# Original Research Article
# Assessing the effect of weed management practices on weed flora, growth and yield of fodder maize (*Zea mays* L.)


## ABSTRACT

A field experiment was conducted at Research Farm, AICRP on Forage Crops, Department of Agronomy, JNKVV, Jabalpur (Madhya Pradesh) during *Kharif* season of the year 2019. The main objective of the experiment was to find out the effect of different weed control treatments on complex weed flora in fodder maize. Ten treatments were tested in randomized block design with three replications. Treatments consisted of 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, tembotrione 120 g/ha, topramezone 35 g/ha, tembotrione 120 g/ha + atrazine 250 g/ha, topramezone 35 g/ha + atrazine 250 g/ha, hand weeding twice at 20 and 40 DAS and weedy check. Weed intensity and dry matter accumulation by weeds were recorded species wise and then the effectiveness of weed management and the weed control efficiency were calculated. In maize field, the predominated weeds were *Echinochloa colona*, *Commelina communis*, and *Digitaria sanguinalis* among monocots, *Phyllanthus niruri* and *Eclipta alba* among dicots along with a respectable sum of numerous minor weeds. Experimental results indicated that hand wedding has recorded highest weed control efficiency (88.64%) followed by PoE application of topramezone 35 g/ha + atrazine 250 g/ha (74.38%) and tembotrione 120 g/ha + atrazine 250 g/ha (68.31%). All weed control treatments significantly affected the plant height, LAI, stem girth and leaf: stem ratio of crop. Among different herbicidal treatments, topramezone 35 g/ha + atrazine 250 g/ha was found significantly superior and gives highest green fodder yield (47.26 t/ha), dry fodder yield (13.64 t/ha), crude protein yield (1.51 t/ha), net monetary returns (Rs. 44824/ha) and B:C ratio (2.72).



***Keywords**: Fodder maize, Green fodder yield, Herbicides, Weed control efficiency, Weed flora*




## 1. INTRODUCTION

Maize (*Zea mays* L.) is known as 'Queen of Cereals' because of its high production potential and wider adaptability [1, 2]. The agricultural production systems in India are based upon mixed farming in

which two major enterprises are crops and livestock. Livestock is the backbone of Indian agriculture and accounts for around 4.4 percent of the country's gross domestic product [3]. India ranks first in milk production. The production of good quality fodder and forage is of great importance for the development of livestock industry in the country [4, 5]. Fodder plays an important role in economizing the cost of production of livestock products especially of milk. Green fodder is the essential component of feeding high yielding milch animals to obtain optimum level of milk production [6]. The green fodder maize (African Tall) contains dry matter (22.2%), crude protein (7.1%), crude fiber (30.2%), in-vitro dry matter digestibility (65.0%), neutral detergent fibre (67.6%), acid detergent fibre (38.3%) and total ash (6.0%) [7].

Weed management is a severe issue in forage crop production and weeds play a large piece in fodder maize production. Worldwide yield losses in maize due to weeds are estimated to be around 37% [8]. Farmers usually give prime importance to few cultural practices and neglect other factors like weed control [9]. Maize crop gets infested with variety of weeds and subjected to heavy weed competition, which often inflicts huge losses. Among different agronomic practices, such as date of sowing, fertilizer management, irrigation and weed management, weeds cause a major problem in rainy season crop due to favourable growth conditions primarily because of wide spacing and initial slow growth, frequent rains, causing huge losses ranging from 28 to 100% [10, 11, 12].

In this context, the use of suitable herbicides is the only substitute to get higher productivity with lower cost involvement. However continuous use of the herbicide causes shift in weed flora and development of resistance to herbicides [13, 14]. Herbicides are used to retain weed-free conditions, during the early stage of growth, either by cultural or mechanical means or through pre-planting, pre-emergence and post-emergence herbicide applications [15, 16]. Atrazine, recommended as a pre-emergence herbicide, is not effective against some of the weeds. Globally, 45 weed species across the many corn growing areas shown resistance against photosystem II (PS II) inhibitor herbicides, like atrazine (Heap 2019). So, there is a need for some alternate post-emergence herbicide which can provide broad spectrum weed control in *kharif* maize without affecting the crop growth and yield of crop. Hence, the current experiment was conducted to evaluate the performance of different herbicides against complex weed flora in fodder maize.

## 2. MATERIALS AND METHODS

A field experiment was conducted at Research Farm, AICRP on Forage Crops, Department of Agronomy, JNKVV, Jabalpur (Madhya Pradesh) during *Kharif* season of the year 2019 to study the effect of different herbicides on growth and yield of fodder maize. The soil of the experimental field was neutral in reaction (pH 7.21) and medium in organic carbon (0.54%) as well as with medium available nitrogen (231.56 kg/ha), available phosphorus (16.59 kg/ha) and available potassium (313.66 kg/ha) contents with normal electrical conductivity (0.33). The experiment was laid out in a randomized complete block design (RCBD) with the following treatments viz., tembotrione 120 g *a.i*/ha at 20 DAS, topramezone 35 g *a.i*/ha at 20 DAS, pre-emergence application of atrazine 1000 g *a.i*/ha, pre-emergence application of pendimethalin 750 g *a.i* /ha, tembotrione 120 g/ha + atrazine 250 g *a.i*/ha at 20 DAS, topramezone 35 g *a.i*/ha + atrazine 250 g *a.i*/ha at 20 DAS, pre emergence application of atrazine 750 g *a.i*/ha + pendimethalin 750 g *a.i*/ha, 2,4-D 500 g *a.i*/ha at 20 DAS, hand weeding twice at 20 and 40 DAS and control. African tall variety of maize was sown with row spacing of 50 cm and seed rate of 40 kg per ha. Observations on weed density, weed dry matter, weed control efficiency, plant growth parameters, yield and economics of fodder maize were recorded.

## 3. RESULTS AND DISCUSSION

### 3.1 Weed flora

The important grassy weeds (*Echinochloa colona, Digitaria sanguinalis* and *Eleusine indica*), sedges (*Cyperus rotundus*) and broad-leaved weeds (*Commelina communis, Phyllanthus niruri* and *Eclipta alba*) were observed in association with maize in the experimental site.

### 3.2 Weed density and dry weight

All the weed management treatments significantly affected the grassy, sedges and broad leaved weeds at 45 DAS (**Table 1**). The data revealed that topramezone 35 g/ha + Atrazine 250 g/ha recorded the lowest density of all the grassy, sedges and broad leaved weeds significantly compared to all other herbicidal treatments and at par with tembotrione 120 g/ha + atrazine 250 g/ha. However, hand weeding was superior among all the weed control treatments and recorded the lowest density of all the weed species. At the same time, the density of all the dominant weeds was higher in weedy check [17].

Significant variation in weed dry weight was recorded due to different weed-management practices at 45 DAS (**Table 2**). The recorded data indicated that higher weed dry weight was recorded in the weedy check treatment, while the lowest weed dry weight was recorded in the hand weeding treatment. However, among herbicidal treatments, the application of pre-emergence herbicide

topramezone 35 g/ha + Atrazine 250 g/ha recorded significantly minimum weed dry weight that established its superiority over other treatments, which is at par with tembotrione 120 g/ha + atrazine 250 g/ha [18].

**Table 1. Influence of different weed control treatments on density of weeds (no/m$^2$) at 45 DAS**

| Treatments | *Echinochloa colona* | *Digitaria sanguinalis* | *Eleusine indica* | *Cyperus rotundus* | *Commelina communis* | *Phyllanthus niruri* | *Eclipta alba* |
|---|---|---|---|---|---|---|---|
| Tembotrione 120 g/ha | 8.34 (69.08) | 4.76 (22.15) | 2.85 (7.65) | 4.57 (20.42) | 4.94 (23.92) | 4.75 (22.08) | 2.99 (8.50) |
| Topramezone 35 g/ha | 8.12 (65.50) | 4.58 (20.44) | 2.69 (6.77) | 4.47 (19.50) | 4.76 (22.17) | 4.53 (20.00) | 2.88 (7.83) |
| Atrazine 1000 g/ha | 9.41 (88.17) | 5.34 (28.07) | 3.69 (13.11) | 5.02 (24.75) | 5.38 (28.50) | 5.38 (28.50) | 3.65 (12.83) |
| Pendimethalin 750 g/ha | 9.68 (93.17) | 5.44 (29.07) | 3.96 (15.17) | 5.19 (26.50) | 5.74 (32.50) | 5.68 (31.75) | 3.75 (13.67) |
| Tembotrione 120 g/ha + Atrazine 250 g/ha | 7.26 (52.17) | 4.33 (18.27) | 2.58 (6.17) | 4.17 (16.92) | 4.51 (19.83) | 4.26 (17.67) | 2.58 (6.17) |
| Topramezone 35 g/ha + Atrazine 250 g/ha | 6.68 (44.58) | 4.22 (17.33) | 2.46 (5.58) | 3.94 (15.00) | 4.36 (18.50) | 4.03 (15.75) | 2.26 (4.67) |
| Atrazine 750 g/ha + Pendimethalin 750 g/ha | 9.00 (80.58) | 5.06 (25.10) | 3.05 (8.83) | 4.87 (23.25) | 5.18 (26.33) | 5.14 (26.00) | 3.67 (13.00) |
| 2,4-D 500 g/ha | 8.51 (71.92) | 4.90 (23.53) | 2.97 (8.33) | 4.83 (22.83) | 5.13 (25.83) | 4.97 (24.17) | 3.31 (10.50) |
| Hand weeding | 2.99 (8.50) | 3.72 (13.38) | 2.17 (4.25) | 2.04 (3.67) | 2.59 (6.25) | 2.45 (5.50) | 1.82 (2.83) |
| Weedy Check | 10.17 (103.00) | 5.85 (33.83) | 5.00 (24.63) | 5.58 (30.67) | 6.05 (36.25) | 5.91 (34.42) | 4.64 (21.00) |
| SEm± | 0.20 | 0.07 | 0.09 | 0.06 | 0.12 | 0.08 | 0.14 |
| CD at 5% | 0.59 | 0.21 | 0.26 | 0.17 | 0.37 | 0.25 | 0.41 |

**Table 2. Influence of different weed control treatments on dry weight of weeds (g/m$^2$) at 45 DAS**

| Treatments | *Echinochloa colona* | *Digitaria sanguinalis* | *Eleusine indica* | *Cyperus rotundus* | *Commelina communis* | *Phyllanthus niruri* | *Eclipta alba* |
|---|---|---|---|---|---|---|---|
| Tembotrione 120 g/ha | 4.59 (20.55) | 4.10 (16.34) | 3.58 (12.32) | 3.21 (9.80) | 3.87 (14.51) | 3.88 (14.56) | 3.52 (11.90) |
| Topramezone 35 g/ha | 4.36 (18.47) | 3.73 (13.40) | 3.40 (11.07) | 2.94 (8.13) | 3.54 (12.02) | 3.60 (12.47) | 3.35 (10.74) |
| Atrazine 1000 g/ha | 5.48 (29.53) | 4.80 (22.53) | 3.96 (15.17) | 4.01 (15.61) | 4.40 (18.92) | 4.64 (20.99) | 4.12 (16.45) |
| Pendimethalin 750 g/ha | 5.55 (30.30) | 5.00 (24.51) | 4.17 (16.90) | 4.46 (19.37) | 4.66 (21.20) | 4.99 (24.37) | 4.30 (17.96) |
| Tembotrione 120 g/ha + Atrazine 250 g/ha | 3.85 (14.36) | 3.48 (11.61) | 3.01 (8.58) | 2.76 (7.10) | 2.99 (8.45) | 3.32 (10.54) | 3.05 (8.80) |
| Topramezone 35 g/ha + Atrazine 250 | 3.50 (11.75) | 3.29 (10.34) | 2.65 (6.53) | 2.58 (6.13) | 2.77 (7.19) | 2.82 (7.43) | 2.72 (6.90) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| g/ha | | | | | | | |
| Atrazine 750 g/ha + Pendimethalin 750 g/ha | 5.36 (28.29) | 4.56 (20.32) | 3.88 (14.52) | 3.63 (12.70) | 4.15 (16.76) | 4.53 (20.03) | 4.00 (15.51) |
| 2,4-D 500 g/ha | 5.17 (26.27) | 4.34 (18.32) | 3.72 (13.37) | 3.45 (11.43) | 3.97 (15.23) | 4.11 (16.39) | 3.84 (14.27) |
| Hand weeding | 2.79 (7.31) | 1.53 (1.88) | 1.26 (1.10) | 1.60 (2.10) | 2.36 (5.18) | 2.48 (5.73) | 1.52 (1.81) |
| Weedy Check | 8.49 (71.53) | 5.36 (28.18) | 4.39 (18.80) | 5.20 (26.58) | 5.52 (29.93) | 5.47 (29.45) | 4.77 (22.28) |
| SEm± | 0.06 | 0.04 | 0.05 | 0.05 | 0.09 | 0.06 | 0.04 |
| CD at 5% | 0.18 | 0.11 | 0.14 | 0.15 | 0.27 | 0.18 | 0.13 |

### 3.3 Weed control efficiency

The weed control efficiency (WCE) had significant inverse relationship with dry matter production by weeds. The weed control efficiency was recorded maximum with hand weeding twice (88.64%) at 45 DAS, because associated weeds produced minimum dry matter with this treatment. The dry matter accumulation by weeds correspondingly reduced in 2,4-D 500 g/ha, Atrazine 750 g/ha + Pendimethalin 750 g/ha, Pendimethalin 750 g/ha and Atrazine 1000 g/ha, therefore the weed control efficiency correspondingly increased with these treatments. Post emergence application of tembotrione 120 g/ha, topramezone 35 g/ha, tembotrione 120 g/ha + atrazine 250 g/ha and topramezone 35 g/ha + atrazine 250 g/ha had minimum dry matter production by weeds. Consequently, these treatments had greater value of weed control efficiency than other herbicides. However, highest weed control treatment was recorded under topramezone 35 g/ha + Atrazine 250 g/ha treatment (74.38%) among herbicidal treatments. These results are in accordance with the results of [19, 20].

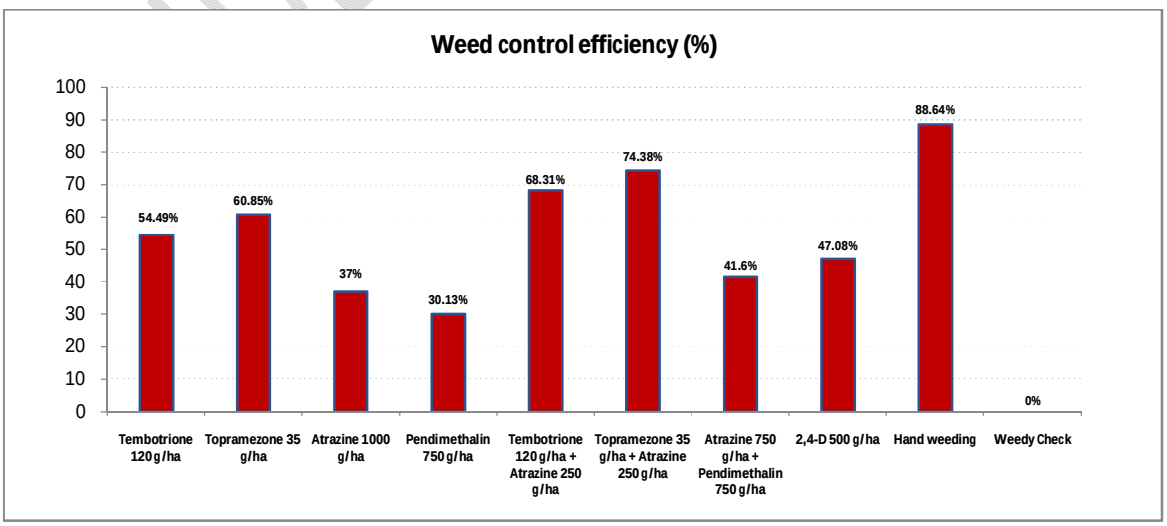


**Figure 1. Influence of different weed control treatments on weed control efficiency at 45 DAS.**

### 3.4 Growth parameters

The plant height, in general was less under all the treatment during early period of crop growth, which was increased with age of crop and was found maximum at 60 DAS (**Table 3**). Plant height was minimum (115.41 cm) under weedy check plots. However, maximum height was recorded in plots receiving twice hand weeding (21.79 cm). Among herbicidal treatments, application of topramezone 35 g/ha + atrazine 250 g/ha caused significant increase of plant height (178.97 cm) which is at par with tembotrione 120 g/ha + atrazine 250 g/ha, topramezone 35 g/ha and tembotrione 120 g/ha. These findings are in agreement with the findings of [21].

LAI differed significantly due to different weed control treatments at 60 DAS (**Table 3**). The LAI was maximum in weed free plot (10.24) among all weed control treatments, whereas minimum value of LAI was recorded in weedy check plots. Application of post emergence herbicides produced significantly higher LAI as compared to weedy check but, they were inferior to that of weed free plot. Among herbicidal treatments, maximum LAI was recorded in topramezone 35 g/ha + atrazine 250 g/ha (8.94). This may be because of better growth and development of foliage under weed free environment and consequently resulted in more assimilatory area per unit land area. Almost similar results were obtained by [22, 23].

Stem girth remarkably differed due to different treatments at 60 DAS crop stage (**Table 3**). Stem girth was less (2.02 cm) in weedy check plot, due to poor control of associated weeds. Application of post emergence herbicides resulted in increased in the stem girth at all the stages. But found significantly inferior to that of topramezone 35 g/ha + atrazine 250 g/ha, (2.23 cm) as well as weed free treatment (2.27 cm) because, both the treatments provided excellent control of associated weeds, resulting in almost weed free environment throughout the critical period of crop-weed competition which, led to optimum growth and development of crop plants and ultimately resulted in more number of leaves per plant under these treatments. Almost similar results were obtained by [24].

All the weed control treatments significantly affected the leaf: stem ratio at harvest stage (**Table 3).** Significantly higher L:S ratio was observed in twice hand weeding (0.82) and was at par with topramezone 35 g/ha + atrazine 250 g/ha (0.79). Significantly lower L:S ratio among all the weed management practices was noticed in control plot (0.66) The higher L:S ratio in twice hand weeding might be due to higher vegetative growth especially leaf growth. This was due to increased availability

of nutrients to the crop by reducing weed growth efficiently. Whereas, lower L:S ratio in unweeded control was mainly due to less crop growth especially leaf growth resulted from higher crop weed competition during critical stages of crop growth. The results align with the findings of [25].

**Table 3. Effect of weed control treatments on leaf area index, stem girth (cm) and leaf:stem ratio of maize at different growth stage**

| Treatments | Plant height (cm) | Leaf area index | Stem girth (cm) | Leaf: Stem |
|---|---|---|---|---|
| Tembotrione 120 g/ha | 168.97 | 6.96 | 2.15 | 0.75 |
| Topramezone 35 g/ha | 170.44 | 7.44 | 2.17 | 0.76 |
| Atrazine 1000 g/ha | 148.07 | 4.04 | 2.07 | 0.69 |
| Pendimethalin 750 g/ha | 139.43 | 3.51 | 2.06 | 0.68 |
| Tembotrione 120 g/ha + Atrazine 250 g/ha | 178.16 | 7.19 | 2.20 | 0.78 |
| Topramezone 35 g/ha + Atrazine 250 g/ha | 178.97 | 8.94 | 2.23 | 0.79 |
| Atrazine 750 g/ha + Pendimethalin 750 g/ha | 151.91 | 5.30 | 2.09 | 0.71 |
| 2,4-D 500 g/ha | 154.99 | 6.30 | 2.12 | 0.73 |
| Hand weeding | 180.58 | 10.24 | 2.27 | 0.82 |
| Weedy Check | 115.41 | 2.35 | 2.02 | 0.66 |
| SEm± | 1.43 | 0.27 | 0.01 | 0.004 |
| CD at 5% | 4.25 | 0.81 | 0.02 | 0.01 |

### 3.5 Yields

It is obvious from the data that green fodder, dry matter and crude protein yield varied significantly under different treatments (**Table 4**). Among all the treatments, the minimum green fodder, dry matter and crude protein yield were recorded under weedy check plot (34.31, 9.59, 1.04 t/ha, respectively) which was increased significantly when weed control measures were adopted. Maximum green fodder, dry matter and crude protein yield were recorded in twice hand weeding at 20 and 40 DAS (47.31, 13.89 and 1.52 t/ha, respectively). However, among herbicidal treatments, topramezone 35 g/ha + atrazine 250 g/ha recorded maximum green fodder, dry matter and crude protein yield (47.26, 13.64 and 1.51 t/ha, respectively). [26, 27] also reported the same results.

**Table 4. Effect of weed control treatments on grain yield, Stover yield, harvest index and weed index of maize**

| Treatments | Green fodder yield (t/ha) | Dry matter yield (t/ha) | Crude protein yield (t/ha) |
|---|---|---|---|
| Tembotrione 120 g/ha | 40.53 | 12.28 | 1.43 |
| Topramezone 35 g/ha | 42.34 | 12.37 | 1.45 |
| Atrazine 1000 g/ha | 36.61 | 11.06 | 1.25 |
| Pendimethalin 750 g/ha | 35.47 | 10.76 | 1.12 |
| Tembotrione 120 g/ha + Atrazine 250 g/ha | 44.26 | 13.35 | 1.50 |
| Topramezone 35 g/ha + Atrazine 250 g/ha | 47.26 | 13.64 | 1.51 |
| Atrazine 750 g/ha + Pendimethalin 750 g/ha | 37.08 | 11.82 | 1.33 |
| 2,4-D 500 g/ha | 37.23 | 12.02 | 1.41 |

| | | | |
|---|---|---|---|
| Hand weeding | 47.31 | 13.89 | 1.52 |
| Weedy Check | 34.31 | 9.59 | 1.04 |
| SEm± | 2.03 | 0.64 | 0.02 |
| CD at 5% | 6.34 | 1.91 | 0.06 |

### 3.6 Economics

Economic analysis of different weed control treatments in fodder maize is given in **Table 5**. The maximum GMR of Rs. 70975/ha was registered in hand weeding treatment, however maximum NMR of Rs. 44824/ha was registered in topramezone 35 g/ha + atrazine 250 g/ha followed by tembotrione 120 g/ha + atrazine 250 g/ha (Rs. 40871/ha). Similarly maximum B:C ratio was found with application of topramezone 35 g/ha + atrazine 250 g/ha (2.72) followed by tembotrione 120 g/ha + atrazine 250 g/ha (2.60). This might be due to good green fodder yield obtained under these treatments because of better management of weeds. The GMR, NMR, and B: C ratio was lowest in weedy check due to more weed density and lesser yield. The differences in B: C ratio is due to the cost of herbicides and productivity of the crop. Similar results were obtained by [28].

**Table 5. Economic analysis of different weed control treatments in fodder maize**

| Treatments | Cost of cultivation (Rs/ha) | Gross monetary returns (Rs/ha) | Net monetary returns (Rs/ha) | B:C Ratio |
|---|---|---|---|---|
| Tembotrione 120 g/ha | 25440 | 60805 | 35365 | 2.39 |
| Topramezone 35 g/ha | 25990 | 63513 | 37523 | 2.44 |
| Atrazine 1000 g/ha | 24590 | 54917 | 30327 | 2.23 |
| Pendimethalin 750 g/ha | 24765 | 53218 | 28453 | 2.15 |
| Tembotrione 120 g/ha + Atrazine 250 g/ha | 25528 | 66399 | 40871 | 2.60 |
| Topramezone 35 g/ha + Atrazine 250 g/ha | 26078 | 70902 | 44824 | 2.72 |
| Atrazine 750 g/ha + Pendimethalin 750 g/ha | 25115 | 55634 | 30519 | 2.22 |
| 2,4-D 500 g/ha | 24390 | 55855 | 31465 | 2.29 |
| Hand weeding | 34240 | 70975 | 36735 | 2.07 |
| Weedy Check | 24240 | 51469 | 27229 | 2.12 |

## 4. CONCLUSION

From the experimental results, it can be concluded that application of topramezone 35 g/ha + atrazine 250 g/ha as PoE at 20 DAS effectively controlled the complex weed flora of fodder maize with highest weed control efficiency and this combination of herbicide was found to be most suitable for obtaining higher grain yield, net return and B: C ratio.

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