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EVALUATION OF EROSION CONTROL EFFICIENCY OF SOIL LOOSENING AGRICULTURAL MACHINERY

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ABSTRACT:
Soil loosening has become a significant part of tillage in the Bulgarian agriculture. It is applied for hard and packed soils as well as for soils with over-moist surface layers and for the past years it has proved its erosion control efficiency. Different types of cultivators – looseners and deep-looseners are being used for performing this operation in our country. Their erosion control performance needs to be estimated in order to use them more efficiently for soil conservation.
Based on research of many years the present report reveals the particular erosion control efficiency of the looseners utilized in the conditions of our country.

KEY WORDS:
soil loosening, cultivator-loosener, deep-loosener, soil erosion, erosion control efficiency.

1. INTRODUCTION

Subsurface tillage, which is tillage without turning up the arable layer, has become a significant part of the agricultural practices in Bulgaria for the last 10 years. Depending on the type of the equipment used it can be applied on agricultural land in the following varieties: loosening (shallow or deep), flat-breaking tillage, surface and zero tillage.

In our country loosening is among the most widespread methods of tillage without turning the arable layer. It is performed in the following cases: packed soil– formation of clods and crevices, packed layer under the arable layer, packed subsoil and soils of unfavorable water and physical qualities (low humus content, insufficient supplies of nutrient and acid reaction). In many countries (the USA, Canada, Russia, Kazakhstan, etc.) soil loosening is already used as an appropriate means for soil erosion (water and wind).It keeps a significant portion of the plant mulch on the soil surface and creates conditions for reducing the soil bulk density as well as for increasing soil porosity and its water permeability.

Based on the research work carried out by Rakov K.G. et al (1982), Stoinev K.V. (1985), Dimitrov P.D. (1998) and other research workers in our country, it has been determined that the field management and erosion control efficiency of soil loosening is higher compared to the conventional deep plowing applied at primary tillage. The tasks and the purposes of this tillage, according to Stoinev K.V. (2004) are

determined by the soil and ecological conditions: erosion reduction, improving the water regime of the soil, melioration of areas with unfavorable water and physical qualities, savings in energy, etc. The various tasks set to loosening necessitate it to be performed at different depth with loosening equipment of different types. In Bulgaria, KRN-1.75 and KRN-2.4 cultivator-looseners and RD-2.5, RDN-80, RDP-80 and RDN-100 deep-looseners are the most widespread equipment. The first operate at depth up to 35-40 cm and are used on soils of medium mechanical composition. They are utilized for primary and pre-sowing tillage as well as for loosening secondarily packed soils. The latter, the deep-looseners, operate at depth greater than 40 cm and are used for tilling heavy packed soils as well as over-moist surface layers of the soil. Some of them (RDN-80 and RDP-80) have been designed so as to perform tillage at two levels alongside – 30-35 cm and up to 80 cm (fig.1). That improves the quality of the operation and significantly reduces the power consumption necessary for carrying out the tillage.

According to Stoinev K.V. (1985) the type of loosener is to be selected depending on the particular conditions – soil type, relief and micro-relief of the soil surface, moisture content, soil pulverization degree, tillage depth, etc. However, in any case, having in mind erosion control, the requirements for efficient loosening are to carry it out along the whole profile, transversely to the slope while the soil should be broken into clods of medium size to maximum percentage and with minimum percentage of small and pulverized fractions, which after all depends on the capabilities of the loosening equipment.

Based on data from research of many years, the purpose of the present report is to evaluate the erosion control qualities of the different types of looseners used in Bulgaria in order to determine their soil conservation efficiency.

2. MATERIALS AND METHODS

The research was carried out in two stages within the periods of 1979 -1983 and 1994-1998 at Nickola Pushkarov Institute on Soil Science, Sofia and the Tractor and Agricultural Equipment Test Center, Plovdiv. The cultivator-looseners KRN-1.75 and KRN-2.4 coupled to wheel tractors T-150K were tested in the experimental fields of Nickola Pushkarov Institute on Soil Science, Sofia in the areas of the villages of Trastenik and Shtraklevo, the district of Rousse, in calcareous and leached black earth soil and in the village of Mogila, the district of Stara Zagora in pseudopodzolic cinnamon forest soil. The performance of the deep-looseners RD-2.5, RDN-80, RDP-80 and RDN-100, coupled to wheel tractors K-700 and K-701 and to chain tractors T-100MGS and T-130 was subject to research in different soil types (leached black earth vertisoil, cinnamon forest soil, grey forest soil and alluvial –meadow soil by the Test Center in Plovdiv.

Several indices characterizing erosion control efficiency were also determined during the experiments with the two types of loosening equipment, following an approved plan and methods, alongside with the other compulsory evaluations at testing. They were respectively: tillage depth, plant residue distribution on soil surface, fallow aggregate composition, expanding of the tilled soil layer and leveling the surface and the bottom of the furrow. Utilizing the method of stationary draining sites enhanced determination of the amount of the surface water runoff and eroded soil after each registered erosion rainfall at testing the cultivator-loosener KRN-1.75 performance on areas with gradient of 5°.

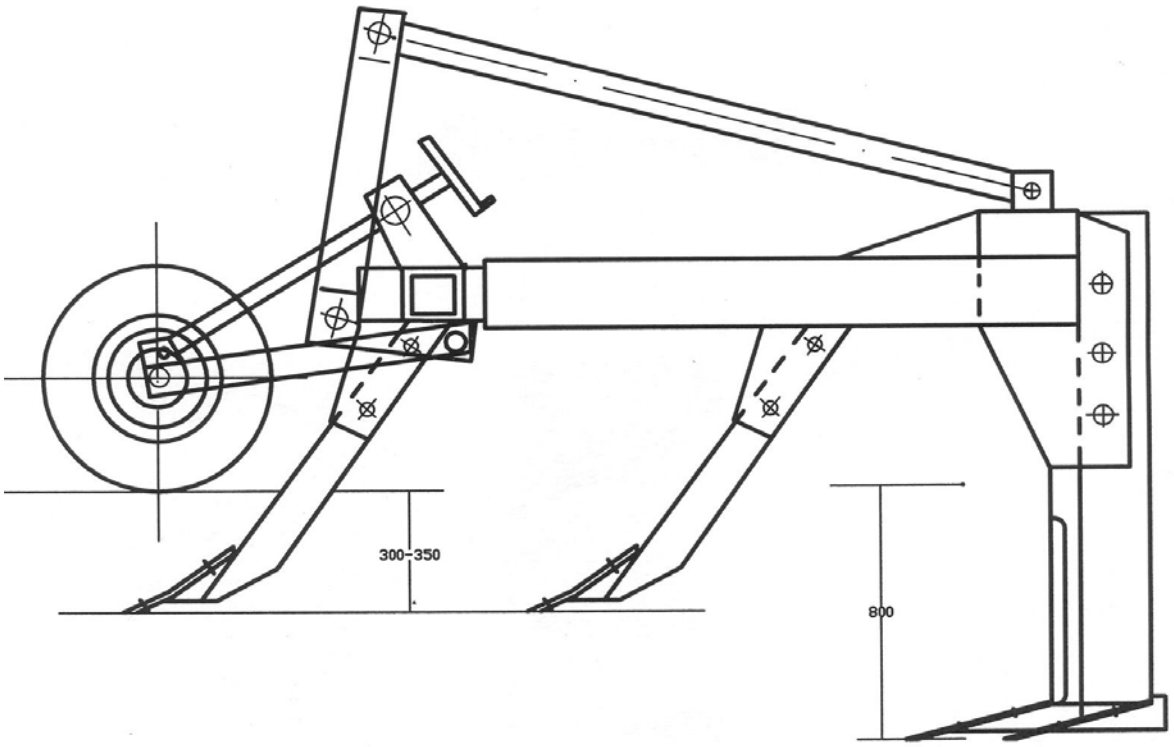

FIGURE 1. Deep-loosener rdn-80

3. RESULTS AND DISCUSSIONS

The results from the research carried out indicate that all looseners which were tested operate at a relatively greater depth compared to the other tillage equipment used for primary tillage in our country. This depth is within the range of 35 cm to 100-120 cm and from erosion control point of view it is better as it creates a significantly powerful layer of loosened soil which can accumulate rainfall water without holding water on the surface or occurrence of water runoff.

Another positive soil conservation quality of the looseners is their ability to achieve better degree of soil pulverization compared to the share plows. Data from Table 1 reveal that at operation all tested looseners break the soil more favorably from erosion control point of view. The soil fractions of size smaller than 10 mm, which are easily washed out and carried away from the rainfall water, are about two times less (from 15.07% to 23,57%) compared to the soil fractions obtained from tillage with plows (from 26.30% to 45.53%).

From erosion control point of view, the other positive sides of the looseners' performance, which were determined during the research process, are as follows:

- Higher degree of preserving the plant residue on the surface of the tilled areas, which is within the range of 58% to 70%. That reduces the striking effect of the rainfall drops on the soil and prevents its additional atomization. Alongside it creates an interception for the surface water runoff which reduces its speed and increases the duration for rainfall water absorption;
- Good soil loosening within the root area. This positive erosion control quality of the looseners is of great field management significance as it creates conditions for better development of the root system and more efficient growth of the agricultural crops;
- Expand the soil (increase its volume) by 10-15 cm which comprises 12-30% of the tillage depth. The research reveals that this is obtained nevertheless the soil type and condition. With two trips of the agricultural equipment the

loosening tools form dead furrows of the depth already mentioned. They prevent the surface water runoff formed by erosion rainfall and fast melting snow, reduce its speed, increase the duration of rainfall absorption thus enhancing the erosion control efficiency of the tillage;

- Help obtain uneven furrow bottom profile after the trips of the different types of looseners. This can be considered the best erosion control quality of the equipment. Fig.2 (a, b, c, d, e) shows the diagrams of the furrow bottom profiles and the surface of the expanded tilled soil at KRN-2.4, RD-2.5, RDN-80,RDP-80 and RDN-100 looseners operation on areas of optimum moisture content. The uneven profile of the furrow bottom as well as the condition of the soil surface after ytips of the tools of the different loosening agricultural equipment is a reliable precondition for reduction in the speed of the surface water runoff, formed by the erosion rainfall or fast melting snow. It is a trustworthy safeguard against water erosion provided the tillage has been performed transversely to the gradient of the slope as it reduces and even prevents it.

TABLE 1. Aggregate composition of the soil (in % of the total amount) in primary tillage with specialized plows, cultivator-looseners and deep-looseners

№	Make of the equipment	Soil fractions in %			
		above 100 mm	from 50 to 100 mm	from 10 to 50 mm	below 10 mm
1.	Plow PNE-2-40P				
	- depth 30 cm	20,21	16,38	37,11	26,30
	- depth 36 cm	18,80	15,72	35,35	30,13
2.	Plow PNE-4/3/-40P				
	-depth 28 cm	31,10	15,77	14,33	38,80
	- depth 37 cm	28,70	16,88	13,56	40,86
3.	Plow PCS-4-35				
	- depth 20 cm				
	- gradient of the slope 0°	15,34	25,90	13,20	45,53
	- gradient of the slope 10°	33,37	22,68	12,50	31,45
4.	Cultivator-loosener				
	KRN-2.4	33,1	25,70	17,63	23,57
5.	Loosener RD-2.5				
	- depth 40 cm	36,52	24,09	17,36	22,03
	- depth 50 cm	35,21	26,17	16,97	21,65
6.	Loosener RDN-80				
	- depth 50 cm	35,85	17,22	25,81	21,12
7.	Loosener RDP-80				
	- depth 70 cm	41,18	17,22	21,87	19,76
8.	Deep-loosener RDN-100				
	- depth 80 cm	46,52	15,71	22,70	15,07
	- дepth 85 cm	42,95	16,09	23,90	17,06

The results from the direct erosion observations were carried out via stationary draining sites show that utilizing cultivator-looseners for primary tillage on slopes reduces the average annual amount of eroded soil by 1.5 times compared to the traditional deep plowing performed by a share plow along the horizontals and by more than 3 times compared to the tillage carried out along the gradient of the slope.

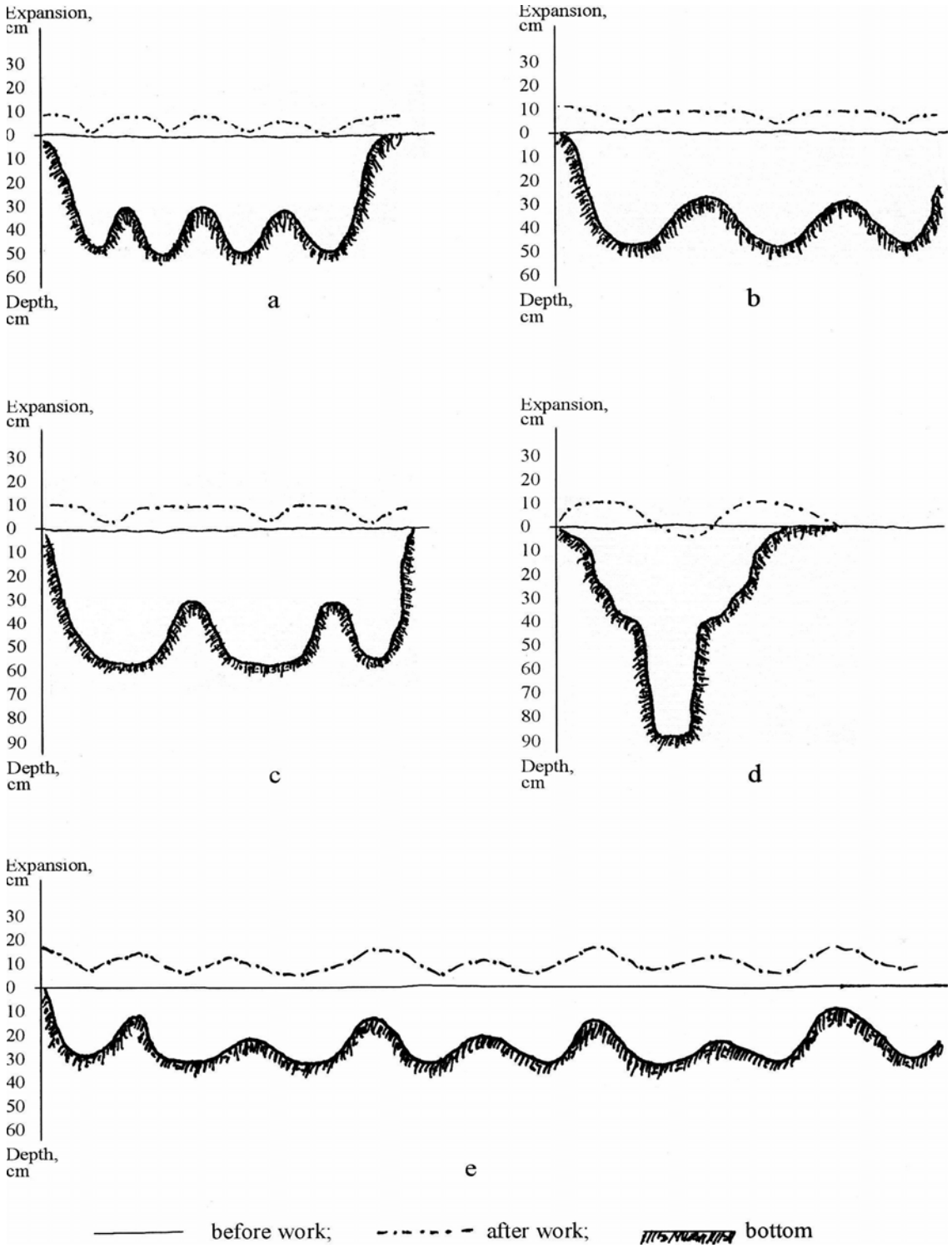

FIGURE 2. Profilegrams of the bottom ot the furrows and the surface of the expanded cultivated soil after work with the scarifiers (looseness of the soil): a) RD-2,5; b) RDN-80; c) RDP-80; d) RDN-100; e) KRN-2,4

4. CONCLUSION

In conclusion the research carried out draws the following inference:

- The cultivator-looseners KRN-1.75 and KRN-2.4 as well as the deep-looseners RD-2.5, RDN-80, RDP-80 and RDN-100, manufactured in the Republic of Bulgaria, yield good erosion control results at operation resulting in greater tillage depth, proper soil pulverization, higher degree of preserving the plant residue on the surface of the tilled area, form uneven profile of the furrow bottom and increase the surface soil volume;

- Utilizing the cultivator-looseners for carrying out primary tillage on slopes creates conditions for reducing the average annual amount of eroded soil by 1.5 times compared to the conventional deep plowing performed by share plows along the terrain horizontals and by more than 3 times compared to the tillage performed along the slope;
- All types of looseners (for shallow and deep loosening) can be utilized successfully as an erosion control means for carrying out primary tillage on slopes within the soil and climatic conditions of Bulgaria.

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