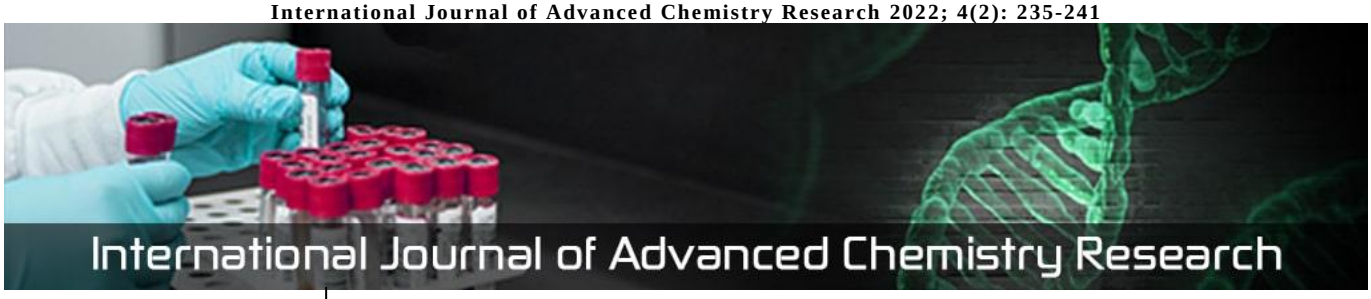

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Krishna Kumar Narang
Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

SK Jha
Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Krishna Kumar Narang
Department of Agronomy, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Effect of weed management on weed dynamics, crop growth, fodder yield and economics of fodder maize (*Zea mays* L.) African tall under Chhattisgarh condition

Krishna Kumar Narang and SK Jha

Abstract
Fodder maize is palatable and nutritious which can be fed as green or dry and makes excellent silage. But it is heavily infested with weeds which often inflicts huge yield and quality losses. A field experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur during *Kharif* 2017. Results showed that the lowest weed density and dry weight was recorded in tank mix application of atrazine 750 g + pendimethalin 750 g ha^{-1} as pre emergence followed by hand weeding twice at 20 and 40 days after sowing and topramezone 35 g + atrazine 250 g ha^{-1} as post emergence. These herbicides also recorded higher weed control efficiency (93-95%) and the lowest weed index (1-2%). Highest green and dry fodder yield were also obtained with the tank mix application of atrazine 750 g + pendimethalin 750 g ha^{-1} as pre emergence followed by hand weeding twice at 20 and 40 days after sowing and topramezone 35 g + atrazine 250 g ha^{-1} as post emergence. Similarly, crude protein yield was also highest under these combinations. Among herbicides, the highest net returns (Rs 41768 ha^{-1}) and benefit: cost ratio (2.68) were also highest with tank mix application of atrazine 750 g + pendimethalin 750 g ha^{-1} as pre emergence followed by hand weeding twice at 20 and 40 days after sowing and topramezone 35 g + atrazine 250 g ha^{-1} as post emergence. Thus, this study suggests tank-mixed herbicide application for better weed control in fodder maize rather than their sole application. These combinations of herbicides may be the alternative of manual weeding.

Keywords: Crude protein, fodder yield, maize, tank mix herbicide, weed control efficiency

Introduction
Maize (*Zea mays* L.) is an ideal forage crop grown throughout the country. It is quick growing high yielding and supplies palatable and nutritious forage which can be feed at any stage of growth without any risk to animals. It can be feed as green or dry and makes excellent silage. Maize produces good quality herbaceous fodder with high palatability. On average, it contains 9-10 % crude protein (CP), 60-64% neutral detergent fiber (NDF), 38-41% acid detergent fibre (ADF), 23-25 % hemicellulose, and 28-30% cellulose on dry matter basis when harvested at milk to early-dough stage. The nutritious green fodder maize is relished by all livestock, especially milch animals due to its succulent and palatable taste. Maize is a short-duration crop grown for green fodder and becomes ready for harvesting in about 8-10 weeks after sowing.

In Chhattisgarh about 80 percent of the population lives in rural areas, largely dependent on agriculture and allied activities for livelihood. Livestock production is the backbone of Indian agriculture contributing 7% to National GDP and a source of employment and ultimate livelihood for 70% of the population in rural areas. Total livestock population in the state consisting of cattle, buffalo, sheep, goat, pig, horses & ponies, mules, donkeys and camels, was 150.40 lakhs in 2012. The total bovine population (Cattle and Buffalo) was 112.03 lakhs and milch animals (in-milk and dry together) in cows and buffaloes are 27.34 lakhs and 29.02 lakhs respectively present in the state. During last census (2012) total number of sheep, goat and pigs in the state was 1.68 lakh, 32.25 lakh and 4.39 thousand respectively. The milk production in India is 94.5 million tones, the highest in the world. The Indian cow produces less than 1000 kg per year. Although we stand high in case of total milk production, the productivity is quite low.

Although the genetic potential contributes significantly towards higher milk production but the genetic potential of high yielding animals can be realized only if they are fed well with quality fodder.

Among the factors accountable for the low yield, weed infestation is the major cause. Excessive growth of weeds in maize field leads to 25 to 80% reduction in crop yield or sometimes to a complete crop failure if weeds are left uncontrolled (Karlen *et al*., 2002; Chikoye & Ekeleme, 2003). Therefore, the full expression of the production potential of forage crops depends on the degree of weed infestation (Kostov, 2006).

Sharma and Nayital (1993) reported that unchecked weed growth in sandy loam soils of Punjab reduced maize yield by 61.3 % compared to weed free check. Weed infestation is a major constraint in maize cultivation that can cause 33 to 72 % of yield loss (Thakur and Sharma, 1996). Reduction in grain yield of maize due to weed infestation ranged from 40 to 60 % depending upon the intensity and types of weed flora (Mishra, 1997). Saini and Angiras (1998) observed that due to severe competition with weeds, maize grain yield was found reduced by 67 % in the weedy check.

Arvadiya *et al.,* (2012) recorded the predominant weed flora in corn field were *Echinochloa crusgalli* L. and *Cynodon dactylon* L among monocot; *Cyperus rotundus* L. among sedges; and *Amaranthus viridis* L., *Digera arvensis* L., *Portulaca oleracea* L., *Alternenthera sessili* L. and *Trianthema ssp* at Navsari. Singh and Sheoran (2008) the important weed species in the field of maize were *Echinochloa colonum* [*E. colona*], *Cyperus rotundus, Eleusine aegyptiacum* [*Dactyloctenium aegyptium*], *Digera arvensis, Commelina benghalensis* and *Sorghum halepense* in Hoshiarpur, Punjab

Major weeds found in Chhattisgarh plains are *Echinochloa colona, Echinochloa crus-galli, Setaria viridis* L., *Leptochloa chinensis, Paspalum distichum* among the grasses. *Cyperus iria, Cyperus difformis, Cyperus rotundus,*among the sedges and *Monochoria veginalis,, Commelina benghalensis, Cynotis axillaris, Ceasulia axillaris, Alternanthera sessillis* L., among the broad leaved weeds.

Mostly farmers are using pre-emergence herbicides for weed control in maize, but their efficacy is reduced by various climatic and edaphic factors. Therefore, the only alternative that needs to be explored is the use of post-emergence herbicides alone and in mixture and the new generation herbicides can control the weed efficiency.

Materials and Methods

A field experiment was carried out at Research Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur during *Kharif* 2017. The experimental farm is located between 21°49 N Latitude and 81°39´ E Longitude at an altitude of 298 meters above the mean sea level. The soil of the experimental field was *vertisol* clayey in texture locally named as *Kanhar*, neutral in pH (7.09), medium in organic carbon (0.60%), low in available nitrogen (237 kg ha^{-1}), medium in available phosphorus (14.3 kg ha^{-1}) and high in available potassium (361 kg ha^{-1}). The experiment was carried out in a randomized block design with ten treatments replicated thrice *viz*. T_1: tembotrione 120 g ha^{-1} at 20 DAS, T_2: topramezone 35 g ha^{-1} at 20 DAS, T3: tembotrione 120 g + atrazine 250 g ha^{-1} at 20 DAS, T_4: topramezone 35 g + atrazine 250 g ha^{-1} 20 DAS, T_5: atrazine 1000 g ha^{-1} pre-emergence, T_6: pendimethalin 1000 g ha^{-1} pre-emergence, T_7: atrazine 750 g + pendimethalin 750 g ha^{-1} pre-emergence, T_8: 2,4-D 500 g ha^{-1} 20 DAS, T_9: hand weeding 20 and 40 DAS and T_{10}: weedy check with the objective to find out appropriate weed management in fodder maize. Sowing of fodder maize (African Tall) was done in the mid-July in *kharif* 2017 of investigation with 30 cm row spacing. Before sowing, the field was thoroughly ploughed and levelled. The recommended doses of fertilizer for fodder maize 80:40:20 $N:P_2O_5:K_2O$ kg ha^{-1} was applied. The full dose of phosphorus, potassium and half dose of the nitrogen through diammonium phosphate, muriate of potash and urea were applied at the time of sowing and remaining quantity of nitrogen was applied at 30 days after sowing. All the recommended package of practices was adopted to raise the crop. All the herbicides were applied as pre and post-emergence using knapsack sprayer fitted with a flat fan nozzle attached by mixing in 500 L of water ha^{-1} as per treatment. Tank mix solution was prepared by mixing the appropriate dose and applied in the field as per treatment.

Weed density was counted at 30 and 60 days after sowing by using a quadrate of 1 m^2 size randomly in the net plot. Weeds were uprooted and cut close to the transition of root and shoot in each plot and collected for dry matter accumulation. The samples were first dried in the sun and then kept in an oven at 60 °C for 48 hours till constant weight was obtained. Species wise dry weight was recorded and total dry weight of weeds was expressed in gm^{-2}. Weed control efficiency (WCE) and weed index (WI) were calculated using formulae as suggested by Kumar and Gill (1969) [11]. The weed density and dry weight data were subjected to square-root transformation [$\sqrt{(x + 0.5)}$] before statistical analysis.

Green fodder yield was recorded in each net plot immediately after harvest. Samples were weighed fresh and oven dried at 60 °C for 48 hr till constant weight for dry matter (DM) determination. Dried samples were ground using a grinder fitted with stainless steel blades. Crude protein content in plant samples was computed by multiplying the N content (micro-Kjeldahl method) with the factor 6.25 (AOAC, 1980) [1]. Crude protein yield (kg ha^{-1}) was calculated by multiplying the protein content with dry matter yield. Cost of cultivation, gross returns, net returns and benefit-cost ratio for each treatment were calculated by taking into consideration of total costs incurred and returns obtained. The results were analysed using the standard statistical procedure given by Gomez and Gomez (1984) [6].

Result and Discussion

Weed flora

The major weed flora observed in the experimental field were *Cyperus iria* L. (sedge), *Cynodon dactylon* L, *Echinochloa spp*. among grasseses; while among broad leaf weeds *Celosia argentea* L., *Alternanthra sessilis* L., *Cynotis axilllaris* L., *Commelina benghalensis* L. Other weeds noticed in lower densities were *Malva perviflora* L., *Euphorbia hirta* L., and *Parthenium hysterophorus* L. among broad leaf weeds.

Weed density (m^2)

Different weed management treatments significantly influenced weed density at 30 and 60 days after sowing (Table 1 and 2). At 30 days after sowing, data indicate that weed density of *Cynotis axillaris* L., (0.91 m^{-2}), *Commelina*

benghalensis L., (0.91 m^{-2}), *Echinochloa spp.* (1.35 m^{-2}), *Cynodon dactilon* L., (1.22 m^{-2}) and *Cyperus iria* L., (1.35 m^{-2}) was significantly lowest in tank mix application of atrazine 750 g *a.i.* + pendimethalin 750 *a.i.* g ha^{-1} as pre emergence, this may be due to effect of pre emergence application of herbicide followed by two hand weeding and tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence application. Lowest weed density of *Alternanthera sessilis* L., (1.08 m^{-2}) *Commelina benghalensis* (1.08 m^{-2}) and *Echinochloa spp.* (1.35 m^{-2}) was recorded in hand weeding, in this treatment may be due to hand weeding done at 20 and 40 days after sowing. Significantly maximum weed density of all the species was recoded in weedy check treatment. It clearly indicated that up to 30 days, application of pre-emergence tank mixture of atrazine + pendimethalin or topramezone + atrazine controls the first flush of weed similarly as hand weeding. At 60 days after sowing, data indicate that weed density of *Celosia argentea* L., (1.35 m^{-2}), *Commelina benghalensis* L., (1.22 m^{-2}) and *Cyperus iria* L. (1.58 m^{-2}) was recorded in hand weeding at 20 and 40 days after sowing followed by tank mix application of tembotrione 120 g + atrazine 250 g ha^{-1} as post emergence and tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence except *Celosia argentea* L. Tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence was recoded lowest weed density of *Alternanthera sessilis* L., (1.58 m^{-2}), *Cynotis axillaris* L., (1.22 m^{-2}), *Echinochloa spp.* (1.58 m^{-2}) and *Cynodon dactilon* L., (1.47 m^{-2}) followed by tank mix application of tembotrione 120 g + atrazine 250 g ha^{-1} as post emergence and tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence. Significantly higher weed density of all species was recorded in weedy check treatment. This might have been due to the uninterrupted growth of weeds by utilizing the growth resource like moisture, nutrient, sunlight to the full extent and offering stiff competition to the crop.

The lower number of weed density under tank-mix application of pre and early post-emergence herbicides as effective as twice manual weeding in forage maize and this combination might be the alternative of hand weeding which is time-consuming, costly and labour dependent operation. The lower number of weeds in the field offer better growth condition for forage maize and it is in agreement with Sanodiya *et al*. (2013) [17] and Madhavi *et al*. (2014) [12].

Weed dry weight (g m^{-2})

Weed dry weight is a better parameter to measure weed competition than weed density as it measures more precisely the growth resources utilized by weeds (Padmavati *et al.*, 1995) [14]. Similar to weed density, dry weight of weeds significantly influenced by treatments at 30 and 60 DAS (Table3 and 4). At 30 days after sowing, significantly lowest weed dry weight of *Alternantrera sessilis* L., (0.93 g m^{-2}), *Commelina benghalensis* L., (0.82 g m^{-2}) and *Echinochloa spp.* (0.80 g m^{-2}) was recorded in hand weeding at 20 and 40 days after sowing followed by tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence. Minimum weed dry weight of *Celosia argentea* L., (0.71 g m^{-2}) was found in hand weeding at 20 and 40 days after sowing followed by tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence. Lower weed dry weight of *Cynotis axillaris* L., (0.79 g m^{-2}) was recorded in tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence followed by 2,4-D 500 g ha^{-1} as post emergence. Minimum weed dry weight of *Cynodon dactilon* L., (1.35 g m^{-2}) was recorded under tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence followed by tank mix application tembtrione 120 g + atrazine 250 g ha^{-1} as post emergence and lowest weed dry weight of *Cyprus irria* L., (0.89 g m^{-2}) was observed in tank mix application tembtrione 120 g + atrazine 250 g ha^{-1} as post emergence followed by tank mix application of topramezone 35g + atrazine 250 g ha^{-1} as post emergence. Significantly highest weed dry weight of *Celosia argentea* L., (3.88 g m^{-2}), *Alternantrera sessilis* L., (4.88 g m^{-2}), *Cynotis axillaris* L., (2.71 g m^{-2}), *Commelina benghalensis* L., (2.66 g m^{-2}), *Echinochloa spp.* (1.63 g m^{-2}), *Cynodon dactilon* L., (4.45 g m^{-2}) and *Cyprus irria* L., (2.66 g m^{-2}) was recorded in weedy check treatment. At 60 days after sowing, significantly lowest weed dry weight of *Alternantrera sessilis* L., (1.57 g m^{-2}), *Cynotis axillaris* L., (1.26 g m^{-2}), *Echinochloa spp.* (1.27 g m^{-2}) *Cynodon dactilon* L., (1.70 g m^{-2}) and *Cyprus irria* L., (0.89 g m^{-2}) was recorded under tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence followed by hand weeding at 20 and 40 days after sowing. Minimum weed dry weight of *Celosia argentea* L., (1.31 g m^{-2}) and *Commelina benghalensis* L., (1.21 g m^{-2}) was observed in hand weeding at 20 and 40 days after sowing followed by tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence. Highest weed dry weight of *Celosia argentea* L., (5.52 g m^{-2}), *Alternantrera sessilis* L., (6.08 g m^{-2}), *Cynotis axillaris* L., (5.11 g m^{-2}), *Commelina benghalensis* L., (5.49 g m^{-2}), *Echinochloa spp.* (4.04 g m^{-2}), *Cynodon dactilon* L., (5.07 g m^{-2}) and *Cyprus irria* L., (4.37 g m^{-2}) was recorded under weedy check treatment.

The lower dry weight in these treatments might be due to better efficacy and prolonged effectiveness of tank-mix herbicides. Applied chemicals are HPPD inhibiting herbicides, which reduced weed growth, resulted in rapid depletion of carbohydrate synthesis of weeds, bleaching of chlorophyll pigment, reduction in leaf area and diminution of photosynthesis process (Bollman *et al*., 2008; Jonathon and Sprague 2017) [3, 8]. A similar result was also reported by Sanodiya *et al.* (2013) [17], Patel *et al.* (2006) [15], Walia *et al.* (2007) [22] and Madhavi *et al.* (2014) [12].

Weed control efficiency

The weed control efficiency (WCE) is a measure of expressing the efficiency of the weed control method. On the basis of the total dry weight of weed in weedy check and treated plot. Chemical weed management practices recorded better WCE at 30 and 60 days after sowing (Table 5). At 30 days after sowing, significantly higher weed control efficiency (95%) was recorded under tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence followed by hand weeding (95%) at 20 and 40 days after sowing and tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence (94%). Lower weed control efficiency was recorded under weedy check. This might be due to the higher efficacy of tank-mixed herbicides which resulted in lower weed dry matter. At 60 days after sowing, significantly higher weed control efficiency (93 %) was recorded under tank mix application of atrazine 750 g *a.i.*+ pendimethalin 750 *a.i.* g ha^{-1} as pre emergence followed by hand weeding (92%) at 20 and 40 days after sowing and tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence (87%). Lower weed control efficiency was recorded under weedy check.

Weed index

The weed index worked out in different weed control treatments on the basis of green fodder yield in comparison to hand weeding treatment (Table 5). The lowest weed index was recorded under tank mix application of atrazine 750 g *a.i.* + pendimethalin 750 *a.i.* g ha^{-1} as pre emergence followed by tank mix application of topramezone + atrazine @ 35 + 250 g *a.i.* ha^{-1} as post emergence (5.27%) and hand weeding at 20 and 40 days after sowing (0.53 %) due to better herbicide selectivity and weed control efficiency. This led to better control of weeds during the critical period of crop weed competition resulted in higher green fodder yield. Highest weed index was noticed in weedy check (43.67 %).

Fodder yield and quality

Herbicide application and hand weeding significantly increased the yield components and fodder yield of maize by limiting the level of weed infestation and its growth (Table 6). Maximum plant height (252 cm), number of green leaves (11.52) of maize plant were obtained in tank mix application of atrazine 750 g *a.i.* + pendimethalin 750 *a.i.* g ha^{-1} as pre emergence which was at par with tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence and hand weeding at 20 and 40 days after sowing.

Maximum fodder and crude protein yield were recorded in tank mix application of atrazine 750 g *a.i.* + pendimethalin 750 *a.i.* g ha^{-1} as pre emergence. Followed by tank mix application of topramezone 35 g + atrazine 250 g ha^{-1} as post emergence and hand weeding at 20 and 40 days after sowing. Dry fodder yield and crude protein yield was statistically at par with hand weeding in case of topramezone 35 g + atrazine 250 g ha^{-1}, atrazine 750 g + pendimethalin 750 g ha^{-1} and tembotrione 120 g + atrazine 250 g ha^{-1} at 20 days after sowing. These results are in accordance with those of Patel *et al.* (2006) [15], Kumar *et al.* (2013) [10], Hatti *et al.* (2014) [7] and Baldaniya *et al.* (2018) [2]. They reported yield with the tank-mixed application of pre and early post-emergence herbicides similar to the hand weeding.

Economics

The cost of cultivation and economic returns of different weed management treatments are shown in Table 7. The cost of cultivation of maize varied from minimum with weedy check (Rs 21532 ha^{-1}) to maximum under hand weeding two times (Rs 29332 ha^{-1}). The new generation herbicides (topramezone and tembotrione) are costly, so the cost of cultivation of these treatments is almost equal to hand weeding two times. Among herbicides, the maximum gross return was fetched in tank mix application of atrazine 750 g *a.i.* + pendimethalin 750 *a.i.* g ha^{-1} as pre emergence and least under weedy check. The maximum net returns were calculated in tank mix application of atrazine 750 g *a.i.* + pendimethalin 750 *a.i.* g ha^{-1} as pre emergence (Rs 39766 ha^{-1}) followed by hand weeding and minimum in weedy check (Rs 30919 ha^{-1}). Higher returns can be attributed to better weed control in these treatments resulting in the increased fodder yield. The benefit to cost ratio was calculated by dividing the value of the gross return to the cost of cultivation in order to determine the economic efficiency. However, the highest benefit to cost ratio was calculated in tank mix application of atrazine 750 g *a.i.* + pendimethalin 750 *a.i.* g ha^{-1} as pre emergence (2.69) followed by Atrazine 1000 g ha^{-1} as pre- emergence (2.39) and lowest in weedy check (1.65). Similar findings were also reported by Patel *et al.* (2006) [15], Walia *et al.* (2007) [21], Kumar *et al.* (2013) [10], Hatti *et al.* (2014) [7] and Madhavi *et al.* (2014) [12].

Table 1: Species wise weed density (m^{-2}) in fodder maize as influenced by weed management practices at 30 DAS

Treatment	Broad leaves				Grasses		Sedges	Others	Total
	Weed density (m^{-2})								
	***Celosia argentea* L.**	***Alternanthera sessilis* L.**	***Cynotis axillaris* L.**	***Commelina benghalensis* L.**	***Echinochloa spp.***	***Cynodon dactylon* L.**	***Cyperus iria* L.**		
T_1 -Tembotrione 120 g ha^{-1} at 20 DAS	1.68 (2.33)	1.96 (3.33)	1.87 (3.00)	1.87 (3.00)	1.96 (3.33)	1.68 (2.33)	1.96 (3.33)	2.27 (4.67)	5.08 (25.32)
T_2 -Topramezone 35g ha^{-1} at 20 DAS	1.58 (2.00)	1.68 (2.33)	1.78 (2.67))	1.58 (2.00)	1.87 (3.00)	1.58 (2.00)	1.68 (2.33)	1.96 (3.33)	4.49 (19.66)
T_3 -Tembotrione 120 g + Atrazine 250 g ha^{-1} at 20 DAS	1.35 (1.33)	1.58 (2.00)	1.68 (2.33)	1.58 (2.00)	1.78 (2.67)	1.35 (1.33)	1.58 (2.00)	1.78 (2.67)	4.10 (16.00)
T_4 -Topramezone 35g + Atrazine250 g ha^{-1}20 DAS	1.22 (1.00)	1.58 (2.00)	1.58 (2.00)	1.22 (1.00)	1.58 (2.00)	1.35 (1.33)	1.58 (2.00)	1.78 (2.67)	3.81 (14.00)
T_5 -Atrazine1000g ha^{-1} pre-emergence	1.35 (1.33)	1.87 (3.00)	1.58 (2.00)	1.35 (1.33)	1.68 (2.33)	1.58 (2.00)	1.58 (2.00)	1.96 (3.33)	4.22 (17.32)
T_6 -Pendimethalin1000 g ha^{-1} pre-emergence	1.78 (2.67)	2.20 (4.33)	1.78 (2.67)	1.87 (3.00)	1.68 (2.33)	1.47 (1.67)	1.68 (2.33)	2.20 (4.33)	4.88 (23.33)
T_7 -Atrazine 750 g+ Pendimethalin 750 g ha^{-1} pre-emergence	1.22 (1.00)	1.22 (1.00)	0.91 (0.33)	0.91 (0.33)	1.35 (1.33)	1.22 (1.00)	1.35 (1.33)	1.68 (2.33)	3.02 (8.65)
T_8 -2,4-D 500 g ha^{-1} 20 DAS	1.68 (2.33)	1.58 (2.00)	1.08 (0.67)	1.22 (1.00)	2.20 (4.33)	1.96 (3.33)	2.27 (4.67)	2.20 (4.33)	4.81 (22.66)
T_9 -Hand weeding 20 and 40 DAS	0.71 (0.00)	1.08 (0.67)	1.35 (1.33)	0.91 (0.33)	1.35 (1.33)	1.35 (1.33)	1.78 (2.67)	1.78 (2.67)	3.29 (10.33)
T_{10} -Weedy Check	5.18 (26.33)	5.08 (25.33)	3.34 (10.67)	2.97 (8.33)	3.54 (12.00)	3.24 (10.00)	5.08 (25.33)	4.06 (16.00)	11.60 (133.99)
SEm	0.03	0.04	0.04	0.03	0.05	0.02	0.02	0.03	0.03
CD at 5 %	0.08	0.12	0.11	0.08	0.14	0.06	0.07	0.10	0.10

Note: Original values are given in parenthesis, which are transformed to $\sqrt{X} + 0.5$

Table 2: Species wise weed density (m^{-2}) in fodder maize as influenced by weed management practices at 60 DAS

Treatment	Broad leaves				Grasses		Sedges	Others	Total
	Weed density (m^{-2})								
	Celosia argentea L.	*Alternanthera sessilis* L.	*Cynotis axillaris* L.	*Commelina benghalensis* L.	*Echinochloa spp.*	*Cynodon dactylon* L.	*Cyperus iria* L.		
T_1 -Tembotrione 120 g ha^{-1} at 20 DAS	2.48 (5.67)	2.68 (6.67)	2.35 (5.00)	2.74 (7.00)	2.55 (6.00)	2.35 (5.00)	2.55 (6.00)	3.24 (10.00)	2.48 (5.67)
T_2 -Topramezone 35g ha^{-1} at 20 DAS	2.20 (4.33)	2.48 (5.67)	2.12 (4.00)	1.87 (3.00)	2.27 (4.67)	1.87 (3.00)	1.87 (3.00)	3.08 (9.00)	2.20 (4.33)
T_3 -Tembotrione 120 g + Atrazine 250 g ha^{-1} at 20 DAS	2.27 (4.67)	2.04 (3.67)	2.12 (4.00)	1.87 (3.00)	2.20 (4.33)	1.87 (3.00)	2.20 (4.33)	3.03 (8.67)	2.27 (4.67)
T_4 -Topramezone 35g + Atrazine250 g ha^{-1}20 DAS	2.12 (4.00)	2.04 (3.67)	2.20 (4.33)	1.96 (3.33)	2.35 (5.00)	1.87 (3.00)	1.87 (3.00)	2.86 (7.67)	2.12 (4.00)
T_5 -Atrazine1000g ha^{-1} pre-emergence	1.96 (3.33)	2.48 (5.67)	1.87 (3.00)	2.12 (4.00)	2.55 (6.00)	2.04 (3.67)	2.35 (5.00)	2.74 (7.00)	1.96 (3.33)
T_6 -Pendimethalin1000 g ha^{-1} pre-emergence	2.20 (4.33)	3.03 (8.67)	2.48 (5.67)	2.55 (6.00)	2.55 (6.00)	2.35 (5.00)	2.35 (5.00)	3.54 (12.00)	2.20 (4.33)
T_7 -Atrazine 750 g+ Pendimethalin 750 g ha^{-1} pre-emergence	1.58 (2.00)	1.58 (2.00)	1.22 (1.00)	1.47 (1.67)	1.58 (2.00)	1.47 (1.67)	1.58 (2.00)	2.55 (6.00)	1.58 (2.00)
T_8 -2,4-D 500 g ha^{-1} 20 DAS	2.48 (5.67)	2.12 (4.00)	2.12 (4.00)	2.12 (4.00)	3.08 (9.00)	2.92 (8.00)	3.24 (10.00)	3.44 (11.33)	2.48 (5.67)
T_9 -Hand weeding 20 and 40 DAS	1.35 (1.33)	1.87 (3.00)	1.58 (2.00)	1.22 (1.00)	1.87 (3.00)	2.12 (4.00)	1.58 (2.00)	2.12 (4.00)	1.35 (1.33)
T_{10} -Weedy Check	6.01 (35.67)	5.76 (32.67)	4.56 (20.33)	4.02 (15.67)	4.60 (20.67)	3.67 (13.00)	6.20 (38.00)	5.05 (25.00)	6.01 (35.67)
SEm	0.02	0.02	0.05	0.06	0.07	0.03	0.04	0.07	0.02
CD at 5 %	0.06	0.06	0.13	0.18	0.21	0.10	0.11	0.22	0.06

Note: Original values are given in parenthesis, which are transformed to $\sqrt{X} + 0.5$

Table 3: Species wise weed dry weight (g m^{-2}) in fodder maize as influenced by weed management practices at 30 DAS

Treatment	Broad leaves				Grasses		Sedges	Others	Total
	Weed dry weight (g m^{-2})								
	Celosia argentea L.	*Alternanthera sessilis* L.	*Cynotis axillaris* L.	*Commelina benghalensis* L.	*Echinochloa spp.*	*Cynodon dactylon* L.	*Cyperus iria* L.		
T_1 -Tembotrione 120 g ha^{-1} at 20 DAS	0.92 (0.34)	1.41 (1.50)	1.11 (0.73)	1.26 (1.08)	0.97 (0.44)	1.69 (2.37)	0.98 (0.47)	1.43 (1.55)	3.00 (8.47)
T_2 -Topramezone 35g ha^{-1} at 20 DAS	1.00 (0.50)	1.25 (1.05)	1.12 (0.77)	1.37 (1.38)	0.97 (0.45)	1.77 (2.63)	0.95 (0.40)	1.20 (0.95)	2.94 (8.13)
T_3 -Tembotrione 120 g + Atrazine 250 g ha^{-1} at 20 DAS	1.08 (0.67)	1.36 (1.35)	0.96 (0.42)	1.32 (1.23)	0.93 (0.36)	1.50 (1.76)	0.89 (0.29)	1.19 (0.92)	2.74 (6.99)
T_4 -Topramezone 35g + Atrazine250 g ha^{-1}20 DAS	0.79 (0.12)	1.22 (1.00)	0.88 (0.27)	1.02 (0.55)	0.89 (0.30)	1.64 (2.20)	0.92 (0.34)	1.06 (0.63)	2.43 (5.40)
T_5 -Atrazine1000g ha^{-1} pre-emergence	0.93 (0..37)	1.47 (1.65)	0.95 (0.40)	1.23 (1.01)	0.94 (0.38)	1.71 (2.42)	0.95 (0.41)	1.18 (0.89)	2.83 (7.52)
T_6 -Pendimethalin1000 g ha^{-1} pre-emergence	1.45 (1.61)	1.88 (3.02)	1.29 (1.15)	1.67 (2.30)	0.92 (0.35)	1.88 (3.02)	1.02 (0.54)	1.62 (2.13)	3.82 (14.12)
T_7 -Atrazine 750 g+ Pendimethalin 750 g ha^{-1} pre-emergence	1.03 (0.55)	1.02 (0.55)	0.79 (0.12)	0.85 (0.22)	0.80 (0.15)	1.35 (1.32)	0.93 (0.19)	1.14 (0.81)	2.10 (3.91)
T_8 -2,4-D 500 g ha^{-1} 20 DAS	1.32 (1.23)	1.05 (1.25)	0.84 (0.20)	0.97 (0.44)	1.04 (0.59)	2.35 (5.04)	1.19 (0.91)	1.33 (1.26)	3.35 (10.73)
T_9 -Hand weeding 20 and 40 DAS	0.71 (0.00)	0.93 (0.36)	0.99 (0.49)	0.82 (0.18)	0.80 (0.15)	1.59 (2.02)	1.02 (0.53)	1.15 (0.82)	2.25 (4.54)
T_{10} -Weedy Check	3.88 (14.54)	4.60 (20.68)	2.71 (6.86)	2.66 (6.58)	1.63 (2.16)	4.45 (19.27)	2.66 (6.56)	2.64 (6.49)	9.15 (83.13)
SEm	0.02	0.03	0.04	0.02	0.03	0.03	0.03	0.03	0.07
CD at 5 %	0.04	0.08	0.11	0.07	0.08	0.08	0.10	0.09	0.20

Note: Original values are given in parenthesis, which are transformed to $\sqrt{X} + 0.5$

Table 4: Species wise weed dry weight (g m^{-2}) in fodder maize as influenced by weed management practices at 60 DAS

Treatment	Broad leaves				Grasses		Sedges	Others	Total
	Weed dry weight (g m^{-2})								
	Celosia argentea L.	*Alternanthera sessilis* L.	*Cynotis axillaris* L.	*Commelina benghalensis* L.	*Echinochloa spp.*	*Cynodon dactylon* L.	*Cyperus iria* L.		
T_1 -Tembotrione 120 g ha^{-1} at 20 DAS	2.61 (6.29)	2.84 (7.55)	2.48 (5.65)	3.94 (14.99)	2.21 (4.38)	3.62 (12.60)	1.16 (0.85)	3.27 (10.21)	22.12 (62.53)
T_2 -Topramezone 35g ha^{-1} at 20 DAS	2.75 (7.09)	2.46 (5.55)	2.78 (7.21)	2.91 (7.95)	2.53 (5.92)	2.70 (6.80)	1.21 (0.96)	2.96 (8.26)	20.30 (49.74)
T_3 -Tembotrione 120 g + Atrazine 250 g ha^{-1} at 20 DAS	1.96 (3.36)	2.45 (5.50)	2.74 (7.00)	2.75 (7.04)	1.90 (3.10)	2.81 (7.41)	1.27 (1.11)	2.99 (8.46)	18.87 (42.98)
T_4 -Topramezone 35g + Atrazine250 g ha^{-1}20 DAS	2.27 (4.64)	2.37 (5.12)	2.73 (6.99)	2.52 (5.84)	2.01 (3.53)	3.09 (9.07)	1.24 (1.05)	2.94 (8.12)	19.17 (44.36)
T_5 -Atrazine1000g ha^{-1} pre-emergence	2.38 (5.16)	3.06 (8.88)	1.97 (3.40)	3.09 (9.07)	2.24 (4.54)	2.92 (8.05)	1.41 (1.50)	2.73 (6.96)	19.82 (47.55)
T_6 -Pendimethalin1000 g ha^{-1} pre-emergence	2.72 (6.90)	3.85 (14.36)	3.20 (9.71)	4.24 (17.50)	2.97 (8.32)	3.83 (14.18)	2.09 (3.85)	3.77 (13.73)	26.67 (88.55)
T_7 -Atrazine 750 g+ Pendimethalin 750 g ha^{-1} pre-emergence	1.57 (1.98)	1.57 (1.98)	1.26 (1.10)	1.42 (1.52)	1.27 (1.11)	1.70 (2.40)	0.89 (0.30)	2.02 (3.59)	11.72 (13.98)
T_8 -2,4-D 500 g ha^{-1} 20 DAS	3.64 (12.77)	2.67 (6.63)	2.92 (8.00)	3.25 (10.08)	3.62 (12.60)	3.70 (13.22)	2.86 (7.70)	3.92 (14.86)	26.59 (85.85)
T_9 -Hand weeding 20 and 40 DAS	1.31 (1.21)	1.86 (2.97)	1.62 (2.12)	1.21 (0.97)	1.47 (1.65)	2.30 (4.80)	1.05 (0.60)	1.82 (2.80)	12.64 (17.12)
T_{10} -Weedy Check	5.52 (29.95)	6.08 (36.46)	5.11 (25.62)	5.49 (29.60)	4.04 (15.82)	5.07 (25.24)	4.37 (18.62)	4.84 (22.88)	40.52 (204.19)
SEm	0.06	0.08	0.05	0.04	0.06	0.04	0.03	0.03	0.06
CD at 5 %	0.18	0.24	0.14	0.11	0.17	0.11	0.08	0.10	0.19

Note: Original values are given in parenthesis, which are transformed to $\sqrt{X} + 0.5$

Table 5: Weed control efficiency (%) and weed index (%) at different growth stages in maize as influenced by weed management practices

Treatment	Weed control efficiency (%)		Weed index (%)
	30 DAS	60 DAS	
T_1: Tembotrione 120 g ha^{-1} at 20 DAS	90	69	13.05
T_2:Topramezone 35g ha^{-1} at 20 DAS	90	76	5.93
T_3:Tembotrione 120 g + Atrazine 250 g ha^{-1} at 20 DAS (Tank mix)	92	79	5.27
T_4 :Topramezone 35g + Atrazine250 g ha^{-1} at 20 DAS (Tank mix)	94	87	13.28
T_5 :Atrazine 1000 g ha^{-1} as pre- emergence	91	77	24.15
T_6 :Pendimethalin1000 g ha^{-1} as pre- emergence	83	57	--
T_7 :Atrazine 750 g+ Pendimethalin 750 g ha^{-1} as pre-emergence (Tank mix)	95	93	26.17
T_8 -2,4-D 500 g ha^{-1} 20 DAS	75	58	0.53
T_9 :Hand weeding 20 and 40 DAS	95	92	43.67
T_{10}:Weedy Check	-	-	--

Table 6: Plant population, plant height, number of leaves plant^{-1}, L:S ratio, green fodder, dry matter yield & crude protein yield as influenced by weed management practices in *Kharif* fodder maize 2017

Treatment	Plant population m^{-1} row length	Plant height (cm)	Numbers of leaves plant^{-1}	L:S ratio	Green fodder yield (q ha^{-1})	Dry matter yield (q ha^{-1})	Crude protein yield (q ha^{-1})
T_1: Tembotrione 120 g ha^{-1} at 20 DAS	6.19	243.1	10.77	2.87	360	79.29	6.43
T_2:Topramezone 35g ha^{-1} at 20 DAS	6.14	245.7	10.77	2.90	367	78.87	6.34
T_3:Tembotrione 120 g + Atrazine 250 g ha^{-1} at 20 DAS (Tank mix)	5.96	246.0	10.95	3.00	395	90.16	7.30
T_4 :Topramezone 35g + Atrazine250 g ha^{-1} at 20 DAS (Tank mix)	6.21	251.3	11.20	3.02	398	89.53	7.30
T_5 :Atrazine 1000 g ha^{-1} as pre-emergence	6.27	255.7	11.00	3.01	365	84.47	6.87
T_6 :Pendimethalin1000 g ha^{-1} as pre-emergence	6.00	250.6	10.47	2.88	320	71.95	5.75
T_7 :Atrazine 750 g+ Pendimethalin 750 g ha^{-1} as pre-emergence (Tank mix)	6.20	252.1	11.52	3.07	422	94.15	7.66
T_8 -2,4-D 500 g ha^{-1} 20 DAS	6.11	237.7	10.60	2.87	310	74.07	5.96
T_9 :Hand weeding 20 and 40 DAS	6.14	255.3	11.03	3.03	418	95.12	7.68
T_{10}:Weedy Check	5.98	213.3	10.00	2.83	237	55.47	4.46
SEm	0.02	4.59	0.23	0.05	14.30	3.99	0.34
CD at 5 %	NS	13.63	0.70	0.13	42.48	11.85	1.04

Table 7: Economics of fodder maize as influenced by weed management practices

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross Return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T_1: Tembotrione 120 g ha^{-1} at 20 DAS	27082	54000	26918	1.99
T_2:Topramezone 35g ha^{-1} at 20 DAS	27787	55050	27263	1.98
T_3:Tembotrione 120 g + Atrazine 250 g ha^{-1} at 20 DAS (Tank mix)	27674	59250	31576	2.14
T_4 :Topramezone 35 g + Atrazine250 g ha^{-1} at 20 DAS Tank mix)	27952	59700	31748	2.14
T_5 :Atrazine 1000 g ha^{-1} as pre- emergence	22881	54750	31869	2.39
T_6 :Pendimethalin1000 g ha^{-1} as pre- emergence	23326	48000	24674	2.06
T_7 :Atrazine 750 g+ Pendimethalin 750 g ha^{-1} as pre-emergence (Tank mix)	23534	63300	39766	2.69
T_8 : 2,4-D 500 g ha^{-1} 20 DAS	22292	46500	24208	2.09
T_9 :Hand weeding 20 and 40 DAS	29332	62700	33368	2.14
T_{10}:Weedy Check	21532	35550	14018	1.65
S.Em ±	--	2145	2145	0.09
CD (P=0.05)	--	6372	6372	0.26

Conclusion

Based on the results, it can be concluded that tank mix application of atrazine 50% WP @ 750 g + pendimethaline 38.7% CS @ 750 g ha^{-1} as pre-emergence and tank mix application of topramezone 33.6% SC @ 35 g + atrazine 50% WP @ 250 g ha^{-1} as post-emergence was found superior to control weeds among weed control treatment and was found comparable with two hand weeding at 20 and 40 DAS for growth, yield attribute and fodder yield of *kharif* fodder maize under clay loam condition of Chhattisgarh plain. Hence, this two pre and post emergence tank mix herbicide can be the best alternative to the hand weeding.

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