Integration of Various Chemical Herbicide on Weed Management and Yield of Kharif Maize (*Zea mays* L.)

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A field experiment was conducted in maize during *kharif* season 2013 on sandy loam soil at Crop Research Centre, Chirori of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U.P.), to evaluate the various integration of chemical Herbicides on weed management and yield of kharif maize (*Zea mays* L.). The experiment was conducted in R.B.D with three replications comprising eleven treatments of weed management (weedy, weed free, Alachlor @ 1500 and 1000 g a.i. ha^{-1}, Atrazine @ 1000 g a.i. ha^{-1}, Metribuzin @ 750 and 250 g a.i. ha^{-1}, Alachlor + Metribuzin @ 750 + 375 g a.i. ha^{-1}, Atrazine + Pendimethalin @ 750 + 500 g a.i. ha^{-1}, Atrazine +2, 4-D @ 500 + 500 g a.i. ha^{-1} and Sesbania (BC) @ 20 kg ha^{-1} + 2, 4-D @ 500 g a.i. ha^{-1}). The results indicated that chemical methods of weed control significantly reduced the weed population and their dry weight effectively over weedy check. The maximum number of grains cob^{-1}, weed control efficiency, nutrient uptake by crop and highest grain yield (49.3 q ha^{-1}) were recorded with the application of Atrazine + Pendimethalin @ 750 + 500 g a.i. ha^{-1} and established its superiority over rest of the herbicides. Similarly, this treatment also resulted into higher gross return, net return and B: C ratio. These values were very close to weed free treatment. The per cent increase in grains and stover yield was to the tune of 107.14 and 57.26 as compared to weedy check.

Keywords: Weed management, Chemical herbicides, Kharif Maize and Weed dry matter.

Maize (*Zea mays* L.) is one of the important cereal crops next only to wheat and rice in the world. In India, maize is used for human consumption, processed food like corn flakes, pop corn etc. and in other industries mainly starch, dextrose, corn syrup and corn oil etc. In India, maize is the third most important food crops after rice and wheat. In India, it occupies an area of about 9.08 million ha and Producing 23.29 million tonnes with an average productivity of 2563 kg ha^{-1}. In Uttar Pradesh, it covers an area of 0.80 million ha produces about 1.20 million tonnes with an average productivity of 1847 kg ha^{-1} (Anonymous, 2013-14). The predominant weed flora were *Echinochloa crusgalli* L. and *Cynodon dactylon* L. among monocots; *Cyperus rotundus* L. among sedges; and *Amaranthus viridis* L., *Digera arvensis* L., *Portulaca oleracea* L., *Alternenthara sessili* L. and *Trianthema* spp. among dicots (Arvadiya *et al* 2012). Major area of maize in India is during *kharif* season in which weed is one the most important yield limiting factor and significantly reduces the yield. Even with a light infestation of weeds under ideal situation the weeds should be controlled throughout the crop growing season. However, the most critical period for crop weed competition are first six weeks after planting of crop because of initial slow growth and wider row spacing of maize, coupled with congenial weather conditions allow luxuriant weed growth which may reduce yield by 28-100% (Dass *et al*. 2012, Pandey *et al*. 1999). Herbicides combination, which can effectively

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control all categories of weeds (grassy, broad-leaved and sedges), including *Cyperus rotundus* in maize, are hardly available. Therefore, a fool-proof strategy for controlling an array of weeds, including annuals and perennials by adopting an integrated approach including herbicides is highly required.

MATERIALS AND METHODS

A field experiment was conducted at crop research centre, chirori of sardar vallabhbhai patel university of agriculture & technology, meerut (UP) was conducted during the *kharif* season, 2013. The soil of the experimental field was sandy loam in texture, neutral in reaction (pH 7.70), and low in organic carbon (0.52%) as well as with low available N (155.40 kg/ha), medium in available P (14.76kg/ha) and medium in available K (139.82 kg/ha) contents with normal electrical conductivity (1.65). The field experiments were carried out with 11 treatments, which lies with alachlor 1.5 kg /ha PE (T_1); atrazine 1.0 kg/ha PE (T_2); alachlor 1.0 kg/ha EPE (15 DAS) (T_3); metrbuzin 0.75 kg/ha PE (T_4); metrbuzin 0.25 kg/ha EPE (15 DAS) (T_5); alachlor 0.75 kg/ha + metrbuzin 0.375 kg/ha (tank-mix PE) (T_6); atrazine 0.75 kg/ha + pendimethalin 0.5 kg/ha (tank-mix PE) (T_7); atrazine 0.5 kg/ha + 2,4-D 0.5 kg/ha POE (T_8); brown manuring (*Sesbania* @ 20 kg/ha+ 2,4-D 0.5 kg/ha at 30 DAS) (T_9); weedy check (T_{10}); and weed-free check (T_{11}). In the brown manuring with *Sesbania aculeata* L. treatments, *Sesbania* seed @ 20 kg/ha was sown by broadcasting over the entire plot at the time of sowing of maize and 2, 4-D at 0.5 kg/ha was sprayed over the *Sesbania* plants at 30 DAS, which were then killed and dried up gradually to serve as much and supplier of nutrients, particularly N. For tank-mix pre emergence (PE), post emergence (POE) and early post emergence (EPE) application of herbicides, required quantities of respective doses of herbicides were sprayed in the field. All the pre, early and post emergence herbicides were applied with 350 l/ha of water using a knapsack sprayer fitted with a flat fan nozzle. Weed-free plots were maintained free from weeds throughout the cropping cycle by manual weeding. The experiment was laid out in a randomized block design with three replications with gross plot size of 5.0× 3.6 m^2. There were eleven treatment combinations, Maize hybrid P 3292 was sown on 23 July in 2013 with a seed rate of 20 kg/ha in rows spaced at 60 cm. half of the recommended dose of N was applied basally through broadcasting and mixed with soil before sowing of maize along with the full dose of $P_2 O_5$ and K_2O. The remaining N was top-dressed as hill placement close to the maize plants at 35 days of growth. Thinning of excessive maize seedlings were done after 20 days of sowing to maintain a plant to plant distance of about 20 cm. Maize received three irrigations including a pre-sowing one. Nitrogen, P and K were given in the form of urea, di-ammonium phosphate and muriate of potash, respectively. Population and dry weight of weeds were recorded at 60 days after sowing stage by placing a quadrate of 0.5 m × 0.5 m randomly from three places in each plot. Data on number and dry weight of weeds were subjected to square-root ($\sqrt{X} + 1$) transformation before analysis of variance.

RESULTS AND DISCUSSION

Effect on weed growth

Seven major weed species comprising of three grassy weeds [*Achrachne racemosa* Heyne ex Roem & Ohwi, *Dactyloctenium aegyptium* (L.) P. Beauv., and *Setaria glauca* (L.) Beauv.], one sedge (*Cyperus rotundus* L.) and three broad-leaved weeds [*Trianthema portulacastrum* L., *Commelina benghalensis* L. and *Digera arvensis* (L) Forsk.] were found in maize field. The differential effects of herbicides, their dose and time of application led to a large variability in weed flora in maize across the treatments. Similar variation in the distribution of weeds has been reported across locations and crop growth stages (Gopinath and Kundu 2008, Angiras *et al*. 2010). Higher tolerance and persistent nature of perennial *Cyperus rotundus* was responsible for its consistent existence in many weed control treatments. All weed control treatments adopted in the study resulted in significant reductions in populations of broadleaved, sedges, grassy weeds as well as total weeds at 60 DAS compared to weedy check (Table-1).

The weed management practices significantly influenced the weed density and dry weight at 60 DAS (Table- 1). In weedy check, the total weed population was significantly higher than

Table 1. Total weed population and weed control efficiency (WCE) at 60 DAS of maize

Treatment	Broad leaved weed (No./m^2)	*Cyprus rotundus* (No./m^2)	Grassy weed (No./m^2)	Total weed population	Weed dry matter (g/m^2)	WCE (%)
Alachlor -1500 g ha^{-1} (T_1) (PE)	2.9 (8)	4.3 (18)	3.6 (12)	6.2 (38)	5.0 (24.3)	85
Atrazine -1000 g ha^{-1} (T_2) (PE)	2.8 (7)	5.0 (25)	3.4 (11)	6.6 (43)	5.4 (28.6)	82
Alachlor -1000 g ha^{-1} (T_3) (EPOE)	3.3 (10)	5.5 (30)	4.1 (16)	7.5 (56)	5.8 (33.8)	79
Metribuzin -750 g ha^{-1} (T_4) (PE)	2.4 (5)	4.2 (17)	2.8 (7)	5.5 (29)	4.6 (20.2)	88
Metribuzin -250 g ha^{-1} (T_5) (EPOE)	2.9 (8)	5.3 (28)	3.7 (13)	7.1 (49)	5.7 (31.6)	80
Alachlor + Metribuzin -750+375 g ha^{-1} (T_6) (tank-mix PE)	2.8 (7)	4.6 (21)	2.9 (8)	6.1 (36)	4.7 (21.3)	87
Atrazine + Pendimethalin -750+500 g ha^{-1} (T_7) (tank-mix PE)	2.6 (6)	3.9 (15)	2.8 (7)	5.4 (28)	4.1 (16.2)	90
Atrazine +2, 4-D -500+500 g ha^{-1} (T_8) (tank-mix POE)	3.4 (11)	6.7 (44)	4.6 (21)	8.7 (76)	6.8 (46.3)	71
Brown manuring (*Sesbania* @ 10 kg/ha+2,4-D 0.5 kg/ha at 30 DAS)	3.3 (10)	5.9 (35)	4.3 (18)	7.9 (63)	6.2 (38.2)	76
Weedy check (T_{10})	6.6 (43)	12.4 (154)	8.7 (76)	16.5 (273)	12.7 (161.9)	00
Weed free (T_{11})	00	00	00	00	00	100
SEm ±	0.04	0.08	0.06	0.11	0.08	-
C.D.(P=0.05)	0.12	0.25	0.17	0.33	0.25	-

Table 2. Effect of various herbicidal treatments on yield attributes and yields of maize

Treatment	Cob length (cm)	No. of grains row cob^{-1}	No. of grains row^{-1}	No. of grains cob^{-1}	Test weight (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Weed Index (%)
Alachlor -1500 g ha^{-1} (T_1) (PE)	18.2	12.3	34.2	417.2	233.2	46.8	67.2	14.3
Atrazine -1000 g ha^{-1} (T_2) (PE)	17.9	12.9	33.8	425.8	234.4	47.3	68.3	13.4
Alachlor -1000 g ha^{-1} (T_3) (EPOE)	18.3	12.8	34.8	431.3	230.5	40.8	65.3	25.3
Metribuzin -750 g ha^{-1} (T_4) (PE)	18.9	13.0	35.4	456.6	248.3	47.9	69.8	12.3
Metribuzin -250 g ha^{-1} (T_5) (EPOE)	17.6	12.4	30.4	410.0	229.8	42.3	66.2	22.5
Alachlor + Metribuzin -750+375 g ha^{-1} (T_6) (tank-mix PE)	19.1	12.8	36.6	480.8	248.8	48.9	70.9	10.4
Atrazine + Pendimethalin -750+500 g ha^{-1} (T_7) (tank-mix PE)	19.3	13.2	38.2	490.6	256.5	49.3	73.6	09.7
Atrazine +2, 4-D -500+500 g ha^{-1} (T_8) (tank-mix POE)	18.6	11.8	32.8	413.0	230.6	42.5	66.5	22.2
Brown manuring (*Sesbania* @ 10 kg/ha+2,4-D 0.5 kg/ha at 30 DAS)	18.5	12.2	32.8	410.3	228.3	42.1	67.3	22.9
Weedy check (T_{10})	17.4	11.0	29.6	396.8	220.8	23.8	46.8	56.4
Weed free (T_{11})	20.4	14.0	40.8	506.0	260.3	54.6	77.2	00.0
SEm ±	0.03	0.40	0.09	1.1	0.43	1.34	2.03	-
C.D.(P=0.05)	0.07	1.12	0.31	3.2	1.30	3.99	6.03	-

all the herbicidal treatments. The weed menace was minimum under hand weeding done at 20 and 40 DAS, but it was marginal at 60 DAS due to emergence of weeds during later part of crops growth. Among the pre-emergence herbicides treatments, activity of atrazine 1.0 kg/ha, alachlor 1.5 kg/ha and metribuzin 0.75 kg/ha and early post emergence herbicides are alachlor 1.0 kg/ha and metrbuzin 0.25 kg/ha alone was not well marked against most of weeds but when all these herbicide applied and combined application of atrazine 0.75 kg/ha + pendimethalin 0.5 kg/ha and alachlor 0.75 kg/ha + metribuzin 0.375 kg/ha controlled most of the associated weeds. Weedy check had the highest weed biomass and it had reduced significantly when weeds were controlled either by use of herbicides or hand weeding (20 and 40 DAS). The lowest weed biomass was recorded under weed free treatment closely followed by combined application of atrazine 0.75 kg/ha + pendimethalin 0.5 kg/ha and alachlor 0.75 kg/ha + metrbuzin 0.375 kg/ha, found significant to reduced the weed biomass. Similar views were also endorsed by Mandal et al. (2004) and Changsaluk (2003).

The WCE was maximum with 2 hand weeding closely followed by combined application of atrazine 0.75 kg/ ha + pendimethalin 0.5 kg/ha and alachlor 0.75 kg/ha + metribuzin 0.375 kg/ha and metribuzin 0.75 kg/ha, alachlor 1.5 kg/ha alone, but lowest WCE found with post-emergence application of combined application of atrazine 0.5 kg/ ha + 2,4-D 0.5 kg/ha followed by brown manuring (*Sesbania* @ 20 kg/ha+ 2,4-D 0.5 kg/ha. Similar observations were also recorded by Malviya and Singh (2007) and Grichar *et al.* (2003). Seed and stover yields were lowest in the plots receiving no weed control measures (weedy check) due to severe competition stress right from crop establishment up to the end of critical period of crop growth, leading to poor growth parameters and yield attributing traits and finally the seed yield. All the treated plots receiving herbicidal treatments and produced higher yield over weedy check plots (Table- 2). The maximum seed and stover yields was noted in hand weeding at 20 and 40 DAS followed by atrazine 0.75 kg/ ha + pendimethalin 0.5 kg/ha and alachlor 0.75 kg/ha + metribuzin 0.375 kg/ha than other treatments. The crop under weed free plots attained lush growth due to elimination of weeds from inter and intra row spaces besides better aeration due to manipulation of surface soil, which resulted into superior yield attributes and development, and consequently the highest yield. Malviya and Singh (2007) also reported that, hand weeding as an effective method of weed control for achieving the maximum yield. Maximum yield loss of 51.7% was recorded under weedy check where, weeds were not controlled in the entire crop season. The weed index was lowest (9.70) in plots receiving pre-emergence application of atrazine 0.75 kg/ ha + pendimethalin 0.5 kg/ha followed by alachlor 0.75 kg/ha + metribuzin 0.375 kg/ha. The lower weed index values under aforesaid treatments are attributed to the reduced competitional stress by weed. Therefore, the yield attributes in crop were superior which ultimately resulted into increased seed yield.

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