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Reproductive Capacity of Jimsonweed (*Datura stramonium* L.), Redroot Pigweed (*Amaranthus retroflexus* L.) and Black Nightshade (*Solanum nigrum* L.) under Different Herbicide Regimes in Maize

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Abstract: Maize is among the major crops in Serbia. Weeds affect maize yield adversely. Jimsonweed, redroot pigweed and black nightshade are the important weeds in maize in Serbia. Herbicide mixtures and/or successive applications of herbicides are used to improve weed control. A field experiment was carried out to investigate efficiency of different herbicide applications on weeds in 2001. Treatments were mesotrione (PRE) plus acetochlor (POST), and five combinations of dimethenamid (PRE) with some POST herbicides such as nicosulfuron, tank mix of atrazine and fluorochloridone, 2,4-D-2 EHE and atrazine. The highest weed control on total weed flora was obtained from the application of dimethenamid plus tank mix of atrazine and fluorochloridone. No jimsonweed was survived after application of mesotrione plus acetochlor, and dimethenamid plus nicosulfuron, redroot pigweed was by dimethenamid plus nicosulfuron, and black nightshade was by mesotrione plus acetochlor. Shoot and root weights of weeds and seed production were in parallel with control levels of weeds.

Key words: dimethenamid, nicosulfuron, atrazine, fluorochloridone, 2,4-D-2 EHE, mesotrione, acetochlor

INTRODUCTION

Maize is an important field crop in Serbia, which is grown on over 1,2 million ha area[1]. Weeds are the most underestimated pest in maize production in Serbia[2] as well as world wide[3]. The slow growth rate of maize seedlings and wide-spread rows create an environment ideal for the growth of weeds [3]. Natural stand of weeds decreased maize yield 38-59 %[4].

Jimsonweed (*Datura stramonium* L.), redroot pigweed (*Amarantus retroflexus* L.) and black nightshade (*Solanum nigrum* L.) are among the economic noxious weeds in maize in Serbia[5,6]. Furthermore redroot pigweed is classified as an invasive alien species in Serbia[7]. Maize crop losses reported 14-63 %, 5 % due to jimsonweed and redroot pigweed interference[8,9]. Increasing jimsonweed density from 1 to 10 per m^{-2} significantly reduced plant height, leaf area index as well as maize yield from 8 to 32 %[10,11,12].

Herbicides from different chemical families are registered for weed control in maize in Serbia[13]. Dimethenamid is mainly a grass herbicide; but, it controls certain annual broadleaf weeds such as redroot pigweed and black nightshade. Atrazine controls mainly broadleaf weeds including redroot pigweed and jimsonweed. They can be applied early preplant, PPI, PRE, or early POST in maize. Acetochlor is applied PPI or PRE, which controls most annual grasses and certain small-seeded broadleaf weeds. Mesotrione can be used PRE or POST to control broadleaf weeds and some grass weeds. Nicosulfuron is POST herbicide for grass weeds. It also controls some broadleaf weeds. Flurochloridone is a PRE herbicide to control broadleaf weeds including redroot pigweed and black nightshade. 2,4-D controls a wide range of broadleaf weeds[14]. However, one herbicide application cannot be enough to control all weeds at the same time. So, different herbicides at different times or at the same time as mixtures can be used. The aim of the current paper was to investigate the effect of dimethenamid and other herbicides followed it under field conditions on jimsonweed, redroot pigweed and black nightshade in a maize field.

MATERIALS AND METHODS

An experiment was carried out in the experimental field of Maize Institute, Zemun Polje, Serbia in 2001. Soil type was loamy calcareous chernozem (Table 1). The previous crop was winter wheat. Based on local recommendations conventional tillage system was applied. Maize was sown at density 70x25 cm in 25 m^2 (5mx5m) plots on 3 May 2001. There were 7 treatments, 6 herbicide treatments (Table 2) and a check without herbicides and cultivation. Herbicide rates were chosen

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Table 1: Chemical properties of loamy calcareous chernosem in the experimental field.

pH							
in water	in n Kcl	Physical sand (>0.01mm)(%)	Dust and clay (<0.01mm)(%)	Humus content (%)	Nitrogen total (%)	Available P ($Al\text{-}P_2O_5$) (mg/100g)	Available K ($Al\text{-}K_2O$)(mg/100g)
7.7 – 8.6	6.85 – 7.45	51.5 – 54.8	45.2 – 48.4	3.06 – 3.35	0.173- 0.219	10.2 – 14.5	28.6 – 32.4

Table 2: Herbicide treatments of experiment.

Treatments	Herbicides			Herbicides		
	Name	Rate (l/ha)	Application Time	Name	Rate (l/ha)	Application Time
T1	Mesotrione*	0.2	PRE	Acetochlor	1.5	POST
T2	Dimethenamid	1.4	PRE	Nicosulfuron	1	POST
T3	Dimethenamid	1.4	PRE	Tank mix of Flurochloridoneand Atrazine	1+1	POST
T4	Dimethenamid	1.4	PRE	2,4-D-2 EHE	1	POST
T5	Dimethenamid	1.4	PRE	Atrazine	1	POST
T6	Dimethenamid	1.4	PRE	-	-	-

* Trade names of herbicides: Callisto (mesotroine), Relay plus (acetochlor), Frontier 900-EC (dimethenamid), Motivell (nicosulfuron), Racer 25-EC (flurochloridone), Atrazin-SC (atrazine), Maton (2,4-D-2 EHE).

Table 3: Meteorological data during the experiment in Zemun Polje.

Months	IV	V	VI	VII	VIII	IX	Yearly Average	Yearly Sum
Precipitation (mm)	148.80	46.20	168.10	41.80	35.10	167.70	148.80	607.70
Temperature (°C)	11.10	17.60	18.20	22.40	23.30	16.30	18.15	108.90

in the range of recommendation. Dimethenamid and mesotrione were applied PRE. The other herbicides applied POST. Nicosulfuron and 2,4-D-2 EHE were applied at 2 to 4 true-leaf growth stage of maize and 3 to5 true-leaf growth stage of weeds while the other POST herbicides were applied at 1 to-2 true-leaf growth stage of maize and 2 to3 true-lea growth stage of weeds. Herbicides were applied with a knapsack-sprayer mounted 02-110 TECSI nozzle (Tee-jet), which delivered 3 L water per plot. Environmental data during the experiment was presented at the Table 3. The experimental design was completely randomized block design with three replications. Maize was grown as farmers do.

The effect of herbicides on total weed flora and given species were assessed on 05.06.2001, 27.06 2001, 06.08 2001, and 05.10.2001 and presented as percent control comparing to no-herbicide check. The number of alive plants for given species in all plots were recorded on 05.06.2001 and the data were subjected to descriptive statistical analyses. When weed species reached the reproductive stage, five survival plants of each species were uprooted randomly from each plot and shoot and root separated. After having plants dried at 60^0C in an oven for 24 hours, shoots and roots were weighted. Seeds of all survival jimsonweed and black nightshade plants in plots were collected three times (in 20 August, 27 August and 5 September) not to lost any seeds after maturing. The data were subjected to descriptive statistical analyses. Maize yield data went under ANOVA and the multiple comparisons.

RESULTS AND DISCUSSIONS

Thirty weed species were determined in the experimental field and the most dense weed species in the

Table 4: Weed Flora in control plots on 27.06.2001 in the experiment

Weed species	Average Density of Weeds (Plant/m^2)	Average Fresh Weight (g/m^2)
SOLNI	11.3	410.4
AMARE	8.0	345.2
CHEAL	6.7	637.9
SETVI	6.0	110.3
SORHA	6.0	360.5
CHEHY	4.0	275.5
SETVE	4.0	95.3
CONAR	2.7	172.4
LATTU	2.0	70.7
AMBAR	1.3	4.9
POLLA	1.3	23.1
CYNDA	1.3	11.3
AMAAL	1.3	17.8
POLAV	1.3	14.9
AGRRE	1.3	2.8
DIGSA	1.3	7.7
DATST	0.7	19.3
PANCG	0.7	4.2
SONAS	0.7	34.5
VERPE	0.7	24.5
CIRAR	0.7	9.9
RUBCA	0.7	6.7
SETGL	0.7	9.2
STEME	0.7	2.1
BILCO	0.7	44.8
RESLU	0.7	6.8
AMABL	0.7	4.9
ATRPA	0.7	14.9
HIBTR	0.7	7.7
SONAR	0.7	10.9
Total	69.3	2761.0

Table 5: The effect of treatments on total weed flora

Assessment Dates	T1	T2	T3	T4	T5	T6
05.06.2001	91.3±21.5	86.5±25.9	93.0±22.3	88.7±30.4	78.6±37.7	63.3±36.6
27.06 2001	68.4±43.8	76.5±40.8	87.0±32.1	71.6±40.4	73.7±38.3	47.6±45.4
06.08 2001	80.33±2.4	77.1±35.2	90.6±17.8	65.8±39.5	80.7±28.8	69.7±37.9
05.10.2001	73.1±40.8	75.3±38.2	82.8±31.7	66.4±41.4	73.7±38.8	58.7±47.7

Table 6: Effect of treatments on maize grain yield

Treatments	T1	T2	T3	T4	T5	T6	Check
Maize yield (t/ha)	10.86 a*	8.27 ab	8.31 ab	10.53 a	7.55 ab	6.22 ab	4.88 b

* means followed by the same letter are not different ($p<0.05$)

Table 7: Effect of treatments on plant survival of jimsonweed, redroot pigweed and black nightshade

Weeds	T1	T2	T3	T4	T5	T6	Check
Jimsonweed	0±0.0	0±0.0	3±1.0	5±2.1	2±0.6	6±2.6	12±1.0
Black Nightshade	0±0.0	14±0.6	9±2.0	10±2.9	10±2.9	15±0.0	15±0.0
Redroot Pigweed	3±1.0	0±0.0	2±1.1	15±0.0	8±2.5	9±1.7	15±0.0

Table 8: Effect of treatments on dry shoot and root weight of jimsonweed, redroot pigweed and black nightshade.

Weed	Dry Weight (g/plant)	T1	T2	T3	T4	T5	T6	Check
Jimsonweed	shoot weight	0.0±0.0	0.0±0.0	3.0±7.8	1.9±3.0	0.9±2.5	5.0±6.0	8.0±6.0
	root weight	0.0±0.0	0.0±0.0	0.6±1.6	1.6±3.5	0.2±0.5	1.0±1.3	3.0±2.0
	total weight	0.0±0.0	0.0±0.0	3.6±10.0	3.5±2.8	1.1±3.7	6.0±5.0	11.0±4.7
Black Nightshade	shoot weight	0.0±0.0	7.8±5.1	2.7±2.9	3.4±4.4	4.6±4.6	8.2±5.9	7.7±7.6
	root weight	0.0±0.0	2.1±1.1	0.7±0.9	1.8±2.4	0.9±1.0	1.8±1.0	1.2±1.0
	total weight	0.0±0.0	9.9±4.5	3.4±2.4	5.2±3.7	5.5±3.9	10.0±5.2	8.9±4.8
Redroot Pigweed	shoot weight	2.0±5.4	0.0±0.0	1.7±4.5	10.6±7.1	6.2±8.0	3.1±5.3	3.9±3.4
	root weight	0.1±0.3	0.0±0.0	0.3±0.7	1.8±1.1	1.4±1.8	0.6±1.0	0.9±0.7
	total weight	2.1±2.1	0.0±0.0	2.0±6.3	12.4±6.7	7.6±7.0	3.7±4.7	4.8±2.6

Table 9: Effect of herbicides on the seed weight of jimson-weed (*D. stramonium* L.) and black nightshade (*S. nigrum* L.) (g/treatment)

Weeds	T1	T2	T3	T4	T5	T6	Check
Jimsonweed	0.0±0.0	0.0±0.0	5.7±6.8	2.3±2.0	2.9±2.5	24.9±37.7	24.6±8.1
Black Nightshade	0.0±0.0	10.0±4.4	6.8±6.4	9.5±10.2	12.7±12.0	22.0±8.0	14.1±9.2

experimental area was black nightshade, which is followed by redroot pigweed, lambsquarters (*Chenopodium album*), green foxtail (*Setaria viridis*), johnsongrass (*Sorghum halepense*) (Table 4). The density of jimsonweed was less than a plant per square meter. The highest control of total florawas obtained from treatments 1 and 3, which controlled weeds over 90 % while at the least control was 63.3 % from treatment 6 (Table 5). Treatments 2 and 4 gave control close to 90 % while the weeds were controlled 78.6 % by treatment 5. Dimethenamid itself did not give a satisfactory control and rate of efficy of treatments differed due to POST applied herbicide. Atrazine followed by dimethenamid gave only less than 80 % control while adding flurochloridone, which is a PRE herbicide although we used early POST, into atrazine improved weed control up to 93 %. Effect of this application treatment 3 lasted longer, i.e. there was still 82.8 % control in October. In addition the effect of treatment 5 did not reduce during the season. It is concluded that the effect of atrazine goes longer. The effect of mesotrione plus acetochlor and dimethenamid plus nicosulfuron was dropped 75 % the end of the cropping season. Maize grain yield was in parallel with effect of treatments on total weed flora (Table 6).

The effect of treatments was different on jimsonweed, black nightshade, and redroot pigweed (Table 7). It was different from the effect on total weed flora too. No jimsonweed survived at treatments 1 and 2. Total death occurred at treatment 1 for black nightshade while at treatment 2 for redroot pigweed. Although treatment 3 was the best on total weed flora, it was not the best on jimsonweed, black nightshade, or redroot pigweed. Except the treatment 1, there was failure at control of black nightshade from other treatments. All black nightshade plants survived at the application of

dimethenamid alone. The label of dimethenamid shows that black night shade cannot be controlled if excessive rainfall occurs early in the season[15] which is occurred in our conditions (Table 3). The similar results had gotten in sugarbeet, i.e. nightshade survived at recommended dose of dimethenamid[16]. In addition black nightshade is not among the weeds that are controlled POST by atrazine[15]. The low effect at treatment 5 could be resulted in atrazine resistance in pigweed[17]. Redroot pigweed can be controlled partially by 2,4-D-2-EHE and locally resistant biotypes may occur[15].

Plant dry weights were parallel with survival rate of herbicides except the effect of treatment 3 on black nightshade (Table 8). Although black nightshade survival high under treatment 3, plant dry weight was low due to possibly suppression. Suppression was determined in most treatments but treatment 6 on all given weeds, treatment 4 and treatment 5 on black nightshade and redroot pigweed, and treatment 2 on black nightshade. The amount of seed produced was generally parallel with plant dry weight (Table 9). Jimsonweed produced seed under treatment 6 as much as non-herbicide check while other treatments reduced reproductive capacity. Except treatment 1, black night shade reproductive capacity was not affected much from any treatment.

It can be concluded that dimethenamid itself should not be recommended in weed control in maize in Serbia. It requires some POST application of an effective herbicide. In the term of the weed control dimethenamid plus tank mix of fluorchloridone and atrazine should be recommended to the farmers because of high and long lasting effect. Mesotrione plus acetochlor treatment was also one of the best choices in our experiment. However, the effect of treatments on maize yield and economic justification should be taken into account. In addition, weed composition in each individual field is another factor for choosing appropriate weed control method. Except the total control of weed flora, weeds were able to produce high amount of dry matter and keep their reproductive capacity.

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