Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 6 (6): 967-971, 2007
ISSN 1682-3974

Determination of the Best Integrated Weed Management System in Maize (*Zea mays*)

[1]Hassan Muhammad Alizade, [1]Iraj Nosratti and [2]Saeed Rasoolzade
[1]Department of Agronomy and Plant Breading,
[2]Department of Horticulture, College of Agriculture and Natural Resources, University of Tehran, Iran

Abstract: In order to determine the best integrated management system in maize field experiments were conducted at Tehran in Iran which revealed that maize grain yield in Double Row (DR) planting pattern was higher than in Single Row (SR) planting pattern in all plots (up to 1.0 t ha^{-1}). Tank mixing atrazine with other preemergence herbicides significantly increased weed control at both planting patterns and the best was atrazine at dose of 1.0 kg ha^{-1} plus alachlor. Among Sulfonylurea herbicide, nicosulfuron gave the highest grain yield. The most efficient Foramsulfuron dosage was 37 g a.i. ha^{-1} which had highest grain yield. It was concluded that the best integrated management system in maize is integrating crop competitiveness with reduced herbicidal mixture and appropriate dosage.

Key words: Maize, single row planting pattern, sulfonylurea, cultivation

INTRODUCTION

Despite several decades of modern weed control practices, weeds continue to be a constant threat to agricultural productivity (Buhler, 2002). Different weed control methods have been used to control the weeds but mechanical and chemical are more frequent used in developing countries such as Iran.

Cultivation plus herbicide application can be beneficial in row crop production (Johnson *et al*., 1998). Newsom and Shaw (1994) and Webster *et al.* (2000) reported pitted morningglory control and soybean yield increased when cultivation followed a POST application of Imazapic.

One of the most important cultural practices to reduce impacts of weed on crops is increasing crop competitiveness by reducing row spacing. Flenet *et al.* (1996) and Tetio-Kagho and Gardner (1988) showed that the crop canopy is more efficient at capturing radiation when the crop is planted in narrower row spicing. Maize can produce higher yields in narrow row spacing with the same population density as conventional row spacing (Teasdale, 1998; Camp *et al*., 1985; Karlen and Camp, 1985).

Although narrow rows and high plant density reduce weed biomass, these practices alone are not sufficient to prevent crop yield losses. Therefore, supplemental measures of weed control such as cultivation and herbicide application are necessary. However, an opportunity exists for reducing herbicide application rates and frequency by combination of all these strategies.

Integrated Weed Management (IWM) diversifies the selection pressure on Weed communities, uses resources more efficiently and provides producers with a broader range of management options (Buhler, 2002). IWM decision strategies also include technologies aimed at altering crop competitiveness with weeds, including cultivar selection, seeding rate (plant density) and time of weed removal (Swanton and Weise, 1991; Tetio-Kagho and Gardner, 1988).

The objective of this study was determination the best integrated weed management system in maize by selecting the most appropriate elements of applied different herbicidal mixtures and herbicide dosages in combination with double and single row (with cultivation) planting patterns.

MATERIALS AND METHODS

Field studies were conducted in 2005 at Research Farm of Natural Resources and Agricultural College, University of Tehran which located in Karaj city, northern of Iran. The study area soil was loam with a pH of 5.7 and 0.85% organic matter and at previous year barely had been planted. SC 704 maize was planted May 19, 2004. One week prior to planting 336 kg ha^{-1} 19:19:19 ($N{:}P_2O_5{:}K_2O$) was applied broadcast. Three weeks after planting 202 kg ha^{-1} of 32:0:0 was side-dressed.

Permethrin (224 g a.i. ha^{-1}) was applied in furrow at planting for insect control. SU herbicides and other herbicides were evaluated at Single Row (SR) planting

Corresponding Author: Hassan Muhammad Alizade, Department of Agronomy and Plant Breading, College of Agriculture and Natural Resources, University of Tehran, Karaj, Iran
Tel: +989123611550

pattern and Double Row (DR) planting pattern. The applied treatments and their rates and timing of application in both planting patterns were same and are listed in Table 1.

A nonionic surfactant (Cytogate) at 0.25% (v/v) was added to all POST treatments. POST treatments applied in both experiments when maize had four leaves. Treatments were arranged in a randomized complete block design with four replications. In both experiments, plots were four 75 cm rows by 10 m in SR, maize plants spacing 20 cm on top of each ridge while in DR arrangement of maize plants was different and plants were placed in two separated 20 cm rows on each ridge which in each of them maize plants were spaced 30 cm apart so that the arrangement of plants on ridge was similar to parallelogram (Fig. 1). Herbicide treatments (Table 1) were applied with an electric backpack sprayer and a hand-held boom calibrated to deliver 140 L ha^{-1} spray volume at 166 kPa.

Weed parameter assessed from two stable 75×75 cm quadrates which placed randomly in plots. Within each quadrate, weed species were identified, counted, clipped at ground level and oven-dried at 80°C for 48 h, then weighed to determine their dry matter. The counting of weeds was made two weeks after treatment and at maize

Table 1: Rate (g a.i. ha^{-1}) and timing of application of used treatments at both planting patterns

Treatments	Rate (g ha^{-1})	Timing
Atrazine (1) + alachlor	1,000 + 4,000	PRE[a]
Atrazine (1/5) + alachlor	1,500 + 4,000	PRE
Atrazine (2) + alachlor	2,000 + 4,000	PRE
Atrazine + acetochlor	1,500 + 2,500	PRE
Atrazine + pendimethalin	1,500 + 1,120	PRE
Atrazine (1/5)	1,500	PRE
Atrazine (2)	2,000	PRE
2,4-D + MCPA[b]	1,000	POST
Bentazon	5,000	POST
Nicosulfuron	35	POST
Foramsulfuron (32)	32	POST
Foramsulfuron (37)	37	POST
Foramsulfuron (42)	42	POST
Rimsulfuron	30	POST
Eradicane	6,000	PPI

[a]Abbreviations: PRE: Preemergence; POST: Postemergence; PPI: Preplant incorporation; [b]Prepackaged mixture

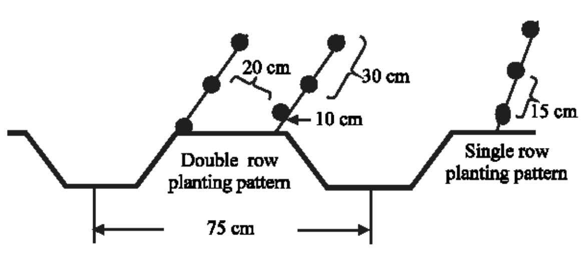

Fig. 1: Position of maize plants on the ridge at double row planting pattern and single row planting pattern

harvest. Maize was harvested 1-3 October 2005 and maize grain yield was obtained from an area of 4 m^2 of plots and was adjusted to 12% moisture content.

The non-transformed data were analyzed using ANOVA in SAS. Means of significant effect were separated using Fisher's protected LSD at the 5% level of probability.

RESULTS

Weed dry matter: The data revealed that different treatments had significant effect on weed dry matter (Table 2). Weed dry matter was lower in all plots in SR planting pattern than in DR planting pattern. The untreated control had the highest weed dry matter in both planting patterns. All treatments that received herbicides and the hoeweeded control had lower weed dry matter than the untreated control in both experiments. In both experiments, broadleaf weeds had more dry matter than grasses. Foramsulfuron at the dose of 42 g ha^{-1} had the lowest weed dry matter. Nicosulfuron had the lowest weed dry matter among sulfonylurea herbicides. This herbicide decreased weeds dry matter in general, by mean of 60%. Like other treatments, at DR planting pattern, nicosulfuron decreased weed dry matter more efficiently. Applying 2.0 kg of atrazine lonely was more effective than dose of 1/5 kg but tank mixing of atrazine with alachlor at all doses increase efficacy of treatment thus weed dry matter was lower. Weed dry matter in plots treated with atrazine + pendimethalin and atrazine + acetochlor was higher than herbicidal mixture of atrazine and alachlor at all doses. Herbicidal mixture atrazine + alachlor at dose of

Table 2: Weed Dry matter (g m^{-2}) of broadleaf and grass weeds at both planting patterns as affected by different treatments

	Weed dry matter (g m^{-2})			
	Single row		Double row	
Treatments	Grass	Broadleaf	Grass	Broadleaf
Atrazine (1) + alachlor	80.00	90.66	25.00	50.00
Atrazine (1/5) + alachlor	70.00	80.66	21.00	40.66
Atrazine (2) + alachlor	60.00	75.00	20.33	35.00
Atrazine + acetochlor	90.00	110.00	25.33	71.66
Atrazine + pendimethalin	110.00	100.33	30.00	50.00
Atrazine (1/5)	90.00	131.00	40.66	88.66
Atrazine (2)	90.00	121.00	35.33	60.00
2,4-D + MCPA[a]	150.00	70.00	70.66	35.00
Bentazon	170.00	71.00	75.00	35.00
Nicosulfuron	110.00	220.66	20.00	92.00
Foramsulfuron (32)	110.00	240.00	30.33	120.00
Foramsulfuron (37)	90.00	218.33	20.66	109.00
Foramsulfuron (42)	116.70	226.00	22.00	115.00
Rimsulfuron	110.00	240.33	60.00	160.00
Eradicane	70.00	246.66	31.33	164.00
Hand-weeded	0.00	0.00	0.00	0.00
Nontreated	150.00	250.00	60.30	125.00
LSD (0.05)	9.09	2.355	8.613	61.407

[a]Prepackaged mixture

Table 3: Effect of different treatments on weed density (plants m^{-2}) at 14 day after treatment and maize harvest at both planting patterns

	Weed density (Plant m^{-2})						
	Single row				Double row		
	Broadleaves		Grasses		Broadleaves		Grasses
Treatments	14 DAT	Corn harvest	14 DAT	Corn harvest	14 DAT	Corn harvest	14 DAT
2,4-D + MCPA[a]	4.00	1.33	14.67	14.00	2.66	1.00	13.90
Bentazone	6.00	6.33	14.20	14.00	5.00	3.00	14.00
Nicosulfuron	16.00	14.00	9.80	8.00	15.00	12.33	8.80
Foramsulfuron (32)	17.00	13.00	11.00	9.00	16.00	13.00	8.30
Foramsulfuron (37)	13.00	13.67	9.00	7.00	15.00	9.00	8.70
Foramsulfuron (42)	15.00	12.00	9.83	6.90	13.30	10.33	8.50
Rimsulfuron	16.60	13.00	8.50	6.66	12.0D	12.67	7.00
Hand-weeded	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nontreated	20.00	15.00	15.00	14.67	19.00	16.00	14.33
LSD (0.05)	0.582	1.405	0.984	0.401	1.208	1.053	1.091

[a]Prepackaged mixture

Table 4: Maize grain yield (t ha^{-1}) as affected by treatments at both planting pattern

	Corn yield (t ha^{-1})	
Treatments	Single row	Double row
Atrazine (1) + alachlor	12.110	13.100
Atrazine (1/5) + alachlor	12.500	13.500
Atrazine (2) + alachlor	12.800	13.900
Atrazine + acetochlor	8.950	9.430
Atrazine + pendimethalin	10.000	10.730
2,4-D + MCPA[a]	9.810	9.970
Bentazon	7.590	9.300
Atrazine (1/5)	7.590	8.850
Atrazine (2)	8.700	9.977
Nicosulfuron	12.000	13.000
Foramsulfuron (32)	9.480	10.640
Foramsulfuron (37)	11.140	11.480
Foramsulfuron (42)	9.050	10.990
Rimsulfuron	9.880	10.740
Eradicane	9.000	10.960
Hand-weeded	13.060	14.150
Nontreated	6.220	8.120
LSD (0.05)	0.699	0.671

[a]Prepackaged mixture

1.0 + 4.0 kg ha^{-1} had the smallest weed dry matter which was the lowest of all other atrazine-contained treatments. Broadleaf Weed dry matter at plots treated with herbicide mixture 2, 4-D + MCPA was similar to hand-weed plot.

Weed density

Broadleaf weeds

14 DAT: The data showed significant ($p<0.05$) effect of different treatments on weed density (plants m^{-2}). Maximum weed number was recorded in weedy check plots while minimum weeds were recorded in untreated plots (Table 3). Applying postemergence (POST) herbicide led to decrease weed density. Foramsulfuron at dose of 42 g a.i. ha^{-1} had the lowest weed number. Herbicidal mixture 2,4-D + MCPA with average of 4 weeds m^{-2} was the best POST treatment and decreased weed density more effectively than bentazone did. In all plots weed density in DR planting pattern was less than that in SR.

At maize harvest: Significant differences ($p\leq 0.05$) were observed in maize grain yield among the treatments at maize harvest (Table 3). The highest weed density was obtained from untreated control plot while the lowest obtained from hand-weeded plots. Foramsulfuron at dose of 42 g a.i. ha^{-1} had the lowest weed density and was The most effective sulfonylurea herbicide. At maize harvest, comparing with weed density at 14 DAT, less weed density was obtained.

Grasses

14 DAT: The data showed significant ($p\leq 0.05$) effect of different treatments on weed density m^2 at 14 DAT. highest weed density were recorded in untreated, 2,4-D + MCPA and bentazone-treated plots while the lowest was obtained from hand-weeded check plots. Totally grass density in DR planting pattern was less than in SR planting pattern.

At maize harvest: The data showed that different treatments significantly affected grass density in SR planting pattern at maize harvest but not in DR planting. The highest weed density was recorded in untreated, 2,4-D + MCPA and bentazone-treated plots while the lowest was recorded in hand-weeded check plots. Different foramsulfuron dosages had similar effect on grass density. In general difference between treatment do not included a wide range.

Maize grain yield: In both planting pattern significant differences were observed in maize grain yield among the treatments ($p\leq 0.05$) (Table 4). At both experiments, the weeded control had the highest yield while the lowest yield was obtained from untreated control. In general with increase in atrazine dosage, yield increased. In DR planting pattern all plots had more grain yield than in SR. The average grain yield in DR and SR was 11.039 and 10.074 t ha^{-1}, respectively. Applying 37 g a.i. ha^{-1} of foramsulfuron had the highest grain yield. Tank mixing atrazine with other preemegence herbicides improved grain yield. The herbicidal mixture of Atrazine (2) + alachlor had highest grain yield and the lowest was obtained from Atrazine + acetochlor-treated plots. Bentazone compare with prepackaged herbicide mixture 2,4-D + MCPA, both broadleaf weed killer, had less grain yield.

DISCUSSION

The results of this study showed that the grain yield of maize was lowest in the untreated control at both experiments. This might be due to weed interference, which may have caused strong competition between the maize and weeds for growth factors, because these plots had the highest weed density and weed dry matter. In DR planting pattern Grain yield in all plots was higher than in SR.

Planting maize in narrow rows compared to wide rows can enhance weed control. Past studies (Forcella *et al*., 1992) have indicated that decreasing maize row spacing can increase weed control for a given herbicide treatment because of more rapid closure of the maize canopy. The shading provided by the canopy in narrow rows may eliminate the need to utilize sequential applications or delay herbicide application by reducing weed seed germination and suppressing weed growth. Cultivation plus herbicide application can be beneficial in row crop production but in this study cultivation could not be as beneficial as narrowing rows. This might be due to presence of free space between rows at early stage of maize growing and consequently severe competition between weeds and maize.

As mentioned in the materials and methods section because the broadleaf weeds species were predominant in the study area, at both experiments the density and dry matter of grasses were less than of broadleaf weeds. Foramsulfuron at dose of 37 g a.i. ha^{-1} had the best effect on controlling weeds. Similar dosage of foramsulfuron has been reported by other researchers (Bunting *et al*., 2004) in order to control maize weeds without injuring crop plants. Nicosulfuron was the best SU herbicide in maintaining maize grain yield.

Because predominant grass weeds species was johnsongrass and Nicosulfuron has been reported to be very effective on rhizomatous perennial temperate weeds (Bruce and Kells, 1997). Tank mixing of atrazine with other preemergence herbicide improved weed control. Tank mixing two or more herbicides is a common practice that is increasingly used in most major agronomic crops to control a wide spectrum of weeds with a minimum cost effectively (Mueller *et al*., 1989; Myers and Coble, 1992).

Tank mixing atrazine at dose of 2.0 kg a.i. ha^{-1} with alachlor had the highest grain yield while tank mixing of this dosage with acetochlor had the lowest grain yield. This might be due to increased range of weed species range controlled by this herbicidal mixture (Curran and Foster, 2002). Alachlor and atrazine are used as selective herbicides for controlling grasses and broadleaf weeds. Based on Products containing alachlor and atrazine are classified as restricted use herbicides. One reason the use of alachlor and atrazine has been restricted is because of concerns about groundwater contamination (Workman *et al*., 1998). Thus the best dosage of atrazine in combination with alachlor would be 1.0 kg ha^{-1}. 2,4-D + MCPA controlled broadleaf weeds more effectively than bentazone did. Weed density at 14 DAT was more than what at maize harvest so that in DR planting pattern the effect of treatment on grass density at crop harvest was not meaningful.

CONCLUSION

Based on these results it can be concluded that the best IWM system is integrating crop competitiveness through decreasing row spacing with reduced herbicidal mixture and best dosage which could control weed in maize effectively without environmental pollution and soil erosion.

REFERENCES

Bruce, A.B. and J.J. Kells, 1997. Quackgrass (*Elytrigia repens*) control in maize (*Zea mays*) with nicosulfuron and primisulfuron. Weed Technol., 11: 373-378.

Buhler, D.D., 2002. Challenges and opportunities for integrated weed management. Weed Sci., 50: 273-280.

Bunting, J.A., C.L. Sprague and D.E. Riechers, 2004. Corn tolerance as affected by the timing of foramsulfuron applications. Weed Technol., 18: 757-762.

Camp, C.R., D.L. Karlen and J.R. Lambert, 1985. Irrigation scheduling and row configurations for maize in the Southeastern Coastal Plain. Trans. Am. Soc. Agric. Eng., 28: 1159-1165.

Curran, B. and R. Foster, 2002. Weed Control Manual 2002. Meister Publishing Company, pp: 578.

Flenet, F., J.R. Kiniry, J.E. Board, M.E. Westgate and D.C. Reicosky, 1996. Row spacing effects on light extinction coefficients of maize, sorghum, soybean and sunflower. Agron. J., 88: 185-190.

Forcella, F., M.E. Westgate and D.D. Warnes, 1992. Effect of row width on herbicide and cultivation requirements in row crops. Am. J. Alt. Agric., 7: 161-167.

Johnson, G.A., T.R. Hovestad and R.E. Greenwald, 1998. Integrated weed management using narrow maize row spacing, herbicides and cultivation. Agron. J., 90: 40-46.

Karlen, D.L. and C.R. Camp, 1985. Row spacing, plant population and water management effects on maize in the Atlantic coastal plain. Agron. J., 77: 393-398.

Mueller, T.C., W.W. Witt and M. Barrett, 1989. Antagonism of johnsongrass (*Sorghum halepense*) control with fenoxaprop, haloxyfop and sethoxydim by 2,4-D. Weed Technol., 3: 86-89.

Myers, P.F. and H.D. Coble, 1992. Antagonism of graminicide activity on annual grass species by imazethapyr. Weed Technol., 6: 333-338.

Newsom, L.J. and D.R. Shaw, 1994. Influence of cultivation timing on weed control in soybean (*Glycine max*) with AC 263, 222. Weed Technol., 8: 760-765.

Swanton, C.J. and S.F. Weise, 1991. Integrated weed management: The rationale and approach. Weed Technol., 5: 657-663.

Teasdale, J.R., 1998. Influence of maize (*Zea mays*) population and row spacing on maize and velvetleaf (*Abutilon theophrasti*) yield. Weed Sci., 31: 81-85.

Tetio-Kagho, F. and F.P. Gardner, 1988. Response of maize to plant population density. I. Canopy development, light relationships and vegetative growth. Agron. J., 80: 930-935.

Webster, E.P., D.R. Shaw, T.A. Baughman, C.E. Snipes and C.T. Bryson, 2000. Influence of Cultivation Timing on Pyrithiobac Performance in Cotton (*Gossypium hirsutum*). Weed Technol., 14: 116-121.

Workman, S.R., S.E. Nokesa, R. Reederb and N. Watermeier, 1998. Atrazine and alachlor concentrations under ridge tillage and chisel-plow tillage in an alluvial plain soil. Soil Tillage Res., 48: 207-214.