Effect of Various Weed Management Practices on Weed Indices in Hybrid Maize

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Abstract: Field experiment was conducted during Summer 2024 at Garden land of Experimental farm, Annamalai University, Annamalai Nagar, Chidambaram Taluk, Cuddalore District, Tamil Nadu to evaluate the effect of different weed management practices in hybrid maize. The field experiment was laid out in Randomized block design (RBD) with three replications. Among the herbicidal treatments evaluated, pre emergence application of atrazine @ 1.0 kg ha^{-1} followed by hand weeding on 30 DAS which helps in reducing weed density and ultimately reduced weed biomass which resulted in increase in crop growth and yield and it was on par with pre emergence application of atrazine @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS. Among the herbicidal treatments pre emergence application of atrazine @ 1.0 kg ha^{-1} followed by hand weeding on 30 DAS recorded the higher weed control index.

Keywords: hybrid maize, atrazine, tembotrione, weed management and weed control index

INTRODUCTION

Maize, commonly known as corn, is a highly adaptable and vital cereal crop, ranking third in global importance after wheat and rice. As part of the grass family (Gramineae), maize plays a significant role in food security, particularly in developing nations. It is often called the "Queen of cereals" due to its exceptional genetic potential for high yields. Nutritionally, maize offers 7.6% crude protein, 2.3% crude fiber, 3.6% crude fat, 63.8% starch, 1.7% total sugars, and provides 3840 kcal/kg of gross energy. Globally, maize is cultivated on 202.92 million hectares, producing 1227.86 million metric tons with an average yield of 6.05 metric tons per hectare in the 2023-24 period. China leads global maize production with 288.84 million metric tons. In India, maize is grown on around 10.40 million hectares, yielding 35.50 million metric tons, with an average productivity of 3.41 metric tons per hectare (Anonymous, 2024). India is a key player in maize farming, ranking 4th in area and 7th in production, contributing approximately 4% of the world's cultivated area and 2% of total maize output (Sairam *et al.,* 2023). Within India, the state of Tamil Nadu dedicates 196,000 hectares to maize, producing 2.827 million metric tons with an average yield of 7.19 metric tons per hectare, making it the fourth largest maize-producing state (Directorate of Economics and Statistics, 2021-22). Although several high-yielding maize hybrids are available, the average yield remains well below its potential. To maximize maize productivity, adopting proper agronomic practices is essential, with effective weed management playing a key role in boosting yields (Ramesh *et al.,* 2017). Weeds pose a significant threat to maize cultivation in India, as they compete intensely with the crop, leading to reduced production. Weeds diminish photosynthetic efficiency, lower dry matter accumulation, and interfere with nutrient allocation to critical areas, which in turn reduces the plant's sink capacity and leads to lower grain yields (Verma *et al.,* 2022). This weed competition is especially damaging during the early stages of maize growth due to the crop's slow initial development and wide row spacing. Severe competition between weeds and maize during critical growth phases can significantly reduce both the quality and quantity of the harvest, as weeds compete with the crop for essential resources such as nutrients, water, light, and space (Rani *et al*., 2020). Effective weed management is key to achieving higher maize yields. High weed density not only raises cultivation costs but also decreases land value and reduces net returns. Proper control of weeds is crucial for unlocking maize's full yield potential. The use of chemical weed control methods has been shown to be just as effective as manual weeding in various crops, with the added advantage of lowering labour costs (Verma *et al.,* 2022). Herbicides offer a cost-efficient and effective solution by keeping weed populations below a critical threshold, preventing excessive

competition before it can negatively affect the crop (Sahu *et al.,* 2023). Manual weeding is an effective method for controlling weeds during the critical growth stages of maize. However, timely weed management has become increasingly challenging due to labour shortages and rising wages during peak periods. As a result, herbicides are seen as a viable and efficient alternative for managing weeds over larger areas compared to hand weeding. Chemical weed control is faster, more effective, and saves both time and labour. Herbicides work by inhibiting or completely eliminating weed growth, playing a crucial role in weed control strategies aimed at maximizing crop yields. Therefore, the current study was undertaken to evaluate different weed control methods in hybrid maize.

MATERIALS AND METHODS

The field experiment was conducted at Experimental farm, Department of Agronomy, Faculty of Agriculture, Annamalai University, Annamalai Nagar during summer season March to June of 2024.The experimental farm is geographically located at 11° 24' N latitude, 79° 44' E longitude, at an altitude of ±5.79 m above mean sea level. The weekly mean maximum temperature ranges from 32 to 39 ºC with a mean of 35.5 °C, while the weekly mean minimum temperature fluctuates between 18 to 23 °C with a mean of 21.13 °C. The relative humidity ranged from 61 to 78 percent, while the average relative humidity was 70.2 percent. The texture of the experimental field soil was clay loam in with a pH of 7.5. The soil was low in available nitrogen, medium in available phosphorus and high in available potassium. The study used the popular maize hybrid P 3302. The experiment used randomised block design, with three replications and nine treatments.

There were nine treatments, *viz.,* T_1- Unweeded control, T_2- Weed free check, T_3- Two hand weeding on 15 and 30 DAS, T_4- Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS,T_5- Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS,T_6- Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS,T_7- Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS,T_8- Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS,T_9- Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS. Hybrid maize seeds were sown at a rate of 20 kg per hectare, planted 5 cm deep with a spacing of 60 x 20 cm. Standard agronomic practices were followed throughout the growing season. Pre-emergence herbicides, atrazine and metribuzin, were applied using a knapsack sprayer fitted with a flood fan nozzle, delivering 500 liters per hectare according to the treatment plan. Hand weeding was carried out at 15 and 30 days after sowing, as outlined in the treatment schedule. Weed counts were taken from a 0.25 m^2 marked area in each randomly selected plot and converted to a per square meter basis for easier comparison. To ensure reliable statistical analysis, the weed count data were transformed using the formula (√("X+0.5")) as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect on weeds

The experiment site included wide range of weed species like The experimental site recorded wide range of weed flora like *Cyperus rotundus, Cynodon dactylon, Echinochloa crusgalli, Echinochloa colonum* (L), *Dactyloctenium aegyotium, Trianthema portulacastrum, Panicum repens* .L., *and Cleome viscosa , Euphorbia hirta.* However only five weeds namely *Cynodon dactylon, Cyperus rotundus, Dactyloctenium aegyotium, Trianthema portulacastrum* and *Cleome viscosa* constituted greater proportion of the weed flora and the impact of weed management weed control treatments proved significance response on this weeds the other weeds occurred only negligible proportions and their occurrence also rare. The weeds observed in the experimental site was also reported by Sairam *et al.* (2023)

Effect on total weed density

Weed density as influenced by different weed management practices significantly at different stages. At all stages significantly lower total number of weeds was recorded in weed free plot among all treatments At 15 DAS**,** the total weed density obtained under weed management practices declined significantly when pre emergence application of atrazine @1.0 kg ha^{-1} followed by one hand weeding on 30 DAS of 25.4 m^{-2} and it was on par with pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application

of tembotrione @ 120g ha^{-1} on 25 DAS of 26.8 m^{-2}. The highest total weed density was recorded with unweeded control at 15 DAS of 157.53 m^{-2} At 30 DAS the lowest weed density was recorded with two hand weeding on 15 and 30 DAS of 28.73 m^{-2} and it was on par with pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS. Highest total weed density was recorded with unweeded control of 200.13 m^{-2}

At 45 DAS the lowest weed density was recorded with two hand weeding on 15 and 30 DAS of 26.19 m^{-2}. Among pre emergence herbicides application of atrazine @1.0 kg ha^{-1} followed by one hand weeding on 30 DAS recorded the lowest weed population of 35.15 m^{-2}. The next best treatment was pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS of 41.19 m^{-2}. Highest total weed density was recorded with unweeded control of 239.02 m^{-2}.

Overall, reduced weed density was observed across all weed management practices. The highest weed density occurred in the unweeded control, while the weed free check had the lowest density among all treatments. The increased weed density in the unweeded control was primarily due to the continuous growth of a wide variety of weeds, which effectively utilized available growth resources. In contrast, the weed free check, which involved regular hand weeding achieved complete weed control but proved more expense due to labour shortages. These findings are consistent with the results of Pandian and Nambi (2002) and Reddy *et al.* (2022). Among the herbicidal treatments, pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS recorded lower weed population at all crop growth stages and it was on par with Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120 g ha^{-1} on 25 DAS, Atrazine interferes with photosynthesis in broadleaf and grass weeds by being absorbed through the roots and leaves, moving upward to new growth areas, ultimately causing the weeds to dry out and die, as reported by Ashraf *et al.* (2016). The combination of atrazine and tembotrione was also effective, as the pre-emergence application of atrazine disrupted photosynthesis early on, while the post-emergence application of tembotrione inhibited the enzyme 4-Hydroxyphenylpyruvate dioxygenase (HPPD), leading to carotenoid depletion and the absence of chloroplast development in emerging foliar tissue, which caused the plants to appear bleached and stunted. The efficacy of tembotrione aligns with the findings of Kumar *et al.* (2018) and Sharma *et al.* (2023).

Table 1. Effect of different weed control treatments on total weed density (g m^{-2}) at different stages of crop growth

Treatments		Total weed density (g m^{-2})		
		15 DAS	30 DAS	45 DAS
T_1	Unweeded control	13.06 (157.53)	14.64 (200.13)	15.95 (239.02)
T_2	Weed free check	2.86 (5.60)	3.94 (11.90)	3.34 (8.10)
T_3	Two hand weeding on 15 and 30 DAS	10.15 (93.16)	5.40 (28.73)	5.16 (26.19)
T_4	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS	5.08 (25.4)	6.97 (48.12)	5.97 (35.15)
T_5	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS	5.64 (31.37)	7.58 (57.05)	7.03 (49.03)
T_6	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	5.22 (26.8)	5.53 (30.15)	6.45 (41.19)

T_7	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	5.53 (30.16)	6.24 (38.44)	7.78 (60.04)
T_8	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS	5.41 (28.81)	6.84 (46.33)	8.51 (72.09)
T_9	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS	5.80 (33.16)	7.21 (51.61)	9.06 (81.64)
	S.Ed	0.20	0.19	0.14
	CD (P=0.05%)	0.40	0.41	0.30

Effect on weed biomass

Weed biomass as influenced by different weed management practices significantly at different stages. Weed free check (1.17, 2.49 and 1.94 g m^{-2} respectively) and unweeded control (37.8, 90.05 and 138.63 g m^{-2} respectively) recorded significantly lower and higher total weed biomass respectively.

At 15 DAS, the total weed biomass obtained under weed management practices declined significantly when pre emergence application of atrazine @ 1.0 kg ha^{-1} followed by hand weeding on 30 DAS of 6.09 g m^{-2} was adopted. However, it was on par with pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS of 6.43 g m^{-2}. The highest total weed biomass was recorded with hand weeding twice at 15 and 30 DAS and unweeded control of 22.35 g m^{-2} and 37.8 g m$^{-2.}$ At 30 DAS the total weed biomass declined significantly with two hand weeding on 15 and 30 DAS of 12.92 g m^{-2} and it was followed by pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120 g ha^{-1} on 25 DAS of 13.56 g m^{-2}. Highest total weed biomass was recorded with unweeded control of 90.05 g m^{-2}

At 45 DAS the lowest weed biomass was recorded with two hand weeding on 15 and 30 DAS of 15.19 g m^{-2}. The next best treatment was pre emergence application of atrazine @ 1.0 kg ha^{-1} followed by hand weeding on 30 DAS of 18.98 g m^{-2} and it was followed by pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS. Highest total weed biomass was recorded with unweeded control of 138.63 g m$^{-2.}$

The highest weed dry matter production (DMP) was observed in the unweeded control. A notable reduction in weed dry matter was achieved with the pre-emergence application of atrazine @ 1.0 kg ha^{-1} followed by one hand weeding at 30 DAS, which was comparable to the pre-emergence application of atrazine @ 1.0 kg ha^{-1} followed by post-emergence application of tembotrione @ 120g ha^{-1} at 25 DAS. These herbicide treatments resulted in lower weed DMP per unit area due to fewer weeds and the rapid depletion of carbohydrate reserves in the weeds, along with the inhibition of photosynthesis. The increased weed DMP in the unweeded control was attributed to the higher weed population and uninterrupted growth throughout the season. This aligns closely with the findings of Nambi *et al.* (2020). The weed-free plot showed the lowest weed DMP, followed by the treatment with two hand weeding at 15 and 30 DAS. Hand weeding effectively reduced weed dry weight by removing all types of weeds during the cropping season, which is consistent with the results reported by Saimaheswari *et al.* (2022).

Table 2. Effect of different weed control treatments on weed biomass (g m^{-2}) at different stages of crop growth

Treatments	Weed biomass (g m^{-2})

		15 DAS	30 DAS	45 DAS
T_1	Unweeded control	6.18 (37.8)	9.51 (90.05)	11.79 (138.63)
T_2	Weed free check	1.29 (1.17)	1.72 (2.49)	1.56 (1.94)
T_3	Two hand weeding on 15 and 30 DAS	4.78 (22.35)	3.66 (12.92)	3.96 (15.19)
T_4	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS	2.56 (6.09)	4.70 (21.65)	4.41 (18.98)
T_5	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS	2.83 (7.52)	5.11 (25.67)	5.19 (26.47)
T_6	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	2.63 (6.43)	3.74 (13.56)	4.76 (22.24)
T_7	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	2.78 (7.23)	4.21 (17.29)	5.73 (32.42)
T_8	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS	2.72 (6.91)	4.61 (20.84)	6.27 (38.92)
T_9	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS	2.90 (7.95)	4.87 (23.22)	6.67 (44.08)
	S.Ed	0.07	0.13	0.20
	CD (P=0.05%)	0.15	0.25	0.43

Effect on weed control efficiency

Weed control efficiency was computed based on weed density at 15, 30 and 45 DAS. At all stages weed free plot recorded maximum WCE.

At 15 DAS, Pre emergence application of atrazine @1.0 kg ha^{-1} followed by hand weeding on 30 DAS registered higher weed control efficiency of 83.87 per cent. The next best treatment was pre emergence application of atrazine @1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS.

At 30 and 45 DAS Two hand weeding at 15 and 30 DAS recorded WCE of 85.64 and 89.04. The next best order was atrazine @1.0 kg ai followed by hand weeding on 30 DAS and it was followed by pre emergence application of atrazine @1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120 g ha^{-1} on 25 DAS.

Weed control efficiency (WCE) measures how effectively weed control treatments reduce weed population and dry weight compared to an unweeded control. The weed-free check and two hand weedings showed the highest WCE. Among the herbicidal treatments, the pre-emergence application of atrazine @ 1.0 kg ha^{-1} followed by one hand weeding at 30 DAS was comparable to the pre-emergence application of atrazine @ 1.0 kg ha^{-1} followed by post-emergence application of tembotrione @ 120g ha^{-1} at 25 DAS. This effectiveness is attributed to significant reductions in broad weed growth at all stages. These findings are consistent with reports from Kakade *et al.* (2020).

Table 3. Effect of different weed control treatments on weed control efficiency (%) at different stages of crop growth

Treatments		Weed control efficiency (%)		
		15 DAS	30 DAS	45 DAS
T_1	Unweeded control	-	-	-
T_2	Weed free check	96.44	94.05	96.61

T_3	Two hand weeding on 15 and 30 DAS	40.86	85.64	89.04
T_4	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS	83.87	75.95	85.29
T_5	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* one hand weeding on 30 DAS	80.08	71.49	79.48
T_6	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	82.98	84.93	82.76
T_7	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	80.85	76.85	74.88
T_8	Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS	81.71	80.79	69.83
T_9	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} *fb* post emergence application of halosulfuron methyl @ 65g ha^{-1} on 25 DAS	78.95	74.21	65.84

CONCLUSION

From the perspective of productivity and economic viability, it concluded that Pre emergence application of atrazine @ 1.0 kg ha^{-1} *fb* post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS in hybrid maize is most effective weed control method for obtaining lower total weed count, weed biomass and higher weed control index.

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