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Effect of weed control methods on growth and yield of maize in western zone of Tamil Nadu

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Abstract
Field trials were conducted at Department of Agronomy during rainy (*kharif*) seasons of 2018 and 2019 at Agricultural College and Research Institute, TNAU, Coimbatore, Tamilnadu, India, to study the effect of different weed management practices on growth, development and yield of maize crop. The experiment was laid out in randomised block design with 10 weed management practices replicated thrice. The results revealed that hand weeding twice at 20 and 40 DAS was significantly superior in recording higher plant height (254.56 cm and 258.2 cm), stem girth (13.68 cm and 13.76 cm plant^{-1}), leaf area index (7.31 and 7.24), chlorophyll index (52.4 and 53.5) and dry matter production (12147 and 12435 kg ha^{-1}) at 90 DAS as compared to other weed management practices and it was found to be at par with PE (pre emergence) atrazine 0.5 kg a.i. ha^{-1} *fb* EPOE (early post emergence) topramezone 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} during 2018 and 2019. Also, hand weeding twice at 20 and 40 DAS, PE atrazine 0.5 kg a.i. ha^{-1} *fb* EPOE topramezone 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} took significantly more number of days for the crop to reach different phenological stages compared to rest of the treatments during both the years of study. Hand weeding twice at 20 and 45 DAS recorded significantly higher grain and stover yield which was comparable with PE atrazine 0.5 kg a.i. ha^{-1} *fb* EPOE topramezone 25.2 g a.i. ha^{-1} and PE atrazine a.i. ha^{-1} *fb* EPOE tembotrione 122 g a.i. ha^{-1}. Significantly higher biological yield and harvest index was recorded in hand weeding twice at 20 and 40 DAS which was on par with PE atrazine 0.5 kg a.i. ha^{-1} *fb* EPOE topramezone 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} during both the years of experimentation.

Keywords: Integrated weed management, maize, growth and yield

Introduction
Globally, maize is the one of the most versatile crop due to its suitability or ability to grow under diversified climatic conditions. It is one of the most important food grain crop which gives higher grain yield and biological yield in a short stipulated period of time. Dass *et al*. (2008) reported that maize is the basic ingredient in numerous products *viz.*, 49% in poultry feed, 25% in food, 12% in feed for livestock, 12% in starch production and 2% in brewery and seed as equal share. In India, the total area, production and average productivity under maize are 9.2 million hectare, 28.7 million tonnes and 3.12 tonnes ha^{-1} respectively [1].

In India, weed infestation is severe in maize crop due to various factors which helps in creating congenial conditions for weed growth. Maize crop predominantly grown in monsoon season, along with wider spacing and slow initial crop growth results to greater loss in crop production. Weeds being injurious, harmful and poisonous are a constant trouble for the successful growth and development of the current crop [2] and also succeeding crop in the same field by producing large seed bank in the same soil resulting in continued presence of weed growth in cropped field and reducing the soil fertility and soil moisture [3]. The critical period of CWC (crop weed competition) in maize crop ranges from 1-6 weeks after sowing. During this period (CWC), adopting any weed management practice plays a vital role in increasing the crop production.

Generally, farmers give more importance to manual weeding (cultural practices) and neglect other methods like chemical weed control. In maize, grain yield was significantly improved by chemical weed control methods [4]. Higher production of maize was recorded from the herbicides treated plot [5].

Maize yield generally responded positively to increased weed control [6]. In view of the importance of the weed management problem, the present research was conducted on response of maize crop to herbicides in terms of tolerance and yield.

Material and Methods

Field trials were conducted at Agricultural College and Research Institute, TNAU, Coimbatore, Tamilnadu, India during *kharif* season of 2018 and 2019 in a randomized block design with ten treatments replicated thrice. The treatments comprised of 10 weed control methods *viz.*, W_1-PE (pre emergence) atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* hand weeding (HW) at 20 DAS, W_2-PE atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* power weeder (PW) at 20 DAS, W_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), W_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, W_5-EPOE (early post emergence) topramezone 336 g/l SC at 25.2 g a.i. ha^{-1} at 20 DAS, W_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, W_7-EPOE tembotrione 420 SC at 122 g a.i. ha^{-1} at 20 DAS, W_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, W_9-control (weedy check) and W_{10}-hand weeding (HW) twice at 20 and 45 DAS,.

Maize cultivar "Maize – COH (M) 6" was dibbled at a spacing of 60 cm x 25 cm between rows and plants, respectively, in plots of size 4.8m x 4.6m. Herbicides were sprayed with Knapsack sprayer fitted with flat fan nozzle. Atrazine and pendimethalin were sprayed as pre-emergence immediately after sowing and topramezone and tembotrione were sprayed as early post emergence after the emergence of weeds at 20 DAS. The different cultural practices recommended for maize crop were adopted during the crop growth period.

In each plot five randomly selected maize plants were tagged for taking observations. Growth parameters *viz.*, plant height (cm), stem girth(cm), leaf area index, chlorophyll index and dry matter production (kg ha^{-1}), were recorded at 90 DAS from penultimate rows of each plot. The leaf area of each leaf was calculated by multiplying the length and breadth. The value thus obtained was multiplied by a constant 0.73 to get actual leaf area and then leaf area index (LAI) was computed by dividing the leaf area plant^{-1} by ground area occupied by each plant (1500 cm^{-2}) [7].

After harvesting the maize crop, cobs and stalks were properly sun dried and bundled. The bundle weight of each net plot (3.0 m × 3.84 m) was recorded and expressed as biological yield. The grain obtained from each net plot was thoroughly cleaned and sun dried. The yield from each plot was recorded separately as kg plot^{-1} and then converted in kg ha^{-1}. After removal of the cobs from stalks in each net plot, the stalks were weighed to determine the stover yield in kg ha^{-1}. Harvest index (%) was determined by dividing the weight of economic yield at 15% moisture content by biological yield per plot and multiplying by 100 given by [8].

The data obtained in respect of different parameters were analysed statistically by the [9]. The significance of "F" and "t" test was tested at 5% level of significance.

Results and Discussion

Plant height

Perusal of the data indicated that weed management practice hand weeding twice at 20 and 40 DAS recorded higher plant height (254.56 cm and 258.20 cm) which was at par with PE atrazine 0.5 kg a.i ha^{-1} *fb* EPOE topramezone 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} (Table 1) at 90 DAS during both the years of 2018 and 2019 experimentation. The height of plant is an important growth character directly linked with the productive potential of plant in terms of yield [10].

Control treatment recorded lower plant height this might be attributed to higher weed densities where the crop weed competition was severe [11]. Among herbicide treatments PE atrazine 0.5 kg a.i ha^{-1} *fb* EPoE topramezone 25.2 g a.i. ha^{-1} (250.13 cm and 250.19 cm) and PE atrazine 0.5 kg a.i ha^{-1} *fb* EPoE tembotrione 122 g a.i. ha^{-1} (248.27 cm and 243.14 cm) produced significantly taller plants than other chemical treatments during both the years of 2018 and 2019 experimentation which were comparable with each other. This was probably due to better weed control with the treatments that enabled lower densities of weeds to compete with crop for growth resources [12].

Leaf area index and chlorophyll index

Results from the study showed that among the herbicide treatments (Table 1 and 2) higher leaf area index (6.94 and 7.16) and chlorophyll index (51.6 and 52.3) was recorded with treatment PE atrazine 0.5 kg a.i ha^{-1} *fb* EPoE topramezone 25.2 g a.i. ha^{-1} during both the years of experimentation however, it was at par with PE atrazine 0.5 kg a.i ha^{-1} *fb* EPOE tembotrione 122 g a.i. ha^{-1}, this could be attributed to better control of weeds in early growth stages of crop which provided the crop plants with optimum environment to utilize growth resources efficiently resulting in better growth of crop.

The reasons for this might be that atrazine functions by binding to the plasto quinine-binding protein in photosynthesis II. Weed death results from starvation and oxidative damage caused by breakdown in the electron transport process. The oxidative damage is accelerated at high light intensity. Significantly lower leaf area index (3.81 and 4.08) and chlorophyll index (40.1 and 39.6) was observed in control at 90 DAS during both the years. This might be due to severe competition of weeds for growth resources which made the crop plant inefficient to utilize growth resources.

Dry matter production and stem girth

The study revealed that among the chemical weed control treatments (Table 1 and 2) higher dry matter production (12087 and 12286 kg ha^{-1}) and stem girth (13.47 and 13.54 cm plant^{-1}) at 90 DAS was recorded under PE atrazine 0.5 kg a.i ha^{-1} *fb* EPOE topramezone 25.2 g a.i. ha^{-1} during both the years of experimentation however, it was at par with PE atrazine 0.5 kg a.i ha^{-1} *fb* EPOE tembotrione 122 g a.i. ha^{-1}. This could be possibly due to better weed control and weed control efficiency resulting in lower weed density and weed dry matter. In fact, plant dry matter accumulation depends on the quantity of total carbon fixed by photosynthesis and the fraction of that carbon converted to dry matter [14].

In addition to the presence of biotic and a biotic stresses, plant dry matter accumulation depends on the quantity of radiation absorbed by the canopy [15]. In addition, lower weed competition with maize, taller maize plants, higher LAI, higher efficiency in intercepting and absorbing solar radiation and partitioning of assimilate and inorganic nutrients may have promoted higher dry matter accumulation under PE atrazine 0.5 kg a.i ha^{-1} *fb* EPOE topramezone 25.2 g a.i. ha^{-1} treatment [12].

Yield

The results of the investigation revealed that the lower grain yield (4387 and 4246 kg ha^{-1}) (Table 3) was found in control treatment during both the years of experimentation. This could be attributed to greater removal of nutrients and moisture by weeds and a severe crop weed competition resulted in poor source and sink development with poor yield components [12, 16,]. Among weed control treatments PE atrazine 0.5 kg a.i ha^{-1} *fb* EPOE topramezone 25.2 g a.i. ha^{-1} recorded higher grain yield (8198 and 8276 k ha^{-1} during 2018 and 2019 respectively) however, it was at par with PE atrazine 0.5 kg a.i ha^{-1} *fb* EPOE tembotrione 122 g a.i. ha^{-1} which could be attributed to improved yield attributes. This improvement in turn was due to higher dry matter production and distribution in different parts, higher LA1 [17]. This implies that with effective and efficient weed control, more plant nutrients are made available to the crop for enhanced leaf area formation that increases solar radiation interception thereby favouring better utilization of photosynthesis for higher grain yield. Stover yield was also significantly higher under 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 (14432, 14502 kg ha^{-1} and 14219, 14393 kg ha^{-1} in 2018 and 2019, respectively). Higher biological yield and stover yield is the effect of higher plant height, more number of functional leaves and higher dry matter production. This also might be due to suppression of weed growth as well as more availability of plant nutrients to maize which favoured better utilization of photo-assimilates for grain yield formation [10]. Harvest index is defined as a ratio of yield biomass to the total biomass at harvest. During both the years of field trial, various weed management practices did not exert any significant impact on harvest index of maize.

Table 1: Effect of weed management practices on plant height, LAI and stem girth of maize at 90 DAS during *kharif* 2018 and 2019

Treatments		Plant height (cm)		LAI		Stem girth (cm)	
		2018	2019	2018	2019	2018	2019
W_1:	PE atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* HW at 20 DAS	230.96	231.54	5.96	6.48	12.38	12.73
W_2:	PE atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* power weeder at 20 DAS	153.05	181.29	4.56	5.73	11.09	11.05
W_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)	142.5	160.07	4.25	5.25	10.95	10.98
W_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	234.12	234.63	6.02	6.52	12.54	12.85
W_5:	EPOE topramezone 336 g/l SC at 25.2 g a.i. ha^{-1} at 20 DAS	208.63	205.78	5.91	6.39	11.92	11.98
W_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	250.13	250.19	6.94	7.16	13.47	13.54
W_7:	EPOE tembotrione 420 SC at 122 g a.i. ha^{-1} at 20 DAS	208.53	202.15	5.87	6.34	11.96	11.64
W_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	248.27	249.87	6.89	7.02	13.39	13.46
W_9:	Hand weeding twice at 20 and 45 DAS	254.56	258.20	7.31	7.24	13.68	13.76
W_{10}:	Control	121.4	140.03	3.81	4.08	10.41	12.73
SEd		5.43	5.40	0.08	0.10	0.16	0.10
CD (P=0.05)		12.16	13.02	0.17	0.25	0.38	0.27

Table 2: Effect of weed management practices on chlorophyll index and dry matter production (DMP) of maize at 90 DAS during *kharif* 2018 and 2019

Treatments		Chlorophyll index		DMP (kg ha^{-1})	
		2018	2019	2018	2019
W_1:	PE atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* HW at 20 DAS	48.6	48.9	8954	9954
W_2:	PE atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* power weeder at 20 DAS	45.2	44.7	6743	6982
W_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)	44.3	43.2	6589	6875
W_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	49.1	49.6	9076	10063
W_5:	EPOE topramezone 336 g/l SC at 25.2 g a.i. ha^{-1} at 20 DAS	47.8	48.1	8435	9023
W_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	51.6	52.3	12087	12286
W_7:	EPOE tembotrione 420 SC at 122 g a.i. ha^{-1} at 20 DAS	47.5	47.8	8391	8967
W_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	51.2	51.9	11925	12267
W_9:	Hand weeding twice at 20 and 45 DAS	52.4	53.5	12147	12435
W_{10}:	Control	40.1	39.6	6125	6314
SEd		1.13	1.5	102.5	104.40
CD (P=0.05)		2.6	3.5	287	261

Table 3: Effect of weed management practices on yield of maize during *kharif* 2018 and 2019

Treatments		Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Harvest index (%)	
		2018	2019	2018	2019	2018	2019
W_1:	PE atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* HW at 20 DAS	7597	7796	12637	12987	0.375	0.375
W_2:	PE atrazine 50% WP at 0.5 kg a.i. ha^{-1} *fb* power weeder at 20 DAS	6673	6572	9976	10015	0.401	0.396
W_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)	6384	6324	9685	9842	0.397	0.391
W_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	7738	7856	12865	13154	0.376	0.374
W_5:	EPOE topramezone 336 g/l SC at 25.2 g a.i. ha^{-1} at 20 DAS	7243	7501	12036	12434	0.376	0.376
W_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	8198	8276	14432	14502	0.362	0.363

	DAS						
W_7:	EPOE tembotrione 420 SC at 122 g a.i. ha^{-1} at 20 DAS	7162	7482	11874	12104	0.376	0.382
W_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	8065	8174	14219	14393	0.362	0.362
W_9:	Hand weeding twice at 20 and 45 DAS	8374	8421	14536	14673	0.366	0.365
W_{10}:	Control	4387	4246	6978	6947	0.386	0.379
SEd		146	130	197	167	0.014	0.015
CD (P=0.05)		316	283	425	406	NS	NS

Conclusion

Various aspects of the present investigation and observation showed that all growth and yield traits were significantly influenced by various weed management practices. Results clearly suggested that PE application of atrazine 50% WP @ 0.5 kg a.i ha^{-1} *fb* EPoE topramezone 336 g/l SC @ 25.2 g a.i. ha^{-1} at 20 DAS or PE atrazine 50% WP @ 0.5 kg a.i ha^{-1} *fb* EPoE tembotrione 420 SC @ 122 g a.i. ha^{-1} at 20 DAS were the appropriate weed management practices for irrigated maize.

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