Soil protection measures during sunflower farming on slopes of Rostov oblast

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Abstract. The article presents data on the study of sunflower in two crop rotations located on the slope of the Bolshoi Log beam, Ak)sy District of Rostov Oblast in 2015 - 2019. Studies have shown that to prevent possible water erosion it is recommended to use chisel processing as the main tillage. This will reduce soil washout by 14–26% and runoff by 16–32%. It was revealed that replacing naked fallow in crop rotation with perennial grasses reduced the amount of washed-out soil by 28% and reduced water flow by 25%. It is shown that all farming methods on sunflower must be performed in the direction across the slope, along the lines close to the horizontals. In the case of a surface runoff caused by melt or storm water, it is recommended to create the irrigation and drainage structures of the shafts - ditches across the slope. The economic assessment of sunflower growing in the system of contour-strip organization of the territory is given.

1. Introduction

Soil erosion leads to a significant decrease in fertility and has a devastating effect on the environment. Environmental measures to increase the efficiency and sustainability of agricultural enterprises also involve a set of measures aimed at maintaining and improving soil fertility, optimizing the structure of sown areas. This will increase the area for additional products. One of the factors contributing to the stabilization and preservation of land fertility is the development of the farming system [1].

In modern conditions, the growing of sunflower is of particular relevance; the demand for it has always been and remains stably high. For its cultivation, a warm, arid climate and fertile soil are necessary. Under these conditions and observing all farming methods, growing this crop is cost-effective [2]. The area of sunflower crops in Russia reached 7.3 million hectares. The main areas of sunflower production in the Russian Federation are the Central, Southern and Volga Federal Districts, in which about 85% of the sown area is concentrated and about 90% of sunflower is produced [3, 4].

Sunflower cultivation is also possible on lands prone to erosion, subject to soil protection measures. On sloping lands, a decrease in moisture supply is observed, due to the runoff of melt and storm water, which leads to a decrease in the productivity of crops, including sunflower. Land degradation is one of the important problems that people face, which has become a powerful factor holding back the sustainable development of regional society and the economy. The use of adaptive-landscape territory organization of the slopes prone to erosion allowed reducing soil erosion by 33–45%.
The use of soil protection treatments as the main tillage reduced soil erosion by more than 11–27%. Soil-protective crop rotations of various parameters, depending on the degree of the slope in the adaptive-landscape system of the agriculture, allow soil fertility to be preserved, and in some areas, restored. On lands not affected by water and wind erosion, located on a watershed and very gentle slopes up to 1°, crop rotation with 20% pure steam, 20% row crops, and 60% of winter and spring grain crops is recommended. On lands prone to erosion with degree of the slopes from 1 to 2°, crop rotation with 10% of naked fallow, 10% of leguminous crops, 20% of row crops, and 40% of winter and spring grain crops, and 20% of perennial grasses is recommended [5].

Therefore, a study aimed at preventing the further development of degradation processes and stabilizing soil fertility is relevant for agricultural production.

The aim of the work was to study the optimization of the conditions for farming the sunflower on the slopes due to the main tillage in the system of contour-strip organization of the territory, which increases the productivity of sunflower, and also reduces and prevents erosion processes.

2. Materials and methods
The studies were carried out on a long-term stationary experimental site located on the slope of the Bolshoi Log beam, Aksay district of the Rostov region in 2015-2019. The experience in studying tillage in crop rotations and the use of fertilizers is placed in the system of contour-landscape organization of the territory of the slope. The soil of the experimental site is a haplic calcic chernozem (loamy). It is on the slope of the southeast exposure with a steepness of 3.5–4.0 °, erosion processes are weakly expressed. Power Ap is 25-30 cm, A + B values are from 30 to 60 cm. The spring runoff layer of 10% coverage is 52 mm; the average annual runoff is about 20 mm. The average annual soil washout (without soil protection measures) is 7–13 tons per hectare.

Sunflower was studied in two crop rotations: “A” (20% naked fallow, 20% tilled crops and 60% white straw crops) and “B” (20% tilled crops, 20% perennial grasses and 60% white straw crops). The precursor of sunflower was spring barley. Two tillage systems were examined: chisel tillage was performed with a chisel plow to a depth of 27-30 cm; dump tillage was performed with a dump plow to a depth of 27-30 cm (control). We explored three options for fertilizing: “0” – zero (without fertilizers), natural fertility; “1” – the first level – N<sub>40</sub> and “2” – the second level – N<sub>60</sub>.

Field experiments are inherent in triplicate in accordance with B.A. Dospekhov, statistical processing was carried out by the method of dispersion analysis according to the same technique (2011) using a personal computer [6, 7]. Washout was studied by measuring the depth, width and length of gullies. Accounting for the crop was carried out with a declared area of 25 m<sup>2</sup>, followed by weighing.

3. Runoff and soil washout
The main water supply to the soil occurs in the autumn-winter period, when the soil in most cases freezes to 15–20 cm. One of the tasks of agriculture is to reduce soil washout to safe limits and to preserve soil moisture for future crops. Surface washout was observed during a period of intense snowmelt. The use of contour-strip organization of the slope allowed to reduce runoff from 7–13 t / ha to 6.0–7.3 t / ha in the control variant.

As a result of the application of chisel tillage, the washout was reduced by 14–26% and the runoff by 16–32%. As a result of replacing naked fallow in the crop rotation with perennial grasses, the amount of washed-out soil on the option of dump tillage decreased by 17%, and of chisel tillage – by 28%. All sunflower farming methods are recommended to be performed in the direction across the slope, along lines close to the horizontal (Table 1).

This trend is confirmed by such an indicator as the coefficient of anti-erosion efficiency, expressed in terms of the ratio of actual soil erosion to maximum permissible erosion (3 t / ha). The coefficient of anti-erosion efficiency with dump tillage is 3.3–4.1. As a result of the application of chisel tillage, the anti-erosion coefficient was reduced to 2.5–3.4.

Surface runoff is formed upon the occurrence of intense snowmelt or heavy rainfall in early spring,
when the soil remains frozen. In combination, these indicators on the slope contribute to the formation of surface runoff. The runoff coefficient shows the amount of precipitation that went into runoff formation. The highest runoff coefficient was in the rotation with 20% naked fallow in the variant with dump tillage (0.35). The introduction of 20% perennial grasses into the crop rotation reduced the surface runoff coefficient to 0.30. The use of chisel tillage reduced the surface runoff coefficient to 0.23–0.29. The use of soil-protective tillage (chisel) helps to preserve crop residues on the soil surface, which ensure snowfall capture in the fields, and improves the absorption of melt water into the soil.

Table 1. Runoff and soil washout in various crop rotations depending on the method of soil cultivation

| Crop rotation | Index                  | «A»   | «B»   |
|---------------|------------------------|-------|-------|
|               | Chisel                 | Dump  | Chisel| Dump  |
| Washout, t / ha | 6.2                   | 7.3   | 4.5   | 6.0   |
| Runoff, mm    | 20.4                   | 24.4  | 15.2  | 22.7  |
| Erosion efficiency coefficient | 3.4                   | 4.1   | 2.5   | 3.3   |
| Surface runoff coefficient | 0.29                | 0.35  | 0.23  | 0.30  |

4. Sunflower yield

The yield of sunflower seeds during the years of research varied depending on the prevailing meteorological conditions and influencing factors - the methods of tillage and nutritional level. On average, over the years of research, in the variant without fertilizers when using dump processing, the yield of sunflower varied from 1.78 to 1.84 t / ha, under the same conditions at the “1” level of nutrition, the yield varied from 2.22 to 2.32 t / ha and against an enhanced background increased from 2.61 to 2.67 t / ha [4]. It was noted that reliable yield increases are largely due to the influence of the nutrition level - up to 23–46% than by the method of tillage 4–6% (Table 2).

Table 2. Sunflower yield and payback of fertilizers by yield increase

| Crop rotation | Tillage | Productivity, t / ha | Yield increase, t / ha |
|---------------|---------|----------------------|------------------------|
|               | «0»     | «1»      | «2»      | «1»     | «2»       |
| A             | Chisel  | 1.88      | 2.34     | 2.72     | 0.46     | 0.84      |
| B             | Dump    | 1.78      | 2.22     | 2.61     | 0.44     | 0.83      |
| B             | Chisel  | 1.94      | 2.40     | 2.82     | 0.46     | 0.87      |
| B             | Dump    | 1.84      | 2.31     | 2.68     | 0.46     | 0.84      |

Least significant difference (p=0.05) - 0.07 t / ha for the tillage factor, 0.10 t / ha for the fertilizer factor

5. Economic and environmental assessment

The ecological state of arable land is interconnected with its economic characteristics. Therefore, increasing environmental efficiency is considered as a factor in the economic stability of farms, due to the conservation of soil fertility. The use of soil-protective (chisel) tillage on erosion threatening slopes allows you to get additional products. The environmental effect of the use of tillage on erosion threatening slopes is assessed using the example of cost savings in restoring soil fertility lost as a result of erosion processes.

Production costs were calculated according to the technological maps. They amounted to 7,260-7,580 rubles on 1 ha. The largest production costs were noted with dump tillage. The maximum costs for the compensation of annual damage from water erosion in sunflower crops were noted during dump processing (7,790–9,390 rubles). As a result of the use of chisel tillage, these costs were reduced by 14–26% (Table 3).

The largest contingent net gain was earned with chisel tillage: 17.45–20.58 thousand rubles / ha, which is 21-24% higher than with dump tillage. The highest profitability was also gained with chisel
tillage - 14.0–58.2%.

**Table 3.** Economic and environmental assessment of sunflower cultivation

| Index                                                   | «A» | Crop rotation | «B» |
|---------------------------------------------------------|-----|---------------|-----|
|                                                       | Chisel | Dump (control) | Chisel | Dump (control) |
| Production costs, thousand rubles / ha                 | 7.26   | 7.58           | 7.26   | 7.58           |
| The cost of compensation for damage from erosion, thousand rubles / ha | 8.05   | 9.39           | 5.75   | 7.79           |
| Total costs, thousand rubles / ha                      | 15.3   | 17.0           | 13.0   | 15.4           |
| Productivity, t / ha                                   | 2.34   | 2.22           | 2.40   | 2.31           |
| Cost of production, thousand rubles                    | 6.54   | 7.64           | 5.42   | 6.66           |
| The cost of production, thousand rubles                | 32.8   | 31.1           | 33.6   | 32.3           |
| Contingent net gain, thousand rubles / ha              | 17.45  | 14.13          | 20.58  | 16.94          |
| Profitability, %                                       | 14.0   | -16.8          | 58.2   | 10.2           |

6. Conclusion

Sunflower is an erosive crop, so its cultivation on erosion threatening slopes is recommended with the use of soil protection technology. To prevent possible water erosion, it is necessary to apply chisel processing as the main tillage. As a result of the application of chisel tillage, runoff was reduced by 16–32%, and washout - by 14–26%.

Replacing naked fallow in crop rotation with perennial grasses reduced the amount of washed-out soil by 28% and reduced water flow by 25%. All sunflower farming methods must be performed in the direction across the slope, along lines close to the horizontals. In the case of a surface runoff caused by melt or storm water it is recommended to create the irrigation and drainage structures of the shafts - ditches across the slope.

Conservation and rational use of precipitation in the form of rain and snow is facilitated by soil-protective tillage (chisel) with the preservation of crop residues on the soil surface ensuring snow retention in the fields. All these activities should be carried out in the system of contour-strip organization of the territory. Implementation of these recommendations will allow you to get a crop of 2.67 t / ha and increase profitability up to 10-14%.

7. Acknowledgments

The work was carried out in the framework of the Program of Federal Scientific Research of the Academy of Sciences of Russia “Fundamentals of creating a new generation of farming systems and agricultural technologies with the aim of preserving and reproducing soil fertility, efficient use of the natural resource potential of agricultural landscapes and the production of a given quantity and quality of agricultural products”.

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