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Effects of Rimsulfuron, Foramsulfuron and Conventional Herbicides on Weed Control and Maize Yield at Three Planting Dates

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ABSTRACT
Field experiment was conducted in 2007 and 2008 in research station of college of agriculture, Shiraz University of Iran, to evaluate the effect of herbicide application and planting dates on yield and yield components of maize and weed control. Treatments were atrazine plus alachlor at 1 + 2.44 and 1.92 + 1.5, 2,4-D + MCPA at 0.36 + 0.31 and 0.54 + 0.46, rimsulfuron at 0.02 and 0.04, foramsulfuron at 0.03 and 0.06 kg a.i. P ha^{-1}, a weed free and a weedy check and three planting dates (5 May, 5 June and 5 July). Results of both years showed that foramsulfuron and atrazine+ alachlor in both applied rates controlled weeds greatly in all planting dates. Combination of 2,4-D + MCPA in both applied rates controlled field bindweed (*Convolvulus arvensis* L.) about 85 to 99% in the 3rd planting date. The minimum weed biomass reduction and lowest maize grain yield was obtained with rimsolforun in both applied rates and 2,4-D + MCPA at 0.36 + 0.31 kg a.i. P ha^{-1} in the first planting date. Maximum weed biomass reduction and the highest maize grain yield were obtained with foramsulfuron in both applied rates in the 3rd planting date and 2nd planting date, respectively.

Key Words: Maize yield, Planting date, Herbicides, Weed control

INTRODUCTION

Maize is a major crop in Iran and ranks third, behind wheat and rice in hectares grown (FAO 2007). Weed control is vital to its success because weeds can reduce yield up to 86% (Bijanzadeh and Ghadiri 2006). A broad spectrum of grasses and broadleaved weeds infests maize fields. Redroot pigweed (*Amaranthus retroflexus*), common lambsquarters (*Chenopodium album* L.), velvetleaf (*Abutilon theophrasti Medik*.), field bindweed (*Convolvulus arvensis* L.), chinese lantern (*Physalis alkekengi)*, johnsongrass (*Sorghum halepense* (L.) Pers.), barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.), purple nutsedge (*Cyperus rotundus* L.), large crabgrass (*Digitaria sanguinalis* (L.) Scop.) and foxtail (*Setaria* spp.) are among the most troublesome weeds in maize in Iran (Mousavi 2001). Herbicides use is an essential component of successful maize production (Hall et al. 1992). Today, high-yielding agriculture heavily depends on herbicides, as they constitute a vital and integral component of weed management practices (Baghestani et al. 2005). However, there are very few herbicide options available for weed control in maize in Iran. Atrazine and alachlor are used for control of annual weeds in maize. Also 2,4-D plus MCPA have been applied POST for about a decade for controlling broadleaf weeds in maize in Iran (Bijanzadeh and Ghadiri 2006). But, none of these options currently keep the weed community at an acceptable level and cannot provide satisfactory control of weeds. In addition, these herbicides are used at high rates. Foramsulfuron, and rimsulfuron are among the newly released dual purpose sulfonylurea herbicides. The use of these herbicides offers the opportunity for a new mode of action for weed management in maize (Baghestani et al. 2007).

Successful maize production is dependent on management decisions including the proper planting date (Kucharik 2008). Studies have shown that the competitive ability of weeds depends to a large extent on their time of emergence relative to the crop. Planting date has a greater role in the emergence and establishment of plants (Singh et al. 1995). One method to reduce weed densities within a growing season is delayed crop planting. Delaying tillage and crop planting to allow for weed seed germination results in reduced weed densities following planting. As planting date is delayed, peak germination of many species passes, resulting in little emergence following crop planting. While delaying planting may be beneficial for weed control, it may reduce crop yield potential. In Minnesota, delaying soybean (*Glycine max* L.) planting from May 10 to June 20 reduced soybean yield by 30% (Buhler and Gunsolus 1996). Delayed planting reduced yield losses due to weeds in soybean and dent maize, explained largely by low weed density resulting from depleted seed banks (Williams 2006). Rushing and Oliver (1998) observed a trend for greater yield reduction from common cocklebur (*Xanthium strumarium* L.) interference in April planted soybean than in May or July planting. Earlier planting increases the length of time that plants can take advantage of favorable growing conditions and accumulate biomass. The highest yields in maize generally result where the growing season is longest and soil moisture is not limiting (Kucharik 2006). Maize planted early in

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spring may be subject to infestation by a greater number of weed species and higher weed densities, and greater liklihood that re-infestation will occur after an early post herbicide application (Gower et al. 2002). Bijanzadeh and Ghadiri (2006) showed that atrazine plus alachlor at 1 + 2.44 and 1.5 + 1.92 kg a.i. P ha^{-1} controlled redroot pigweed 60 to 100%. Rimsulfuron plus primisulfuron plus prosulfuron at 0.02 + 0.03 + 0.03 and 0.04 + 0.02 + 0.02 kg a.i. P ha^{-1} reduced johnsongrass biomass 96 to 100%. 2,4-D plus MCPA at 0.36 + 0.31 and 0.54 + 0.46 kg a.i. P ha^{-1}, and alachlor plus 2,4-D plus MCPA at 1.92 + 0.54 + 0.46 kg a.i. P ha^{-1} and 2.44 and 2.44 + 0.36 + 0.31 kg a.i. P ha^{-1} controlled 80 to 100% of field bindweed and results showed that all herbicide treatments increased maize grain yield as compared with the weedy check.

Although in many locations of Iran, maize is planted as a first crop in spring, in some locations including Fars province, it is planted in summer as a second crop. Therefore, it is important to investigate the effects of herbicides application on dominant weeds control, yield and yield component of maize at different planting dates.

MATERIALS AND METHODS

Field experiment was conducted during the 2007 and 2008 at the Kooshkak Agricultural Experiment Station northwest of Shiraz (30° 7′ N. 52°′′ 34′′ E), Iran. In both years, the plots were located on a silty loam (Ramjerd line, mixed, mesic, typic Calixerolie) with 0.6 organic matter 15 to 20% sand, 51 to 54% silt, 20 to 31% clay and pH of 7.7. The mean monthly temperature in two years is given in table 1. Seedbed preparation included spring disking and moldboard plowing. The field was fertilized according to soil test recommendations with 45 kg phosphor P ha^{-1} and 80 kg nitrogen P ha^{-1}. Maize seeds (SC 704) were planted 5 cm deep. Each plot was 3 m wide by 8 m long and consisted of 4 rows of maize with 75 cm between-row and 15 cm within row spacing. One row was left unsown between two plots to prevent herbicide drift on neighboring plots.

Table 1. Average temperatures (° C) during growing seasons in 2007 & 2008.

Months	2007	2008
May	19.02	18.39
June	23.84	23.71
July	27.77	27.20
August	25.97	27.13
September	23.76	24.47
October	17.85	19.28
November	13.48	12.18

The experimental design was split plot with three replications. The main factor was three planting dates: 5 May (early planting date), 5 June (normal planting date), and 5 July (late planting date). The sub factor was herbicide application. Treatments were atrazine plus alachlor at 1 + 2.44 and 1.92 + 1.5 kg a.i. P ha^{-1}, 2,4-D + MCPA at 0.36 + 0.31 and 0.54 + 0.46 kg a.i. P ha^{-1}, rimsulfuron at 0.02 and 0.04 kg a.i. P ha^{-1}, foramsulfuron at 0.06 and 0.03 kg a.i. P ha^{-1}. Control treatments consisted of weedy and hand- weeded checks. Atrazine and alachlor were applied PRE immediately after maize planting and all other herbicides were applied POST at 2 week after planting (WAP). Herbicides were applied as a broadcast application in 300 L ha^{-1} of water with 20-L knapsack sprayed equipped with one flat-fan nozzle 8002 at a pressure of 271 k Pa.

At 6 and 12 WAP, weeds were harvested from a 1-m^{-2} area in each plot. Weeds were separated by species, counted, and then oven dried at 72 °C for 48 h. Maize grain yield was determined by harvesting of ears from the middle two rows of each plot. Statistical analyses were performed using MINITAB 11 and MSTATC computer software.

RESULTS

Weeds control

In both years, predominant weed species were redroot pigweed, field bindweed and chinese lantern. In 2007, at 6 WAP, application of the atrazine plus alachlor and foramsulfuron in both applied rates, and all planting dates, reduced redroot pigweed biomass (from 94 to 100%) and chinese lantern biomass (from 91 to 100%), and maximum control of field bindweed was achieved with 2,4-D + MCPA at 0.46 + 0.54 kg a.i. P ha^{-1} all planting dates, foramsulfuron in both applied rates and 2,4-D + MCPA at 0.675 kg a.i. P ha^{-1} in the first planting date (Table 2). Minimum control of redroot pigweed was obtained with 2,4-D + MCPA at 0.675 kg a.i. P ha^{-} and rimsulfuron at 0.02 kg a.i. P ha^{-1} in the first planting date and worst control of chinese lantern was achieved with rimsulfuron in both applied rates in first and 2nd planting date and 2,4-D + MCPA at 0.675 kg a.i. P ha^{-1} in the first planting date (Table 2). Rimsulfuron in both applied rates in all planting dates couldn't control field bindweed.

Table 2. Effect of herbicide application and planting date on weed biomass reduction (%) at 6 and 12 WAP in 2007.

Treatments	Dose (kg a.i. P ha^{-1})	Weed biomass reduction (%)					
		First planting date(5 May)					
		redroot pigweed		chinese lantern		field bindweed	
		6 WAP[a]	12 WAP	6 WAP	12 WAP	6 WAP	12 WAP
Weedy check	_	0	0	0	0	0	0
Weed free check	_	100	100	100	100	100	100
Atrazine + Alachlor	1.5 + 1.92	100	89.70	100	53.64	91.02	87.18
2,4-D+ MCPA	0.36 + 0.31	57.20	26.41	42.26	3.42	97.97	91.88
Rimsulfuron	0.02	68.21	31.83	39.37	27.89	55.37	42.00
Foramsulfuron	0.06	97.52	95.95	91.20	91.18	92.66	83.57
Atrazine + Alachlor	1 + 2.44	100	91.62	100	52.07	81.01	76.78
2,4-D+ MCPA	0.46 + 0.54	88.91	66.50	64.39	0.33	97.57	89.79
Rimsulfuron	0.04	78.84	70.71	39.64	39.47	58.84	35.00
Foramsulfuron	0.03	94.04	88.69	97.79	90.40	95.79	60.79
2nd planting date (5 June)							
Weedy check	_	0	0	0	0	0	0
Weed free check	_	100	100	100	100	100	100
Atrazine + Alachlor	1.5 + 1.92	100	82.57	100	68.66	78.32	75.11
2,4-D+ MCPA	0.36 + 0.31	39.80	15.30	71.97	27.54	92.26	87.50
Rimsulfuron	0.02	69.83	16.98	68.24	64.29	38.40	5.47
Foramsulfuron	0.06	99.38	86.12	97.16	92.77	71.20	72.50
Atrazine + Alachlor	1 + 2.44	100	91.82	100	68.02	68.64	25.00
2,4-D+ MCPA	0.46 + 0.54	69.27	26.20	68.03	34.30	91.85	80.18
Rimsulfuron	0.04	67.92	43.08	65.54	51.16	46.35	20.46
Foramsulfuron	0.03	98.77	67.43	98.01	92.16	77.55	72.55
3rd planting date (5 July)							
Weedy check	_	0	0	0	0	0	0
Weed free check	_	100	100	100	100	100	100
Atrazine + Alachlor	1.5 + 1.92	98.25	96.34	100	77.36	78.34	70.00
2,4-D+ MCPA	0.36 + 0.31	63.60	42.70	60.12	51.70	91.94	84.67
Rimsulfuron	0.02	57.56	41.35	56.68	39.20	54.60	17.80
Foramsulfuron	0.06	100	85.90	100	98.13	83.85	82.87
Atrazine + Alachlor	1 + 2.44	100	83.60	84.46	64.89	71.85	70.00
2,4-D+ MCPA	0.46 + 0.54	59.81	18.60	57.02	50.89	98.84	98.65
Rimsulfuron	0.04	54.19	19.70	54.77	27.96	35.02	16.67
Foramsulfuron	0.03	80.73	76.24	100	94.29	81.13	80.65
Standard error (df =54)		0.002	1.44	0.02	0.21	0.45	0.96
LSD (0.05)[b]		0.07	13.79	0.08	7.50	14.79	16.75

[a] WAP, weeks after planting.
[b] Least significant difference at P = 0.05.
Analyze based on $(x + 0.5)^{1/2}$ transformation of original data

At 12 WAP, atrazine plus alachlor at 1.5 + 1.92 kg a.i. P ha^{-1} in 3rd planting date reduced redroot pigweed biomass 96% and minimum control of redroot pigweed was obtained with rimsulfuron at 0.02 kg a.i. P ha^{-1} and 2,4-D + MCPA at 0.675 kg a.i. P ha^{-1} in the first planting date (Table 2). The highest control of chinese lantern was obtained with foramsulfuron in both applied rates in all planting date and the lowest control was achieved with 2,4-D + MCPA in both applied rates in the first planting date. Field bindweed was controlled with 2,4-D + MCPA in both applied rates in 3rd planting date, but rimsulfuron in both applied rates in the first and 2nd planting date couldn't control it (Table 2).

In 2008, 6 WAP, the highest control of redroot pigweed was achieved with foramsulfuron and atrazine plus alachlor in both applied rates, in all planting dates and the lowest was obtained with rimsulfuron in both applied rates in the first and 2nd planting date and 2,4-D + MCPA at 0.46 + 0.54 kg a.i. P ha^{-1} in 2nd planting date (Table 3). Maximum reduction in chinese lantern biomass was obtained with foramsulfuron in both applied rates and atrazine plus alachlor at 1.5 + 1.92 kg a.i. P ha^{-1} in all planting dates and atrazine plus alachlor at 1 + 2.44 kg a.i. P ha^{-1} in 2nd and 3rd planting date and minimum reduction in chinese lantern biomass was achieved with 2,4-D + MCPA and rimsulfuron in both applied rates in all planting dates (Table 3).

Field bindweed was controlled with 2,4-D + MCPA in both applied rates, in all planting dates and foramsulfuron, atrazine plus alachlor in both applied rates in 2nd and 3rd planting date (Table 3). Rimsulfuron in both applied rates in first planting date couldn't control field bindweed (Table 3). At 12 WAP, the highest control of redroot pigweed biomass was achieved with atrazine plus alachlor at 1.5 + 1.92 kg a.i. P ha^{-1} in 3rd planting date and the worst control of redroot pigweed biomass was obtained with 2,4-D + MCPA at 0.675 kg a.i. P ha^{-1} and rimsulfuron at 0.02 kg a.i. P ha^{-1} in first planting date (Table 3). Maximum reduction in chinese lantern biomass was obtained with foramsulfuron in both applied rates in all planting dates and atrazine plus alachlor in both applied rates in 3rd planting date and minimum reduction in chinese lantern biomass was achieved with rimsulfuron and 2,4-D + MCPA in both applied rates in first planting date (Table 3). The results indicated that 2,4-D + MCPA in both applied rates, and in all planting dates provided the highest control of field bindweed (from 80 to 100%) and rimsulfuron in both applied rates, in all planting dates provided the lowest control (from 0 to 33%) (Table 3).

Table 3. Effect of herbicide application and planting date on weed biomass reduction (%) at 6 and 12 WAP in 2008.

Treatments	Dose (kg a.i. P ha^{-1})	Weed biomass reduction (%)					
		First planting date(5 May)					
		redroot pigweed		chinese lantern		field bindweed	
		6 WAP[a]	12 WAP	6 WAP	12 WAP	6 WAP	12 WAP
Weedy check	_	0	0	0	0	0	0
Weed free check	_	100	100	100	100	100	100
Atrazine + Alachlor	1.5 + 1.92	82.09	83.98	96.51	63.32	81.63	71.33
2,4-D+ MCPA	0.36 + 0.31	50.94	18.96	66.20	28.20	100	100
Rimsulfuron	0.02	37.60	14.31	62.80	29.79	58.24	4.60
Foramsulfuron	0.06	100	95.54	100	91.01	71.41	63.95
Atrazine + Alachlor	1 + 2.44	85.81	85.56	90.49	73.63	66.44	58.18
2,4-D+ MCPA	0.46 + 0.54	56.51	56.00	74.58	24.80	100	94.57
Rimsulfuron	0.04	33.44	12.49	65.00	41.60	47.45	26.06
Foramsulfuron	0.03	94.04	75.13	96.34	90.99	84.73	53.70
		2nd planting date (5 June)					
Weedy check	_	0	0	0	0	0	0
Weed free check	_	100	100	100	100	100	100
Atrazine + Alachlor	1.5 + 1.92	100	87.05	96.77	88.79	92.31	71.48
2,4-D+ MCPA	0.36 + 0.31	58.24	48.82	63.91	41.59	100	100
Rimsulfuron	0.02	50.00	10.86	62.50	32.84	1.89	0
Foramsulfuron	0.06	100	93.53	100	92.77	100	43.80
Atrazine + Alachlor	1 + 2.44	100	95.79	93.61	47.90	90.92	55.50
2,4-D+ MCPA	0.46 + 0.54	22.63	18.60	88.20	14.20	100	81.04
Rimsulfuron	0.04	13.60	30.99	67.72	29.10	9.61	0
Foramsulfuron	0.03	100	77.05	100	84.59	100	45.33
		3rd planting date (5 July)					
Weedy check	_	0	0	0	0	0	0
Weed free check	_	100	100	100	100	100	100
Atrazine + Alachlor	1.5 + 1.92	100	100	100	71.09	67.80	64.84
2,4-D+ MCPA	0.36 + 0.31	59.40	40.01	69.80	42.50	100	80.66
Rimsulfuron	0.02	57.60	15.56	66.06	25.66	61.02	33.00
Foramsulfuron	0.06	100	84.67	100	100	74.45	72.40
Atrazine + Alachlor	1 + 2.44	100	67.50	100	61.00	64.54	34.28
2,4-D+ MCPA	0.46 + 0.54	15.56	14.44	60.00	1.34	100	87.90
Rimsulfuron	0.04	18.78	17.58	61.23	58.30	51.35	13.54
Foramsulfuron	0.03	100	77.39	100	91.84	84.12	59.88
Standard error (df =54)		1.62	0.009	0.02	6.44	4.17	0.34
LSD (0.05)[b]		18.54	0.05	0.05	19.81	15.46	9.82

[a] WAP, weeks after planting.
[b] Least significant difference at P = 0.05.
Analyze based on $(x + 0.5)^{1/2}$ transformation of original data

Maize grain yield and yield components

The effect of weed interference on maize grain yield was considerable relative to the hand- weeded controls. Maize yields in the weedy checks were reduced by approximately 77 and 64% during 2007 and 2008, respectively (Tables 4 and 5). All herbicide treatments improved maize grain yields compared to the weedy check. In both years, weed free check in the 2nd planting date had the highest maize grain yield (11.27 t/ha in 2007 and 16.82 t/ha in 2008). Foramsulfuron and atrazine plus alachlor at both applied rates in the 2nd planting date, achieved next to the highest maize grain yield (Tables 4 and 5). In both years, rimsulfuron at 0.02 and 0.04 kg a.i. P ha^{-1} in all planting dates didn't completely control weeds and therefore, maize grain yield decreased. In both years in 2nd and 3rd planting dates, none of the herbicide treatments showed significant effect on number of rows per cob, but the higher number of row per cob was observed in plots treated with herbicides (Tables 4 and 5).

Table 4. Effect of herbicide application and planting date on grain yield, grain 1000 weight, number of grain per row, number of row per ear and number of grain per ear in 2007.

Treatments	Dose (kg a.i. P ha^{-1})	Grain yield (t/ha)	1000 grain weight (g)	Number of kernel per row	Number of row per cob	Number of kernel per cob
First planting date (5 May)						
Weedy check	_	0.02	26.95	2.00	3.30	7.66
Weed free check	_	0.29	101.10	4.00	6.67	26.66
Atrazine + Alachlor	1.5 + 1.92	0.07l	50.00	3.00	4.30	12.67
2,4-D+ MCPA	0.36 + 0.31	0.04	40.28	4.00	3.00	10.32
Rimsulfuron	0.02	0.03	37.50	2.70	3.60	9.67
Foramsulfuron	0.06	0.16	35.60	4.00	6.00	21.33
Atrazine + Alachlor	1 + 2.44	0.08	50.00	3.20	4.33	14.67
2,4-D+ MCPA	0.46 + 0.54	0.04	29.17	2.70	3.30	8.70
Rimsulfuron	0.04	0.02	31.94	2.30	3.30	7.67
Foramsulfuron	0.03	0.14	81.94	3.40	6.32	18.67
2nd planting date (5 June)						
Weedy check	_	2.60	208.00	13.70	11.70	162
Weed free check	_	11.27	317.70	37.00	14.00	518.30
Atrazine + Alachlor	1.5 + 1.92	6.66	269.00	31.30	13.00	408
2,4-D+ MCPA	0.36 + 0.31	4.35	226.00	23.20	13.00	336
Rimsulfuron	0.02	3.09	221.60	17.30	12.00	204.70
Foramsulfuron	0.06	6.92	265.70	30.67	13.30	406.34
Atrazine + Alachlor	1 + 2.44	5.63	270.00	25.30	14.00	351.2
2,4-D+ MCPA	0.46 + 0.54	4.96	240.00	23.00	12.00	276.2
Rimsulfuron	0.04	3.85	217.33	29.00	11.70	328.3
Foramsulfuron	0.03	6.74	280.70	27.67	13.67	375
3rd planting date (5 July)						
Weedy check	_	1.30	108.70	9	12.67	132.33
Weed free check	_	6.07	212.00	23.30	14.00	327.7
Atrazine + Alachlor	1.5 + 1.92	4.73	167.70	19.10	13.67	251
2,4-D+ MCPA	0.36 + 0.31	2.56	150.00	14.30	13.00	175
Rimsulfuron	0.02	1.37	129.00	12.00	12.00	160.32
Foramsulfuron	0.06	4.70	171.67	18.70	14.67	239.7
Atrazine + Alachlor	1 + 2.44	3.27	168.00	18.00	12.67	231.7
2,4-D+ MCPA	0.46 + 0.54	3.04	164.66	15.00	14.00	214.3
Rimsulfuron	0.04	2.23	144.63	13.00	13.00	177.3
Foramsulfuron	0.03	4.78	172.50	20.40	14.00	285
Standard error (df =54)		0.24	0.84	0.16	0.81	1.85
LSD (0.05)[a]		0.80	54.79	6.36	0.49	2.22

[a] Least significant difference at P = 0.05.
Analyze based on $(x + 0.5)^{1/2}$ transformation of original data

Table 5. Effect of herbicide application and planting date on grain yield, grain 1000 weight, number of grain per row, number of row per ear and number of grain per year in 2008.

Treatments	Dose (kg a.i. P ha^{-1})	Grain yield (t/ha)	1000 grain weight (g)	Number of kernel per row	Number of row per cob	Number of kernel per cob
First planting date (5 May)						
Weedy check	_	0.04	23.45	2.65	3.30	9.00
Weed free check	_	0.21	107.40	6.70	6.70	44.00
Atrazine + Alachlor	1.5 + 1.92	0.09	45.75	5.32	4.00	23.00
2,4-D+ MCPA	0.36 + 0.31	0.05	28.16	4.67	3.00	14.33
Rimsulfuron	0.02	0.06	30.99	3.62	3.60	13.00
Foramsulfuron	0.06	0.17	88.60	6.33	6.00	36.67
Atrazine + Alachlor	1 + 2.44	0.10	54.64	5.30	4.00	23.00
2,4-D+ MCPA	0.46 + 0.54	0.06	30.43	3.00	3.25	11.33
Rimsulfuron	0.04	0.04	21.90	3.71	3.22	12.33
Foramsulfuron	0.03	0.18	92.70	5.66	6.30	35.30
2nd planting date (5 June)						
Weedy check	_	5.82	245.00	28.00	13.00	364.00
Weed free check	_	16.82	339.30	45.30	16.00	726.69
Atrazine + Alachlor	1.5 + 1.92	14.43	304.00	40.33	14.00	560.00
2,4-D+ MCPA	0.36 + 0.31	10.52	301.17	36.00	13.00	470.70
Rimsulfuron	0.02	8.90	289.00	31.00	13.00	409.68
Foramsulfuron	0.06	12.8	304.50	45.50	15.00	637.00
Atrazine + Alachlor	1 + 2.44	12.0	289.00	40.00	14.67	560.00
2,4-D+ MCPA	0.46 + 0.54	8.99	248.31	29.27	13.33	392.30
Rimsulfuron	0.04	9.17	283.00	31.00	13.00	404.32
Foramsulfuron	0.03	10.32	304.00	37.25	14.00	561.00
3rd planting date (5 July)						
Weedy check	_	4.35	140.33	29.18	12.00	433.30
Weed free check	_	11.46	247.00	46.20	14.00	648.67
Atrazine + Alachlor	1.5 + 1.92	7.49	195.70	44.00	13.00	572.00
2,4-D+ MCPA	0.36 + 0.31	5.37	183.32	41.32	12.00	496.00
Rimsulfuron	0.02	4.67	175.60	29.00	13.30	388.00
Foramsulfuron	0.06	8.21	211.70	44.27	14.00	560.70
Atrazine + Alachlor	1 + 2.44	7.53	211.30	43.67	14.00	552.70
2,4-D+ MCPA	0.46 + 0.54	6.27	202.00	40.30	14.00	568.70
Rimsulfuron	0.04	4.96	147.60	38.29	13.00	493.30
Foramsulfuron	0.03	7.95	210.70	43.23	14.00	606.00
Standard error (df =54)		8.6	0.48	0.04	1.32	1.34
LSD (0.05) [a]		4.80	1.52	0.35	1.88	1.89

[a] Least significant difference at P = 0.05.
Analyze based on $(x + 0.5)^{1/2}$ transformation of original data

In 2007, the highest number of kernel per row was obtained with atrazine plus alachlor at 1.5 + 1.92 kg a.i. P ha^{-1} and foramsulfuron at 0.06 kg a.i. P ha^{-1}, in 2nd planting date 31.30 and 30.67, respectively and in 2008, the highest number of kernel per row was obtained with atrazine plus alachlor and foramsulfuron at both applied rates in 2nd planting date and with atrazine plus alachlor, foramsulfuron and 2,4-D +MCPA at both applied rates in 3rd planting date (Table 5). The lowest number of kernel per row was achieved with all treatments in the first planting date in both years. In both years, foramsulfuron and atrazine plus alachlor at both applied rates in the 2nd planting date had the highest 1000-grain weight (Tables 4 and 5). Foramsulfuron at 0.06 kg a.i. P ha^{-1}, atrazine plus alachlor at 1 + 2.44 kg a.i. P ha^{-1}, atrazine plus alachlor at 1.5 + 1.92 kg a.i. P ha^{-1} and foramsulfuron at 0.03 kg a.i. P ha^{-1}

increased 1000 kernel weight 155 and 128%, 142 and 120%, 141 and 118% and 138 and 128% compared with the weedy check in 2007 and 2008, respectively.

The number of kernel per cob plays an important role in determining the final yield of maize. In 2007, foramsulfuron and atrazine plus alachlor at both applied rates in the 2nd planting date had the highest number of kernel per cob (Table 4), and in 2008 foramsulfuron and atrazine plus alachlor at both applied rates in the 2nd and 3rd planting date had the highest number of kernels per cob (Table 5).

DISCUSSION

Weeds control

Results of both years showed that herbicide application and planting date had significant effect on weed dry weight. In both years at 6 and 12 WAP, minimum reduction in weed biomass was obtained with weedy check which was significantly different from the other treatments. Therefore, foramsulfuron at 0.06 kg a.i. P ha^{-1}, foramsulfuron at 0.03 kg a.i. P ha^{-1}, and atrazine plus alachlor at both applied rates provided better weed control compared with the other treatments, respectively, and rimsulfuron at both rates had the worst weed control compared with the other treatments.

In this research, rimsulfuron got the lowest rank among the tested herbicides because rimsulfuron couldn't control dominant broadleaf weeds. Bijanzadeh and Ghadiri (2006) reported that maximum reduction in weed biomass was observed with atrazine plus alachlor at 1 + 2.44 and 1.5 + 1.92 kg a.i. P ha^{-1} and minimum reduction in weed biomass was observed with rimsulfuron at 0.02 and 0.04 kg a.i. P ha^{-1}. Bunting et al. (2005) observed that foramsulfuron applied alone controlled giant foxtail, fall panicum (*Panicum dichotomiflorum*), and redroot pigweed 88, 99 and 99%, respectively. Baghestani et al. (2007) indicated that nicosulfuron and foramsulfuron at 80 and 562.5 g a.i. P ha^{-1}, respectively, provided satisfactory control of broadleaved and grass weeds and rimsulfuron at 10 g a.i. P ha^{-1}controlled grass weeds in maize.

Results showed that weed dry weight was 2.3 times or more in early (5 May) compared with late (5 July) planting date. Reduced weed control by herbicide application at the early planting date was generally the result of re-infestation after application. The effectiveness of overall weed control at the late planting date was primarily due to lower weed population densities and a shorter duration of weed emergence after planting and therefore less re-infestation after herbicide application. Gower et al. (2002) reported that in the late planting date, average giant foxtail population density was 25 to 59% lower than early planting date. Broadleaf weed population densities were approximately 40% lower in the late-planted compared with the early-planted maize.

Maize grain yield and yield components

Results of both years showed that herbicide application and planting date had significant effect on maize grain yield. The highest maize grain yield were obtained with foramsulfuron in both applied rates in the 3rd planting date and 2nd planting date, respectively, and the lowest maize grain yield was obtained with rimosolforun in both applied rates and 2,4-D + MCPA at 0.36 + 0.31 kg a.i. P ha^{-1} in the first planting date. Bijanzadeh and Ghadiri (2006) indicated that atrazine plus alachlor at 1 + 2.44 and 1.5 + 1.92 kg a.i. P ha^{-1} had the highest maize yield, and maize grain yield decrease with rimsulfuron 0.02 and 0.04 and primisulfuron plus prosulfuron at 0.02 + 0.02 and 0.03 + 0.03 kg a.i. P ha^{-1} due to poor control of broadleaf weeds. Salarzai (2001) reported that the grain yield was significantly affected by different herbicides. Herbicide by reducing weed density increased the grain yield.

Research showed that maize planted earlier than normal for the region can produce yield equal to or greater than maize planted later than normal (Swanson and Wilhelm 1996). Nafziger (1994) showed accelerating decline in yield as planting date is advanced or delayed from the optimum. Cirilo and Andrade (1994) reported that early-planted maize had lower radiation use efficiency from emergence to silking compared with later-planted maize. Differences in radiation use efficiency among seedlings planted at different times may, in part, explain the reduced yield for maize planted before the optimum date. Kernel number is the yield component that most influences grain yields of maize (Cox et al. 2006). Evans et al. (2003b) reported that early season weed competition reduced kernel number. Reduced levels of yield and yield components at the earlier planting dates may have been the result of lower soil temperatures, which slowed emergence, plant growth, and development. In some locations, yields were reduced by early planting because ear development occurred after a period of sever drought (Norwood 2001).

In this study, all treatments in the first planting date had lowest maize grain yield and yield components because in this planting date we encountered with cricket and prevalence of maize dwarf mosaic virus. Also because of shortening of growing season in third planting date and bad environmental conditions for anthesis and unsuitable filling grain in this planting date, grain yield decreased. While delaying planting may be beneficial for weed control, it may reduce crop yield potential (Buhler and Gunsolus 1996). These results do indicate that rates of development and growth and yield are greatest when maize is planted near the optimum time. Results of this study indicate that grain yield and yield component values were greatest for maize planted near 5 June and decreased for either earlier or later planting. This result agrees with the research conducted by Nafziger (1994), in which an optimum date of planting exists and that planting before or after that optimum date results in yield reduction.

Results of both years showed that planting date and herbicide type had significant effect on weed dry weight and corn yield. The 3rd planting date had the lowest weed dry weight. The effectiveness of overall weed control at the late planting date was primarily due to lower weed population densities and a shorter duration of weed emergence after planting, and therefore less re-infestation after herbicide application. Foramsulfuron at 0.06 kg a.i. P ha^{-1} and atrazine+ alachlor at 1.5+ 1.92 kg a.i. P ha^{-1} in 3rd planting date had lowest weed dry weight and in 2nd planting date had the highest maize grain yield.

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