

Original Research Article

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Effect of Pre and Post Emergence Herbicides on Weeds, Productivity and Profitability of Maize (*Zea mays* L.)

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ABSTRACT

A field investigation entitled “Effect of sequential application of pre-emergence and post emergence herbicides on weeds, productivity and profitability of maize (*Zea mays* L.)” was carried out at AICRP on weed management field of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the *Kharif* season of the year 2018-19 with an objective to study the relative efficacy of pre and post emergence herbicides on weed control in maize and to study its effect on productivity and profitability of maize. The experiment was laid out in randomized block design with twelve treatment replicated thrice. The soil of experimental field characterized as clay loam in texture, having slightly alkaline pH (7.5), moderate organic carbon status (5.38%), low nitrogen content (219.33 kg ha⁻¹), medium available phosphorus content (15.30 kg ha⁻¹) and high available potassium (340.67 kg ha⁻¹). Maize (Pioneer hybrid 3396) was sown on 25th June 2018 at 60×20 cm spacing with 120:60:30 NPK kg ha⁻¹. The results revealed that among the herbicidal treatments, Atrazine 0.50 kg/ha fb tembotrione 0.120 kg/ha was found to be effective in controlling weeds across the crop growth period., Among the various treatments under study weed free recorded significantly higher values of major parameters whereas, in herbicidal treatments, the maximum growth and yield attributes were recorded with treatment Atrazine 0.50 kg/ha fb tembotrione 0.120 kg/ha which was at par with Atrazine 0.50 kg/ha fb 2,4-D sodium salt @0.5 kg/ha. Among the post emergence herbicides, reduction in weed population, weed dry matter, higher weed control efficiency (79.78) and lowest weed index (7.62) was found with Atrazine 0.50 kg/ha PE fb tembotrione 0.120 kg/ha POE 20 DAS. Atrazine 0.50 kg/ha fb tembotrione 0.120 kg/ha was found most economical with maximum value of GMR (75709 Rs ha⁻¹), NMR (53059 Rs ha⁻¹) and B: C ratio (3.34).

Keywords

Atrazine, Maize,
Pre-emergence,
Post-emergence,
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Introduction

Maize (*Zea mays* L.) being one of the most important cereals and has attained a commercial crop status and has scope to

increase the present maize yields. Now in some literature, maize is regarded as “King of cereals” because of its high production potential and wider adaptability. In India, maize occupies a proud place both as food

and feed for animals and it is the third important food crops after rice and wheat. It is cultivated over an area of 8.9 million hectares with a production of about 23 million tones and productivity of 2584 kg/ha in India, However in Maharashtra it occupies an area of about 0.9 million hectare with a production of 2.06 million tones and productivity of 2900 kg/ha (Anonymous, 2016). Rainy season maize suffers from severe weed competition and depending upon the intensity, nature, stages and duration of weed infestation; yield losses vary 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 per cent 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. Weeds are regarded as pest of crops because they lower down the productivity, increase the cost of production and inferior the quality of produce. The quantities of growth factors used by weeds are thus unavailable to the crop. Many grassy and broadleaf weeds 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. Yield loss occurs up to 33% to complete crop failure due to weed competition in maize. Rout *et al.*, (1996) revealed that weeds cause enormous damage upto 30 to 50 per cent in maize crop. 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). Due to increased cost and non availability of labour in required quantity timely for hand weeding, role of herbicide is significant preposition. Herbicides not only control the weeds timely and effectively but

also offer great scope for minimizing the cost of weed control irrespective of the situation. The conventional method of weed control (hoeing/ hand weeding) are very laborious, expensive and time consuming and needs to be often repeated at different intervals. Frequent rainfall during rainfed cropping season does not permit manual and mechanical methods of weeding at the appropriate time. Use of pre and post emergence application of herbicides would make herbicidal weed control more acceptable to farmers which will not change the existing agronomic practices but will allow for complete control of weeds. Sequential use of pre and post emergence herbicides at temporal variation may help in avoiding the problem of weeds throughout the growth stages. Chemical weed management by using pre emergence 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 planned with a objective to study the efficacy of sequential application of pre and post emergence herbicides and its effect on weed flora, growth, productivity and profitability of maize (*Zea mays* L.).

Materials and Methods

The present field experiment was conducted during *Kharif* season of the year 2018-19 at the research farm of AICRP-Weed Management, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) in Randomized Block Design with three replication having twelve different treatments of weed management including Atrazine@1 kg a.i/ha.(T₁), Pendimethalin@1kg/ha (T₂), Metribuzin 0.35 kg/ha(T₃), Atrazine 0.50kg/ha + Pendimethalin 0.50kg/ha(T₄), 2,4-D sodium salt@ 0.80 kg/ha (T₅),

Tembotrione 0.120 kg/ha (T₆), Atrazine 0.50 kg/ha fb 2,4-D sodium salt @0.5kg/ha (T₇), Atrazine 0.50 kg/ha fb tembotrione 0.120 kg/ha (T₈), Topramezone 0.0252kg/ha (T₉), Halosulfuron methyl 0.05 kg/ha (T₁₀), Weed free(T₁₁)and Weedy check (T₁₂). The soil of experimental field characterized as clay loam in texture, having slightly alkaline pH (7.5), moderate organic carbon status (5.38%), low nitrogen content (219.33 kg ha⁻¹), medium available phosphorus content (15.30 kg ha⁻¹) and high available potassium (340.67 kg ha⁻¹). Maize (Pioneer hybrid 3396) was sown on 25th June 2018 at 60 × 20 cm spacing with 120:60:30 NPK kg ha⁻¹. The crop was harvested on 12th October, 2018. 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 lit. per ha. for PE and 500 lit. per ha. for PoE. The observations on weed density and weed biomass were taken at 20 days interval upto harvest from four randomly selected spots by using a quadrat of 50 cm x 50 cm quadrat from net plot area. Then weeds were grouped as monocot species 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 was 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 treatment. Data on various 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 observed in entire field. 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 oleraceae*, *Lagasca mollis*, *Euphorbia geniculata* *euphorbia hirta*, *phyllanthus niruri*, *Abutilon indicum*, *Abelmoschus moschatus*, *Boerhavia diffusa*, *Calotropis gigantea*, *Ageratum conyzoides*, *Bidenspilosa*, *Mimosa pudica*, *Alternanathera triandra parthenium* *Hysterophorus*, *Digera arvensis* among the dicot weeds and *Cynodon dactylon*, *Cyperus rotundus*, *Amaranthis viridis*, *Dinebra arabica*, *Panicum spp.* *Cynodon dactylon*, *Cyperu srotundus*, *commelina benghalensis*, *Ischaemum pilosum*, *Digitaria sanguinalis*, *Dinebra retroflexa*, *Poa annua*, were the major monocot weeds observed in the experimental field.

Effect on weeds

The data presented in Tables 1 revealed that the weed control treatments significantly reduced the total (monocot+ dicot) weed population and total dry weed biomass when compared with unweeded control. Initially at 20 DAS significantly lowest total weeds density was recorded in weed free treatment (T₁₁) than rest of the weed management treatments. Among the herbicidal treatments Atrazine@1 kg a.i/ha (T₁) and Metribuzin 0.35 kg/ha (T₃), produced lower weed count but were statistically at par with each other. The Weedy check (T₁₂) recorded significantly higher weed population at all the growth stages during the experimentation. At harvest stage, treatment weed free (T₁₁) found significantly superior in reducing the total weeds population than rest of the weed management treatments. The combination of Atrazine 0.50kg/ha fb tembotrione 0.120 kg/ha (T₈) showed its superiority in lowering down the weed population over all other herbicidal treatments. Total weed density and

weed dry biomass was reduced significantly due to various weed control treatments at all stages of crop growth. This might be due to the herbicidal application alone 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).

Weed control efficiency of maize was significantly influenced by weed management treatments, where all the treatments resulted in increase of weed control efficiency over the weedy check. The sequential application of pre and post emergence herbicides was found superior to only post emergence herbicide applications. The highest weed control efficiency was observed in treatment Weed free (T₁₁) from 20 DAS up to at harvest, because of keeping weed free environment and found superior over rest of all herbicidal treatments. Among the herbicides at harvest, the highest weed control efficiency (79.78%) was found with atrazine 0.50 kg /ha fb tembotrione 0.120 kg/ha POE 20 DAS (T₈) followed by Atrazine 0.50 kg /ha PE fb 2,4-D sodium salt @ 0.50 kg/ha POE 30 DAS (77.95%) and Atrazine 1.0 kg/ha PE (70.06) . This showed that all the pre -emergence and post emergence herbicides used in this experiment were compatible, which increased their efficiency without any phytotoxic effect causing adverse effect on maize crop. Data on weed index as indicated in Table 1 showed the least yield reduction (7.62%) with atrazine 0.50 kg /ha fb tembotrione 0.120 kg/ha POE 20 DAS followed by the treatments Atrazine 0.50 kg/ha fb 2,4-D sodium salt @ 0.5kg/ha (9.16%) and Atrazine @1 kg a.i/ha (11.6%). Whereas yield reduction varied from 7.62% to 31.26 % 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. Lower is the weed index in chemical treatments, better the efficiency of that herbicide in controlling

weeds, which provided favorable conditions for crop growth which ultimately increased the grain yield of maize crop as compared to weedy check treatment. This result corroborate with finding of Patel *et al.*, (2006), Shantveerayya and Agasimani (2012) and Gantoli *et al.*, (2013).

Effect on growth and yield

Weed management treatments significantly affected the growth and yield attributing characters of maize (Table-3). Significantly maximum plant height (226.29 cm) and plant dry matter (234.80 g) of maize at harvest was recorded in weed free treatment which was at par with atrazine 0.50 kg /ha fb tembotrione 0.120 kg/ha POE 20 DAS and Atrazine 0.50 kg /ha fb 2,4-D sodium salt @ 0.50 kg/ha POE 30 DAS . Significant reduction in plant height was noticed in unweeded control treatment at harvest might be due to the fact that weeds suppressed the vegetative growth of plants by the competition between crop and weeds for soil moisture, plant nutrients, solar radiation and space during active growth period. Taller plants with broader leaf area might have accumulated higher plant dry matter at harvest stage of maize. Similar results were found by Walia *et al.*, (2007) and Kandasamy (2018).

Significantly maximum cob weight (225.83) at harvest was found in weed free treatment and among the herbicidal treatments maximum cob weight was recorded in atrazine 0.50 kg /ha fb tembotrione 0.120 kg/ha POE 20 DAS (219.23 g). Similar trend was observed with regards to grain weight per cob which was found maximum (147.83 g) in weed free treatment followed by 0.50 kg /ha fb tembotrione 0.120 kg/ha POE 20 DAS (144.10). Significantly higher test weight was found in weed free treatment over rest of the treatments. The lowest yield attributes values were recorded with weedy check (Table 3).

Table.1 Weed density (No./m²) and weed dry matter (g/m²) as influenced by different weed control treatments in maize

Treatments	Total weed density (No./m ²)					Weed dry matter (g/m ²)				
	20 DAS	20 DAS	40 DAS	60 DAS	80 DAS	At harvest	40 DAS	60 DAS	80 DAS	At harvest
T₁ : Atrazine 1 kg a.i/ha PE	3.99 (15.43)	3.71 (13.27)	5.80 (33.28)	7.37 (55.47)	7.53 (56.20)	6.94 (47.70)	5.70 (29.65)	6.91 (44.20)	7.07 (43.9)	6.57 (42.00)
T₂ : Pendimethalin 1 kg/ha PE	5.44 (27.46)	5.07 (25.32)	7.52 (56.06)	7.47 (71.20)	8.34 (72.47)	8.09 (64.87)	7.95 (63.03)	8.70 (75.13)	8.79 (76.67)	8.39 (69.93)
T₃ : Metribuzin 0.35 kg/ha PE	4.27 (17.80)	4.49 (19.77)	6.51 (41.92)	7.73 (58.43)	7.89 (61.83)	8.44 (60.06)	5.64 (47.00)	7.66 (60.78)	7.79 (61.06)	7.34 (52.24)
T₄ : Atrazine 0.50 kg + Pendimethalin 0.50kg/ha PE	5.02 (24.67)	4.75 (22.13)	6.85 (46.47)	8.02 (63.83)	7.82 (66.09)	7.29 (52.77)	7.00 (35.17)	7.14 (46.48)	7.24 (51.97)	6.78 (47.16)
T₅ : 2,4-D sodium salt @ 0.80 kg/ha POE 30 DAS	7.55 (56.67)	6.12 (37.03)	6.9 (48.40)	8.24 (67.37)	8.43 (70.67)	7.94 (62.71)	7.22 (52.78)	8.15 (72.91)	8.25 (61.63)	7.85 (62.6)
T₆ : Tembotrione 0.120 kg/ha POE 20 DAS	7.67 (58.33)	6.31 (39.33)	6.30 (39.22)	7.64 (57.93)	7.71 (58.97)	7.51 (55.97)	6.54 (44.85)	7.39 (56.18)	7.50 (67.64)	7.03 (48.90)
T₇ : Atrazine 0.50 kg /ha fb 2,4-D sodium salt @ 0.50 kg/ha POE 30 DAS	5.73 (35.37)	5.32 (27.89)	4.91 (23.83)	6.69 (44.37)	6.77 (45.43)	5.96 (35.13)	5.13 (26.83)	6.34 (39.73)	6.50 (39.8)	5.79 (34.73)
T₈ : Atrazine 0.50 kg/ha fb tembotrione 0.120 kg/ha POE 20 DAS	6.33 (38.20)	5.83 (33.56)	4.71 (21.88)	6.44 (41.01)	6.48 (41.57)	5.70 (32.21)	4.93 (22.77)	6.07 (36.40)	6.27 (39.00)	5.59 (27.47)
T₉ : Topramezone 0.0252 kg/ha POE 20 DAS	7.61 (57.50)	6.15 (37.39)	6.04 (36.17)	7.58 (57.07)	7.61 (57.50)	7.65 (53.10)	6.99 (41.25)	7.23 (49.00)	7.35 (53.57)	6.93 (48.10)
T₁₀ : Halosulfuron methyl 0.05 kg/ha POE 20 DAS	7.47 (55.07)	6.19 (37.92)	6.52 (42.14)	7.96 (62.97)	8.04 (64.23)	7.94 (62.59)	6.56 (51.62)	7.93 (64.16)	8.01 (64.32)	7.55 (56.64)
T₁₁ : Weed free	2.41 (5.39)	1.53 (1.83)	2.02 (3.63)	2.66 (6.60)	2.68 (6.73)	2.33 (4.93)	2.76 (7.13)	3.29 (10.33)	3.35 (10.90)	2.77 (7.24)
T₁₂ : Weedy check	7.85 (61.07)	6.45 (41.07)	12.09 (145.80)	12.62 (158.90)	12.61 (160.60)	12.64 (159.30)	10.94 (133.90)	12.96 (167.41)	13.06 (170.13)	12.89 (165.77)
SE (M) ±	0.29	0.27	0.25	0.33	0.32	0.38	0.26	0.35	0.32	0.30
C. D. at 5 %	0.87	0.79	0.76	0.97	0.94	1.11	0.78	1.03	0.94	0.88

- Figures in parenthesis are original values

Table.2 Weed control efficiency (%) and weed index (%) as influenced by weed control treatments in maize

Treatments	Weed control efficiency (%)					Weed index (%)
	20 DAS	40 DAS	60 DAS	80 DAS	At harvest	
T₁ : Atrazine 1 kg a.i/ha PE	67.69	77.17	65.09	65.01	70.06	11.6
T₂ : Pendimethalin 1 kg/ha PE	38.35	61.55	55.19	54.88	56.77	31.26
T₃ : Metribuzin 0.35 kg/ha PE	51.86	71.25	63.23	61.50	62.30	20.84
T₄ : Atrazine 0.50 kg + Pendimethalin 0.50kg/ha PE	46.12	68.13	59.83	58.85	66.87	18.77
T₅ : 2,4-D sodium salt @ 0.80 kg/ha POE 30 DAS	9.84	66.80	57.54	56.00	60.63	25.52
T₆ : Tembotrione 0.120 kg/ha POE 20 DAS	4.24	73.10	63.54	63.28	64.87	23.37
T₇ : Atrazine 0.50 kg /ha fb 2,4-D sodium salt @ 0.50 kg/ha POE 30 DAS	32.09	83.66	72.08	71.71	77.95	9.16
T₈ : Atrazine 0.50 kg/ha fb tembotrione 0.120 kg/ha POE 20 DAS	18.29	84.99	74.19	74.12	79.78	7.62
T₉ : Topramezone 0.0252 kg/ha POE 20 DAS	8.96	75.19	64.08	64.20	66.67	21.04
T₁₀ : Halosulfuron methyl 0.05 kg/ha POE 20DAS	7.67	71.10	60.37	60.01	60.71	27.95
T₁₁ : Weed free	95.54	97.51	95.85	95.81	96.91	--
T₁₂ : Weedy check	--	--	--	--	--	54.88

Table.3 Growth, Yield attributes and grain yield (Kg/ha) of maize as influenced by weed control treatments

Treatments	Plant height (cm)	Plant dry matter at harvest (g)	Cob weight at harvest (g)	Grain weight cob ⁻¹ (g)	Test wt. (100 seed) (g)	Grain yield (Kg/ha)	GMR (Rs./ha.)	NMR (Rs./ha.)	B:C ratio
T₁ : Atrazine 1 kg a.i/ha PE	220.34	228.80	214.41	140.47	27.13	4596	72679	50829	3.32
T₂ : Pendimethalin 1 kg/ha PE	197.45	214.47	185.71	113.60	25.89	3574	63687	42277	2.97
T₃ : Metribuzin 0.35 kg/ha PE	199.58	219.29	197.59	131.73	26.59	4115	66080	44100	3.01
T₄ : Atrazine 0.50 kg + Pendimethalin 0.50kg/ha PE	207.22	224.50	200.50	132.13	26.97	4223	67002	44552	2.98
T₅ : 2,4-D sodium salt @ 0.80 kg/ha POE 30 DAS	204.96	215.83	187.67	127.97	26.19	3872	58492	36962	2.72
T₆ : Tembotrione 0.120 kg/ha POE 20 DAS	211.74	221.17	195.06	130.10	26.34	3984	60858	38478	2.72
T₇ : Atrazine 0.50 kg /ha fb 2,4-D sodium salt @ 0.50 kg/ha POE 30 DAS	223.51	231.60	216.15	141.13	27.27	4723	74110	51650	3.30
T₈ : Atrazine 0.50 kg/ha fb tembotrione 0.120 kg/ha POE 20 DAS	226.29	234.80	219.23	144.10	27.43	4803	75709	53059	3.34
T₉ : Topramezone 0.0252 kg/ha POE 20 DAS	215.21	223.33	199.00	130.60	26.73	4105	66666	43286	2.85
T₁₀ : Halosulfuron methyl 0.05 kg/ha POE 20DAS	202.96	213.90	179.28	115.70	26.07	3746	62617	37437	2.49
T₁₁ : Weed free	228.64	236.53	225.83	147.83	27.96	5199	81539	51549	2.72
T₁₂ : Weedy check	169.97	181.67	132.35	78.30	22.67	2345	40315	19825	1.97
SE (m) ±	2.61	2.87	4.01	2.64	0.29	206	2975	2975	--
CD P= 0.05	7.66	8.40	11.74	7.72	0.87	605	8709	8709	--

This might be due to the control of weeds at the germination phase by the pre-emergence application of herbicides and significant reduction at later growth stages as late germinating weeds were controlled by tembotrione and 2,4-D resulted in reduced crop weed competition for the growth factor such as light, space and nutrients which turn helped in efficient photosynthetic activity in which cob weight, grain weight, test weight and number of grain are depends. These results are in conformity with the findings of Kamble *et al.*, (2005) and Tesfay *et al.*, (2014) and Triveni *et al.*, (2017).

Different weed control treatments registered significant increase in grain yield of maize compared to unweeded control. Among the treatments unweeded control registered the lowest average grain yield, whereas the treatments atrazine 0.50 kg /ha *fb* tembotrione 0.120 kg/ha POE 20 DAS (4803 kg/ha) and Atrazine 0.50 kg /ha *fb* 2,4-D sodium salt @ 0.50 kg/ha POE 30 DAS (4723 kg/ha) proved as effective as weed free treatment (5199 kg/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 are 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 Waliya *et al.*, (2009).

Economics

As indicated in Table 3, the maximum GMR of Rs. 81539 ha⁻¹ was registered in weed free treatment, however maximum NMR of Rs. 53059 ha⁻¹ was registered in treatment of atrazine 0.50 kg /ha *fb* tembotrione 0.120 kg/ha POE 20 DAS. Similarly maximum B:C

ratio was found with application of atrazine 0.50 kg /ha *fb* tembotrione 0.120 kg/ha POE 20 DAS (3.34) which was closely followed by Atrazine 1.0 kg /ha PE (3.32) . This might be owing to good grain 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 Shantveerayya and Agasimani (2011), Swetha *et al.*, (2015) and Gupta *et al.*, (2018). Though the weed free treatment resulted in highest grain yield owing to 96.91% weed control efficiency but could not found as profitable as herbicidal treatment due to higher expenditure incurred on engaging more labours. Similar results was obtained by Shantveerayya and Agasimani.(2011). Therefore, it is concluded that ,pre emergence application of atrazine 0.50 kg /ha followed by tembotrione 0.120 kg/ha POE 20 DAS produced best results in reducing the weed density and dry weight and found to be more effective in getting higher weed control efficiency, yield and economic returns of maize.

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