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Weed Control and Grain Yield Response to Nitrogen Management and Herbicides

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ABSTRACT

In order to investigate the effect of herbicides application and nitrogen (N) levels on weed control and grain yield of corn, two field experiments were conducted in 2007 and 2008. The treatments consisted of four levels of 50, 100, 150, and 200 kg N P ha^{-1} as main plots and herbicides including atrazine plus alachlor at 1+2.44 and 1.92+1.5, 2, 4-D plus MCPA at 0.36+0.31 and 0.54+0.46, rimsulfuron at 0.02 and 0.04 and foramsulfuron at 0.03 and 0.06 kg a.i. P ha^{-1} were the sub factors. A weed-free and a weedy check were also included. The results revealed that increased levels of applied nitrogen tended to enhance the total weed biomass significantly. Foramsulfuron controlled field bindweed (*Convolvulus arvensis* L.) effectively in both years. Redroot pigweed (*Amaranthus retroflexus* L.) was satisfactorily controlled by foramsulfuron in both years. Rimsulfuron and 2,4-D plus MCPA had the highest redroot pigweed dry weight and controlled chinese-lantern-plant (*Physalis alkekengii* L.) less effectively compared with field bindweed and redroot pigweed. Addition of N increased the competitive ability of corn against weeds and resulted in higher grain yield. Foramsulfuron controlled weeds effectively and caused significant increase in corn grain yield between 44 and 66% higher than weedy check in both years.

Key Words: Herbicide, nitrogen, weed control, grain yield.

INTRODUCTION

Maize is a major crop in Iran and ranks third, behind wheat and rice in hectares grown (FAO 2005). Grain yield in maize can be severely reduced by competition with weeds (Najafi and Tollenaar 2005). Managing for increased competitive ability of crops with weeds is an important component of integrated weed management systems (Gill *et al.*, 1997, Mohler 2001). Effective fertilizer management may be able to reduce weed interference with crops (Di Tomaso 1995, O'Donovan *et al*. 2001). Nitrogen is the major nutrient added to increase crop yield (Raun and Johnson 1999), but it is not always recognized that altered soil fertility levels can markedly affect crop-weed competitive interactions.

In Iran, herbicides have been the main means of weed control for more than 30 years (Zand *et al*., 2007). Today, high-yielding agriculture heavily depends on herbicides, as they constitute a vital and integral component of weed management practices (Rao 2000, Baghestani *et al*., 2005). However, there are very few herbicide options available for weed control in maize in Iran (Hadizadeh *et al*., 2006). And, 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. One alternative tactic based on herbicides to manage herbicide-resistant weeds may include the use of newly released dual purpose herbicides with new modes of action. Using these herbicides, it will be possible to switch from high-dose to low-dose herbicides, providing rotational options with current herbicides, and thus increasing the number of modes of action available for use. Foramsulfuron, and rimsulfuron are among the newly released dual purpose sulfonylurea herbicides. These herbicides have been reported to be very effective on grasses, broadleaved weeds, and rhizomatous perennial temperate weeds in maize (Koeppe *et al*., 2000, Lum *et al*., 2005). Information on the impact of several management techniques, i.e., herbicide rates and fertilizer application, is needed for developing a reliable integrated weed management (IWM). Therefore, this study was concerned with effects of different management inputs of nitrogen fertilizer and herbicide rates on the yield of corn and weed biomass.

MATERIALS AND METHODS

Field experiments were conducted in 2007 and 2008 in Kooshkak research center of college of agriculture, Shiraz University, Iran. The study area soil was clay loam, with a mean pH of 7.7 and mean soil organic matter content of 0.6% for both years. The experimental design was split-plot with a randomized complete block arrangement with three replications. The main-plot factor consisted of four N application rates. Herbicides comprised levels of the split-plot factor. The four N application rates selected were 50, 100, 150 and 200 kg pure N/ha that 1/3 of the nitrogen was applied immediately after sowing and the remaining 2/3 was used at the 6-8 leaf stage. Nitrogen fertilizer was applied as urea recourse. Herbicides including atrazine plus alachlor at 1+2.44 and 1.92+1.5, 2, 4-D plus MCPA at 0.36+0.31 and 0.54+0.46, rimsulfuron at 0.02 and 0.04 and foramsulfuron at 0.03 and 0.06 kg a.i. P ha^{-1} were the sub factors. All treatments were applied with a hand sprayer equipped with Flat Fan nozzle at a pressure of 291 kPa. A weed-free and a weedy check were also included. A corn hybrid Sc

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704 was planted on June 3 in 2007 and on June 17 in 2008, respectively. Final plant populations averaged 80,000 plants P ha^{-1} and were similar between both years. Weed parameters were assessed from 50×50 cm stable quadrate placed randomly in plots. Within each quadrate, weed species were identified, counted, clipped at ground level and oven-dried at 80°C for 48h, then weighed to determine their dry matter. The counting of weeds were made 6 and 12 weeks after maize planting. Maize was harvested at economic maturity in both years, and maize grain yield was obtained from an area of $1m^2$ of plots and adjusted to %12 moisture content. All data were subjected to analysis of variance (ANOVA) using SAS statistical software (SAS Institute 2000). The assumptions of variance analysis were tested by insuring that the residuals were random, homogenous, with a normal distribution about a mean of zero. The weed biomass and maize yield data were subjected to transformation where required. Data were analyzed separately by year because weather conditions, planting dates and weed species were different at each year.

RESULTS AND DISCUSSION

Weed biomass

Total weed biomass varied with year and fertilizer treatments. In 2007, the first weed evaluation conducted at 6 week after planting (WAP) showed weed biomass was not affected by N application (P>0.05). Nonetheless, increased levels of applied nitrogen tended to enhance the weed biomass from 31.36 to 51.62 g P m^2. The second weed assessment managed at 12WAP showed that increase in applied fertilizer caused to augment the weed biomass significantly (P<0.05). The greatest weed biomass was observed in 200 kg N P ha^{-1} with 215.83 g P m^2, and no significant differences were observed among the three highest nitrogen levels. The N50 was among treatments with the lowest weed biomass (163.47 g P m^2), indicating that weed growth responded positively to higher soil N levels. Iqbal and Wright (1997) reported that low N supply significantly (P<0.001) decreased plant dry weight of weed species, They indicated low N supply decreased net photosynthetic rate (P_n) that resulted in decreases in dry weight of weeds. Sheibani and Ghadiri (2011) also found that the lowest weed biomass was obtained from N0 plots. However, in contrast to these results, Jornsgard *et al.* (1996) reported that an increased level of applied N tended to decrease the total weed biomass. In 2008, N application significantly (P<0.05) affected weed biomass at 6 WAP. The highest weed biomass recorded from 200 kg N P ha^{-1} (25.85 g P m^2), and no significant differences are observed among the three highest nitrogen levels. At 12WAP, observed results were similar to 6WAP.

For the three weed species analyzed individually, the species showed variation in their growth response to increasing levels of nitrogen (data not shown). No significant effect of nitrogen level was found on biomass of field bindweed at both weed evaluations in any years; although there was a tendency for the highest biomass to occur at N150 and N50, at 12WAP in first year. It can therefore be assumed that field bindweed in competition with other weeds had a lower biomass at N200 than the N150 and N50. Weeds may be more competitive when fertility is enhanced with N addition because of the superior uptake efficiency of many weed species (Di Tomaso 1995) and nutrient availability can modify competitive interactions between species. Because of an indirect effect of nitrogen, the lower crop biomass at low nitrogen levels allowed more light to reach the weeds, thereby increasing the weed biomass with time compared with higher levels of applied nitrogen.

The data showed that nitrogen had significant effect (p<0.05) on biomass of redroot pigweed at the first weed assessment in any year and there was increase in weed biomass with addition levels of applied nitrogen. At the second weed evaluation, nitrogen level did not influence the biomass of redroot pigweed However, there was a trend for the maximum biomass at N150 and N50. Similar to field bindweed, this was likely due to competitive inhibitor effect of chinese-lantern-plant at N200 (with 125.56 g P m^2 dry matter).

Chinese-lantern-plant biomass also was not affected by N application (P>0.05) in both weed evaluations. But at first weed assessment, the highest weed biomass was obtained from N150 plots while its density was maximum at the highest nitrogen level.

The data revealed that various herbicides had significant effect (P<0.05) on total weed biomass at both weed evaluations in any year; the highest weed biomass was obtained from untreated plots while minimum obtained from weed check plot. At both weed evaluations in any year, among herbicides, rimsulfuron at 0.02 kg a.i. P ha^{-1} had the highest weed biomass while foramsulfuron and atrazine plus alachlor at two applied rates had the less weed biomass (data not shown). This result agrees with Bijanzadeh and Ghadiri (2006) who found that atrazine plus alachlor at two applied rates had the lowest total weed biomass, and rimsulfuron and 2, 4- D plus MCPA at two applied rates had the highest total weed biomass. Zaremohazabieh and Ghadiri (2011) reported that foramsulfuron and atrazine plus alachlor at both applied rates provided better weed control, and rimsulfuron at both rates had the worst weed control compared with the other treatments. Nosratti *et al.* (2007) stated that among SU herbicides, rimsulfuron had the highest weed dry matter while foramsulfuron had less weed dry matter. Baghestani *et al.* (2007) also found that foramsulfuron at the highest rate provided satisfactory control of broadleaved and grass weeds in maize.

Interaction effect of nitrogen and herbicide on total weed biomass showed that in 2007, the highest weed biomass was recorded for weedy check and N150, and 2, 4- D plus MCPA at 0.36+0.31 and N200 at 6 and 12 WAP, respectively (table1). The lowest weed biomass was recorded for foramsulfuron at 0.06 kg a.i. P ha^{-1} and N50 at both weed evaluation. In 2008, the highest weed biomass was recorded for weedy check and N200 at both weed evaluation, and the lowest weed biomass recorded for 2, 4- D plus MCPA at 0.36+0.31 kg a.i. P ha^{-1} and N50 and foramsulfuron at 0.06 kg a.i. P ha^{-1} and N50 at 6 and 12 WAP, respectively (Table 1).

For the three weed species analyzed individually, the species showed variation in their growth response to different herbicides. Data showed that at 6 WAP, herbicides had significant effect on field bindweed biomass. Foramsulfuron was the best treatment and decreased weed dry matter by 94% and 95% when applied at the highest rate, and compared to the best treatment, 2, 4- D plus MCPA at 0.36+ 0.31 kg a.i. P ha^{-1} had minimum weed biomass, 91% and 75% weed dry matter reduction in 2007 and 2008, respectively. Bijanzadeh and Ghadiri (2006) showed that 2, 4- D plus MCPA controlled field bindweed between 84% and 100%, while rimsulfuron controlled it between 46% and 53%. They reported that atrazine plus alachlor was highly active on field bindweed. At 12 WAP, the highest reduction in field bindweed biomass was achieved with 2, 4- D plus MCPA (over 81%). Foramsulfuron caused negative impact on field bindweed growth and as a result biomass production (between 47% and 77%) in both years, but in 2008, 2, 4- D plus MCPA at 0.54+ 0.46 was less effective than foramsulfuron, only 63% weed biomass reduction. Similar to 6 WAP, the highest weed biomass was obtained from rimsulfuron (from 22% to 42% reduction in weed biomass) and atrazine plus alachlor (from 39% to 44% biomass reduction), and they were not significantly different from weedy check. Our results are not consistent with finding of Bijanzadeh and Ghadiri (2006) who reported that field bindweed biomass reduction was highest when treated by 2, 4- D plus MCPA and after weedy check. Rimsulfuron had the maximum field bindweed biomass.

Interaction effect of nitrogen and herbicide on field bindweed showed that in 2007, the highest field bindweed biomass was obtained from weedy check and N150, and atrazine plus alachlor at 1+2.44 and N150 at 6 and 12 WAP, respectively (table 2). The lowest field bindweed biomass was obtained from 2, 4- D plus MCPA at 0.36+0.31 and N200 in both weed evaluations. In 2008, the maximum field bindweed biomass was recorded for weedy check and N200 in both weed evaluations, and the minimum for foramsulfuron at 0.06 and N150, and 2, 4- D plus MCPA at 0.36+0.31 and N100 at 6 and 12 WAP, respectively (Table 3). In our study, application of foramsulfuron gave field bindweed control similar to that obtained by 2,4-D plus MCPA. This result indicates that dual purpose herbicides did not have any superiority on current broadleaved weed herbicide 2,4-D plus MCPA.

In the case of redroot pigweed, dry matter at both weed evaluations affected significantly ($P<0.05$) by varios herbicides in both years. At 6WAP, foramsulfuron and atrazine plus alachlor were the most effective herbicides and decreased redroot pigweed dry matter over 92% in 2007 and at least 85% in 2008. As observed, rimsulfuron and 2, 4- D plus MCPA acted poorer on redroot pigweed compared with foramsulfuron and atrazine plus alachlor; however, redroot pigweed biomass reduction was 85% when sprayed with 2, 4- D plus MCPA at 0.36+0.31 in 2008. Similar results were obtained for 6WAP, at 12WAP, redroot pigweed biomass reduction was highest when foramsulfuron and atrazine plus alachlor were applied, and percent redroot pigweed biomass reduction ranged from 88% to 93% by foramsulfuron and from 64% to 82% by atrazine plus alachlor in 2007, and from 84% to 91% by foramsulfuron and from 83% to 86% by atrazine plus alachlor in 2008. Pitter *et al.* (1985) stated that the tank mixtures of atrazine at 2 kg a.i. P ha^{-1} with alachlor at 1.4 kg a.i. P ha^{-1} provided 99% control of redroot pigweed. redroot pigweed biomass reduction was 26% to 59% by rimsulfuron and 37% to 42% by 2, 4- D plus MCPA in 2007, and 36% to 53% by rimsulfuron and 49% to 58% by 2, 4- D plus MCPA in 2008. Contrary to our results, Koeppe *et al.* (2000) reported that rimsulfuron was very effective on broadleaved weeds such as *Amaranthus retroflexus* L. (redroot pigweed) and C. album. Jeffrey *et al.* (2005) reported that redroot pigweed was controlled excellent (99%) with foramsulfuron alone.

Intraction effect of nitrogen and herbicide on redroot pigweed showed that in 2007, the highest redroot pigweed biomass was obtained from weedy check and N200 and rimsulfuron at 0.04 and N200, and the lowest obtained from foramsulfuron at 0.06 and N50 and atrazine plus alachlor at 1+2.44 and N100 at 6 and 12 WAP, respectively (Table 2). In 2008, the maximum redroot pigweed biomass was recorded for weedy check and N200, and the minimum for 2, 4- D plus MCPA at 0.36+0.31 and N50 and foramsulfuron at 0.03 and N100 at 6 and 12 WAP, respectively (Table 3).

Table 1. Intraction effect of nitrogen and herbicide on total weed biomass (g/m^2) in 2007 and 2008.

		2007							
Herbicides	**Dose (kga.i./ha)**	**6 WAP**[a]				**12WAP**			
		50	**100**	**150**	**200**	**50**	**100**	**150**	**200**
Atrazine+Alachlor	1+2.44	42.80	24.66	46.93	55.26	173.29	121.13	204.41	115.94
Atrazine+Alachlor	1.5+1.92	18.33	42.66	45.33	37.93	108.96	70.81	170.98	139.40
2,4-D+MCPA	0.36+0.31	19.26	38.46	44.73	38.90	214.68	226.62	268.53	382.46
2,4-D+MCPA	0.54+0.46	47.40	25.26	58.06	64.60	214.96	202.85	220.38	331.05
Rimsulfuron	0.02	41.40	45.80	57.88	85.13	172.73	325.84	317.93	337.60
Rimsulfuron	0.04	40.66	80.86	64.00	75.53	205.08	233.57	278.80	316.05
Foramsulfuron	0.03	37.33	16.06	12.73	9.86	210.85	124.01	78.78	82.57
Foramsulfuron	0.06	1.01	6.22	7.97	8.66	64.44	105.72	169.18	113.36
Hand weeded	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Untreated	-	65.42	107.40	175.53	140.34	269.69	277.98	352.21	339.84
LSD (0.05)		38.17				102.5			

		2008							
Herbicides	**Dose (kga.i./ha)**	**6 WAP**				**12WAP**			
		50	**100**	**150**	**200**	**50**	**100**	**150**	**200**
Atrazine+Alachlor	1+2.44	35.16	17.21	17.60	24.66	47.50	55.18f	140.85	74.96
Atrazine+Alachlor	1.5+1.92	11.56	11.53	17.26	20.13	62.78	58.44	70.88	97.65
2,4-D+MCPA	0.36+0.31	2.86	7.56	9.66	4.64	100.92	89.57	70.90	100.22
2,4-D+MCPA	0.54+0.46	14.98	42.25	34.44	7.90	86.53	90.62	69.97	186.78
Rimsulfuron	0.02	10.53	54.44	27.83	42.04	107.58	180.22	113.66	149.26
Rimsulfuron	0.04	10.76	14.68	52.92	28.58	149.86	122.41	150.89	119.58
Foramsulfuron	0.03	15.17	11.84	6.00	16.76	70.96	52.44	57.66	57.94
Foramsulfuron	0.06	3.80	3.53	3.32	2.66	46.42	14.20	30.38	38.92
Hand weeded	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Untreated	-	28.85	43.12	71.66	111.08	165.73	176.65	224.25	291.38
LSD (0.05)[b]		9.05				16.05			

[a]WAP, week after planting.

[b] Least significant difference at P = 0.05.

Analyze based on $(x + 0.5)^{1/2}$ transformation of original data.

Table 2. Intraction effect of nitrogen and herbicide on weed biomass (g/m^2) at 6 and 12 weeks after planting in 2007.

							6 WAP						
Herbicides	**Dose (kga.i./ha)**	***C. arvensis***				***A. retroflexus***				***P. alkekengi***			
		50	**100**	**150**	**200**	**50**	**100**	**150**	**200**	**50**	**100**	**150**	**200**
Atrazine+Alachlor	1+2.44	35.73	8.00	44.00	52.53	1.46	2.13	2.93	2.73	4.00	12.53	0.00	0.00
Atrazine+Alachlor	1.5+1.92	16.80	38.66	41.46	3.33	1.53	2.53	3.46	2.86	0.00	1.46	0.00	1.73
2,4-D+MCPA	0.36+0.31	0.00	13.20	10.66	0.80	11.27	17.80	29.93	20.36	6.93c	6.53	3.86	17.20
2,4-D+MCPA	0.54+0.46	27.06	3.60	20.40	16.00	11.00	18.33	29.53	31.40	8.00	2.93	8.13	16.50
Rimsulfuron	0.02	23.33	22.80	0.00	33.46	10.60	20.33	25.88	33.53	7.46	2.26	31.60	16.53
Rimsulfuron	0.04	24.80	48.93	32.40	35.73	10.93	23.93	23.73	28.87	4.26	5.86	7.33	10.00
Foramsulfuron	0.03	27.73	13.46	8.26	6.66	1.46	2.60	2.86	3.20	8.13	0.00	1.33	0.00
Foramsulfuron	0.06	0.00	4.09	5.57	5.86	1.01	2.13	2.40	2.80	0.00	0.00	0.00	0.00
Hand weeded	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Untreated	-	39.33	58.40	99.86	83.21	17.40	30.73	40.33	41.67	8.66	17.32	28.00	14.26
LSD (0.05)		7.04				5.13				9.47			
							12 WAP						
Herbicides	**Dose (kga.i./ha)**	***C. arvensis***				***A. retroflexus***				***P. alkekengi***			
		50	**100**	**150**	**200**	**50**	**100**	**150**	**200**	**50**	**100**	**150**	**200**
Atrazine+Alachlor	1+2.44	102.56	38.50	194.26	100.97	30.20	3.33	6.21	6.00	4.84	72.53	3.93	0.00
Atrazine+Alachlor	1.5+1.92	56.26	44.73	77.26	112.32	29.09	12.80	23.69	24.02	0.00	0.00	0.00	1.60
2,4-D+MCPA	0.36+0.31	6.12	6.81	61.84	0.66	37.18	22.00	48.40	36.06	154.2	197.81	115.56	345.73
2,4-D+MCPA	0.54+0.46	19.90	11.76	20.49	32.74	48.30	38.57	52.26	18.26	146.74	145.68	141.77	266.26
Rimsulfuron	0.02	50.04	93.14	84.62	56.13	30.46	9.57	37.40	25.46	87.29	191.45	169.10	225.21
Rimsulfuron	0.04	107.86	52.54	77.14	99.74	26.26	58.65	17.25	83.09	69.61	108.77	156.09	130.54
Foramsulfuron	0.03	93.06	65.26	46.52	34.89	11.20	12.66	5.33	0.00	95.65	11.00	20.62	20.82
Foramsulfuron	0.06	39.26	87.93	44.32	41.05	0.00	4.49	11.85	0.00	7.60	11.96	108.18	62.30
Hand weeded	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Untreated	-	92.42	122.48	164.30	71.80	50.18	69.84	71.70	57.94	113.21	83.00	112.70	203.08
LSD (0.05)		1.35				0.68				18.84			

Table 3. Intraction effect of nitrogen and herbicide on weed biomass (g/m^2) at 6 and 12 weeks after planting in 2008.

Herbicides	Dose (kga.i./ha)	*C. arvensis*				*A. retroflexus*			
6 WAP									
		50	**100**	**150**	**200**	**50**	**100**	**150**	**200**
Atrazine+Alachlor	1+2.44	35.16	17.21	16.13	24.66	0.00	0.00	1.46	0.00
Atrazine+Alachlor	1.5+1.92	7.05	7.00	17.26	20.13	4.50	4.53	0.00	0.00
2,4-D+MCPA	0.36+0.31	2.09	1.78	4.86	4.64	0.77	3.20	4.80	0.00
2,4-D+MCPA	0.54+0.46	8.06	35.06	27.60	0.00	3.25	5.52	4.53	7.90
Rimsulfuron	0.02	10.53	40.72	11.74	26.82	0.00	9.59	14.68	15.21
Rimsulfuron	0.04	3.73	14.68	40.04	16.04	4.38	0.00	11.61	12.54
Foramsulfuron	0.03	13.73	11.84	2.44	13.46	0.00	0.00	2.12	3.29
Foramsulfuron	0.06	1.37	3.53	1.33	2.66	0.00	0.00	1.98	0.00
Hand weeded	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Untreated	-	24.18	30.10	51.76	78.64	4.26	10.49	16.96	28.45
LSD (0.05)		1.15				7.34			
12 WAP									
Herbicides	**Dose (kga.i./ha)**	***C. arvensis***				***A. retroflexus***			
		50	**100**	**150**	**200**	**50**	**100**	**150**	**200**
Atrazine+Alachlor	1+2.44	47.40	40.65	86.48	46.92	0.00	14.53	31.01	28.04
Atrazine+Alachlor	1.5+1.92	56.38	20.94	43.65	81.40	0.00	35.33	23.12	0.00
2,4-D+MCPA	0.36+0.31	20.13	4.00	9.00	17.90	47.20	35.08	31.08	68.02
2,4-D+MCPA	0.54+0.46	39.92	5.26	5.54	82.18	36.29	66.21	46.76	69.01
Rimsulfuron	0.02	70.61	82.56	61.09	69.00	17.86	75.98	43.86	63.54
Rimsulfuron	0.04	66.73	49.20	56.61	35.38	50.45	71.37	74.80	79.60
Foramsulfuron	0.03	21.02	29.46	0.00	37.22	22.84	13.13	31.62	0.00
Foramsulfuron	0.06	17.60	14.20	27.36	23.97	25.06	0.00	0.00	14.94
Hand weeded	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Untreated	-	78.13	68.10	100.37	114.34	73.97	78.34	113.40	163.21
LSD (0.05)		15.35				7.37			

Statistical analysis showed significant differences in percent biomass reduction among herbicides. Foramsulfuron and atrazine plus alachlor at two applied rates provided acceptable control of chinese-lantern-plant, but rimsulfuron and 2, 4- D plus MCPA at two applied rates failed to control of chinese-lantern-plant (data not shown). Application of foramsulfuron at the higher rate gave maximum chinese-lantern-plant control by 100% at 6WAP, while after weedy check, rimsulfuron at 0.02 kg a.i. P ha^{-1} resulted in reduction of less than 15%. At 12 WAP, chinese-lantern-plant biomass was higher than weedy check when maize was sprayed with 2, 4- D plus MCPA at two applied rates and rimsulfuron at 0.02 kg a.i. P ha^{-1}. Nevertheless, the highest chinese-lantern-plant biomass reduction (100%) was achieved with atrazine plus alachlor at the higher rate. Our results are in agreement with Bijanzadeh and Ghadiri (2006) who found 2, 4- D plus MCPA at two applied rates did not have acceptable control of chinese-lantern-plant and significant differences existed among 2, 4- D plus MCPA and other treatments.

Intraction effect of nitrogen and herbicide on chinese-lantern-plant showed that the highest chinese-lantern-plant biomass was obtained from rimsulfuron at 0.02 and N150, and the lowest from foramsulfuron at 0.03 and N150 at 6 WAP and at 12 WAP the maximum chinese-lantern-plant biomass was recorded for 2, 4- D plus MCPA at 0.36+0.31 and N200, and the minimum for atrazine plus alachlor at 1.5+1.92 and N200 (Table 2).

Maize grain yield

The data showed that grain yield was variable across both years and N levels had significant ($P<0.05$) effect on grain yield of maize. Results suggest that addition of N improved early season corn growth, which improved the competitive ability of corn against weeds and resulted in a significant ($P<0.05$) increase in grain yield of corn. However, grain yield did not respond to N addition from 100 to 150 kg a.i. P ha^{-1} at first year. This can mainly be due to increase in duration of weed interference and a significant ($P<0.05$) decrease in the number of grain ear, that indicates corn and weeds were competing before anthesis rather than after. Since the weed dry matter was higher in N200, this was an expected finding as grain yield responded negatively to highest soil N level. Nevertheless, in many cases, high crop N fertilization can provide both crop and weed with enough nutrients, and because of this weed competitive ability was reduced and as a result yield increased (Di Tomaso 1995).

In general, in 2008 the grain yield was higher than 2007. The increased yield during 2008 than in 2007 growing season could be attributed to the greater competitive ability of corn during that growing season as a result of the favorable weather condition and reduction in weed diversity and density.

Results indicated that different herbicides had significant ($P<0.05$) effect on grain yield of maize at both years. The maximum maize grain yield was recorded in hand weeded check plots while minimum grain yield was recorded in untreated check plots (data not shown). Corn grain yield reduction was 69% and 53% in the weedy check compared with the weed-free control in 2007 and 2008, respectively. This is due to weed interference which had caused strong competition between maize and weeds for growth factors because these plots had the highest weed dry matter. Then, foramsulfuron had the greatest effect on grain yield and increased maize grain yield higher than herbicidal mixture atrazine pluze alachlor at both years. Corn grain yield increased 66% (at two applied rates) in 2007 and between 44% (at 0.03 kg a.i. P ha^{-1}) and 47% (at 0.06 kg a.i. P ha^{-1}) in 2008 when corn was treated with foramsulfuron compared with the weedy control. This is confirmed by high weed population and biomass reductions in this treatment. As observed, the lowest yielding maize were present in the rimsulfuron and 2, 4- D plus MCPA at two applied rates, respectively. Since the weeds escaped control where maize was sprayed with these herbicides, this could be attributed to their lower range of weed spectrum control.

These results agree with Baghestani *et al.* (2007) who stated that plots treated with 2, 4- D plus MCPA resulted in lowest yield and yield was highest when nicosuluron and fromsulfuron were applied at the highest rate. They reported that rimsulfuron at all rates could not give a satisfactory maize yield. Nosratti *et al.* (2007) also found that rimsulfuron was the weakest herbicide; however herbicidal mixture of atrazine plus alachlor had the greatest effect on grain yield.

Intraction effect of nitrogen and herbicide on maize grain showed that the highest grain yield was obtained from weed-free check and N200 and the lowest grain yield was obtained from weedy check and N50 in both years (Table 4). Presence of weeds and lack of N supply should have caused a reduction in available nitrogen for crop with decrease in yield (below, 1995). Decreased N supply may reduce yield of corn directly by affecting photosynthetic productivity, and indirectly by resulting in increased weed competition. N supply can affect plant growth and productivity by altering both leaf area and photosynthetic capacity (Frederick and Camberato 1995). The low LAI during the silking period indicated that a suboptimal level of photosynthetic photon flux density (PPFD) was being intercepted. This may have reduced the number of kernels being set and affected kernel weight, thus lowering dry matter accumulation and crop yield (Rajcan and Swanton 2001). Dhima and Eleftherohorinos (2001) indicated that nitrogen fertilization (150 kg a.i. P ha^{-1}) slightly increased yield of crops grown without weed competition compared to the (0 kg N). Tollenaar *et al.* (1994) reported that interference from mixed weeds emerging shortly after corn reduced corn biomass, harvest index, and final grain yield to a greater extent at low vs. high levels of soil N.

In conclusion, this study reveals that increased levels of nitrogen tended to enhance the total weed biomass and the progress in early season corn growth with addition of N improved the competitive ability of corn against weeds and resulted in greater grain yield. However, there was no difference among higher N levels. Foramsulfuron at 0.06 kg a.i. P ha^{-1} is a suitable option for post-emergence control of broadleaved and grass weeds in maize in Iran. Since hand weeding is a costly and time-consuming job for a crop such as maize, the use of this herbicide treatment offers an opportunity for an efficient and cost-effective weed control method in maize. Also, 2, 4- D plus MCPA could be replaced by foramsulfuron at 0.06 kg a.i. P ha^{-1} since it gives an acceptable control of broadleaved weeds while it provides satisfactory grass weed control. This would especially be beneficial from an ecological point of view since application of dual purpose herbicides allows recorded herbicide consumption rate.

Table 4. Intraction effect of nitrogen and herbicide on maize grain yield (g/m^2) in 2007 and 2008.

Herbicides	Dose	2007				2008			
	(kga.i./ha)	50	100	150	200	50	100	150	200
Atrazine+Alachlor	1+2.44	549.11	463.26	552.75	631.45	942.40	1073.00	1191.60	1218.80
Atrazine+Alachlor	1.5+1.92	428.05	536.83	554.41	604.18	899.60	1037.73	1237.20	1208.00
2,4-D+MCPA	0.36+0.31	509.01	496.50	395.85	650.83	991.80	1153.40	1036.60	1178.40
2,4-D+MCPA	0.54+0.46	299.81	448.45	345.66	369.50	839.20	953.01	957.93	1234.40
Rimsulfuron	0.02	316.61	527.88	509.13	374.40	800.00	752.00	678.80	1093.00
Rimsulfuron	0.04	353.95	487.05	423.38	478.80	720.13	891.86	874.00	1183.46
Foramsulfuron	0.03	598.68	843.00	729.70	860.26	986.80	1185.00	1124.60	1271.00
Foramsulfuron	0.06	600.45	830.95	753.63	847.40	1051.00	1256.40	1210.80	1325.60
Hand weeded	-	657.86	896.95	868.86	922.91	1143.86	1397.73	1478.66	1481.46
Untreated	-	197.66	216.45	272.60	348.70	509.33	629.60	566.53	861.33
LSD (0.05)		92.43				232.3			

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