SOIL TYPE INFLUENCE ON DRAINAGE DISCHARGE AND YIELD OF SOYBEAN

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Abstract: Research was carried out at two experimental fields in Jelenscak near Popovaca in the period 1999 – 2002. Drainpipes installed at two different soil types - Stagnosol and Gleysol have been with similar ways of installation. Stagnosol had higher average drainage efficiency in February, April and December, while Gleysol had higher drainage in all other months, with exemption of November, when average efficiency was the same. Average soybean yield in 2002 at drained Stagnosol was 3.0 t ha^{-1} compared with the yield at drained Glaysol of only 2.1 t ha^{-1}.

Keywords: Stagnosols, Gleysols, drainage efficiency, soybean yield

Introduction

Subsurface drainage is important to maintain productivity of the poorly drained soils, especially in humid regions. In this paper we present results with drainage efficiency obtained in two field trials, one was carried out at drained Stagnosol, and the other one at drained Gleysol. Both field trials are placed in a same area and they are relatively close each to other, at the distance about 1000 m. Stagnosols and Gleysols in Croatia are the soil types that are very often hydro-ameliorated with drainage installation. According to the FAO WRB for Soil Resources (2006), the main obstacle to utilization of Gleysols is the necessity to install a drainage system and to lower the groundwater table. At the same time agricultural suitability of Stagnosols is limited because of their oxygen deficiency resulting from water stagnation above a dense subsoil. The main goal of our research was to find out differences in drainage discharge of two different soil types in same years and to define soil fertility in terms of soybean yield. According to Gombos (2007), presence of clay minerals in heavy soils influence soil volume and water regime in the case of high rainfall. Different drainpipe spacing and different nitrogen fertilization levels significantly influence productivity of soils in experimental area (Simunic et al., 2002., Mesic et al., 2007.). Soil tillage practices are also very important for soil fertility (Birkás et al., 2007, Kisic et al., 2006), but at drained soils tillage is also influenced by drainage efficiency.

Materials and methods

Research was carried out at two experimental fields in Jelenscak near Popovaca in the period 1999 – 2002. Drainpipes installed at two different soil types - Stagnosol and Gleysol have been with similar ways of installation. Between different treatments with different drainpipe spacing we have selected treatments with same properties. At both locations drainage pipes were installed at distance of 20 m and have the following characteristics: length 95 m to 120 m, diameter 65 mm, average slope 0.3% and average depth 1m at Gleysol and 1.20 m at Stagnosol. Stagnosol have been subsoiled during year 2000. to the average depth or 55 cm. In the periods with drainage discharge at

Stagnosol water amounts were measured on a daily basis, while at Gleysol drainage discharge was measured permanently by means of electronic gauges – limnimeters. On both experimental plots soybean (*Glycine hispida max.*) was grown in 2002. Soil tillage practices were also the same, as well as it was fertilization with NPK. From field experiment on Stagnosol, with different nitrogen fertilization rates we have selected treatment with fertilization of 100 kg ha^{-1} N, that is the same amount that was applied for fertilization at Gleysol. Application of mineral fertilizer was the same for both fields, as well as it was application of herbicides, topdressing, the date of sowing (May 4. 2002) and the date of harvest (Oct. 17. 2002).

Results and discussion

Both soil types are located in Sava river valley, drained Stagnosol at an average altitude of 97.2 m, and drained Gleysol at altitude of 96.4 m. Average groundwater table depth is 1.75 m for Stagnosol and 1.25 m for Gleysol with strong fluctuations influenced by precipitation and drainage. Basic soil properties are presented in Table 1. According to the mechanical composition of arable layer Stagnosol is loamy, while Gleysol is silty clayey. Soil swelling and shrinking properties are determined by the percentage and type of clay minerals in soil, together with humus content. When it is dry Gleysol has a high proportion of large blocky aggregates, cracks are large and rainwater can easily percolate through the soil. When soil is wet, clay particles swell and water retention is very low. At Stagnosol structure is also problematic, but lower percentage of clay result with lower porosity when soil is dry, compared with Gleysol. Vertical hydraulic conductivity of Stagnosol is 0.40 m day^{-1}, while of Gleysol is only 0.01 m day^{-1}.

Table 1. Basic properties of Stagnosol and Gleysol

Depth	Content of particles, %		Poro sity,	Capacity, %		Bulk density,	Humus,	pH,	P	K
cm	Silt	Clay	%	Water	Air	kg dm^{-3}	%	KCl	mg kg^{-1}	
Stagnosol										
0-32	31	21	44	40	4	1.54	1.01	4.8	37.5	43.4
32-52	31	23	40	39	1	1.65	0.91	5.1	11.4	29.7
52-97	25	24	43	41	2	1.58	0.35	6.0	16.8	26.7
97-115	21	19	43	38	5	1.57	0.22	7.4	16.6	20.5
Gleysol										
0-35	47	46	48	44	4	1.35	3.00	5.3	25.8	62.8
35-75	45	48	49	45	4			5.2		
75-115	55	39	46	42	4			7.1		

Precipitation has predominant influence on time and intensity of drainage outflow. Annual precipitation for the studied period and average monthly precipitation representative for the experimental station are presented in Table 2. According to analyses of average monthly values of drainage efficiency for Stagnosol and Gleysol (Table 3), it is possible to conclude that differences are noticeable during whole year. Despite of that, average annual drainage efficiency is almost the same for both studied soil types. Although it is not possible to explain all recorded differences, it is obvious

that Stagnosol has higher average drainage efficiency in February, April and December, while Gleysol has higher drainage in all other months, with exemption of November, when average efficiency is the same.

Table 2. Annual and long term average precipitation, mm

Year	Precipitation, mm												Σ
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	
1999	36	36	24	112	92	74	80	67	67	47	59	79	773
2000	26	49	72	125	28	48	58	3	82	49	96	79	715
2001	88	4	102	60	35	121	35	44	197	15	78	35	814
2002	16	49	32	135	79	63	90	78	112	67	114	41	876
1965-84	**53**	**51**	**59**	**73**	**80**	**90**	**77**	**85**	**80**	**63**	**87**	**65**	**865**

Drainage efficiency of Stagnosol during summer months is smaller compared to the values recorded for Gleysol. In dry years formation of cracks in Gleysol is much more evident than in Stagnosol. According to Novak (1999) crack closing is not immediate even during heavy rainfall, and it can last for few days. Differences in drainage efficiency between Stagnosol and Gleysol, in autumn period for years 1999 and 2000, can be explained with faster water percolation through cracks in Gleysol than in Stagnosol. During vegetation period of soybean in 2002. there is no recorded drainage discharge for Stagnosol in the period from June to September, while drainpipes installed in Glaysol were active during whole summer. Differences in drainage efficiency for Stagnosol and Gleysol in 2002 can serve for the estimation of water saturation and soil moisture.

Table 3. Drainage efficiency in % of annual precipitation for Gleysol and Stagnosol, 1999 – 2002

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Σ
Stagnosol													
1999	78	147	4	23	5	20	0	0	0	2	42	73	27
2000	4	65	0	30	0	0	0	0	0	0	0	49	15
2001	52	375	72	27	0	0	0	0	7	0	51	77	28
2002	31	76	13	49	13	0	0	0	0	1	17	5	16
Average	**41**	**166**	**22**	**32**	**5**	**5**	**0**	**0**	**2**	**1**	**28**	**51**	**22**
% RSD	76	87	151	36	133	200	-	-	200	119	85	65	32
Gleysol													
1999	108	108	8	19	14	18	8	0	9	21	49	73	31
2000	31	40	21	23	16	0	0	0	0	0	0	61	17
2001	31	228	37	30	0	5	6	10	45	0	44	22	29
2002	176	14	45	7	11	3	6	6	28	0	19	28	17
Average	**86**	**98**	**28**	**20**	**10**	**6**	**5**	**4**	**21**	**5**	**28**	**46**	**23**
% RSD	81	98	59	47	70	120	68	124	98	200	82	54	32

According to the soybean yield it can be concluded that response to drainage was greater in coarser textured Stagnosol than finer textured Glaysol (Figure 1). The difference is statistically significant at the 95% probability level. If absolute values of soybean yield were compared, than it was clear that drainage efficiency had strongly influenced on the soybean development, especially when all agrotechnical practices were unvariant in the soybean cultivation.

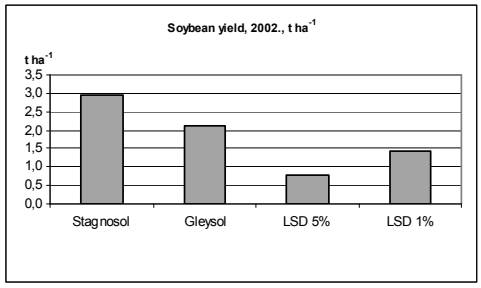

Figure 1. Soybean yield at Stagnosol and Gleysol

Conclusions

Average soybean yield in 2002 at drained Stagnosol was 3.0 t ha^{-1} compared with the yield at drained Glaysol of only 2.1 t ha^{-1}. Before drainage installation area with Stagnosols have been used as arable land, while lower positions with Gleysols as dominant soil type were pastures, very often flooded after periods of high precipitation. Drained Stagnosols and Glaysols can be fertile soils owing to their chemical properties, but drainage efficiency can strongly influence their fertility.

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References

Birkás, M. - Kalmár, T. – Bottlik, L. – Takács, T. 2007. Importance of Soil Quality in Environment Protection. Agriculturae Conspectus Scientificus, **72**, 1: 21-26.

FAO. 2006. World reference base for soil resources 2006. A framework for international classification, correlation and communication. FAO, Rome, 128.

Gomboš, M. 2007. Soil water regime in clay-loam soils. Cereal Research Communications, **35**, 2: 417-420.

Kisic, I. - Basic, F. - Mesic, M., - Sabolic, M. 2006. Influence of tillage systems on soybean yield characteristics. Cereal Research Communications, **34,** 1: 223-226.

Mesic, M.- Basic, F. – Kisic, I. – Butorac, A. – Gaspar, I. 2007. Influence of mineral nitrogen fertilization on corn grain yield and nitrogen leaching. Cereal Research Communications, **35,** 2: 773-776.

Novak, V. 1999. Soil-crack characteristics – estimation methods applied to heavy soil in the NOPEX area. Agricultural and Forest Meteorology, 98-99: 501-507.

Simunic, I. – Tomic, F. – Mesic, M. - Kolak, I. 2002. Nitrogen Leaching from Hydroameliorated Soil. Die Bodenkultur, **53**, 2: 73-83.