

INFLUENCES OF SOIL TILLAGE AND FERTILIZATION ON MAIZE YIELD AND WEED INFESTATION

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Abstract

The field experiment was conducted after wheat harvesting (July 1997) on Zemun Polje chernozem. Maize was grown under dry farming system (without irrigation) for three growing seasons (the factor A: 1998, 1999 and 2000). Soil tillage systems (the factor B) included three treatments as follows: B1) zero tillage (direct sowing in non-cultivated soil), B2) minimum tillage (tillage with a soil miller only and sowing) and B3) conventional tillage (stubble field shallow ploughing, ploughing in autumn, presowing soil preparing and sowing). In each soil tillage treatment three levels of fertilization were used as follows: C1) unfertilized (control), C2) the first level of fertilization (kg ha^{-1} : 150 N + 105 P₂O₅ + 75 K₂O) and C3) the second level of fertilization (kg ha^{-1} : 300 N + 211 P₂O₅ + 150 K₂O). The field experiment was conducted in four replicates. Area of base plot was 25 m². Under drought stress of the 2000 growing season it was only 6.08 t ha⁻¹ or 35% lower compared to 1999. The conventional tillage (yield 9.86 t ha⁻¹) resulted by 24% and 84% yield increases compared to reduced tillage and zero-tillage, respectively. Using the second rate of fertilizer (yield 8.86 t ha⁻¹) increased yields by 17% and 32% compared to the first rate and non-fertilized treatments, respectively. Weeds infestations (weeds m⁻²) under conventional tillage was considerably lower (7) compared to reduced (39) and zero-tillage (46).

Key words: maize, soil tillage, fertilization, yield, weeds

Introduction

Maize is the first ranged crop on arable lands in Serbia. In the last decade period it was grown between 1.25 and 1.40 million hectares/year or near 40% of total arable lands. As soil tillage influences considerably in increase of inputs, there are conception for its reduction by omission of some tillage intervention. However in Serbia is prevailing conventional or classical soil tillage system including considerable consumption of time, energy and human work. Also, as affected by many soil tillage intervention there are some negative influences on physical properties of soil (Zugec, 1986; Komljenovic, 1994). Aim of this study was testing soil tillage and fertilization systems influences on maize yields and weed composition on chernozem soil.

Material and methods

The field experiment

The field experiment was conducted after wheat harvesting (July 1997) on the experimental field of Maize Research Institute in Zemun Polje (chernozem soil type: pH in H₂O = 7.7; pH in 1nKCl = 7.0; AL-method: 16.4 mg P₂O₅ and 31.2 mg K₂O 100 g⁻¹). Maize was grown under dry farming system for three growing seasons (1998, 1999 and 2000). Soil tillage systems included three treatments as follows: B1) zero tillage (direct sowing in non-

cultivated soil), B2) minimum tillage (tillage with a soil miller only and sowing) and B3) conventional tillage (stubble field shallow ploughing, ploughing in autumn, preparing soil and sowing). In each soil tillage treatment three levels of fertilization were used as follows: C1) unfertilized (control), C2) the first level of fertilization (kg ha^{-1} : 150 N + 105 P_2O_5 + 75 K_2O) and C3) the second level of fertilization (kg ha^{-1} : 300 N + 211 P_2O_5 + 150 K_2O). The field experiment was conducted in four replicates by split – split – plot method. Area of base plot was 25 m^2 . Weed infestation was determined by the method of testing quadrates. Herbicides were applied post-emergence at early growing stage of maize after determination of weed infestation. Maize hybrid of late-maturity group (ZPSC 704) was sown in the second half of April by pneumatic sowing machine adapted for direct sowing. Density of sowing was 60600 seed ha^{-1} . Maize was harvested manually in the first half of October. Maize yields were calculated on realized plant density and 14% grain moisture basis. The field trial was continued according to same method for the next three growing seasons.

Weather conditions

Drought stress and excess of precipitation were main weather characteristics for 2000 and 1999, respectively, while 1998 was in that regard similar to long-term means (Table 1).

Table 1. Weather characteristics (the data of Weather Bureau Zemun Polje)

Month	Precipitation (mm)			Mean air-temperature ($^{\circ}\text{C}$)			LTM	
	1998	1999	2000	1998	1999	2000	mm	$^{\circ}\text{C}$
April (IV)	30.6	73.3	58.8	13.9	12.8	16.1	49.1	11.4
May (V)	55.2	62.9	38.2	16.3	17.4	19.3	62.3	16.7
June (VI)	81.2	152.5	30.6	22.1	20.5	21.5	80.1	19.9
July (VII)	34.8	264.1	28.4	23.1	21.9	22.0	62.4	21.7
August (VIII)	41.1	12.6	7.2	22.9	22.7	23.7	50.6	21.2
September (IX)	88.5	85.4	57.2	16.4	19.6	17.5	43.5	17.4
IV-IX: Total	331.4	650.8	202.6				348.0	
IV-IX: Mean				19.1	19.1	20.0		18.0

Results and discussion

Grain yield of maize considerably depended on the year, soil tillage and fertilization. For example, under drought stress of the 2000 growing season it was only 6.08 t ha^{-1} or 35% lower compared to the previous year. The conventional tillage (yield 9.86 t ha^{-1}) resulted by 24% and 84% yield increases compared to reduced and zero-tillage, respectively. Using the second rate of fertilizer (yield 8.86 t ha^{-1}) increased yields by 17% and 32% compared to the first rate and non-fertilized treatments, respectively. Zero-tillage resulted by 10% (1998), 48% (1999) and 71% (2000) yield reduction compared to the conventional tillage. Maize yields on unfertilized plots were lower by 35% (1998), 8% (1999) and 32% (2000) compared to the second rate of fertilization. Yield reduction on the unfertilized plots compared to the second rate of fertilization was the higher under conditions of zero-tillage (39%) than on the reduced tillage (18%) and conventional tillage (20%). Influences of soil tillage on yield reduction was depended also on the fertilization. For example, yield reductions on the zero-tillage treatment compared to the conventional tillage were as follows: 52%, 49% and 38%, for unfertilized, the first rate and the second rate fertilization, respectively.

Table 2. Influences of year (A), soil tillage (B) and fertilization (C) and their interactions (AB, AC and BC) on maize yields (the hybrid ZPSC 704) on Zemun Polje chernozem

Year (factor A)	Soil tillage (factor B)			Fertilization (factor C)*			Mean
	B1	B2	B3	C1	C2	C3	
Grain yield of maize (t/ha on 14% grain moisture basis)							
Interaction AxB				Interaction AxC			A
1998	7.18	7.91	7.97	6.32	7.05	9.69	7.69
1999	5.94	10.72	11.47	8.92	9.50	9.72	9.38
2000	2.96	5.15	10.12	4.87	6.20	7.16	6.08
Mean C				6.70	7.58	8.86	
				Interaction BxC			B
Zero tillage (B1)				4.19	5.04	6.85	5.36
Reduced tillage (B2)				7.18	7.87	8.73	7.93
Conventional tillage (B3)				8.73	9.84	10.99	9.86
Analysis of variance (LSD and F values)							
LSD 5%	A: 0.40	B: 0.40	C: 0.30	AB: 0.70	AC: 0.52	BC: 0.52	
LSD 1%	0.55	0.55	0.40	0.95	0.69	n.s.	
F values	148.95**	277.78**	104.62**	67.56**	16.68**	2.97*	

* kg/ha (N+ P₂O₅+ K₂O): C1 = 0 , C2 = 150+105+75, C3 = 300+ 211+150

Table 3. Influences of year and soil tillage on weeds infestations

Weed arts	Number of plants per square metter								
	Zero tillage			Minimum tillage			Conventional tillage		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
<i>Cirsium arvense</i>	15.3	6.0	15.3	3.3	8.0	13.3	0.7	1.3	0
<i>Convolvulus arvensis</i>	4.0	0.6	7.3	2.7	5.3	8.7	0.7	2.6	2.3
<i>Rubus caesius</i>	0	6.0	0	0	5.3	0	0	2.0	0
<i>Sorghum halepense</i>	2.0	6.6	12.0	0	12.0	8.7	0	2.0	0.7
<i>Amaranthus retroflexus</i>	0.7	0	11.3	0	0	8.0	0.7	0	0
<i>Datura stramonium</i>	0	0	1.3	0.7	0	0	0.7	0	0
<i>Hibiscus trionum</i>	0	0	0.7	4.7	0	1.0	0	0	1.7
<i>Solanum nigrum</i>	0	0	4.7	0	0	5.3	0.7	0	0.7
The other weed arts	2.7	16.2	14.4	2.7	18.4	12.6	0.7	1.9	1.3
Total more-annual weeds	24.0	31.1	40.6	8.7	47.8	36.0	1.4	9.8	4.3
Total annual weeds	0.7	4.3	36.2	1.4	1.2	21.6	2.8	0	2.8
Total	24.7	35.4	76.8	10.1	49.0	57.6	4.2	9.8	7.1
Mean on soil tillage level	45.6			38.9			7.0		
Total number of weed arts									
	6	13	11	6	10	9	6	6	5

Weeds infestations (weeds m⁻²) under conventional tillage was considerably lower (7) compared to reduced (39) and zero-tillage (46). More-annual weeds were dominant compared to annual weeds (Table 3). As under reduced tillage conditions have been evidently perennial weeds increases, application of integral soil and crop management practices including increased fertilization for weed control were suggested (Saric and Djalovic 2004). As major eastern parts of Hungary and Croatia have similar environmental conditions as northern Serbia, some results of soil tillage treatments under these conditions were shown. For example, Birkas and Gyuricza (2000) tested weed infestation under conditions of Hungary as affected by different soil tillage practices. Lack of fertilization, shallows spring tillage, cropping without rotation, long-term applied shallow tillage, spring ploughing and double disking are noted as factors promoting weed infestation. Birkas et al. (2002) concluded that soil condition deteriorated by disk-pan compaction decreased the maize yield significantly by 20 and 42% (w/w) comparing to soils with no disk-pan. Soil condition deteriorated by disk-

pan, increase weed infestation in maize, however, the soil loosening had a limiting effect on the perennial weeds. Percze et al. (2002) concluded that disk tillage combined with loosening proved to be a favourable subsoil conservation method. Birkas et al. (2004a) tested tillage effects on compaction, earthworms and other soil quality indicators in Hungary. The data show that annual disking and ploughing causes subsoil compaction at the depth of tillage within 3 years and that the compacted layer expanded both in surface and deeper layers after the 5th year. Birkas et al. (2004b) tested factors affecting the production loss under drought conditions. In Gödöllő experiments on Chromic Luvisol, the ratio of the clod:aggregate:dust were 54:18:18 % in the annually disked soil, while in the ploughed soil resulted of 52:31:17 %. These ratios differed (49:36:15) by the use of a soil structure conservation method (direct drilling). Stipesevic et al. (2000) applied five soil tillage (ST) treatments for maize-winter wheat – winter barley rotation on loessive pseudogley of Eastern Croatia. ST were as follows: *a*) conventional (stubble field discharrowing, ploughing to 30-35 cm, spring: diskharrowing and vibrocultivation, inter-row cultivation, *b*) *a* following discharrowing in previous year, *c*) diskharrowing following *a* in previous year, *d*) diskharrowing every year, the other as *a*, *e*) diskharrowing and loosening of plow-layer (30-35 cm), the other as *a*. Maize yielded significantly higher following *a* and *b* treatments.

References

- Birkás M., Gyuricza Cs. (2000): Direktsaat-Dauerversuchsergebnisse mit Körnermais im pannonischen Produktionsgebiet Ungarns. *Die Bodenkultur*, 51 (1): 19-34.
- Birkás M., Jolánkai M., Gyuricza C., Percze A. (2004a): Tillage effects on compaction, earthworms and other soil quality indicators in Hungary. *Soil Till. Res. Special Issue "Soil Quality as an Indicator of Sustainable Tillage Practices"* (ed. Karlen, D.L.) 78 (2): 185-196.
- Birkás M., Szalai T., Gyuricza C., Gecse M., Bordás K. (2002): Effects of the disk tillage on soil condition, crop yield and weed infestation. *Rostlinná Vyroba*, 48(1): 20-26.
- Birkás M., Ujj, A., Bencsik, K. (2004): Factors affecting the production loss under drought. *Proceedings of the 13th conference on nutrition of domestic animals. "Zadavec-Erjavec Days"* (ed. Pen, A.) 4-5 Nov., 2004., Radenci, Slovenia, pp. 47-53.
- Komljenovic I. (1994): Efekti redukovane obrade zemljišta za kukuruz u agroekološkim uslovima Slavonije (Effects of reduced tillage for maize under agroecological conditions of Slavonia province) - Doctoral Thesis, University of Belgrade, Faculty of Agriculture.
- Percze A., Gyuricza Cs., Birkás M., Szemók A, Ujj A. (2002): Extension of the tillagepan compaction and its impacts on some crop production factors. *Agriculture, Nitra*, 48: 282-290.
- Stipesevic, B., Zucec, I., Josipovic, M. (2000): Investigation of Rational Soil Tillage for Maize (*Zea mays L.*) in Eastern Croatia. *Proc. of the 15th Conference of the International Soil Tillage Research Organization (ISTRO), CD-ROM, 2-7 VII 2000., Fort Worth, Texas, SAD.*
- Saric T., Djalovic I. (2004): The effect of soil tillage systems, crop rotation and herbicides on johnsongrass control in maize. *Herbologia* 3 (2): 87-96.
- Zucec I. (1986): The Effect of Reduced Soil Tillage on Maize (*Zea mays L.*) Grain Yield in Eastern Croatia. *Soil & Tillage Research*, 7. p.p. 19-28.