COMPARISON OF SEASONAL CHANGES OF UNSATURATED HYDRAULIC CONDUCTIVITY ON TWO AGRICULTURAL CATCHMENTS

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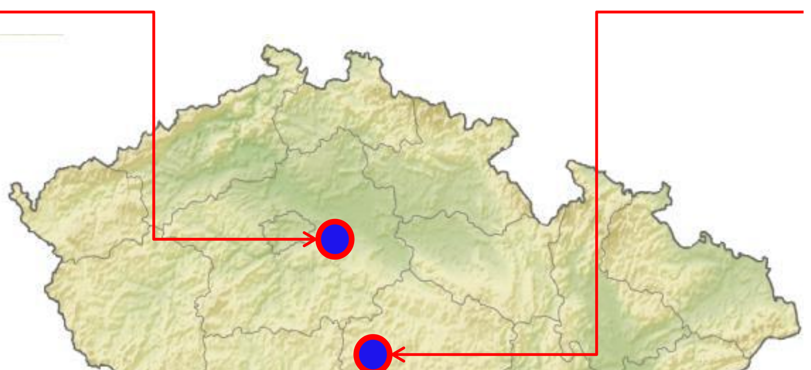
Abstract

Hydraulic conductivity of soil in arable land is strongly dependent on agrotechnological procedures, soil compaction, plant growth etc. This contribution is focused on measurement of the unsaturated hydraulic conductivity of the topsoil using newly designed automated multipoint tension infiltrometer on two agricultural catchments Nučice and Kopaninský stream. Thirteen infiltration campaigns were carried out during three years. All tension infiltration experiments were performed using pressure head of -3 cm. Initial and saturated water contents and bulk density were measured on undisturbed samples collected during each measuring campaign. The main goal of the contribution is to describe the seasonal changes the unsaturated hydraulic conductivity on arable land. Results show that unsaturated hydraulic conductivity was significantly affected by soil compaction. Lowest unsaturated conductivity was observed in spring.

Experimental catchments

Nučice
(Central Bohemia)

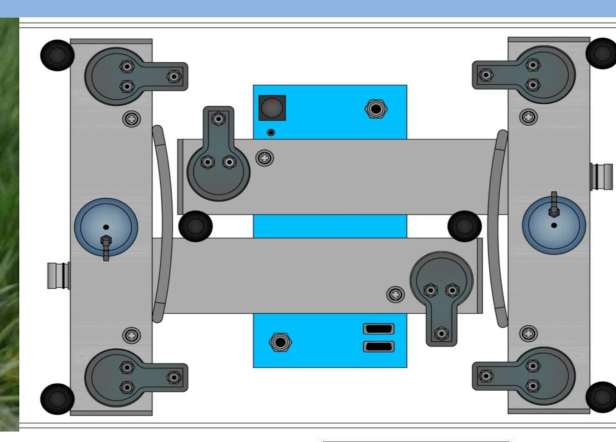
Area: 50 ha
Altitude: 410 m a.s.l.
Average annual temperature: 9 °C
Annual precipitation: 650 mm
Land use: Arable soil
Soil type: Cambisol
Texture: Loam – Clay loam
van Genuchten model param.:
α = 0.048 cm-1 ; n = 1.312

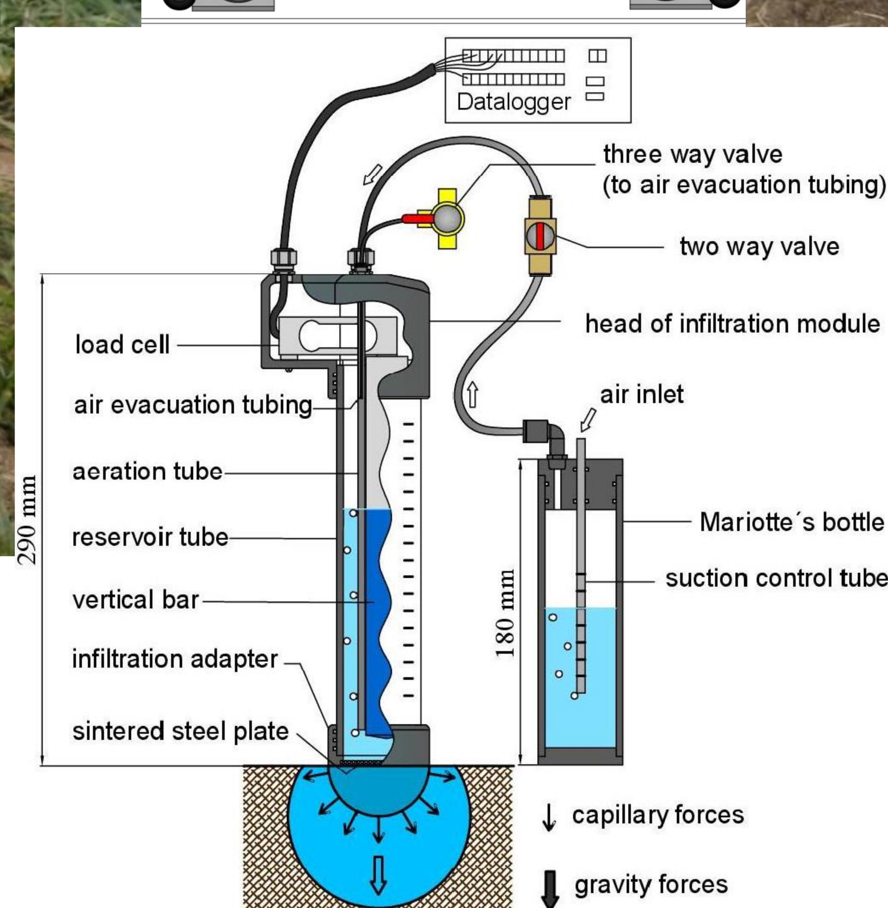


Kopaninský stream
(Bohemo-Moravian Highland)

Area: 710 ha
Altitude: 467 – 578 m a.s.l.
Average annual temperature: 7 °C
Annual precipitation: 665 mm
Land use: Arable soil
Soil type: Cambisol
Texture: Loamy sand
van Genuchten model param.:
α = 0.043 cm^{-1} ; n = 1.545

MultiDisk – Generation I





MultiDisk – Generation II

MultiDisk infiltrometer (Generations I and II)

- Disk diameter is 44.5 mm
- Two independent groups of three infiltrometer modules attached to a common Mariotte´s bottle (pressure head adjustment)
- Built-in data logger, a thermometer and a high capacity battery
- Data are visualized via portable keyboard and can be uploaded to PC

Cumulative infiltration measuring principle

The cumulative infiltration is measured via changes of buoyant force acting on the vertical bar that is immersed in water in the reservoir tube. During the infiltration, changes of buoyant force are sensed using electronic load cell to which is attached the vertical bar.

Experiments

- 13 infiltration campaigns in total (i.e. 78 tension infiltrations / 70 evaluated)
- Set suction pressure head h_0 = -3.0 cm
- Maximum 1 – 3 cm of topsoil were removed prior the infiltration
- Thin contact layer (approx. 1 mm) of dry fine quartz sand used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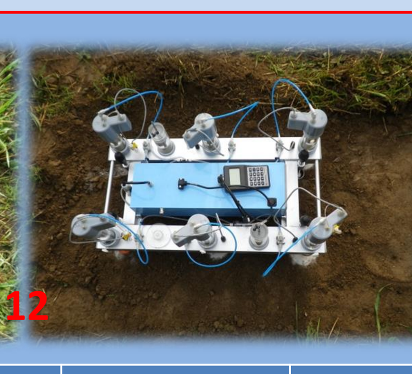
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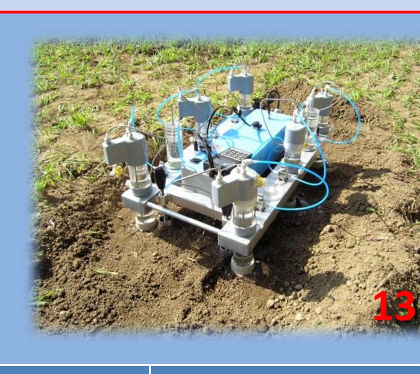
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Experimental catchment	Fig. no.	Date	Description of actual soil cultivating and crop development phases	Soil crust	Temperature	θ_{init}	θ_s	ρ_d	$K(h_0)$	Number of evaluated measurements
					(°C)	(-)	(-)	($g\ cm^{-3}$)	($cm\ min^{-1}$)	
Nučice	1	25.10.2012	young winter barley (few weeks after sowing)	no	9	0.33	0.43	1.49	3.16E-03	5
	2	22.4.2013	between postharvest stubble management and sowing	yes	21	0.23	0.50	1.30	8.49E-04	5
	3	25.7.2013	fully grown oat (1 m high)	yes	28	0.15	0.45	1.40	2.83E-03	6
	4	4.10.2013	after fresh postharvest stubble management	no	14	0.37	0.44	1.39	2.74E-03	6
	5	13.3.2014	stubble breaking sowed with winter wheat	yes	14	0.27	0.53	1.25	7.08E-04	4
	6	10.4.2014	winter barley (30 cm)	yes	9	0.23	0.54	1.22	7.55E-04	6
	7	15.5.2014	winter barley (50 – 60 cm)	yes	15	0.25	0.47	1.33	1.47E-03	6
	8	19.6.2014	grown barley (80 cm)	yes	24	0.11	0.45	1.35	2.73E-03	6
	9	6.8.2014	fully grown barley (1 m)	yes	29	0.24	0.42	1.41	1.95E-03	6
	10	1.10.2014	freshly sowed winter wheat (only few days)	no	20	0.31	0.49	1.24	2.80E-03	6
Kopaninský stream	11	16.5.2013	young spring cereal (5 - 10 cm)	yes	22	0.25	0.52	1.40	2.19E-03	5
	12	9.10.2013	stubble field with grass cover after fertilization	no	13	0.25	0.45	1.41	9.86E-04	5
	13	29.9.2014	young winter cereal	no	23	0.29	0.47	1.33	1.71E-03	4


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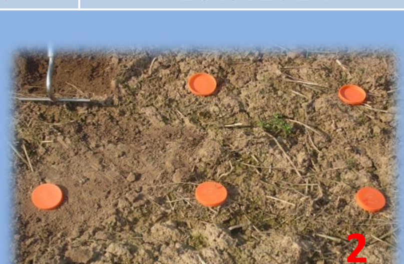
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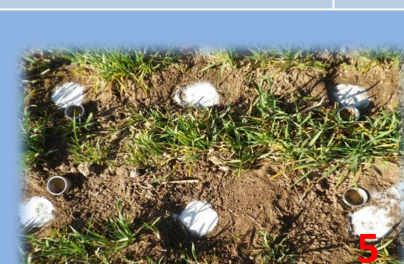
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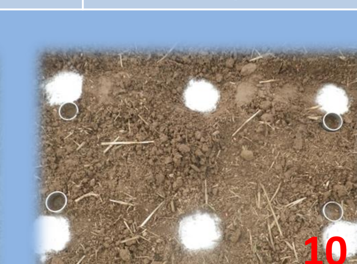
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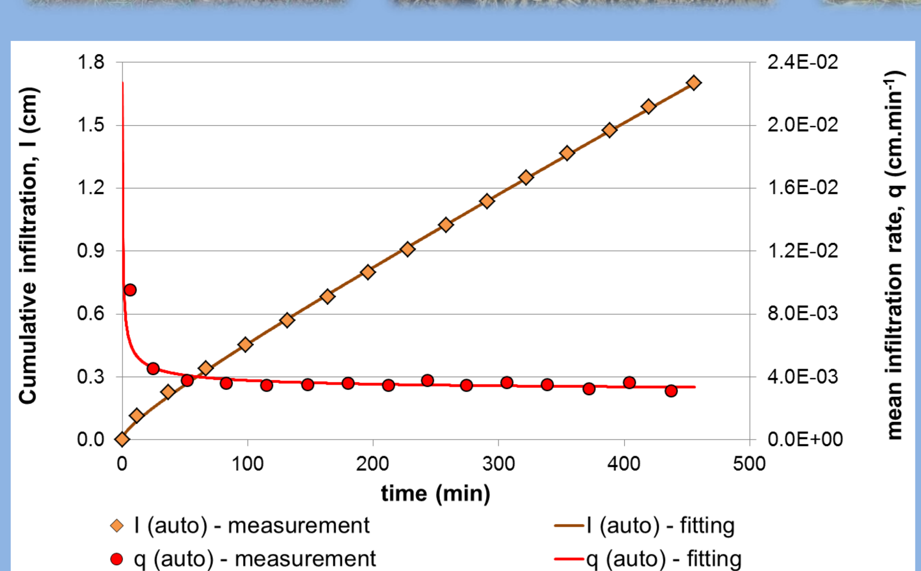
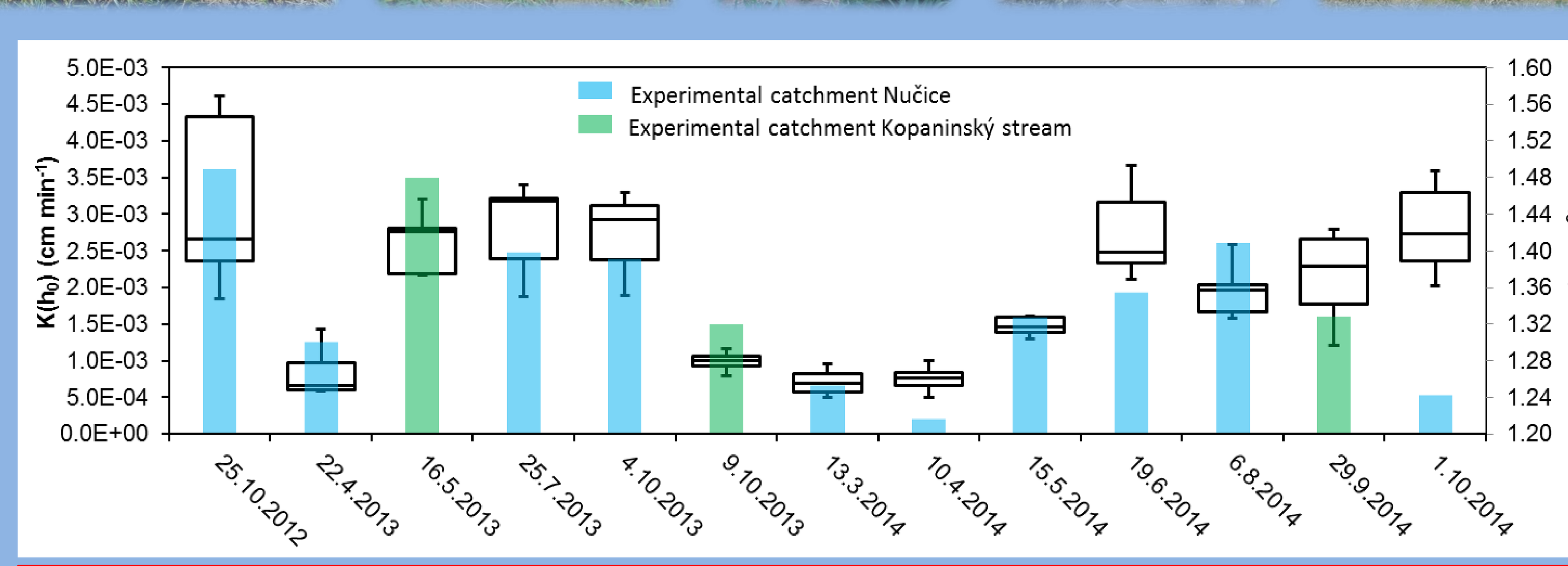


← A typical result of infiltration experiment

$$I = C_1 t^{1/2} + C_2 t \quad (1)$$

$$C_2 = K_{h0} A_2 \quad (2)$$

where A_2 is dimensionless coefficient dependent on van Genuchten`s parametr n (-) (Dohnal et al., 2010).



Evaluation of unsaturated hydraulic conductivity in time. Box and whisker plot depicts minimum, maximum, median, first and third quartiles of the measured hydraulic conductivity. Blue and green columns represent actual topsoil bulk density.

Near-saturated hydraulic conductivity ***K(h₀)*** ($cm.min^{-1}$) is calculated using Zhang`s relationship (2) (1997) after determination coefficients $C_1$ ($cm.min^{-1/2}$) and $C_2$ ($cm.min^{-1}$) by fitting of measured cumulative infiltration $I$ (cm) using Philip`s equation (1) (Philip, 1957).

Conclusions

- MultiDisk infiltrometer proved to be a reliable and efficient tool for the field work
- Relation between near-saturated hydraulic conductivity and a bulk density (ρ_d) was observed
- It is necessary to conduct further measurements to describe in detail temporal variations of K

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