Basic tillage techniques in the sunflower cultivation

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Abstract. In the arid conditions of the Nizhneje Povolzhje region, the farmers’ main task is to accumulate the greatest amount of moisture by the sowing crops time. This is largely facilitated by the correct choice of the basic tillage method. The results of the research carried out on Southern chestnut soils 2017-2019 were aimed at solving a complex of problems related to the development of the technology adapted to the conditions of the Volgograd region. The soil density observations in sunflower crops showed that the soil density during dump plowing by the plow PN-4-35 to the depth of 0.27-0.30 m for sunflower harvesting was 1.24 t/m³. With loosening by chisel "Rancho" to the depth of 0.35-0.37 m it was equal to 1.21 t/m³. When loosening by chisel "Rancho" to the depth of 0.35-0.37 m with a reservoir turnover of 0.15-0.17 m³ the density was 1.16 t/m³. When loosening by the chisel "Rancho" to the depth of 0.35-0.37 m with a pruning flat-cutting foot at the depth of 0.15-0.17 m it was 1.18 t/m³. The highest yield of sunflower was formed on the variant of chisel loosening by "Rancho" to the depth of 0.35-0.37 m with a reservoir turnover of 0.15-0.17 m.

1. Introduction

Scientific research and practice of agriculture in recent years proved that with the increase in the agriculture intensification and culture level, many functions and foundations of tillage changed. However, despite some changes in the requirements for tillage, it continues to be the fundamental basis of agriculture [1, 2].

Rigid schemes of tillage systems in crop rotation fields (annual plowing, annual minimum, preserving treatment, combined with a pre-established sequence of techniques, etc.) without taking into account the agrophysical state, water-air properties of the soil and the phytosanitary state of a particular field immediately before processing, inevitably led to negative results [3].

The correct choice of the tillage method and time creates optimal conditions for the growth of cultivated plants, which allows to compensate for the stress caused by the defeat of their harmful organisms [4, 5].

High production processes mechanization in agriculture is associated with tillage. This technique is a universal means of influencing the physical, chemical and biological properties of the soil, its fertility and yield [6].
When cultivating the soil, many tasks of agriculture are solved. First of all, its physical condition is maintained or improved, its water and air properties are improved: soil becomes more loose, lumpy, and structural. With differentiated anti-erosion treatment, erosion processes are weakened, precipitation runoff from the soil surface decreases, which reduces the loss of nutrients from the surface runoff and into the ground water, and rivers, lakes and artificial reservoirs are less polluted with biogenic elements. Thus, a properly selected set of tillage techniques also solves environmental problems [7, 8, 9].

In the arid conditions of the Nizhneje Povolzhje region, the farmers’ main task is to accumulate the greatest amount of moisture by the sowing crops time. This is largely facilitated by the correct choice of the basic tillage method [10].

Our research was aimed at solving a complex of problems related to the development of the technology that meets modern economic requirements and is adapted to the Volgograd region conditions.

2. Materials and methods
The experimental part of the research was carried out in LLC "Kolos" of the Mikhailovsky district, the Volgograd region in 2017-2019. The soil of the experimental site is southern chestnut soil. The humus content in the arable layer is 4.6%, the thickness of the humus horizon is 35 cm. Total nitrogen is 0.3%, mobile phosphorus is 0.16%, exchangeable potassium is 2.1%, pH is 7.2. Meteorological conditions in 2011-2013 can be characterized as arid. During the growing season, 118.1 mm fell in 2017, 87.4 mm in 2018, and 187.6 mm in 2019, but 81.0 mm of them fell in September. The scientific research was conducted in a two-factor experiment according to the diagram shown in Figure 1.

The repetition was threefold, the placement was randomized. The size of the sowing plots was 60 × 8.4 m, the area was 504 m². The size of the registration plots was 50 × 6 m, the area was 300 m². The width of the sowing plots was determined by the working width of the Kinze seeder - 8.4 meters and was one pass of the seeder. When harvesting, a Case Axial-Flow 5088 combine with a header width of 6 meters was used. The passage with calculation of yield was carried out in the middle of each plot. The setting of experiments, all observations and accounting in the experiments were carried out according to generally accepted methods.

3. Results and discussion
The observations of the soil density in sunflower crops with different methods of basic soil cultivation in our experiments showed that the soil density during moldboard plowing by the PN-4-35 plow to the depth of 0.27-0.30 m, it had the following values in certain periods: in spring before sowing 1.14 t/m³, in the stage of basket formation 1.16 t/m³, for harvesting time 1.24 t/m³. When loosening by chisel "Rancho" to the depth of 0.35-0.37 m in spring before sowing 1.12 t/m³, in the stage of basket formation 1.14 t/m³, for harvesting 1.21 t/m³. When loosening by chisel "Rancho" to the depth of 0.35-0.37 m with the seed turnover of 0.15-0.17 m in spring before sowing 1.05 t/m³, in the stage of basket formation 1.10 t/m³, for harvesting time 1.16 t/m³. When loosening by chisel "Rancho" to the depth of 0.35-0.37 m with a pruning flat-cutting paw at the depth of 0.15-0.17 m in spring before sowing 1.08 t/m³, in the stage of basket formation 1.11 t/m³, for harvesting time 1.18 t/m³. On the option of "direct sowing" without tillage in spring before sowing, the soil density was 1.24 t/m³, in the stage of basket formation,
1.29 t/m³, and 1.37 t/m³ for harvesting time. Thus, it went beyond the optimal values. And this, in our opinion, was one of the main reasons for the decline in sunflower yields on this option of soil cultivation.

The values of the total on-off ratio on average for the growing season of sunflower in all the years of research for all methods of basic processing did not go beyond the optimal boundaries. The only exceptions are variants without processing - i.e. direct seeding. On these variants in all years the duty cycle was below the optimal values from 49.96 to 48.02%, and every year it became less and less (Table 1).

Table 1. Basic tillage methods influence on soil composition in the 0-0.4 m layer.

| Soil basic tillage method | 2017 | 2018 | 2019 | Average for 2017-2019 |
|---------------------------|------|------|------|-----------------------|
| Option 1                  | 57.55| 57.12| 57.03| 57.24                 |
| Option 2                  | 57.24| 57.35| 57.76| 57.46                 |
| Option 3                  | 57.65| 57.75| 58.84| 57.85                 |
| Option 4                  | 57.64| 57.76| 57.85| 57.75                 |
| Option 5                  | 49.96| 49.65| 48.02| 49.21                 |

Observations of the soil structure, its macro-aggregate composition showed that deep tillage with a seam turnover led to the increase in the blocky fraction up to 32%, had a lower structural coefficient, but a greater criterion of water resistance. On average, over the years of study, when plowing with the PN-4-35 plow on 0.27-0.30 m, the soil layer 0-0.3 m contained macroaggregates (particles from 0.25 to 10 mm) - 54.8%, with chisel loosening by the "Rancho" working body by 0.35-0.37 m with seam turnover by 0.15-0.17 m - 58.9%, with chisel moldboardless loosening by the "Rancho" working body by 0.35-0.37 m - 67.5%, and with “no” tillage, or direct sowing - 74.5%. There were 4.5-8.7% more water-resistant aggregates in the arable layer during chisel treatments than during plowing, and on options without tillage by 2.3-6.5% more than on options with chisel treatments.

By the spring, by the time of sunflower sowing, the largest reserve of productive moisture was accumulated in the variants of chisel loosening by the Rancho working body by 0.35-0.37 m with a seam turnover of 0.15-0.17 m; chisel loosening by the "Rancho" working body by 0.35-0.37 m with a trimming flat-cutting paw at the depth of 0.15-0.17 m; chisel moldboardless loosening by the "Rancho" working body by 0.35-0.37 m. This pattern was observed in all years of research. The difference in the reserves of productive moisture ranged from 46.2 to 55.5 mm in a meter layer and 13.4-21.2 mm in a 30-centimeter layer.

Table 2. The content of available moisture in a meter and 30-cm soil layer in spring before sowing, mm (average for 2017-2019).

| Soil basic tillage method | Layer 0-1.00 m | Layer 0-0.30 m |
|---------------------------|----------------|----------------|
| Option 1                  | 135.7          | 40.2           |
| Option 2                  | 148.6          | 44.7           |
| Option 3                  | 157.9          | 52.5           |
| Option 4                  | 151.2          | 48.7           |
| Option 5                  | 102.4          | 31.3           |

The study of the influence of the main tillage methods on sunflower weediness showed that chisel loosening by the Rancho working bodies to the depth of 0.35-0.37 m with a cutting paw at the depth of 0.15-0.17 m led to a decrease in weeds from 6 weeds per 2018 to 12 weeds per square meter in 2019.
The second most effective weed control option was the option with seam turnover - moldboard plowing with a PN-4-35 plow to the depth of 0.27-0.30 m and chisel loosening by Rancho working bodies to the depth of 0.35-0.37 m with a layer turnover of 0.15-0.17 m (on these options, before harvesting sunflower, 11 and 12 weeds per square meter were observed respectively in 2018 and 17 weeds in 2019) and the most contaminated were sunflower crops cultivated by using direct sowing technology - from 16 weeds per square meter in 2018 to 23 weeds per square meter in 2019.

The density of standing hybrids Rigasol and Opera for harvesting in the experiment was almost the same. It also did not differ very much in the way of basic tillage. Only on the variant of direct sowing (without treatment), there were 0.3-0.8 thousand pieces left for harvesting, plants/ha less than other variants. The mass of 1000 oilseeds varied on average over three years of research from 44.1 grams for the direct sowing option to 57.2 grams for the chisel loosening by the Rancho working bodies by 0.35-0.37 m with a seam turnover of 0.15-0.17 m for the Rigasol hybrid and from 46.5 grams for the direct sowing option to 59.8 grams for the chisel loosening by the Rancho working bodies by 0.35-0.37 m with a seam turnover of 0.15-0.17 m from the Opera hybrid. The smallest number of oilseeds in the basket of the Rigasol hybrid on average over three years of research - 739 was also formed on the direct sowing option, and the largest 1168 on the chisel loosening by the "Rancho" working bodies by 0.35-0.37 m with a seam rotation of 0.15-0.17 m. The yield in all the years of research was created both for the Rigasol hybrid and for the Opera hybrid on the version of chisel loosening by the Rancho working bodies by 0.35-0.37 m with a seam turnover of 0.15-0.17 m. In 2017-2019, it was 2.84 and 3.04 t/ha, respectively. The lowest biological yield was recorded on the direct sowing option, respectively, in the hybrid Rigasol and Opera 1.36 and 1.59 t/ha.

Table 3. Productivity of sunflower hybrids Rigasol and Opera, depending on the basic tillage method, t/ha.

| Soil basic tillage method | Rigasol  | Opera  |
|--------------------------|----------|--------|
|                          | 2017     | 2018   | 2019   | 2017 | 2018 | 2019 |
| Option 1                 | 1.84     | 1.23   | 1.97   | 1.96 | 1.41 | 2.05 |
| Option 2                 | 1.79     | 1.27   | 2.16   | 1.95 | 1.44 | 2.29 |
| Option 3                 | 2.05     | 1.48   | 2.27   | 2.12 | 1.55 | 2.45 |
| Option 4                 | 2.01     | 1.52   | 2.21   | 2.06 | 1.59 | 2.38 |
| Option 5                 | 0.83     | 0.52   | 1.54   | 0.86 | 0.51 | 1.77 |
| LSD05                    | 0.032    | 0.024  | 0.036  | 0.038| 0.026| 0.040|

Direct combining of sunflower showed that the highest hybrids yield was formed on the variants of Rancho chisel loosening to the depth of 0.35-0.37 m with a seam turnover of 0.15-0.17 m and Rancho chisel loosening to the depth of 0.35-0.37 m with a pruning flat-cutting paw at the depth of 0.15-0.17 m. The differences between them were from 0.04 to 0.07 t/ha, moreover, when cultivating both hybrids, in the increase in yield with moldless loosening with a pruning flat cutting paw in drier 2018 and in the increase yields on the Rancho chisel loosening option to the depth of 0.35-0.37 m with a seam turnover of 0.15-0.17 m in 2017 and 2019 more favorable in terms of meteorological conditions. The options for plowing with the PN-4-35 plow to the depth of 0.27-0.30 m and traditional chisel loosening "Rancho" to the depth of 0.35-0.37 m were inferior to these options in terms of sunflower yield by an average of 0.23-0.25 tons per hectare. The lowest yield was on the direct sowing option on average for 2017-2019 for the Rigasol hybrid 0.87 t/ha, for the Opera hybrid it was 1.05 t/ha.

It should also be noted that this experiment was based on the herbicide-free background, therefore, the yield of simple chisel loosening decreased due to increased weediness, in the second experiment on
backgrounds with the introduction of herbicides, the yield on all versions of chisel loosening was practically leveled. And on the option of direct sowing without tillage, especially in the dry 2018, it turned out, one might say, a deplorable harvest of 5 centners, i.e. below the level of economic feasibility of sowing.

4. Conclusion
As the result of the studies carried out from 2017 to 2019 in the zone of southern chernozems of the Nizhneje Povolzhje region, it was found that when comparing the methods of basic tillage when cultivating sunflower hybrids, the best values of agrophysical soil parameters, the content of available moisture, weediness of crops, and as the result, the maximum levels of sunflower yield on options for the Rancho chisel loosening to the depth of 0.35-0.37 m with a seam turnover of 0.15-0.17 m and Rancho chisel loosening to the depth of 0.35-0.37 m with an undercut flat-cut paw at the depth of 0.15-0.17 m.

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