World Journal of Agricultural Research, *2013, Vol. 1, No. 2, 25-29*
Available online at http://pubs.sciepub.com/wjar/1/2/1

DOI:10.12691/wjar-1-2-1

Effectiveness of Repeated Reduced Rates of Selective Broadleaf Herbicides for Postemergence Weed Control in Sugar Beet (*Beta Vulgaris*)

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Received January 09, 2013; Revised May 01, 2013; Accepted May 02, 2013

Abstract Field experiments were conducted at three sites (Karaj, Mashhad and Orumieh, Iran), during 2005 to determine the influence of reduced rates of broadleaf herbicides in different combinations on sugar beet and weeds. Experiments were laid out in a randomized complete block design with factorial arrangement of the treatments and three replications. The treatments were 10 different combined herbicides that applied at recommended (full rates) and reduced rates (half rates). Data were recorded 30 days after herbicide application on percentage of weed density and biomass reductions. The data for individual traits were subjected to the ANOVA technique and significant means were separated by the Duncan's multiple range test. The analysis of the data showed that herbicide combinations and herbicide doses were statistically significant for all the parameters investigated except weed frequency reduction at Karaj and Orumieh. The interaction of herbicide combinations and doses could not reach the level of significance in any of the traits examined. The results indicated more efficacies of herbicides combinations when they used repeatedly in low-than labeled dose.

Keywords: *sugar beet, tank mixed herbicides, low dose, weed*

1. Introduction

Broadleaf weeds in sugar beet are a major limitation for profitable sugar production and herbicides are an important tool for their control. The total potential losses from weeds would be between 26 and 100% of the potential sugar beet yield [7,8]. Annual broad-leaved weeds are usually more competitive than annual grasses [8].They often grow to a height two to three times that of sugar beet by mid- summer [4]. Therefore, their control is an essential component of sugar beet production.

Lamb's squarters (*Chenopodium album* L.*)*, Amaranth *(Amaranthus* spp.), Black nightshade (*Solanum nigrum* L.*)*, Bindweed (*Convolvulus arvensis* L.), Prostrate knotweed (*Polygonum aviculare* L.), Jimpsonweed (*Datura stramonium* L.), Mallow *(Malva* spp.), and Blader ketmia (*Hibiscus trionum* L.) are the major broadleaf weeds of sugar beet fields in Iran. Although until 2008, 10 herbicide active ingredients were registered in Iran for Broadleaf weeds control in sugar beet [9], because of the continued losses in sugar beet caused by broadleaf weeds, current herbicide application strategies require reassessment. In addition, the range of weed species controlled by each herbicide is limited and continues and extensive application of current herbicides may also led to herbicide-resistant weed biotypes. Despite widespread farmer adoption of herbicides, there is ever-increasing interest in reducing herbicide doses and overall herbicide use [3]. Successful long-term weed management will require a shift away from simply controlling problem weeds to systems that restrict weed competition with crops. There are a lot of strategies for increasing of herbicide effectiveness. Tank-mixed and repeated reduced rates application of herbicides are two ways to increasing herbicides effects [4,10]. Weed control is often higher from tank-mixed herbicides than from a single herbicide [1,5] and there are a few reasons for the potential successful use of reduced doses, including: i) registered doses are set to ensure adequate control over a wide spectrum of weed species, weed densities, growth stages, and environmental conditions, ii) maximum weed control is not always necessary for optimum crop yields and iii) combining reduced doses of herbicides with other management practices(such as competitive crops) can markedly increase the odds of successful weed control [11]. Many studies have demonstrate good weed control with reduced herbicide doses. When reducing herbicide dose by 50%, its effectiveness varies from 75-100% [4]. For example, Belles *et al.*(2000) reported that a 50% dose of tralkoxydim consistently gave>85% wild oat(*Avena fatua* L.) control in barely(*Hordeum vulgare* L.) [2]. Another results have also shown that it is possible to reduce herbicide doses in sugar beet [6]. However, some authors state that the risk associated with reduced herbicide doses increased in the absence of other weed management practices such as higher crop seed rates or competitive cultivars [3]. Zhang *et al*.(2000), in their discussion on the reliability and risks associated with the use of reduced herbicide doses, stressed the importance of cropping systems that keep weed populations at low levels [11]. Some crops are likely to be more amenable than others to the use of reduced herbicide doses. Competitive ability of crops, inter-row cultivation in row crops and high crop density are three factors that enhance the likelihood of success with reduced herbicide doses [3].

The instant studies were undertaken to evaluate the efficacy of different herbicides mixture used in recommended and reduced doses on dynamic of broad leaf weeds in sugar beet with these objectives: a) to fined out the most effectiveness tank mixture of herbicides for the control of broad leaf weeds in sugar beet crop, b) to evaluate the possibility of broadleaf weeds control with reduced rates of herbicides.

2. Materials and Methods

Field experiments were established in 2005 at the Iranian Research Institute of Plant Protection farms at three locations: Mashhad(59° 15' N, 35° 43' E, 985m a.s.l.), Karaj(35° 41 N, 50° 50 E, 1200m a.s.l.) and Orumieh(37° 21' N, 45° 14' E, 1295 m a.s.l.). The field experiments were laid out in a randomized complete block design with factorial arrangement of the treatments and three replications. The treatments were 10 different combined herbicides (A factor) that applied at recommended (full rate) and 50% lower-than-labeled (half rate)(B factor)(Table 2). In a well-prepared soil (with characteristics that mentioned in Table 1 for each location), the basal dose of NPK was applied. All the phosphorous and potassium were applied at the time of planting, while nitrogen was applied in two split doses, first half at the time of planting and the remaining half at 4-6 true sugar beet leaves. Sugar beet (*Beta vulgaris* cv. Rasoul) was seeded 3-cm deep on May 6(at Mashhad), May 11 (at Karaj) and May 13(at Orumieh), 2005 at a density of 10 plants m^{-2} and rows spaced 55cm apart. The sugar beet cultivars selected for inclusion in this experiment are common cultivars grown in Karaj, Mashhad and Orumieh. Sugar beet was furrow irrigated within 7d of planting to enhance seed germination and seedling emergence.

Herbicide were applied as broadcast treatment in water at 400 Lha^{-1} and 2.5 bar using an Elegance 18 knapsack sprayer(Goizeper S. Cooperative Company, Guipuzcoa, Spain) equipped with a flooding nozzle. In each experimental plot, herbicide combinations just applied to one-half of plot, and the remaining half was kept and used as its control.

Weed number and dry-weight were sampled four week after herbicide application within a fixed 0.5*0.5m quadrate in the herbicide-treated and untreated halves of each plot. The reduction was calculated by dividing the weed biomass in the treated half by the weed biomass in the untreated half and multiplying by 100. Sugar beet injury was also estimated visually 14d after the final herbicide treatment by comparison of each herbicide combinations to nontreated control and by application of rating scale of 0(no injury) to 100(completely killed).

Data recorded for each trait were statistically analyzed to the ANOVA technique by using SAS and MSTAT softwares and means were separated by using Duncan's Multiple Range Test (DMRT). In addition, because the data were converted to percentage of control compared with untreated half, ratings for percentage of weed control were square-root transformed to obtain a more normal distribution, but because no benefit from this transformation was obtained, nontransformed data were used for the analysis.

Table 1. Soil characteristics in each location

Location	Texture	$EC*10^3$	PH	OC(%)
Karaj	Loam	0.786	8.05	0.556
Mashhad	Silty-Loam	1.18	7.7	0.59
Orumieh	Silt	2.12	7.8	1.4

Table 2. Herbicide combinations, application doses and growth stages of sugar beet at the time of herbicide application

Herbicide combination	Application dose[a]	Formulations (g ai/ha)	Application time (leaf stage)[B]
Phenmedipham(EC 15.7%)+chloridazon(WP 80%)	100	942+4000	4TL
Triflusulfuron(DF 50%)+ chloridazon	100	15+4000	2 TL
(Phenmedipham+Desmedipham+ethofumesate)(EC18%) + chloridazon	100	720+ 4000	2 TL
Desmedipham (EC 15.7%)+chloridazon	100	314+ 4000	Cot
Phenmedipham+ metamitron (WP 70%)	100	942+3150	Cot
Desmedipham+ Triflusulfuron	100	314+15	2 TL
(Phenmedipham+Desmedipham+ethofumesate)+ Triflusulfuron	100	720+15	2 TL
Desmedipham+clopyralid (SL 30%)	100	314+150	2 TL
(Phenmedipham+Desmedipham+ethofumesate)+ clopyralid	100	720+150	2 TL
Desmedipham+metamitron	100	314+3150	2 TL
Phenmedipham+chloridazon	50	471+2000	2 TL & 4 TL
Triflusulfuron+ chloridazon	50	7.5+2000	2 TL & 4 TL
(Phenmedipham+Desmedipham+ethofumesate)+ chloridazon	50	360+2000	2 TL & 4 TL
Desmedipham+chloridazon	50	157+2000	Cot & 2 TL
Desmedipham+metamitron	50	157+1575	Cot & 2 TL
Desmedipham+ Triflusulfuron	50	157+15	2 TL & 4 TL
(Phenmedipham+Desmedipham+ ethofumesate)+ Triflusulfuron	50	720+15	2 TL & 4 TL
Desmedipham+ clopyralid	50	314+75	2 TL & 4 TL
(Phenmedipham+Desmedipham+ethofumesate)+ clopyralid	50	720+75	2 TL & 4 TL
Phenmedipham+ metamitron	50	471+1575	2 TL & 4 TL

a: 100%=full rate and 50%=half rate application doses.

b: Abbrevations: Cot, Cotyledon; 2 TL, two-true-leaf; 4 TL, four-true-leaf.

Table 3. Mean squares of percentage frequency and biomass reductions of broadleaf weeds at different locations

Source Of Variation (S.O.V.)	Mean Squares					
	Orumieh		Mashhad		Karaj	
	Frequency	biomass	Frequency	biomass	Frequency	biomass
Rep	22.3 ns	51.3 ns	2.3 ns	0.8 ns	84.7 ns	102.9 ns
Herbicide combinations	206.0 *	226.7 **	691.3 **	566.6 **	1094.5 **	902.8 **
Dose	78.4 ns	1374.1 **	6934.3 **	4577.1 **	1107.6 ns	1810.0 **
Herbicide combinations* Dose	149.5 ns	233.7 **	560.6 **	379.9 **	417.6 ns	219.5 ns
Error	89.3	59.6	14.4	17.0	333.9	155.4
CV(%)	13.5	9.7	5.4	5.6	24.8	17

Ns:no significant, *: significant at (*P=0.05*), and **: significant at (*P=0.01*).

Table 4. Effect of herbicide combinations on percentage of weed density and biomass reduction

Herbicide combinations	Orumieh		Mashhad		Karaj	
	Frequency	biomass	Frequency	biomass	Frequency	biomass
Phenmedipham+chloridazon	77.1 a	86.6 a	68.7 d	75.2 bcd	75.1 abc	90.1 ab
Triflusulfuron+ chloridazon	69.7 ab	75.1 bc	71.6 cd	74.7 cd	68.4 bc	70.1 c
(Phenmedipham+Desmedipham+ethofumesate)+ chloridazon	69.9 ab	86.0 a	72.2 cd	80.3 b	84.7 ab	93.7 ab
Desmedipham+chloridazon	59.6 b	73.7 bc	75.4 c	76.7 bcd	64.8 c	78.3 bc
Phenmedipham+ metamitron	61.9 b	72.0 c	62.0 e	72.9 de	54.3 c	88.6 ab
Desmedipham+ Triflusulfuron	75.7 a	87.3 a	81.4 b	86.1 a	74.9 abc	90.2 ab
(Phenmedipham+Desmedipham+ethofumesate)+ Triflusulfuron	77.1 a	79.7 abc	86.0 a	90.0 a	92.7 a	93.5 ab
Desmedipham+clopyralid	69.0 ab	71.3 c	54.3 f	54.4 f	59.0 c	63.1 c
(Phenmedipham+Desmedipham+ethofumesate)+ clopyralid	69.1 ab	79.8 abc	53.2 f	69.5 e	67.0 bc	67.1 c
Desmedipham+metamitron	70.2 ab	82.7 ab	74.5 c	79.4 bc	93.9 a	95.6 a

The means sharing a letter in common do not differ significantly(P=0.05).

Table 5. Mean percentage of weed density and biomass reductions for the interaction between herbicide combinations and application doses at different locations.

Herbicide combinations (dose)[a]	Mashhad		Orumieh		Karaj	
	Frequency	biomass	Frequency	biomass	Frequency	biomass
Phenmedipham+chloridazon(1)	54.10	67.51	83.45	90.67	62.74	86.56
Phenmedipham+chloridazon(0.5)	83.46	82.91	70.86	82.61	87.52	93.75
Triflusulfuron+ chloridazon(1)	62.60	59.24	67.59	64.18	71.90	58.59
Triflusulfuron+ chloridazon(0.5)	80.69	90.28	71.96	86.02	65.02	81.70
(Phenmedipham+Desmedipham+ethofumesate)+ chloridazon(1)	69.54	84.70	77.83	88.57	74.56	91.70
(Phenmedipham+Desmedipham+ethofumesate)+ chloridazon(0.5)	75.05	75.93	62.16	83.52	94.95	95.71
Desmedipham+chloridazon(1)	63.09	61.80	64.96	65.27	47.88	66.32
Desmedipham+chloridazon(0.5)	87.89	91.74	54.31	82.31	81.83	90.29
Phenmedipham+ metamitron(1)	48.48	66.56	58.43	60.94	52.86	84.73
Phenmedipham+ metamitron(0.5)	75.62	79.26	65.49	83.23	55.80	92.65
Desmedipham+ Triflusulfuron(1)	85.01	86.37	80.53	86.39	87.46	94.16
Desmedipham+ Triflusulfuron(0.5)	77.83	85.99	71.01	88.32	62.36	86.25
(Phenmedipham+Desmedipham+ethofumesate)+ Triflusulfuron(1)	86.68	88.80	80.29	81.80	88.30	92.24
(Phenmedipham+Desmedipham+ethofumesate)+ Triflusulfuron(0.5)	85.37	91.39	73.96	77.69	97.27	94.92
Desmedipham+clopyralid(1)	43.03	41.26	68.91	58.67	52.78	57.87
Desmedipham+clopyralid(0.5)	65.60	67.66	69.27	83.95	65.23	68.41
(Phenmedipham+Desmedipham+ethofumesate)+ clopyralid(1)	23.75	49.13	66.07	73.12	61.33	50.78
(Phenmedipham+Desmedipham+ethofumesate)+ clopyralid(0.5)	82.78	90.04	72.19	86.58	72.85	83.53
Desmedipham+metamitron(1)	56.06	66.98	63.29	77.20	92.53	92.84
Desmedipham+metamitron(0.5)	93.05	91.83	77.26	88.30	95.45	98.42
SE[B]	2.2	2.38	5.46	4.46	10.54	7.2

a: Herbicide application rates :(1)= full rate, (0.5)= half rate
b: Standard error.

3. Results and Discussion

3.1. Weed Flora and Density

The weed spectrum differed among the locations. At Mashhad, *Chenopodium album*, *Amaranthus retroflexus*, and *A. blitoides* dominated the weed flora composition. At Karaj, *Ch. album, A. retroflexus, A. blitoides, Solanom nigrum* and *Hibiscus canabinus* and at Orumieh, *Ch. Album, A. retroflexus* and *Portulaca oleraceae* were the most frequently found. The analysis of variance showed that herbicide combinations were significant statistically at Karaj, Mashhad and Orumieh while doses and interactions of herbicide combinations with dose were only evaluated as significant statistically at Mashhad (Table 3). At Karaj, the best weed control was achieved with Desmedipham + metamitron (93.9%)(Table 4). However, it had significant difference only with Desmedipham + clopyralid (63.1%), (Phenmedipham + Desmedipham + ethofumesate) + clopyralid (67.1%), Triflusulfuron + chloridazon(70.1%) and Desmedipham + chloridazon (78.3%). At Mashhad, (Phenmedipham + Desmedipham + ethofumesate) + Triflusulfuron (80.0%) was the best combination and had the largest effect on weed density reduction. The percentage of weed population reduction although was less satisfactory at Orumieh, may be because of their different weather in compare with other locations. The cooler environmental condition in Orumieh is probably responsible for the reduced effectiveness of the herbicide combinations in this rigion. It is evident from the data in Table 3 that almost similar weed density reduction was recorded in all herbicide combinations. However, the highest weed density reduction was recorded in Phenmedipham + chloridazon and (Phenmedipham + Desmedipham + ethofumesate) + Triflusulfuron (by 77.1% reduction).

In contrast at Orumieh, weed populations were lower in repeated reduced rates (half rates) of herbicide combinations as compared to the full rate applications at Mashhad and Karaj (Figure 1). At Orumieh however, the largest weed population reduction achieved from recommended application of Phenmedipham+chloridazon, while half rate application of Desmedipham+metamitron was the best treatment(P=0.05) (Table 5).

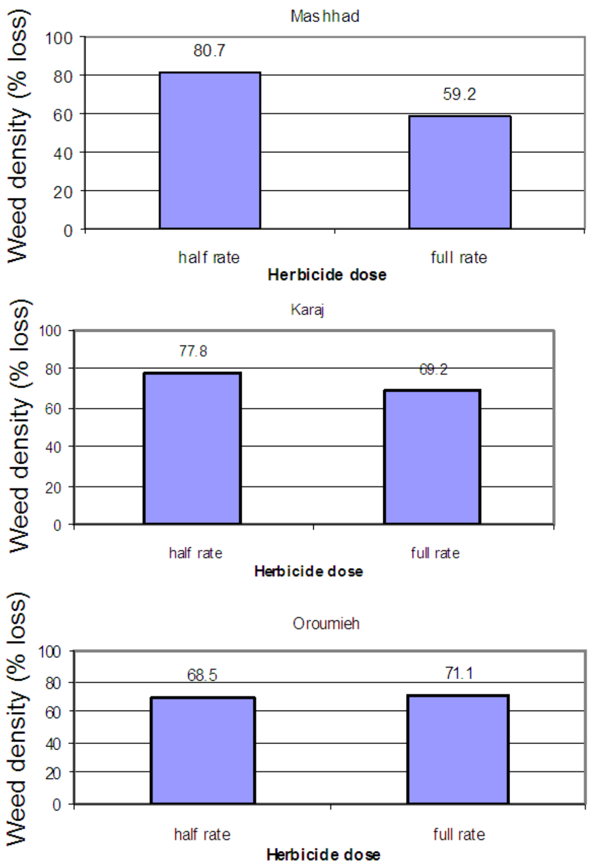

Figure 1. Effect of repeated reduced rates of herbicide combinations as compared to full rates on percentage of weed population reduction at Mashhad, Karaj and Orumieh

Totally, the effect of reduced herbicide doses on weed population reduction was less satisfactory. There are a lot of ways for increasing effectiveness of half rate herbicides application. Integration of reduced herbicide doses with other weed management methods(such as competitive cropping systems) to attain long-term weed management is emphasized in numerous articles [3,11,12]. For example, weed populations are reduced over time and existing weeds are suppressed in those systems employing good agronomic practices and competitive crops. Indeed, reduced doses of herbicides were more efficacious at low than at high weed densities [3]. Thus, any crop production practice that reduces weed populations over time is important to the successful use of reduced herbicide doses.

3.2. Weed Biomass

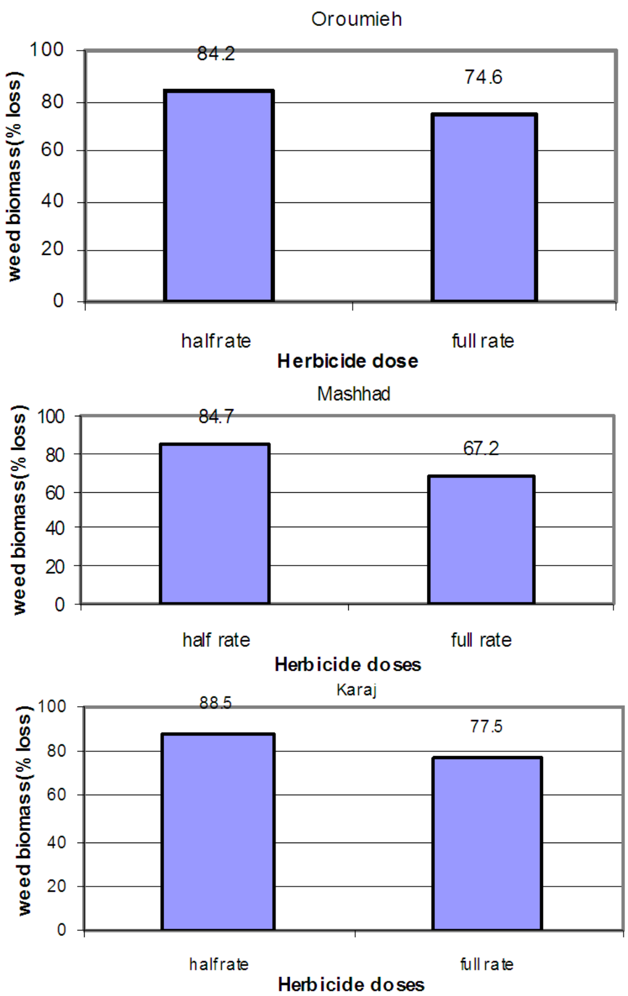

Figure 2. Effect of repeated reduced rates of herbicide combinations as compared to full rates on percentage of weed biomass reduction at Mashhad, Karaj and Orumieh

The analysis of variance showed significant differences between herbicide combinations and application doses (Table 3). The perusal of data in Table 3 exhibits that Desmedipham + metamitron (95.6%), (Phenmedipham + Desmedipham + ethofumesate) + Triflusulfuron(90.0%) and Desmedipham + Triflusulfuron (87.3%) treatments were the three herbicide combinations that had the largest biomass percentage reduction at Karaj, Mashhad and Orumieh respectively (Table 4). The results indicated that these combinations enhanced the performance of herbicides and providing better weed control than when either herbicide is used alone, or when used in separate applications. Half rate doses of herbicides were also reduced weed biomass significantly. This treatment was better than full rate treatment (with significantly difference, $P=0.05$) at three locations (Figure 2). The results indicated that repeated reduced rates (half rates) of herbicide combinations, reduced weed biomass significantly more than recommended rates at different locations (Table 5). In many cases, the weed biomass reductions were more in Karaj than Mashhad and Orumieh. Air temperature, soil moisture and relative humidity all have been reported to affect herbicide efficacy and the importance of this factors only increases with reduced herbicide doses [3]. In addition, any crop production practice that reduces weed populations over time is important to the successful use of reduced herbicide doses.

These results are in conformity with Blackshaw *et al*.(2006), Deveikyte and Seibutis(2006), and Wilson *et al*.(2005) who reported that application of the tank-mixed and repeated reduced rate of herbicides reduced weeds to a vary degree sometimes approaching 100% [3,4,10]. Our findings however, contrary to the work reported by Johnson(1996) [5]. The variability in findings could be attributed to the different herbicidal combinations tested by those researchers. However, combining reduced doses of herbicides with other management practices can markedly increase the odds of successful weed control and the risk associated with reduced herbicide doses increased in the absence of other weed management practices [3].

None of the herbicide combinations caused visual injury or delayed maturity in sugar beet.

References

[1] Ashrafi, Z.Y., H.R. Mashhadi, S. Sadeghi, and R.E. Blackshaw. 2009. Study effects of planting methods and tank mixed herbicides on weeds controlling and wheat yield. *J. Agr. Sci*. 1(1), 101-111.

[2] Bells, D.S., D.C. Thill, and B. Shafi. 2000. Rate and Avena fatua density effects on seed production and viability in *Hordeum vulgare. Weed Sci*. 48, 378-384.

[3] Blackshaw, R.E., J.T. O' Donovan, K.N. Harker, G.W. Clayton, and R.T. Stougaard. 2006. Reduced herbicide doses in field crops: A review. *Weed Biol. Manag*. 6, 10-17.

[4] Deveikyte, I. and V. Seibutis. 2006. Broadleaf weeds and sugar beet response to phenmedipham, desmedipham, ethofumesate and triflusulfuron-methyl. *Agronomy Research,* 4, 159-162.

[5] Johnson B. J. 1996. Tank-mixed postemergence herbicides for Large crabgrass (*Digitaria sanguinalis*) and Goosegrass(Eleusine indica) control in Bermuda grass (*Cynodon dactylon*) turf. *Weed Technol*, 10(4), 716-721.

[6] Lajos, K., and M. Lajos. 2000. Weed control with reduced herbicide application in sugar beet Hungary. *Journal of Plant Diseases and protection.* 7, 623-627.

[7] May, M. 2001. Crop protection in sugar beet. *Pesticide Outlook* 12(5), 188-191.

[8] Schweizer, E.E. & Dexter, A.G. 1987. Weed control in sugar beets (*Beta vulgaris*) in North America, *Rev. Weed Sci*. 3, 1133.

[9] Sheykhi G. A., H. Najafi, S. Abasi, F. Saber and M. Rashid. 2009. The pesticide guide of Iran. Paytakht press. pp.237.

[10] Wilson, R. G., J. A. Smith, and C. D. Yonts. 2005. Repeated reduced rates of broadleaf herbicides in combination with methylated seed oil for postemergence weed control in sugarbeet(*Beta vulgaris*). *Weed Technol*. 19(4), 855-860.

[11] Zhang, J., S.E. Weaver, and A.S. Hamill. 2000. Risks and reliability of using herbicides at below-labeled rates. *Weed Technol.* 14, 106-115.

[12] Zoschke, A. 1994. Toward reduced herbicide rates and adapted weed management. *Weed Technol.* 8, 376-386.