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Study on effect of weed management practices on weed dynamics and productivity of *kharif* maize

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Abstract

Field trials were conducted at Agricultural College and Research Institute, TNAU, Coimbatore, Tamilnadu, India, during two consecutive *kharif* (rainy) seasons of 2018 and 2019. The experiment was laid in a randomized block design different weed control methods viz., pre emergence (PE) atrazine at 0.5 kg a.i. ha⁻¹ fb hand weeding (HW) at 20 DAS, PE atrazine at 0.5 kg a.i. ha⁻¹ fb power weeder (PW) at 20 DAS, PE atrazine at 0.5 kg a.i. ha⁻¹ + pendimethalin at 1 kg a.i. ha⁻¹ (Tank mix), PE atrazine at 0.5 kg a.i. ha⁻¹ + pendimethalin at 1 kg a.i. ha⁻¹ fb HW at 20 DAS, early post emergence (EPOE) topamezone at 25.2 g a.i. ha⁻¹, PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE topamezone at 25.2 g a.i. ha⁻¹, EPOE tembotrione at 122 g a.i. ha⁻¹, PE atrazine 0.5 kg a.i. ha⁻¹ fb EPOE tembotrione 122 g a.i. ha⁻¹, hand weeding twice at 20 and 40 DAS and control (weedy check) with 3 replications for each treatment. The results revealed that the experimental field was infested with all categories of weeds including grasses, broad-leaved weeds and sedges. Among them the most predominant weeds were *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Echinochloa colona*, *Amaranthus viridis*, *Digera arvensis* and *Trianthema portulacastrum*. Among the chemical weed control methods PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE topamezone at 25.2 g a.i. ha⁻¹ and PE atrazine 0.5 kg a.i. ha⁻¹ fb EPOE tembotrione 122 g a.i. ha⁻¹ recorded significantly lower weed density as well as weed dry weight of BLW, grasses, sedges and total weed at 90 DAS during 2018 and 2019, respectively. As a consequence of effective weed control, the above treatments recorded significantly higher weed control efficiency (WCE) and lower weed index (WI) during 2018 and 2019, at 90 DAS. These treatments were statistically comparable with hand weeding twice at 20 and 45 DAS. Uncontrolled weed growth in control (weedy check) recorded higher weed density and weed dry matter in maize crop during both the years of experimentation.

Keywords: Pre emergence herbicide, early post emergence herbicide, weeds control efficiency and weed index

Introduction

Maize is the third largest cereal crop after rice and wheat with regard to area and production in India. There are numerous reasons for lower production of maize in our country. Among them, weed infestation in maize is the key detrimental factor causing huge grain yield loss, because of slow initial crop growth and wide row spacing along with frequent rains during rainy season. Crop yield loss was recorded up to 90% depending upon weed flora and density when weed species reaches above the critical population thresholds [1, 2]. Now-a-days, the scarcity of labour is increasing in agriculture. Management of weeds especially during critical stages in cropped field has become a real challenge to the farmers.

Herbicides are used to control weed growth and harvest 150% grain yield than the weedy check in maize. Few herbicides viz., atrazine, pendimethalin, 2, 4-D and oxyfluorfen are widely used for weed control in maize crop. Among herbicides, farmers are applying mostly atrazine at 1 kg ha⁻¹ in maize, because of application flexibility (both pre and post emergence herbicide), lower cost, broad spectrum nature and compatibility with various herbicide mixtures [3]. However, the repeated application of same herbicide causes shift in weed flora and development of resistance in weeds. Globally, 45 weed species across many maize growing regions have exhibited resistance against photosystem II (PSII) inhibitor herbicides, viz., atrazine [4]. This necessitates, having herbicides with alternative modes of action herbicides in maize to reduce the risk of evolution of herbicide resistance in weeds.

Topamezone and tembotrione are HPPD (p-hydroxyphenylpyruvate dioxygenase) enzyme inhibitors which control major annual dicot weeds with lesser impact against monocot weed [5].

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It also acts as alternative to control weeds which developed resistance to triazine. These enzyme inhibitor herbicides are being preferred by corn growers due to their broad spectrum weed control, better crop tolerance and compatibility of herbicide mixture (tank mix). It provides early post emergence weed control. PS II and HPPD enzyme inhibitor also effectively control glyphosate resistance weeds [6]. Furthermore, the usage of herbicides having independent mode of action either in tank-mix combination or rotation, drastically delays the emergence of new flush of weeds [7]. Mostly farmers adopt manual weeding only after sufficient weed growth. It is essential to remove the early flush of weeds at right time. For this, the pre-emergence herbicides can be used thereby the maize fields will be weed free in the first 30-35 days of crop growth. But farmers are unable to apply pre-emergence herbicides at time of sowing, since they give priority on completion of sowing. Moreover, there is acute shortage of labour even for sowing operation. Hence, there is need to use early post emergence herbicides, which can be conveniently applied after 15 to 20 days of sowing when the sowing is over. Hence, a field trial was conducted to evaluate different weed management practices (Integrated weed management) in maize under assured rainfall conditions.

Material and Methods

Field trials were carried out during two consecutive *kharif* (rainy) season of 2018 and 2019 at Agricultural College and Research Institute, Coimbatore, TNAU, Tamilnadu, India. The soil was sandy clay loam having pH (8.4, 8.2) and organic carbon content (0.34%, 0.38%) during 2018 and 2019, respectively. Ten weed control treatments (Table 1) evaluated were: T₁-PE (pre emergence) atrazine at 0.5 kg a.i. ha⁻¹ *fb* hand weeding (HW) at 20 DAS, T₂-PE atrazine at 0.5 kg a.i. ha⁻¹ *fb* power weeder (PW) at 20 DAS, T₃-PE atrazine at 0.5 kg a.i. ha⁻¹ + pendimethalin at 1 kg a.i. ha⁻¹ (Tank mix), T₄-PE atrazine at 0.5 kg a.i. ha⁻¹ + pendimethalin at 1 kg a.i. ha⁻¹ (Tank mix) *fb* HW at 20 DAS, T₅-EPOE (Early post emergence) topramezone at 25.2 g a.i. ha⁻¹, T₆-PE atrazine at 0.5 kg a.i. ha⁻¹ *fb* EPOE topramezone at 25.2 g a.i. ha⁻¹, T₇-EPOE tembotrione at 122 g a.i. ha⁻¹ and T₈-PE atrazine at 0.5 kg a.i. ha⁻¹ *fb* EPOE tembotrione at 122 g a.i. ha⁻¹ and T₉-control, T₁₀-hand weeding twice at 20 and 45 DAS. All the herbicides were applied as pre emergence (PE) and early post emergence (EPOE) using knapsack sprayer having flat fan nozzles delivering 500 litres of water ha⁻¹.

Each treatment was replicated thrice and tested in randomized block design. Maize hybrid 'COH (M) 6' was sown during second and first week of July during 2018 and 2019, respectively having 60 cm row to row spacing and 25 cm plant to plant spacing. Immediately after sowing of the seeds, a light irrigation was given to the crop for uniform germination and next day herbicide was sprayed as per the treatment. Gap filling and thinning were done at 10-12 DAS to maintain uniform plant stand. Fertilizer (250:75:75 kg N P₂O₅ K₂O ha⁻¹) and irrigation were applied and cultivation practices were followed according to recommended package of practice for maize. Phosphorus and potash were applied at sowing time. Nitrogen was applied in three splits, at sowing, knee high and tasselling stage. The crop was manually harvested in the third week and second week of October during 2018 and 2019, respectively and threshing was done using maize thresher.

Data on weed density (No. m⁻²) and dry weight (g m⁻²) at 90 DAS (at harvest) were recorded randomly at four spots in each treatment plot using a quadrat of 0.5 m x 0.5 m. For dry

weight, weed samples were dried at 70°C till a constant weight was obtained. Prior to statistical analysis weed data were subjected to square root transformation $\sqrt{X + 0.5}$ to normalize their distribution. All the data obtained in the study were statistically analysed using F-test and CD values at P=0.05 were used to determine the significance of difference between treatments [8]. Based on total weed dry weight, weed control efficiency (WCE) was computed by using the formulae [9]. Weed index (WI) was computed by using the formulae [10]. All the indices are expressed in percentage.

$$\text{Weed control efficiency} = \frac{\text{WDM}_c - \text{WDM}_t}{\text{WDM}_c} \times 100$$

Where

WDM_c = Weed dry weight (g m⁻²) in control plot

WDM_t = Weed dry weight (g m⁻²) in treated plot

$$\text{weed index} = \frac{X - Y}{X} \times 100$$

Where

X = Yield from minimum weed competition plot

Y = Yield from the treatment plot

Results and Discussion

Weed flora

In experimental field, major weed species associated with maize crop were *Amaranthus viridis* Hook. F. *Boerhavia diffusa* L. *Corchorus olitorius* L. *Digera arvensis* Fross K. *Euphorbia hirta* L. *Parthenium hysterophorus* L. *Phyllanthus niruri* L. *Trianthema portulacastrum* L. *Sida acuta* Burm. F. among broad leaved weed (BLW); *Cynodon dactylon* (L.) Pers., *Dactyloctenium aegyptium* (L.) Willd., *Dinebra retroflexa* (Vahl.) Panzer., *Echinochloa colona* (L.) Link. among grasses and *Cyperus rotundus* L. in sedges.

Weed density and weed dry weight

All the weed management practices significantly affected the density and dry weight of BLW, grasses, sedges and total weeds when compared to control during both the years of study (Table 1 and 2). Sedges were recorded only in second year (2019). Among the weed management practices, hand weeding twice at 20 and 45 DAS reduced the density and dry weight of BLW (12.66 No. m⁻², 18.02 g m⁻² and 14.33 No. m⁻², 18.26 g m⁻²), grasses (9.66 No. m⁻², 10.51 g m⁻² and 9.33 No. m⁻², 10.98 g m⁻²) sedges (0.33 No. m⁻², 0.42 g m⁻²) and total weed (22.32 No. m⁻² and 28.53 g m⁻²; 23.99 No. m⁻² and 29.66 g m⁻²) to a greater extent at 90 DAS during both the years of 2018 and 2019 which was statistically at par with PE atrazine at 0.5 kg a.i. ha⁻¹ *fb* EPOE topramezone at 25.2 g a.i. ha⁻¹ and PE atrazine at 0.5 kg a.i. ha⁻¹ *fb* EPOE tembotrione at 122 g a.i. ha⁻¹. The pre emergence application of atrazine at 0.5 kg a.i. ha⁻¹ found to controlled BLW effectively upto 20- 25 days and had little effect on grasses after its application. Late emerging weeds were effectively controlled by early post-emergence application of topramezone at 25.2 g a.i. ha⁻¹ and tembotrione 122 g a.i. ha⁻¹. Among the three categories of weeds, BLW was dominant and early post-emergence application of topramezone at 25.2 g a.i. ha⁻¹ was found effective in control of BLW. Hence PE atrazine at 0.5 kg a.i. ha⁻¹ *fb* EPOE topramezone at 25.2 g a.i. ha⁻¹ treatment recorded significantly lower density of weeds and weed dry weight [11]. While, the lower weed density and dry weight of

weeds were observed in hand weeding twice at 20 and 45 DAS due to season long weed removal and the highest was recorded in control (weedy check) due to uncontrolled weed growth.

Weed control efficiency

The crop yield is directly proportional to weed control efficiency. The weed control efficiency (Table 3) at 90 DAS was higher in hand weeding twice at 20 and 45 DAS, PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE topramezone at 25.2 g a.i. ha⁻¹ and PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE tembotrione at 122 g a.i. ha⁻¹ during both the years of study, PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE topramezone at 25.2 g a.i. ha⁻¹ and PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE tembotrione at 122 g a.i. ha⁻¹ were the best treatments among the herbicides treatments in terms of higher WCE^[12]. Other treatments were also found to control weed growth but it was lesser compared to PE

atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE topramezone at 25.2 g a.i. ha⁻¹ and PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE tembotrione at 122 g a.i. ha⁻¹ treatments during both years of investigation.

Weed index

Weed index is directly proportional to crop yield loss. Weed index (Table 3) was significantly higher in control treatment (47.61% and 49.58% in 2018 and 2019, respectively) which caused greater yield loss due to uncontrolled weed growth^[13]. Among the chemical weed control treatments, it was significantly higher in PE atrazine at 0.5 kg a.i. ha⁻¹ + pendimethalin at 1 kg a.i. ha⁻¹ (Tank mix) (23.76% and 24.90% in 2018 and 2019 respectively). Lower weed index was recorded in PE atrazine at 0.5 kg a.i. ha⁻¹ fb EPOE topramezone at 25.2 g a.i. ha⁻¹ (2.10% and 1.72% in 2018 and 2019, respectively) which was statistically comparable with hand weeding twice at 20 and 45 DAS.

Table 1: Effect of weed management practices on density of weeds (No. m⁻²) in maize at 90 DAS during *kharif* 2018 and 2019

Treatments		2018			2019			
		BLW	Grasses	Total	BLW	Grasses	Sedges	Total
T ₁ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb HW at 20 DAS	4.22 (17.33)	4.10 (16.33)	5.84 (33.66)	4.71 (21.66)	4.10 (16.33)	1.22 (1.00)	6.28 (38.99)
T ₂ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb power weeder at 20 DAS	5.11 (25.66)	5.21 (26.66)	7.27 (52.32)	5.58 (30.66)	5.76 (32.66)	1.47 (1.66)	8.09 (64.98)
T ₃ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ + pendimethalin 30% EC at 1 kg a.i. ha ⁻¹ (Tank mix)	6.04 (36.00)	5.70 (32.00)	8.28 (68.00)	5.76 (32.66)	6.28 (39.00)	1.58 (2.00)	8.61 (73.66)
T ₄ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ + pendimethalin 30% EC at 1 kg a.i. ha ⁻¹ (Tank mix) fb HW at 20 DAS	4.26 (17.66)	4.02 (15.66)	5.82 (33.32)	4.74 (22.00)	3.94 (15.00)	1.22 (1.00)	6.20 (38.00)
T ₅ :	EPOE topramezone 336 g/l SC at 25.2 g a.i. ha ⁻¹ at 20 DAS	4.30 (18.00)	4.14 (16.66)	5.93 (34.66)	4.81 (22.66)	4.22 (17.33)	1.35 (1.33)	6.47 (41.32)
T ₆ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb EPOE topramezone 336 g/l SC at 25.2 g a.i. ha ⁻¹ at 20 DAS	3.72 (13.33)	3.29 (10.33)	4.92 (23.66)	3.89 (14.66)	3.44 (11.33)	0.91 (0.33)	5.18 (26.32)
T ₇ :	EPOE tembotrione 420 SC at 122 g a.i. ha ⁻¹ at 20 DAS	4.38 (18.66)	4.22 (17.33)	6.04 (35.99)	4.85 (23.00)	4.26 (17.66)	1.35 (1.33)	6.52 (41.99)
T ₈ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb EPOE tembotrione 420 SC at 122 g a.i. ha ⁻¹ at 20 DAS	3.76 (13.66)	3.39 (11.00)	5.02 (24.66)	4.02 (15.66)	3.49 (11.66)	1.08 (0.66)	5.34 (27.98)
T ₉ :	Hand weeding twice at 20 and 45 DAS	3.63 (12.66)	3.19 (9.66)	4.78 (22.32)	3.85 (14.33)	3.14 (9.33)	0.91 (0.33)	4.95 (23.99)
T ₁₀ :	Control	8.39 (70.00)	5.93 (34.66)	10.25 (104.66)	7.84 (61.00)	6.34 (39.66)	1.68 (2.33)	10.17 (102.99)
SEd		0.07	0.15	0.12	0.07	0.17	0.06	0.16
CD (P=0.05)		0.19	0.34	0.32	0.19	0.37	0.17	0.43

Figure in parenthesis are original values, which were transformed $\sqrt{X + 0.5}$ and statistically analysed.

Table 2: Effect of weed management practices on weed dry weight (g m⁻²) in maize at 90 DAS during *kharif* 2018 and 2019

Treatments		2018			2019			
		BLW	Grasses	Total	BLW	Grasses	Sedges	Total
T ₁ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb HW at 20 DAS	5.01 (24.65)	4.35 (18.46)	6.60 (43.11)	5.38 (28.47)	4.42 (19.01)	1.57 (1.95)	7.07 (49.43)
T ₂ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb power weeder at 20 DAS	6.13 (37.06)	5.50 (29.74)	8.20 (66.80)	6.34 (39.67)	6.29 (39.04)	1.84 (2.87)	9.06 (81.58)
T ₃ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ + pendimethalin 30% EC at 1 kg a.i. ha ⁻¹ (Tank mix)	7.25 (52.12)	5.52 (30.01)	9.09 (82.13)	6.56 (42.50)	6.85 (46.47)	1.91 (3.16)	9.62 (92.13)
T ₄ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ + pendimethalin 30% EC at 1 kg a.i. ha ⁻¹ (Tank mix) fb HW at 20 DAS	5.03 (24.79)	4.22 (17.32)	6.53 (42.11)	5.34 (28.01)	4.25 (17.56)	1.62 (2.13)	6.94 (47.7)
T ₅ :	EPOE topramezone 336 g/l SC at 25.2 g a.i. ha ⁻¹ at 20 DAS	5.17 (26.18)	4.40 (18.85)	6.75 (45.03)	5.45 (29.25)	4.59 (20.54)	1.72 (2.45)	7.26 (52.24)
T ₆ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb EPOE topramezone 336 g/l SC at 25.2 g a.i. ha ⁻¹ at 20 DAS	4.46 (19.43)	3.45 (11.38)	5.60 (30.81)	4.42 (19.02)	3.64 (12.75)	1.23 (1.01)	5.77 (32.78)
T ₇ :	EPOE tembotrione 420 SC at 122 g a.i. ha ⁻¹ at 20 DAS	5.24 (27.00)	4.41 (18.91)	6.81 (45.91)	5.51 (29.91)	4.64 (21.06)	1.73 (2.50)	7.35 (53.47)
T ₈ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ fb EPOE tembotrione 420 SC at 122 g a.i. ha ⁻¹ at 20 DAS	4.53 (20.00)	3.56 (12.17)	5.72 (32.17)	4.52 (19.95)	3.68 (13.01)	1.33 (1.26)	5.89 (34.22)
T ₉ :	Hand weeding twice at 20 and 45 DAS	4.30 (18.02)	3.32 (10.51)	5.39 (28.53)	4.33 (18.26)	3.39 (10.98)	0.96 (0.42)	5.49 (29.66)
T ₁₀ :	Control	10.15 (102.54)	6.48 (41.54)	12.02 (144.08)	9.48 (89.34)	6.93 (47.53)	2.00 (3.52)	11.87 (140.39)

SEd	0.14	0.11	0.13	0.10	0.15	0.08	0.16
CD (P=0.05)	0.32	0.28	0.37	0.25	0.39	0.21	0.42

Figure in parenthesis are original values, which were transformed $\sqrt{X + 0.5}$ and statistically analysed.

Table 3: Effect of weed management practices on weed control efficiency (%) at 90 DAS and weed index (%) in maize during *kharif* 2018 and 2019

Treatments		Weed control efficiency		Weed index	
		2018	2019	2018	2019
T ₁ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ /b HW at 20 DAS	70.08	64.79	9.28	7.42
T ₂ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ /b power weeder at 20 DAS	53.64	41.89	20.31	21.96
T ₃ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ + pendimethalin 30% EC at 1 kg a.i. ha ⁻¹ (Tank mix)	43.00	34.38	23.76	24.90
T ₄ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ + pendimethalin 30% EC at 1 kg a.i. ha ⁻¹ (Tank mix) /b HW at 20 DAS	70.77	66.02	7.59	6.71
T ₅ :	EPOE topramezone 336 g/l SC at 25.2 g a.i. ha ⁻¹ at 20 DAS	68.75	62.79	13.51	10.93
T ₆ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ /b EPOE topramezone 336 g/l SC at 25.2 g a.i. ha ⁻¹ at 20 DAS	78.62	76.65	2.10	1.72
T ₇ :	EPOE tembotrione 420 SC at 122 g a.i. ha ⁻¹ at 20 DAS	68.14	61.91	14.47	11.15
T ₈ :	PE atrazine 50% WP at 0.5 kg a.i. ha ⁻¹ /b EPOE tembotrione 420 SC at 122 g a.i. ha ⁻¹ at 20 DAS	77.67	75.63	3.69	2.93
T ₉ :	Hand weeding twice at 20 and 45 DAS	80.20	78.87	0.00	0.00
T ₁₀ :	Control	0	0	47.61	49.58

Data not statistically analysed.

Conclusion

Based on findings from the present investigation, use of sequential application of herbicides as pre emergence (atrazine at 0.5 kg a.i. ha⁻¹) followed by early post emergence (topramezone at 25.2 g a.i. ha⁻¹ or tembotrione at 122 g a.i. ha⁻¹) was effective in controlling weeds in maize as compared to application of either topramezone or tembotrione alone, which was comparable with hand weeding twice at 20 and 45 DAS.

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