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Weed Dynamics of Fodder Maize as Influenced by Different Herbicides

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The advancements in fodder maize cultivation practices over the past few years, has paved a change in the makeup of weed associations. This made it necessary to incorporate new, effective herbicides in the struggle against maize's primary weeds. Therefore, a field experiment was conducted at Research Farm, AICRP on Forage Crops, Department of Agronomy, JNKVV, Jabalpur (Madhya Pradesh) during *Kharif* season 2019 to devise an appropriate combination of herbicides required for the control of the complex weed diversity in fodder maize. The field experiment was laid out in randomized block design (RBD) with ten treatments (eight herbicidal combinations along with hand weeding twice at 20 and 40 DAS and a weedy check) and replicated thrice. Observations were recorded on the weed parameters and fodder yield of maize. Among monocots, the experimental field was infested with *Echinochloa colona*, *Commelina communis* and *Digitaria sanguinalis. Phyllanthus niruri* and *Eclipta alba* were dominated among dicots. Among all herbicidal treatment, topramezone 35 g/ha plus atrazine 250 g/ha was found to be significantly superior in reducing total weed density (9.49/m^2, 11.50/m^2) and total weed dry weight (6.43 g/m^2, 7.91 g/m^2) at 30 and 45 DAS, respectively and recorded the lowest weed index (1.82%). Also, the maximum green fodder yield (472.68 q/ha) was recorded in topramazone 35 g/ha + atrazine 250

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g/ha compared to other treatments. Overall, this study indicated that the combination of topramazone 35 g/ha + atrazine 250 g/ha could be an alternative approach to hand weeding and alone herbicides in fodder maize.

Keywords: Herbicidal application; weed dynamics; weed control efficiency; weed index; yield.

1. INTRODUCTION

Population growth causes the demand for animal products like milk, eggs, and meat to rise dramatically [1]. The increased demand for animal products has encouraged growth in the number of cattle within the current farming system while also highlighting the importance of the security of feed and fodder in the nation [2]. Currently, the nation has a net deficit of 64.1% in feeds, 21.9% in dry crop residue, and 61.1% in green fodder [3]. Thus, the country's cattle industry would have a significant problem in meeting the demand for feed and fodder [4].

"Maize is the most ideal and appropriate crop for fodder as well as silage production. Maize (*Zea mays* L.) belongs to the *Gramineae* family and is a staple food crop in the universe, second only to wheat and rice" [5]. "Maize has become an important grain because of its huge production potential and adaptability to a wide range of environments" [6]. "Maize assumes a special significance on account of its utilization as food, feed, fodder and stalk besides several industrial uses. It is one of the most important dual purpose cereal crops all over the world" [7]. "The production of good quality fodder and forage is of great importance for the development of livestock industry in the country" [8].

"Fodder maize encounters a serious weed issue because the majority of farmers don't use any weed management techniques, which results in a lower yield of green and dry fodder per unit area" [9]. "The quantities of growth factors used by weeds are thus unavailable to the crop; the extent of nutrient loss varies from 30-40% of the applied nutrients" [10,11]. "Wider row spacing and initial slow crop growth make maize highly sensitive to weed competition up to six weeks growth period, when the maximum yield loss due to weed competition occurs" [12].

"Hand weeding is very cumbersome, tedious, and costly. The unavailability of labourers during the critical period of the crop-weed competition is another issue" [13]. "Chemical weed management by using post-emergence herbicides can lead to the efficient and cost effective control of weeds during critical period of crop weed competition [14], which may not be possible in manual or mechanical weeding due to its high cost of cultivation" [15,16]. "Few herbicides like Atrazine, Oxyfluorfen, 2,4-D and Pendimethalin are available for weed control in maize. At present farmers are applying only 2, 4-D at 1.0 kg/ha or Atrazine at 1.0 kg/ha as post-emergence herbicides in maize, but these herbicides control only broad leaf weeds. Control of grasses and sedges remain a problem for the farmers, especially when the too high or too low soil moisture hinders the intercultural operation and scarcity of labour during critical stages of weeding" [17,18]. Hence, there is an immense need to find out the best chemical for effective weed management in maize. Hence, this study was undertaken to identify the best chemical weed management practices in fodder maize.

2. MATERIALS AND METHODS

The experiment was executed during the *Kharif* season 2019 at Research Farm, AICRP on Forage Crops, Department of Agronomy, JNKVV, Jabalpur (Madhya Pradesh). The experiment was carried out in a randomized complete block design with three replications. Ten different treatments for weed management were applied in the fodder maize field viz. T1- tembotrione 120 g *a.i*/ha (Post emergence at 20 DAS), T2- topramezone 35 g *a.i*/ha (Post emergence at 20 DAS), T3- atrazine 1000 g *a.i*/ha (Pre emergence), T4- pendimethalin 750 g *a.i* /ha (Pre emergence), T5- tembotrione 120 g *a.i.* /ha + atrazine 250 g *a.i*/ha (Post emergence at 20 DAS), T6- topramezone 35 g *a.i*/ha + atrazine 250 g *a.i*/ha (Post emergence at 20 DAS), T7- atrazine 750 g *a.i/*ha + pendimethalin 750 g *a.i*/ha (Pre emergence), T8- 2,4-D 500 g *a.i*/ha (Post emergence at 20 DAS), T9- hand weeding twice at 20 and 40 DAS and T10- weedy check. "African tall" variety of fodder maize was sown with row spacing of 50 cm and seed rate of 40 kg/ha. The soil of the experimental field was neutral in reaction (pH 7.21) and low in organic carbon (0.54%) as well as with medium available nitrogen (231.56 kg/ha), medium available phosphorus (16.59 kg/ha) and medium available potassium (313.66

kg/ha) contents with normal electrical conductivity (0.33). Observations on weed density, weed dry matter, weed control efficiency, weed index and yield of fodder maize were recorded. The calculation of weed control efficiency is based on the reduction of the dry matter yield of the weeds in the treated plots compared with the weed control at 45 DAS, and expressed as a percentage [19].

$$WCE = \frac{DMC - DMT}{DMC} \times 100$$

Where,

WCE = Weed control efficiency (%)
DMC = Dry matter of weeds in weedy check plot
DMT = Dry matter of weeds in treated plot

Weed Index was calculated using the formula [20]

Weed Index = (Yield from weed free plot − Yield from treated plot / Yield from weed free plot) x 100

The data obtained on various parameters are tabulated and statistically analyzed [21]. The significance of the difference between a pair of means was tested by the least significant difference (LSD) test at a significance level of 5% [22].

3. RESULTS AND DISCUSSION

3.1 Dominant Weed Flora

"The dominant weeds associated with crop in the experimental field mainly comprised of *Echinochloa colona, Cyperus rotundus, Commelina communis, Eclipta alba, Digitaria sanguinalis, Eleusine indica* and *Phyllanthus niruri.* While, other minor weeds were also present. Almost similar weed flora is reported in maize [23] and other crops" [24].

3.2 Relative Density of Weeds

The data for species-wise weeds observed in weedy check plots at the 30 and 45 DAS stages of maize are shown in Table 1 indicated that, monocot weeds dominated (76.31%) compared to dicot weeds (16.68%). Other species of weeds also marked their presence in less number. At the 30 and 45 DAS stages, *Echinochloa colona* (35.17%), *Commelina communis* (12.43%), and *Digitaria sanguinalis* (10.79%) were the most prevalent monocot weeds, whereas dicot weeds like *Phyllanthus niruri* (10.12%) and *Eclipta alba* (6.55%) were more sparsely distributed in the maize ecosystem (Fig. 1). These findings were in conformity to those of [25,26]

3.3 Density and dry Weight of Weeds

Total weed density and dry weight at 30 and 45 DAS varied significantly due to different weed control treatments (Table 2). The results clearly show that the weedy check plots had the highest weed density and dry weight of total weeds, including minor weeds, at both stages due to uninterrupted growth in the absence of weed control measures. However, chemical method of weed control resulted in an decrease in weed density and dry weight. Pre-emergence application of atrazine 1000 g/ha, pendimethalin 750 g/ha, atrazine 750 g/ha + pendimethalin 750 g/ha and post-emergence application of 2,4-D 500 g/ha slightly decreased the total density and dry weight of monocot and dicot weeds. However, the reduction was more pronounced when post emergence application of topramezone 35 g/ha + atrazine 250 g/ha herbicides were applied at 20 DAS. In comparison to other herbicides, the post-emergence applications of topramezone 35 g/ha + atrazine 250 g/ha successfully controlled both monocot and dicot weeds and successfully recorded the lowest weed density (9.49, 11.50/m^2) and dry weight (6.43, 7.91 g/m^2) at 30 and 45 DAS, respectively. However, the hand weeding performed at 20 and 40 DAS reduced the density and dry weight of weeds to the greatest degree over herbicidal treatments [27,28].

3.4 Weed Control Efficiency

Among various weed control treatments, the highest weed control efficiency were recorded under hand weeding treatment and it was closely followed by topramezone 35 g/ha + atrazine 250 g/ha. These results indicate that in addition to post-emergence herbicides, imposition of hand weeding ultimately provided weed free and congenial environment as the outcome of improved weed control efficiency of fodder maize crop. While, the lowest weed control efficiency was recorded with weedy check treatment. These results are in accordance with the esults indicated by Madhavi and Malviya et al. [29,30].

Table 1. Species wise mean intensity and relative density of weeds in weedy check plots at 30 and 45 DAS

S. No.	Weeds	Density (no/m^2)		Mean	Relative density (%)
		30 DAS	45 DAS		
A.	**Monocots**				
1.	*Echinochloa colona*	99.92	103	101.46	35.17
2.	*Digitaria sanguinalis*	28.42	33.83	31.13	10.79
3.	*Eleusine indica*	16.57	24.63	20.60	7.14
4.	*Cyperus rotundus*	31.5	30.67	31.09	10.77
5.	*Commelina communis*	35.5	36.25	35.88	12.43
	Sub-total			220.15	76.31
B.	**Dicots**				
	Phyllanthus niruri	24	34.42	29.21	10.12
	Eclipta alba	16.8	21.00	18.90	6.55
	Sub-total			48.11	16.68
C.	**Other weeds**	16	24.50	20.25	7.01
	Total			288.51	100

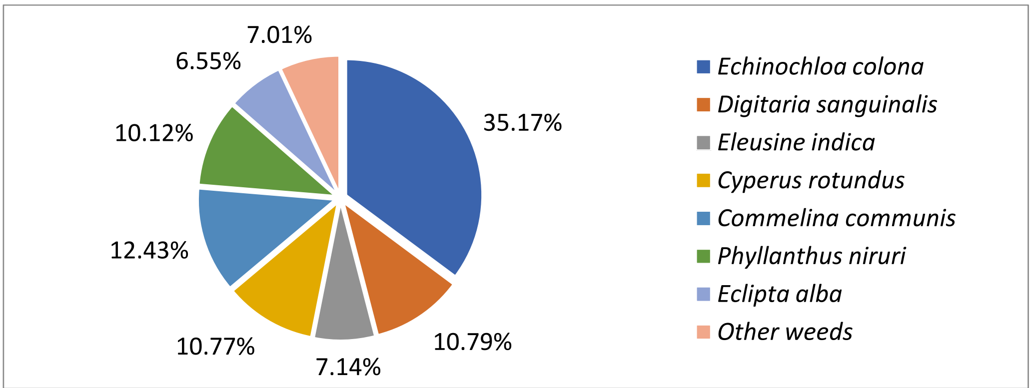

Fig. 1. Relative density of weeds at 30 and 45 DAS

Table 2. Weed density (no./m^2) and weed dry weight (g/m^2) as influenced by different weed control treatments in fodder maize

Treatments	Total weed density (no./m^2)		Total weed dry weight (g/m2)	
	30 DAS	45 DAS	30 DAS	45 DAS
T_1- Tembotrione 120 g/ha	11.50 (131.78)	13.67 (186.30)	9.10 (82.23)	10.52 (110.26)
T_2- Topramezone 35 g/ha	11.04 (121.44)	13.20 (173.62)	8.31 (68.65)	9.76 (94.84)
T_3- Atrazine 1000 g/ha	13.77 (189.25)	15.65 (244.60)	11.14 (123.69)	12.37 (152.62)
T_4- Pendimethalin 75 g/ha	14.86 (220.34)	16.30 (265.40)	11.79 (138.59)	13.03 (169.28)
T_5- Tembotrione 120 g/ha + Atrazine 250 g/ha	10.08 (101.07)	12.24 (149.43)	7.33 (53.27)	8.79 (76.78)
T_6- Topramezone 35 g/ha + Atrazine 250 g/ha	9.49 (89.60)	11.50 (131.92)	6.43 (40.90)	7.91 (62.06)
T_7- Atrazine 750 g/ha + Pendimethalin 750 g/ha	13.17 (173.05)	14.90 (221.43)	10.44 (108.40)	11.92 (141.49)
T_8- 2,4-D 500 g/ha	12.75 (162.14)	14.29 (203.78)	9.85 (96.60)	11.34 (128.20)
T_9- Hand weeding	6.78 (45.47)	7.02 (48.80)	2.49 (5.70)	5.28 (27.51)
T_{10}- Weedy Check	16.41 (268.70)	17.57 (308.30)	14.16 (199.96)	15.58 (242.27)
SEm±	0.06	0.15	0.06	0.08
CD at 5%	0.19	0.46	0.17	0.22

*Transformed values: $\sqrt{x + 0.5}$
Original figures are given in parenthesis

Table 3. Weed control efficiency (%), weed index (%) and yield as influenced by different weed control treatments in fodder maize

Treatments	Weed control efficiency (%) at 45 DAS	Weed index (%)	Green fodder yield (q/ha)
T_1- Tembotrione 120 g/ha	54.49	11.60	405.37
T_2- Topramezone 35 g/ha	60.85	10.93	423.42
T_3- Atrazine 1000 g/ha	37.00	20.38	366.11
T_4- Pendimethalin 75 g/ha	30.13	22.50	354.79
T_5- Tembotrione 120 g/ha + Atrazine 250 g/ha	68.31	3.87	442.66
T_6- Topramezone 35 g/ha + Atrazine 250 g/ha	74.38	1.82	472.68
T_7- Atrazine 750 g/ha + Pendimethalin 750 g/ha	41.60	14.92	370.89
T_8- 2,4-D 500 g/ha	47.08	13.93	372.36
T_9- Hand weeding	88.64	0.00	473.17
T_{10}- Weedy Check	0.00	31.53	343.12
SEm±	-	0.38	5.53
CD at 5%	-	1.14	16.44

3.5 Weed Index

Weed index is a measure of reduction in the green fodder yield due to weed competition stress as against weed free treatment. Data showed that maximum yield loss of 31.53% was recorded under weedy check and weeds were not controlled in the entire crop season. Presence of weeds created stressful conditions for nutrients, space, soil moisture and light; thus, suppressed the growth and development of maize crops. Among weed control practices, hand weeding registered the lowest weed index, however, due to the economical prospective, it was not considered. Among the herbicidal treatments, the weed index was lowest (1.82 %) in plots receiving application of topramezone 35 g/ha + atrazine 250 g/ha followed by tembotrione 120 g/ha + atrazine 250 g/ha (3.87 %) and topramezone 35 g/ha (10.93 %). The lower weed index values under aforesaid treatments are attributed to the reduced competition stress by weed. Therefore, the yield attributes in crop were superior which ultimately resulted into increased green fodder yield. These findings are in line with the results of [31, 32].

3.6 Green Fodder Yield

Green fodder yield in response to a specific treatment is the outcome of a complex phenomenon that is influenced by both the production methods used and the genetic makeup of the crop plants (Table 3). Depending on the associated weed species, their density, the length of the crop weed competition, etc., weeds significantly harmed the crop, and their cumulative impact was demonstrated in a lower crop yield. Due to intense competition stress from the start of the critical period of crop growth until the end, the green fodder yield was lowest (343.12 q/ha) in the plots getting no weed control measures (weedy check). All of the treated plots, which either received manual weeding or herbicidal treatments produced greater yields over weedy check plot. The maximum green fodder yield was noted in hand weeding treatment (473.17 q/ha). However, among the herbicidal applications, topramezone 35 g/ha + atrazine 250 g/ha recorded the maximum green fodder yield (472.68 q/ha). Due to the removal of weeds from between and within the rows as well as improved soil aeration, the crop in weed-free plots grew lushly. More space, water, light, and nutrients were thus made available for the better growth and development, leading to superior yield attributes and development, and ultimately the highest yield [33,34].

4. CONCLUSION

Weeds are the leading problem creators in fodder maize production. The control of weeds, therefore, becomes necessary through an appropriate combination of herbicides. Therefore, based on the current experiment, it can be concluded that, the application of topramezone 35 g/ha + atrazine 250 g/ha successfully controls the complex weed flora associated with fodder maize due to the broad-spectrum control of grassy and broad-leaved weeds in fodder maize and gives the higher green fodder yield (472.68

q/ha). The hand weeding treatment despite having highest green fodder yield could not be adopted by the farmers due to rise in cost of cultivation. The lesser weed competition resulted in better vegetative growth which contributed to higher yields. Thus, farmers can adopt the post emergence application of application of topramezone 35 g/ha + atrazine 250 g/ha at 20 DAS as a wise alternative for weed management in fodder maize.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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