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WEED MANAGEMENT INDICES AS INFLUENCED BY HERBIGATION BASED WEED MANAGEMENT IN HYBRID MAIZE (*ZEA MAYS* L.)

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ABSTRACT

A field experiment was conducted during *kharif* season of 2023 at Annamalai University, Cuddalore, Tamil Nadu to evaluate the efficacy of herbicides applied in different methods in hybrid maize (*Zea mays* L.). The experiment was laid out in Randomized block design (RBD) with three replications. In this investigation, totally twelve treatments were comprised *viz.*,T_1- Control (Unweeded), T_2- Hand weeding twice on 20 & 40 DAS, T_3- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE, T_4- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE, T_5- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1}spraying as PoE, T_6- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* to pramezone 33.6% SC @ 30 g a.i ha^{-1} spraying as PoE, T_7- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying as PoE, T_8- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE*fb* to pramezone 33.6% SC @ 30 g a.i ha^{-1} spraying as PoE, T_9- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} herbigation as PoE, T_{10}- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* to pramezone 33.6%SC @ 30 g a.i ha^{-1} herbigation as PoE, T_{11}- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} herbigation as PoE, T_{12}- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* to pramezone 33.6%SC @ 30 g a.i ha^{-1} herbigation as PoE. The maize hybrid DKC 9178 was used for the study. Among the herbicidal treatments, lower weedpersistence index, weed growth rate and higher weed management index, agronomic management indexwas achieved with the treatment PE application of Mesotrione 40% SC @ 90 g a.i.ha^{-1} on 3DAS Herbigation + PoE application of Tembotrione 34.4% SC @ 110 g a.i.ha^{-1} on 21DAS spraying, which is at par with the twice hand weeding at 20 and 40 DAS.

Key words : Herbigation, Weed indices, Weed management index, Agronomic management index, Weed growth rate.

Introduction

In maize cultivation, weeds are the leading cause of yield loss, outpacing the effects of other pests like insects and pathogens. According to Neelam Sharma and Manisha Rayamajhi (2022), weeds are responsible for around 37 percent of global maize yield losses. Beyond their impact on yield, weeds also provide alternative hosts for numerous insects and diseases. They compete with maize for vital growth factors such as light, nutrients, moisture and space. Maize, being more widely spaced than other cereal crops, along with its slower initial growth, allows weeds to thrive with minimal resistance. Consequently, managing weeds during the early growth stages of maize is essential. The critical period for weed competition in maize lasts up to 45 days after sowing (Ayana, 2023). In terms of weed management strategies, farmers can choose between hand weeding performed twice or a combination of pre-emergence atrazine spraying followed by one hand weeding session. While these practices are widely recognized and implemented

by many farmers, the current availability and efficiency of labor have become significant concerns, compounded by rising wage rates. As a result, there is a noticeable shift towards chemical weed management methods. Traditional herbicide application through spraying presents several drawbacks, including spray drift, inconsistent herbicide distribution, potential harm to neighboring sensitive crops, human exposure to hazardous chemicals and the presence of untreated patches in fields. A modern alternative to address these issues is the application of herbicides via drip irrigation, known as herbigation, which represents an innovative approach to weed management in maize cultivation. The advantages of herbigation include reduced spraying costs and decreased spray drift to adjacent fields. Furthermore, it allows for timely herbicide application, especially during periods of heavy rainfall when fields are saturated and it targets the weed roots directly, thereby improving the efficacy of the herbicides.Therefore, an experiment was designed to study the efficacy ofpre and post emergence herbicides applied in different methods.

Materials and Methods

The field experiment took place at the experimental farm of the Agronomy Department at Annamalai University in Tamil Nadu, specifically in garden land field number 12A, during *Kharif*, 2022. The experimental farm is situated at a latitude of 11° 24' N and a longitude of 79° 44' E, with an elevation of +5.79 meters above mean sea level. The texture class of the soil was clay loam and it was low in available Nitrogen (Subbiah and Asija, 1956) (267.00 kgha^{-1}), medium in available in phosphorous (Olsen *et al*., 1954) (19.50 kgha^{-1}) and higher in available potassium (Stanford and English, 1949) (308.80 kgha^{-1}) with the pH (Jackson, 1973) of 7.5 and EC (Jackson, 1973) of 0.39 dSm^{-1}. The experimental field was meticulously prepared to achieve a fine tilth of soil, resulting in the establishment of gross plots measuring 10 × 5 m, with a 30 cm buffer surrounding each bed. Each row was equipped with a single drip lateral, which served two rows of maize. These laterals were installed with inline emitters designed to provide a flow rate of 4lph. The study was structured using a randomized block design, incorporating twelve different treatments, each replicated three times. The treatments *viz*., T_1- Control (Unweeded), T_2- Hand weedingtwice on 20 & 40 DAS, T_3- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE, T_4- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE, T_5- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying as PoE, T_6- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* to pramezone 33.6% SC @ 30 g a.i ha^{-1}spraying as PoE, T_7- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying as PoE, T_8- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE*fb* to pramezone 33.6% SC @ 30 g a.i ha^{-1} spraying as PoE, T_9- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} herbigation as PoE, T_{10}- Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* to pramezone 33.6%SC @ 30 g a.i ha^{-1} herbigation as PoE, T_{11}- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} herbigation as PoE, T_{12}- Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE*fb* to pramezone 33.6% SC @ 30 g a.i ha^{-1} herbigation as PoE were adopted.

The maize hybrid DKC 9178 was used for the study. The recommended fertilizer dose of 250:75:75 kgha^{-1} of N, P_2O_5 and K_2O was employed to maize crop.At 15, 30, and 45 (DAS), weed density was assessed by randomly positioning a 0.5 m × 0.5 m quadrat in three distinct areas of each plot.The total weed count was documented and expressed as the no. m^{-2}. The collected weeds were then dried in a hot air oven set to 70^{0}C until they reached a stable weight, with the resulting dry weight reported ing m^{-2}.

Weed Persistence Index (WPI)

$$WPI = \frac{\text{Weed dry weight in treated plot}}{\text{Weed dry weight in control}} \times \frac{\text{Weed population in control}}{\text{Weed population in treated}}$$

Weed Management Index (WMI)

$$WMI = \frac{\dfrac{\text{Weed dry treated plot} - \text{Yield of control}}{\text{Yield of control}}}{\dfrac{\text{Weed dry weight in control} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in control plot}}}$$

Agronomic Management Index (AMI)

$$AMI = \frac{\dfrac{\text{Yield of treated plot} - \text{Yield of control}}{\text{Yield of control}} - \dfrac{\text{Weed dry weight in control plot} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in control plot}}}{\dfrac{\text{Weed dry weight in control plot} - \text{Weed dry weight in treated plot}}{\text{Weed dry weight in control plot}}}$$

Weed Growth Rate (WGR)

$$WGR = \frac{w_2 - w_1}{t_2 - t_1}$$

Where,

w_1 = Weed dry weight (g m^{-2}) at time t_1

w_2 = Weed dry weight (g m^{-2}) at time t_2

Results and Discussion

Weed flora

The weed flora composition in the experimental field was composed of four grasses namely *Chloris barbata, Cynodon dactylon, Dactyloctenium aegyptium* and *Digitaria sanguinalis*, one sedge *Cyperus rotundus* and four broad leaved weeds such as, *Boerhavia erecta, Cleome gynandra, Cleome viscosa* and *Trianthema portulacastrum*.

Weed density and dry weight

A notable variation in the weed density and weed dry weight were observed due to the implementation of various herbigation weed management strategies (Table 1). At 15 DAS,plots received herbigation of Mesotrione 40% SC @ 90 g a.i. ha^{-1} (T_4, T_7, T_8, T_{11} and T_{12}) substantially reduced weed count and weed dry weight over herbigation of Pendimethalin 30% EC @ 0.75 kg a.i. ha^{-1} (T_3, T_5, T_6, T_9 and T_{10}). However, higher weed count was witnessed in hand weeding twice at 20 and 40 DAS (T_2) and unweeded control (T_1). During 30 DAS, PE herbigation of Mesotrione 40% SC @ 90 g a.i. ha^{-1} *fb* PoE spraying of Tembotrione 34.4% SC @ 110 g a.i. ha^{-1} (T_7) recorded lower weed count of 15.86 no. m^{-2} and lower weed dry weight of 10.94 g m^{-2} than the rest of the treatments and it was statistically on par with hand weeding twice at 20 and 40 DAS (T_2). The lower weed density and dry weight might be due to the herbigation with mesotrione offers the significant advantage of uniform herbicide distribution and movement in the soil, which was greatly absorbed by the imbibed weed seeds and affects the germination greatly and resulted in lowered weed density and dry matter production. The findings are consistent with the research by Nalayini *et al.* (2013). Moreover, the post emergence foliar application of Tembotrione resulted in inhibition of the enzyme 4-hydroxy phenyl pyruvate dioxygenase (HPPD). This inhibition disrupts carotenoid synthesis, leading to a depletion of carotenoids. This process caused poor weed growth, reduced population of total weeds including sensitive weeds such as grasses and broad leaves weeds and resulted in reduced weed density with lower biomass accumulation by weeds Duary *et al.* (2015) also reported the same results.

However, hand weeding twice at 20 and 40 DAS (T_2) recorded significantly lower weed count of 12.54 no.m^{-2} and lower weed dry weight of 8.67 g m^{-2} at 45 DAS. This was statistically comparable with PE herbigation of Mesotrione 40% SC @ 90 g a.i. ha^{-1} *fb* PoE spraying of Tembotrione 34.4% SC @ 110 g a.i. ha^{-1} (T_7). The thorough eradication of multiple weed species, such as grasses, sedges and broad-leaved weeds, during the early stages by manually resulted lower density and lower dry matter production in weeds. These findings are as same as Gupta *et al.* (2018). Unweeded control (T_1) filed higher weed density and weed dry weight at 30 and 45 DAS. The same was produced by Rana *et al.* (2018).

Weed Persistence Index

The index of weed persistence measures the amount of dry matter accumulated by weeds per count, in relation to the control (Mishra *et al*., 2016) (Table 2) high lightened that theMesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying as PoE registered lower weed persistence index (0.65). This was closely followed by Pendimethalin 30% EC @ 0.75 kg a.i ha^{-1} herbigation as PE *fb* topramezone 33.6% SC @ 30 g a.i ha^{-1} spraying as PoE (0.83).

Weed management index

This index indicates the ratio of yield enhancement over the control due to weed management practices, as well as the percentage of weed suppression resulting from the respective treatment (Chauhan *et al*., 2022) (Table 2). Higher WMI (0.93) was significantly recorded by Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying as PoE. Hand weeding twice at 20 and 40 DAS stood next in merit by registering WMI of 0.94.

Agronomic management index

Higher AMI (-0.07) was recorded by hand weeding twice at 20 and 40 DAS. This was sincerely followed by Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying (Table 2).

Weed Growth rate

Weed growth rate is the ratio of weed dry weight at regular intervals to the time of observation. It was expressed as g m^{-1} day^{-1} (Table 2). At 15-30 DAS, Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying profoundly documented lower weed growth rate of -0.32 g m^{-1} day^{-1}. At 30-45 DAS, lower weed growth rate (-0.17 g m^{-1} day^{-1}) was achieved by hand weeding twice at 20 and 40 DAS. This was followed by Mesotrione 40% SC @ 90 g a.i ha^{-1} herbigation as PE *fb* tembotrione 34.4% SC @ 110 g a.i ha^{-1} spraying with a WGR of 0.08 g m^{-1} day^{-1}.

Table 1 : Weed density (no. m^{-2}), dry weight (g m^{-2}) and grain yield (kg ha^{-1}) as influenced by herbigation based weed management in hybrid maize.

Treatments	Weed count (no. m^{-2})			Weed density (g m^{-2})			Grain yield (kg ha^{-1})
	15 DAS	30 DAS	45 DAS	15 DAS	30 DAS	45 DAS	
T_1	9.85(96.58)	12.69(160.54)	14.36(205.65)	8.34(69.12)	10.45(108.65)	12.76(162.32)	3459
T_2	9.74(94.38)	4.08(16.18)	3.61(12.54)	8.31(68.54)	3.43(11.26)	3.03(8.67)	6154
T_3	5.39(28.59)	8.14(65.72)	10.80(116.24)	4.70(21.58)	7.08(49.58)	9.33(86.58)	3898
T_4	4.25(17.56)	7.63(57.69)	10.13(102.15)	3.94(15.03)	6.60(43.12)	9.09(82.12)	4288
T_5	5.40(28.65)	5.58(30.68)	7.21(51.42)	4.71(21.65)	5.12(25.75)	6.09(36.54)	5286
T_6	5.48(29.54)	6.20(37.91)	8.12(65.48)	4.78(22.35)	5.57(30.54)	6.57(42.68)	4854
T_7	4.39(18.76)	4.04(15.86)	4.91(23.65)	4.02(15.68)	3.38(10.94)	3.56(12.14)	6017
T_8	4.30(17.98)	4.90(23.48)	6.12(36.96)	3.95(15.13)	4.44(19.23)	5.24(26.91)	5624
T_9	5.34(27.98)	7.07(49.43)	9.15(83.25)	4.65(21.13)	6.28(38.92)	7.72(59.11)	4730
T_{10}	5.45(29.21)	7.13(50.39)	9.40(87.87)	4.75(22.02)	6.34(39.64)	7.88(61.58)	4720
T_{11}	4.35(18.45)	6.79(45.56)	8.93(79.16)	4.16(16.84)	6.07(36.38)	7.58(56.98)	4421
T_{12}	4.41(18.92)	6.91(47.29)	9.07(81.71)	4.17(16.89)	6.14(37.26)	7.60(57.23)	4735
SE_D	0.34	0.31	0.54	0.18	0.11	0.35	180.34
CD (p=0.05)	0.71	0.66	1.12	0.38	0.22	0.72	374.01

*Figures in the parenthesis represents original values, data of weed density and dry weight are $\sqrt{x} + 0.5$ transformed.

Table 2 : Weed Persistence Index (WPI), Weed Management Index (WMI), Agronomic Management Index (AMI) and Weed Growth Rate (WGR) (g m^{-1} day^{-1}) as influenced by herbigation based weed management in hybrid maize.

Treatments	WPI*	WMI*	AMI*	WGR*(g $m^{-1}day^{-1}$)	
				15-30 DAS	30-45 DAS
T_1	-	-	-	2.64	3.58
T_2	0.88	0.93	-0.07	-3.82	-0.17
T_3	0.94	0.27	-0.73	1.87	2.47
T_4	1.02	0.49	-0.51	1.87	2.60
T_5	0.90	0.80	-0.20	0.27	0.72
T_6	0.83	0.67	-0.33	0.55	0.81
T_7	0.65	0.94	-0.06	-0.32	0.08
T_8	0.92	0.89	-0.11	0.27	0.51
T_9	0.90	0.58	-0.42	1.19	1.35
T_{10}	0.89	0.59	-0.41	1.17	1.46
T_{11}	0.91	0.57	-0.43	1.30	1.37
T_{12}	0.89	0.57	-0.43	1.36	1.33

*Data has not been statistically analyzed.

Grain yield

Different weed management practices had a substantial effect on grain yield (kg ha^{-1}) of hybrid maize grown under drip irrigation. The grain yield (Table 1) of hybrid maize ranged from 3459 to 6154kg ha^{-1}. Hand weeding twice at 20 and 40 DAS (T_2) outclassed over all other treatments by achieving maximum grain yield of 6154 kg ha^{-1}. This was statistically similar to PE herbigation of Mesotrione 40% SC @ 90 g a.i. ha^{-1} *fb* PoE spraying of Tembotrione 34.4% SC @ 110 g a.i. ha^{-1} (T_7). The unweeded control (T_1) documented lower grain yield of 3459 kg ha^{-1} than rest of the treatments. The superior expression of yield in hand weeding can likely be linked to a diminished resurgence frequency, the vigorous growth of weeds, and more effective weed control measures. This is in line with the outcomes of Gupta *et al.* (2023). From the above results it can be concluded that hand weeding twice at 20 and 40 DAS recorded higher grain yield and also it was statistically on par with PE herbigation of Mesotrione 40% SC @ 90 g a.i. ha^{-1} *fb* PoE spraying of Tembotrione 34.4% SC @ 110 g a.i. ha^{-1}. Moreover, the abovesaid treatment (T_7) documented better weed management indicesthan all other treatments. Therefore, PE herbigation of Mesotrione 40% SC @ 90 g a.i. ha^{-1} *fb* PoE spraying of Tembotrione 34.4% SC @ 110 g a.i. ha^{-1} proved to be an effective and a profitable alternative to the existing recommendation of weed control (Two hand weeding at 20 and 40 DAS).

Conflict of interest

Authors have no conflict of interest in the publishing of this research article.

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