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A NOVEL TECHNOLOGY IN AGRICULTURAL MANAGEMENT SYSTEMS: ADJUVANT PLUS HERBICIDE APPLICATION

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ABSTRACT

Dose-response and surfactant application studies are an important tool in weed science. At 65 days after emergence the plots were differently foliar sprayed by100%, 80% and 60% of registered dose respectively along with two different adjuvants of Kimia and D-octil. Plots receiving no herbicide treatment served as control. In over dose of metribuzin time to flowering happened 52.4 days after crop emergence. Whereas, in 560 g and 420 g ai ha^{-1} doses of metribuzin 50% flowering stage happened 61.2 and 59.4 days after emergence. Size of tubers affected significantly by herbicide dose and adjuvants. Weight of tubers per potato plants ranged from 321 g in 420 g ai ha^{-1} of metribuzin with and in absent of surfactant of kimia up to 560 g ai ha^{-1} of metribuzin with surfactant materials used of D-octil and kimia. Weeds biomass was a dose dependent trait in potato along with surfactants, and good responded to herbicide application. There is a positive response in tuber yield to surfactant use when 80% of registered dose of metribuzin sprayed. In dilute solutions of metribuzin, surfactant using did not influenced tuber yield. It may be necessary for the farmers to reduce herbicide application to 80% of registered dose by surfactant usage. The time to flowering, stolon number per plant and weeds biomass had a marked increasing effect on the tuber yield of potato.

Keywords: adjuvant, dilute solution, dose-response, flowering stage, weed science.

INTRODUCTION

Adjuvants and surfactants are spray solution additives, and are considered to be any product added to herbicides solution to improve the performance of the spray mixture. Surfactant materials 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. 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 [1]. 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 [2].

Chemical weed control seems indispensable and has proved efficient in controlling weed [3]. 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. There are normally many groups of damaging weeds in potato fields such as wild mustard (*Sinapisarvensis*) and redroot pigweed (*Amaranthusretroflexus*), which they are moderately drought tolerant noxious weeds in crop plant fields of Iran and appear in higher densities [4].

The effects of adjuvants 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 adjuvant 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 [5].

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 [6]. Determining which adjuvant is the most effective is important in order to optimize herbicide efficacy. This study was designed to determine the effect of Metribuzin along with adjuvant materials on efficiency of weeds control in potato fields under semi-arid and cold climatically conditions of Ardabil, Iran.

MATERIALS AND METHODS

Site description

The experiment was conducted at the Research Station of Islamic Azad University, Ardabil, Iran, during 2012-2013, in a loam soil with pH of 7.2 and organic matter of 1.3%. The climate of research site is semi-arid and cold with an average annual precipitation of 339 mm. Some of weather data in experimental site during crop growth cycle is given in Table-1.

Table-1. Some of weather data for experimental site during growth period of potato.

Month	Temperature (°C)	Precipitation (mm)	Relative humidity (%)
April	18.0	42.9	65.3
May	18.3	40.4	60.3
June	24.0	22.5	64.8
July	33.0	18.5	50.7
August	25.1	16.4	50.7
September	18.1	20.1	73.1
Total	-	158.0	-

Experimental design

Seeds of potato (*Solanumtuberosum* var. Agria) used for this study were obtained from Ardabil Seed Improvement Institute, Iran. The cultivar under study was a late-repining variety with growth period of 145-155 days. The experimental field had been in a wheat-sunflower rotation cycle for the last two years. The experiment was laid out factorially in a randomized complete block design in field condition with three replicates and plot sizes was 5 m × 4 m.

In all the plots two cultivations with a tractor-drawn cultivator along with manuring 20 $t.ha^{-1}$ followed by a planking were given to achieve desirable soil structure. Then fields were furrowed and plotted in the early spring before sowing. Seeds were hand sown on 5th May in rows 75 cm apart and 20 cm on the rows at 6-7 cm depth. Based on soil analysis fertilizers P and K were applied basally at the rate of 120 and 140 kg. ha^{-1} respectively. Nitrogen was applied at the rate of 140 kg. ha^{-1}, of which 50% was applied basally and the rest at earlier flowering. Eight irrigations were given to all treatments until 30 days prior to harvesting. No herbicide before sowing was used to control weeds. At 65 days after emergence the plots were differently foliar sprayed by 700g, 560g and 420g ai $ha^{-1}$of Metribuzin (4-amino-6-tert-butyl-3-(methylthio)-as-triazin-5 (4H)-one) (100%, 80% and 60% of registered dose respectively)along with two different adjuvants of Kimia and D-octil. Plots receiving no herbicide treatment served as control.

Metribuzin is a herbicide used both pre- and post-emergence in crops including soybean, potatoes, tomatoes and sugarcane. It acts by inhibiting photosynthesis by disrupting photosystem II. It is widely used in agriculture and has been found to contaminate groundwater [7]. This herbicide has been previously tested safe on well-established potato plants.

Measurements

In field condition number of emerged seeds was recorded according to the seedling evaluation handbook of the Association of Official Seed Analysis (AOSA) [8]. At harvesting stages, the middle four potato rows of each plot were hand harvested. Any pesticide used to control insects. The tubers harvested separately for each plot between 26-30 September when the tubers were fully ripened. Agronomic traits and yield components was examined by standard procedures.

Statistical analysis

Data were statistically analyzed using the software MSTAT-C. Analysis of variance was used to test the significance of variance sources, while Duncan's Multiple range test (P=0.05) was used to compare the differences among treatment means. In statistics, stepwise regression includes regression models in which the choice of predictive variables is carried out by an automatic procedure [1]. In this study, to formulate the relationship among seven independent growth variables measured in our experiment for potato crop with a dependent variable, multiple regression analysis was carried out for the time to 50% flowering (X_1), stolon number per plant (X_2), tuber size (X_3), weight of tubers per plant(X_4) and weeds biomass (X_5); and tuber yield (GY) as a dependent variable. Furthermore, the stepwise regression analysis was also carried out for the data obtained to test the significance of the independent variables affecting the tuber yield.

RESULTS AND DISCUSSIONS

Time to 50% flowering

Interaction of herbicide dose and adjuvants influenced time to 50% flowering of potato (Table-2). Without regarding to adjuvant materials used, in over dose of metribuzin time to 50% flowering happened 52.4 days after crop emergence. Whereas, in 80% and 60% registered doses of metribuzin50% flowering stage delayed nearly 9.3 days (Figure-1). The early flowering of potato cultivars could be influence positively its yield production as Bellinder *et al*. [9] and Blackshaw *et al*. [10] emphasized on it.

Table-2. Mean squares for studied traits in potato under limited dose of metribuzin application along with adjuvants.

SV	df	Time to 50% flowering	Stolon number per plant	Tuber size	Weight of tubers per plant	Weeds biomass	Tuber yield
Replicate	2	13.88	41.04	13.30	4.92	37.37 *	102033.33
Herbicide dose	2	60.56	180.00 **	39.00 **	51.59 **	81.09 **	408170.33 **
Adjuvant	2	129.33 *	100.29 **	223.00 **	216.70 **	42.00 *	1882092.33 **
Interaction	4	195.52 **	54.54 *	25.03 *	80.98 **	40.91 *	208241.66 *
Error	16	49.09	18.85	7.58	10.00	14.01	60850.00
CV (5%)	-	19.90	13.63	10.70	10.20	13.66	18.88

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

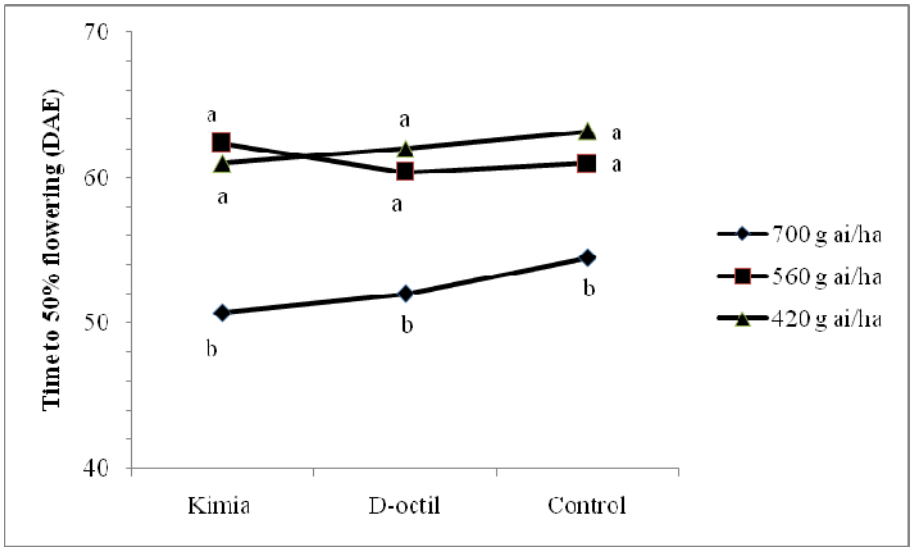

Figure-1. Interaction of herbicide dose and adjuvants on time to 50% flowering of potato.

Stolon number per plant

When potato plants foliar sprayed with 560 g ai $ha^{-1}$of metribuzin averaged stolon number per plant was 4.2 stolon, but only 3.3 stolon from 700 g and 420 g ai ha^{-1} doses of metribuzin (Table-2). Baziramakenga and Leroux [11] reported that yield components in potato significantly affected by weed control managements.

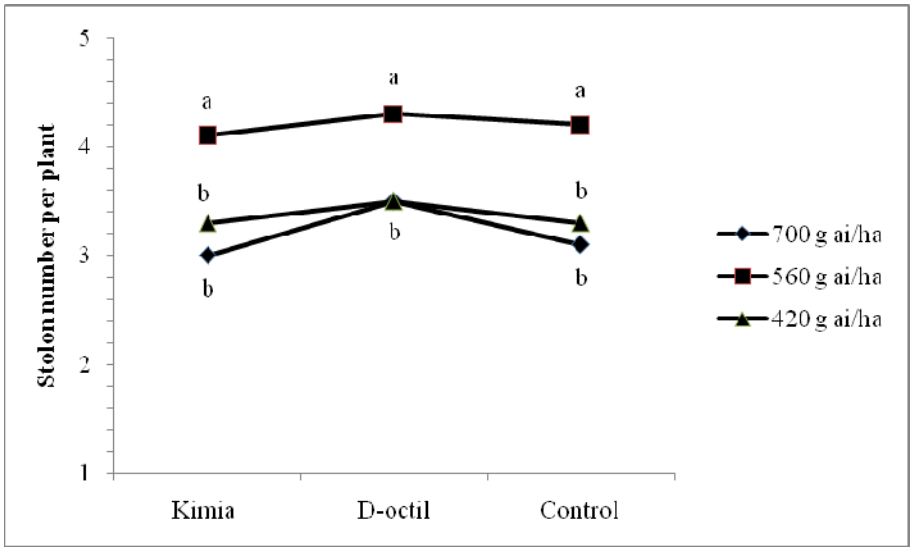

Figure-2. Interaction of herbicide dose and adjuvants onstolon number per plant of potato.

Tuber size

Size of tubers affected significantly by herbicide dose and adjuvants (Table-2). Application of metribuzinin registered dose of 700 g ai ha^{-1} lead to produced larger tubers with 81.5 mm diameter, but there is no significant difference among other treatments with tuber size of 70.2 mm diameter (Figure-3). In this experiment larger tuber produced in full dose herbicide application treatments was not un-expected due to lower stolon number per plant (Figure-3).

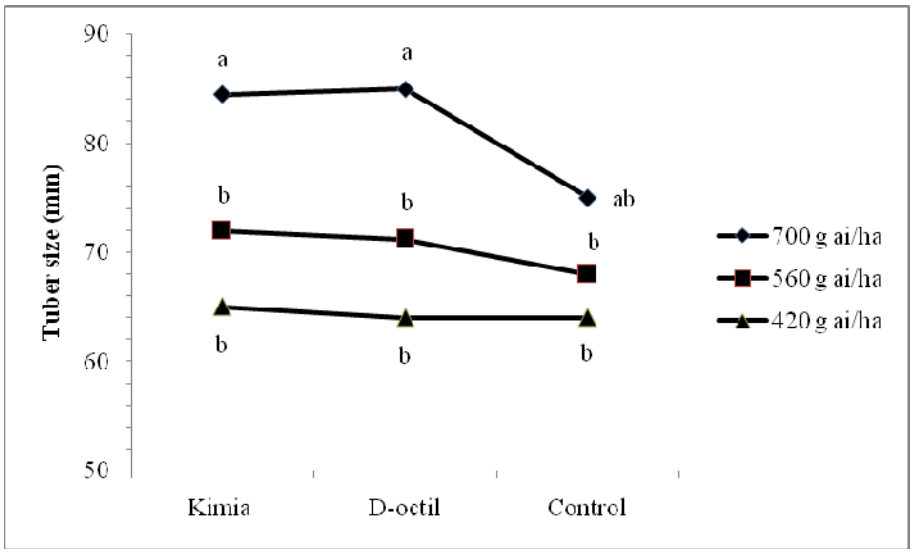

Figure-3. Interaction of herbicide dose and adjuvants ontuber sizeof potato.

Weight of tubers per plant

Weight of tubers per potato plants ranged from 321 g in 420 g ai ha^{-1} of metribuzin with and in absent of surfactant of kimia up to 560 g ai ha^{-1} of metribuzin with surfactant materials used of D-octil and kimia. There is no significant difference for weight of tubers per plant between surfactants used with 80% of registered dose of metribuzin. Over dose application of metribuzin along with surfactants lead to lower tuber weight than limited dose (560 g ai ha^{-1}) (Table-3).

Weeds biomass

In our experiment weeds biomass was a dose dependent trait in potato along with surfactants, and good responded to herbicide application (Table-3). 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 [12], and greater environmental and health hazards [13].

Table-3. Mean comparisons for weight of tubers per plant of potato and weeds biomass under metribuzin application along with adjuvants.

Treatments		**Weight of tubers per plant** (g)	**Weeds biomass** (g m^{-2})
Herbicide dose	**Adjuvant**		
700 g ai ha^{-1}	Kimia	380 b	49.5 c
	D-octil	386 b	36.8 b
	Control	350 c	83.2 e
560 g ai ha^{-1}	Kimia	448 a	33.0ab
	D-octil	452 a	22.5 a
	Control	371 b	65.9 d
420 g ai ha^{-1}	Kimia	321 d	40.2bc
	D-octil	364bc	40.9bc
	Control	321 d	70.9 d

Means in each column with the same letter have not significant different at 5% probability level.

Weeds under foliar application of 560 g ai ha^{-1} of metribuzin along with both surfactant materials used better controlled than other treatments studied especially in comparison with full dose application of metribuzinin absent of surfactant. Above ground dry biomass of weeds nearly 20 days after potato flowering were 83.2 g and 68.4 g in over dose application of metribuzin without surfactant and in averaged of 560 g and 420 g ai ha^{-1} of metribuzin without surfactant, but only 27.8 g from 560 g ai ha^{-1} of metribuzin with both surfactants (Table-3).

Successful herbicide application is dependent upon weed species, the timeliness and thoroughness of application, conditions at the time of application, herbicide rate, adjuvtants application and crop management after the application [4]. The efficacy of any herbicide depends predominately on the dose used [14] 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 [15]. However, it is not always necessarily to apply full herbicide dose [16] and there can flexibility regarding herbicide rates depending on the weed spectrum, densities, their growth stage and environmental conditions [17].

Adjuvants enhance the efficacy of post-emergence herbicides [5, 18, 19, 14]. Application of herbicides in proper dose along with suitable surfactants would reduce off-target movement of herbicide, and maximize weed control [1]. For example, imazethapyr controlled kochia [*Kochiascoparia* (L.) Schrad.] and green foxtail [*Setariaviridis*(L.) Beauv.] Better when applied with various petroleum oil adjuvants [22]. 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 [23].

Tuber yield

Tuber yield affected significantly by herbicide dose and adjuvants (Table-2). There is a positive response in tuber yield to surfactant use when 80 % of registered dose of metribuzin sprayed. In dilute solutions of metribuzin, surfactant using did not influenced tuber yield, and all of these treatments produced 19.8 t ha^{-1} tuber. The highest yield obtained from foliar application of 560 g ai ha^{-1} of metribuzin with surfactants of D-octil and kimia. Yield inover dose application of metribuzin treatments was same as control for560 g ai ha^{-1} of metribuzin (Figure-4).

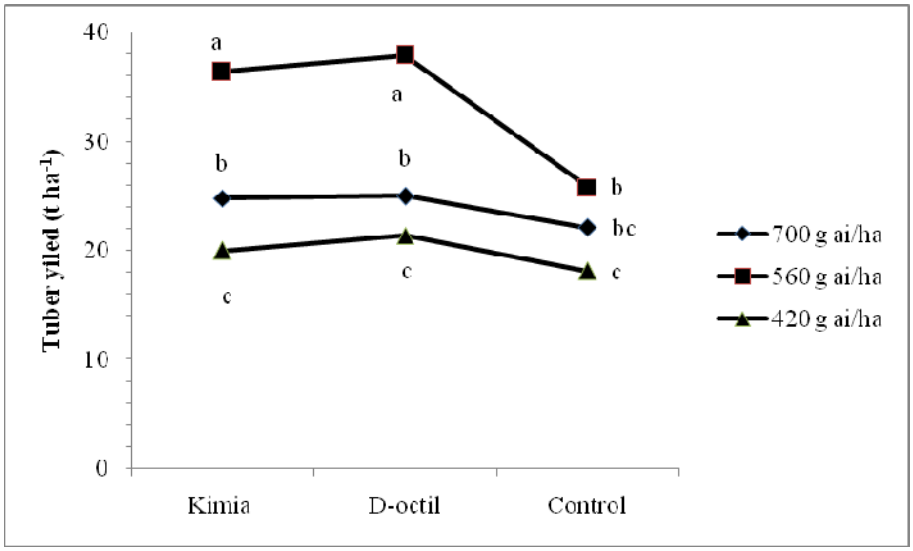

Figure-4. Interaction of herbicide dose and adjuvants on tuber yield of potato.

Regression analysis

The multiple regression equation for tuber yield is as follows:

$$TY = 11.525 + 3.152(X_1) + 2.333(X_2) + 4.111(X_3) + 11.258(X_4) + 12.589(X_5) \quad (1)$$

The stepwise regression equation is as follows:

$$TY = 100.258 + 4.565\ (X_1) + 14.102\ (X_2) + 45.555\ (X_5);\ R^2 = 64 \quad (2)$$

Table-4. Standard regression coefficients, T values and probability level of traits in model.

	Time to 50% flowering	Stolon number per plant	Weeds biomass
Standard regression coefficients	+0.444	+0.436	+0.500
T values	+1.200	+1.159	-2.450
Prob.	0.036	0.029	0.008

CONCLUSIONS

These data suggest that surfactant play a major role in efficacy of the herbicide used. However, since metribuzinis highly effective on weeds control in potato field at low concentrations, it may be necessary for the farmers to reduce herbicide application to 80% of registered dose by surfactant usage. The stepwise regression analysis verified that the time to 50% flowering, stolon number per plant and weeds biomass had a marked increasing effect on the tuber yield of potato.

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REFERENCES

[1] Gupta O.P. 2006. Modern Weed Management. Dahalia Publ., India.

[2] Kellogg R.L., Nehring R., Grube A., Goss D.W. and Plotkin S. 2010. Environmental indicators of pesticide leaching and run-off from farm fields. United States Department of Agriculture and Natural Resources.

[3] Kahramanoglu I. and Uygur F.N. 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.

[4] 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.

[5] Van Valkenburg J.W. 1982. Terminology, classification, and chemistry. In: Hodgson R.H. (Ed.),

Adjuvants for Herbicides. Weed Science Society ofAmerica, IL. 1-3.

[6] Seefeldt S.S., Jensen J.E. and Fuerst E.P. 1995. Log-analysis of herbicide dose-response relationships. Weed Technology. 9: 218-227.

[7] Undabeytia T.S., Recio E., Maqueda C., Morillo E., Gómez-Pantoja E. and Sánchez-Verdejo T. 2011. Reduced metribuzin pollution with phosphatidylcholine-clay formulations. Pest Management Science. 67(3): 271-278.

[8] Association of Official Seed Analysis (AOSA). 1983. Seed vigor testing handbook. Contribution No. 32 to the handbook of seed testing. Association of official seed analysis, Springfield. II. p. 321.

[9] Bellinder R.R., Kirkwyland J.J., Wallace R.W. and Colquhoun J.B. 2007. Weed control and potato (*Solanum tuberosum*) yield with banded herbicides and cultivation. Weed Technology. 14:30-35.

[10] Blackshaw R.E., Odonovan J.T., Harker K.N., Clayton G.W. and Stougaard R.N. 2006. Reduced herbicide doses in field crops: A review. Weed Biology and Management. 6: 10-17.

[11] Baziramakenga R. and Leroux G.D. 2007. Critical period of quackgrass (*Elitrigia repens*) removal in potato (*Solanum tuberosum*). Weed Science. 42: 528-533.

[12] 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.

[13] Rao V.S. 2000. Principles of Weed Sciences. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, India.

[14] Steckel G.J., Wax L.M, Simmons F.W. and Phillips W.H. 1997. Glufosinate efficacy on annual weeds is influenced by rate and growth stage. Weed Technology. 11: 484-488.

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

[16] Talgre L., Lauringson E. and Koppel M. 2008. Effect of reduced herbicide dosages on weed ifestation in spring barley. Zemdirbyste-Agriculture. 95: 194-201.

[17] Barroso J., Ruiz D.C., Escribano L. and Fernandez-Quintanilla C. 2009. Comparison of three chemical control strategies for Avena sterilis. Crop Protection. 28: 393-400.

[18] Hatzios K.K. and Penner D. 1985. Interactions of herbicides with other agro-chemicals in higher plants. Review in Weed Science. 1: 163-168.

[19] [19] McWhorter, C.G. 1992. Use of adjuvants. In: Hodgson R.H. (Ed.), Adjuvants for Herbicides. Weed Science Society of America, IL. 10-25.

[20] Wanamarta G. and Penner D. 1989. Foliar penetration of herbicides. Rev. Weed Science. 4: 215-231.

[21] Al-Khatib K. 2011. Weed Control in Wheat. Washington State University Extension. Extension bulletin. 1803.

[22] Manthey F.A., Matysiak R. and Nalewaja J.D. 1992. Petroleum oil and emulsifier affect the phytotoxicity of imazethapyr. Weed Technology. 6: 81-84.

[23] James Grichar, W. andSestakD.C.2000. Effect of adjuvants on control of nutsedge (*Cyperus esculentusand* C. rotundus) by imazapic and imazethapyr. Crop Protection. 19: 461-465.