IYDROLOGIC FEATURES OF PERENNIAL FORAGE GRASS AND LEGUME STANDS IN WINTER PERIOD

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The research made on the system of six elementary basins was aimed at observation of alfalfa, perennial ryegrass and common bent grass influence on a surface run - off amount from rain and snow precipitation in winter period. As one of the main indexes was selected portion of surface run-off φ, defined as a ratio between an amount of surface run-off and an amount of causal precipitation. The research proved, that forage grasses and legumes belong to those crops, whose stands are the most prone to creation surface run-off. On the alfalfa stands in a period 1995/1996 does a value = 0.415 on the surface inclination 3%, φ = 0.662 on the surface inclination 8% and φ = 0.702 on the surface inclination 12%; at the same time showed a winter wheat stand the value φ = 0.177 on the surface inclination 8%. In winter period 1998/1999 showed the stand of perennial ryegrass (*Lolium perene*), variety Ahoj value φ = 0.270 on the surface inclination 8%, the stand of common bent grass (*Agrostis tenuis*), variety Bardot the value φ = 0.158. At the same time showed a winter wheat stand the value φ = 0.097 on the surface inclination 12%. On perennial grasses (grassland) stands are an initial run-off intensities high and gradually falls; on winter cereals stands is the reverse situation.

winter surface run-off; snow melting; frozen soil; portion of surface run-off; water infiltration

TRODUCTION

Each hydrologic process in the landscape region has its beginning in in-ractions of precipitation with surface formation of earth lithosphere. Hy-ologically most important formation is soil and plant cover. Thus the soil comes not only a basic factor of agricultural and forest production as well an important hydrologic agent which markedly participates in creation of ater and moisture regime of the landscape. From this point of view it cides upon mutual ratio of infiltration and surface run-off in precipitation n-off action. However, it is not a constant. It changes due to the action of tural and antropic factors.

Of many natural agents which cause deformation on infiltration ability of il in summer season mechanical properties of rains are applied the most, in nter period cryogenic or ice-forming processes in soil.

Antropic factors acting sculpturing on soil permeability represent entire agricultural activity of man on soil. Our research has been aimed at cryogenic processes taking place in soil of sites of perennial forage crops and deformation of soil permeability which induce these processes.

The aim of the research was to know regularities of origin and course of surface run-offs on sites of alfalfa, perennial ryegrass and common bent grass in winter period. The research followed the previous studies of the authors (Kasprzak, 1972, 1975) as well as the latest studies of foreign authors, particularly Stähli (1997), Johnsson (1991), Gusev (1989), Kane (1980) and others.

MATERIAL AND METHOD

Research was carried out in the system of elementary basins established in 1965 in the cadastr of the village Kníničky near Brno. Ther research object is situated at an altitude 214 m above sea level and consists of six rectangular run-off areas of the size 5 x 4 m, arranged in three pairs, registered under the letters A, B, C, differing by inclination of the surface (I_A = 8%, I_B = 3%, I_C = 12%); soils are loamy, southern exposure. Run-off areas are equipped with an apparatus for measurement of surface run-offs from precipitation. A part of the system is a meteorological station.

Measurement carried out in winter period of 1994/1995 studied the sizes of surface run-offs induced by snow melting or rain on the alfalfa sites, cultivated in the whole system of elementary basins in the second cropping year.

The aim of the measurements performed in winter period of 1995/1996 were surface run-offs from the alfalfa stands cultivated in the third cropping year and for comparison also from the winter wheat stands (A2).

Measurements carried out in winter period of 1998/1999 studied the amounts of surface run-offs of perennial ryegrass, the variety Ahoj (A1 and common bent grass, the variety Bardot (A2) cultivated in the second cropping year; measurements were also carried out on the winter wheat (C2) site for comparison.

As one of the main indicators of the rate of run-off capacity of sites the coefficient of surface run-off defined as a ratio of sum of run-offs to sum of precipitation fallen down on the site for winter period, i.e. November to February or March, including, resp.: $\varphi = H_o/H_s$, where H_o means the sum (height) of water run-off from soil surface H_s – sum (height) of precipitation.

In evaluations of the rate of inclination of sites to formation of surface run-offs values of partial coefficients of surface run-offs φ_o were used, evaluated always after the period of persistence of one snow cover: $\varphi_o = \Sigma H_s - \Sigma E_d$, where E_d – sum of daily evaporation from snow cover (E_d = 0.21 – 0.45 mm.d^{-1}).

Infiltration coefficient into frozen soil or infiltration soil capacity I_p = %, resp.; the following relations may be applied here: $\varphi_i = 1 - \varphi_o$; $I_p = 100\ (1 - \varphi_o)$.

Intensity of surface run-off i_o = mm.h^{-1} in the time interval Δt = minutes for volume of run-off V_o = litres was determined from the relationship: $i_o = 3.077\ V_o/\Delta t$ (valid for the given run-off area).

RESULTS

In winter period 1994/1995 whole-season surface run-off coefficient on alfalfa site with surface inclination 3% had the value φ_B = 0.207, with inclination 8% – the value φ_A = 0.261 and with inclination 12% had the value φ_C = 0.289.

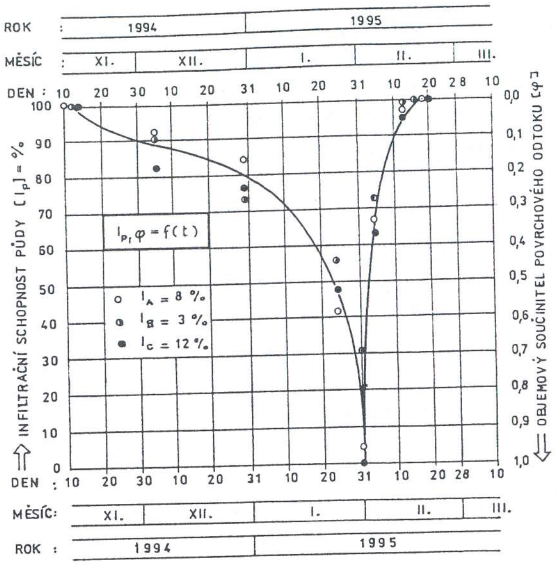
Maximum values of partial run-offs in the terminal period of melting (30 January to 5 February 1995) on the alfalfa sites with surface inclination 3% amounted to φ_o = 0.696, with inclination 8% amounted to φ_o = 0.944 and with inclination 12% amounted to φ_o = 1.007.

Immediate maximum values of run-off coefficients were reached at the combination of snow melting and precipitation (29 January 1995), that are max. φ_B = 0.907, max. φ_A = 1.178 and max. φ_C = 1.110. It is remarkable that on this day and later destructive floods were in the whole Central and Western Europe. Hundreds of thousands inhabitants were evacuated, some casualties were too. A valuable benefit obtained from the processed measurements is an information on time course of cryogenic deformation of infiltration soil capacity (Fig. 1).

To compare the production and course of surface run-offs on compacted soils (alfalfa) and semi-light (winter wheat), the area A2 was loosened in autumn 1995 and sown with wheat. Results processed in graphs related to run-off measurements in winter season 1995/1996 are presented in Figs. 2 and 3. The whole-season coefficient values of coefficients of surface run-off of these maximum values were as follows: φ_B = 0.415, φ_A = 0.622, and φ_C = 0.702. On the winter wheat stand the maximum value φ_C = 0.177, what is 3.74 times lower than on the alfalfa stand with identical surface inclination and exposure.

On the alfalfa stands partial coefficient of surface run-off of these maximum values were as follows: φ_B = 0.699, φ_A = 0.959, and φ_C = 0.992. On the winter wheat maximum value of partial coefficient of run-off was only φ_A = 0.366.

In winter season 1998/1999 production and course of surface run-offs on grasslands and perennial ryegrass (variety Ahoj) and common bent grass (variety Bardot), as well as on winter wheat (C2) were studied. Graphically plotted results of run-off measurements are presented in Figs. 4 and 5. Survey



1. Time course of cryogenic deformation of infiltration capacity of soil with alfalfa stand cultivated on slopes with inclination $I_A = 8\%$, $I_B = 3\%$ and $I_C = 12\%$

rok = year, měsíc = month, den = day, infiltrační schopnost půdy = infiltration capacity of soil, objemový součinitel povrchového odtoku = volume coefficient of surface run-off

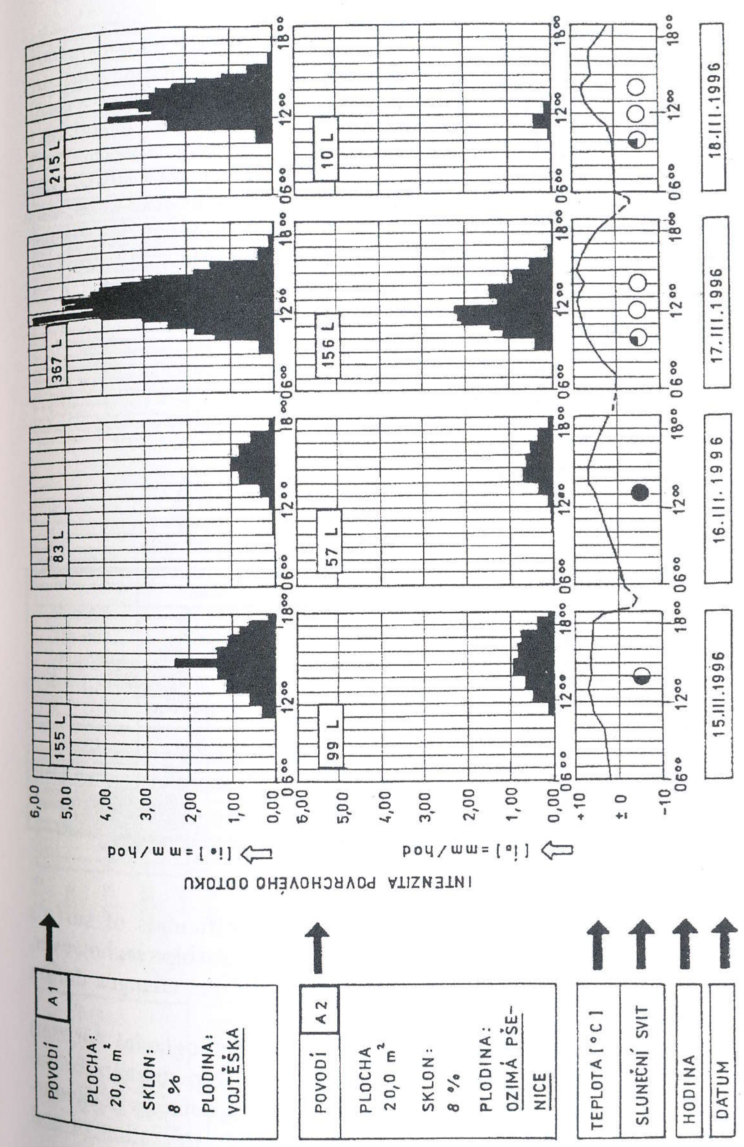
of the coefficient values of surface run-offs and the rate of run-off capacity of sites are given in Table I.

Table II presents average values of amount of root and above-ground biomass of perennial ryegrass and common bent grass from measurements carried out from six monoliths in each species according to Fiala (in Rychnovská, 1987).

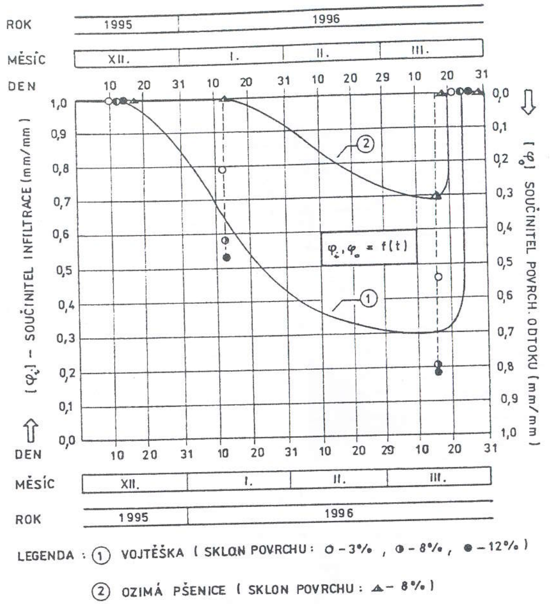
DISCUSSION

The research proved that perennial grasses and clover crops belong to those crops whose sites are most sensitive to formation of surface-run-offs in winter, and then particularly in pre-spring period. Some grasses, e.g. common bent grass (variety Bardot), however, may reduce surface run-offs.

The reasons of the differences found among presented grasses (ryegrass and bent grass) may consist in different stratification and production of above-ground phytomass (stubble) as reported by Straková et al. (1999). By specific peculiarities of common bent grass Bardot are confirmed the results of our previous research and resistance of root system against fluvial erosion on slopes (Vítek, Hrabě et al., 1983). It follows from the results of Table II that increased run-offs on the perennial ryegrass stand are not caused by smaller root phytomass. It should be necessary to continue in



2. Daily amount of surface run-off and course of intensities of run-offs from melting snow on the alfalfa stand (A1) and winter wheat (A2)
povodí = water basin, plocha = area, sklon = inclination, plodina = crop, vojtěška = alfalfa, ozimá pšenice = winter wheat, teplota = temperature, sluneční svit = sunshine, hodina = hour, datum = date, intenzita povrchového odtoku = intensity of surface run-off



3. Time course of cryogenic infiltration capacity of soil on alfalfa and winter wheat stands

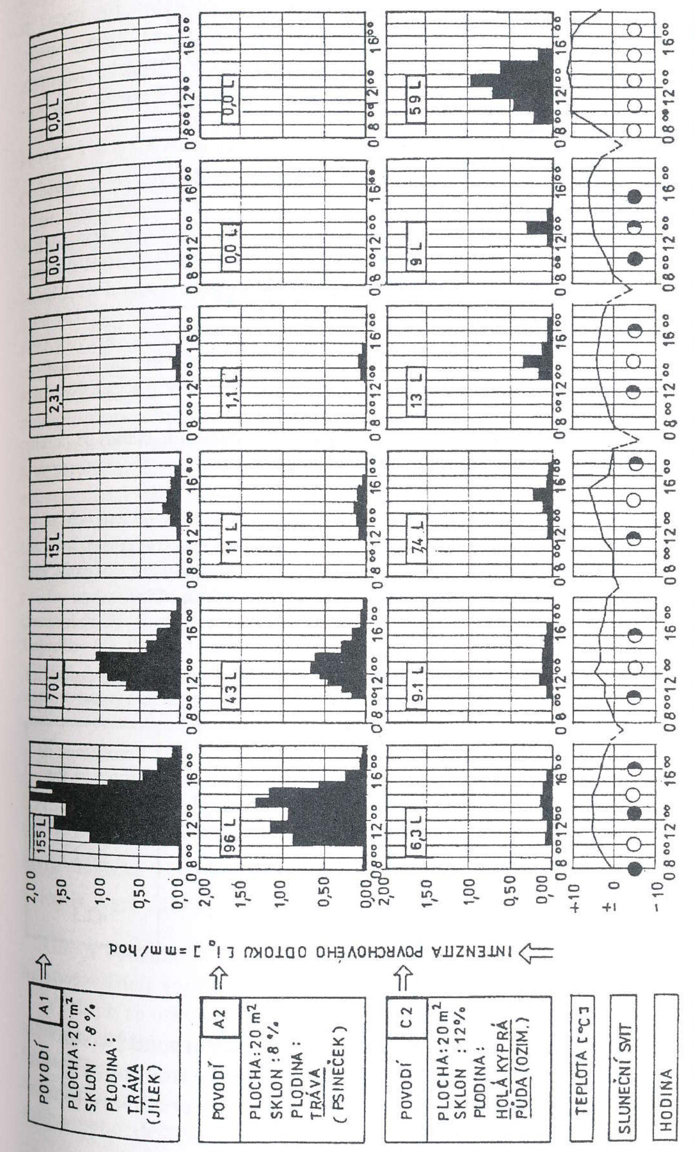
součinitel infiltrace = infiltration coefficient, součinitel povrchového odtoku = coefficient of surface run-off, rok = year, měsíc = month, den = day, vojtěška = alfalfa, ozimá pšenice = winter wheat, sklon povrchu = surface inclination

I. Survey of coefficients of surface run-offs and rate of run-off capacity of sites.

Crop	River basin	Surface inclination	Run-off coefficient: winter period (1. XI.– 28. II. 1999)	Run-off coefficient: main melting (7. II. – 27. II. 1999)	Rate of run-off capacity (m_0) = %
Perennial ryegrass	A 1	8 %	0.270	0.936	100.0
Common bent grass	A 2	8 %	0.158	0.584	62.4
Winter wheat	C 2	12 %	0.010	0.287	30.7

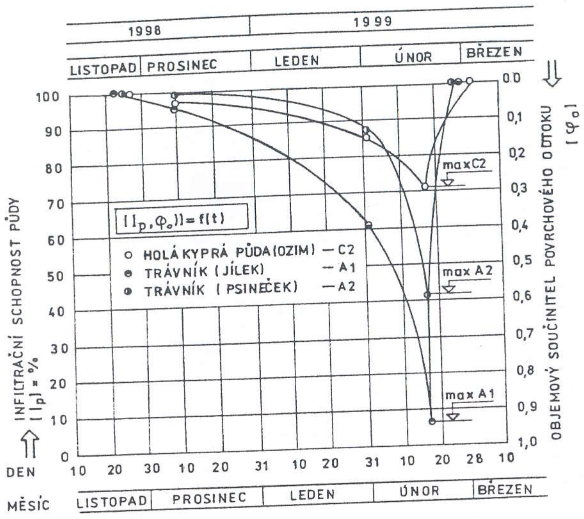
searching for reasons of great differences between coefficients of surface run-offs in the given grasses. The research of these relationships is, however, conducted in critical year periods, because dynamics of the changes during the year is marked.

Run-off capacity impermeable layer of frozen soil (pedoglacial horizon) appears easier on grassed soil than on soils which were prepared agrotechnically in autumn (winter cereals after tillage). The reason consists in favourable properties of grassed soils allowing thermocapillary migration of soil



4. Daily amount of surface run-off and course of intensities of run-offs from melting snow on the stand of perennial ryegrass (A1), common bent grass (A2) and winter wheat (C2)

povodí = water basin, plocha = area, sklon = inclination, plodina = crop, tráva (jílek) = grass (ryegrass), tráva (psineček) = grass (bent grass), holá kyprá půda (ozim) = bare loose soil (winter crop), teplota = temperature, sluneční svit = sunshine, hodina = hour, datum = date



5. Time course of cryogenic deformation of infiltration capacity of soil on the stands of perennial ryegrass stands (A1), common bent grass (A2) and winter wheat

listopad = November, prosinec = December, leden = January, únor = February, březen = March, holá kyprá půda (ozim) = bare loose soil (winter crop), trávník (jílek) = grass (ryegrass), trávník (psineček) = grass (bent grass), infiltrační schopnost půdy = infiltration capacity of soil, objemový součinitel povrchového odtoku = volume coefficient of surface run-off

II. The total amount of root biomass and its stratification in common bent grass and perennial ryegrass in model river basins at Kniničky (March 1999)

Grass species, variety	Root biomass weight (t. ha^{-1})			Percentage of roots in the layer 2–20 cm
	0–2 cm including stubble	2–20 cm	0–20 cm	
Common bent grass, variety Bardot	4.82	2.96	7.78	38.1
Perennial ryegrass, variety Ahoj	5.97	4.37	10.34	42.3

water to frost-penetrated surface layer, soil shading, grown around by stubble and reducing action of solar radiation on soil surface during melting. For the same reasons soils of grasslands defreeze into the depth slower and are longer ready for formation of surface run-offs.

Melting of snow cover takes place in sites with stands of perennial forage crops faster than in sites with other crops. It is caused by the fact that snow cover remains in the grassland „hanged on", what allows approach of heat to it from all sides. Moreover, snow is melting very fast in close vicinity of grass stems which penetrate snow cover over its surface. An information that amount of surface run-offs grows proportionally with surface inclination of the site is very important.

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Hydrologické vlastnosti stanovišť víceletých pícnin v zimním období.

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Cílem výzkumu bylo poznání zákonitosti vzniku a průběhu povrchových odtoků na stanovištích vojtěšky seté, jílku vytrvalého a psinečku tenkého v zimním období. Výzkum se uskutečnil na soustavě elementárních povodí v katastru obce Kníničky u Brna. Objekt se skládá ze tří dvojic obdélníkových odtokových ploch 5 x 4 m, lišících se vzájemně sklonem povrchu (3, 8 a 12 %). Měření uskutečněná v zimním období roku 1994/1995 sledovala velikosti povrchových odtoků vyvolaných táním sněhu nebo deštěm na stanovištích vojtěšky. Předmětem měření uskutečněných

v zimním období 1995/1996 byly povrchové odtoky ze stanovišť vojtěšky a pro srovnání také ze stanovišť ozimé pšenice. Měření uskutečněná v zimním období 1998/1999 sledovala velikosti povrchových odtoků na stanovišti jílku vytrvalého a psinečku tenkého; pro porovnání byla měření uskutečněna rovněž na stanovišti ozimé pšenice.

Jako jeden z hlavních ukazatelů míry odtokotvornosti stanovišť byl zvolen součinitel povrchového odtoku φ definovaný jako poměr úhrnu odtoků k úhrnu srážek, spadlých na stanoviště za zimní období, tj. listopad až únor, resp. březen včetně: $\varphi = V_o / V_s$, kde: V_o – objem povrchově odteklé vody, V_s – objem srážkové vody spadlé na stanoviště.

Při hodnocení míry náchylnosti stanovišť k tvorbě povrchových odtoků bylo použito hodnot parciálních součinitelů povrchových odtoků φ_o, vyhodnocených vždy pro období trvání jedné sněhové pokrývky: $\varphi_o = \Sigma H_o / \Sigma H_s - \Sigma E_d$, kde E_d – úhrn denního výparu ze sněhové pokrývky ($E_d = 0{,}21 \div 0{,}45$ mm.d^{-1}).

V zimním období 1994/1995 měl celosezonní součinitel povrchového odtoku na stanovišti vojtěšky hodnotu φ = 0,207–0,289.

Maximální hodnoty parciálních odtoků ve vrcholném období tání (30. 1. až 5. 2. 1995) na stanovištích vojtěšky činily φ_o = 0,696–1,007. Časový průběh kryogenní deformace infiltrační schopnosti půdy je znázorněn na obr. 1. Okamžitých maximálních hodnot odtokových součinitelů bylo dosaženo při kombinaci tání sněhu a deště (29. 1. 1995), a to max. φ_B = 0,907–1,178. Graficky zpracované výsledky odtokových měření v zimním období 1995/1996 prezentují obr. 2 a 3. Celosezonní hodnoty součinitelů povrchových odtoků na stanovištích vojtěšky byly φ = 0,415–0,702. Na stanovišti ozimé pšenice byla hodnota φ_A = 0,177, tedy 3,74krát menší než na stanovišti vojtěšky se stejným sklonem povrchu a expozicí. Ze zimního období 1998/1999 jsou graficky zpracované povrchové odtoky znázorněny na obr. 4 a 5. Přehled hodnot součinitelů povrchových odtoků a míry odtokotvornosti stanovišť je uveden v tab. I, stratifikaci kořenové biomasy a její celkové množství u sledovaných trav ukazuje tab. II.

Výzkum prokázal, že víceleté trávy a jeteloviny patří k plodinám, jejichž stanoviště jsou nejvíce náchylná k tvorbě povrchových odtoků v zimním a zejména pak v předjarním období. Odtokotvorná nepropustná vrstva zledovatělé půdy (pedoglaciální horizont) vzniká na zatravněných půdách snadněji než na půdách, které byly na podzim agrotechnicky připraveny (ozimé obiloviny po orbě). Také tání sněhové pokrývky probíhá na stanovištích s porosty víceletých pícnin rychleji než na stanovištích jiných plodin.

zimní povrchový odtok; tání sněhu; pedoglaciální horizont; součinitel povrchového odtoku

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