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Impact of herbicides on yield, economics and phytotoxicity in kharif maize

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Abstract
A field experiment was carried during *kharif* 2015 at Agricultural Research farm, TCA, Dholi, a campas of Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar. The treatments comprised of atrazine, Pendimethalin, halosulfuron, 2, 4-D di methyl amine, metribuzine, Power weeder and hand weeding and there combinations arranged in RBD design with 12 treatments. Among the different weed management practices significantly higher plant height was found with the application of atrazine @ 1.5 kg/ha (PE) fb halosulfuron @ 60g/ha (PoE) during the year of experiment. However, the higher yield recorded under weed free plot (hand weeding twice at 20 and 40 DAS) but it was found at par with atrazine @ 1.5 kg/ha (PE) fb halosulfuron @ 60 g/ha (PoE) and pendimethalin (1000 ml/ha) as pre-emergence fb Atrazine (750 g/ha) + 2, 4-D dimethyl amine (75 %) at 25 DAS as post-emergence. Maximum net return and B:C ratio were recorded under atrazine @ 1.5 kg/ha pre-emergence fb halosulfuron methyl @ 60 g/ha post-emergence (T_7) which was found at par with pendimethalin (1000 ml/ha) as pre-emergence fb atrazine (750 g/ha) + 2, 4-D dimethyl amine (75 %) at 25 DAS as post-emergence (T_9). However, among the different herbicidal treatments application of halosulfuron methyl, atrazine, pendimethalin and 2,4-D were safe to the maize crop but use of metribuzine @ 0.75 kg/ha caused phototoxic effect on maize during the year of experimentation.

Keywords: atrazine, halosulfuron, pre-emergence, post-emergence, B: C ratio and phototoxic effect.

Introduction
Maize ranks third in the cereals world production after rice and wheat, but in productivity it surpasses all cereals. In India, it is grown over an area of 9.43 m ha with total production of 24.35 m tones (Anonymous, 2014) [1]. It is well known that maize is a heavy feeder for both nutrients and soil moisture due to its high productivity. Maize, being a rainy season and widely spaced crop, gets infested with variety of weeds and subjected to heavy weed competition, which often inflicts huge losses ranging from 28 to 100 per cent (Patel *et al*., 2006) [4]. The main weeds, which grow are annual grasses, sedges and broad leaf weeds. Earlier, weeds were controlled mechanically by hoeing and by bullock-drawn/tractor drawn implements. But now use of chemical herbicides is widespread. The maximum loss in yield in crop due to weed competition is estimated to occur during the first 3-6 weeks, i.e., before the crop canopy has developed thick enough to smother the weeds. Weed control in maize can be highly sophisticated. Because it is grown in wide rows, mechanical cultivation to control weeds growing between the rows is possible and still practiced, but most weed control in developed countries is by using herbicides. The choice of weed control measures therefore, depend largely on its effectiveness and economics. Due to increased cost and non-availability of manual labour in required quantity for hand weeding, herbicides not only control the weeds timely and effectively but also offer great scope for minimizing the cost of weed control irrespective of situation. Use of pre-emergence 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. However, the knowledge about the suitable herbicide with right dose and application time is necessary to have effective control of targeted weed without any phototoxic injury to the plant. Such knowledge is lacking especially in Indian farmers field condition resulting into either yield loss due to weed or complete failure of crop due to phototoxic injury of herbicides. Hence, Keeping the above facts in view, the present investigation entitled “Impact of Herbicides on Yield Economics and phytotoxicity in Kharif Maize” was planned and conducted at Agricultural Research Farm of Tirhut collage of Agriculture, Dholi during kharif 2015.

Materials and Methods

A field experiment was carried out during *kharif* season of 2015 at Rajendra Agricultural University, Pusa, Bihar in a randomized block design with three replications. The experimental soil was alkaline in reaction with pH 8.3. The rainfall received during the crop season of respective years was 740 mm. The treatments involving two pre-emergence herbicides and five post-emergence herbicides. The pre-emergence herbicides *viz*., atrazine and pendimethalin were used at high concentrations in the first two treatments @ 1.5 kg/ ha and 1000 ml/ha and in rest of the treatments these were used @ 750 g/ha and 750 ml/ha, respectively. The other herbicides such as halosulfuron @ 60 g/ha 2,4-D di methyl amine @ (75 %) at 25 DAS as (PoE) and metribuzin @ 0.75 kg/ ha were combined with first two herbicides and used as sequenced treatments along with power weeder, weed free check, weedy (control) check. Maize hybrid Shaktiman-5 was manually dibbled at a spacing of 60 x 20 cm with seed rate of 20 kg/ha sown on 01 July 2015. In maize, half dose of nitrogen was applied as basal dose along with full dose of P and K and the remaining nitrogen were applied in two splits dose each at knee high and pre-tasselling stage. Pre-emergence and Post-emergence herbicides were applied at within 72 hours and 25 days after sowing using water volume of 600 liters/ha. Cost of cultivation and gross return were calculated on the basis of prevailing market prices of different inputs and produces, respectively.

Table 1: Yield and Economics as affected by different weed management practices in *kharif* maize

Treatments	Grain yield (q/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha	Net return (₹/ha)	B:C ratio
T_1 Control (weedy cheack)	30.86	28077	52428	24351	0.87
T_2 Weed free	49.30	41657	82365	40708	0.98
T_3 Atrazine @ 1.5 kg/ha as (PE)	41.79	29885	70540	40655	1.36
T_4 Atrazine (750 g/ha) + Pendimethalin (750 ml/ha) as (PE)	38.15	30435	66661	36226	1.19
T_5 Atrazine (750 g/ha)+2,4-D dimethyl amine (75%) at 25 DAS as (PoE)	37.59	29503	65608	36105	1.22
T_6 Halosulfuron @ 60 g/ha at 25 DAS as (PoE)	39.46	28865	68480	39615	1.37
T_7 Atrazine @ 1.5 kg/ha as (PE) fb Halosulfuron @ 60 g/ha at 25 DAS as (PoE)	48.50	30753	79259	48505	1.58
T_8 Metribuzine @ 0.75 kg/ha at 7-10 DAS as early (PoE)	37.36	30284	64253	33969	1.12
T_9 Pendimethalin (1000 ml/ha) as (PE) fb Atrazine (750 g/ha) + 2,4-D dimethyl amine (75%) at 25 DAS as (PoE)	47.08	31517	77728	46211	1.47
T_{10} Atrazine @1.5 kg/ha as (PE) fb Metribuzine @ 0.75 kg/ha as (PoE)	39.23	32172	66967	34795	1.08
T_{11} Atrazine (750 g/ha)+Pendimethalin (750 ml/ha) as (PE) fb one power weeder at 35 DAS	42.90	30823	72138	41315	1.34
T_{12} Two power weeder at 20 and 35DAS	41.72	29629	71449	41820	1.41
S.Em±	2.38	-	3588	1346	0.07
CD (0.05)	6.99	-	10524	3949	0.19

Table 2: Phytotoxicity of herbicides on Kharif maize

Treatments	Phytotoxic Scoring Remark				
	3 DAA	5 DAA	7 DAA	9 DAA	
T_1 : Control (weedy cheack)	0	0	0	0	No injury, normal growth
T_2 : Weed free	0	0	0	0	No injury, normal growth
T_3 : Atrazine @ 1.5 kg/ha as (PE)	0	0	0	0	No injury, normal growth
T_4 : Atrazine (750 g/ha) + Pendimethalin (750 ml/ha) as (PE)	0	0	0	0	No injury, normal growth
T_5 : Atrazine (750 g/ha)+2,4-D dimethyl amine (75%) at 25 DAS as (PoE)	0	0	0	0	No injury, normal growth
T_6 : Halosulfuron @ 60 g/ha at 25 DAS as (PoE)	0	0	0	0	No injury, normal growth
T_7 : Atrazine @1.5 kg/ha as (PE) fb Halosulfuron @ 60 g/ha at 25 DAS as (PoE)	0	0	0	0	No injury, normal growth
T_8 : Metribuzine @ 0.75 kg/ha at 7-10 DAS as early (PoE)	1	2	2	2	Slight discoloration, chlorosis, stunted growth, a few plants lost, injury more pronounced but effect temporary, possibility in reduction in yield
T_9 : Pendimethalin (1000 ml/ha) as (PE) fb Atrazine (750 g/ha) + 2,4-D dimethyl amine (75%) at 25 DAS as (PoE)	0	0	0	0	No injury, normal growth
T_{10} : Atrazine @1.5 kg/ha as (PE) fb Metribuzine @ 0.75 kg/ha as (PoE)	1	2	2	2	Slight discoloration, chlorosis, stunted growth, a few plants lost, injury more pronounced but effect temporary, possibility in reduction in yield
T_{11} : Atrazine (750 g/ha)+Pendimethalin (750 ml/ha) as (PE) fb one power weeder at 35 DAS	0	0	0	0	No injury, normal growth
T_{12} : Two power weeder at 20 and 35 DAS	0	0	0	0	No injury, normal growth

Results and Discussion

Yield

The final yield of kharif maize is the result of the successful completion of the growth and developmental activities, which depends on the genetic potential of the genotype and the environmental conditions to which it is exposed during the

course of its life cycle and agronomic management efficiencies. Significantly higher grain yield was recorded under weed free situation (hand weeding twice at 20 DAS and at 40 DAS (T2) (49.30 q/ha) which was found at par with atrazine @ 1.5 kg/ha pre-emergence fb halosulfuron methyl @ 60 g/ha post-emergence (T7) (48.50 q/ha), pendimethalin (1000 ml/ha) as pre-emergence fb atrazine (750 g/ha) + 2,4-D dimethyl amine (75 %) at 25 DAS as post-emergence (T9) (47.08 q/ha) and atrazine @ 750 g/ha + pendimethaline @ 750 ml/ha as pre-emergence fb one power weeder at 35 DAS (T11) (42.90 q/ha) and significantly superior over rest of the treatments. The reason for higher economic yield in case of hand weeding, chemical treatment and mechanical weeding alone or in combination appears to be the consequence of relatively much less competition from weeds at the most critical stages of crop- weed competition. Controlling weeds at the early growth as well as at later stages provided congenial atmosphere for better utilization of natural resources and external inputs by the crop. The results are in conformity with those reported by Bahar *et al*. (2009) [7] and Channabasavanaa *et al*. (2015) [8]. The least grain yield was recorded (30.86 q/ha) under control (weedy check) with similar results were reported by Rao *et al*. (2009) [2].

Economic

Maximum gross return was recorded in treatment weed free check (hand weeding twice at 20 and 40 DAS) (T_2). Among the different herbicidal treatments atrazine @ 1.5 kg/ha pre-emergence fb halosulfuron methyl @ 60 g/ha post-emergence (T_7) which was found statistically at par with pendimethalin (1000 ml/ha) as pre-emergence fb atrazine (750 g/ha) + 2,4-D dimethyl amine (75 %) at 25 DAS as post-emergence (T_9), atrazine @ 750 g/ha+ pendimethalin @ 750 ml/ha as pre-emergence fb one power weeder at 35 DAS (T_{11}) and two power weeder at 20 and 35 DAS (T_{12}) recorded maximum gross return. The treatment weedy check recorded minimum gross return as compared to all other treatments. There was significant increase in grain and straw yield due to hand weeding practices and best combination of weed control treatments i.e. T_7, T_9 and T_{11} resulted in significant increase in gross return. However, the maximum net return and B:C ratio were recorded under atrazine @ 1.5 kg/ha pre-emergence fb halosulfuron methyl @ 60 g/ha post-emergence (T_7) which was pound at par with pendimethalin (1000 ml/ha) as pre-emergence fb atrazine (750 g/ha) + 2, 4-D dimethyl amine (75 %) at 25 DAS as post-emergence (T_9). Due to lower cost of cultivation than weed free check (hand weeding twice at 20 DAS and 40 DAS). The higher gross return and lower cost of cultivation of this two treatments produced maximum net return. Higher economics due to chemical control in maize have been supported by Porwal *et al*. (2000) [6] and Kolage *et al*. (2004) [5] by using atrazine.

Phytotoxicity of herbicides

Table 2 indicated that all doses of herbicides such as recommended doses of halosulfuron methyl, atrazine, pendimethalin and 2,4-D were safe to the maize crop but use of metribuzine @ 0.75 kg/ha caused phytotoxic effect on maize. Because of phytotoxicity such as necrosis and wilting, the photo-synthetic activity of plants was adversely affected and decreased in their dry matter production rate and finally reduction of maize yield. However, slight discoloration of maize leaves in atrazine @ 0.625 kg/ha + metribuzine @ 0.5 kg/ha fb 2, 4-D @ 0.5 kg/ha, alachlor @ 0.75 kg/ha+ metribuzine @ 0.5 kg/ha fb 2, 4-D @ 0.5 kg/ha caused phytotoxic effect on maize the results are in line with findings reported by Singh (2011) [3] and Rao *et al*. (2009) [2].

Conclusion

Keeping in view the result obtained from present investigation the following broad conclusion can be drawn. Application of atrazine @ 1.5 kg a.i./ha pre-emergence fb halosulfuron @ 60 g a.i./ha post-emergence significantly enhancened grain yield over rest of weed control treatments except weed free (hand weeding twice at 20 DAS and 40 DAS) and pendimethalin @ 1000 ml/ha pre-emergence fb atrazine (750 g/ha) +2, 4-D dimethyl amine (75 %) as post-emergence. Atrazine @ 1.5 kg/ha pre-emergence fb halosulfuron @ 60 g/ha post-emergence although, recorded highest net return and B:C ratio but net return was found to be at par with pendimethalin @ 1000 ml/ha pre-emergence fb atrazine (750g/ha) + 2, 4-D dimethyl amine (75 %) as post-emergence while, B:C ration was similar to pendimethalin @ 1000 ml/ha pre-emergence fb atrazine (750 g/ha) +2, 4-D dimethyl amine (75 %) as post-emergence and two power weeder at 20 and 35 DAS and were significantly higher over rest of the weed control treatments. All doses of herbicides such as recommended doses of halosulfuron methyl, atrazine, pendimethalin and 2,4-D were safe to the maize crop but use of metribuzine @ 0.75 kg/ha caused phytotoxic effect on maize.

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