Technology of strip chemical treatment in the resource-saving system of agriculture in Volgograd region

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Abstract. To preserve and restore disturbed lands and reduce the damaging impact on air, plants and soil, it is necessary to apply resource-saving technologies. Strip-till technology is recommended for tilled crops. The technical solution is offered to increase the efficiency of the working solution use due to the rational distribution on the objects of influence and increase of its uniformity. That is, it is possible to reduce the hectare rate of consumption of the working solution by using the method of strip chemical treatment of plants. This is achieved by the redistribution of the working solution between the row and the row with the cultivated plant. The technical solution is to equip the serial sprayer with two lines with spray nozzles and special separator bodies. After a quick changeover in the field without the use of special tools, it is possible to switch from continuous spraying to strip spraying and back. At switching over to strip spraying, the spray solution is sprayed strictly along the strips of cultivated plant growth and covers the whole surface of stem and leaves. This allows reducing the cost of liquid chemicalization agents application and accurately redistributing the working solution.

1. Introduction
In recent years, the competent use of resource-saving technologies is not only resource-efficient, but also cost-effective, as they allow to reduce costs and achieve higher yields of crops. At present, the resource-saving approach is actively implemented through strip-till technology [1]. The technology provides for strip-till tillage within the strip where the cultivated plant grows and develops, and the technological operations help to create favorable conditions for their growth and development. The row spacing remains untreated, which allows to accumulate plant residues and thus reduce erosion processes, retain moisture, make soil decompaction in the untreated strip naturally. Hoarse vegetation in the row spacing is in worse conditions than the cultivated plants in the treated strips, worse development and dying. The best results are achieved when growing in strip farming system of row crops, responsive to the depth of processing (sunflower, corn, soybean, sorghum, mustard, etc.). Good prospects in the application of strip farming technology in melon, vegetable and cotton crops. These directions show a positive effect in economic and energy aspects when growing these crops with row width of 0.9 and 1.2 m [2, 3]. On the territory of the Volgograd region strip farming is applied on the area of 914 thousand ha, and on the whole Russia 14,450 thousand ha. This emphasizes the prospects of developing the chosen research area. A significant disadvantage of strip-till technology is an
increase in chemical treatment costs and chemical inputs. Therefore, one of the ways to improve strip-till technology is to reduce costs and decrease the volume of working solution application. At the same time, it is important that the rate of chemical agent application to the object of influence remains the same.

As the rule, technological processes of plant protection in the field are carried out with liquid working solutions based on spraying. The liquid fertilizers main advantage is their rational use by plants [4]. Analysis of the structure of using the sprayer technological processes in the cultivation of sunflower allows to notice that for operations on the application of soil herbicide, protection from weeds, pests and diseases is more expedient to conduct treatment using the technology of continuous spraying, and foliar fertilization and desiccation should be carried out directly on the objects of influence, i.e., the cultivated crop. In this connection, it is important to substantiate the technological process of plants chemical treatment taking into account the specific cultivated crop and its development phase [5, 6].

2. Materials and methods

Application of the given technological approach allows to redistribute working solution with active substance, which as the result reduces hectare rates, while the rate of application on objects remains the same. In addition, the application of a differentiated approach to chemistry application will reduce stress on cultivated plants.

A team of scientists from the Volgograd state administration proposed to improve the known technological process and design the boom sprayer, adapting it for processing in strips, where the strips of cultivated plants growth alternate with the rows of weed vegetation [5, 7]. To do this, it is needed to redistribute the working solution on the strips with simultaneous coverage of the plant on the entire surface in the vertical plane. This is achieved by using side nozzles with oriented spray cones towards each other (RF Patent 2709762). The side nozzles should be placed over the row-spacing. During spraying the working solution between the upper edges of the spray cones is a zone of intersection with the spray angle of less than 180 degrees, and the lower edges are in the abris zone projection of a number of plants on the soil. The application of this lateral atomization method contributes to the transformation of atomization flows from each nozzle to a new more stable flow at their confluence. That is, the proposed method makes it possible to achieve a constant distribution (density) of the working solution within the treated band, regardless of the vertical vibrations of the boom [8, 9, 10].

The developed technical solution allows, due to switching between the bodies for several sprayers, to quickly adjust the sprayer both for the technology of continuous and strip distribution of the spray liquid [11, 12].

By using the plants strip chemical treatment method it is possible to reduce the per-hectare norm of chemical means of plant care within 25...45% relatively to the continuous treatment, without reducing the norms and quality of treatment of objects of influence [13]. Preliminary calculations of the economic effect of cultivated sunflower on the territory of the Volgograd region only from the introduction of strip chemical treatment technology will be within 1150-1200 rubles/ha (as of 2020 prices).

In order to achieve this scientific goal, a laboratory unit was installed as a change in the method of application of the solution to the plant, the working body of which is a Dropleg tube with slotted nozzles at 65° and 80°. The laboratory unit allows for a number of studies aimed at determining the nozzle performance over time when the system pressure changes from 1 to 4 atm., to measure the horizontal spray cone of the nozzles with the determination of the inflection point when narrowing the spray cone to the surface. The installation allows to change the height of the boom in the vertical direction depending on the phase of sunflower development. One can also change the angle of inclination of the spray cone relative to the vertical axis of the nozzle by 35°, 45°, 55° [14, 15]. A characteristic feature of the installation is the ability to observe the point of streams confluence directed at an angle towards each other. To process the parameters of the spray cone was drawn up a
program and methods of testing in accordance with All Union State standard, maps were made to fix
the parameters of the study. Based on the obtained readings, the Excel program was used to plot the
test parameters. Field observations were made during the whole phase of sunflower growth and
development with strict periodicity. All measurements were recorded with the help of video and photo
shooting.

3. Results and discussion
Scientific researches of a new method of applying a working solution to a plant are aimed at studying
the architectural features of the development phase of a specific cultivated crop. According to the table
of complex sunflower protection, processing is performed and depends on the phase of development,
caused by the growth of the stem and the number of pairs of leaves. Thus, if up to two pairs of leaves
grow, the whole processing of protection against weeds, pests and diseases is carried out (Figure 1).

| Days  | 0  | 5   | 12  | 16   | 18-53 | 57 | 59-61 | 65-71 | 90-94 |
|-------|----|-----|-----|------|-------|----|-------|-------|------|
| Plant height, m | 0  | 0.03 | 0.2 | 0.5  | 1.0   | 1.3 | 1.7   | 1.7   | 1.6  |
| Appointment | Before seeding | Germination | 1 pair of leaves | 2-3 pairs of leaves | 4-6 pairs of leaves | Budding | Flowering | The beginning of the browning of baskets | Full maturation |
| 1. Application of soil herbicide | + | | | | | | | | |
| 2. Protection from weeds | 5 | | | | | | | | |
| 3. Protection from pests | + | | | | | | | | |
| 4. Protection from disease | + | | | | | | | | |
| 5. Foliar application | | | | | | | | | |
| 6. Desiccation | | | | | | | | 90 |
| № operations | 3 | 4 | 5,6 | 7,8,9 | 10 | 11 | 12 | 13 |

... solid processing
... processing in the aisle
... processing by culture

Figure 1. Complex sunflower protection depending on the development phase.

However, when the plant reaches a height of 0.5 m continuous processing is not appropriate,
because the structure of the upper and lower tiers of leaves will overlap each other, and thus the
quality of processing will suffer. To analyze this assumption, measurements of sunflower, the
dependence of stem growth on the width of the leaf layers of the upper and lower tiers were made and a graph was drawn (Figure 2).

![Graph of leaf layers width](image)

**Figure 2.** Architectural features of sunflower in tiers.

As can be seen from the graph, the upper leaves overlap the lower tiers of leaves, which means that the drops of the working solution in this phase of sunflower development will not fall sufficiently on the stem, the back and outside of the leaves covered with the upper tiers. All this will lead to the development of diseases and pests, less effect from the application of liquid complex fertilizers and, ultimately, the decrease in the quality and quantity of crops [16, 17]. Therefore, in the second stage of research it was necessary to change the angle of inclination of the spray cone axis from the vertical for spray nozzles with the cone of 80° and 65°. Researches were carried out for angles of inclination of the spray cone axis by 35°, 45° and 55°. The behavior of upper and lower branches of the spray cone was studied and dependencies of pressure influence on the geometry of the sides of the spray cone were determined [5].

Experimental studies showed that the shape of the spray cone is identical to that of the vertical spray cone when the flow deviates by 0.6-0.8 m from the vertical axis of the nozzle. Then the shape changes under the influence of gravity and depends on the droplet size and flow intensity. In this case, the lower branch deviates from the vertical axis of 0.08 to 0.19 m. Accordingly, when two opposite flows merge, the working solution is transferred from the untreated part of the row spacing to the treated strip. The determination of this fact experimentally allows to draw a conclusion concerning reduction of row spacing contamination by chemical solutions. Complex solution of the problem in the part of solution redistribution allows reducing the consumption of hectare rate of working solution application at constant rate of pouring on the plant. It also reduces the dependence of the spray cone on the influence of weather conditions, turning it into more stable and uniform spray. The use of such technology and a new method of applying the solution to the plant in the future provides an opportunity to assess energy efficiency and savings of the working solution. From the point of view of practical approach, on the field it will look like an improvement in the volume of plant capture, when the axis of the spray cone at an angle of 45°, and thus improves the coating of the side leaves of the crop. If we talk about the percentage ratio, the distance of coverage captures increases by 87.5%.

4. Conclusions

Thus, the following conclusions can be drawn from the results of the carried out studies. In the applied technological processes of sunflower seedlings chemical treatment are not fully taken into account architectural features of the plant, which reduces the quality of spraying in the development phase of 2 - 8 pairs of leaves. The new method of application of the solution to the plants taking into account the
redistribution of the solution from the row spacing to the treated strip will be considered the most effective. For this purpose, a technical solution was developed, which allows mixing working solution flows directed towards each other with formation of a new flow. Application of the lateral atomization method allows to convert atomization flows from each nozzle into a new, more stable flow, having constant geometrical parameters with a larger coverage area at the plant tip and invariable at vibrations of the sprayer boom.

On the basis of theoretical calculations, taking into account previously obtained data from laboratory and field tests, the decrease in the flow rate of the working solution when processing sunflower with a row spacing of 0.7 m is 20-22%. In the future, this technology can be successfully used in the production of vegetable and melon crops, and when processing cotton with a row spacing of 0.9 m, this technology is especially relevant, as it will achieve the reduction in the volume of chemicals by 35-40%. The Volgograd region takes one of the leading places in production of vegetable crops, which can also be grown by strip technology. This technology also has good prospects for sale on melon crops, medicinal herbs and in cotton production.

References
[1] Pleskachev Yu N, Borisenko I B, Misyuryaev V Yu and Sidorov A N 2012 Improving methods of processing dark chestnut soils and applying nitrogen fertilizers for sunflower Fertility 2(65) 24-25
[2] Pleskachev Yu N, Semina N I and Antonnikova S E 2013 Innovative approaches in sunflower Proc. of the Nizhnevolszhsky Agrouniversity Complex: Science and Higher Professional Education 4(32) 36-41
[3] Pleskachev Yu N, Misyuryaev V Yu and Semina N I 2013 The use of organic farming elements in sunflower cultivation Scientific Review 3 15-18
[4] Pleskachev Yu N, Semina N I and Dolgov E Yu 2018 Technological methods of sunflower cultivation in the chernozem zone of the Volgograd region Scientific Life 12 175-182
[5] Voronov S I, Borodychev V V, Solodovnikov A P, Pleskachev Y N and Basakin M P 2020 The fight against creeping bitterness in the cultivation of winter wheat Agrarian Scientific J. 4 10-14
[6] Voronov S I, Misyuryaev V Yu, Korzhenko I A and Savinov E V 2020 Productivity of winter wheat in fields cleared of creeping mustard Agrarian Scientific J. 7 10-14
[7] Voronov S I, Kirichkova I V, Korzhenko I A and Savinov E V 2020 Measures to combat bitterness in the link of the crop rotation black steam-winter wheat Agrarian Russia 12 9-13
[8] Guo Hua M I, DaLi W U, Yan Ling C H, Ting Ting X A, Guo Zhong F G, Qian L I, Dong S H, Xiao Po S U, Qiang G A 2018 The ways to reduce chemical fertilizer input and increase fertilizer use efficiency in Maize in Northeast China Scientia Agricultura Sinica 51(14) 2758-2770
[9] Borisenko I B, Ovchinnikov A S, Meznikova M V, Fomin S D, Bocharnikov V S, Rogachev A F and Ulybina E I 2019 Resource-saving method of chemical treatment of tilled crops IOP Conf. Ser.: Earth Environ. Sci. 341 012092
[10] Borisenko I B, Meznikova M V and Ulybina E I 2020 Scientific aspects of technical modernization of sprayers for chemical protection sunflower Proc. of the Nizhnevolszhsky Agrouniversity Complex: Science and Higher Professional Education 4(60) 193-197
[11] Churzin V N and Dubovchenko A O 2020 The yield of sunflower hybrids depending on the moisture supply of crops in the chernozems of the Volgograd region Proc. of the Nizhnevolszhsky Agrouniversity Complex: Science and Higher Professional Education 1(57) 158-167
[12] Jaskulsa I, Gałęzewski L, Piekarczyk M and Jaskulski D 2018 Strip-till technology - a method for uniformity in the emergence and plant growth of winter rapeseed (Brassica napus L.) in different environmental conditions of Northern Poland Italian J. of Agronomy 13(3) 194-199
[13] Shaprov M N and Borisenko P I 2013 Agrotechnical approaches in the design of the working
body of minimal tillage with strip deepening Proc. of the Nizhnevolzhsky Agrouniversity Complex: Science and Higher Professional Education 4(32) 193-197

[14] Churzin V N and Dubovichenko A O 2020 The impact of ways of the main processing water-physical properties of southern black soil and yield of sunflower Proc. of the Nizhnevolzhsky Agrouniversity Complex: Science and Higher Professional Education 3(59) 181-189

[15] Shchukin S V, Gornich E A, Trufanov A M and Voronin A N 2019 Assessment of the effect of energy-saving technologies of basic tillage on the content of organic matter and agrophysical indicators of fertility Proc. of the Nizhnevolzhsky Agrouniversity Complex: Science and Higher Professional Education 4(56) 119-167

[16] Canales E, Bergtold J and Williams J 2018 Modeling the choice of tillage used for dryland corn, wheat and soybean production by farmers in Kansas Agricultural and Resource Economics Review 47(1) 90-117

[17] Medvedev G A, Yekaterinicheva N G, Tkachenko A V 2020 Efficiency of innovative systems of sunflower cultivation in the southern chernozems of the Volgograd region Proc. of the Nizhnevolzhsky Agrouniversity Complex: Science and Higher Professional Education 3(59) 116-124