Effect of herbicide combinations on growth and yield of *Kharif* maize (*Zea mays* L.)

ABSTRACT

The present investigation entitled "Weed management in kharif maize (Zea mays L.)" was carried out during kharif 2019 at College Farm, College of Agriculture, Badnapur, Dist.-Jalna. Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (India). Randomized Block design was used for study comprised of ten treatments. Among treatments, weed free treatment attributed more number of leaves, maximum plant height, dry matter production and leaf area per plant followed by treatment of topramezone 33.6 % SC @ 25.2 g a.i.ha^{-1} + atrazine 50 % WP @ 250 g a.i. ha^{-1}. Poor growth attributes were recorded in weedy check. Significantly maximum values of yield attributes were recorded in treatment of topramezone 33.6 % SC @ 25.2 g a.i.ha^{-1} + atrazine 50 % WP@ 250(g)a.i.ha^{-1}followed by treatment of tembotrione 42 % SC @ 105 g a.i. ha^{-1}+ atrazine 50% WP @ 250 g a,i. ha^{-1}. Minimum values of yield attributes were attributed in weedy check. Treatment of topramezone + atrazine @ 25.2 + 250 g a.i ha^{-1} as PE (T_6) found effective in limiting weed growth and recorded lower weed index, weed dry matter with higher weed control efficiency followed by tembotrione +atrazine @105 + 250 (g) a.i.ha^{-1}as PoE (T_7) at all growth stages of crop. The benefit cost ratio was highest (2.94) with application of topramezone + atrazine @25.2 + 250 g a.i ha^{-1} followed by tembotrione + atrazine @ 105 + 250 g a.i. ha^{-1} as PoE (2.81) whereas weedy check recorded significantly lower B:C ratio(1.50) over other treatments.

(Keywords: Weed management, Kharif maize, growth, yield, nutrient uptake)

INTRODUCTION

Maize is grown over an area of 215 million hectares with a total production of 765 million tones with an average productivity of 3543 kg ha^{-1}. India rank second at global level in acreage (9.86 million hectare) and production (31.51 million tones) with an average productivity of 3195 kg ha^{-1}. Maharashtra ranks third at national level with an acreage of 1.15 million hectare and production of 3.44 million tones with average productivity of 3000 kg ha^{-1} (Anonymous, 2019-20). Maize is highly productive crop with diversified uses, mainly as food and feed for livestock. It is an important source of carbohydrate, protein, iron, vitamin B and minerals.

The yield of maize under Indian condition may be attributed by number of factors among them weeds causes harmful effect on the growing plants and interfere with land use pattern (Raut *et al.* 2017). Maize crop gets infested with different monocot as well as dicot weeds and is subjected to heavy weed competition, which often inflicts huge losses. Rajeshkumar et al 2017 reported 63.75% yield reduction in maize due no control of weeds and they further concluded that weed management strategies attempt to limit the deleterious effects of weeds growing with crop plants. These effects could be quite variable, but the most common is competition for

available resources. Maize is most sensitive to weed competition especially during early stage of crop growth. It grows slowly during first 3 to 4 weeks

Weed infestation is one of the major constraints of low productivity of maize. The average yield loss due to weeds in maize in India is 29.5-74.0 %. (Chopra *et al.,* 2017). The quantities of growth factors used by weeds are thus unavailable to the crop. Chemical weed control is a better supplement to conventional methods and forms an integral part of the modern crop production. Most of the presently available herbicides provide a narrow spectrum weed control. Many of them have activity only on annual species, while a few are only effective against perennials. Continuous usage of same herbicide or similar herbicides year after year over several years do certainly lead to elimination of sensitive weed species but leave out the tolerant weed species resulting in a gradual built up of their population. Hence, use of two different chemicals with different mode of action may enhance the efficacy of weed control

The use of herbicide or chemical add great significance particularly in intensive agriculture due to their ability of providing targeted, quick and effective weed control, moreover, provide economical weed management in terms of time, labour and money (Yenpredditwar *et al.,*2017). Maize is grown during *kharif* season where manual method of weed control is difficult to adopt due to marshy or inaccessible field conditions as a result of aberrations of monsoon and scarcity of labour and also manual weeding in maize based intercropping systems is difficult due to closely spaced crop rows of component crops. Therefore, pre-emergence and post-emergence herbicides hold a key for early season weed control in such system. Few herbicides like atrazine, oxyfluorfen, 2,4-D and pendimethalin are available for weed control in maize but with few limitations for broad spectrum weed control and late emerging weeds in the crop. Recently introduced herbicide viz., Topramezone and tembotrione are selective, post-emergence herbicides. Tank mix application of these post emergence herbicides with lower dose of atrazine was reported to be more effective providing broad spectrum weed control than alone application of individual chemicals. So there is need to evaluate alternate post emergence herbicides in combination with conventional herbicides like atrazine/ 2,4-D which can provide broad spectrum weed control in maize crop in different weed seed bank regions.

MATERIALS AND METHODS

The experiment, "Weed management in *Kharif* maize (*Zea mays* L.)" was carried out during *Kharif* 201 Experimental Farm of Agronomy, College of Agriculture Badnapur, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra (India). Soil of the experimental field was clayey in texture, moderate in available nitrogen and low in available phosphorus with high in available potassium, soil was moderately alkaline in reaction. The experimental site is situated at 19.8682 ^{0}N latitude and 75.7256 ^{0}E longitude and an altitude of 523 m above mean sea level. The randomized block design consisting of ten treatments and three replications was used. Net plot size and gross plot size was 3.5 x 4.5 m^2 and 4.8x 5.1 m^2, respectively. Maize crop variety DKC-9133 was sown with dibbled method at 60 cm row to row and 30 cm plant to plant distance during *Kharif* 2019. The doses of herbicides were calculated as per the treatments simultaneously with required calibration of knapsack sprayer. The powder or liquid formulation was diluted in the water according to the different doses and 1.2 L of spray solution per plot was applied for each treatment with the help of knapsack sprayer. Treatments consisted of T_1-Atrazine 50 %WP @ 1 kg a.i ha^{-1} (PE), T_2- 2,4 –D Dimethyl Amine salt 58 % SL @ 1 kg a.i. ha^{-1} (PoE), T_3-Topramezone 33.6 % SC @ 67.2 g a.i ha^{-1} (PoE at 15 DAS), T_4- Topramezone 33.6% SC @ 25.2 g a.i ha^{-1} (PoE at 15 DAS), T_5-Tembotrione 42% SC@ 105 g a.i ha^{-1} (PoE 15 DAS), T_6-Topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} +Atrazine 50%WP @ 250 g a.i. ha^{-1} (PoE at 15DAS), T_7-Tembotrione 42 % SC @ 105 g a.i ha^{-1} +Atrazine 50% WP @ 250 g a.i. ha^{-1} (PoE 15DAS), T_8 –One hand weeding at 30 DAS, T_9 : Weedy check, T_{10}- Weed free. Fertilizer dose 175:50:50 NPK kg/ha was applied as common to all treatments.

Entire dose of P_2O_5, and K_2O and $^1/_3$ of N of were applied as basal dose. Remaining Nitrogen was applied in two more splits at knee height stage and at tasseling stage. Irrigation was given two times during two dry spells.

RESULTS AND DISCUSSION

Growth attributes:

At harvest, significantly highest number of functional leaves plant^{-1} was recorded due to the weed free treatment (T_{10}) which was at par with topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} +atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) and tembotrione 42 % SC @ 105 g a.i ha^{-1} + atrazine 50% WP @ 250 g a.i ha^{-1} (T_7) and topramezone 33.6% SC @ 67.2 g a.i ha^{-1} as PoE (T_3). The significantly lowest mean number of functional leaves was observed in weedy check (T_9).

Data presented in Table 1indicated that**,** significantly highest plant height (148.56 cm) was recorded with weed free treatment (T_{10}) which was found superior than the other treatments except topramezone 33.6% SC@ 25.2 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) (148 cm) and topramezone 33.6% SC@ 67.2 g a.i ha^{-1} as PoE (T_3) (147.8 cm), respectively, however, significantly lowest plant height was recorded due to Weedy check (T_9) (135.13 cm) at harvest.

Treatment of weed free (T_{10}) condition recorded higher plant dry matter (186.88 g) Plant^{-1},however, it was on par with topramezone 33.6% SC @ 25.2g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) (182.91g) at harvest. Significantly lowest plant dry matter (165.88 g) was recorded with weedy check (T_9), however, it was on par with 2,4-D Dimethyl amine salt 58 % SL@ 1 kg a.i ha^{-1} (T_2) (168.8 g) at harvest.

Weed free treatment (T_{10}) recorded significantly higher leaf area which was at par with topramezone 33.6% SC@ 25.2 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) at harvest. Weedy check (T_9) recorded significantly lower leaf area which was at par with 2,4- D Dimethyl Amine salt 58 % SL @ 1 Kg a.i ha^{-1} as post emergence (T_2) and topramezone 33.6% SC @ 25.2g a.i ha^{-1} (T_4) at 60 DAS, respectively. At 90 DAS significantly lower leaf area was observed due to (T_9) weedy check.

Superior performance of topramezone + atrazine @ 25.2 + 250 g a.i ha^{-1} + MSO (adjuvant) as PoE and tembotrione + atrazine @ 105 + 250 g a.i ha^{-1} + stefes mero (adjuvant) as PoE was reported by Swetha *et al.*(2015) and noted that better performance of growth attributes under application of topramezone and tembotrione with atrazine was due to timely weed control.

Yield attributes:

Weed free treatment (T_{10}) recorded higher number of rows per cob (14 rows) which was at par with topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} + attrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) (13.93 rows) which was at par with tembotrione 42 % SC @ 105 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_7) (13.66 rows) and Topramezone 33.6 % SC @ 67.2 a.i ha^{-1} (T_3) (13.40 rows). Significantly lowest number of rows per cob recorded in (T_9) weedy check (11.17rows).

Higher length of cob (17.70 cm) was recorded in weed free treatment (T_{10}) which was at par with rest of treatments except topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} (T_4), 2,4–D dimethyl Amine salt 58 % SL @ 1 Kg a.i ha^{-1} (T_2) (16.04 cm),Tembotrione 42 % SC @ 105 g a.i ha^{-1} (T_5) (15.58 cm), respectively. Significantly lowest length of cob was recorded in weedy check (T_9) (14.61 cm).

Weed free treatment (T_{10}) recorded higher girth of cob (14.54 cm) which was at par with rest of the treatments, however, it was significantly superior over weedy check (T_9) (13.63 cm), 2,4 -D dimethyl amine salt 58 % SL @ 1 kg a.i ha^{-1} (T_2) (14.02 cm), tembotrione 42% SC @ 105 g a.i ha^{-1} (T_5) (13.70 cm), respectively.

Weed free treatment (T_{10}) recorded higher weight of cob (214.52 g) which was at par with topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) (208.33 g) and it was at par with tembotrione 42 % SC @ 105 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_7) (202 g) and topramezone 33.6 % SC @ 67.2 g a.i ha^{-1} (201.32 g) (T_3), respectively. Significantly lowest weight of cob was recorded in (T_9) weedy check (153.50 g).

Data presented in Table 1. Indicated that Weed free treatment (T_{10}) recorded higher number of grains per cob (468) which was at par with topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) (465.05), respectively. Significantly lowest numbers of grains per cob were recorded in weedy check (T_9) (410.57).

Glimpse of data presented in Table 1 revealed that, application of herbicide with combination of pre-emergence and post emergence herbicides resulted in better growth of the crop ultimately proved beneficial for better values of yield attributes *viz.*, number of rows cob^{-1}, length of cob, girth of cob, weight of cob, number of grains cob^{-1}, weight of grains cob^{-1} and test weight, which can be attributed to better control of weeds by the combination of herbicides similar findings were observed by Swetha *et al.* (2015). Whereas minimum values of yield attributes were observed in weedy check. These findings were in conformity with Sharma *et al.* (2014).

Table 1. Growth attributes at harvest and yield attributes of maize (*Zea mays* L.) influenced by different weed management treatments.

Treatments	Mean number of leaves plant^{-1}	Plant height (cm) plant^{-1}	Dry matter accumulation (g) plant^{-1}	Mean leaf area (cm)^2 plant	Number of rows cob $^{-1}$	Length of cob(cm)	Girth of cob(cm)	Weight of cob(g)	Test weight (g)
T$_1$: Atrazine 50 %WP@1 Kg a.i ha^{-1} (PE)	10.83	144.7	176.30	81.35	13.13	16.86	14.40	196.30	34.96
T$_2$:2,4 –D Dimethyl Amine salt 58 %SL @1 Kg a.i ha^{-1} (PoE).	11.56	141.56	168.6	75.9	13	16.04	14.02	180.54	34.16
T$_3$:Topramezone33.6 %SC @ 67.2g a.i ha^{-1} (PoE at 15DAS)	12.17	147.80	179.54	78.22	13.40	16.94	14.43	201.32	38.23
T$_4$: Topramezone33.6 %SC @25.2 g a.i ha^{-1} (PoE at 15DAS)	10.38	142.03	172.38	76.54	12.93	16.07	14.31	192.03	36.37
T$_5$: Tembotrione42 %SC @ 105 g a.i ha^{-1} (PoE15 DAS)	11.57	142.03	173.76	79.50	13.00	15.58	13.70	190.92	35.93
T$_6$:Topramezone33.6 %SC@ 25.2g a.i ha^{-1} + Atrazine 50 % WP @ 250 (g) a.i ha^{-1} (PoE at 15 DAS)	13.06	148	182.91	89.80	13.93	17.58	14.50	208.33	39.5
T$_7$:Tembotrione42% SC@105g a.i ha^{-1} + Atrazine 50 % WP @ 250 (g) a.i ha^{-1} (PoE15 DAS)	12.66	144.86	177.76	82.60	13.66	17.51	14.45	202.0	37.5
T$_8$: One hand weeding at 30 DAS	11.13	140.53	169.58	77.97	12.97	16.99	14.23	171.43	34.33
T$_9$: Weedy check	8.07	135.13	165.84	69	11.17	14.61	13.63	153.50	33.10
T$_{10}$:Weed free	13.5	148.56	186.88	92.26	14	17.70	14.54	214.52	40.5
SE(m)+	0.30	0.75	2.1	1.08	0.18	0.41	0.25	3.66	0.52
CD at 5 %	1.13	2.89	7.0	2.49	0.60	1.57	0.59	14.04	2.01
General mean	11.49	143.52	170.17	80.40	13.12	16.59	14.22	191.09	36.47

Yield:

Data presented in Table 2 reported that, efficient utilization of soil and climatic resources by maize plant in the presence of relatively low weed density and dry weight led to maximum grain yield (58.90q ha^{-1}) in weed free treatment (T_{10}) which was at par with topramezone 33.6% SC @ 25.2g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) (56.69 q ha^{-1}) and tembotrione 42 % SC @ 105g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_7) (54.50 kg/ha), respectively. Significantly lowest grain yield was recorded in weedy check (T_9) (27.34 q ha^{-1}). Madhavi *et al.* (2014) reported that efficiency of maize crop to partition the dry matter into its economic yield was highest in tank mix application of HPPD (4- hydroxyl-phenyl pyruvate dioxygenase) with atrazine.

Data presented in Table 2 regarding stover yield was significantly influenced by different weed management treatments. Highest stover yield was recorded in weed free treatment (74.67 q/ha) which was significantly superior to all other treatments; this might be due to the continuous removal of weeds. Similar findings were reported by Malviya *et al.* (2012). However, treatment (T_{10}) was found at par with topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_6) (73.00 q ha^{-1}) as post emergence and it was at par with tembotrione 42 % SC @ 105 g a.i ha^{-1} + atrazine 50 % WP@ 250 g a.i ha^{-1} (T_7) (72.62 q ha^{-1}) and topramezone 33.6 % SC @ 67.2 g a.i ha^{-1} (T_3) (72.34 q ha^{-1}), respectively. Higher stover yield in weed control treatments could be due to better growth and development of maize, which produced more biomass. Significantly lower stover yield was recorded in weedy check. This is due to higher crop weed competition in weedy check treatment.

Highest biological yield (133.57 q ha^{-1}) was recorded in weed free treatment which was on par with topramezone 33.6 % SC @ 25.2 g a.i. ha^{-1} + atrazine 50 % WP @ 250 g a,i. ha^{-1} as post emergence and it was at par with tembotrione 42 % SC @ 105 g a.i. ha^{-1}+ atrazine 50 % WP @ 250 g a.i. ha^{-1}, topramezone 33.6%SC @ 67.2 g a.i. $ha^{-1}$and atrazine 50% WP @1Kg a.i. ha^{-1}, respectively. Significantly lowest biological yield was recorded in weedy check. Similar findings were reported by Swetha *et al*. (2015).

Table 2. Yield attributes of *kharif* maize (*Zea mays* L.) influenced by different weed management treatments.

Treatments	Weed dry weight (g m^2)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological Yield(q ha^{-1})	Harvest Index
T_1: Atrazine 50 %WP@1 Kga.i/ha(PE)	32.6	53.60	71.07	124.67	42.99
T_2:2,4 –D Dimethyl Amine salt 58 %SL @1Kg a.i ha^{-1} (PoE).	46.0	51.37	70.62	121.99	42.11
T_3:Topramezone33.6 %SC @ 67.2g a.i ha^{-1} (PoEat 15DAS)	26.54	54.43	72.34	126.77	42.93
T_4: Topramezone33.6 %SC @25.2 g a.i ha^{-1} (PoEat 15DAS)	47.75	48.28	71.17	119.45	40.41
T_5: Tembotrione42 %SC @ 105 g a.i ha^{-1} (PoE15 DAS)	51.71	45.96	70.34	116.30	39.51
T_6:Topramezone33.6 %SC@ 25.2g a.i ha^{-1} + Atrazine 50 % WP @ 250 (g) a.i. /ha(PoE at 15 DAS)	22.43	56.69	73.00	129.69	43.71
T_7:Tembotrione42% SC @105g a.i ha^{-1} + Atrazine 50 % WP @ 250 (g) a.i./ha (PoE15 DAS)	25.28	54.50	72.62	127.12	42.87
T_8:Onehandweedingat30 DAS	57.35	47.00	67.10	114.10	41.19
T_9: Weedy check	102.2	27.34	57.89	85.23	32.07
T_{10}:Weed free	00	58.90	74.67	133.57	44.09
SE(m)+	1.86	1.40	1.17	3.11	-
CDat5%	5.53	4.40	3.54	10.09	-
General mean	**41.20**	**49.81**	**70.08**	**119.99**	**-**

Data on harvest index revealed significant increase in harvest index in weed control treatments. Highest harvest index (44.09%) was recorded in weed free treatment (T_{10}) which was at par with topramezone 33.6 % SC @ 25.2 g a.i ha^{-1} + atrazine 50 % WP @ 250 g a.i ha^{-1} (T_7) (43.71%), atrazine 50 % WP @ 1 Kg a.i ha^{-1} (T_1) (42.99%), topramezone 33.6 % SC@ 67.2 g a.i ha^{-1} (T_3) (42.93 %) and tembotrione 42 % SC @ 105 g a.i ha^{-1} + atrazine 50 % WP@ 250 g a.i ha^{-1} (T_7) (42.87%), respectively. While the lowest harvest index (32.07 %) was recorded in (T_9) weedy check. This might be due to higher harvest index that the crop had a higher capacity to translocate photosynthates towards economic sinks in presence of low weed competition. A similar report of increase in the harvest index with reduced weed competition was reported earlier by Sanodiya *et al.*(2013).

CONCLUSION

In the present investigation, an attempt was made to study the effect of combination of pre emergence and post emergence herbicides on growth and yield of *kharif* maize. Growth and yield of maize was significantly improved due to tank mix application of herbicide combinations viz., topramezone + atrazine @ 25.2 + 250 g a.i ha^{-1} as PoE (15 DAS) and tembotrione + atrazine @ 105 + 250 g a.i ha^{-1} as PoE (15 DAS) application over alone application of atrazine @1 kg a.i. ha^{-1}(PE), 2,4-D @1 kg a.i. ha^{-1}(PoE at 15 DAS), Tembotrione @105 g a.i. $ha^{-1}$and Topramezone @25.2 and 67.5 g a.i. ha^{-1}(PoE at 15 DAS).

REFERENCES:

Anonymous, 2019-20. Directorate of Economics & Statistics, Department of Agriculture & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India pp-265-266.

Chopra P. and angiras, N. N. 2007. Influence of tillage and weed control methods on growth, productivity and quality of maize (*Zea mays* L.) *Journal of Crop and Weed* **3**(2) : 10-14.

Malviya, A.; Malviya, N., Singh and Band Singh, A.K. 2012. Integrated weed management in maize (Zea mays L.) under rainfed conditions. *Indian Journal of Dryland Agriculture Research & Development* **27**(1): 70-73.

Rajeshkumar,A. venkataraman N.S., Ramadass S., Ashokkumar N. and Thirumeninathan S. 2017. Effect of weed control and cropping system on weed population and productivity of maize grown sole or intercropped with pulses. *Journal of Crop and Weed* **13**(3): 150-155.

Rana S.S., Badiyala D., Sharma N., RajendraKumar and Pathaniya P. 2017. Impact of tembotrione on weed growth, yield and economics of maize (Zea mays L.) under mid hill of Himachal Pradesh. *Pesticide Research journal* **29** (1):27-34.

Raut V.G, Khawale V.S., Moharkar R., Bhadoriya R. and Meshram D. 2017. Effect of different herbicides on weeds and grain yield of maize J. Soils and crops **27** (1): 248-252.

Sanodiya, P.; Jha, A. K and Shrivastava, A. 2013. Effect of integrated weed management on seed yield of fodder maize. *Indian Journal of Weed Science* **45**(3): 214–216.

Sharma, P., Duary, B. and Singh, R. 2014. Tank mix application of tembotrione and atrazine to reduce weed growth and increase productivity of maize. *Indian Journal of Weed Science* **50**(3): 305–308.

Swetha K,; Madhavi M, Pratibha G and Ramprakash T. 2015. Weed management with new generation herbicides in maize. *Indian Journal of Weed Science* **47**(4):432–433.

Swetha, K. 2015.Weed management with new generation herbicides in *kharif* maize. M.Sc.(Agri.) Thesis submitted to Professor Jayashankar Telangana State Agricultural University, Hyderabad, India.

Yenpredditwar M.D., Ingole P.G., Paslawar A.N,Bhale V.M. and Deshmukh, J. P. 2017. Effect of integrated weed management practices on seed cotton yield and economics of high density planting system of cotton J. Soils and crops **27**(1): 55-59.