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EFFECT OF FORMASULFURON + ISOXADIFEN-ETHYL IN COMBINATION WITH UREA FOR WEED CONTROL IN MAIZE (*ZEA MAYS* L.)

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ABSTRACT

A field experiment was conducted at Faisalabad, Pakistan to study the effects of formasulfuron + isoxadifen-ethyl applied alone and in combination with urea on weeds and yield of spring (March-May) and autumn (August-October) planted maize (Zea mays L.). Six treatments comprised of control, manual hoeing, formasulfuron + isoxadifen-ethyl @ 1125 g and 1125 g a.i. ha^{-1} + 1% urea, 1125 g a.i. ha^{-1} + 2% urea and 1125 g a.i. ha^{-1} + 3% urea solution sprayed as post-emergence. Manual hoeing, and formasulfuron + isoxadifen-ethyl @1125 g a.i. ha^{-1} combined with 3% urea were most effective treatments for controlling Cyperus rotundus, Achyranthus aspera and Trianthema portulacastrum. Maximum weed control efficiency with formasulfuron + isoxadifen-ethyl @1125 g a.i. ha^{-1} combined with 3% urea was 87.00% for C. rotundus, 75.19% for A. aspera in spring maize. It was 82.05% for C. rotundus and 89.97% for T. portulacastrum in autumn maize. Maize yield from formasulfuron + isoxadifen-ethyl @1125 g a.i. ha^{-1} + 3% urea treated plots was 56% higher in spring and 68% higher in autumn than those from control and was comparable to that of manual weeding. Maximum loss in grain yield due to un-weeded control plots in spring and autumn maize was 44 and 41%, respectively.

Key words: Formasulfuron + isoxadifen-ethyl, urea, weeds, maize, grain yield

INTRODUCTION

Maize is third most important cereal crop grown in Pakistan after wheat and rice and is known as the "King of grain crops". Average grain yield is 3.48 t ha^{-1} (Anonymous, 2006). Among factors responsible for low yield, weeds are considered to be the most important one. Weeds interference in maize leads to 37-68% reduction in its yield (Adigun and Lagoke, 2003). Weed control is, therefore, essential for obtaining higher crop harvest. An increase of 31-33% in maize grain yield has been reported with adequate weed control (Maina *et al.,* 2001; Chikoye *et al.*, 2005). Mechanical methods of weed control are useful but are expensive and time consuming.

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Moreover, acute shortage of labour for agricultural operations means it will not be possible or economical to continue with traditional practices. Therefore, in view of these limitations, chemical weed control is an important and effective alternative if properly employed. Weed control efficiency of 85-95% has been reported with herbicides in maize (Knezevic *et al*., 2003; Alister and Kogan, 2005). Different types of pre- and post-emergence herbicides are used to control weeds in maize. Post-emergence herbicides are generally absorbed through weeds foliage. Leaf cuticle is composed of waxes and cutin that affect herbicide absorption. The use of adjuvant in combination with herbicide enhances herbicide retention on leaf surface and penetration through cuticle. Urea fertilizer is an effective adjuvant, which can be used along with herbicides for controlling weeds more effectively (Getmanetz *et al*., 1991; Ssango and Balitenda, 2003; Singh and Singh, 2003; Bunting *et al*., 2004). Therefore, the present research study was conducted to determine effects of formasulfuron + isoxadifen-ethyl alone and in combination with urea on weeds and yield of maize under field conditions.

MATERIALS AND METHODS

The study was carried out at University of Agriculture, Faisalabad, Pakistan on a sandy clay loam soil. Six treatments viz. control; manual hoeing (2 hoeings); formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1}; formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} + 1% urea; formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} + 2% urea and formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} + 3% urea solution, were studied. The experiment was laid out in a randomized complete block design with four replications, and a net plot size measuring 7 x 3 m. Maize variety "Golden" was sown as a test crop in August and March with a single row hand drill using a seed rate of 35 kg ha^{-1} in rows 75 cm apart. Plant to plant distance of 25 cm within rows was maintained by thinning extra plants twice at an early growth stage. Fertilizers were applied @160:80 kg NP ha^{-1}. All of the P and half of N were broadcast manually and incorporated into soil at seed-bed preparation while remaining N was applied using broadcast method before second irrigation. In all, five irrigations were applied to autumn and eight to spring crop. Spray volume was used @ 300 L ha^{-1}. This amount was determined through calibration before spraying herbicide. Herbicide (mixed formulation) was dissolved after preparing 3% urea solution in water. The herbicide was applied using a knapsack hand sprayer fitted with a flat fan nozzle. Hoeing was done twice using a hand hoe in respective treatment when soil was moist after first and second irrigation. Weeds were counted from an area of one meter square at 15 and 25 days after spray at two places selected at random

in each plot with the help of a quadrate. Total dry weight of weeds was recorded by cutting at ground level from a randomly selected area of one meter square at two different places at maturity. After harvesting, weeds were cleaned and dried at room temperature and then in oven at 70°C for 72 hours. Ten cobs were taken randomly from each plot. Number of grains from each cob was counted after shelling. To measure 100-grain weight, five samples each of 100-grains were taken randomly from maize from each plot and weighed on an automatic electric balance. All cobs from each plot were separated manually and shelled with the help of a mechanical sheller and weighed to record grain yield. Data were analysed and least significant difference test was applied at 5% probability level to compare treatment means (Steel *et al.*, 1997).

RESULTS

Effect on weeds

Weed flora at experimental site comprised of *A. aspera, C. rotundus and T. portulacastrum*. Application of formasulfuron + isoxadifen-ethyl alone and in combination with 1, 2 and 3% urea solution significantly reduced the density of different weeds compared with control (Table 1). In spring maize, formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} + 3% urea solution performed better in controlling *C. rotundus* after manual hoeing. In autumn maize, formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} with 1 and 3% urea solution and manual hoeing were at par with one another in respect of *C. rotundus* control.

In regards to control of broad leaf weeds i.e. *A. aspera* in spring and *T. portulacastrum* in autumn maize, formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} with 1, 2 and 3% urea solution and manual hoeing did not differ. Formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} with various concentrations of urea significantly reduced total dry weight of weeds at harvest over control. Formasulfuron + isoxadifen-ethyl with 3% urea solution performed better than other treatments (Table-1).

Performance of maize

Formasulfuron + isoxadifen-ethyl alone and along with various concentrations of urea solution did not affect cobs per plant significantly in spring crop but significantly increased cobs per plant in autumn maize (Table 2). Application of formasulfuron + isoxadifen-ethyl alone and in combination with 1, 2 and 3% urea solution significantly increased grains per cob and 100-grain weight over control in both seasons. There was significant variation among different weed control treatments with respect of grains per cob in spring crop but these treatments were at par similar with respect of 100-grain weight in spring and autumn maize (Table-2).

Table-2. Effect of formasulfuron + isoxadifen-ethyl alone and with urea on yield and yield components of maize.

Formulations	Spring maize				Autumn maize			
	No. of cobs per plant	No. of grains per cob	100-grain weight (g)	Grain yield t ha^{-1}	No. of cobs per plant	No. of grins per cob	100-grain weight (g)	Grain Yield t ha^{-1}
Control	1.00	281.00 e	21.636	2.31 e	0.97 b	488.5 b	22.08 c	3.35 b
Manual hoeing	1.06	480.00 a	24.87 a	4.12 a (98.35)	1.12 ab	563.3 a	23.65 b	4.71 a (40.47)
Formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1}	1.00	360.80 b	24.19 a	2.88 d (24.67)	1.12 ab	606.5 a	23.85 ab	4.94 a (47.24)
Formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} + 1 urea	1.00	351.70 c	24.94 a	2.98 d (29.00)	1.20 a	599.5 a	23.90 ab	5.00 a (49.12)
Formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} + 2% urea	1.06	313.00 d	26.11 a	3.42 c (48.05)	1.20 a	592.5 a	24.10 ab	5.48 a (63.24)
Formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} +3% urea	1.06	362.20 b	24.67 a	3.62 b (56.70)	1.25 a	603.0 a	24.67 a	5.65 a (68.40)
LSD	**NS**	**6.676**	**2.362**	**0.152**	**0.172**	**44.28**	**0.979**	**0.956**

Means sharing the same letters did not differ significantly at 5% level of probability
Figures in parenthesis show % increase over control

Table-1. Effect of formasulfuron + isoxadifen-ethyl alone and with urea on weed density and dry weight in maize.

Formulations	Spring maize					Autumn maize				
	C. rotundus (m^{-2})		*A. aspera* (m^{-2})		Dry weight (gm^{-2})	*C. rotundus* (m^{-2})		*T. portulacasum* (m^{-2})		Dry weight (gm^{-2})
	15 DAS	25 DAS	15 DAS	25 DAS		15 DAS	25 DAS	15 DAS	25 DAS	
Control	108.00 a	106.00 a	3.33 a	2.66 a	295.90 a	29.25 a	10.75 a	143.00 a	172.00 a	138.9 a
Manual hoeing	14.00 e (87.o4)	4.66 e (95.60)	1.00 b (70.00)	0.33 c (87.59)	35.04 f (88.15)	8.00 b (72.65)	7.50 ab (30.23)	24.25 b (83.04)	32.25 b (81.25)	55.88 b (59.77)
Formasulfuron + isoxadifen-ethyl @ 1125 g $a.i.ha^{-1}$	42.33 b (60.80)	34.67 b (63.48)	1.66 b (50.15)	1.33 b (50.00)	104.20b (64.78)	5.00 b (82.90)	6.73 ab (37.39)	20.75 b (85.49)	22.50 b (86.92)	42.92 b (69.10)
Formasulfuron + isoxadifen-ethyl @ 1125 g $a.i.ha^{-1}$ + 1% urea	31.67 c (70.67)	28.33bc (73.27)	2.00 b (39.93)	1.00 bc (62.41)	68.78 d (76.76)	4.00 b (86.32)	5.75 b (46.51)	27.75 b (80.59)	24.00 b (86.05)	55.75 b (59.86)
Formasulfuron + isoxadifen-ethyl @ 1125 g $a.i.ha^{-1}$ + 2% urea	28.67cd (73.45)	24.00cd (77.35)	2.00 b (39.93)	1.00 bc (62.41)	77.21 c (73.91)	4.25 b (85.47)	4.00 b (62.79)	23.75 b (83.39)	26.75 b (84.40)	49.67 b (64.24)
Formasulfuron + isoxadifen-ethyl @ 1125 g $a.i.ha^{-1}$ +3% urea	21.33de (80.25)	19.00 d (87.00)	1.33 b (60.00)	0.66 bc (75.19)	41.78 e (85.88)	5.25 b (82.05)	4.50 b (58.14)	19.50 b (86.36)	17.25 b (89.97)	43.48 b (68.69)
LSD	**9.029**	**7.837**	**1.135**	**0.878**	**4.974**	**9.141**	**4.96**	**16.623**	**21.40**	**17.92**

Means sharing the same letter did not differ significantly at 5% level of probability.
Values in parenthesis show weed control efficiency (%).

There was a significant increase in grain yield of maize with formasulfuron + isoxadifen-ethyl either applied alone or with 1, 2 and 3% urea solution. In spring maize, manual hoeing resulted in highest grain yield, followed by formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} + 3% urea solution. Manual hoeing and formasulfuron + isoxadifen-ethyl alone and with various concentrations of urea were at par in respect of maize grain yield in case of autumn maize (Table-2).

DISCUSSION

The unchecked growth of weeds throughout the maize crop life cycle resulted in maximum number of weeds and their dry weight. It is thus evident that effectiveness of pre- mixed formasulfuron + isoxadifen-ethyl for weed control in maize can be enhanced by adding 3% urea solution. Several studies have reported improved weed control with herbicides when used in combination with urea solution due to improved penetration and enhanced phytotoxicity of herbicides (Borona *et al*., 2003; Ssango and Balitenda, 2003; Singh and Singh, 2003; Bunting *et al*., 2004).

Decrease in yield components of maize in the control treatments was due to unchecked growth of weeds, which competed with the crop plants for available growth resources. On the other hand, efficient utilization of soil and climatic resources by maize plants in presence of relatively low weed numbers in different weed control treatments led to increased grain number and grain weight of maize (Shekhawat and Gautam, 2002). Increase in grain yield due to different treatments over control was 24.7-78.4% and 40.5-68.4% in spring and autumn maize, respectively. Increase in maize grain yield as a result of better weed control with combined use of herbicide and urea have been previously reported (Ssango and Balitenda, 2003; Singh and Singh, 2003).

CONCLUSION

It can be concluded from our study that formasulfuron + isoxadifen-ethyl @ 1125 g a.i. ha^{-1} +3% urea solution applied as post-emergence proved to be the most effective chemical weed control treatment to increase grain yield of maize.

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