ERODIBILITY OF SOIL BY WIND IN THE REGION OF CENTRAL EUROPE

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Abstract
The region of South Moravia (south east Czech Republic) is the area most threatened by wind erosion in the Czech Republic. A field experiment to investigate wind erosion was established in 2002 near Zabcice village, 25 km south from Brno. The field experiment was conducted on agricultural farm land that belongs to the Mendel University of Agriculture and Forestry Brno. The soil wind erodibility was studied from March to November 2002. The field experiment was based on the wind speed measurements in the ground layer of the atmosphere, on the soil samples analyses to assess surface humidity, and on the laboratory analyses to determinate soil structure and content of non-erodable particles in the soil. The experimental locality is mostly threatened by wind erosion in the springtime, when the measured loss of soil by wind was 22 kg/ha. Each of the other study months had soil losses of less than 14 kg/ha which is the maximal tolerable amount of soil loss for the Czech Republic conditions.

Additional Keywords: erosion, non-erodable particles, relative moisture, wind velocity

Introduction
In all regions of Czech Republic the unification of land into large fields resulted in a spreading of erosion in the past and the consequences of it appear up to date. Wind erosion potentially threatens 28,8 % of agricultural soil in Czech Republic. Topically serious problem is then approximately 10 % of agricultural soil. Wind erosion occurs mainly in those areas where is a lack of precipitation together with predominantly high temperatures, and the occurrence of light soil sorts, such as sandy soils. In Czech Republic, the most threatened area by wind erosion is the area of South Moravia (the southeast of the CR).

Materials and Methods
Environmental factors, which cause wind erosion (mutual action of soil structure determined by the proportions of non-erodable soil particles, soil moisture determined by relative moisture, and wind velocity on the soil surface), express the threat of soil by wind erosion that is also known as erodibility. The erodibility is not static, it changes according to the soil humidity. Pasak's equation (1970) (1) can be used for the calculation of soil erodibility by wind:

$$E = 22{,}02 - 0{,}72P - 1{,}69V + 2{,}64R, \quad (1)$$

where E = erodibility (g/m^2), P = content of non-erodable particles in the soil (%), V = relative soil moisture (%), R = wind velocity on soil surface (m/s).

The maximum permissible quantity of carried off soil is the average of material carried away in the case of a 60 percent proportion of particles larger than 0,84 mm, i.e. of non-erodable particles (Chepil *et al.* 1964). According to Pasak (1970), the permissible quantity of carried off material, i.e. the index of erodibility 1, equals the average potential wind erosion of 1,4 g/m^2, i.e. 14 kg/ha. However, also this loss of soil is dangerous if we consider the fact that the forming of a soil layer of from 0,5 to 2,0 cm requires in nature almost 100 years.

Field Sites
The field experiment run at the land of the agricultural farm in Zabcice that belongs to the Mendel University of Agriculture and Forestry Brno. Zabcice village is situated 25 km south from Brno, South Moravia (latitude 49° 01´ N., longitude 16° 37´ E., elevation 179 m above the see).

Heavy alluvium forms lands along the river Svratka, which the experimental field is located on. The soils of the experimental field could be classified as gley fluvial soils on the alluvial carbonateless sediments – heavy, deep soils. The arable soils are neutral to slightly acid, poor in humus.

The study field belongs to the area influenced of pannonic climate, which is distinguished predominantly at continental climate of east Europe and effect of Atlantic Ocean. Warm, dry summers and cold winters with snow

are mainly characterized for this region. The average annual temperature for the study area is 9,3 °C, the annual sum of precipitation is 450-550 mm. Wind that causes large evaporation of the soil moisture, increases drought of the climate. Precipitation of the vegetative period is spread out very irregularly (Roznovsky and Svoboda 1995).

Analysis
The proportion of particles larger than 0,8 mm in dry soil can be considered to be a decisive criterion for the estimation of the potential erodibility of soil by wind. The amount of non-erodable soil particles could be found out by the aggregate analysis, by the sifting of the average dry soil sample from the soil surface through a sieve with meshes of 0,8 mm. The content of non-erodable particles in the soil P (percentage) could be calculated from the equation (2) (Pasak 1970):

$$P = \frac{p}{c} \times 100 \text{ , (2)}$$

where p = weight of the soil sample after its sieving through the sieve with meshes of 0,8 mm (g), c = weight of the dry soil sample before the sieving (g).

The relative soil moisture was calculated as the quotient of momentary soil moisture and non-available water. The non-available water was determined from the content of the 1st category of grains by division by 2,4 (3), (4) (Pasak 1970):

$$V = \frac{V_O}{Vn} \text{ , (3)}$$

$$Vn = \frac{o}{2{,}4} \text{ , (4)}$$

where V = relative soil moisture (%), V_O = momentary soil moisture (%), V_n = non-available water (%), o = content of the 1st category of grains (%).

The sampling of the soil for the determination of the momentary soil moisture was done in regular time intervals from March to November 2002. For the detection of the soil moisture a gravimetric method was used. The soil samples were taken from the flat smooth surface without the vegetation and its rests. The content of the 1st category of grains (clay particles, grains smaller than 0,01 mm) was determined by a particle-size analysis of the soil, by the pipette method (Jandak 1989).

The wind velocity was measured by Low Power Anemometer A100L2 by British Campbell Scientific at the meteorological station Zabcice on the soil surface. The anemometer measured the wind speed 20 cm above the ground without vegetation, lower position was not possible, because of the body of the anemometer (position of the rotor is 20 cm above the ground).

Results and Discussion
The proportion of non-erodable particles in the soil of the experimental area is 43,33 % (average of three measurements). According to Pasak (1970), the proportion of particles larger than 0,8 mm in dry soil can be considered to be a decisive criterion for the estimation of the potential erodibility of soil by wind. Soils with the content of non-erodable particles more than 60 % are taken as soils that do not erode.

For the determination of the relative soil moisture it was necessary to know the momentary soil moisture and the content of the 1st category of soil grains. The momentary moisture of the soil surface without vegetation was regularly monitored once a week from March to November 2002 by the gravimetric method. The lowest momentary soil moisture 2,1 % was registered on 4.4.2002, on the contrary the highest 16,7 % on 21.3.2002. The content of the 1st category of grains was determined by a particle-size analysis of the soil, by the pipette method. In the soil sample there was found out 43,1 % of the grains smaller than 0,01 mm. The content of the non-available water was calculated after inserting of above mentioned into the equation (4). The relative soil moisture range from 0,1 to 0,9 %, when the lowest value was registered on two days 4.4. and 6.6.2002, the highest on 21.3.2002.

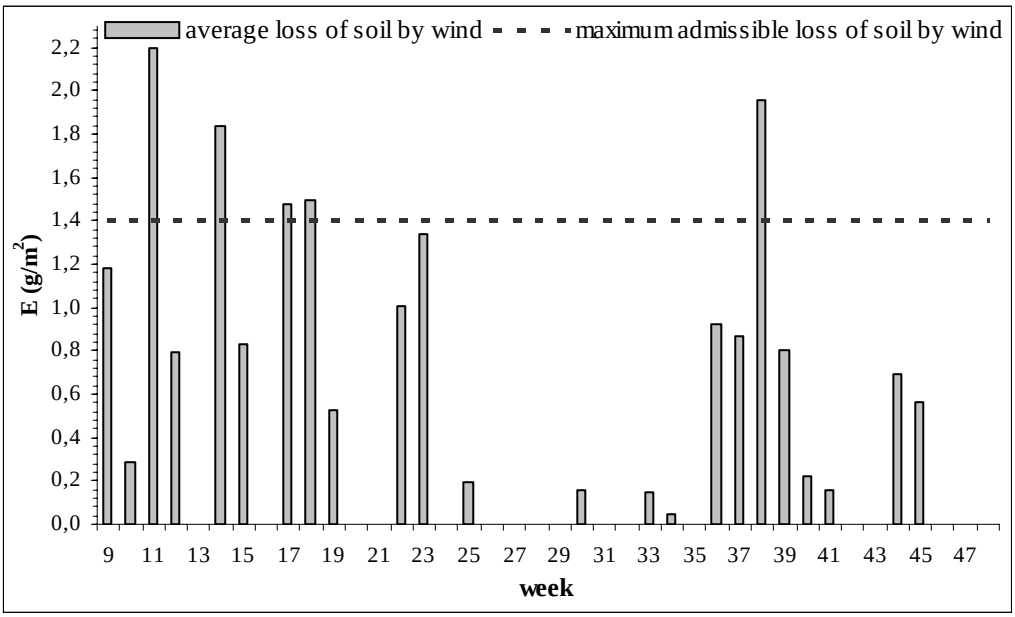

Figure 1. Maximum loss of soil by wind in the individual weeks of the period March-November 2002

The wind velocity of the experimental area was measured continuously from March to December 2002. The anemometer was connected in the analogue way and it recorded the quarter of an hour averages of wind speed of the ground layer of the air – 20 cm above the ground. The highest wind speed was measured in the eleventh week of the year 2002, when also the highest loss of the soil by wind was registered – 22 kg/ha.

The erodibility of soil by wind was monitored during days, when the sampling of the soil for the determination of the soil moisture was done. Momentary erodibility of soil by wind was probed. When the average daily wind speed was inserted to the equation of the erodibility (1), almost any loss of soil by wind was not found out. Therefore maximum daily wind speed was calculated with. The maximum loss of soil by wind in chosen days of the year 2002, it means, at these days, when the soil moisture was measured, is 0,4 g/m^2. According to Pasak *et al.* (1983), this amount of soil loss is inconsiderable. The maximum permissible quantity of carried off material is, for the conditions of Czech Republic, 1,4 g/m^2, and any day does not reach this level.

Table 1. Erodibility of soil by wind during 2002

Month	E (g/m^2)
March	2,2
April	1,8
May	1,5
June	1,3
July	0,2
August	0,1
September	2,0
October	0,2
November	0,7
Average	1,1
Minimum	0,1
Maximum	2,2

When the soil erodibility by wind in the individual weeks of the period March-November 2002 was calculated, with inserting of maximum weekly wind speed, maximum loss of soil by wind was 2,2 g/m^2, i.e. 22 kg/ha, in the eleventh week of the year 2002. Figure 1 shows the quantity of soil loss by wind in the weeks of the year 2002 in comparison with the maximum permissible one. Its value is exceeded altogether five times, four times in spring and once in autumn.

Table 1 shows average values of soil erodibility by wind of each month of the monitored period. According to the table, the most endangered soil is in March, April, and also September, when the values of erodibility are higher then the maximum permissible one. All the other study months do not show greater soil losses. Occurrence of wind erosion was registered mainly at places, where the soil is without vegetation or where the vegetation is weakly developed. 90 % of wind erosion arises at the cultivated soil (Chepil *et al.* 1964).

Conclusions

It follows from the general assessment of the erodibility of soil by wind in the cadastral area Zabcice that the experimental locality is endangered by wind erosion first of all in spring. Cultivated crops in early stage of growth are not sufficient protection of soil against erosion, there is a danger of injury of their stalks by saltation of soil particles or by exposure of roots of young plants. More considerable loss of soil was not found out in other study months.

Erosion is a nature phenomenon, whose unfavorable effect causes harm especially in the case of a combination of certain conditions. The method of anti-erosion protection must concentrate above all on a preventive elimination of removable causes, it must know the qualitatively differing forms of erosion and their quantitative spreading.

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