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Effect of different weed control methods on weed dynamics and yield of fodder maize (*Zea mays* L.)

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Abstract
Cultivation techniques of fodder maize during recent years have led to a shift in the composition of weed populations. This would necessitate the integration of new, efficient herbicides in the control of primary weeds in maize crop. Hence, a field trial was carried out at Livestock Farm Complex, Veterinary College and Research Institute, Namakkal during *kharif* season 2022 to determine the most suitable weed management method to control the diverse weed species in fodder maize. The experiment was carried out in Randomized Block Design (RBD) with seven treatments replicated thrice. Data was collected on weed parameters and yield of fodder maize. The experimental field was infested with *Trianthema portulacastrum*, *Cleome gynandra*, *Boerhaavia diffusa*, *Digera arvensis* and *Cyanotis axillaris*. Among the grassy weeds, *Cynodon dactylon* and *Dactyloctenium aegyptium* were the dominant weed species.The results of this study indicated that application of Atrazine 1.0 kg ha^{-1} followed by (fb) hand weeding can effectively control the diverse weed population in fodder maize fields, resulting in higher green fodder yield of 41.1 t ha^{-1}.

Keywords: Fodder maize, weed control, herbicides and green fodder yield

Introduction
Maize (*Zea mays* L.) is considered to be the most suitable crop as a fodder and also silage making. Belonging to the Gramineae family, maize is a staple food crop globally, after wheat and rice. Its significance lies in its versatility, being utilized for food, feed, fodder, stalk and various industrial purposes. Maize is a crucial dual-purpose cereal crop worldwide. The quality production of fodder and forage plays a vital role in the development of the livestock industry. However, weed infestation poses a significant challenge in fodder maize cultivation, as many farmers neglect weed management practices, resulting in reduced green and dry fodder yield. Nedim *et al.* (2004) [9] suggested that weed-free condition between three and seven to ten leaf stages ensures good yield. Another study showed that the critical period for weed control was five weeks, which corresponded to the one to five leaf stage of maize (Isik *et al.*, 2006) [4]. Weeds compete with maize for growth factors, leading to nutrient loss ranging from 30-40%. Maize is highly sensitive to weed infestation during the initial stage of growth which results in highest yield loss up to six weeks after planting. Hand weeding is labour-intensive and costly, especially when labourers are scarce during critical crop-weed competition periods. Chemical weed management offers an efficient and cost-effective solution to weed control during this crucial phase, which may not be feasible with manual or mechanical weeding due to high cultivation costs (Uddin *et al.*, 2020) [13]. Herbicides like Atrazine, Oxyfluorfen, 2,4-D and Pendimethalin are available for weed control in maize especially for broadleaved weeds rather than grasses and sedges (Patel Raghav *et al.*, 2023) [10].
The control of grasses and sedge continues a great challenge to the farmers, particularly when soil moisture levels are either too high or too low, impeding intercultural operations. Consequently, there is a pressing need to discover the most effective chemical solution for weed management in maize. Therefore, this trial aims to determine different weed control methods using herbicides for weed control in fodder maize.

Materials and Methods

Field experiments were conducted at Livestock Farm Complex, Veterinary College and Research Institute, Namakkal during *kharif,* 2022 to determine the most suitable weed management method to control diverse weed species in African Tall variety of fodder maize**.** The experiment was carried out in a Randomized Block Design with seven treatments and three replicates. The treatments were applied in the fodder maize field for weed management *viz*., T_1 - Atrazine 1.0 kg ha^{-1}, T_2 - Atrazine 1.0 kg ha^{-1} fb Hand weeding on 20 DAS, T_3 - Atrazine 1.0 kg ha^{-1} fb Twin wheel hoe weeding on 20 DAS, T_4 - Atrazine 1.0 kg ha^{-1} fb 2,4-D 0.5 kg ha^{-1}on 20 DAS, T_5 - Hand weeding twice on 20 and 40 DAS, T_6 - Twin wheel hoe weeding twice on 20 and 40 DAS, T_7 -Weed free check. "African tall" variety of fodder maize was sown with row spacing of 30 x 15 cm and adopted a seed rate of 40 kg/ha. The soil of the experimental field was alkaline in reaction (pH 7.75) and high in organic carbon (0.98%) as well as with low available nitrogen (245 kg/ha), high available phosphorus (29.36 kg/ha) and medium available potassium (198 kg/ha). The observations on weed density, weed dry matter, weed control efficiency, growth parameters and yield of green fodder maize were also recorded.

Weed density

The weed count was recorded species wise by using 0.5 m x 0.5 m (0.25 m^2) quadrat from four randomly fixed places in each plot and the weeds falling within the frames of the quadrat were counted, recorded and its mean values were expressed in number of weeds m^{-2} as suggested by Burnside and Wicks (1965) [2]. The total weed density was recorded at 30 and 45 DAS and expressed in numbers m^{-2}.

Weed dry weight

The weeds falling within the frames of the quadrats were collected, shade dried and later dried in hot-air oven at 80ºC for 72 hours. The dry weight of weeds were recorded at 30 and 45 DAS and expressed in kg ha^{-1}.

Weed control efficiency

Weed control efficiency (WCE) was calculated as per the procedure given by Mani *et al.*(1973) [7] and expressed in percentage.

$$WCE = \frac{WDC - WDT}{WDC} x100$$

Where,

WDC - Weed dry weight in unweeded control plot (kg ha^{-1})

WDT - Weed dry weight in treated plot (kg ha^{-1})

The data were statistically analysed following the procedure given by Gomez and Gomez (2010) [3] for randomised block design. The data pertaining to weeds and germination were transformed to square root scale of $\sqrt{(X+2)}$ and analysed. Whenever significant difference existed, critical difference was constructed at 5 percent probability level.

Results and Discussion

Dominant weed flora

Weed flora of the experimental fields consisted of predominantly five species of broadleaved weeds, two species of grassy weeds and a sedge weed. The predominant broadleaved weeds were *Trianthema portulacastrum*, *Cleome gynandra*, *Boerhaavia diffusa*, *Digera arvensis* and *Cyanotis axillaris*. Among the grassy weeds, *Cynodon dactylon* and *Dactyloctenium aegyptium* were dominant. *Cyperus rotundus* was the only sedge weed found in the experimental fields.

Weed density and dry weight

Different weed control methods had a significant impact on total weed density and dry weight at 30 and 45 DAS, as shown in Table 1. The results clearly indicate that the plots without any weed control measures had the highest weed density (17.30/m^2) and dry weight (13.69 g/m^2), at both stages due to uninterrupted growth. However, hand weeded plot and using chemical method of weed control led to a decrease in weed density and dry weight. The pre-emergence application of atrazine 1.0 kg ha^{-1}followed by hand weeding at 20 DAS and Atrazine1.0 kg ha^{-1} followed by twin wheel hoe weeding at 20 DAS and Atrazine 0.75 kg ha^{-1} followed by the post-emergence application of 2,4-D @ 0.75 kg ha^{-1} slightly reduced the density and dry weight of both monocot and dicot weeds. However, hand weeding performed at 20 and 40 DAS had the greatest impact in reducing weed density and dry weight compared to herbicidal treatments. Similar results were also reported by Nagalakshmi *et al*, (2006) [8] and Sahu *et al*, (2022) [11].

Weed control efficiency

The hand weeding method ensured the highest weed control efficiency among other weed control methods as shown in Table 1. It was closely followed by the application of atrazine 1.0 kg ha^{-1} followed by hand weeding at 20 DAS. These findings suggested that, implementing hand weeding ultimately leads to a weed-free and favourable environment in addition to using pre-emergence herbicide, resulted in better weed control efficiency in fodder maize. On the other hand, the weedy check treatment showed the lowest weed control efficiency which aligns with the findings reported by Malviya *et al.*(2012) [5].

Green Fodder Yield

The green fodder yield is a complex process which depends on both the production methods and the genetic makeup of the crop plants (Table. 2). Weeds are significantly affects the crop yield, depending on factors like weed species, density and the duration of crop-weed competition. In this study, it was observed that weeds had a detrimental impact on the crop, resulting in lower green fodder yield. The plots that did not receive any weed control measures had the lowest yield (30.2 t ha^{-1}) because of intense competition for nutrients during crop growth. Similar results were also reported by Swetha *et al*, (2015) [12]. However, the plots that received hand weeding and herbicidal treatments showed higher yields compared to weedy check plot. Among the treatments hand weeding twice at 20 DAS and 40 DAS recorded maximum green fodder yield of 42.9 t ha^{-1}and this was significantly on par with the application of Atrazine 1.0 kg ha followed by hand weeding at 20 DAS recorded 41.1 t ha^{-1} (Table. 2). The removal of weeds from both between and within the rows, along with improved soil aeration, allowed the crop in weed-free plots to grow vigorously, which was also reported by Baldaniya *et al.* (2018) [1] and Mandal *et al.* (2012) [6]. This created more space, water, light and nutrients for better growth and development, resulting in superior yield attributes and ultimately the highest yield.

Table 1: Weed density (No./m^2) and weed dry weight (gm/m^2) and weed control efficiency (%) as influenced by different weed control treatments in fodder maize

Treatments	Weed Density		Weed Dry Weight		WCE (%)	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
T_1- Atrazine 1.0 kg ha^{-1}	15.26 (232.45)	16.93 (285.97)	8.86 (78.0)	13.39 (178.9)	58.3%	36.4%
T_2 - Atrazine 1.0 kg ha^{-1} *fb* Hand weeding on 20 DAS	5.57 (30.54)	6.14 (37.24)	4.46 (19.4)	5.69 (31.8)	89.6%	88.7%
T_3 - Atrazine 1.0 kg ha^{-1} *fb* Twin wheel hoe weeding on 20 DAS	9.39 (87.65)	12.44 (154.25)	7.86 (61.2)	11.03 (121.2)	67.2%	56.9%
T_4 - Atrazine 1.0 kg ha^{-1} *fb* 2,4 D 0.5 kg ha^{-1} on 20 DAS	13.17 (172.85)	13.81 (190.14)	8.30 (68.4)	10.70 (113.9)	63.4%	59.5%
T_5 - Hand weeding twice 20 and 40 DAS	6.08 (36.45)	5.00 (24.50)	3.94 (15.0)	3.90 (14.7)	92.0%	94.8%
T_6 - Twin wheel hoe weeding twice on 20 DAS and 40 DAS	11.17 (124.24)	11.32 (127.54)	9.05 (81.4)	9.27 (85.5)	56.5%	69.6%
T_7 - Weedy check	17.30 (298.64)	18.91 (357.04)	13.69 (186.9)	16.78 (281.2)	0.0	0.0
S.Ed	0.08	0.18	0.07	0.12	-	-
CD (P=0.05)	0.19	0.54	0.19	0.27	-	-

*Figures in parenthesis are original values

Table 2: Growth parameters (at harvest) and green fodder yield as influenced by different weed control treatments in fodder maize

Treatments	No. of leaves / plant	Plant height (cm)	Green Fodder Yield(t ha^{-1})
T_1- Atrazine 1.0 kg ha^{-1}	9.8	175.4	34.1
T_2 - Atrazine 1.0 kg ha^{-1} *fb* Hand weeding on 20 DAS	11.4	210.4	41.1
T_3 - Atrazine 1.0 kg ha^{-1} *fb* Twin wheel hoe weeding on 20 DAS	11.1	198.7	38.4
T_4 - Atrazine 1.0 kg ha^{-1} *fb* 2,4 D 0.5 kg ha^{-1}on 20 DAS	10.1	184.0	39.0
T_5 - Hand weeding twice 20 and 40 DAS	12.7	227.4	42.9
T_6 - Twin wheel hoe weeding twice on 20 DAS and 40 DAS	10.5	181.0	35.8
T_7 - Weedy check	7.9	147.4	30.2
S.Ed	0.07	0.42	0.69
CD (P=0.05)	0.17	0.94	1.87

Conclusion

Weeds possess a significant challenge in the production of fodder maize. To effectively address this issue, a strategic use of herbicides is essential. The results of this study indicate that hand weeding twice at 20 DAS and 40 DAS recorded maximum green fodder yield of 42.9 t ha^{-1} and this was significantly on par with the application of atrazine 1.0 kg ha followed by hand weeding at 20 DAS recorded 40.2 t ha^{-1} can effectively control the diverse weed population in fodder maize fields, resulting in a higher green fodder yield. Although hand weeding produced the highest yield, it is not a feasible option for farmers due to increased cost of labour for weed control. By reducing weed competition, there was a noticeable improvement in vegetative growth and overall yield.

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