Influence of rate of flow of working fluid on efficiency of application of herbicides in winter wheat

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Abstract. The greening factor in the application of herbicides is the targeted use of herbicides, and increasing productivity, generally by reducing the rate of flow of the working fluid. The aim of our study was to assess the influence of the rate of flow of the working fluid and size of nozzles on the efficiency of herbicides in winter wheat. The studies were conducted in 2019 at the experimental station of the State budgetary educational institution "Stavropol state agrarian University". In winter wheat studies were conducted on cultivar Tanya, the forecrop - sunflower. We studied the biological efficiency of the experimental tank mixture of herbicides c compared with the tank mixture of herbicides used at the experimental station. The results showed that the decrease in consumption rate of working solution to 50-100 l/ha and use nozzles caliber ST 110-01 and ST 110-02 has a negative effect: firstly on the expression of herbicidal activity, which leads to the increase of the period of oppression and destruction, as the cereals and dicotyledonous weeds; secondly on the species sensitivity of weeds reducing it from 2 to 7 %; third on the biological efficiency of herbicides, reducing it by 2-3% in the number of destroyed weeds and up to 6% on their biological ground.

1. Introduction
A number of technological and biological requirements are put forward to a balanced model of herbicides of vegetative action, which, first of all, include the combined spectrum of phytotoxic action, high potential for technical efficiency, the absence of toxic effects on cultivated plants, limited migration in the environment, and accelerated detoxification [1-3]. The greater the correspondence of any herbicide to the indicated positions, the greater the prospects for such general recognition and agrotechnological value are of such preparations [4].

The greening factor in the application of herbicides is the target nature of the use of herbicides, and an increase in labor productivity, as a rule by reducing the rate of flow of working fluid [5]. Herbicides of the system of vegetative use make it possible to reduce these two projections to one focus and prevent disturbance of the stability of the agroecosystem [6]. Currently, there are certain disputes regarding the effect of fluid flow rates on the efficiency of preparations [7, 8].

2. Materials and methods
The aim of our research was to assess the effect of the working fluid flow rate and spray gauge on the efficiency of the use of herbicides in winter wheat crops in the zone of unstable moisture in the Stavropol Territory.
The studies were carried out in 2019 at the experimental station FBSEI HE “Stavropol State Agrarian University”. In winter wheat crops, research was conducted on the Tanya cultivar, the forecrop being sunflower.

The soil cover is represented by leached chernozem, medium-power medium humus, medium and heavy loamy. Leached chernozems are characterized by high fertility, the absence of harmful salts, high humus content, good lumpy-granular structure, which is combined with favorable climatic conditions of the moderately humid zone.

We studied the biological efficiency of the tank mixture of herbicides manufactured by LLC “Singenta” Derby, SK (100 flumetsulam g / l +75 florasulam g / l) and Axial, CE (45 pinoxaden g / l + 11.25 clocvintoset-mexyl g / l) compared with the tank mixture of herbicides used at the Granstar Pro experimental station, VDG (750 tribenuron-methyl g / kg) + Senator, BP (480 dicamba g / l) + Avantix 100, CE (100 Fenoxaprop-P-ethyl g / l + 27 Cloquintos-mexyl g / l).

In the experiments there was a control and four variants of the experiment according to the scheme for the application of various norms of flowing fluid and economic control (table 1).

### Table 1. Scheme of experience and consumption rates of preparations.

| №  | Experience option                  | The consumption rate of the preparation, kg, l / ha | Spray gun gauge | The rate of flow of the working fluid, l / ha |
|----|-----------------------------------|---------------------------------------------------|-----------------|---------------------------------------------|
| 1  | Control (no processing)           | -                                                 | -               | -                                           |
| 2  | Derby, SK + Axial, CE             | 0.06 + 1.1                                        | ST 110-01 (orange) | 50                                          |
| 3  | Derby, SK + Axial, CE             | 0.06 + 1.1                                        | ST 110-02 (yellow) | 100                                         |
| 4  | Derby, SK + Axial, CE             | 0.06 + 1.1                                        | ST/CT 110-03 (blue) | 150                                         |
| 5  | Derby, SK + Axial, CE             | 0.06 + 1.1                                        | ST/CT 110-04 (red) | 200                                         |
| 6  | Granstar Pro, VDG + Senator, BP + Avantix, CE (economic control) | 0.015 + 0.15 + 0.75 | ST/CT 110-04 (red) | 200                                         |

Duration of use of pesticides: herbicides - phase "end of tillering"; the application method is a single ground treatment with the Jondir self-propelled sprayer with a working fluid flow rate according to the experimental scheme. We used standard ST / CT series slotted spray guns with a spray angle of 110 °, an operating pressure of 4 atmospheres, and a sprayer speed of about 10 km / h. To achieve the required rate of working fluid pouring on the experimental versions, the types of nozzles were changed: when making 200 l / ha, nozzles of the caliber ST / CT 110-04 (red) were used, when making 150 l / ha, nozzles of the caliber ST / CT 110-03 (blue), when applying 100 l / ha, nozzles of the caliber ST 110-02 were used (yellow), when applying 50 l / ha, nozzles of the caliber ST 110-01 (orange) were used. Color coding is according to ISO 10625.

To determine the biological efficiency of herbicides, we carried out two counts of the weediness of crops by the instrumental method with the determination of the dominant species composition of weeds of their quantity. On each option, 16 accounting sites were taken, 0.25 m² each, on each plot along two diagonals, and counting sites located.

The efficiency of the herbicides was calculated in the second and third counts, in relation to the initial weed in the experiment with the mandatory amendment to the control (“corrected” percentage of weed deaths).

### 3. Results and discussion
When accounting on April 17, 2019 in winter wheat crops before treatment with herbicides, the following weed species were prevailing; their number in the experiment variants was as follows:
veronica (species) - up to 17 pcs / m², field violet - up to 16 pcs / m², foxtail - up to 15 pcs / m², uneven roofing - up to 13 pcs / m², stalk-clad clear-leaved - up to 15 pcs / m², tenure - up to 22 pcs / m², pierced yarrow - up to 15 pcs / m², odorless chamomile - up to 14 pcs / m², cornflower blue - up to 6 pcs / m², pcs / m², wild oats - up to 7 pcs / m², ragweed - up to 59 pcs / m², pink sow thistle - up to 2 pcs / m², field bindweed - up to 5 t / m², only 1 m² numbered from 389 to 421 pcs / m² weeds, their weight varied from 762 to 983 g / m².

Spraying with a tank mixture of the studied preparations and economic control was carried out on 04.18.2019.

Observations of the dynamics of death of weeds under the influence of the studied herbicides were visually carried out daily. The results of the observations are placed in table 2.

**Table 2.** The dynamics of death of weeds, depending on the rate of flow of the working fluid under the action of herbicides on winter wheat.

| №  | Experience option               | The first signs, days | Oppression 50%, days | Death more than 50%, days | Full death, days |
|----|--------------------------------|-----------------------|-----------------------|---------------------------|-----------------|
|    |                                | Monocotyledous (Axial 0.91 l/ha) |                        |                           |                 |
| 1  | Control                        | 4                     | 15                    | 25                        | 34              |
| 2  | 50 l/ha;ST 110-01              | 3                     | 10                    | 18                        | 28              |
| 3  | 100 l/ha;ST 110-02             | 1                     | 7                     | 15                        | 23              |
| 4  | 150 l/ha;ST/CT 110-03          | 1                     | 4                     | 6                         | 18              |
| 5  | 200 l/ha;ST/CT 110-04          | 1                     | 4                     | 6                         | 18              |
| 6  | Avantix;ST/CT 110-04           | 3                     | 7                     | 10                        | 21              |

|    |                                | Dicotyledorous (Derby, SK 0.06 L / ha) |                        |                           |                 |
| 1  | Control                        | 4                     | 7                     | 11                        | 23              |
| 2  | 50 l/ha;ST 110-01              | 2                     | 5                     | 7                         | 19              |
| 3  | 100 l/ha;ST 110-02             | 1                     | 4                     | 6                         | 18              |
| 4  | 150 l/ha;ST/CT 110-03          | 1                     | 4                     | 6                         | 18              |
| 5  | 200 l/ha;ST/CT 110-04          | 1                     | 4                     | 6                         | 18              |
| 6  | Granstar Pro + Senator; ST / CT 110-04 | 3                     | 7                     | 10                        | 21              |

In the variant with application of Axial on cereal weeds (Neravnovesynkh roofing, empty Oats (Oat grass), Echinochloa, the ordinary quack Grass, Foxtail (Mice) green Foxtail (Mouse) gray, Foxtail myservicekey) the first signs of oppression: a stop in growth and development that we observed on the 3rd and 4th day after treatment in the commercial control (Avantix) on day 7. Discoloration the appearance of chlorotic spots and necrotech inhibited by 50% when using the preparation of Axial occurs at 7-15 a day depending on the rate of flow of the working fluid and used sprayers in the commercial control (Avantix) at day 14. The death of more than 50% of cereal comes on a 15-25 day in the commercial control (Avantix) by 23 days. Complete destruction of weeds in crops of winter wheat at application of preparation is noted on Axial us 21-34 days depending on the rate of flow of the working fluid and used sprayers in the commercial control (Avantix) by 32 days.

The preparation Derby, KS on dicotyledonous weeds observed in the first days of application of the wilting and twisting on the sensor visible through the weeds at 1 and 2 days after herbicide application, depending on, depending on the rate of flow of the working fluid and used sprayers in the commercial control (Granstar Pro, EDC + Senator) for 3 days. Swelling of the points of growth and dieback, discoloration and the appearance of chlorotic spots mikrotechnik inhibited by 50% when using the preparation occurs at 4-7 day depending on the rate of flow of the working fluid in the commercial control (Granstar Pro, EDC + Senator,Parliament of 0.015 + 0.15 l/ha) on day 7. The death of more than 50% of cereal comes on a 6-11 day in the commercial control (Granstar Pro, EDC + Senator,Parliament of 0.015 + 0.15 l/ha) for 10 days. Complete destruction of weeds in crops of winter wheat is at 18-23
days in economic control (Granstar Pro, EDC + Senator, Parliament of 0.015 + 0.15 l/ha) at 21 days. (table 2).

After analyzing the data on the species sensitivity of dicotyledonous weeds to reduce the flow rate of the working fluid to 50 and 100 l/ha when using nozzles ST 110-01 and ST 110-02 when spraying with Derby herbicide, SK in winter wheat crops, we see that biological efficiency against all types of weed vegetation. The greatest decrease in efficiency occurs in relation to perennial weeds, such as field bindweed, reduced to 75.4%, pink thistle to 78.3%. On average, according to the option, with a decrease in the rate of flow of the working solution to 50 and 101/ha and the use of a sprayer ST 110-01 and ST 110-02, the species biological efficiency of the Derby herbicide in relation to dicotyledonous weeds decreases by 0.8% (table 3).

### Table 3. Species biological efficiency of the Derby herbicide depending on the rate of flow of working fluid in winter wheat crops (%).

| №  | Weed species         | 50 ST 110-01 | 100 ST 110-02 | 150 ST/CT 110-03 | 200 ST/CT 110-03 |
|----|----------------------|--------------|--------------|------------------|-----------------|
| 1  | Veronica (species)   | 85.4         | 91.2         | 93.6             | 94.1            |
| 2  | Field violet         | 92.6         | 98.7         | 100              | 100             |
| 3  | Stem lamb            | 93.6         | 97.3         | 100              | 100             |
| 4  | Cleavers             | 91.3         | 95.2         | 100              | 100             |
| 5  | Piercing yarn        | 93.2         | 98.2         | 100              | 100             |
| 6  | Mayweed              | 91.3         | 94.4         | 98.4             | 100             |
| 7  | Blue cornflower      | 92.7         | 94.9         | 95.6             | 95.8            |
| 8  | Pink sow thistle     | 78.3         | 88.7         | 94.2             | 94.8            |
| 9  | Field bindweed       | 75.4         | 90.8         | 94.5             | 95.7            |
| 10 | Hook thistle         | 82.3         | 86.4         | 93.9             | 94.4            |
| 11 | Ural gerbil          | 95.1         | 96.4         | 97.8             | 98.5            |
| 12 | Leaf Ambrosia        | 93.4         | 99.1         | 100              | 100             |
|    | Average              | 88.7         | 94.3         | 97.3             | 98.1            |

Having analyzed the data on the species sensitivity of monocotyledonous weeds to the axial herbicide, CE in winter wheat crops with a decrease in the working fluid flow rate to 50 and 100 l/ha and the use of ST 110-01 and ST 110-02 sprayers, we see that this leads to a decrease in the biological efficiency of the herbicide by 13.1 and 8.1%, respectively (table 4).

Accounting carried out on 05/11/2019 showed that the control showed an increase in density of 5.0% and averaged 443 pcs/m2 of weeds, and an increase in mass of 167.2% and amounted to 2625 g/m2. In the version where the treatment was carried out by Derby, SK (100 + 75 g/kg) + Axial, CE (45 + 11.25 g/l) with a working fluid flow rate of 50 l/ha, a decrease in density was noted by 93.7%; masses - 90.1%. In the variant where the treatment was carried out with the same herbicides, but with a working fluid consumption of 100 l/ha, a decrease in density was noted by 95.3% and mass - 92.6%.

### Table 4. Species biological efficacies of Axial herbicide depending on the rate of flow of working fluid in winter wheat crops (%).

| №  | Weed species       | 50 ST 110-01 | 100 ST 110-02 | 150 ST/CT 110-03 | 200 ST/CT 110-03 |
|----|-------------------|--------------|--------------|------------------|-----------------|
In an option with the introduction of a working fluid flow rate of 150 l/ha, a decrease in density was noted by 96.5%; mass - 95.8% and in the variant where they brought in at a rate of flow of working fluid of 200 l/ha a decrease in density was noted by 97.2%; mass - 96.0%. In the economic control, where the tank mixture of herbicides Granstar Pro, VDG (750 g/kg) + Senator, BP (480 g/l) + Avantix, CE (100 + 27 g/l)), with a consumption rate of 0.015 + 0, was used 15 + 0.75 l/ha reduction in density was noted by 96.6%; mass - 93.4% (table 5).

Table 5. The influence of the flow rate of the working fluid of Derby herbicide on weeds in winter wheat crops 05.11.2019.

| №  | Experience option | Total weeds per m² | Quantity, pcs. | Mass, g | Density reduction, % | Mass reduction, % |
|----|-------------------|--------------------|----------------|--------|----------------------|-------------------|
| 1  | Control           | 443                | 2625           | -      | -                    | -                 |
| 2  | 50 l/ha; ST 110-01| 25                 | 89             | 93,7   | 90,1                 |                   |
| 3  | 100 l/ha; ST 110-02| 19              | 67             | 95,3   | 92,6                 |                   |
| 4  | 150 l/ha; ST/CT 110-03| 14           | 38             | 96,5   | 95,8                 |                   |
| 5  | 200 l/ha; ST/CT 110-04| 11          | 36             | 97,2   | 96,0                 |                   |
| 6  | Granstar Pro, EDC + Senator, BP + Avantix, CE| 14  | 59             | 96,6   | 93,4                 |                   |

Similar data were obtained both by the validity of the working fluid flow rate and before harvesting on July 5, 2019. Accounting carried out before harvesting winter wheat showed that the control showed an increase in density by 7.0%, and the weight increase was 296.2%. By harvesting, the efficiency of herbicides did not decrease significantly in density by 1.0 - 2.0%, in mass - by 0.5 - 1.3%. This happened due to the emergence of late spring weeds (ragweed, etc.) and the growth of species that showed moderate resistance to herbicides (sow thistle and veronica species), but they were in the lower tier of agrocenosis and did not have economic significance (table 6).

Table 6. The effect of herbicides on weeds in winter wheat crops 05.07.2019.

| №  | Experience option | Total weeds per m² | Quantity, pcs. | Mass, g | Density reduction, % | Mass reduction, % |
|----|-------------------|--------------------|----------------|--------|----------------------|-------------------|
| 1  | Control           | 451                | 3356           | -      | -                    | -                 |
| 2  | 50 l/ha; ST 110-01| 28                 | 101            | 93,0   | 88,8                 |                   |
| 3  | 100 l/ha; ST 110-02| 21              | 79             | 94,8   | 91,2                 |                   |
| 4  | 150 l/ha; ST/CT 110-03| 16           | 51             | 96,0   | 94,3                 |                   |
| 5  | 200 l/ha; ST/CT 110-04| 14          | 45             | 96,5   | 95,0                 |                   |
| 6  | Granstar Pro, EDC + Senator, BP + Avantix, CE| 18  | 84             | 95,6   | 90,6                 |                   |
fluid flow rate of 100 l / ha, a decrease in density was noted by 94.8%; mass - 91.2%. In the variant with the introduction of a working fluid flow rate of 150 l / ha, a decrease in density was noted by 96.0%; masses - 94.3% and in the variant where they brought in at a rate of flow of working fluid of 200 l / ha, a decrease in density was noted by 96.5%; masses - 95.0%. In the economic control, where the tank mixture of herbicides Granstar Pro, VDG (750 g / kg) + Senator, BP (480 g / l) + Avantix, CE (100 + 27 g / l)), with a consumption rate of 0.015 + 0, was used 15 + 0.75 l / ha a decrease in density was noted by 95.6%; mass - 90.6%.

4. Conclusions
As a result of the data obtained, we see that a decrease in the rate of consumption of the working solution to 50-100 l / ha and the use of atomizers of the caliber ST 110-01 and ST 110-02 negatively affect: firstly, the manifestation of herbicidal activity, which leads to an increase in the duration of inhibition and death of both cereal and dicotyledonous weed vegetation; secondly, on the species sensitivity of weeds, reducing it from 3.8 to 13.1%; thirdly, on the biological efficiency of the herbicides used, reducing it by 2-3% in the number of weeds destroyed and up to 6% in their biological mass.

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