ASPECTS OF SPRINKLING IRRIGATION ON SLOPES

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Abstract

Irrigation-induced erosion is one of the most serious sustainability issues in agriculture, impacting not only the future strategic and commercial viability of irrigation agriculture, but also the survival and comfort of earth's human population. Preventing irrigation-induced erosion to maintain high crop yields and the quality advantages of irrigated agriculture is also a key to the preservation of natural ecosystems. The paper presents some results of experimental research having the aim to determine the intensity and admissible duration of water application, and the maximum no erosive irrigation depth. The research was carried out within the experimental field and laboratory study. The values of irrigation depth and the maximum admissible intensity, leading to a decline in soil erosion from sprinkler irrigation was determined.

Key words: (Sprinkler irrigation, erosion, slope land)

Irrigation of agricultural land, in addition to the many advantages determines - in terms of design or improper operation - and negative effects on the environment. Worldwide, the total area landscaped, 100 million hectares are affected or present danger of being affected by salinization processes, excess moisture, and erosion. The occurrence of these phenomena leads to reduced soil fertility landscaped perimeters and even their total degradation when appropriate measures are taken (ICID - CIID, 1999).

The future development of irrigated agriculture will be limited water and land crisis, environmental degradation, degradation of existing facilities, inadequate management.

Erosion caused by an obstacle in the expansion of irrigation and drainage facilities on slopes by worsening physical and hydro by reducing the content of humus, nitrogen and phosphorus, increasing soil carbon content. Harvests eroded land with distant horizon, are drastically reduced (Ailincăi C. *et al.* 2009).

In Romania, the studies of ICPA on the principle of ameliorative mapping both land prepared by the end of 1982 (2.38 million ha) and the rest up to 3.12 million ha were to be furnished to the end 1989 indicates a weight of approx. 15% erodability potentially land under irrigation conditions.

Irrigation erosion is influenced by natural factors (slope, texture, stability fluid) and anthropogenic (technical elements of watering). Intensity is stronger erosion by runoff and watering it, it decreases from the first to the last watering. In the U.S., it is estimated that soil loss from furrow irrigation can reach from 2-20 $t \cdot acre^{-1}$ and year, very high compared to allowable losses that are 5 $t \cdot acre^{-1}$ and year (Sojka R. *et al.* 1996). In these circumstances, the 90-100 years of irrigation of these lands, now many areas totally or partially lost horizon A.

The negative effects of soil losses are manifold. Horizon underlying horizon of most soils suffer a degradation of physico - chemical, easily compacted form crust deficient phosphorus and micronutrients. All these negative influences soil fertility, plant growth and ultimately crop production.

Costs related to agricultural activity increases, the benefits fall, questioning the very opportunity irrigation.

Eroded soil is deposited in the lowlands, clogged waterways, fishing facilities and reservoirs. Once the soil leachates and are large quantities of chemical fertilizers and pesticides, the negative environmental impact, causing eutrophication of surface water sources and groundwater pollution.

To eliminate these drawbacks, the arrangement of sloping lands for irrigation, must be taken into account a number of principles concerning the organization of the territory erosion related to reducing water losses and soil, increasing

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soil fertility, increase agricultural production, reduce operating costs (Bucur D. *et al.* 2006).

Spatial hydro sloping land is a complex problem whose solution requires accurate agreeing the principles of conservation of soil quality through specific works to prevent erosion, intensive agricultural exploitation of these areas (irrigation, chemical treatment, and mechanization), and mining may have a negative impact on the environment. Resolving this contradiction is only possible through a proper approach to all aspects of design, construction and operation of these facilities.

MATERIAL AND METHOD

The source data used for the study are from field experiments, carried out in region of the Moldavian Plateau and also laboratory studies.

Land with slope 5-17% was irrigated to determine irrigation technical elements.

The irrigation equipment type hand move was positioned following the direction of the level curves. For sprinkler irrigation different schemes were used with sprinkler type and 6, 7, 7.5, 8 and 9 mm nozzles dimension.

Field crops at different stages of vegetative, soil protection from erosion are studied. Soil type semi-mould is leached with medium texture characterized by a steady rate of infiltration medium of approx. 12.3mm / h.

Runoff recorded for different size of the sprinkler nozzle and the operating pressure was measured in the field. Laboratory studies have led to the establishment spray drop kinetic energy from irrigation sprinklers. The connections presented to estimate drop energy can be used to help select the most suitable type of sprinkler for particular climate, soil, and crop conditions.

If the sprinkler application rate exceeds the intake rate of the soil, runoff will occur. The sprinkler application rate is influenced by the discharge rate of the sprinkler heads and the sprinkler spacing. Reducing the sprinkler head discharge rate or increasing the distance between sprinkler heads decreases the application rate. Runoff rate can also be higher in sprinkler systems with poor irrigation uniformity.

Using statistics processing, the influence of the ground slope and the degree of crop canopy on the maximum admissible intensity was determined.

The sprinkler's application rate is a feature of every type of sprinkler, and it can vary depending on the operating pressure, the size of the sprinkler nozzle and the watering scheme. Not creating a correlation between the intensity and the intake rate of the soil, is the main cause which can trigger the processes of erosion on the sloping land.

Emerging of the runoffs can be determined – for a certain application rate – by the drop's kinetic energy and in a small manner by the stable intake rate of the soil.

The spraydrop kinetic energy and their impact on the soil were estimated using the formulas proposed by Kinkaid D. C. (1996):

$$E_k = e_0 + e_1 k_p \qquad (1)$$

where:

E_k – the total energy per kg. of sprinkled water (J/kg);

e_0, e_1 – the coefficients depending on the type of the sprinkler;

k_p = d/H – the fineness index;

d – the diameter of the nozzle (mm);

H – the nozzle's pressure head (mcA).

The kinetic energy has the following value:

$$E_K = 2.79 + 7.2 d_{50} \quad \text{(J/kg)} \qquad (2)$$

where:

d_{50} – the average diameter of the sprinkled water drops

The rate of the drops of which diameter is lower than d, from the total distributed volume of the sprinkler can be determined using the next formula, proposed by J. Li şi R. Kawanok (1994):

$$Pv = \left[1 - e^{-0.693\left(\frac{d}{d_{50}}\right)^n}\right]100\ (\%) \qquad (3)$$

where:

$$d_{50} = a_d + b_d(d/H) \qquad d(\text{mm}); \qquad (4)$$

$$n = a_n + b_n(d/H) \qquad H(\text{m}). \qquad (5)$$

RESULTS AND DISCUSSION

After analysing the functional features of the sprinklers which are contained by the irrigation systems around the country, using the formulas, we obtained the next values:

e0 = 6.50; e1 = 71.60;

ad = 0.31; bd = 11.90;

an= 1.82; n = 3.00;

Using the above-mentioned formulas, we determined the average diameter of the drops, the distribution rate, and the kinetic energy of the sprinkled rain, depending on the fineness index k_p.

In the following tables and figures we will present our obtained values.

Table 1

Average diameter of the drops depending on the fineness index k_p

k_p	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60
d_{50} (mm)	1.5	1.6	1.8	1.9	2.0	2.1	3.0	3.2	3.3	3.5	3.6

Table 2

The rate of the drops which diameter is lower than „d"

depending on the fineness index k_p

k_p = 0.10									
d (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	
P_v (%)	6.2	24.2	48.1	70.0	85.6	98.1	99.4	99.9	
k_p = 0.20									
d (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	
P_v (%)	3.16	15.8	36.7	60.1	79.3	91.3	97.1	99.2	
k_p = 0.30									
d (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
P_v (%)	1.54	9.73	26.5	49.1	70.9	86.9	95.4	98.8	99.8
k_p = 0.40									
d (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
P_v (%)	0.7	5.7	18.2	38.1	60.9	80.4	92.5	97.9	99.6
k_p = 0.50									
d (mm)	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5
P_v (%)	0.3	3.3	11.9	28.1	50.0	71.9	87.9	96.3	99.2

Knowing the distribution of the drops grouped by sizes like the average diameter of the drops d_{50}, it is possible to determine the kinetic energy of the rain for a type of sprinkler and the used watering scheme, and so we can estimate the effect of application rate on the intake rate, implicitly on the runoff process (*figure 1*).

The observations we made during the research, are showing us that for the cambic chernozem with loam – clay texture type of soil, the value of the kinetic energy from which the sudden decrease of the intake rate of the soil is about 500 J/m^2.

Processing the experimental data regarding the size of the runoffs on various slopes and application rates, have led to obtaining some equations of power type between application rates I_{adm} (mm/h) and the slope of the land i(%) depending on the fineness index k_p (*figure 2*):

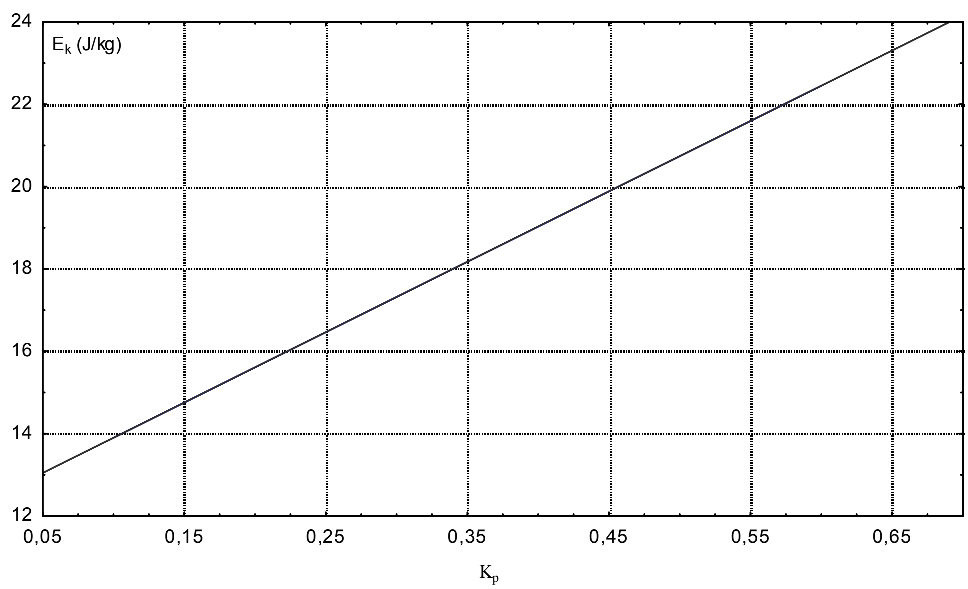

Fig. 1 **The spraydrop kinetic energy**

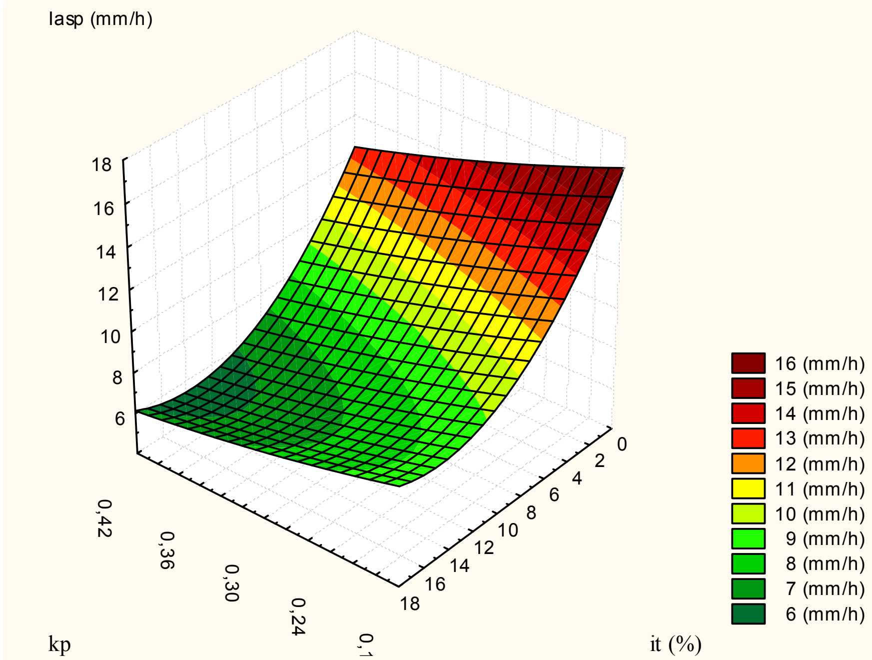

Fig. 2 **The sprinkler application rates and the ground slope depending on the fineness index**

$$I_{asp} = 20,914 - 26,77k_p - 1,16i + 15,479k_p^2 + 0,349k_p i + 0,037i^2$$

This value is available for soil unprotected by vegetation and is of interest in the design phase in order to choose the correct equipment and the optimum work layout by allowing the pumping station parameters and distribution network to be configured.

CONCLUSIONS

When sprinkling the sloping land, the amplitude of erosion phenomenon is bound by the soil type, energetically characteristics, sprinkle intensity, watering duration, implicitly the watering rate, sloping land, and vegetation covering degree of the soil.

The researchers results shows a correlation between the watering intensity and the kinetic energy of sprinkle (through fineness index and diameter droplets) and the stabilized water infiltration speed, the value is inverted in proportion with the sloping land.

The analysis of the specific energy associated with sprinkler, correlated with the intensity achieved by it in operating in a particular watering scheme, leads to the following conclusion: the increase of the specific energy implies a sharp decrease of the highest allowable ground slope. For this reason, the slopes above 6% do not justify the use of high flow and long-range sprinkler flow.

REFERENCES

Ailincai C., Jitareanu G, Bucur D, Ailincai Despina, Zbant Maria, 2009 *Evaluation of the long-term effect of crop rotation on water runoff, soil and nutrient losses in the Moldavian Plateau,* Cercetări Agronomice în Moldova, Vol. XLII , No. 1 (137) / 2009.

Bucur D., Ailincai C., 2006 *Prevention of soil erosion on irrigated sloping land from Moldavia Plain,* Lucr. st., Seria Agronomie, vol. 49, U.S.A.M.V. Iasi, 375 – 383.

Kinkaid D.C. 1996 *Spray drop kinetic energy from irrigation sprinklers,* Trans. ASAE vol. 39, no. 3.

Li J., Kawanok R., 1994 *Drop lot size distribution from different shaper sprinkler nozzles,* Trans. ASAE, vol. 37, no. 6.

Sojka R.E. 1996 *Management options for control of irrigation – induced erosion,* USDA – ARS, available on-line at: http://kimberly.ars.usda.gov/WebErode.htm