EXCESS WATER IN DRAINED SOIL

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Abstract: The research objective was to determine excess water (drainage discharge) in drained Gleyic Podzoluvisol (pseudogley-gley) at drainpipe spacings from 15 m with contact material - gravel). The three-year research (1999-2001) was done on the amelioration trial field Jelenščak, Kutina, in the central Sava valley. Drainage discharge was measured with electronic meters and compared to excess water in soil mathematically calculated by Palmer's method.
Excess water measured with electronic meters amounted to 236 mm in 1999, 130 mm in 2000, and 133 mm in 2001. Excess water in soil calculated by Palmer's method was 263 mm in 1999, 124 mm in 2000, and 160 mm in 2001.
The obtained results clearly show that the difference between of direct measurements and those given by Palmer's method was the lesser in 2000 (drainage discharge was higher for 6 mm), while differences were indentical in 1999 and in 2001 (drainage discharges were higher for 27 mm).
Consequently, excess water in drained soil of the central Sava valley calculated by Palmer's method is acceptable and gave rather reliable date of excess water in drained soil.
Keywords: Excess water, drained Gleyic Podzoluvisol, drainage discharge, Palmer's method

WASSERÜBERSCHUSS IN ENTWÄSSERTEM BODEN

Zusammenfassung: Das Forschungsziel war, Wasserüberschuss (Drainageauslauf) im entwässerten Pseudogley-Gley Boden festzustellen, wobei der Abstand zwischen den Drainrohren 15 m und das kontakthydraulische Material Kies war. Die dreijährigen Erhebungen (1999-2001) fanden auf dem entwässerten Versuchsfeld Jelenscak Kutina im Mittleren Sava-Tal. Der Drainauslauf wurde mit elektronischen Messgeräten nachgewiesen und mit dem mathematisch nach der Palmerschen Methode errechneten Wasserüberschuss im Boden verglichen.
Der mit elektronischen Messgeräten erhobene Wasserüberschuss betrug im Jahr 1999 236 mm, 2000 130 mm und 2001 133 mm. Der mit der Palmerschen Methode errechnete Wasserüberschuss im Boden betrug 1999 263 mm, 2000 124 mm und 2001 160 mm.
Im Hinblick auf die festgestellten Ergebnisse ist es ersichtlich, dass die Differenz zwischen der direkten Messung und der Palmerschen Methode im Jahr 2000 am geringsten war (der Drainauslauf war um 6 mm größer), während 1999 und 2001 diese Differenzen identisch waren (die Drainausläufe waren um je 27 mm geringer).
Abschließend kann man sagen, dass der durch die Palmersche Methode errechnete Wasserüberschuss im entwässerten Boden im Mittleren Sava-Tal akzeptabel ist und ziemlich zuversichtlich auf den Wasserüberschuss im entwässerten Boden schließen lässt.
Schlagworte: Wasserüberschuss, entwässerter Pseudogley-Gley, Drainauslauf, Palmersche Methode

1. Introduction

Diverse occurrences of soil water translocation, changes in its reserves along the soil profile and exchange of water between the soil and other natural factors constitute the water regime of soil. The quantitative expression for soil water regime is the water balance of soil. From the hydropedological and plant-production aspect, this means water uptake into soil, its

retention in soil and water loss from soil in the system soil-plant-atmosphere. In liquid state, water is lost from soil through its surface runoff and/or percolation.

Excess water in drained soils is reflected in the rate of drainage discharge. The relation between total drainage discharge and its duration indicates the efficiency of pipe drainage for draining excess water from soil, that is, drainage intensity. Systems with higher drainage discharge and its shorter duration are more efficient.

2. Methods

In the period 1999-2001, investigations involving a drainpipe spacing of 15 m combined with contact hydraulic material – gravel were conducted on drained Gleyic Podzoluvisol with the following objectives:

To determine the total annual drainage discharge (excess water) and compare it with the mathematical model after Palmer. Reference evapotranspiration was calculated according to the Penman-Monteith method.

Investigations were carried out at the amelioration trial field Jelenščak near Kutina, on drained Gleyic Podzoluvisol. The studied drainpipe spacing was 15 m in combination with contact hydraulic material – gravel (ø 5-25 mm). Drainpipe length was 95 m, diameter 65 mm, average slope 3 ‰ and average depth 1 m. Drainpipes discharged directly into open canals. Plastic (PVC) pipes, corrugated and perforated, were used. Drainage discharge was measured continuously by means of automatic electronic meters (limnimeters), which were installed at the drainpipe end discharging into open canals.

Maize was sown at the beginning of May and harvested in October 1999. Winter wheat was sown in the autumn of 2000 and harvested in July 2001.

3. Results and discussion

3.1. Soil and precipitation characteristics

Major soil and precipitation characteristics are given in Tables 1 and 2.

Table 1. Major characteristics of drained Gleyic Podzoluvisol

Depth, cm	Particle content, %		Porosity, %	Capacity, %		Water permeability, m/day	Soil water constants, mm		
	Silt	Clay		Water	Air		*PKv	*Tv	*FAv
0-35	47	46	48	44	4	0.011	*315	*189	*126
35-75	45	48	49	45	4	0.010			
75-115	55	39	46	42	4	0.011			
115-130	63	25	49	45	4				

Legend:
***** Values refer to the depth up to 1 m.
PKv=0.33 bara
Tv =15.0 bara
FAv=PKv-Tv

To the depth of 0.75 m the soil is of silty clayey textural composition. To the depth of 0.75-1.15 m the soil has lighter texture. Silty component prevails in the textural composition (55%) while the clay content decreases (34%). At depths over 1.15 m the soil is silty loamy. The soil is porous, with a total pore volume of 48-49%. Soil water retention capacity ranges from 42-45% and its air capacity is low. Vertical hydraulic conductivity is very low (0.011 m/day).

Table 2.Total monthly and annual precipitation (mm), 1999-2001

Yr.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
‘99	42	63	38	126	107	89	86	66	95	73	92	104	981

‘00	29	37	63	77	26	47	73	20	83	71	88	134	748
‘01	91	12	96	83	62	128	44	22	250	9	132	46	975

Meteorological station Sisak

Total annual precipitation ranged from 748.3 mm (2000) to 980.4 mm (1999). The primary precipitation maximum was recorded in the autumn while the secondary maximum was mainly in the late spring period.

3.2. Hydrological relations

Results relating to excess water (drainage discharge) are given in Table 3, while excess water calculated by the mathematical method after Palmer is presented in Table 4.

Table 3. Mean monthly and annual drainage discharge (mm)

Yr.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
‘99	51	70	2	29	12	7	6		1	3	11	44	236
‘00	3	35	30	29								33	130
‘01	19	23	37	10				4	11		15	14	133

It can be seen from Table 3 that there are certain differences in total drainage discharge between the years studied. The lowest total drainage discharge was recorded in 2000 - 130 mm (or 17.4% of total annual precipitation) while the highest total drainage discharge was determined in 1999 - 236 mm (or 24.1% of total annual precipitation). The total drainage discharge increased with the increase in total precipitation (Šimunić et al.,1995 and Petošić et al., 1998). The largest quantities of drainage discharge were recorded in the autumn-winter and spring periods, at the time of the highest precipitation and the lowest evapotranspiration. These results are in agreement with other research results (Vidaček et al., 1991 and Tomić et al., 1994 and 1996). However, the dynamics and total drainage discharge are also affected by the quantity and time of rainfalls, soil vegetable cover and crop stage (Šimunić et al., 2002).

Table 4. Balance of precipitation water in soil after Palmer (1999-2001)

Yr.	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Σ
’99	Off	39	56	35	101	89	76	74	59	81	64	79	87	840
	ETo/ETc	12	22	53	69	40	96	143	103	60	26	18	12	654
	AE	12	22	51	69	40	93	102	73	60	26	18	12	578
	OT	27	34		16	49					1	61	75	**263**
	ETc-AE			1			3	42	31					77
‘00	Off	28	34	57	67	25	44	65	20	72	63	76	105	655
	ETo/ETc	9	25	59	84	124	165	164	152	81	12	7	4	886
	AE	9	25	59	82	64	77	82	36	72	12	7	4	529
	OT	18	9										97	**124**
	ETc-AE				2	60	88	82	116	9				357
‘01	Off	78	12	81	72	56	102	41	21	150	9	104	42	768
	ETo/ETc	16	28	53	79	124	129	143	136	66	47	24	12	856
	AE	16	26	53	79	84	110	68	42	66	30	24	12	610
	OT	62		15								53	30	**160**
	ETc-AE		2			40	19	75	95		17			248

Original method of Palmer W.C., 1965; corrected and calibrated by Vidaček Ž., 1981.

Legend:

Off - effective precipitation, in mm;
ETo - reference evapotranspiration, in mm;
ETc - crop evapotranspiration, in mm;
AE - effective evapotranspiration, in mm;
OT - discharge or soil excess water, in mm;
ETc-AE- lack or deficiency of water in soil, in mm

Excess water in soil calculated according to Palmer's model (Table 4) was higher in 1999 and 2001 compared to the measured total drainage discharge. The difference for these two years amounted to 27 mm. In 2000, excess water calculated according to Palmer's model was lower compared to the total drainage discharge. The difference was 6 mm. It is thus evident that there are certain differences between the measured and calculated water excess in drained soil, which is due to a number of factors. The authors maintain that the recorded differences are within allowable limits. Palmer's model provides reliable data on water loss from soil (Tanić and Vidaček 1989). The authors think that this model is suitable for calculating excess water in drained soil in the agroecological region of the central Sava valley.

4. Conclusions

Three-year investigations of excess water in drained soil point to the following conclusions:

1. The measured excess water in soil ranged from 130 mm (or 17.4% of total annual precipitation) in 2000 to 236 mm (or 24.1% of total annual precipitation) in 1999.
2. Excess water in soil calculated according to Palmer's model ranged from 124 mm in 2000 to 263 mm in 1999.
3. Excess water in soil calculated according to Palmer's model was higher in 1999 and 2001 compared to the measured total drainage discharge. The difference was 27 mm.
4. In 2000, excess water in soil calculated according to Palmer's model was lower relative to the measured total drainage discharge. The difference was 6 mm.
5. It is evident that there are certain differences between the measured excess water and that calculated according to the mathematical model after Palmer, which is due to a number of factors.
6. The authors maintain that the recorded differences are within allowable limits, and that this model can be used to calculate excess water in drained soil in the agroecological region of the central Sava valley.

5. References

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