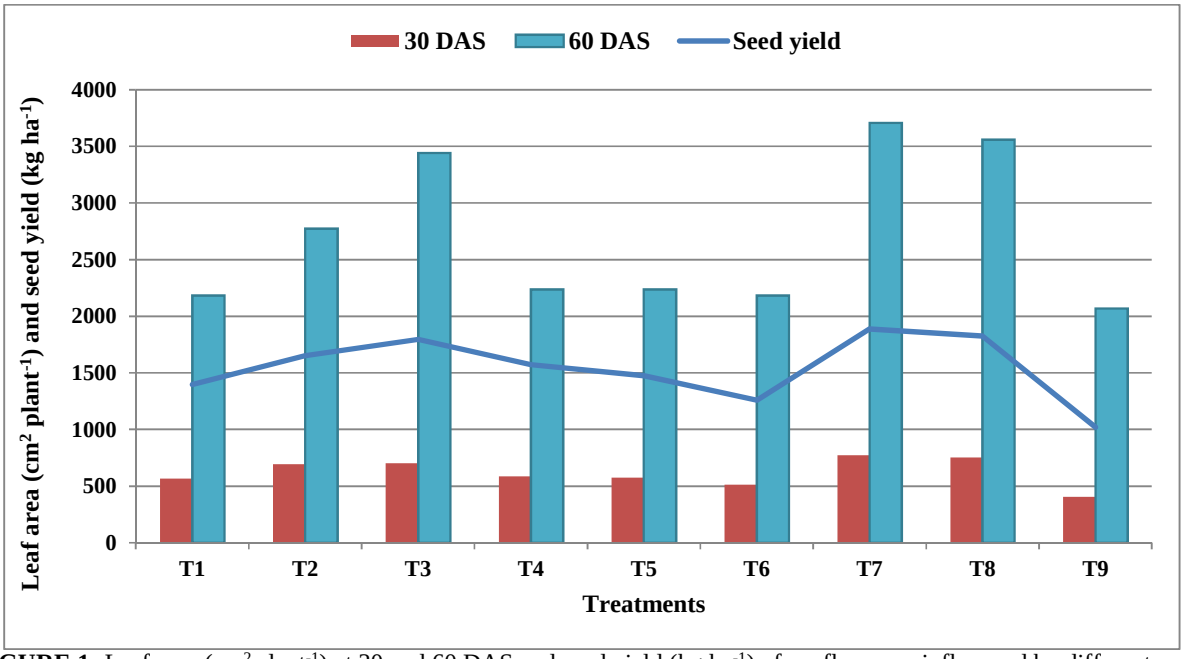

FIGURE 1: Leaf area (cm^2 $plant^{-1}$) at 30 and 60 DAS and seed yield (kg ha^{-1}) of sunflower as influenced by different weed management practice

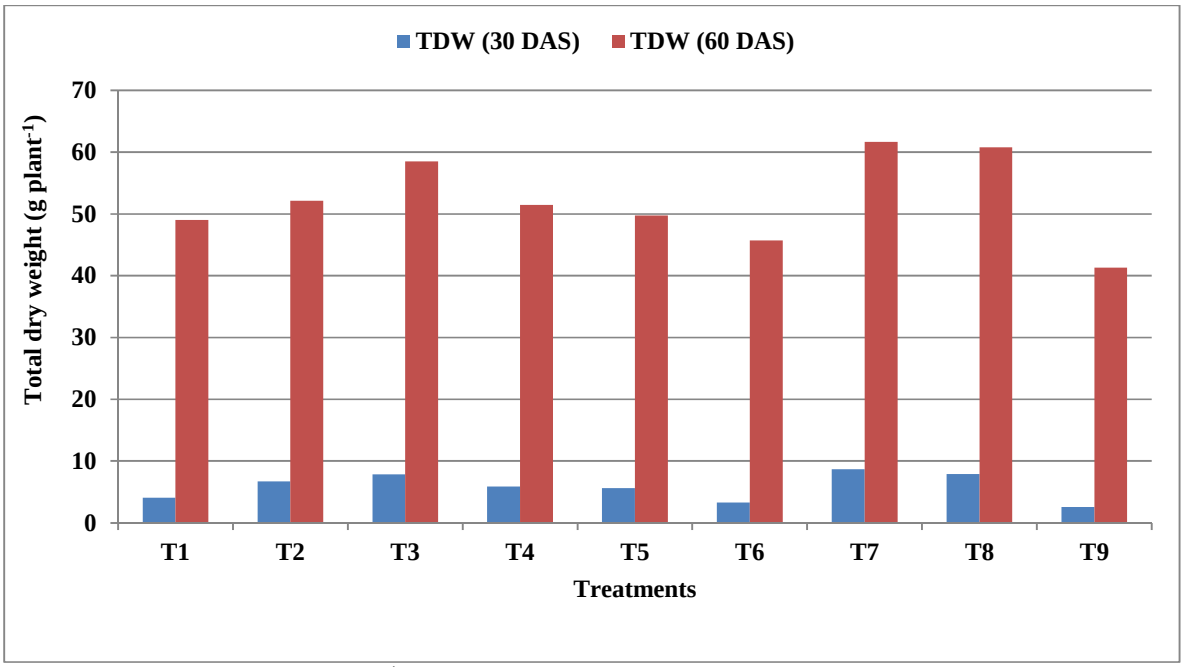

FIGURE 2: Total dry weight (g $plant^{-1}$) of sunflower at 30 and 60 DAS as influenced by different weed management practices

CONCLUSION

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 most efficient weed management practice for obtaining higher growth and developmental indices and also higher yield in sunflower

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