UDC 632.5:633.15
Original scientific paper

EFFECTS OF CROP DENSITY AND HERBICIDE TREATMENT ON THE FLORISTIC COMPOSITION AND STRUCTURE OF WEED COMMUNITY IN MAIZE

Milena STANOJEVIĆ [1*], Lidija STEFANOVIĆ [1], Borivoje ŠINŽAR [2] and Sava VRBNIČANIN [2]
[1] Maize Research Institute, Zemun Polje, Belgrade-Zemun
Yugoslavia
[2] Faculty of Agriculture, Belgrade-Zemun

Stanojević Milena, Lidija Stefanović, Borivoje Šinžar and Sava Vrbničanin (2001): *Effects of crop density and herbicide treatment on the floristic composition and structure of weed community in maize.* Acta herbologica, Vol. 10, No. 1, 23–35.

Effects of crop density and herbicide treatment on the distribution of weed species in a weed community in maize at the location of Zemun Polje were investigated. During the maize growing seasons in 1996 and 1997, floristic composition and structure of weed community were surveyed. Furthermore, the number of species, number of plants per species and fresh weight of all weeds per area unit over all densities in both treated and untreated variants were also determined. Changes, occurring under effects of higher maize crop densities and herbicide application, were analysed on the basis of distributed weed species and their plants per species. Moreover, relative distribution of certain weed groups was determined. Significant effects of crop density x herbicide application interaction were observed in reducing the relative distribution of certain broad-leaved and perennial weeds in the total maize weediness at Zemun Polje.

Key words: maize, weed association, weed species, herbicide application

Corresponding author: Milena S.Simić, Maize Research Institute Zemun Polje, Slobodana Bajića 1, 11185 Zemun Polje. Tel. 011/3756-704, e-mail: smilena@mrizp.co.yu

INTRODUCTION

Weed communities in agro-ecosystems, especially in row crops such as maize, are very dynamic and changeable. According to floristic-phytocoenological studies by KOJIĆ (1975), ŠINŽAR and DEJOVIĆ (1975) it may be concluded that the row crop weed association *Hibisco-Eragrostietum megastachuae* Tx 1950 of the alliance *Eragrostion* Tx. 1950 prevails in maize crop at the investigated location. The following species are the most frequent in the association: *Hibiscus trionum*, *Chenopodium album*, *Anagalis arvensis*, *Portulaca oleracea*, *Amaranthus retroflexus*, *Solanum nigrum*, *Convolvulus arvensis*, *Digitaria sanguinalis*, *Setaria glauca*, *Cirsium arvense*, etc. (KOJIĆ and ŠINŽAR, 1985). Although broad-leaved weeds, regarding their spread and distribution, prevail in maize crop, a special place in weed communities of this crop belongs to weeds of the family *Poaceae*, whose distribution has increased through long-standing application of herbicides (STEFANOVIĆ and ŠINŽAR, 1992).

Various measures, including preventive and direct ones (crop rotation, tillage, herbicide application, etc.), are being taken to control weeds growing in maize (STOJAKOVIĆ *et al.*, 1980; BOŽIĆ, 1980; LOZANOVSKI *et al.*, 1980). Long-running use of herbicides has been the first and foremost measure of weed control in the maize crop. Besides its high efficiency in weed control, however, it may also lead to many adverse effects, including primarily: change in the floristic composition and structure of weed communities, spreading of resistant and especially perennial weed species of the family *Poaceae*, occurrence of weed species resistant to applied herbicides, detrimental effects on crop plants, accumulation of herbicides and their residues in soil, water and plant parts (LOZANOVSKI *et al*, 1980; ŠINŽAR *et al.*, 1988; AJDER, 1991, SEILER *et al.*, 1992; ŠINŽAR and STEFANOVIĆ, 1993; STEFANOVIĆ *et al.*, 1994). In recent times, several methods of weed control have been recommended as part of the integrated weed management system in order to avoid adverse effects of herbicide application (SWANTON and WEISE, 1991, 1996; KOVAČEVIĆ and MOMIROVIĆ, 1996). The system includes chemical control as well as combined employment of all other measures that reduce weed abundance but do not decrease maize yield and do not endanger the environment (SWANTON and WEISE, 1996).

Maize growth at optimum or slightly higher crop densities, with no gaps, may greatly contribute to a decrease in weed coverage and low yield reduction caused by weeds (WALKER and BUCHANAN, 1982; SWANTON and WEISE, 1991). Technological measures such as narrow row spacing of genotypes "tolerant" to higher density are based on better utilisation of light by the crop and prevention of weed resurgence (YELVERTON and COBLE, 1991; HOLT, 1995). Morphological and physiological adjustment of crops relating to their responses to light are the next potential method of controlling the crop/weed relationship. It particularly concerns the elimination of weed species that are very competitive for light and cannot develop under conditions of "closer maize plant spacing". The results obtained by VIDENOVIĆ and STEFANOVIĆ (1994) indicate that higher maize sowing densities may reduce maize weediness by as much as 22.9 %. According to TOLLENAAR *et al.* (1994), an increase in maize density of 4 to 10 plants m^{-2} results in a weed biomass decrease of 63% down to 50%, and 71% to 39% in mid-season and at the end of the growing season respectively, which shows that maize competitiveness increases with sowing density in comparison to weeds. Naturally, crop density, as a cropping practice effecting a reduction in weediness, is not sufficient. This measure is fully employed and meaningful only as a part of the integrated weed management concept.

Considering that maize growth at optimum, higher or lower sowing densities can affect weed distribution in the crop, detailed studies of the effects of different maize sowing densities on the floristic composition and structure of maize weed community with and without herbicide treatment were carried out.

MATERIAL AND METHODS

Trials, involving 4 replicates and a preceding winter wheat crop, were carried out on the experimental field of the Maize Research Institute, Zemun Polje, on a slightly calcareous chernozem soil over the 1996-1997 period. The level of weed infestation was studied at the following crop densities: 40,816 plants ha^{-1} (D_1), 69,686 plants ha^{-1} (D_2) and 98,522 plants ha^{-1} (D_3). Inter-row spacing of 70 cm was equal for all three densities. A combination of herbicides atrazine-500 and Dual 720-EC was applied at the rates of 1.0 and 2.88 l of active ingredient ha^{-1} at the post-planting pre-emergence stage in the treatment variant (T). The herbicides were not applied in the control variant (C).

The composition of weed community was analysed in both years. Weed distribution was determined at each density in both treated and untreated variants. The number of weed species and the number of individual plants were determined per square meter. Fresh weight of each weed species was determined, but cumulative values for particular weed groups were presented. Finally, relative distribution (%) of plants and fresh weight of particular weed groups (broad-leaved, grass, annual and perennial species) in total weediness was analysed. Distribution of each weed group at different densities was compared with the total number of their plants or total fresh weight at the lowest density D_1 (100.0%) for each year independently. Grain yield (t ha^{-1}) was determined in each variant at the end of the maize growing season and presented with a 14% moisture adjustment. The acquired data were statistically processed by the factorial analysis of variance, while mean differences were tested by LSD test and t-test.

Meteorological conditions

The average monthly air temperature over the growing seasons of both years (18.2 °C and 18.0°C) did not significantly differ from a long-standing mean value (18.1 °C) (Table 1).

Table 1. Meteorological conditions during maize growing season in 1996 and 1997

Years	Months						
	IV	V	VI	VII	VIII	IX	$\overline{X}$
Air temperatures (°C)							
Long-term average	11.4	16.7	19.9	21.7	21.2	17.4	18.1
1996.	12.1	19.0	21.5	21.1	21.6	13.8	18.2
1997.	8.3	18.7	21.8	21.4	21.6	16.0	18.0
Precipitation (mm)							
Long-term average	49.1	62.3	80.1	62.4	50.6	43.5	348.0
1996.	44.6	74.3	72.3	29.0	75.3	98.7	394.2
1997.	87.0	51.0	31.0	131.0	103.0	31.2	434.2

Rainfall amounts over the growing seasons of both years of investigation (394.2 mm and 434.2 mm) exceeded the long-standing mean value. However, their distribution significantly differed over the years. In 1996, there was only 29.0 mm of rainfall in July, the middle of the growing season, which is significantly lower than the long-term mean (62.4 mm). On the other hand, in 1997, the corresponding amount was 131.0 mm, i.e. twice the long-standing mean for July.

RESULTS AND DISCUSSION

In 1996, 23 weed species with 83.9 plants per m^2 were found in the control variant with the lowest crop density (D_1). The greater the density was, the lower the number of weeds and their plants per m^2 (Table 2).

Table 2. Floristic and quantitative changes within maize weed association in relation to crop density and herbicide treatment in 1996

LF	Weed species	Control			Treated		
		G_1	G_2	G_3	G_1	G_2	G_3
T	*Amaranthus albus* L.	13.8	15.5	13.3	5.3	4.8	3.7
T	*Solanum nigrum* L.	15.5	13.3	10.3	8.3	5.5	6.0
T	*Amaranthus retroflexus* L.	14.2	10.8	9.3	3.2	3.7	1.8
G	*Cirsium arvense* (L.) Scop.	10.2	6.3	8.0	9.3	2.7	0.3
G	*Convolvulus arvensis* L.	6.7	5.2	4.7	6.0	3.8	3.3
T	*Hibiscus trionum* L.	4.0	4.5	2.3	1.8	0.7	1.5
T	*Chenopodium hybridum* L.	5.0	2.2	1.8	1.2	1.7	0.2
G	*Sorghum halepense* (L.) Pers.	3.8	2.3	2.2	3.0	1.8	1.3
T	*Datura stramonium* L.	3.3	1.2	2.8	1.7	0.3	1.3
T	*Digitaria sanguinalis* (L.) Scop.	0.8	2.2	3.7	6.3	5.2	4.5
T	*Portulaca oleracea* L.	1.5	0.7	1.7	0.3	0.2	0.3
G	*Sonchus arvensis* L.	1.3	0.5	0.7	-	-	-
T	*Chenopodium album* L.	0.5	0.3	0.2	0.2	-	0.2
T	*Senecio vulgaris* L.	0.7	-	-	-	-	-

T	*Panicum crus-galli* (L.)R et Sch.	0.5	-	-	-	-	-
G	*Convolvulus sepium* (L.) R.Br.	0.5	-	-	-	-	-
T	*Sonchus oleraceus* (L.) Gou.	0.3	0.2	-	-	-	-
T	*Stachys annua* L.	0.2	-	0.3	-	0.2	-
T	*Anagallis arvensis* L.	0.2	0.2	-	-	-	-
T	*Sinapis arvensis* L.	0.2	0.2	-	-	-	-
T	*Reseda lutea* L.	0.3	-	-	-	-	-
T	*Abutilon theophrasti* Medik.	0.2	-	-	0.2	-	-
T	*Amaranthus blitoides* S.Watson	-	0.2	-	-	-	-
T	*Lamium purpureum* L.	0.2	-	-	-	-	-
T	*Heliotropium europaeum* L.	-	-	-	0.5	-	-
Total number of weed species		23	17	14	14	12	12
% of total number of weed species		**100.0**	**73.9**	**60.9**	**100.0**	**85.7**	**85.7**
Total number of weed plants per species (number m^{-2})		83.9	65.8	61.3	47.3	30.6	24.4
% of total number of weed plants per species		**100.0**	**78.4**	**73.1**	**100.0**	**64.7**	**51.6**
Total fresh weight of weeds (g m^{-2})		**1746.8**	**1319.6**	**1043.3**	**413.7**	**183.0**	**139.1**
% of total fresh weight of weeds		**100.0**	**75.5**	**59.7**	**100.0**	**44.2**	**33.6**

Hence, the average number of weed species and plant individuals m^{-2} was 17 and 65.8 m^{-2} respectively for D_2 density, and 14 and 61.3 m^{-2} for D_3 density. This trend is even more evident under conditions of herbicide treatment: the greater the density was, the lower the total number of weed plants - D_1 (47.3 plants m^{-2}), D_3 (24.4 plants m^{-2}). The decrease amounted to 48.4%. In 1996, the following species prevailed: *Amaranthus albus*, *Solanum nigrum* and *Amaranthus retroflexus* (annual species) and *Cirsium arvense* and *Convolvulus arvensis* (perennial species). The following species, found at the lowest density (D_1), were absent from density D_2: *Senecio vulgaris, Panicum crus-galli, Conolvulus sepium, Stachys annua, Reseda lutea, Abutilon theophrasti* and *Lamimum purpureum.* Besides those mentioned, the following species were detected at the highest density (D_3): *Sonchus oleraceus, Anagallis arvensis* and *Amaranthus blitoides*. Almost all listed weed species have index 4 regarding their light parameter. It reflects their great demand for light, due to which longer periods of shading under high densities are unfavourable for their development (LANDOLT, 1997). This can serve as an explanation why they were not found in maize crops of higher densities, where closer plant spacing reduced the amounts of light penetrating into lower strata of the community. Higher crop densities in 1996 did not lead to a decrease either in weed plants or fresh weight per m^2 of the species *Digitaria sanguinalis*. Only when herbicides were applied the number of weed plants decreased with the increase in maize density.

Effects of higher maize crop densities under conditions of herbicide treatment and without it were made even more evident by the decrease in fresh weight of present weed species. Total fresh weight of weeds decreased 40.3% (from 1746 g m^{-2} at density D_1 to 1043.3 g m^{-2} at density D_3) in non-treatment conditions. The decrease in total weed fresh weight was even greater in the treated variant (66.4% - from 413.7 g m^{-2} at density D_1 to 139.1g m^{-2} at density D_3). Such a great decrease in weed weight speaks in favour of a combined application of chemical measures and cropping practices in weed control in maize.

Effects of maize densities on changes in the number of plants of certain weed groups in 1996 are shown in Table 3. The maize density increase (from D_1 to D_3) resulted in a relative decrease in the number of plants of broad-leaved weed species, i.e. 23.9% (from 93.9% to 66.0%) and 41.0% down in non-treated and treated variants, respectively. The higher the crop density was the greater the decrease in annual and perennial weed species in both treated and non-treated variants. Herbicide application combined with cropping practices led to a lowering of the relative distribution of narrow-leaved weed species, which was not detected in variants without herbicide application.

Table 3. Relative distribution of weed plants of certain species (%) over observed crop densities in 1996

Number of weed plants per m^2	Control			Treatment		
	G_1	G_2	G_3	G_1	G_2	G_3
Total	83.9	65.8	61.3	47.3	30.6	24.4
Broad-leaved species	78.8	61.3	55.4	38.0	23.6	18.6
Narrow-leaved species	5.1	4.5	5.9	9.3	7.0	5.8
Annual species	61.4	51.5	45.7	29.0	22.3	19.5
Perennial species	22.5	14.3	15.6	18.3	8.3	4.9
%						
Total	**100.0**	78.4	73.1	**100.0**	64.7	51.6
Broad-leaved species	93.9	73.1	66.0	80.3	49.9	39.3
Narrow-leaved species	6.1	5.3	7.1	19.7	14.8	12.3
Annual species	73.2	61.4	54.5	61.3	47.1	41.2
Perennial species	26.8	17.0	18.6	38.7	17.5	10.4

Relative distribution of the fresh weight of certain weed groups in total weediness in 1996 (Table 4) illustrates even better the changes in floristic composition and structure of weed community depending on maize densities.

The table shows that the maize density increase resulted in an even greater decrease in the fresh weight of narrow-leaved weeds in conditions of herbicide treatment.

Table 4. Relative distribution of fresh weight of certain weed groups (%) over observed crop densities in 1996

	Control			Treatment		
Fresh weight (g m^{-2})	G_1	G_2	G_3	G_1	G_2	G_3
Total	1746.8	1319.6	1043.3	413.7	183.0	139.1
Broad-leaved species	1640.3	1210.4	923.8	304.7	113.1	75.3
Narrow-leaved species	106.5	109.2	119.5	109.0	69.9	63.8
Annual species	1422.3	1045.0	848.3	271.8	127.6	92.1
Perennial species	324.5	274.6	195.0	141.9	55.4	47.0
%						
Total	**100.0**	75.5	59.7	**100.0**	44.2	33.6
Broad-leaved species	93.9	69.3	52.9	73.7	27.3	18.2
Narrow-leaved species	6.1	6.2	6.8	26.3	16.9	15.4
Annual species	81.4	59.8	48.6	65.7	30.8	22.3
Perennial species	18.6	15.7	11.1	34.3	13.4	11.3

In 1997, due to high precipitation and its better distribution, a greater number of species and plants per species occurred in the experimental plot (Table 5). The maize crop density increase showed a similar trend as in 1996: the number of species, their individual plants and fresh weight of weeds per m^2 decreased in conditions with and without herbicide treatment. Hence, the total number of weed plants per species decreased to 21 in D_2 and D_3, and to 27 in D_1 compared with the control variant. The number of species in the variant without herbicide treatment and with higher maize crop densities decreased from 140.7 to 110.2 plants per m^2, or 21.7%. The corresponding values in conditions involving herbicide treatment decreased from 32.7 to 19.4 plants per m^2, or 40.7%. The annual species *Chenopodium hybridum, Solanum nigrum, Amaranthus retroflexus,* and the perennial species *Convolvulus arvensis* prevailed. The following species failed to appear when crop density was raised from D_1 to D_2: *Bilderdykia convolvulus, Heliotropium europaeum, Stellaria media, Sonchus asper, Reseda lutea, Amaranthus blitoides, Taraxacum officinale* and *Polygonum lapathifolium.* Furthermore, neither the variety *Sonatas arvensis* nor the variety *Ambrosia artemisiifolia* were observed in the highest crop density variant D_3. An analysis of species distribution showed that although these varieties differed from those in 1996, light requirements of the majority were great and had index 4 as the light parameter. In 1997, crop density increase effected no reduction in the number of plants of the species *Cirsium arvense.*

Table 5. Floristic and quantitative changes within maize weed association in relation to crop density and herbicide treatment in 1997

LF	Weed species	Control G_1	Control G_2	Control G_3	Treatment G_1	Treatment G_2	Treatment G_3
T	*Chenopodium hybridum* L.	29.2	22.0	29.7	6.0	5.5	2.8
T	*Solanum nigrum* L.	26.8	22.6	19.3	4.0	3.0	1.2
T	*Amaranthus retroflexus* L.	22.0	19.0	16.5	2.3	1.5	0.5
G	*Convolvulus arvensis* L.	9.3	7.2	6.8	10.0	9.8	9.0
T	*Stachys annua* L.	10.5	8.3	3.7	0.5	0.7	-
T	*Amaranthus albus* L.	8.7	6.7	5.5	0.2	0.3	0.2
T	*Chenopodium album* L.	6.8	5.5	6.5	0.5	0.7	0.3
T	*Datura stramonium* L.	5.3	6.5	4.5	2.0	2.8	0.8
G	*Cirsium arvense* (L.) Scop.	3.8	1.7	7.2	2.5	8.0	1.5
G	*Convolvulus sepium* (L.) R.Br.	4.2	5.7	2.0	1.0	0.7	0.7
T	*Digitaria sanguinalis* (L.) Scop.	2.7	3.0	2.2	0.5	0.3	0.2
T	*Hibiscus trionum* L.	2.5	0.8	2.2	1.7	0.2	0.7
T	*Anagallis arvensis* L.	3.0	3.7	1.2	-	-	-
T	*Portulaca oleracea* L.	1.3	0.7	1.0	-	0.2	-
G	*Sorghum halepense* (L.) Pers.	1.0	1.2	0.3	1.0	0.5	0.8
T	*Panicum crus-galli* (L.) R.et Sch.	0.5	0.2	0.3	-	-	-
T	*Sinapis arvensis* L.	0.5	0.3	-	-	-	-
T	*Setaria glauca* (L.) Beauv.	0.3	0.2	0.3	-	-	-
T	*Bilderdykia convolvulus* (L.) Dum.	0.2	-	0.3	-	-	-
T	*Stellaria media* (L.) Vill.	0.5	-	-	-	-	-
G	*Sonchus arvensis* L.	-	0.3	-	-	-	-
T	*Setaria verticillata* (L.) P.B.	-	-	0.3	-	-	0.2
T	*Heliotropium europaeum* L.	0.3	-	-	-	0.2	-
T	*Ambrosia artemisiifolia* L.	0.2	0.2	-	0.2	-	-
T	*Setaria viridis* (L.) Beauv.	-	0.2	0.2	-	-	-
T	*Sonchus asper* (L.) Hill	0.3	-	-	-	-	-
T	*Resead lutea* L.	0.2	-	-	-	-	-
T	*Amaranthus blitoides* S. Watson	0.2	-	-	-	-	-
T	*Abutilon theophrasti* Medik.	-	-	0.2	0.3	-	0.5
G	*Taraxacum officinale* Web.	0.2	-	-	-	-	-
T	*Polygonum aviculare* L.	0.2	-	-	-	-	-
Total number of weed species		27	21	21	15	15	14
% of total number of weed species		**100.0**	**77.8**	**77.8**	**100.0**	**100.0**	**9.3**
Total number of weed plant per species (number m^{-2})		**140.7**	**116.0**	110.2	32.7	34.4	19.4
% of total number of weed plant per species		**100.0**	**82.4**	**78.3**	**100.0**	**1.5.2**	**59.3**
Total fresh weight of weeds (g m^{-2})		**1834.7**	**1075.1**	807.2	283.7	179.9	123.3
% of total fresh weight of weeds		**100.0**	**58.6**	**44.0**	**100.0**	**63.4**	**43.5**

In 1997, crop density increase led to a 56% decrease in total fresh weight of weeds in conditions without herbicide treatment, i.e. from 1834.7 g m^{-2} in D_1 to 807.2 g m^{-2} in D_3. The corresponding values in the variant involving herbicide treatment amounted to 56.5% (decrease from 283.7 g m^{-2} in D_1 to 123.3 g m^{-2} in D_3).

Table 6 shows the distribution of certain weed groups, i.e. the number of plants m^{-2} over maize densities in conditions of herbicide treatment and without it.

Table 6. Relative distribution of weed plants of certain species (%) over observed crop densities in 1997

Number of weed plants per m^2	Control			Treatment		
	G_1	G_2	G_3	G_1	G_2	G_3
Total	140.7	116.0	110.2	32.7	34.4	19.4
Broad-leaved species	136.2	111.2	106.6	31.2	33.6	18.2
Narrow-leaved species	4.5	4.8	3.6	1.5	0.8	1.2
Annual species	122.2	99.9	93.9	18.2	15.4	7.4
Perennial species	18.5	16.1	16.3	14.5	19.0	12.0
%						
Total	100.0	82.4	78.3	100.0	105.2	59.3
Broad-leaved species	96.8	79.0	75.8	95.4	102.7	55.7
Narrow-leaved species	3.2	3.4	2.5	4.6	2.5	3.6
Annual species	86.8	71.0	66.7	55.7	47.1	22.6
Perennial species	13.2	11.4	11.6	44.3	58.1	36.7

The presented results indicate a deviation in the reduction of both the total number of plants and the number of broad-leaved weed species occurring under crop density increase - at density D_2, the number of plants of all weed species is higher 5.2% and the number of plants of broad-leaved species is higher 2.7% npared to D_1. However, the number of plants of these weed groups at the highest density D_3 is significantly lower than in D_1. In 1997, total fresh weight followed a regular pattern of reduction over weed groups at D_2 and D_3 densities compared with D_1 (Table 7).

Table 7. Relative distribution of fresh weight of certain weed groups (%) over observed crop densities in 1997

Fresh weight (g m^{-2})	Control			Treatment		
	G_1	G_2	G_3	G_1	G_2	G_3
Total	1834.7	1075.1	807.2	283.7	179.9	123.3
Broad-leaved species	1785.5	1037.1	780.6	246.8	166.8	111.4
Narrow-leaved species	49.2	38.0	26.6	36.9	13.1	11.9
Annual species	1643.6	911.6	705.4	162.6	66.6	27.6
Perennial species	191.1	163.5	101.8	121.1	113.3	95.7
%						
Total	100.0	58.6	44.0	100.0	63.4	43.5
Broad-leaved species	97.3	56.5	42.5	87.0	58.8	39.3
Narrow-leaved species	2.7	2.1	1.5	13.0	4.6	4.2
Annual species	89.6	49.7	38.4	57.3	23.5	9.7
Perennial species	10.4	8.9	5.6	42.7	39.9	33.8

In 1997, crop density increase effected a reduction in fresh weight of narrow-leaved and perennial weeds in conditions of herbicide treatment and without it.

Maize grain yield increased with higher crop densities in both variants, especially the treated one, both in 1996 and 1997 (Tables 8 and 9).

Table 8. Effects of maize crop densities and herbicide treatment on grain yield ($t\ ha^{-1}$) in 1996

Herbicide treatment	Maize crop density			
	G_1	G_2	G_3	$\overline{X}$
T	8.44	9.02	9.94	11.14**
K	10.37	11.08	11.96	9.13**
$\overline{X}$	9.41[b]	10.05[b]	10.95[a]	$t_{0.01}$= 5.464
$LSD_{0.05}$= 0.8582				

Statistically significant differences in maize grain yield were determined between densities in treated and untreated variants in both years of investigation. In 1997, the density x herbicide treatment interaction statistically significantly affected maize grain yield (Table 9).

Table 9. Effects of maize crop densities and herbicide treatment on grain yield ($t\ ha^{-1}$) in 1997

Herbicide treatment	Maize crop density			
	G_1	G_2	G_3	$\overline{X}$
T	8.39[c]	10.72[b]	11.35[ab]	12.07**
K	11.25[ab]	13.12[a]	13.21[a]	10.18**
		$LSD_{0.01}$= 2.039		
$\overline{X}$	9.82[b]	11.92[a]	12.28[a]	$t_{0.01}$= 4.228
$LSD_{0.01}$= 1.212				

A clearly expressed dry spell during the maize growing season in 1996 adversely affected the growth and development of certain weed species. On the other hand, well-hydrated conditions in the mid-growing season of 1997 had a positive effect on the crop and especially the weeds in it. An analysis of effects of higher maize crop densities on the floristic composition and structure of weed community in both years of investigation shows that the employment of this measure of weed control is fully justified. The maize weed community at the investigated location was becoming increasingly therophytic and geophytic with growing participation of both annual and perennial species of the family *Poaceae* (ŠINŽAR *et al.*, 1996). The greater the maize crop density was, the lower the number of weed species and plants per species and weed fresh weight in both variants (treated and control) over both years of investigation. Weed distribution under observed conditions of maize growth was reduced due to both inter- and intra-species competition. In other words, there is a competition going on between each weed species and the crop itself and other weeds in conditions of increased crop density. Greater maize crop densities reduce the amount of light reaching weed plants, which consequently affects their development (WALKER *et al.*, 1988; TETIO-KAGHO, 1988; TOLLENAAR *et al.*, 1992; MOHLER and CALLOWAY, 1992). The acquired results indicate that weed species were not equally affected by the increase in crop density. Higher crop densities in 1996 failed to effect a decrease in either weed individuals or fresh weight of the species *Digitaria sanguinalis* per m^2. In 1997, higher crop density did not affect the variety *Cirsium arvense.*

The obtained results show that a combination of increased or at least recommended maize crop densities and herbicide treatments gives better results in curbing weeds in this crop. At the same time, the achieved maize grain yields were high, so that this way of weed control in maize at the location of Zemun Polje is fully justified.

CONCLUSION

The following conclusions may be drawn based on the obtained results:

- qualitative and quantitative distribution of certain weed species within the weed community in both years of investigation significantly decreased with the increase of maize crop density and herbicide treatment,
- maize density increase from D_1 to D_3 led to an elimination of weeds with greater demand for light in the maize crop,
- maize density increase did not result in a lower number of plants and fresh weight of the species *Digitaria sanguinalis* and *Cirsium arvense* in 1996 and 1997, respectively,
- relative participation of plants per species and fresh weight of certain weed groups within total weediness decreased in both years with the increase in maize density under non-treatment and especially treatment conditions,
- in 1997, the increased maize density effected a decrease in fresh weight of narrow-leaved weeds both in conditions of herbicide treatment and without it, while in 1996 the decrease was found to be attributable only to herbicide treatment,
- average grain yield was statistically significantly higher in treatment conditions (11.14 t ha^{-1} and 12.07 t ha^{-1}) than in non-treatment (9.13 t ha^{-1} and 10.18 t ha^{-1}), which justifies herbicide application in weed control,
- based on the analysis of effects of different crop densities and herbicide treatment on the number of species, number of plants per species and fresh weight of weeds and certain weed groups, on the one hand, and maize grain yield, on the other hand, we have established that crop density increase reduced the weed community in conditions of herbicide treatment. At the same time, high grain yields of maize were achieved, which justifies such a method of weed control in maize growing at the location of Zemun Polje.

REFERENCES

AJDER S. (1991): Uticaj nekih herbicida na fitocenološke promene korovske zajednice useva kukuruza. Magistarska teza. Poljoprivredni fakultet, Beograd.

BOŽIĆ D. (1980): Značaj agrotehničkih mera u borbi protiv korova. Zbornik referata I kongresa o korovima, Banja Koviljača, 73-86.

HOLT S.J. (1995): Plant Responses to Light: A Potential Tool for Weed Management. Weed Science. *43*, 474-482.

KOJIĆ M. (1975): Pregled korovske vegetacije okopavina i strnih žita Jugoslavije. Zbornik 11. Jugoslovenskog savetovanja o borbi protiv korova, Novi Sad, 5-32.

KOJIĆ M. i B. ŠINŽAR (1985): Korovi. Naučna knjiga. Beograd.

KOVAČEVIĆ D. i N. MOMIROVIĆ (1996): Integralne mere suzbijanja korova u savremenoj tehnologiji gajenja kukuruza. Zbornik radova V kongresa o korovima, Banja Koviljača, 410-431.

LANDOLT E. (1977): Oekologsche Zeigerwerte zur Schweizer Flora. Geobot. Inst. ETH, Zurich

LOZANOVSKI R., R. GRUPČE, T. KOSTOV i LJ. NACEVA (1980): Uticaj plodoreda i primene nekih herbicida na dinamiku fitocenoloških odnosa korovskih sinuzija. Zbornik referata I kongresa o korovima, Banja Koviljača, 287-307.

MOHLER C. L. and B.M. CALLOWAY (1992): Effects of tillage and mulch on the emergence and survival of weeds in corn. Journal of Applied Ecology. *29*, 21-34.

STOJKOVIĆ L., S. PARABUĆSKI, M. ČANAK i B. BELIĆ (1975): Uticaj agrotehničkih mera na osobine korovske sinuzije i produktivnost useva agrofitocenoze kukuruza. Zbornik radova 11 Jugoslovenskog savetovanja o borbi protiv korova, Novi Sad, 257-259.

SWANTON J.C. and F.S. WEISE (1991): Interated Weed Management: The Rationale and Approach. Weed Technology, *5*, 657-663.

SWANTON J.C. and F.S. WEISE (1996): Weed Science Beyond the Weeds: The Role of Interated Weed Management (IMW) in Agroecosystem Health. Weed Science, *44*, 437-445.

ŠINŽAR B. i R. DEJOVIĆ (1975): Prilog poznavanju korovske vegetacije kukuruza istočnog Srema. Zbornik radova 11. Jugoslovenskog savetovanja o borbi protiv korova, Novi Sad, 55-64.

ŠINŽAR B. i L. STEFANOVIĆ (1993): Zastupljenost i rasprostranjenost višegodišnjih vrsta korova u usevu kukuruza u Srbiji. Acta herbologica, *2*,(1), 37-45.

ŠINŽAR B., L. STEFANOVIĆ I M. STANOJEVIĆ (1996): Prilog poznavanju višegodišnjih promena florističkog sastava korovske zajednice useva kukuruza. Zbornik radova V kongresa o korovima, Banja Koviljača, 301-310.

ŠINŽAR B., L. STEFANOVIĆ i M. STANOJEVIĆ (1998): Promene korovske flore i vegetacije kukuruza pri višegodišnjoj primeni herbicida. Pesticidi, *13*, 119-130.

TETIO-KAGHO F. and F. P GARDNER (1988): Responses of Maize to Plant population Density. I. Canopy Development, Light Relationships and Vegetative Growth. Agronomy Journal, *80*, 930-935.

TOLLENAAR M., M.L. DWYER and W.D. STEWART (1992): Ear and kernel formation in maize hybrids representing three decades of yield improvement in Ontario. Crop Science, *32*, 432-438.

TOLLENAAR M., A.A. DIBO, A. AGUILERA, F.S. WEISE and J.C. SWANTON (1994): Effect of Crop Density on Weed Interference in Maize. Agronomy Journal, *86*, 591-595.

VIDENOVIĆ Ž. i L. STEFANOVIĆ (1994): Uticaj mera gajenja na pojavu korova u kukuruzu. Savremena poljoprivreda. *42*, (3), 97-104.

WALKER H.R. and A.G. BUCHANAN (1982): Crop Manipulation in Integrated Weed Management Systems. Weed Science. *30 Supl.*, 17-24.

WALKER G.K., E.R. BLACKSHAW and J. DEKKER (1988): Leaf Area and Competition for Light Between Plant Species usin Direct Sunlight Transmission. Weed Technology. 2, 159-165.

YELVERTON H.F. and H.D. COBLE (1991): Narrow Row Spacing and Canopy Formation Reduces Weed Resurgence in Soybeans (*Glycine max*). Weed Technology. *5*, 169-174.

Received June 26, 2000
Accepted September 17, 2000

UTICAJ GUSTINE USEVA NA FLORISTIČKI SASTAV I GRAĐU KOROVSKE ZAJEDNICE KUKURUZA U USLOVIMA PRIMENE HERBICIDA

Milena STANOJEVIĆ [1], Lidija STEFANOVIĆ [1], Borivoje ŠINŽAR [2] and Sava VRBNIČANIN [2]
[1] Institut za kukuruz, Zemun Polje, Beograd-Zemun
[2] Poljoprivredni fakultet, Beograd-Zemun
Jugoslavija

Izvod

Proučavan je uticaj gustine gajenja useva i primene herbicida na zastupljenost vrsta korova u korovskoj zajednici kukuruza, na lokalitetu Zemun Polja. Tokom vegetacionog perioda kukuruza u 1996. i 1997. godini, sniman je floristički sastav i građa korovske zajednice i utvrđen broj vrsta, broj njihovih jedinki i sveža masa svih korova po jedinici površine, u svakoj gustini. Na varijanti sa i bez primene herbicida. Na osnovu zastupljenosti vrsta korova i njihovih jedinki analizirane su promene nastale pod uticajem povećanja gustine kukuruza i usled primene herbicida i izračunata relativna zastupljenost pojedinih grupa korova. U obe godine ispitivanja došlo je do redukcije korovske zajednice sa povećanjem gustine useva u uslovima bez, a naročito u uslovima sa primenom herbicida. Značajan uticaj interakcije gustine i primene herbicida je ostvaren kod smanjenja relativnog učešća grupe uskolisnih i višegodišnjih korova u ukupnoj zakorovljenosti kukuruza Zemun Polja.

Primljeno 26. juna 2000.
Odobreno 17. septembra 2000.