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# EROSION AND POWER APPROACH TO OPTIMIZING EROSION CONTROL FIELD MANAGEMENT METHODS AND TECHNIQUES

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**ABSTRACT:**
An important point at developing erosion control field management methods and techniques is their optimization. So far, in Bulgaria it has been performed based on predicting the average annual quantities of erosion soil loss estimated according to the universal equation of Wischmeier and Smith (1960; 1978) and compared to the permissible erosion with respective soil types according to recognized methods, included in the national long-term program for soil erosion control. This makes more difficult to estimate the technical and economic losses due to erosion as well as assess the return of the expenditures for limiting them and calls for developing new methods for erosion control optimization including complex assessment of the chosen erosion control method or technique. The present report reviews a new erosion and power approach to optimizing erosion control field management methods and techniques. It creates possibilities for specifying and substantiating the assessment of this methods and techniques as their effect on soil erosion is viewed not only on the basis of the soil erosion quantity but also on the basis of the power consumption used for its reduction.
**KEY WORDS:**
erosion control prediction, a universal soil-loss estimating equation, optimization of erosion control methods, power efficiency parameter.

## 1. INTRODUCTION

One of the most important points at developing water erosion control field management methods and techniques is optimizing the utilized erosion control methods and techniques. We believe that optimizing the erosion control method and technique means choosing the best, the most efficient and the most appropriate version out of all possible soil erosion control methods and techniques for particular soil, terrain and climatic conditions with the purpose of achieving the most efficient erosion control.

So far, in our country this optimization has been accomplished according to recognized methods, which are included in the National Long-term Program for Erosion Control. According to it the universal equation of Wischmeier and Smith (1960, 1978) for predicting the average annual soil loss is being used as basis in determining the necessity of utilizing different erosion control methods and techniques for limiting the erosion to the permissible boundaries. The equation is as follows:

$$A = RK.LSCP \quad (1)$$

where:
- A - the soil erosion average annual quantity, kg/da;
- R - the rainfall erosion parameter for the respective area of the country;
- K - the parameter of the soil susceptibility to erosion in the condition of humus tilled in the direction of the slope (at gradient of 10% and 25 m length of the slope);
- L - the parameter of the significance of the slope length on the soil erosion;
- S - the parameter of the significance of the gradient of the slope on the soil erosion

$$LS = \sqrt{L}\left(0{,}00111S^2 + 0{,}00776S + 0{,}0111\right) \quad (2)$$

where:
- L is the length of the slope, m;
- S – the gradient of the slope, %;
- C – the parameter of the effect of the crop and the crop rotation on soil erosion which is represented as the ratio of the average annual quantity soil erosion from the area of the crops (crop rotation) sown in the direction of the slope to the eroded soil from the humus tilled in the direction of the slope.
- P – the parameter of the efficiency of the erosion control methods or techniques, represented as the ratio of the quantity of the eroded soil in the areas tilled with erosion control methods to the quantity of the eroded soil in the areas utilizing agricultural farming practice with soil tillage and crop sowing in the direction of the slope.
- R, K, C and P parameter values for the particular soil and terrain conditions of the areas in our country are respectively given in The Methods for Developing a National Long-term Erosion Control Program in the Republic of Bulgaria (1977) or can be determined by specially developed maps in 1:200000 scale for the rainfall erosion and soil susceptibility to erosion [Sabev L., S.Stanev (1963) and Russeva S.S. (2002)].

Based on equation (1) and the data of parameters of the factors participating in it and determined in accordance with the above-mentioned method, the first to be estimated is the average annual soil erosion quantity (A) for each particular agricultural area of specified climatic, topographic, soil and field management conditions. After that the average annual soil erosion quantities thus estimated are compared to the permissible average annual soil erosion data ($A_{permissible}$) for the respective soil difference in our country as specified in The Methods for Developing a National Long-term Erosion Control Program in the Republic of Bulgaria (1977).

If the estimated average annual soil erosion quantities (A) are equal or lower than the permissible ($A_{permissible}$) for a particular soil difference, it means that there is no need for additional methods or techniques for erosion control, i.e. the soil is well protected from erosion in the particular farming area. In case (A) is higher than ($A_{permissible}$), a method or a technique must be selected for limiting the erosion to the permissible boundaries. This option is selected on the basis of the estimated optimal values of the P-factor at the finally selected crop via equation (1) according to the following formula:

$$Poptimal = \frac{Apermissible}{RKLSC} \quad (3)$$

As seen, this manner for optimizing erosion control method or technique has so far been performed only on the basis of the soil erosion quantity and its permissible boundaries. According to Onchev N.G. (1983) that makes it more difficult to estimate soil erosion loss as well as the return of the expenses on limiting it. It is obvious that in order to turn the erosion control optimization into a complete well-grounded system for soil erosion control it is necessary to develop new methods which will allow determining the most efficient economic versions of erosion control optimization. This can be accomplished via a complex assessment of the selected erosion control method or technique, i.e. by means of determining not only its erosion control efficiency but the technical (power and operational) and economic ones as well.

The purpose of this development is to create methods for optimizing erosion control field management methods and techniques through introduction and utilization of indexes for technical erosion assessment.

## 2. THE POINT OF THE METHODS

It is our belief that at optimizing particular erosion control field management method or technique beside its erosion control efficiency, the most important thing is estimating its technical efficiency and the power and operational indexes of the technical means, which take part in it.

A generalized index of this estimate is the power consumption for applying the erosion control field management method or technique and stating it more precisely – the power efficiency index. It represents soil erosion quantity per unit power consumption. Its determination for a particular erosion control field management method is carried out with the data obtained from the power and operational tests carried into effect with the tractor and the machinery coupled to it or other equipment performing this erosion control field management method or technique.

After determining the towing resistance $F_T$ via strain measuring method and calculating the towing capacity $P_T$, the effective output $P_e$ and hourly output of the tractor and the machinery coupled to it W at given operating speed $V_p$, it is also possible to estimate the power consumption used for carrying out the method or the technique per unit of area according to Iofinov (1974) and Levi (1987) and in accordance with the Unified Methods for Carrying out Tests and Determining the Power Indexes (1976) using the following formula:

$$E_p = \frac{P_e}{W} \quad (4)$$

where:

- $E_p$ - power consumption for carrying out the method or technique per unit of area, kwh/da;
- $P_e = \frac{P_T}{\eta_{Tp}}$ - effective output used at carrying out the method or technique, kw;
- $P_T$ – towing capacity of the tractor, kw;
- $\eta_{Tp}$ – tractor efficiency (the towing efficiency of the tractor);
- W – the actual hourly output have the tractor and the equipment coupled to it at carrying out the method and technique, da/h.

The power consumption used for carrying out the erosion control field management method or technique per unit of area as well as the power consumption used for carrying out the conventional field management method or technique at which soil tillage and crop sowing in the direction of the slope are calculated according to this formula.

Beside this, the stationary method for measuring the erosion via the so called draining sites can help estimate the moment soil erosion which occurs after each rainfall and the average annual soil erosion quantities in areas in which erosion control field management method or technique has been applied as well as in areas in which it has not been applied.

Taking under consideration the results obtained about the power consumption and soil erosion quantities it is possible to determine the power efficiency index of the erosion control field management method as well as that of the conventional field management method applied in the direction of the slope via the formula:

$$a_e = \frac{A_{ср.г.}}{E_p} \tag{5}$$

where:

- $a_e$ is the power efficiency index of the field management method or technology, kg/kwh;
- $A_{ср.г.}$ – the average annual soil erosion quantity, kg/da;
- $E_p$ – the power consumption used for carrying out the particular field management method or technique per unit of area, kwh/da.

After calculating in that manner the values of this index at the erosion control field management method or technique ($a_{e\ пр.}$) and at the conventional field management method ($a_{e\ т}$) carried out in the direction of the slope, the above can be compared to each other and the ration between them determined via the formula:

$$B = \frac{a_{eпр}}{a_{eт}} \tag{6}$$

where:

- B - the parameter of the power efficiency effect on soil erosion;
- $a_{e\ пр}$ – the power efficiency index of the erosion control field management method or technique, kg/kwh;
- $a_{e\ т}$ – the power efficiency index of the conventional field management method or technology carried out in the direction of the slope, kg/kwh.

Developing further the formula (6) for the parameter of the power efficiency effect, which we have introduced, we obtain the following:

$$B = \frac{a_{e\,пр}}{a_{e\,т}} = \frac{\dfrac{A_{пр.}}{E_{p\,пр.}}}{\dfrac{A_т}{E_{p\,т}}} = \frac{A_{пр.}}{A_т} \cdot \frac{E_{p\,т}}{E_{p\,пр.}} = P.K_E \tag{7}$$

where:

- $A_{пр.}$ – the average annual soil erosion quantity resulting from applying the erosion control field management method or technique, kg/da;
- $A_т$ – the average annual soil erosion quantity resulting from applying the conventional field management method or technology carried out in the direction of the slope, kg/da;
- $E_{p\ пр.}$ – the power consumption used for carrying out erosion control field management method or technique per unit of area, kwh/da;

- $E_{p\ T}$ – the power consumption for performing the conventional field management method or technique carried out in the direction of the slope, kwh/da;
- P – the parameter of the efficiency of the erosion control field management methods or techniques;
- $K_E$ – the factor of efficient utilization of the power in the applied methods and techniques.

## 3. RESULTS AND DISCUSSIONS

Analyses of the results obtained after calculating formula (7) lead to the conclusion that the parameter of the power efficiency effect on soil erosion (B) which we have introduced actually presents expanded and enlarged P-factor with the introduced factor ($K_E$) from formula (7), giving the efficient power utilization in the applied field management methods and techniques. This factor is expressed as ratio between the power consumption used for carrying out the conventional field management method or technique at which each tillage and crop sowing is in the direction of the slope to the power consumption used for carrying out erosion control field management method or technique. It characterizes a particular erosion control field management method or technique according to the number and power consumption of the erosion control technological operations (tillage) included in this method or technique.

The more the erosion control technological operations (tillage) included in it are, the higher the power consumption for carrying it out is and the lower the factor ($K_E$) is. In this case the value of the parameter of the power efficiency effect on soil erosion (B) is also lower. Having in mind the accepted designations in the universal equation (1) of Wischmeier and Smith we accept the designation:

$$B = P.K_E = P^{/} \qquad (8)$$

where:

- $P^{/}$ is a parameter characterizing (representing) parameter P described in a function of the erosion control field management method or technique and in accordance with its erosive effect and power consumption.

This newly introduced parameter ($P^{/}$), in the way it is, can be used in universal equation (1) for predicting the average annual soil erosion losses and in our opinion allows to specify and substantiate the methods for optimizing the erosion control field management methods and techniques as their effect on soil erosion will already be estimated not only on the basis of the soil erosion quantity but based on the power consumption used for reducing it as well.

**BIBLIOGRAPHY**

[1.] *** Unified Methods for Carrying out Tests. Power Indexes and Methods for Measuring, Specifying and Assessment. (1976), BDS, Sofia, pp.6-10.

[2.] IOFINOV S.A. Operation of the Machinery and Tractor Park. Kolos, Moscow, pp.94-101. 1974.

[3.] LEVI S.A.. Operation of Agricultural Equipment. Zemizdat, Sofia, pp.121-122.

[4.] *** Methods for Creating National Long-term Program for Erosion Control in the Republic of Bulgaria 1977, Ministry of Forests and Forestry, Sofia, pp.10-38. 1987.

[5.] ONCHEV N.G. Prognosticating Area Water Erosion in the Republic of Bulgaria and Optimization of Erosion Control Activities, Agricultural Academy, Sofia, pp.10-23. 1983.
[6.] ONCHEV N.G. Erosion Intensity and Optimization of Erosion Control Activities. Zemedelie Plus No.9, Sofia, pp.21-24. 2001.
[7.] RUSSEVA S.S., Information Basis for Developing Geographic Data Base for Estimating Erosion Risks. Research Work Qualifying for an Academic Degree of Senior Research Associate I Degree, Nikola Pushkarov Institute on Soil, Sofia. 2002
[8.] SABEV L., S. STANEV. Climatic Regions in Bulgaria and Their Climate, Sofia. 1963.
[9.] WISCHMEIER, W.H., and D.D. Smith A Universal Soil – loss Estimating Equation Guide Conservation Farm – planning. Seventh Cong. Int. Soil Scl. Soc., Madison, Wisc. 1960.
[10.] WISCHMEIER, W.H., D.D. Smith Predicting Rainfall – erosion Losses – A Guide to Conservation Planning. Agricultural Handbook № 537. 1978.