ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LIX 29 Number 6, 2011

EVALUATION OF THE INFILTRATION CAPACITY OF SOIL IN A WINTER WHEAT STAND DURING THE GROWING SEASON 2010

T. Mašíček, F. Toman, M. Vičanová, V. Hubačíková

Received: May 27, 2011

Abstract

MAŠÍČEK, T., TOMAN, F., VIČANOVÁ, M., HUBAČÍKOVÁ, V.: *Evaluation of the infiltration capacity of soil in a winter wheat stand during the growing season 2010.* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 6, pp. 225–234

The aim of the presented paper was to map the course of infiltration during the growing season of 2010 in a winter wheat stand on a selected locality in the Sazomín cadastral area on the basis of selected hydro-physical properties of soil (specific weight, reduced volume weight, actual soil moisture, absorptivity, retention water capacity, porosity, capillary, semi-capillary and non-capillary pores and aeration) evaluated from the analyses of undisturbed soil samples. In order to assess the infiltration capacity of soil at the U Jasana locality in the season April–October, four surveys were realized always with three measurements within each of the surveys. The measurement of infiltration took place in the form of basin irrigation. To evaluate field measurements of infiltration empirical relations were used, namely Kostiakov equations. The highest cumulative infiltration and speed of infiltration were noted in June at the high actual soil moisture and closed stand. In case of October measurement, effects of agro-technical operations became evident on the slightly lower infiltration capacity of soil as compared to June measurements at nearly identical moisture conditions. The lowest infiltration capacity of soil reaching the same level, namely in spite of different moisture conditions and the stand character (July – full-grown stand, August – stubble-field) was found in July and August.

soil, speed of infiltration, soil water, hydro-physical properties of soil

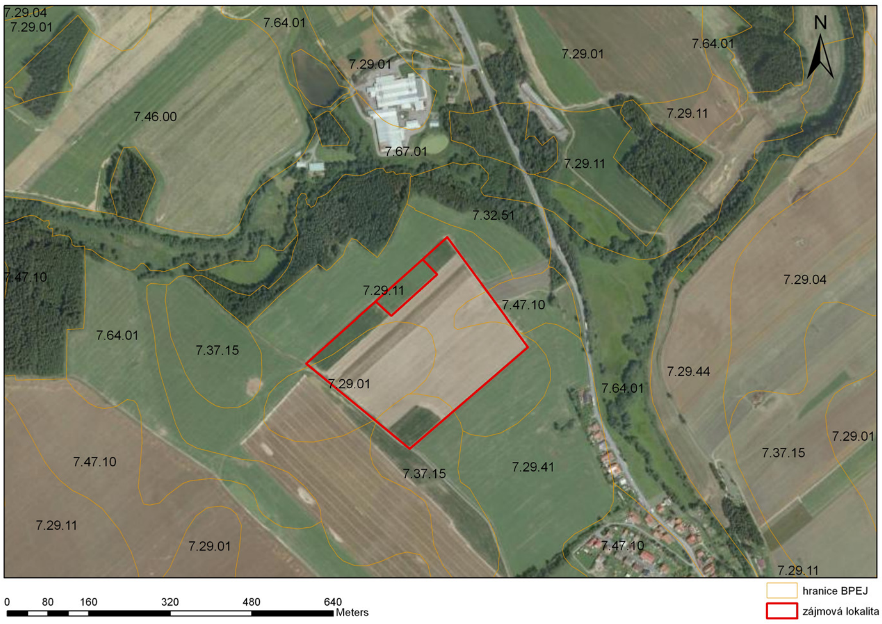
All processes taking place in soil are closely related to water. At the high infiltration capacity of soils supplies of soil water, which is one of the main conditions of soil fertility, are supplemented. With respect to the unequal distribution of precipitation during the year, infiltration of water into soil appears to be an important theme. Results of measurements will help to determine the soil profile condition, soil compaction and the capacity of soil to hold up water.

On the basis of these findings it is possible to propose optimum procedure at the cultivation and use of land. With respect to the present way of soil management, to preserve the maximum amount of water in the soil profile appears to be a priority. The aim of the presented paper was to map the course of infiltration during the growing season 2010 in the winter wheat stand at a selected locality in the Sazomín cadastral area on the basis of selected hydro-physical properties of soil evaluated from analyses of undisturbed soil samples. In order to assess infiltration possibilities of soil at a locality U Jasana in the season April–October, four surveys were realized always with three measurements within each of the surveys.

MATERIAL AND METHODS

Characteristics of the area

The selected land (locality U Jasana) is used by the Vatín Research Grazing Station managed by the Department of Animal Nutrition and Grazing, Faculty of Agronomy, Mendel University in Brno. The locality is situated at the Bohemian-Moravian



1: *An orthophotograph map of the studied area with a marked experimental plot U Jasana*
[Source: Orthophoto map – Geodis, s.r.o., map of BPEJ – VÚMOP Prague]

Upland, 7 km south of Žďár nad Sázavou, at the southern limit of the Žďárské vrchy Protected Landscape Area (CHKO Žďárské vrchy), between villages Vatín and Sazomín in the cadastral area of Sazomín. The land is slightly of steep character, no watercourse occurs in the immediate vicinity (Fig. 1).

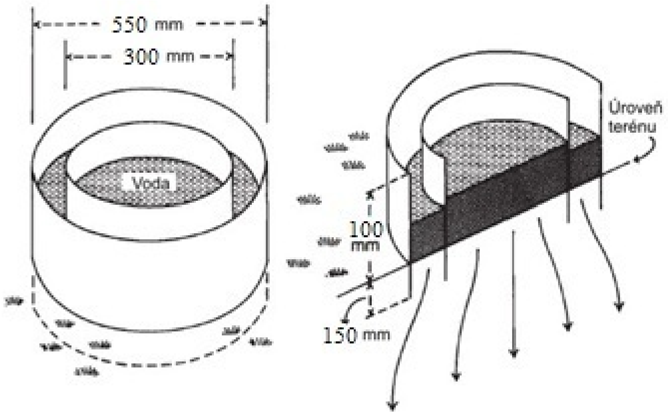
The land is used as arable land where winter wheat Biskay was grown in the monitored year. On the land, sharing (postharvest stubble-breaking) was carried out in 2009 and the presowing preparation of soil by means of a compactor and the actual sowing a crops. In spring 2010, fertilization by industrial fertilizers was carried out. Ammonium nitrate with limestone and ammonium nitrate with urea were used. After harvest, organic fertilizers were used, namely semi-liquid manure (slurry). According to Atlas of weather of the Czech Republic (Tolasz, 2007), the mean annual air temperature ranges in the area between 5 and 7 °C, annual total precipitation in a long-term average 650–750 mm. Precipitation in summer reach 200–300 mm and, on the contrary, the least amount of precipitation in winter amounts to 125–200 mm. According to Quitt classification (1971), the studied area belongs to the climatic area of a slightly warm MT 3. According to classification given in the Atlas of weather of the CSR, the area of interest ranks among slightly warm regions, slightly moist sub-region, slightly warm district, slightly moist, upland (Vesecký *et al.*, 1958). The studied locality is situated in the Žďár bioregion, at the borderland of southern Moravia and eastern Bohemia occupying the best part of the geomorphologic unit of the Žďárské vrchy Hills (Culek, 1996). According to the Geological map of the Czech Republic the area of interest is situated on precambric crystalline schists created particularly by gneiss and migmatite, rarely amphiboles completed by the small proportion of granodiorite to diores (Fusán *et al.*, 1993). According to Culek (1996), dystric Cambisols dominate in the bioregion, on the highest ridges Cambisol podzols predominate. The code of a classified soil-ecological unit (BPEJ) was provided by Research Institute of Soil Reclamation and Soil Protection, v.v.i. in Prague. The land (plot of interest) code is 7. 29. 11. According to the notice of the CR Ministry of Agriculture No. 327/1998 Gaz., which determines characteristics of classified soil-ecological units and a procedure for their administration and up-dating as amended by the act No. 546/2002 Gaz., this code expresses following soil characteristics:

- *climatic region:* MT 4, slightly warm, moist,
- *main soil unit:* modal, eubasic to mesobasic Cambisols, medium-heavy to medium-heavy lighter, without skeleton to medium skeletal, with prevailing good moisture conditions,
- *slope:* moderate slope (3–7°),
- *slope orientation:* omnidirectional,
- *soil skeleton:* unskeletal with an admixture, weakly skeletal,
- *soil depth:* deep, medium-deep.

METHODS

The infiltration capacity of soil is determined as the amount of water infiltrated per a time interval or the course of infiltration rate during time. To assess the infiltration capacity of soil at the locality of interest the method was used of concentric cylinders according to Vališ and Šálek (1976).

The infiltration capacity was monitored on the soil surface by means of two concentric cylinders



2: *The set of concentric cylinders determined to measure infiltration*
[source: http://www.fce.vutbr.cz/veda/JUNIORSTAV2007/Sekce_3/Sedlackova_Radovana_CL.pdf]

embedded into soil in the monitored stand. The outer cylinder provides vertical and lateral infiltration, inner cylinder vertical infiltration in the centre of monitoring (Fig. 2). Results of examination from the central cylinder were used for the actual evaluation. The outer cylinder diameter was 55 cm and that of inner cylinder 30 cm. Because of the statistical significance always three measurements were carried out. At the evaluation of irrigation basin infiltration Kostiakov equations were used. Based on field measurements, the dependence of infiltration rate v on time t was determined and also the dependence of cumulative infiltration i on time t. The expression of these dependences by means of empirical equations of Kostiakov was described in detail by Kutílek *et al.* (1993), Vališ, Šálek (1976), Velebný, Novák (1989) etc.

At each of the measurements, soil samples were taken at the locality by means of Kopecký physical cylinders from the soil depth of 10, 20 and 30 cm followed by laboratory processing and evaluation of selected hydro-physical properties of soil (specific weight, reduced volume weight, actual soil moisture, absorptivity, retention water capacity, porosity, capillary, semi-capillary and non-capillary pores and aeration). On the basis of these selected parameters it was possible to evaluate the infiltration (Vičanová *et al.*, 2010). The procedure of taking soil samples in undisturbed condition by means of Kopecký physical cylinders for the determination of physical properties of soil is described in detail in a methodical manual "Evaluation of the quality of soil in an ecologically managing enterprise" (Pokorný *et al.*, 2007). Samples for the determination of physical properties of soil were taken in three repetitions from each of the depths. Selected hydro-physical parameters were determined according to Jandák *et al.* (2003). Values of daily totals of precipitation were obtained from a meteorological station of the Vatín Research Grazing Station.

RESULTS AND DISCUSSION

Soils at the U Jasana locality were evaluated according to Novák particle-size classification as loamy-sandy (light) to sandy-loamy (medium-weight). The proportion of clay particles (< 0.01 mm) at a depth of 10 cm: 23.60 %, at 20 cm: 21.70 % and at 30 cm: 13 %.

Results of soil analyses

Result of the analysis of undisturbed soil samples from particular measurements are given in Tabs. I. to IV. Reduced volume weight, actual soil moisture, aeration and porosity including the relation of the proportion of capillary, semi-capillary and non-capillary pores are commented.

The reduced volume weight increases with depth, as compared to Lhotský critical value (1984) for sandy-loamy soils (PH – 1.55 $g.cm^{-3}$) and loamy-sandy soils (HP – 1.60 $g.cm^{-3}$) it was not exceeded at any depth. At a depth of 10 and 20 cm, soil occurs in good uncompacted condition but at a depth of 30 cm, the reduced volume weight already approaches a critical value for harmful compaction. The porosity at a depth of 10, 20 and 30 cm ranges in optimum values (the critical value of porosity according to Lhotský for sandy-loamy soils is 42 % vol. and for loamy-sandy soils 40 % vol.). The proportion of capillary pores, which roughly 2/3 total porosity should reach at a depth of 10 and 20 cm characterises favourable conditions. At a depth of 30 cm, the proportion of capillary pores decreases in favour of semi-capillary and non-capillary pores. The actual soil moisture reaches the highest values at a depth of 10 cm gradually decreasing with depth. The high actual soil moisture at a depth of 10 and 20 cm is caused by significant precipitation totals in the second half of May and at the beginning of June. The precipitation total for the period mentioned above amounted to 108 mm. Aeration at a depth of 10 and 20 cm does not reach ideal values, which vary between 18 and 24% in

I: *Analysis of an undisturbed soil sample (June 8, 2010)*

Parameter	10 cm	20 cm	30 cm
Actual moisture [% vol.]	31.13	28.71	17.77
Absorptivity = full water capacity [% vol.]	46.70	43.91	37.65
Maximum capillary water capacity [% vol.]	39.31	36.32	25.51
Retention water capacity = field water capacity [% vol.]	28.74	28.11	16.30
Specific weight [g.cm^{-3}]	2.62	2.62	2.66
Reduced volume weight[g.cm^{-3}]	1.42	1.46	1.59
Porosity [% vol.]	45.80	44.15	40.10
Capillary pores [% vol.]	28.74	28.11	16.30
Semi-capillary pores [% vol.]	15.04	11.87	15.70
Non-capillary pores [% vol.]	2.02	4.17	8.10
Aeration [% vol.]	14.67	15.44	22.33
30-minute moisture [% vol.]	43.78	39.98	32.00

II: *Analysis of an undisturbed soil sample (July 8, 2010)*

Parameter	10 cm	20 cm	30 cm
Actual moisture [% vol.]	8.74	9.13	No sampling
Absorptivity = full water capacity [% vol.]	50.46	40.82	
Maximum capillary water capacity [% vol.]	41.21	34.28	
Retention water capacity = field water capacity [% vol.]	27.25	28.37	
Specific weight [g.cm^{-3}]	2.62	2.65	
Reduced volume weight[g.cm^{-3}]	1.27	1.52	
Porosity [% vol.]	51.66	42.52	
Capillary pores [% vol.]	27.25	28.37	
Semi-capillary pores [% vol.]	19.25	8.69	
Non-capillary pores [% vol.]	5.16	5.46	
Aeration [% vol.]	42.92	33.39	
30-minute moisture [% vol.]	46.50	37.06	

the arable land horizon for soils in good condition (Jandák *et al.*, 2003). This condition is caused by high actual moisture at depths mentioned above. At a depth of 30 cm, aeration occurs at optimum range with respect to lower actual moisture.

From the measurements, physical characteristics were evaluated only from the depth of 10 and 20 cm. The reason of absence of the analysis of undisturbed soil samples from depth of 30 cm consisted in the occurrence of stones, which made impossible to carry out sampling. Reduced volume weight increases with depth. At a depth of 10 cm, soil is in good not compacted condition. At 20 cm, the value of reduced volume weight already approaches Lhotský critical value for sandy-loamy soils. Decreasing porosity corresponds with the increasing value of reduced volume weight. Compared to the previous measurement the actual soil moisture markedly decreased, which was caused by the longest (three-week) period without precipitation proceeding the day of measurement during the monitored period. The highest soil aeration is related to the low actual soil moisture. The soil aeration was exceeded minimally twice as compared with other measurements and proceeds therefore above the limit of optimum range. High porosity participates also in the condition, namely in the surface layer. Optimum conditions of intraaggregate (capillary) and interaggregate (semicapillary and non-capillary) pores are reached only at a depth of 20 cm. At 10 cm, this optimum relation is increased in favour of interaggregate pores (particularly semicapillary).

At a depth of 10 and 20 cm, reduced volume weight reaches optimum values, on the other hand, at a depth of 30 cm, critical limit for loamy-sandy soils (1.60 g.cm^{-3}) is slightly exceeded, which refers to marks of harmful soil compaction at this depth. The initial moisture is higher as compared with July measurements which are affected by significant precipitation totals in the second half of July and during August. The precipitation total amounted to 241 mm for the given period. The porosity at 10 and 20 cm does not markedly differ from previous measurements at 30 cm slight decrease is noted below the critical value, which amounts to for loamy-sandy soils 40% vol. The ratio of intraaggregate and aggregate and interaggregate pores is balanced with the slight occurrence at a depth of 20 cm in detrimental of capillary pores. The significant fall of soil aeration as against previous measurements

III: *Analysis of an undisturbed soil sample (August 26, 2010)*

Parameter	10 cm	20 cm	30 cm
Actual moisture [% vol.]	33.03	31.89	26.63
Absorptivity = full water capacity [% vol.]	43.09	47.96	36.35
Maximum capillary water capacity [% vol.]	36.47	37.82	30.47
Retention water capacity = field water capacity [% vol.]	30.33	30.58	26.20
Specific weight [g.cm^{-3}]	2.64	2.64	2.69
Reduced volume weight[g.cm^{-3}]	1.41	1.30	1.62
Porosity [% vol.]	46.59	50.76	39.90
Capillary pores [% vol.]	30.33	30.58	26.20
Semi-capillary pores [% vol.]	9.01	12.09	7.06
Non-capillary pores [% vol.]	7.22	8.09	6.64
Aeration [% vol.]	13.56	18.87	13.27
30-minute moisture [% vol.]	39.34	42.67	33.26

IV: *Analysis of an undisturbed soil sample (October 13, 2010)*

Parameter	10 cm	20 cm	30 cm
Actual moisture [% vol.]	30.18	28.22	20.08
Absorptivity = full water capacity [% vol.]	47.56	37.42	34.17
Maximum capillary water capacity [% vol.]	38.06	32.21	25.94
Retention water capacity = field water capacity [% vol.]	24.02	22.27	15.49
Specific weight [g.cm^{-3}]	2.71	2.71	2.72
Reduced volume weight[g.cm^{-3}]	1.26	1.62	1.71
Porosity [% vol.]	53.50	40.22	37.01
Capillary pores [% vol.]	24.02	22.27	15.49
Semi-capillary pores [% vol.]	18.73	12.26	13.98
Non-capillary pores [% vol.]	10.75	5.69	7.54
Aeration [% vol.]	23.32	12.00	16.93
30-minute moisture [% vol.]	42.75	34.53	29.47

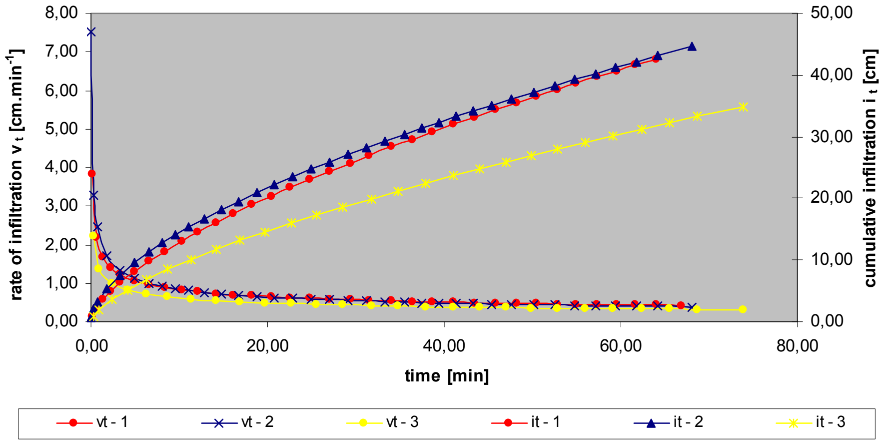
is caused above all by the marked increase of actual soil moisture.

Reduced volume weight at 10 cm does not exceed a limit for harmful compaction, at 20 cm the limit of harmful compaction for sandy-loamy soils is exceeded by 0.07 g.cm^{-3} and at 30 cm it exceeds the limit for loamy-sandy soils by 0.11 g.cm^{-3} above the critical value. The soil shows harmful compaction, which results in a significant fall of porosity below the critical value. At 30 cm, porosity ranges 2.99 % vol. below the critical value for loamy-sandy soils and at 20 cm 1.78 % vol. for sandy-loamy soils. Compared to previous measurements, the ratio of intraaggregate and interaggregate pores at all depths is markedly imbalanced with the predominance of interaggregate pores. Higher values of actual soil moisture at 10 and 20 cm correspond with significant precipitation totals at the end of September and lower air temperatures in this period manifesting in the lower water evaporation from soil. Soil aeration at 10 cm ranges at optimum intervals unlike 20 and 30 cm depth where it is lower, however, always above the critical value 10 % vol.

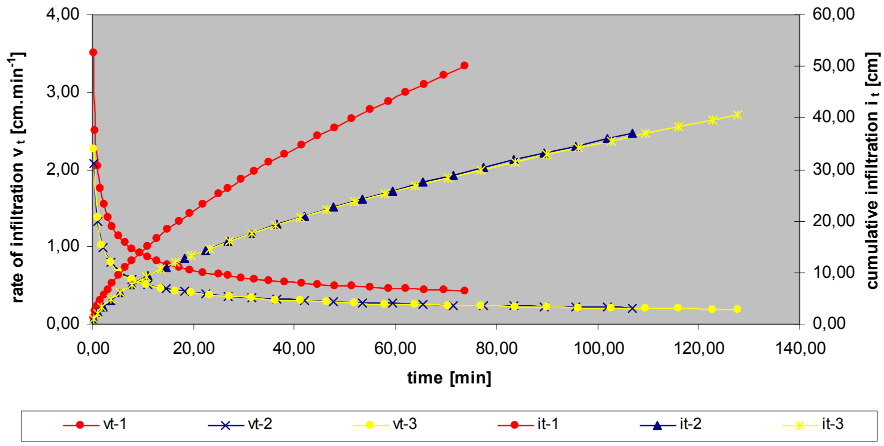
Results of infiltration measurements

Results of the infiltration capacity of soils from particular measurements are given in Figs. 3 to 6 illustrating the dependence of cumulative infiltration and infiltration rate on time. The infiltration capacity of soil was monitored in the course of the growing season against a background of changing hydro-physical properties of soil.

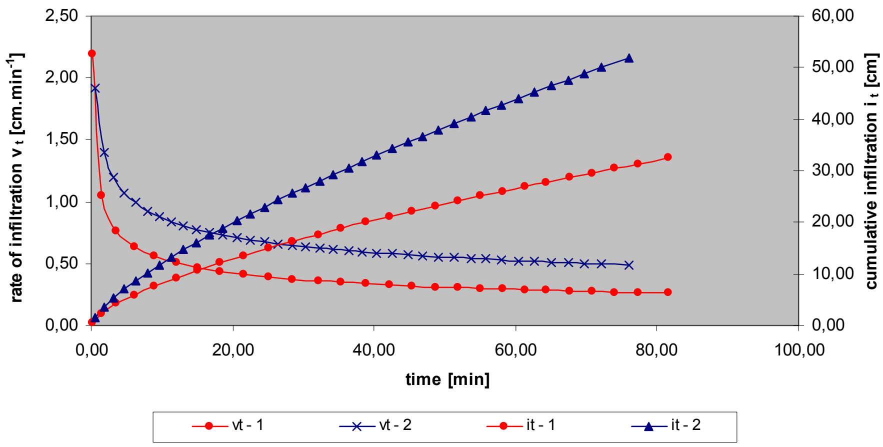
The cumulative infiltration expresses good infiltration capacity of soil in this period. Two measurements are nearly identical and in the 60th minute of measurement the cumulative infiltration ranges about a value of 40 cm. Measurement from the third infiltration series shows lower values of cumulative infiltration and infiltration velocity, which can be caused by the soil profile heterogeneity, i.e. air closed in pores, obstructions in the way of infiltrating water and other effects. In spite of the high initial soil moisture at this measurement, effects of a closed full-grown stand and good root penetration of the soil profile and soil volume weight showing no marks of harmful compaction participated in the good cumulative infiltration and infiltration rate.



3: *Dependence of the rate of infiltration and cumulative infiltration on time, June 8, 2010*



4: *Dependence of the rate of infiltration and cumulative infiltration on time, July 8, 2010*



5: *Dependence of the rate of infiltration and cumulative infiltration on time, August 26, 2010*

As compared to previous measurements from June 8, 2010, the soil shows lower infiltration capacity. The reason of this condition is the actual soil moisture caused by the longest period without precipitation before the day of measurement. At two repetitions values of cumulative infiltration in the 60th minute occur under the limit of 30 cm. One repetition shows higher values of cumulative infiltration and higher velocity as compared with other repetitions. This deviation can be caused by the soil profile heterogeneity, in this case by preference ways (cracks in the dried soil profile, corridors of soul animals – voles, mice), which enable water to penetrate into the soil profile fast and easily.

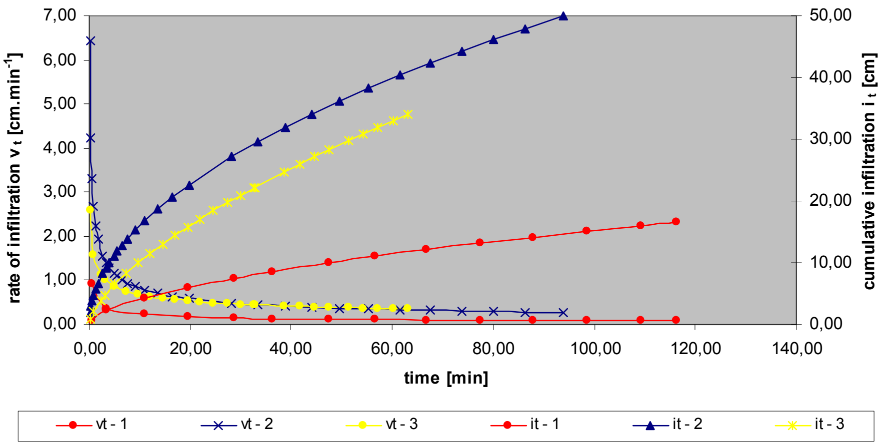
At that day, one repetition was cancelled from technical reasons. Two repetitions, which were performed, significantly differed. Variance in the water infiltration rate and cumulative infiltration is caused by the soil environment heterogeneity. With respect to this fact it is not possible to estimate what measurements are representative and at the same time to determine effects of hydro-physical characteristics of soil on water infiltration. At the first repetition, the cumulative infiltration in the 60th minute of measurement reached a value below 30 cm and the rate of infiltration 0.35 cm.min^{-1}. At the second test, cumulative infiltration exceeded a value of 40 cm and the rate of infiltration was 0.6 cm.min^{-1}.

The second and third repetitions in the day of measurement could be considered as balanced (cumulative infiltration in the 60th minute 40 cm and 33 cm, infiltration rate at both repetitions 0.4 cm.min^{-1}). A difference in the determined value of cumulative infiltration in the 60th minute after the test start amounts to 7 cm. The rate of water infiltration reaches balanced values at these repetitions for the majority of the measurement time. Only at the beginning of measurements, faster infiltration rate was noted at the second experiment. The third repetition markedly differs from the two repetitions. Cumulative infiltration and the rate of water infiltration reach the lowest values determined throughout the growing season (cumulative infiltration – 12 cm, infiltration rate 0,1 cm.min^{-1}). This variation can be caused again by the heterogeneity of the soil profile (stones, air closed in pores).

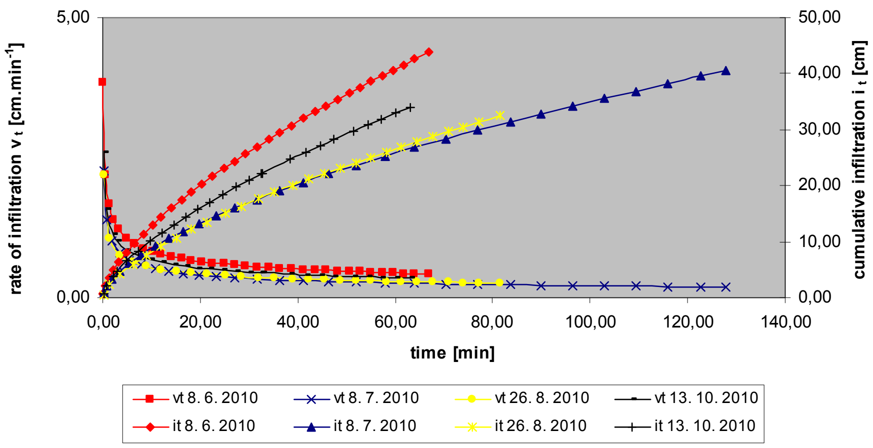
CONCLUSION

The course of the infiltration capacity of soil during the monitored period is illustrated in Figure 7.

The higher infiltration capacity of soil (values of cumulative infiltration and infiltration rate) was noted at the beginning and at the end of the monitored period. In both cases, also roughly the same initial soil moisture was found at all depths.



6: *Dependence of the rate of infiltration and cumulative infiltration on time, October 13, 2010*



7: *Comparison of the dependence of infiltration rate and cumulative infiltration on time throughout the monitored period*

Highest values of cumulative infiltration and infiltration rate were determined in June. The lower infiltration capacity of soil in October as compared to June measurements could be affected by its higher compaction at a depth of 20 and 30 cm caused by the passage of farm machines in connection with the pre-sowing preparation of soil and the subsequent sowing of triticale. The lower infiltration capacity of soil during the growing season was determined in the summer season (July, August). Values of cumulative infiltration and infiltration rate in this season were identical despite several fold different actual soil moisture (July – about 9% vol., August – about 32% vol.). On the other hand, in spite of nearly identical initial soil moisture in June and August measured values show absolutely different infiltration capacity of soil. Effects of a fully closed stand in June as against August after the crop harvest (winter wheat) could participate in this situation. Comparing the infiltration capacity of soil during the monitored period it was possible to find out effects of the developmental stage of a stand and agro-technical measures on the infiltration of water into soil. Considering the complexity and effects of many factors on the course of infiltration it is not possible to trace unambiguous patterns of these factors on the infiltration capacity of soil. Soil is a complex and various system, which changes momentarily. Thus, on the basis of measuring the infiltration capacity of soil in one growing season it is not possible to express definite conclusions.

To express comprehensive and more accurate conclusions, multiyear monitoring will be necessary. Effects of a human factor cannot be even ignored at the realization of actual measurements. Thus, it would be of interest to compare results of the infiltration capacity of soil determined by various methods. In spite of facts mentioned above, problems of monitoring the infiltration capacity of soils show their foundation from the point of view of a possibility to create conditions supporting water infiltration with a subsequent effect to decrease soil loss by water erosion and flood control protection.

SUMMARY

The aim of the presented paper was to map the course of infiltration during the growing season 2010 in the winter wheat stand at a selected locality in the Sazomín cadastral area on the basis of analyses of intact samples and evaluation of hydro-physical properties of soil. In the season April–October, four surveys were realized always with three measurements within each of them.

The land is of slightly steep character and no watercourse occurs in its immediate vicinity. On the land, stubble breaking was carrier out in 2009 as well as the presowing treatment of soil by means of a compactor. In spring 2010, industrial fertilizers ware applied. Ammonium nitrate with limestone and ammonium nitrate with urea were used. After harvest, organic manures, namely semi-liquid manure (slurry) were used in autumn.

Soil at the monitored locality was evaluated as loamy-sandy soil (light) to sandy-loamy (medium-weight) (according to Novák soil-texture classification). The proportion of clay particles (< 0.01 mm) at a depth of 10 cm 23.60%, at 20 cm 21.70% and at 30 cm 13%.

The measurement of infiltration was carried out in the form of an irrigation basin. With respect to statistical significance three sets of concentric cylinders were used with the diameter of an inner cylinder 30 cm. To evaluate field measurements of infiltration empirical relations were used, namely Kostiakov equation.

At the same time, with each of the infiltration measurements taking intact soil samples was carried out for the laboratory determination of physical properties of soil by means of Kopecký cylinders from a depth of 10, 20 and 30 cm and calculation of selected hydro-physical parameters of soil.

Characteristic values of soil samples are given in tables. The course of infiltration rate and cumulative infiltration on the selected land is demonstrated by means of a diagram.

The highest cumulative infiltration and infiltration rate were noted in June at the high actual soil moisture and a fully closed stand. In case of October measurements, effects of agro-technical operations participated in the slightly lower infiltration capacity of soil as compared to June measurements at nearly identical moisture conditions. The lowest infiltration capacity of soil reaching the same level in spite of different moisture conditions and the stand character (July – full-grown stand, August – stubble-field) was determined in July and August.

At the mutual comparison of the infiltration capacity of soil during the monitored period, it was possible to note effects of the stand developmental stage and agro-technical measures on water infiltration at some measurements. Nevertheless, with respect to the complexity and effects of many factors on the course of infiltration it is not possible to trace unambiguous patterns of these factors on the infiltration capacity of soil. Integrated and more accurate conclusions require multiyear monitoring.

Acknowledgements

The study was carried out with the support of Research Project No. MSM6215648905 *Biological and technological aspects of sustainability of controlled ecosystems and their adaptation to climate change* issued by the Ministry of Education of the CR.

REFERENCES

CULEK, M. a kol., 1996: *Biogeografické členění České republiky*. 1. vyd. Praha: Enigma, 347 s. ISBN 80-85368-80-3.

JANDÁK, J. a kol., 2003: *Cvičení z půdoznalství*. Skriptum MZLU v Brně. 1. vyd. Brno, 92 s. ISBN 80-7157-733-2.

KUTÍLEK, M., KURÁŽ, V., CÍSLEROVÁ, M., 1993: *Hydropedologie*. ČVUT v Praze. 1. vyd. Praha, 150 s.

LHOTSKÝ, J. a kol., 1984: *Soustava opatření k zúrodňování zhutněných půd*. Metodika ÚVTIZ 14/1984, Praha, 39 s.

POKORNÝ, E., ŠARAPATKA, B., HEJÁTKOVÁ, K., 2007: *Hodnocení kvality půdy v ekologicky hospodařícím podniku*. Metodická pomůcka. Náměšť nad Oslavou. ZERA, 28 s. ISBN 80-903548-5-8.

QUITT, E., 1971: *Klimatické oblasti Československa*. Brno. ČSAV GEU Brno, Studia geographica, 74 s.

SEDLÁČKOVÁ, R., 2007: Změna fyzikálních vlastností a infiltrační schopnosti půdy v závislosti na použitém systému zpracování [on-line]. [cit. 2011-05-01]. Dostupné na: *http://www.fce.vutbr.cz/veda/JUNIORSTAV2007/Sekce_3/Sedlackova_Radovana_CL.pdf*.

TOLASZ, R. a kol., 2007: *Atlas podnebí Česka*. Praha: Český hydrometeorologický ústav, Olomouc: Univerzita Palackého v Olomouci. 255 s. ISBN 978-80-86690-26-1 (CHMI), 978-80-244-1626-7 (UP).

VALIŠ, S., ŠÁLEK, J., 1976: *Hydropedologické praktikum*. Brno: VUT v Brně. 183 s.

VELEBNÝ, V., NOVÁK, V., 1989: *Hydropedológia*. Bratislava: SVŠT. 145 s.

VESECKÝ, A., PETROVIČ, Š., BRIEDOŇ, V., KARSKÝ, V. [eds.], 1958: *Atlas podnebí Československé republiky*. Praha: Ústřední správa geodézie a kartografie. 92 s.

VIČANOVÁ, M., TOMAN, F., STEJSKAL, B., MAŠÍČEK, T., KNOTEK, J., KOTOVICOVÁ, J., 2010: Rychlost vsaku vody do půdy na vybrané lokalitě v Žabčicích v průběhu vegetační sezony 2008. *Acta universitatis agriculturae et silviculturae Mendelianae Brunensis*. sv. LVIII, č. 5, s. 399–406. ISSN 1211-8516.

Decree No. 327/1998 Coll., defining the characteristics of valued soil ecological units and the procedure for their keeping and updating, as amended by Decree No. 546/2002 Coll.

Maps:

FUSÁN, O., KODYM, O., MATĚJKA, A., 1993: *Geologická mapa České republiky* M 1:1 000 000. Kolín: Český geologický ústav, ISBN 80-7075-145-2.

Geodis, s.r.o.: *Orthophoto map.*

VÚMOP Prague: *map of BPEJ.*

Address

Ing. Tomáš Mašíček, Ph.D., prof. Ing. František Toman, CSc., Ing. Martina Vičanová, Ing. Věra Hubačíková, Ústav aplikované a krajinné ekologie, Mendelova univerzita v Brně, Zemědělská 1, 613 00 Brno, Česká republika e-mail: tomas.masicek@mendelu.cz, tomanf@mendelu.cz, martina.vicanova@mendelu.cz, verah@mendelu.cz