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ANTI-EROSIVE ENERGY EFFICIENCY OF SOIL-PROTECTION AGRICULTURAL METHODS, TECHNOLOGIES AND MACHINES FOR THE CULTIVATION OF CEREALS ON SLOPING TERRAIN

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ABSTRACT:
This paper is written on the basis of the results of a five-year research carried out on specific soil, climatic and terrain conditions of the Republic of Bulgaria which determined the anti-erosive energy efficiency of the soil-protection agricultural methods, technologies and machines applied on sloping lands for the cultivation of cereal crops (grain wheat and grain maize), a process which is used for the further optimization of the soil protection agricultural methods. Acknowledged for this purpose anti-erosive energy efficiency indicators measuring the specific energy consumption per unit of additionally protected from water erosion soil and a unit of additionally obtained crop yield, as well as an indicator of anti-erosive efficiency of an individual anti-erosive agricultural machine (a machine-tractor unit) or a technological machine complex, have been described.
KEY WORDS:
water erosion, anti-erosive methods and technologies, anti-erosive machines, anti-erosivive efficiency, optimize anti-erosive methods and technology, indicators for the specific energy consumption, an indicator of anti-erosive efficiency.

1. INTRODUCTION

In the Republic of Bulgaria with the highest share of the growing crops (around 55%) is the group of cereal crops. Main distribution of them have wheat and maize of which between 1.4 - 1.7 million hectares are planted each year. A significant proportion of these areas (between 45 - 50%) as a result of the terrain conditions of the country are slopes of greater than 3° (5.2%) which are potentially at risk from the effects of water erosion processes [1,2,8]. For these agricultural lands, therefore, a new system of anti-erosive measures and practices combining different cultivation methods, technologies and machines, is necessary to be applied. A higher efficiency of the fight against water erosion of soil requires that these methods, technologies and machines are fully analyzed and their impact on water erosion assessed not only on the basis of the amount of soil erosion, but also on the basis of a comprehensive evaluation. This includes defining the anti-erosive energy efficiency[3,4].

General indicators of this assessment are the additional energy consumption for the application of the specific anti-erosive agricultural method or technology and in particular the anti-erosive energy indicators measuring the specific energy consumption per unit of additionally protected from water erosion soil and a unit of additionally obtained output, as well as an indicator of anti-erosive efficiency of an individual anti-erosive agricultural machine (a machine-tractor unit) or a technological machine complex. New approaches and methodologies to optimize anti-erosive agricultural methods, technologies, and specialized machinery, using indicators for erosion and agricultural technical assessment, have been applied in Bulgaria lately [1, 4, 5,6].

Based on them a number of studies determining these parameters have been conducted. The purpose of this paper is to take into account the results of these studies to determine the anti-erosive energy efficiency of the applied in that country soil-protection agricultural methods, technologies and machines for the cultivation of cereals (wheat and maize) grown on sloping areas, a process which is necessary for the further optimization of the soil protective agricultural needs[1,7,9,10].

2. EXPOSITION

Tests conducted in the period 2004 - 2008 in the experimental fields of Rousse Anti-erosive Research Centre in the land of the village of Trastenik, Rousse region, on soil of black earth carbonate, with an average slope of the terrain 5° (8.7 %), have been described.

Subject of research were anti-erosive agricultural methods (cutting and vertical mulching) and technologies for growing grain wheat and grain maize on sloping terrains (anti-erosive technology for growing wheat, including the methods of vertical mulching and cutting after germination of plants in winter, soil-protection technology for minimal soil cultivation for wheat growing, including vertical mulching methods and direct sowing, anti-erosive technology for grain maize, including the method of cutting after deep ploughing, together with the sowing of maize and with the digging of the crop, and a combined anti-erosive method of furrowing with cutting and earthing up of grain maize.

Tested were the machine-tractor units for cutting in deep ploughing and sowing wheat, for vertical mulching, for anti-erosive soil inter row cultivation and sowing of cover crops, for anti-erosive soil inter row cultivation on slope terrains (for digging together with cutting), anti-erosive and combined cultivation of the soil (for furrowing, cutting or trnching), as well as the technological anti-erosive complex of machines for wheat growing (including a device for vertically mulching, cutting) and technological anti-erosive complex of machinery for a minimum soil cultivation for wheat growing (including devices for vertical mulching and a planter for direct sowing), an anti-erosive technological complex of machines for maize growing (including a cutter, a machine for anti-erosive inter row soil cultivation and sowing, a device for inter row anti-erosive soil cultivation for cover crop growing on sloping terrain, and a device for a combined anti-erosive soil cultivation), and the soil-protection technological machine complex for a minimum soil cultivation for grain maize (including a cultivator – loosening the soil as a first step of the cultivation process, a machine for inter row anti-erosive soil cultivation and sowing, a device for inter row anti-erosive cultivation of soil for cover crops growing on sloping terrains and a device foe a combined anti-erosive soil cultivation).

The results achieved from the conducted anti-erosive and agro-technical experiments of the soil-protection agricultural methods, technologies and machines applied for the cultivation of grain wheat and grain maize on sloping terrains and their performance indicators are given in Table 1 and Table 2.

The calculated values of anti-erosive energy efficiency indicators presented in Table 1 give the efficient energy use of the agricultural methods and technologies applied in Bulgaria in order to preserve the soil from water erosion and to increase the productivity of the growing crops. Each of them describes a method or an anti-erosive agricultural technology, according to the energy-saving capacity of the anti-erosive technological operations (processes) involved in this method or technology.

The increase of the number of the indicators shows an increase of energy consumption, which in its turn leads to a decrease of the value of the specific additional costs for energy per unit of soil saved from further water erosion and from the specific additional expenditure of energy spent per unit for the obtaining of additional crop yield. The introductions of these indicators serve as criteria for evaluation and comparative analysis of the anti-erosive agricultural methods and technologies.

Table 1. Anti-erosive energy indicators of soil –protective (to combat water erosion and soil thickening) methods and technologies for the cultivation of wheat and maize grain on sloping terrain

№	Soil-protection method and technology	INDICATORS				
		Energy-consump-tion E_p, kwh/ha	Average output O_{av}, kg/ha	Average annual soil erosion quantity kg/ha	Anti-erosive energy indicators $e_{ед}$, kwh/kg	Indicator of anti-erosive energy efficiency e_{ce}, kwh/kg
1.	Traditional technology for wheat planting along the slope	151,0	2545,4	3917,0	0,0593*	0,0385*
2.	Traditional technology for wheat planting across the slope	155,30	2667,8	2128,2	0,0351	0,0024
3.	Cutting for wheat growing	162,49	3621,3	820,0	0,0180	0,0029
4.	Wheat vertical mulching	174,46	3836,3	595,3	0,028	0,0056
5.	Anti-erosive technology for wheat	185,95	3949,4	191,3	0,0362	0,0076
6.	Soil-protection technology for wheat	161,90	3183,4	504,6	0,0171	0,0032
7.	Traditional technology for maize planted along the slope	182,41	3132,2	9735,4	0,0579*	0,0187*
8.	Traditional technology for maize planted across the slope	189,90	3362,2	2754,2	0,0326	0,0011
9.	Anti-erosive technology for maize	212,28	4568,7	784,7	0,0285	0,0026
10.	Soil-protection technology for maize	205,98	3966,4	746,0	0,0283	0,0026

By further analyzing the data from Table 2 we can conclude that each aggregate constituting the machine complex for protecting the soil from water erosion shows good performance when implemented in individual technological operations in the cultivation of cereals (wheat and grain maize) on sloping lands.

When combined in technological complexes of machines for the cultivation of grain wheat and grain maize on sloping terrains and when they are used complexly in the specific soil-protection technology, the anti-erosive efficiency indicator significantly increases. Its average value is 24.23 when anti-erosive technology complex machinery is used for the cultivation of wheat on sloping lands, and it is 7.77 when soil-protection technological complex machinery is used for a minimum soil cultivation for planting wheat. The value of this indicator in the anti-erosive technological complex of machines and in the soil-protection one for a minimum treatment of the soil in the cultivation of grain maize is 14.17 and 13.05.

Table 2. Machine, equipment and technological machine complex anti-erosive efficiency for anti-erosive soil-protection

№	Machine, equipment and technological machine complexes	Type of the cultivated crop	Average anti-erosive efficiency indicator value I_{ef}
1.	Cutter Sh-2-140 with a bunker for mulching	wheat	5,43
2.	Cutter Sh-2-140 with a bunker for mulching	Deep autumn ploughing with winter cutting	2,35
3.	Cutter Sh-2-140 with a bunker for mulching	Deep autumn ploughing with spring cutting	3,10
4.	A device for anti-erosive cultivation and planting between the rows	Grain maize	3,40
5.	A device for anti-erosive cultivation of crops with a cutter	Grain maize	2,93
6.	A device for a combined anti-erosive soil cultivation	Grain maize	4,40
7.	A device for vertical mulching	wheat areas	7,07
8.	Anti-erosive technological machine complex for wheat cultivation	Wheat	24,23
9.	Soil-protection technological machine complex for wheat cultivation	Wheat	7,77
10.	Anti-erosive technological machine complex for maize cultivation	Maize	14,17
11.	Soil-protection technological complex for minimal maize cultivation	Maize	13,05

3. CONCLUSION

From the conducted experiments and the achieved results the following conclusions can be made:

1. The use of agro-erosive energy indicators for measuring the specific additional costs of energy saved from combating further water soil erosion per unit and for a unit additionally received crop production, allows a full agro-anti-erosive energy saving evaluation to be made. This helps the energy optimization of the agricultural soil-protection methods and techniques implemented in Bulgaria for growing cereal crops (wheat and grain maize) on sloping terrains.
2. The used anti-erosive efficiency indicator of the individual machines or technological complexes of machines serves as a criterion for evaluation when choosing the most suitable one in carrying out the anti-erosive agricultural methods and technologies for the cultivation of cereals (wheat and grain maize) on sloping terrains.
3. From the applied in the Republic of Bulgaria agricultural methods and technologies for protecting soil from water erosion in the cultivation of cereals (wheat and grain maize) on sloping terrains the best energy anti-erosive efficiency have the soil-protection technologies for minimal soil cultivation in the growing of wheat and grain maize on sloping terrains. Indicators for their specific additional costs of energy saved from further protection of soil from water erosion and of an additional yield obtained per unit are respectively 0,0032 kwh / kg and 0,0171 kwh / kg in the cultivation of wheat and 0,0026 kwh / kg and 0,0283 kwh / kg in the cultivation of grain maize.
4. In Bulgaria, the highest anti-erosive efficiency have the anti-erosive technological complexes of machines for the cultivation of wheat and grain maize. Their average indicator of technological efficiency for the cultivation of wheat is 24,23, and for cultivation of grain maize -14,17.

BIBLIOGRAPHY

[1] Beloev H.I., Technology and machinery system for a minimum soil cultivation on sloping terrains in the conditions of sustainable agriculture. Dissertation for the award of the DSc degree, A. Kanchev University of Rousse, Rousse, 2008.

[2] Beloev H.I., Energy studies of a combined vertical mulching machine. Agricultural machinery, № 1, Sofia, 2008.

[3] Beloev H.I., Operational research on anti-erosive machine-tractor units for vertical mulching. Agricultural machinery, № 2, Sofia, 2008, pp 18-21.

[4] Beloev H.I., P. Dimitrov. Methodology for energy-agroerozive assessment of soil-protection agricultural methods and technologies. Agricultural machinery, № 3, Sofia, 2008, pp 54-56.

[5] Beloev H.I., D. Stanchev. Performance of machine-tractor units using soil-protection technologies in the cultivation of agricultural crops on sloping terrains. Printing base Roo A. Kanchev, Rousse, 2008, p.110

[6] Beloev Hr. Operational and Power Producing Capacity Comparative Analyses of Machine Tractor Aggregates for Vertical Mulcing. Acta technologica agriculturae - The Scientific Journal for Agricultural Engineering, Volume 11, Number 2, Nitra, Slovakia, 2008.

[7] Dimitrov P., Hr. Beloev. Power research on a breaker and dead – furrower with a hopper for vertical mulching. Energy efficiency and agricultural engineering, Third Conference, Rousse, 2006.

[8] Dimitrov P.D. Anti-erosive agricultural methods, technologies and equipment systems for the cultivation of grain wheat and grain maize on sloping terrains. A dissertation for the scientific DSc degree, IP N. Pushkarov, Sofia, p. 286.

[9] K. Stoyanov, Energy study of agricultural unit for ploughing. International Scientific Conference EE § AE, 4-6 April, Rousse, 2006.

[10] Stoyanov K.E., Study of the performance indicators of an agricultural plowing aggregate depending on the state of the system of compulsory filling of the engine of a tractor T-150K. Dissertation for the award of PhD educational and scientific degree A. Kanchev University of Rousse, Rousse, 2007.