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EFFECT OF POST-EMERGENCE HERBICIDES ON WEEDS AND YIELD OF MAIZE

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ABSTRACT

Weeds are a major problem in maize and significantly decrease grain yield of maize in Kosovo. Field experiment was carried out during 2010 to identify weed species and to investigate the efficacy of herbicides on weeds and their effect on grain yield. Three different herbicides were applied after maize emergence, namely Monosan herbi (2,4-D-dimetil ammonium), Maton (2,4-D-izoktilester), and Equip (foramsulfuron+isoxadifen-éthyl-safener) in the maize variety ZP-434 in the region of Lipjan (central part of Kosovo). The trial was set in a randomized block design with four replications with a plot size of 7.5 m^2. A total number of 23 weed species were recorded in the experimental field. Maximum weed density (62.8, 23.5 and 9.3 m^{-2}) was recorded for Amaranthus retroflexus, Chenopodium album and Cirsium arvense, respectively. Herbicide application reduced the weed density and positively affected the grain yield in comparison to an untreated control. Foramsulfuron+isoxadifen-éthyl-safener proved most efficient as compared to 2,4-D-izoktilester and 2,4-D-dimetil ammonium. Comparatively high grain yields (3.1 t ha^{-1}) were found in plots treated with foramsulfuron + isoxadifen-éthyl-safener while the grain yield in 2,4-D-izoktilester and 2,4-D-dimetil ammonium treated plots was 2.7 t ha^{-1} and 2.5 t ha^{-1}, respectively.

Key words: Chemical control, grain yield, herbicide, maize, weeds

INTRODUCTION

Since centuries, the arable weed vegetation of Kosovo has been affected by multiple management measures and environmental features at various spatial scales. Weeds have become an increasing problem in maize and some weed species such as *Amaranthus retroflexus, Echinochloa crus-galli, Chenopodium album, Cirsium arvense* are widespread all over the arable land of Kosovo, especially in maize crop (Mehmeti *et al.* 2009; 2011).

In the Kosovo, along with far-reaching political and socio-economic alterations, agricultural land use has changed in the recent

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past. Today, wheat, maize and potatoes, are the predominant crops. Maize is produced on about 37,000 ha, where about 16,500 ha are cropped with maize and about 20,000 ha are characterized by mixed-cropping of maize and beans (Statistical Office of Kosovo, 2010). About three decades ago, the weed vegetation in the Kosovo region was highly diverse and even today, on the regional scale, about 250 weed species occur on the arable land (Mehmeti *et al.* 2008).

However, on the patch scale, i.e. on the scale of the arable field, only few species occur. Herbicide application and/or intensive mechanical weed control are common. To date, several studies on the relationships between weed composition in arable land, soil disturbance and herbicide application were conducted in Kosovo (Mehmeti and Demaj, 2010; Mehmeti *et al.* 2008; Mehmeti, 2003, 2004; Susuri *et al*. 2001; Shala, 1987; Kojić and Pejčinović, 1982).

Pests, plant diseases and weeds cause high losses of maize yield. Yield losses due to weeds have been reported up to 35 % (Oerke, 2005; Dangwal, *et al.* 2010). Thus, in maize production, it is necessary to undertake control of weeds which cause losses of maize grain yield. The use of herbicides may reduce such losses, as herbicides may reduce the weed infestation (Mehmeti, 2004), provided that the herbicide-treated weeds are not herbicide resistant. In general, a wide range of herbicides is available. The weed communities are very dynamic and variable in their floristic aspects (Mijatović and Lozanovski, 1984) and the presence and structure of weeds occurring in a field varies between fields and regions depending on climatic conditions, soil, crop, weed management, and weather conditions during the vegetation period.

Keeping in view the importance of weeds, the aim of the instant research presented was to identify weed species and to investigate the efficacy of herbicides on maize and to evaluate herbicide effects on grain yield, which is a very important crop in Kosovo.

MATERIALS AND METHODS

A field experiment was conducted in 2010. The research was done in a maize field on vertisol soil in the municipality of Lipjan (Kosovo). Weather condition at the experimental site is described in the Tables 1 and 2. The maize variety ZP-434 was sown manually in April, by using 25 kg ha^{-1} seeds, soil tillage was prepared by ploughing at 30-35 cm depth of the field followed by harrowing. Fertilizer was applied NPK 15:15:15 in doses of 200 kg ha^{-1} in all plots. In summer, supplementary fertilization with 150 kg ha^{-1} of ammonium nitrate was applied also in all plots. Experimental field was irrigated as and when needed. The previous crop was winter wheat.

Herbicide treatment was carried out using the CP-3 special knapsack sprayer of the capacity of 20 l, and the amount of water used was 400 l per ha. In Table-3, the basic data on the applied herbicides is provided. The trial was set in a randomized block design with four replications and elementary plots of 7.5 m^2 (3 m x 2.5 m). Each plot consisted of 4 rows; row to row distance was kept at 70 cm and plant to plant 25 cm. There were 4 treatments (Table-3).

The weed species were identified in the laboratory of the Faculty of Agriculture in Prishtina, Department of Plant Protection, using the Šarić (1991) and Demiri (1979). Nomenclature follows Wisskirchen and Haeupler, 1998 and life form (Ellenberg, *et al.* 1992). Moreover, number of weed individuals and aboveground dry biomass of the crop and of weeds were recorded. For the estimation of the aboveground dry biomass of crop and the weeds, samples were harvested for each repetition of experiment in September 2010. The aboveground dry biomass of crop and the weeds was recorded by cutting at ground level for each of repetition of one square meter. After harvesting, crop and weeds were cleaned and were dried at room temperature.

The estimation of weeds was conducted based on the quantity-quality method for 1 m^2. Research methods in phytocenosis are based on quantitative and qualitative analytical settings. The biomass of weeds pecies m^{-2} is measured here in this research.

All three herbicides were applied at 3-5 leaf stage of maize. Thirty days after herbicide application, the number and structure of weeds and the efficacy of herbicides were estimated by comparing sprayed plots and control plots (untreated). The efficacy of herbicides was calculated by the equation (Šarić, 1991),

$$KE\ \% = \frac{A \times 100}{B}\ \%$$

Where KE % is the coefficient of efficacy, A is the number of killed weeds m^{-2}, and B is the number of weeds m^{-2} in the untreated plots. The equation can be applied to weed species individuals ($KE_{ind.}$), weed and crop biomass (KEbiom) and to weed species numbers ($KE_{spec.}$).

Table-1. Mean air temperature (°C) in Prishtina, near to the studied field, in the year of the experiment and between 1951-1980 ('long-term average') (Zajmi, 1996).

	Months								
	III	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**Average**
Year	**Air temperature ^{0}C**								
2010	6.6	11.5	16.0	19.5	21.7	23.0	17.0	9.5	15.60
1951-80	4.7	10.4	14.6	18.0	20.2	19.9	16.1	11.0	14.36
Δ	+1.9	+1.1	+1.4	+1.0	+1.5	+3.1	+0.9	-1.5	+1.24

Δ: difference between 2010 and the long-term average.

Table-2. Rainfall (mm) in Prishtina, near to the studied field, in the year of the experiment and between 1951-1980 ('long-term average') (Zajmi, 1996).

	Months								
	III	IV	V	VI	VII	VIII	IX	X	Average
Year	Amount rainfall mm								
2010	49.1	78.5	77.2	67.8	14.9	23.7	31.8	84.7	53.46
1951-80	34.0	47.0	72.0	55.0	43.0	39.0	47.0	62.0	49.87
Δ	+15.1	+31.5	+5.2	+12.8	-29.9	-16.7	-16.8	+22.7	3.59

Δ: difference between 2010 and the long-term average.

Table-3. Detail of the applied herbicides.

Variants	Active ingredient	Product	Rate L ha^{-1}	Application
1	2,4-D-dimetil ammonium	Monosan herbi SL	2 l	Post emergence
2	2,4-D-izoktilester	Maton 600 SE	1.2 l	Post emergence
3	foramsulfuron+isoxadifen-éthyl (safener)	Equip OD	2 l	Post emergence
4		Control		

Statistical Analysis

Statistical analysis was performed using one-way ANOVA (Vukadinović, 1994). Mean values were calculated and significant differences among the means were established as based on LSD-tests.

Meteorological conditions

Information on air temperature and rainfall near to the maize field under study are given in Tables 1 and 2. The data refer to Prishtina, about 16 km away from the field under study. In comparison to an average year (mean values for 1951 to 1980 according to (Zajmi, 1996).

RESULTS AND DISCUSSION

Weed density

In the experiment, the total number of 23 weed species were recorded, indicating a species-rich weed community in the experimental field (Table-4).Among them, the most numerous are annual broad-leaved plants. These results are not in accordance with Mehmeti *et al.* (2011), who investigated weed composition in two production systems in maize crop in municipality of Vushtrri (Kosovo), and reported only 9 weed species. However, Mehmeti *et al.* (2008) showed that the current weed flora in maize crop in Kosovo is species-poor at the field scale (about 8.0 weed species 25 m^{-2}).

The number of weed individuals was very high in the control plots (Table-4). The most dense weed species were *Amaranthus retroflexus* (62 plants m^{-2}), *Chenopodium album* (23 plants m^{-2}) and *Cirsium arvense* (9 plants m^{-2}), *Anthemis arvensis* (7 plants m^{-2}), *Polygonum aviculare* (4 plants m^{-2}) and *Hibiscus trionum* (4 plants m^{-2})

were documented. Thus, the same species were dominant as in former studies conducted in maize fields of Kosovo (Mehmeti *et al.* 2008, 2009), but also in southern east Europe (Demjanova, *et al.* 2007; Vrbničanin *et al.* 2006; Volenik and Knezević, 1984; Ognjanović, 1984; Lozanovski *et al.* 1980). The individual numbers of all other species, which occurred in the experimental fields, were much lower. The predominance of species may be favoured by e.g. herbicide resistance, similar life cycles and habitat preferences of weeds and crops, high seed production, (moderately) seed banks, rhizomes and nitrophily. With respect to the species life forms, therophytes prevailed with 71.7 %, while hemicryptophytes (19.5 %) and geophytes (6.5 %) and cameophytes (2.2 %) were less important. These results are in accordance with Pejčinović (1987), who also found that therophytes dominated (28.57-66.23 %) in row crops in Kosovo.

Herbicide efficacy

It is evident from the results (Table-4) that all three herbicides reduced the weed infestation in the maize crop in comparison to the control plots. However, the highest control of weeds obtained from foramsulfuron+isoxadifen-éthyl-safener (74.1 %), while the 2,4-D-izoktilester (60.3 %) and 2,4-D-dimetil ammonium (48.4 %) did not give a satisfactory control. The foramsulfuron + isoxadifen-éthyl-safener were highly efficient by reducing weed species numbers ($KE_{spec.}$= 55.0 %), while 2,4-D-izoktilester and 2,4-D-dimetil ammonium were less efficient in the reduction of weed species numbers ($KE_{spec.}$= 25.0 % and 20.0 %). In our trials, *Amaranthus retroflexus, Hibiscus trionum,* and *Anthemis arvensis*, were the species that proved resistant (Table-4) to the tested herbicides 2,4-D-dimetil ammonium and 2,4-D-izoktilester. The dominant species as *Amaranthus retroflexus* and *Hibiscus trionum* (Table-4) have been found highly susceptible to foramsulfuron+ isoxadifen-éthyl-safener. However, *Amaranthus retroflexus* was proved to be resistant to the tested herbicides 2,4-D-dimetil ammonium and 2,4-D-izoktilester. Moreover, *Chenopodium album* was proved to be resistant to foramsulfuron+isoxadifen-éthyl-safener and 2,4-D-izoktilester, while had the highest susceptibility to 2,4-D-dimetil ammonium (Table-4).

Grain yield

In comparison to the control plots (1.5 t ha^{-1}), all herbicide treated plots showed increased grain yields (Table-4). These results are in line with many publications of Munsif *et al.* (2009), Abdullah *et al*. (2007), and Khan and Haq (2004) who reported that grain yields were affected by weed control treatments. Results indicated that comparatively higher grain yield were found in plots treated with foramsulfuron+isoxadifen-éthyl-safener (3.1 t ha^{-1}) and 2,4-D-izoktilester (2.6 t ha^{-1}). Yields were lower (2.5 t ha^{-1}) in 2,4-D-dimetil ammonium treated plots (Fig. 1).

Table-4. Species life forms, number of individuals and coefficients of herbicide efficacy (KE) in the investigated maize crop.

Life form	Species name	2,4-D-dimetil ammonium	2,4-D-izoktilester	foramsulfuron+ isoxadifen-éthyl	Control
T	*Alopecurus myosuroides* Hudson.	0.5	0.5	0	0
T	*Amaranthus retroflexus* L.	39.3	15.3	0	62.8
T	*Anthemis arvensis* L.	3.0	3.8	0.5	7.5
T	*Capsella bursa-pastoris* (L.) Med.	0	2.5	0	2.8
T	*Chenopodium album* L.	0	7.0	16.5	23.5
G	*Cirsium arvense* (L.) Scop.	1.5	0	2.8	9.3
G, Hli	*Convolvulus arvensis* L.	0.8	0	0.8	2.8
T	*Echinochloa crus-galli* (L) P.B.	1.5	1.3	0.3	0.5
T	*Galinsoga parviflora* Cav.	0.8	1.5	0	0.5
T	*Gallium aparine* L.	0.5	0	0	0
T	*Hibiscus trionum* L.	6.0	9.0	0	4.0
H,T	*Lactuca serriola* L.	0.5	0	0	0.8
T	*Lamium amplexicaule* L.	1.0	0.3	0	0
T	*Matricaria chamomilla* L.	0.3	0	0	0.3
H	*Planatago lanceolata* L.	0	0	0	0.3
H	*Planatago major* L.	0	0.5	0.5	1.3
T	*Polygonum aviculare* L.	3.0	2.3	3.3	4.3
Tli	*Polygonum convolvulus* L.	0	0.5	0.3	0.5
T	*Setaria viridis* P.B.	0	0.3	0	0.5
H	*Taraxacum officinale* Web.	0.5	0	0	1.8
C,H	*Trifolium repens* L.	1.3	2.5	0	0.5
T	*Veronica hederofilia* L.	4.5	2.8	7.8	2.0
T	*Xanthium strummarium* L.	0	0	0	0.5
Number of individuals m^{-2}		64.8	49.8	32.5	125.5
$KE_{ind.}$ (%)		48.4	60.3	74.1	0
Species number		16	15	9	20
$KE_{spec.}$ (%)		20.0	25.0	55.0	0
Maize yield grain (t ha^{-1})		2.5	2.7	3.1	1.5
Abovegorund dry biomass of maize g m^{-2}		676	699	704	474
Aboveground dry biomass of weeds g m^{-2}		312	226	196	341
$KE_{biom..}$ (%)		8.5	33.7	45.3	0

The tested herbicide 2,4-D-dimetil ammonium and 2,4-D-izoktilester had no significant differences for the grain yield with control plots, while foramsulfuron+isoxadifen-éthyl-safener had significant differences with control plots, but not with the other tested herbicides.

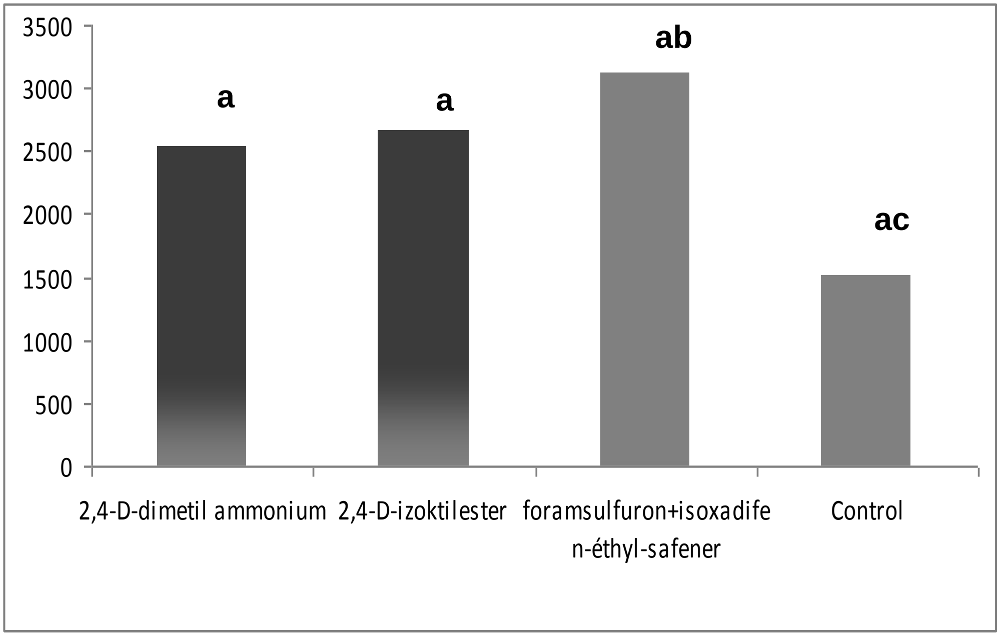

Figure 1. Yield of maize (t ha^{-1}) depending on herbicide treatment; a, b, c – Results with same letters are not significant, according to ANOVA test.

Biomass yield of maize and weeds

The tested herbicides reduced the biomass of the weeds and strongly favored the aboveground biomass of the crop (maize). The herbicide foramsulfuron+isoxadifen-éthyl-safener had the highest efficacy in reduction of above dry biomass of weeds 171.0 g m^{-2}, while in control plots the biomass of above dry biomass of weeds was 340.7 g m^{-2}.

The results are supported by Bogdan *et al.* (2007) who reported that large weed biomass noted in the control variant. However and Abdullah *et al.* (2007) presented similar results and concluded that dry weight of weeds was significantly affected by different herbicide treatments.

The tested herbicide 2,4-D-dimetil ammonium and 2,4-D-izoktilester had no significant differences for the aboveground dry biomass of weeds with control plots, while foramsulfuron+isoxadifen-éthyl-safener had significant differences with control plots, but not with the other herbicides (Fig. 2).

The differences in dry biomass between the plots treated with herbicide and control plots may be especially high due to the herbicide use and climatic conditions (high air temperatures, low rainfall) in the study region in 2010. The degree of weed control may vary widely depending of herbicide efficacy (Mehmeti, 2003; Khan and Haq, 2004) and climatic conditions (Bogdan *et al.*, 2007).

However, mechanical weed control and herbicides have impact in reduction of above dry biomass of weeds (Mehmeti *et al.*, 2011; Bogdan *et al.*, 2007), but this depends from the maize variety, sowing density, time of germination and climatic conditions.

In the experimental field without weed control, the mean aboveground dry biomass of maize was 473.0 g m^{-2}. In the experimental field with weed control, the average dry biomass of maize was 754.0 g m^{-2} for the foramsulfuron+isoxadifen-éthyl-safener, whereas for the 2,4-D-izoktilester was 699.0 g m^{-2}, and 2,4-D-dimetil ammonium 676.0 g m^{-2}. The data in aboveground dry biomass of maize showed significant differences only among foramsulfuron+isoxadifen-éthyl-safener and control plots, but not between the other tested herbicides (Fig. 3).

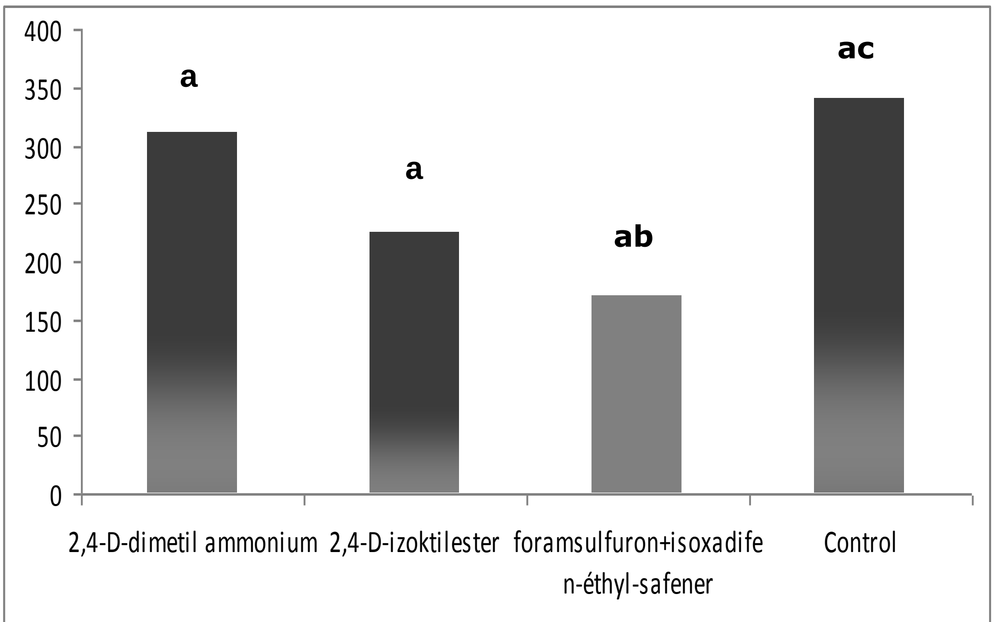

Figure 2. Impact of herbicides in above dry biomass of weeds (g m^{-2}).

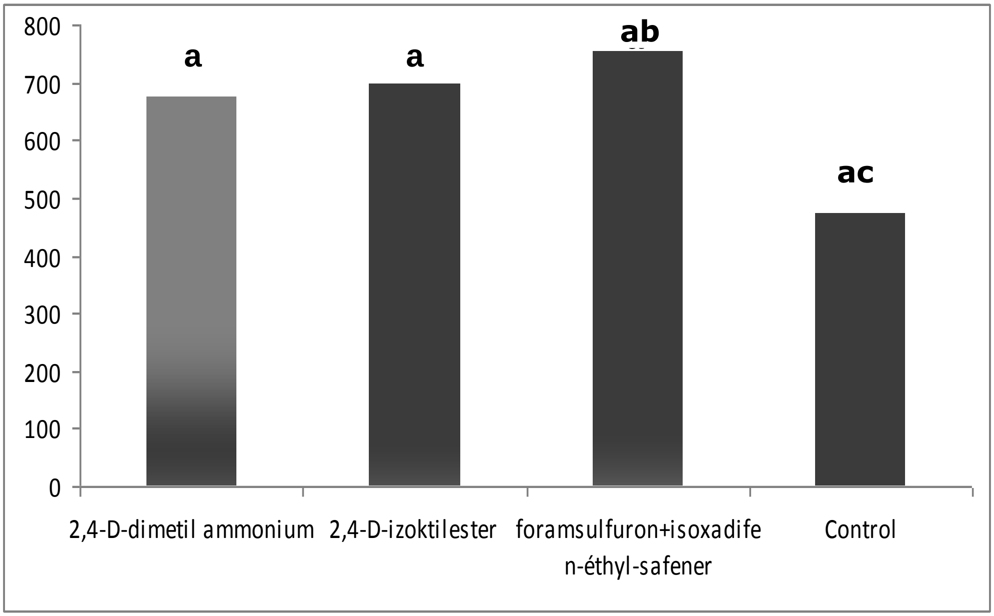

Figure 3. Impact of herbicides in above dry biomass of maize (g m^{-2}).

CONCLUSION

It can be concluded that 2,4-D-izoktilester and 2,4-D-dimetil ammonium should not be recommended for weed control in maize in Kosovo. Based on the results presented, it can also be deduced that foramsulfuron + isoxadifen - éthyl-safener should be recommended in the studied region for successful weed control and high maize grain yields.

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