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Efficacy of pre- and post-emergence herbicides in maize

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ABSTRACT

A field investigation was carried out at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during three consecutive *Kharif* seasons (2016-2018) to study the relative efficacy of herbicides on weed control in maize. Results revealed that, among the herbicidal treatments, atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE at 20 DAS produced less weed count and weed dry matter than rest of the herbicides. Among the herbicidal treatments, maximum growth and yield attributes were recorded with treatment of atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha which was at par with atrazine 0.5 kg/ha *fb* 2,4-D sodium salt 0.5 kg/ha. Yield reduction varied from 12.49% to 54.17% in the herbicide applied plots as compared to weed free treatment. Atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS (4.33 t/ha) and atrazine 1.0 kg/ha PE (3.89 t/ha) proved as effective as weed free treatment (4.91 t/ha) and recorded significantly higher grain yield with net monitory returns of ₹ 47832/ha and B:C ratio of 3.22.

INTRODUCTION

Maize (*Zea mays* L.) being one of the most important cereals, has attained the status of commercial crop. In India, it is cultivated over an area of 8.9 million hectares with a production of about 23 million tones and productivity of 2.58 t/ha (Anonymous 2016). However, in Maharashtra it occupies an area of about 0.9 million hectare with a production of 2.06 million tones and productivity of 2.90 t/ha. (Anonymous 2016). Rainy season maize suffers from severe weed competition depending upon the intensity, nature, stages and duration of weed infestation and yield losses varied from 28-100 per cent (Patel *et al*. 2006). A wide spaced crop suffers from heavy weed infestation due to slow initial growth particularly during *Kharif* season. Weed depletes 30-40% of applied nutrients from the soil. They interfere with efficiency of fertilizer utilization by crops plants because a sizeable portion of the fertilizer added to the soil is used by weed. The quantities of growth factors used by weeds are thus unavailable to the crop. Some of the grassy and broad-leaf weeds found in maize field are *Cyperus rotundus, Cynodon dactylon, Commelina benghalensis, Cyanotis oxillaris, Denebra arabica, Tridax procumbens, Lagasca mollis, Euphorbia hirta, Euphorbia geniculata, Parthenium hysterophorus, Digera arvensis, Phyllanthus niruri, Celosia argentina* and *Acalyfa indica.* These are among the deadly weeds of the world which infest the maize field and thus, increase the cost of production as hand weeding is not effective against these weeds.

Management of weeds is considered to be an important factor for achieving higher productivity. Rout *et al.* (1996) revealed that weeds cause enormous damage upto 30 to 50% in maize crop. Uncontrolled weed growth may reduce maize yield as much as 90% (Ratta *et al.* 1991). Weeds also pose severe problems for crop husbandry and infest fallow land, reduce soil fertility and moisture conditions and develop a potential threat to the succeeding crops (Khan *et al.* 2003). Chemical weed management by using pre- and post-emergence herbicides can lead to the efficient and cost-effective control of weeds during critical period of crop weed competition, which may not be possible in manual or mechanical weeding due to its high cost of cultivation (Triveni *et al.* 2017). The present investigation was therefore, done with an objective to study the efficacy of pre and post-emergence herbicides and its effect on weed flora, growth and yield of maize.

MATERIALS AND METHODS

The present field experiment was conducted during three consecutive *Kharif* season (2016-2018) at the research farm AICRP-Weed Management, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) in a randomized block design with three replication having twelve different treatments of weed

management. namely weed free , weedy check, 2,4-D sodium salt 0.80 kg/ha PoE 30 DAS, 2,4-D sodium salt 1.20 kg/ha PoE 30 DAS, atrazine 1.0 kg/ha PE, atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS, pendimethalin 1.0 kg/ha PE, atrazine 0.5 kg + pendimethalin 0.5 kg/ha PE, 2,4-D sodium salt 0.5 kg PoE 30 DAS, topramezone 0.0252 kg/ha PoE 20 DAS, halosulfuron-methyl 0.05 kg/ha PoE 20 DAS and metribuzin 0.35 kg/ha PE.

The soil of the experimental field was black and clayey in texture and slightly alkaline in reaction, low in nitrogen, medium in phosphorous and fairly rich in potash. The maize variety '*Maharaja*' was sown at the spacing of 60x30 cm on 23rd June, 25th June and 22nd June during the year 2016, 2017 and 2018, respectively with recommended dose of fertilizer 120:60:30 NPK kg/ha. The application of herbicide was done as per the treatments with manually operated knapsack sprayer attached with a flood jet nozzle. After calibrating the sprayer, water volume used was 700 liter. per ha for PE and 500 liter per ha. for PoE spray. The observations on weed density and weed biomass were taken at 15 days-interval upto harvest from four randomly selected spots from net plot area by using a quadrate of 50 x 50 cm. Then, weeds were grouped as monocot and dicot species. Weed control efficiency (WCE) was calculated by using standard formula suggested by Maity and Mukherjee (2011). Phytotoxicity symptoms due to herbicides on crop were recorded by using a visual score scale of 0-10. Visual assessment of herbicide toxicity on crop was monitored 10 days after application of herbicide in respective treatments. Data on various crop growth and yield attributing characters were statistically analysed as per the standard procedure.

RESULTS AND DISCUSSION

Weed flora

Both broad- and narrow-leaved weeds were observed but dominance of broad-leaved weeds was more in entire field. In general dominance of dicot weeds (67.9%) was recorded during the experimental period. The major weed flora during *Kharif* season in maize crop in the selected area composed of *Xanthium strumarium, Celosia argentea, Tridax procumbens, Phyllanthus niruri, Portulaca oleracae, Lagasca mollis, Euphorbia geniculata, Euphorbia hirta*, *Abutilon indicum*, *Abelmoschus moschatus, Boerhavia diffusa*, *Calotropis gigantea*, *Ageratum conyzoides*, *Bidens pilosa*, *Mimosa pudica*, *Alternanthera triandra, Parthenium hysterophorus, Digera arvensis, Cynodon dactylon, Cyperus rotundus, Amaranthis viridis, Dinebra arabica, Panicum* spp*., Commelina benghalensis, Ischaemum pilosum*, *Digitaria sanguinalis, Dinebra retroflexa, Poa annua, Cyanotis axillaris etc.*

Effect on weeds

Weed control treatments significantly reduced the weed population and weed biomass when compared with unweeded control (**Table 1**). The sequential application of atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS produced less weed count and weed dry matter than rest of the herbicides tested during the study, but it was at par with atrazine 1.0 kg/ha PE. Similar trend of results was also noticed in individual years. This might be due to the herbicidal application alone (higher dose) and in combination which were effective in timely reducing total weed population. Similar results were reported by Gantoli *et al.* (2013), Madhavi *et al*. (2014) and Singh *et al.* (2015).

The sequential application of pre- and post-emergence herbicides was found superior to only post-emergence herbicide applications. The highest weed control efficiency (76.11%) was found with atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS followed by atrazine 1.0 kg/ha PE (71.08%) and atrazine 0.5 kg + pendimethalin 0.5 kg/ha PE. This showed that all the pre-emergence herbicides used in this experiment were compatible, which increased their efficiency over post-emergence herbicide application without any phytotoxic effects causing adversity. Weed index as showed that there was least yield reduction (12.49%) with atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS followed by atrazine 1.0 kg/ha PE (22.88%) and atrazine 0.5 kg + pendimethalin 0.5 kg/ha PE (22.97%). Whereas yield reduction varied from 12.49% to 54.17% in the herbicide applied plots as compared to weed free treatment. The weed index was lower in all the treatments as compared to weedy check. Similar trend of weed control efficiency and weed index were recorded during 2016-17 to 2018-19. This result corroborate with finding of Patel *et al*. (2006), Shantveerayya and Agasimani (2011) and Gantoli *et al*. (2013).

Effect on crop

Maximum cob weight (135.53g) at harvest was found in weed free which was at par with atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS and atrazine 1.0 kg/ha PE. Grain weight per cob was found maximum (86.06 g) and was recorded in weed free treatment followed by atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS and atrazine 1.0 kg/ha PE. Significantly higher test weight was found in weed free over rest of the treatments. The

lowest yield attributes values were recorded in weedy check. (**Table 2**). The similar type of result with chemical and mechanical measures of weed control were also reported by Walia *et al*. (2007) and Triveni *et al*. (2017).

Different weed control treatments registered significant increase in grain yield of maize compared to unweeded control. Unweeded control registered the lowest average grain yield, whereas the treatments atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS (4.33 t/ha) and atrazine 1.0 kg/ha PE (3.89 t/ha) proved as effective as weed free treatment (4.91 t/ha) and recorded significantly higher grain yield over rest of the treatments. It may be due to better control of weeds initially by pre-emergence spray and after that late emerging weeds were controlled by post-emergence herbicides. The higher yield in these treatments might be due to more availability of nutrients and moisture as there was less competition between weeds and crop. Similar results were also found by Shantveerayya and Agasimani, (2012), Sharma (2007) and Walia *et al*. (2009). The overall yield levels of maize were low during the study due to less rainfall received at grain filling stage of maize.

Table 1. Weed count, weed dry matter, weed control efficiency and weed index as influenced by different weed control treatments (pooled of three years)

Treatment	Weed density (no./m^2)				Weed dry matter (g/m^2)				Weed control efficiency (%)	Weed index (%)
	2016	2017	2018	Pooled	2016	2017	2018	Pooled		
2,4-D sodium salt 0.80 kg/ha PoE 30 DAS	8.41 (70.3)	8.34 (69.2)	8.74 (76.5)	8.51 (72.0)	7.98 (63.3)	7.91 (62.2)	7.30 (53.3)	7.73 (59.6)	61.20	27.10
2,4-D sodium salt 1.20 kg/ha PoE 30 DAS	8.02 (64.0)	7.95 (62.9)	8.00 (64.0)	7.99 (63.6)	7.83 (60.9)	7.76 (59.8)	7.49 (56.1)	7.69 (58.9)	61.62	26.00
Atrazine 1.0 kg/ha PE	6.54 (42.3)	6.45 (41.2)	6.24 (38.9)	6.41 (40.8)	7.00 (48.6)	6.92 (47.5)	6.11 (37.3)	6.68 (44.5)	71.08	22.88
Atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS	5.81 (33.3)	5.71 (32.2)	6.01 (36.1)	5.84 (33.9)	6.21 (38.2)	6.12 (37.1)	5.91 (35.0)	6.08 (36.7)	76.11	12.49
Pendimethalin 1.0 kg/ha PE	7.79 (60.7)	7.72 (59.5)	7.63 (58.2)	7.71 (59.5)	8.04 (64.2)	7.97 (63.1)	7.78 (60.5)	7.93 (62.6)	59.23	23.54
Atrazine 0.5 kg + pendimethalin 0.5 kg/ha PE	6.81 (46.0)	6.72 (44.9)	6.98 (48.8)	6.84 (46.5)	7.90 (61.9)	7.83 (60.8)	7.95 (63.3)	7.90 (62.0)	67.64	22.97
2,4-D sodium salt 0.5 g PoE 30 DAS	7.08 (49.7)	7.00 (48.5)	7.23 (53.7)	7.14 (50.7)	7.40 (54.2)	7.32 (53.1)	7.15 (51.1)	7.29 (34.7)	65.64	26.25
Topramezone 0.0252 kg/ha PoE 20 DAS	6.86 (46.7)	6.78 (45.5)	7.10 (50.4)	6.91 (47.5)	7.22 (51.7)	7.14 (50.6)	6.84 (46.8)	7.07 (49.7)	59.62	23.36
Halosulfuron-methyl 0.05 kg/ha PoE 20 DAS	7.64 (58.0)	7.56 (56.9)	7.80 (60.8)	7.57 (58.6)	7.96 (62.8)	7.89 (61.7)	7.78 (60.5)	7.88 (61.7)	59.83	24.80
Metribuzin 0.35 kg/ha PE	7.36 (53.7)	7.28 (52.5)	7.57 (57.2)	7.50 (54.5)	7.45 (55.1)	7.38 (54.0)	7.96 (63.3)	7.60 (57.5)	62.56	23.18
Weed free	3.12 (9.3)	2.93 (8.1)	2.91 (8.5)	2.99 (8.6)	2.44 (5.5)	2.20 (4.3)	2.73 (7.4)	2.46 (5.8)	96.35	0.00
Weedy check	12.77 (162.7)	12.73 (161.5)	12.98 (168.0)	12.83 (164.1)	12.42 (153.9)	12.38 (152.8)	12.38 (152.7)	12.39 (153.1)	0.00	54.17
LSD (p=0.05)	0.68	0.60	0.52	0.59	0.49	0.53	0.58	0.45		

Figures in parentheses are original values

Table 2. Yield attributes and grain yield as influenced by weed control treatments (pooled of three years)

Treatment	Cob weight at harvest (g)	Grain weight/ cob (g)	Test wt. (100-seed) (g)	Grain yield (t/ha)			
				2016	2017	2018	Pooled
2,4-D sodium salt 0.80 kg/ha PoE 30 DAS	105.49	58.94	24.69	3.57	3.52	3.71	3.60
2,4-D sodium salt 1.20 kg/ha PoE 30 DAS	115.71	70.41	24.75	3.63	3.58	3.77	3.66
Atrazine 1.0 kg/ha PE	131.62	83.88	25.55	3.77	3.73	4.16	3.89
Atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS	132.18	84.10	26.15	4.27	4.24	4.47	4.33
Pendimethalin 1.0 kg/ha PE	113.62	71.98	25.30	3.74	3.69	3.91	3.78
Atrazine 0.5 kg + pendimethalin 0.5 kg/ha PE	126.98	78.43	25.53	3.77	3.73	3.87	3.79
2,4-D sodium salt 0.5 g PoE 30 DAS	113.56	69.62	24.82	3.61	3.56	3.77	3.65
Topramezone 0.0252 kg/ha PoE 20 DAS	128.88	81.10	25.45	3.76	3.72	3.94	3.81
Halosulfuron-methyl 0.05 kg/ha PoE 20 DAS	112.73	70.87	25.18	3.67	3.63	3.84	3.71
Metribuzin 0.35 kg/ha PE	125.37	77.78	25.38	3.77	3.73	3.92	3.80
Weed free	135.53	86.06	26.55	4.90	4.86	4.99	4.91
Weedy check	97.03	50.56	24.27	2.24	2.21	2.37	2.27
LSD (p=0.05)	8.69	9.16	1.12	0.46	0.48	0.51	0.45

Table 3. Gross monetary returns, net monetary returns and B:C as influenced by weed control treatments (pooled of 3 years)

Treatment	GMR (x10^3 ₹/ha)				NMR (x10^3 ₹/ha)				B:C ratio			
	2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled
2,4-D sodium salt 0.80 kg/ha PoE 30 DAS	57.78	56.58	49.47	54.61	37.42	36.82	25.69	33.31	2.84	2.86	2.08	2.59
2,4-D sodium salt 1.20 kg/ha PoE 30 DAS	58.70	57.49	55.39	57.19	38.16	37.56	35.22	36.98	2.86	2.88	2.75	2.83
Atrazine 1.0 kg/ha PE	60.92	59.72	72.33	64.32	40.17	39.57	47.66	42.47	2.94	2.96	2.93	2.94
Atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS	68.21	67.00	72.94	69.38	47.07	46.46	49.97	0.00	3.23	3.26	3.18	3.22
Pendimethalin 1.0 kg/ha PE	59.82	58.62	57.29	58.58	38.28	37.68	33.62	36.53	2.78	2.80	2.42	2.67
Atrazine 0.5 kg + pendimethalin 0.5 kg/ha PE	60.54	59.33	65.01	61.63	39.39	38.79	43.02	40.40	2.86	2.89	2.96	2.90
2,4-D sodium salt 0.5 g PoE 30 DAS	58.30	57.10	55.02	56.81	36.12	35.52	33.45	35.03	2.63	2.65	2.55	2.61
Topramezone 0.0252 kg/ha PoE 20 DAS	60.66	59.46	66.59	62.24	38.45	37.85	41.24	39.18	2.73	2.75	2.63	2.70
Halosulfuron-methyl 0.05 kg/ha PoE 20 DAS	59.47	58.26	56.55	58.09	35.46	34.85	28.64	32.98	2.48	2.49	2.03	2.33
Metribuzin 0.35 kg/ha PE	60.83	59.63	69.45	63.30	39.92	39.32	44.98	41.41	2.91	2.94	2.84	2.89
Weed free	76.98	75.78	76.72	76.50	50.91	48.40	50.85	50.06	2.95	2.77	2.97	2.90
Weedy check	38.77	37.57	35.33	37.22	19.30	18.70	15.86	17.95	1.99	1.99	1.81	1.93

GMR - Gross monetary returns, NMR - Net monetary returns

Economics

Based on an average B:C ratio atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS (3.22) was closely followed by atrazine 1.0 kg/ha PE (2.94) while atrazine 0.5 kg + pendimethalin 0.5 kg/ha PE and 2,4-D sodium salt 1.20 kg/ha PoE 30 DAS recorded more or less identical values (**Table 3**). This might be owing to good seed yield obtained under these treatments because of better management of weeds. The gross monetary return (GMR), net monetary returns (NMR) and B:C ratio was the lowest in weedy check due to more weed density and lesser yield. The highest pooled GMR of ₹ 69381/ha, NMR of ₹ 47832/ha and B:C ratio (3.22) was registered in treatments of atrazine 0.5 kg/ha *fb* tembotrione 0.120 kg/ha PoE 20 DAS closely followed by atrazine 1.0 kg /ha PE. The differences in B:C ratio is due to the cost of herbicides and productivity of the crop. Similar results were obtained by Shantveerayya and Agasimani (2011), Swetha *et al.* (2015) and Gupta *et al.* (2018). Though the weed free treatment resulted in highest seed yield (4.91 kg/ha) owing to 97.42% weed control efficiency but due to higher expenditure incurred on engaging more labours, it could not found as profitable as herbicidal treatments.

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