UDC 632.5:633.15
Original scientific paper

INTEGRATED WEED MANAGEMENT SYSTEM IN MAIZE WEED CONTROL

Milena SIMIĆ[1], Lidija STEFANOVIĆ[1], Dušan KOVAČEVIĆ[2], Borivoj ŠINŽAR[2], Nebojša MOMIROVIĆ[2] and Snežana OLJAČA[2]

[1]Maize Research Institute Zemun Polje, Zemun, Serbia and Montenegro
[2]Faculty of Agriculture, Zemun, Serbia and Montenegro

Simić Milena, Lidija Stefanović, Dušan Kovačević, Borivoj Šinžar, Nebojša Momirović and Snežana Oljača (2004): *Integrated weed management system in maize weed control.* - Acta herbologica, Vol. 13, No. 2, 437-442, Beograd.

A joint effect of four cropping practices (irrigation, crop density, hybrid and herbicide application) on maize weed infestation, expressed by fresh mass of weeds (g m^{-2}), was monitored in a four year period (1996-1999). Fresh mass of weeds was higher on the average for all years in the area under irrigation than in the area under rainfed conditions and it statistically significantly decreased under increased crop densities. Fresh mass of weeds was significantly higher in the control than in the herbicide treated variant. The increased crop density and herbicide application interaction affected fresh mass of weeds in such a way that it was the lowest in the highest density in the treated variant almost in each year of investigation. In addition, fresh mass of weeds was affected by the herbicide application and maize hybrid interaction.

Key words: water regime; maize density; herbicide application; hybrid; fresh mass of weeds

Corresponding author: Milena Simić, Maize Research Institute Zemun Polje, Slobodana Bajića 1, 11080 Zemun, Serbia and Montenegro; E-mail: smilena@mrizp.co.yu

INTRODUCTION

In order to alleviate negative effects of herbicides throughout the world, including our country, a combined application of several weed control measures within the integrated weed management has been recommended (SWANTON AND WEISE, 1996; KOVAČEVIĆ AND MOMIROVIĆ, 1996). Considering that there are many weed species in maize crops characterised by different life cycles and modes of survival, it is not realistic to expect that the application of any individual measure can satisfactorily control the weed infestation level (SHAW, 1982). The concept of the integrated system suggests the development of a programme for weed control by a combined or integral application of preventive, direct, mechanical and chemical measures (KNEŽEVIĆ, 2002). The integrated weed management encompasses several measures such as crop rotation, tillage, irrigation, crop density, fertilisation, selection of genotypes, herbicide application, etc. (BOŽIĆ *et al.*, 1996). Bearing in mind all stated, the starting point is an assumption that the higher crop density, alongside with the application of herbicides and irrigation, can favourably affect the reduction of weediness and thereby can increase yields of different maize hybrids cultivated within the investigated system.

MATERIAL AND METHODS

A four-factorial trial was set up according to the split plot method for the factor of irrigation application (A_0 - rainfed; A_1- irrigation) in the experimental field of the Maize Research Institute, Zemun Polje, during the period 1996-1999. The remaining factors (maize crop density, hybrid and herbicide application) were tested according to a randomised block design with four replications. The following factors were observed: maize densities: B_1- 40,816; B_2 - 69,686 and B3- 98,522 plants ha^{-1}; maize hybrids: C_1 - ZPSC 42A and C_2 - ZPSC 704; herbicides application: D_1 - control and D_2 - treated variant. The combination of herbicides atrazine+metochlor in the amount of 1.0 and 2.88 l a.i. ha^{-1} was applied after sowing and prior to emergence. Herbicides were not applied in the control variant. Watering was done when soil moisture approached the lower level of easy available water, which amounts to approximately 75% of field water capacity for slightly calcareous chernozem. During summer, weed sampling from one square meter areas was done in order to estimate fresh mass of each weed species. Total weed fresh mass values ($g\ m^{-2}$) were statistically processed by the analysis of variance for each year separately, while differences of means were tested by the LSD test.

Meteorological conditions varied over the years of investigations, hence the year of 1998 was extremely dry, while in 1999, due to precipitation surplus, the irrigation was not applied.

RESULTS AND DISCUSSION

Fresh mass of weeds was greater in irrigated areas than in the areas under rainfed conditions on the average for all years (Table 1). According to the F-test

the determined differences were statistically significant. Total fresh mass of weeds was greater by 28.60% under irrigated conditions than under rainfed conditions.

Table 1. - Average total fresh mass of weeds (g m^{-2}) depending on water regime, maize crop density, hybrid and herbicide application

Factors	0Water regime		Maize crop density			Hybrid		Herbicide application	
	A_0	A_1	B_1	B_2	B_3	C_1	C_2	D_1	D_2
$\overline{X}$ (1996-99)	1183,17	1657,12	2024,14^a	1240,67^b	995,63^c	1392,83	1447,45	2196,75	643,55
Statistical significance	*F = 48,54***		*F = 83,15*** *LSD $_{0,01}$= 216,2*			*F = 0,65*		*F = 521,25***	

Means followed by the same letters are not statistically different for P<0.05 and P<0.01 (LSD-test); A_0, A_1 - water regime; B_1, B_2, B_3 - maize densities; C_1, C_2 - hybrid; D_1 - control; D_2 - treated variant

Maize weediness, expressed by fresh mass, statistically reduces with the increase of maize crop density. The highest and lowest values of fresh mass of weeds were recorded in the lowest (B_1) and highest (B_3) density, respectively. The determined differences were statistically very significant. Fresh mass of weeds was the highest in the hybrid ZPSC 704.

The statistical analysis indicated a very significant effect of herbicides on weed infestation, so that fresh mass of weeds was significantly higher in the control than in the treated variant. Similar regularities were determined in previous studies on weediness of maize crops cultivated within specific cropping systems (MOMIROVIĆ *et al.*, 1997; STANOJEVIĆ *et al.*, 2001). The effects of maize crop densities and the herbicide application as individual measures on the reduction of weediness is obvious, while the effects of irrigation and hybrid are somewhat less pronounced. As the aim of the present study was to determine the effects of the combined application of several measures on the reduction of maize weediness, the interaction of observed factors is much more important in weed control. The increased crop density and herbicide interaction resulted in a reduction of fresh mass of weeds, which was the lowest in the highest density on the treated variant almost in each year of investigation (Table 2).

Table 2. - Total fresh mass of weeds (g m^{-2}) depending on maize crop density and herbicide application Interaction

Year	Herbicide	Maize crop density			Statistical significance
		B_1	B_2	B_3	
1996.	D_1	2305,48	1765,70	1670,20	*F = 0,41^{ns}*
	D_2	1137,79	299,96	356,09	
1997.	D_1	2739,08^a	1197,12^b	774,25^c	*F = 19,91***
	D_2	904,85b^c	361,40^d	177,48^d	*LSD$_{0,01}$= 390,20*
1998.	D_1	5500,88^a	4354,57^b	3454,76^c	*F = 3,63**
	D_2	1678,75^d	1058,15^d	1008,43^d	*LSD$_{0,05}$= 728,00*
1999.	D_1	1501,90^a	672,48^b	424,55^{bc}	*F = 12,22***
	D_2	424,39^{bc}	215,95^{cd}	99,33^d	*LSD$_{0,01}$= 304,90*

Means followed by the same letters are not statistically different for P<0.05 and P<0.01 (LSD-test); ns - not significant; B_1, B_2, B_3 - maize densities; C_1, C_2 - hybrid; D_1 - control; D_2 - treated variant

Beside interspecies, intraspecies competition is also pronounced in summer in accordance with the gradual formation of the crop stand, hence the different competitive relations within agrophytocenosis, especially under conditions of higher densities (KROPFF AND LOTZ, 1993). The interaction between herbicide application and higher crop densities thus resulted in the reduction of fresh mass of weeds, and the determined differences were statistically significant in 1997, 1998 and 1999. The herbicide and maize hybrid interaction also affected fresh mass of weeds (Table 3). Statistically significant differences were registered for the fresh mass of weeds depending on effects of this interaction in 1996 and 1998. The hybrid C_1 as an early maturity hybrid has the advantage over the hybrid C_2 in the initial stage of the growing period, due to which the fresh mass of weeds is mostly greater in the latter hybrid in both control and treated variants. The lowest fresh mass of weeds (528.21 g m^{-2}) was detected in the hybrid C_1 in the area treated with herbicides. The stated results give priority to studies that consider the role of genotype in increasing the competitiveness of maize against weeds (TOLLENAAR AND AGUILERA, 1992).

Table 3. - Total fresh mass of weeds (g m^{-2}) depending on maize hybrid and herbicide application interaction

Hybrid	Years							
	1996		1997		1998		1999	
	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
C_1	$1544,58^b$	$528,21^c$	1497,91	519,00	$4823,67^a$	$1208,40^c$	765,85	254,95
C_2	$2283,00^a$	$667,69^c$	1642,38	443,48	$4049,77^b$	$1288,48^c$	966,77	238,16
Statistical significance	$F = 4,95^*$ $LSD_{0.05} = 380,10$		$F = 1,68^{ns}$		$F = 4,11^*$ $LSD_{0.05} = 594,40$		$F = 2,69^{ns}$	

Means followed by the same letters are not statistically different for P<0.05 and P<0.01 (LSD-test); ns - not significant;; D_1 - control; D_2 - treated variant

The obtained results clearly show that the use of genotypes selected for a certain purpose and their sowing in different densities in order to control weeds, requires special attention especially under conditions of limited water supply. The results acquired aditionally show that maize growing in higher densities very significantly reduces weediness, but the efficacy of such growing system depends on the selection of hybrids. Certain genotypes considerably differ in morphological aspects and competitive ability in relation to weeds (LEMERLE *et al.*, 1996; SIMIĆ AND STEFANOVIĆ, 2002). In particular, newly developed hybrids positively respond to cultivation in increased densities, in such a way that they better control weed infestation and have higher yields (KORRES AND FROUD-WILLIAMS, 2002). The obtained results favour the assumption that several measures included in an integrated weed management system with herbicide application can successfully control weeds in maize crops.

CONCLUSION

Fresh mass of weeds was on the average for all years higher under irrigation than under rainfed conditions.

Weed infestation of maize crops, expressed as fresh mass, statistically significantly reduced under higher crop densities.

Fresh mass of weeds was very significantly lower in the treated than in the control variant in all years and on the average, which was confirmed by statistical analysis.

Total fresh mass of weeds under rainfed conditions was higher for the hybrid ZPSC 704, while under the irrigation conditions it was higher for the hybrid ZPSC 42A.

Higher cropping density and herbicide interaction affected the fresh mass of weeds in such a way that it was the lowest under the highest density in the treated variant in all years of investigation. The herbicide and maize hybrid interaction also affected the fresh mass of weeds.

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Recieved March 25, 2004
Accepted April 10, 2004

INTEGRALNI SISTEM MERA U KONTROLI ZAKOROVLJENOSTI KUKURUZA

Milena SIMIĆ[1], Lidija STEFANOVIĆ[1], Dušan KOVAČEVIĆ[2], Borivoj ŠINŽAR[2], Nebojša MOMIROVIĆ[2] i Snežana OLJAČA[2]

[1]Institut za kukuruz Zemun Polje, Zemun
[2]Poljoprivredni fakultet, Zemun

I z v o d

U četvorogodišnjem periodu 1996-1999. godine ispitivan je uticaj kombinovane primene četiri mere gajenja (navodnjavanja, gustine useva, hibrida i primene herbicida) na zakorovljenost kukuruza, izraženu kroz svežu masu korova (g m^{-2}). Sveža masa korova je, prosečno za sve godine, bila veća na površini u navodnjavanju i statistički se značajno smanjivala sa povećanjem gustine gajenja. Sveža masa korova je bila statistički vrlo značajno veća na kontrolnoj u odnosu na herbicidima tretiranu varijantu. Ukupna sveža masa korova, u uslovima prirodnog vodnog režima, bila je veća u hibridu ZPSC 704, a u uslovima navodnjavanja u hibridu ZPSC 42A. Povećana gustina gajenja i primena herbicida u interakciji su uticale da sveža masa korova bude najmanja u najvećoj gustini, na tretiranoj varijanti skoro u svim godinama ispitivanja. Na svežu masu korova, uticala je i interakcija primene herbicida sa hibridom kukuruza.

Dobijeni rezultati idu u prilog pretpostavci da se, i u našim uslovima, primenom više mera kao dela integralnog sistema, uz primenu herbicida, mogu uspešno suzbijati korovi u kukuruzu.

Primljeno 25. marta 2004.
Odobreno 10. aprila 2004.