Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231-6345 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jls.htm
2014 Vol. 4 (2) April-June, pp.271 -278/Gahkani and Mirshekari
Research Article

EFFECT OF DILUTE SOLUTIONS OF NICOSULFURON ALONG WITH SURFACTANTS ON WEEDS CONTROL EFFICIENCY IN CORN (*ZEA MAYS* VAR. POPCORN) FIELD

Mitra Nazeri Gahkani and Bahram Mirshekari*
Department of Agronomy and Plant Breeding, College of Agriculture, Tabriz Branch, Islamic Azad University, Tabriz, Iran
** Author for Correspondence*

ABSTRACT
Determining which adjuvant is the most effective is important in order to optimize herbicide efficacy. To study effect of Nicosulfuron along with surfactant on efficiency of weeds control in popcorn fields a split plot experiment was conducted in Islamic Azad University, Tabriz, Iran, during 2012-2013 in a randomized complete block design. The Nicosulfuron herbicide was applied in concentrations of 1 and 2 L ha^{-1} with surfactants of volk oil, sunflower oil and corn oil. Seeds produced in those plants treated with 1 L ha^{-1} Nicosulfuron were heavier than 2 L ha^{-1}. Similarly, crop plants Nicosulfuron sprayed along with volk oil and sunflower oil produced larger seeds. Above ground biomass of weeds in those plots sprayed with Nicosulfuron in absent of surfactant was 14 g m^{-2} higher than average of Nicosulfuron application along with all kind of surfactants. Since Nicosulfuron is highly effective on weeds control at low rates of 1 L ha^{-1}, it may be necessary for corn farmers to reduce its application to sub-optimum rates by surfactant usage. In the absent of surfactant, full dose of herbicide application will be suitable for weed controlling in corn field, which is lead to higher seed production.

Keywords: *Herbicide Concentration, Seed Production, Suboptimum Application, Surfactant*

INTRODUCTION
Weeds are the most omnipresent class of pests that interfere with crop plants through competition and allelopathy, resulting in direct loss to quantity and quality of the product (Gupta, 2006). Chemical weed control seems indispensable and has proved efficient in controlling weed (Kahramanoglu and Uygur, 2010). In Iran, herbicide usage accounts for 41% of the total pesticide consumption. Out of total imports of herbicides into the country 50% were used in wheat and corn fields.
Indiscriminate use of herbicides for weed control during the past few decades has resulted in serious ecological and environmental problems, such as resistance and shifts in weed populations (Heap, 2007), and greater environmental and health hazards (Rao, 2000). Providing a weed-free environment from the time of planting to canopy closing is important for strengthening the native ground cover’s competitive ability against weed invasions. Selective and dual purpose herbicides kill specific targets while leaving the desired crop relatively unharmed (Kellogg *et al.*, 2010).
There are normally many groups of damaging weeds in corn fields (Al-Khatib, 2011). Wild mustard (*Sinapis arvensis*), redroot pigweed (*Amaranthus retroflexus*) and wild oat (*Avena fatua* L.) are moderately drought tolerant noxious weeds in corn fields of Iran and appear in higher densities (Haile and Girma 2010). Success of a herbicide application is dependent upon weed species, the timeliness and thoroughness of application, conditions at the time of application, herbicide rate, adjutants application and crop management after the application.
The term surfactant is a blend of *surface active agents*. Adjuvants and surfactants are spray solution additives, and are considered to be any product added to a pesticide solution to improve the performance of the spray mixture. Surfactants (surface active agents) are a type of adjuvant designed to enhance the absorbing, emulsifying, dispersing, spreading, sticking, wetting, or penetrating properties of pesticides. Surfactants are most often used with herbicides to help a pesticide spread over a leaf surface and penetrate the waxy cuticle of a leaf or to penetrate through the small hairs present on a leaf surface. Surfactants are compounds that lower the surface tension (or interfacial tension) between two liquids or between a liquid

and a solid. Surfactants may act as detergents, wetting agents, emulsifiers, foaming agents, and dispersants (Al-Khatib, 2011)**.**

The effects of surfactants on the foliar uptake of herbicides are complex and only partially understood. In an experiment, when a suitable surfactant was used, herbicide uptake into both bean and wheat foliage increased steadily with increasing surfactant concentration and reached a maximum at 0.5%. In the presence of a constant surfactant, higher percentage uptake of herbicide was obtained with higher concentrations for glyphosate, but with lower concentrations in the case of 2,4-D. In the presence of an organosilicone surfactant, the stomatal uptake of glyphosate varied with both surfactant concentration and plant species. The effect of non-silicone surfactants on the cuticular uptake of glyphosate also varied with plant species (Valkenburg, 1982).

The efficacy of any herbicide depends predominately on the dose used (Steckel *et al.*, 1997) and in many instances the same is also decisive for its selectivity. Registered herbicide doses are set to achieve upper limits of weed control under varying compositions, densities, weed growth stages and environmental conditions, and there may be an overestimation of the dose required to get adequate control (Zhang *et al.*, 2000). However, it is not always necessarily to apply full herbicide dose (Talgre *et al.*, 2008) and there can flexibility regarding herbicide rates depending on the weed spectrum, densities, their growth stage and environmental conditions (Barroso *et al.*, 2009). Dose-response and surfactant application studies are an important tool in weed science. The use of such studies has become especially prevalent following the widespread development of herbicide resistant weeds (Seefeldt *et al.*, 1995).

Determining which adjuvant is the most effective is important in order to optimize herbicide efficacy. The present study was designed to determine the effect of a newly introduced post-emergence herbicide Nicosulfuron “Cruz” as a dual purposes herbicide along with different surfactants on efficiency of weeds control in popcorn fields under semi arid regions.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Research Station of Islamic Azad University, Tabriz (Lat. 38°, 5´; Long. 46°, 17´ and elevation 1360 m), Iran, during 2012-2013, in a sandy loam soil with pH of 7.6 and organic matter of 1%. The climate of research site is semi-arid and cold with an average annual precipitation of 270 mm. The experimental field had been in a corn-potato rotation cycle for the last two years. The experimental area was ploughed in the fall and manured with 10 t ha^{-1} and then disked and plotted before sowing the seeds.

Materials Studied

Table 1: Meteorological data for experimental area in Tabriz during April-August 2013

	April	**May**	**June**	**July**	**August**
Precipitation (mm)	8.7	44.1	57.3	0.7	15
Minimum temperature (^oC)	3.4	4.2	9.3	10.3	15
Maximum temperature (^oC)	16.9	18.2	22.9	23.8	22.3
Mean daily temperature (^oC)	9.6	11.2	16.1	17.5	17.3
Minimum humidity (%)	40	45	44	43	52
Maximum humidity (%)	87	86	89	85	91
Mean humidity (%)	64	66	67	64	71
Total of sun days	200.5	250	266	326.5	223.1

Source: Tabriz meteorological office, Iran

In this study, post-emergence herbicide including Nicosulfuron “Cruz” was used to control corn weeds. This herbicide has been previously tested safe on well established corn plants. The herbicide was applied before stem elongation of corn in spring with concentrations of 1 and 2 L ha^{-1}. Surfactants were volk oil, sunflower oil and corn oil along with a treatment of non-surfactant application). The split plot experiment

Research Article

was laid out in a randomized complete block design with 3 replicates. A hybrid high yielding variety of popcorn was sown at 8 seeds m^{-2} in 60-cm rows in 8^{th} April 2013. Fertilizers were used according to the soil test and weeds in control plots were controlled monthly by hand weeding. At maturity in 16^{th} August, corn plants at the center 1-m^2 portion of each plot were hand harvested.

Statistical Analysis

All data were statistically analyzed based on RCBD using MSTAT-C software. The means of the treatments were compared using the least significant difference test at * $P < 0.05$.

RESULTS AND DISCUSSION

Variance Analysis

Analysis of variance for study effect of dilute solutions of Nicosulfuron along with surfactants on weeds control efficiency in corn (*Zea mays* var. popcorn) field indicated that herbicide dose influenced stem height, ear development height, ear length, seed row number per ear, seed number per ear and 300 seed weight of corn.

Surfactants are almost always present in herbicide treatment solutions with the aim to improve spray droplet retention on and penetration of active ingredients into plant foliage. In our experiment surfactant materials used influenced ear length, seed row number per ear, seed number per ear, 300 seed weight of corn and weeds biomass. Interaction of herbicide dose × surfactant also influenced seed yield of corn (Table 2).

Table 2: Mean squares for studied variables in wheat cultivars

SOV	df	Stem height	Chlorophyle content index	Ear development height	Ear diameter	Ear length	Seed row number per ear	Seed number per ear	300 seed weight	Seed yield	Weeds biomass
Replication	2	156.32	120.00*	12.15	0.12	500.15	14.10	110.44	1100.58	54.11	1250.41
Herbicide dose (a)	1	198.55**	49.00	401.45*	25.33	500.22*	7.98*	300.58*	18.52**	146.42*	500.47
Ea	2	50.25	40.45	102.88	11.56	102.17	15.78	22.41	0.22	22.11	220.58
Surfactant (b)	3	58.22	12.78	555.74	0.27	248.77*	4.55*	560.01**	110.22*	77.23*	723.10**
a×b	3	451.88	40.45	75.11	0.18	89.42	5.42	61.47	28.44	90.57**	124.12
Eab	12	265.20	60.25	105.36	50.36	33.69	8.01	59.53	25.33	16.99	100.00
CV (%)	-	13.13	14.22	24.00	19.00	16.11	19.11	14.25	25.25	18.33	18.45

**, ** mean significant difference at 5% and 1% probability levels, respectively.*

Mean Comparisons

When the Nicosulfuron herbicide foliar sprayed with 1 L ha^{-1} concentration, stem height of crop plants at ripening stage improved 17 cm, as well as chlorophyle content index of corn leaves increased 25%, compared to 2 L ha^{-1} (Table 3).

Based on mean comparisons, when maize was sprayed with 1 L ha^{-1} herbicide concentration, first ear developed on the height of 55 cm on stem, but only in 43 cm height in 2 L ha^{-1} concentration (Table 3), that was caused difficulty in mechanical harvesting.

Table 3: Mean comparisons of some of studied traits in popcorn affected by herbicide dose

	Herbicide dose (L ha^{-1})	
	1	**2**
Stem height (cm)	180.4	163.5
Ear development height (cm)	55	43
Seed row number per ear	17.3	14.7
Seed number per ear	650	549

Ear length in those plants sprayed with 1 L ha^{-1} Nicosulfuron, was longer than 2 L ha^{-1} (Table 3). Crop oil concentrates are composed of paraffin based petroleum oil and surfactants. Crop oil concentrates reduce surface tension and improve herbicide uptake and leaf surface spreading. Among surfactant materials, highest ear length was obtained from volk oil and sunflower oil, and the lower length from corn oil and control (Figure 1).

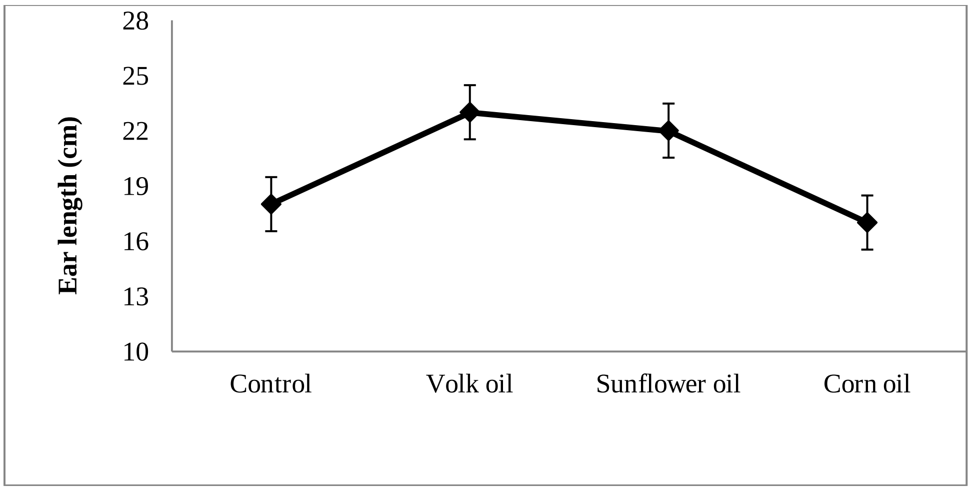

Figure 1: Ear length of corn as affected by surfactant

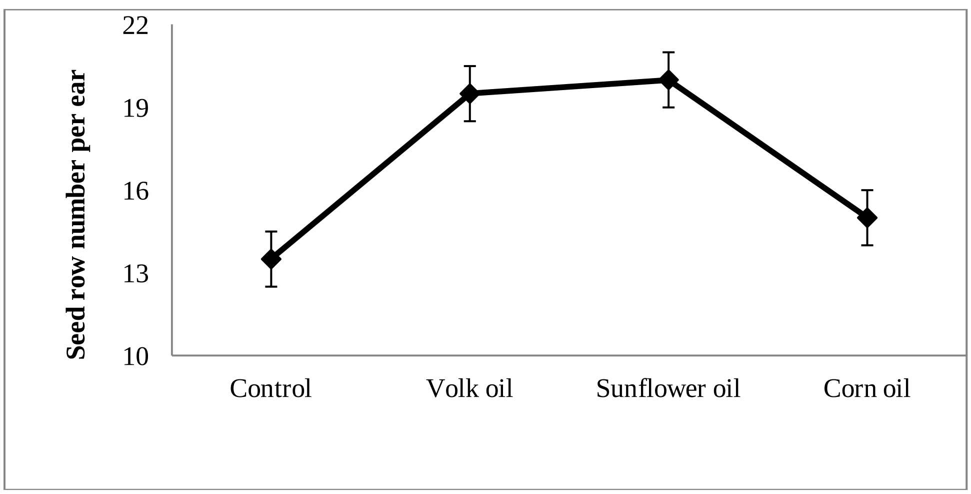

Figure 2: Seed row number per ear of corn as affected by surfactant

Seed row number per ear in 1 L ha^{-1} was greater than 2 L ha^{-1} Nicosulfuron (Table 3). Study effects of surfactans on seed row number per ear revealed that there is a positive response to volk oil and sunflower oil in corn plants. Whereas, when plants treated with corn oil or non-treated, seed row number per ear reduced from 20 row up to 14.5 row (Figure 2). Seed number per ear was a dose dependent trait in corn,

Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231-6345 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jls.htm
2014 Vol. 4 (2) April-June, pp.271 -278/Gahkani and Mirshekari
Research Article

and good responded to herbicide application. Number of seeds per ear was greater in limited dose of Nicosulfuron (Table 3). Seed number per ear ranged from 666 seeds in sunflower oil to 540 seeds in control plots (Figure 3).

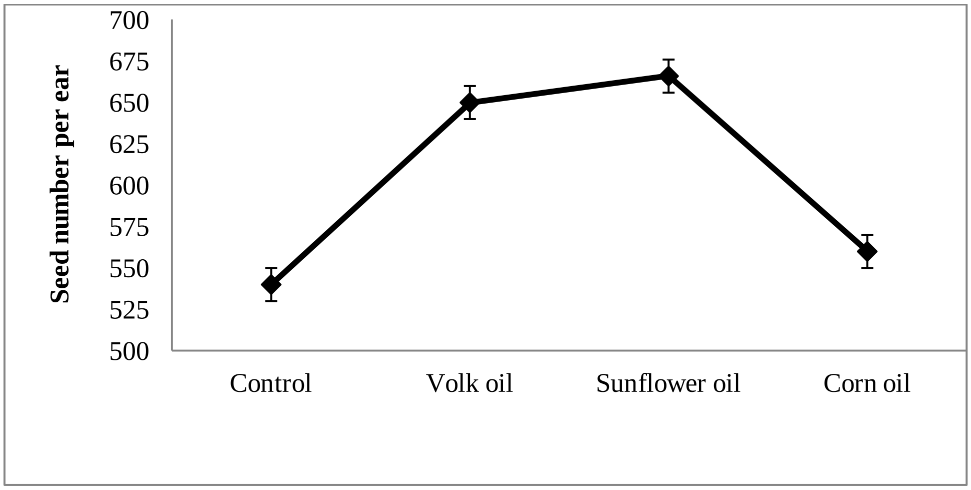

Figure 3: Seed number per earof corn as affected by surfactant

Seeds produced in those plants treated with 1 L ha^{-1} Nicosulfuron were heavier than 2 L ha^{-1}. Similarly, crop plants Nicosulfuron sprayed along with volk oil and sunflower oil as surfactant materials produced larger seeds with 300 seed weight of 42.5 g, but only 36.5 g from control and corn oil treatments (Figure 4). Seed oils are produced by reacting fatty acids from seed oils with an alcohol to form esters. The methyl or ethyl esters produced by this reaction are combined with surfactants/ emulsifiers to form an esterified seed oil. These surfactants reduce surface tension and improve herbicide uptake by improving herbicide distribution on the leaf surface, which is lead to improvement of crop yield and its components (Grichar and Sestak, 2000).

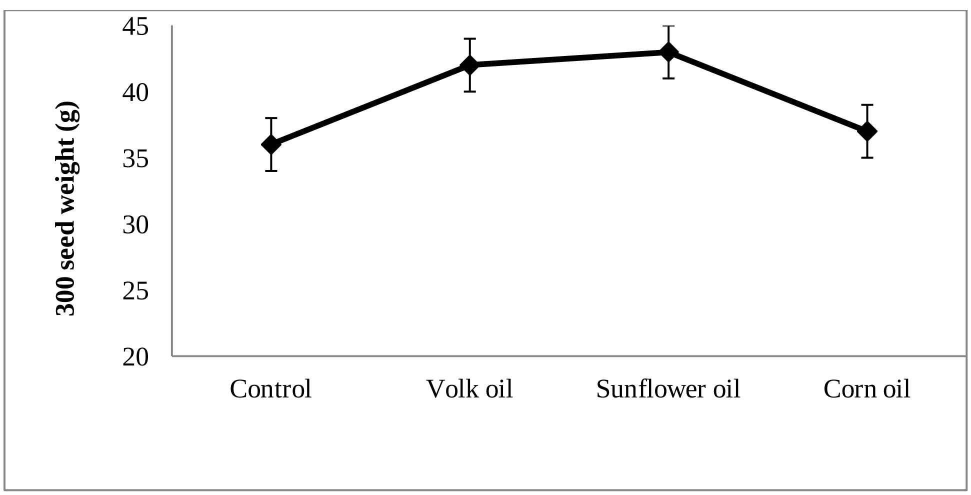

Figure 4: 300 seed weight of corn as affected by surfactant

Interaction of herbicide dose × surfactant indicated that seed yield ranged from 625 g m^{-2} in 1 L ha^{-1} Nicosulfuron sprayed plants along with sunflower oil up to 535 g m^{-2} in two treatments of 1 L ha^{-1} Nicosulfuron sprayed plants without surfactant and 2 L ha^{-1} Nicosulfuron along with corn oil (Figure 5).

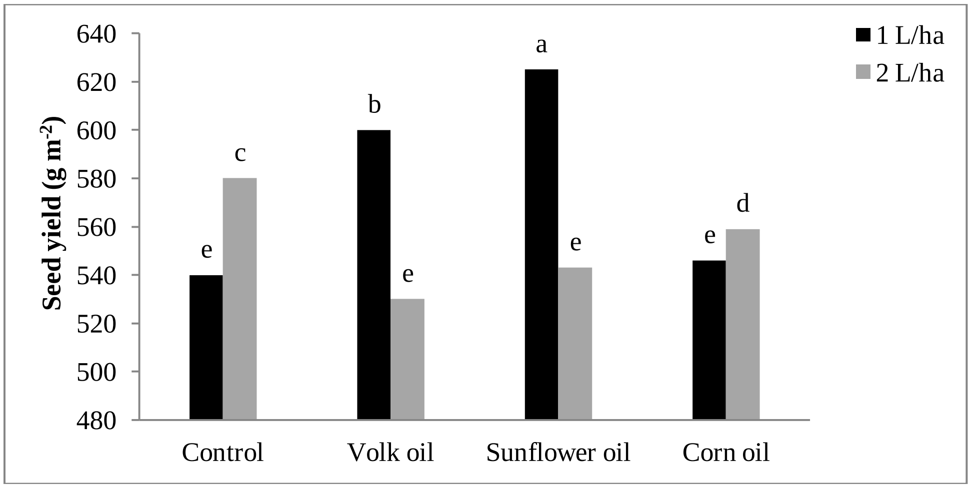

Figure 5: Weeds biomass of corn as affected by surfactant

Above ground biomass of weeds in those plots sprayed with Nicosulfuron in absent of surfactant was 14 g m^{-2} higher than average of Nicosulfuron application along with all kind of surfactants (Figure 6). Adjuvants enhance the efficacy of post-emergence herbicides (Hatzios and Penner 1985; Whorter and 1992; Valkenburg, 1982; Wanamarta and Penner 1989). Application of herbicides in proper dose along with suitable surfactants would reduce off-target movement of herbicide, and maximize weed control (Al-Khatib, 2011)**.** For example, imazethapyr controlled kochia [*Kochia scoparia* (L.) Schrad.] and green foxtail [*Setaria viridis* (L.) Beauv.] better when applied with various petroleum oil adjuvants (Manthey *et al.*, 1992).

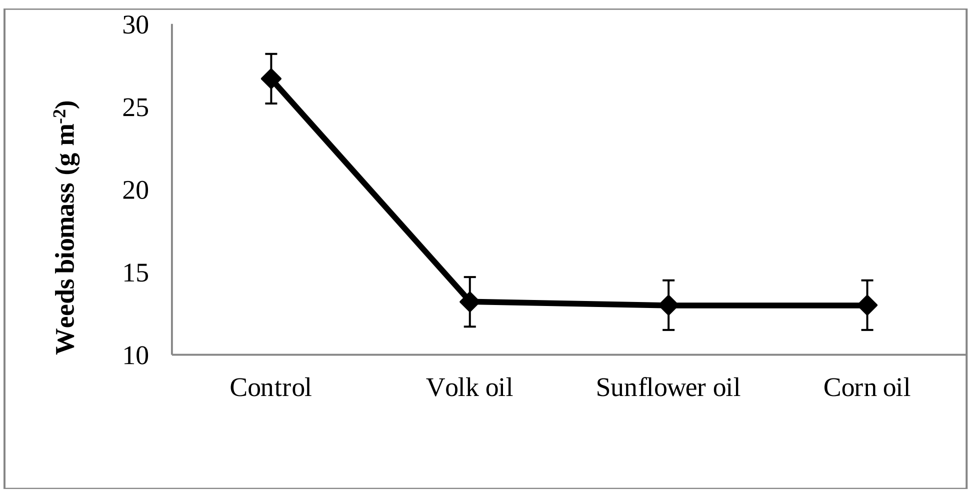

Figure 6: Weeds biomass of corn as affected by surfactant

Imazethapyr controlled yellow nutsedge more effectively when applied with Plex, Silkin, Agri-Dex, Kinetic, Chaser, or Sun-It as surfactants. Additionally, Agri-Dex, Chaser, Plex and Sun It-II were more efficacious adjuvants than Silkin (Grichar and Sestak, 2000). Our results with Nicosulfuron agree with other reports that adjuvants differ in their enhancement of control (Manthey *et al.*, 1992; Prendeville and Warren, 1975).

Conclusion

These data suggest that surfactant play a role in efficacy of the herbicide used. However, since Nicosulfuron is highly effective on weeds control at rates as low as 1 L ha^{-1}, it may be necessary for corn farmers to reduce herbicide application to suboptimum rates by surfactant usage. In the absent of surfactant, full dose of herbicide application will be suitable for weed controlling in corn field, which is lead to higher seed production.

ACKNOWLEDGEMENTS
The authors would like to offer particular thanks to the Seed Improvement Institute of Iran for kindly providing the materials studied. The corresponding author is also grateful to Prof. Dr. K. Arsalan, from Department of Agronomy, University of Izmir, Turkey, for critically reviewing of the manuscript.

REFERENCES

Al-Khatib K (2011). Weed Control in Wheat. Washington State University Extension. Extension bulletin, 1803.

Barroso J, Ruiz DC, Escribano L and Fernandez-Quintanilla C (2009). Comparison of three chemical control strategies for *Avena sterilis*. *Crop Protection* **28** 393-400.

Belles DS, Thill DC, Shafi B (2004). PP-604 rate and *Avea fatua* density effects on seed production and viability in *Hordeum vulgare*. *Weed Science* **48** 378-384.

Gupta OP (2006). *Modern Weed Management* (Dahalia Publ., India).

Haile D and Girma F (2010). Integrated effect of seeding rate, herbicide dosage and application timing on durum wheat (*Triticum turgidum* L. *var. durum*) yield, yield components and wild oat (*Avena fatua* L.) control in south eastern Ethiopia. Oromia Agricultural Research Institute, Sinana Agricultural Research Center.

Hatzios KK and Penner D (1985). Interactions of herbicides with other agro-chemicals in higher plants. *Reviews of Weed Science* **1** 163-168.

Heap I (2007). The international survey of herbicide resistant weeds. Herbicide Resistance Action Committee (HRAC), North American Herbicide Resistance Action Committee (NAHRAC), and Weed Science Society of America (WSSA), Corvallis, Oregon, USA.

James Grichar W & Sestak DC (2000). Effect of adjuvants on control of nutsedge (*Cyperus esculentus* and *C. rotundus*) by imazapic and imazethapyr. *Crop Protection* **19** 461-465.

Kahramanoglu I and Uygur FN (2010). The effects of reduced doses and application timing of metribuzin on redroot pigweed (*Amaranthus retroflexus* L.) and wild mustard (*Sinapis arvensis* L.). *Turkish Journal of Agriculture and Forestry* **34** 467-474.

Kellogg RL, Nehring R, Grube A, Goss DW and Plotkin S (2010). Environmental indicators of pesticide leaching and run-off from farm fields. *United States Department of Agriculture and Natural Resources.*

Khaliq A, Matloob A, Tanveer A, Ahsan Areeb A, Aslam F and Abbas N (2011). Reduced doses of a sulfonylurea herbicide for weed management in wheat fields of Punjab, Pakistan. *Chilean Journal of Agricultural Research* **71**(3) 22-27.

Khan M and Haq N (2002). Wheat Crop Yield Loss Assessment due to Weeds. *Sarhad Journal of Agriculture* **18** 449-453.

Madandoustm M (2006). Determination of seeding rate and selective herbicide for controlling of *Hordeum* spp. in wheat fields. *10th Iranian Congress on Agronomy and Plant Improvement, Karaj, Iran*.

Manthey FA, Matysiak R and Nalewaja JD (1992). Petroleum oil and emulsifier affect the phytotoxicity of imazethapyr. *Weed Technology* **6** 81-84.

Mc Whorter CG (1992). The use of adjuvants. In: *Adjuvants for Herbicides*. Edited by Hodgson RH (Weed Sci. Soc. Am. Champaign, IL) 10-25.

Prendeville GN and Warren GF (1975). Spreading and penetration of herbicides dissolved in oil carriers. *Weed Research* **15** 233-241.

Rao VS (2000). *Principles of Weed Sciences* (Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India).

Seefeldt SS, Jensen JE and Fuerst EP (1995). Log-logistic analysis of herbicide dose-response relationships. *Weed Technology* **9** 218-227.

Steckel GJ, Wax LM, Simmons FW and Phillips WH (1997). Glufosinate efficacy on annual weeds is influenced by rate and growth stage. *Weed Technology* **11** 484-488.
Talgre L, Lauringson E and Koppel M (2008). Effect of reduced herbicide dosages on weed ifestation in spring barley. *Zemdirbyste-Agriculture* **95** 194-201.
Tanner DG, Giref S and Workiye T (1995). Competitive ability of ethiopian spring bread wheat cultivars with *Avena fatua* L. *African Crop Science Journal* **3** 83-91.
Van Valkenburg JW (1982). Terminology, classi"cation, and chemistry. In: *Adjuvants for Herbicides*. edited by Hodgson R.H. (Weed Sci. Soc. Am., Champaign, IL) 1-3.
Wanamarta G and Penner D (1989). Foliar penetration of herbicides. *Review of Weed Science* **4** 215-231.
Zhang J, Weaver SE and Hamill AS (2000). Risks and reliability of using herbicides at below-labeled rates. *Weed Technology* **14** 106-115.