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Effect of different weed control treatments on growth and yield of 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. This might be due to maintenance of weed free environment, particularly throughout vital growth stages of crop, cut back crop weed competition helped in higher growth and development of hybrid maize crop leading to higher grain yield.

Keywords: Hybrid maize, atrazine, tembotrione and grain yield

Introduction
Maize, commonly known as corn, is a highly versatile and essential cereal crop, ranking third in global importance after wheat and rice. As a member of the grass family (Gramineae), it plays a crucial role in food security, especially in developing countries. With its remarkable genetic potential for high yields, maize is often referred to as the "Queen of cereals." It has a rich nutritional profile, featuring 7.6% crude protein, 2.3% crude fibre, 3.6% crude fat, 63.8% starch, 1.7% total sugars, and an impressive 3840 kcal/kg of gross energy. Globally, maize is grown on 202.92 million hectares, yielding 1227.86 million metric tons, with an average productivity of 6.05 metric tons per hectare for the year 2023-24. China leads the world in maize production, producing 288.84 million metric tons. In India, maize covers approximately 10.40 million hectares, producing 35.50 million metric tons, with an average yield of 3.41 metric tons per hectare (Anonymous, 2024) [1]. India is a major player in maize cultivation, ranking 4th in terms of area and 7th in production worldwide, contributing about 4% of the global cultivation area and 2% of total maize production (Sairam *et al.,* 2023) [13]. Within India, Tamil Nadu grows maize on 196,000 hectares, producing 2.827 million metric tons with a productivity of 7.19 metric tons per hectare, making it the fourth largest maize producer in the country (Directorate of Economics and Statistics, 2021-22).

Despite the availability of several high-yielding hybrids, the average maize yield remains significantly below its potential. To fully exploit maize's capabilities, implementing appropriate agronomic practices is crucial, with weed management being particularly important for improving crop yields (Ramesh *et al.,* 2017) [9]. Weeds are a major threat to maize, contributing to lower production in India due to intense competition with the crop. They reduce photosynthetic efficiency, dry matter production, and the distribution of nutrients to key areas, ultimately decreasing the crop's sink capacity and resulting in lower grain yields (Verma *et al.,* 2022) [17]. Weed interference is particularly problematic 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 diminish both the quality and quantity of the harvest, as weeds vie with the crop for essential resources such as nutrients, moisture, sunlight, and space (Rani *et al.,* 2020) [10].

Effective weed management is therefore crucial for achieving higher yields. Additionally, a high weed intensity increases cultivation costs, reduces land value, and lowers net returns. Proper weed management is essential to realizing maize's full yield potential. Using chemicals for weed management has proven to be as effective as manual eradication in various crops and offers additional benefits, such as reducing labor costs associated with manual weeding (Verma *et al.*, 2022) [17]. Herbicides, by keeping weed populations below a critical threshold, provide a cost-effective and efficient means of controlling excessive weed competition before it impacts the crop (Sahu *et al.*, 2023) [11]. Hence, the present study has been carried out to evaluate the best weed management practices on growth and yield attributes of 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, placed 5 cm deep with a spacing of 60 x 20 cm. Standard cultural practices were followed throughout the growing season. Pre-emergence herbicide applications of atrazine and metribuzin were carried out using a knapsack sprayer equipped with a flood fan nozzle, applying 500 liters per hectare according to the treatment schedule. Hand weeding was performed at 15 and 30 days after sowing, as specified in the treatment schedule. Weed counts were recorded from a 0.25 m² tagged area in each randomly selected net plot, then converted to a per square meter basis for ease of comparison. To ensure accurate statistical analysis, the weed count data were transformed using (√("X+0.5")) as recommended by Gomez and Gomez (1984) [7]. The green cob and green fodder yields were then assessed.

Results and Discussion

Effect of different weed management practices on Plant height (cm)

Among the different weed management practices, the highest plant height was observed under two hand weeding at 15 and 30 DAS at all stages of crop growth. The next best treatment was recorded under atrazine @1.0 kg *ai* fb hand weeding on 30 DAS, which is recorded the plant height of 77.37, 180.65, 208.96 cm at 30, 60 DAS and at harvest stage respectively. 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. This effect could be attributed to reduced weed infestation during the early stages of the crop, leading to lower weed density and biomass. As a result, there was less competition between the crop and weeds, allowing the crop to fully utilize nutrients, moisture, space, and light. Consequently, this enhanced growth parameters. Similar results were observed by Nambi *et al.* (2020) [15]. In contrast, the unweeded control exhibited significantly shorter plant height at all stages due to intense weed competition and limited availability of growth-promoting factors, which substantially hindered plant growth and reduced height.

Table 1: Effect of different weed control treatments on plant height on 30, 60 and 90 DAS (cm) in hybrid maize

Treatments		Plant height(cm)		
		30 DAS	60 DAS	Harvest stage
T_1	Unweeded control	52.87	98.4	122.3
T_2	Weed free check	86.37	193.65	228.32
T_3	Two hand weeding on 15 and 30 DAS	81.87	186.15	218.13
T_4	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	77.37	180.65	208.96
T_5	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	69.79	171.63	195.87
T_6	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	74.28	176.13	204.28
T_7	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	67.18	167.8	191.21
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	63.87	153.2	185.3
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	60.39	133.2	173.1
	S.Ed	1.42	2.24	2.48
	CD (P=0.05%)	3.03	4.51	5.01

Effect of different weed management practices on leaf area index: Weed free check registered higher LAI over herbicidal and hand weeding of weed control of all stages. The treatment two hand weeding at 15 and 30 DAS significantly recorded the highest leaf area index of 2.65, 4.12 at 40 and 60 DAS respectively. The next best treatment was pre emergence application of atrazine @1.0 kg ha^{-1} fb one hand weeding on 30 DAS which recorded the leaf area index of 2.43, 3.86 at 20 and 40 DAS. The increased LAI are likely attributed to reduced weed infestation during the early stages of the crop, leading to lower weed density and biomass. This reduction minimized competition for resources, allowing the crop to fully utilize nutrients, moisture, space, and light. Similar findings are reported by Krishnaprabhu *et al.* (2020) [8]. In contrast, the unweeded control showed a significantly lower LAI.

Table 2: Effect of different weed control treatments on leaf area index at 40, 60 DAS in hybrid maize

Treatments		Leaf area index	
		40 DAS	60 DAS
T_1	Unweeded control	1.45	2.19
T_2	Weed free check	2.81	4.53
T_3	Two hand weeding on 15 and 30 DAS	2.65	4.12
T_4	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	2.43	3.86
T_5	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	2.23	3.21
T_6	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	2.40	3.81
T_7	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	2.20	3.19
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	1.97	2.88
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	1.67	2.45
	S.Ed	0.04	0.06
	CD (P=0.05%)	0.08	0.13

Effect of different weed management practices on dry matter production

All the treatments exerted significant influenced on crop DMP. Weed free check recorded highest DMP than other treatments. Among treatments, hand weeding on 15 and 30 DAS significantly recorded the highest dry matter production of 5785, 7399 and
12498 kg ha^{-1} at 30, 60 DAS and harvest stage, respectively. The next best treatment was pre emergence application of atrazine @1.0 kg ha^{-1} fb one hand weeding on 30 DAS which was recorded the dry matter production of 5400, 7016 and 11998 kg ha^{-1} at 30,
60 DAS and harvest. 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.

The herbicide treatments resulted in lower weed dry matter production per unit area because they reduced the number of weeds, quickly depleting their carbohydrate reserves and inhibiting photosynthesis. In contrast, the unweeded control showed higher weed dry matter production due to the increased weed population and continuous weed growth throughout the season. This finding aligns with the results reported by Pandian and Nambi (2002) [15] and Arivukkarasu *et al.* (2020) [2].

The weed-free plot had the lowest weed dry matter production (DMP), followed by the treatment involving two hand weedings at 15 and 30 days after sowing (DAS). Hand weeding effectively reduced weed dry weight by removing all types of weeds during the cropping season. This observation is consistent with the findings of Saimaheswari *et al.* (2022) [12].

Table 3: Effect of different weed control treatments on dry matter production at 30, 60, 90 DAS (kg ha^{-1}) in hybrid maize

Treatments		Dry matter production (kg ha^{-1})		
		30 DAS	60 DAS	Harvest stage
T_1	Unweeded control	2224	2996	4773
T_2	Weed free check	5785	7686	12908
T_3	Two hand weeding on 15 and 30 DAS	5591	7399	12498
T_4	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	5400	7016	11998
T_5	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	4765	6258	11134
T_6	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	5292	6813	11719
T_7	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	4712	6096	10818
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	3995	5869	10398
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	3567	5489	9829
	S.Ed	53.95	95.02	138.55
	CD (P=0.05%)	107.96	203.1	279.11

Effect of different weed management practices on yield parameters

Weed free plot registered highest yield parameters than other treatments. Among the weed control treatments two hand weeding on 15 and 30 DAS significantly recorded the higher cob length, cob girth, number of grains cob^{-1}, cob weight. The next best treatment was pre emergence application of atrazine @1.0 kg ha^{-1} fb one hand weeding on 30 DAS 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. This might be due to the efficient use of soil moisture and nutrients created optimal conditions for the development of mature grains. This could be because the reduced weed population offered a more favourable environment for the crop, leading to an increased rate of photosynthetic accumulation and improved nutrient translocation from source to sink. Similar findings were reported by Sharma *et al.* (2018) [14] and Divya *et al*. (2023) [6].

The lower value of yield parameters was recorded with unweeded control. This was a result of heightened competition between the crop and weeds for various resources such as light, moisture, space, and nutrients.

Effect of different weed management practices on grain yield

Weed free plot recorded higher grain yield than other treatments. Among the weed control measures two hand weeding on 15 and 30 DAS significantly registered the highest grain yield of 4944 kg ha^{-1}. The next best treatment was pre emergence application of atrazine @1.0 kg ha^{-1} fb one hand weeding on 30 DAS with the grain yield of

4756 kg ha^{-1} and this treatment 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. This might be due to the efficient utilization of soil moisture and nutrients created ideal conditions for the development of mature grains. This could be attributed to the reduced weed population, which provided a more favourable environment for the crop, leading to a higher rate of photosynthetic accumulation and improved translocation of nutrients from source to sink. Similar results were reported by Sharma *et al.* (2018) [14]. The treatment unweeded control registered the lowest grain yield of 1800 kg ha^{-1}. This was a result of heightened competition between the crop and weeds for various resources such as light, moisture, space, and nutrients. Yield losses of a similar scale due to weed competition have been reported by Chang *et al.* (2021) [3] and Deshmane *et al.* (2023) [4].

Table 4: Effect of different weed control treatments on yield parameters in hybrid maize

Treatments		Yield parameters				
		Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	Cob weight (g)	Grain yield (kg ha^{-1})
T_1	Unweeded control	12.36	9.89	183	180.22	1800
T_2	Weed free check	20.82	15.84	354	339.68	5125
T_3	Two hand weeding on 15 and 30 DAS	19.58	14.68	335	320.45	4944
T_4	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	18.64	14.16	299	304.60	4756
T_5	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb one hand weeding on 30 DAS	16.98	13.51	272	282.01	4409
T_6	Pre emergence application of atrazine @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	18.23	13.69	282.42	294.39	4598
T_7	Pre emergence application of metribuzin @ 1.0 kg ha^{-1} fb post emergence application of tembotrione @ 120g ha^{-1} on 25 DAS	17.62	13.11	259	288.56	4269
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	13.87	10.45	219	233.67	4082
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	15.21	11.15	240	246.44	3901
	S.Ed	0.32	0.22	7.90	4.82	78.97
	CD (P=0.05%)	0.64	0.48	16.89	10.31	158.85

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 should be prioritized over other treatments for controlling weeds and increased growth and grain yield of hybrid maize.

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