# Weediness of agrocenoses in grain-fallow crop rotation depending on agrotechnological methods

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**Abstract.** The purpose of this research was to study the influence of basic tillage systems and chemicalization options on the weed infestation of agrocenoses in a grain-fallow crop rotation. The experiment was conducted at the Tambov Research Institute of Agriculture on typical, heavy loamy chernozem soil with a humus content of 6.8-7.0%. Five systems of basic tillage were studied. Three levels of mineral nutrition and two levels of plant protection were also investigated. The agrocenoses were characterized by a mixed type of weed infestation with a predominance of annual weed species. The surface treatment system led to an increase in agrocenosis infestation in terms of weed numbers by 27.6% and air-dry mass by 41.4%. Combined treatment systems helped reduce the number of weeds by 27.6 and 37.9%, and their biomass by 23.4 and 32.4%. The application of mineral fertilizers decreased crop infestation, while chemical weeding of crops reduced the number of weeds by 53.6-71.7% and the air-dry mass by 62.0-72.1%. Ploughless cultivation systems significantly reduced the productivity of arable land in the crop rotation. Traditional moldboard and combined systems provided equal output from 1 hectare of arable land.

## 1 Introduction

The effectiveness of using soil fertility and means of intensification is largely determined by the contamination of agrocenoses, which is one of the most significant factors limiting the growth of agricultural production [1-3]. In technological complexes for cultivating field crops of different intensity levels, the use of one or another method of soil cultivation remains an important issue [4-6]. Increasing the intensity of tillage and the use of extreme minimization of tillage leads to deterioration of fertility, increased weediness of fields and, ultimately, a decrease in the productivity of field crops [7,8].

To improve technological complexes for cultivating crops in crop rotations, it is necessary to optimize the plant nutrition system [9,10]. The use of fertilizers against the background of various soil treatments led to an increase in the number of annual weeds and a decrease in the number of shoots of perennial weeds in winter wheat crops [11]. At the same time, there

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is experimental data indicating an insignificant effect of fertilizers on the degree of weediness in agrocenoses [12].

In agrotechnological complexes for cultivating agricultural crops, one of the main factors limiting the development and spread of weeds and other harmful objects is the chemical method of protection, used taking into account soil and climatic conditions, the species composition of harmful objects and the economic threshold of harmfulness [13].

## 2 Materials and methods

The purpose of the research is to study the influence of elements of crop cultivation technologies on the productivity of grain-fallow crop rotation in the conditions of the northeast of the Central Chernozem Zone.

One of the objectives of the research was to determine the influence of basic tillage systems, fertilizers and herbicides on the weed infestation of agrophytocenoses of grain-fallow crop rotation to optimize crop cultivation technologies.

The research was carried out in 2021-2023 on the experimental field of the Tambov Research Institute of Agriculture - of the I.V. Michurin Federal State Budgetary Scientific Research Center" in a four-field grain fallow crop rotation, deployed in space and time: fallow - winter wheat - soybeans - barley. The repetition in the stationary field experiment is threefold with sequential placement of options. The split plot method was used in the experiment. First-order plots (basic tillage) – the sown area of the plot is 374 m2, the accounting area is 230 $m^2$; second order (fertilizers) - 1242 m and 62 $m^2$, respectively, and third order plots - (plant protection) - sown area 62 m, accounting area - 25 $m^2$. We studied five main tillage systems in crop rotation (factor A): traditional mouldboard, mixed-depth for grain crops at 20-22 cm, soybeans at 25-27 cm, permanent surface (discing at 10-12 cm) for all crops of the crop rotation, permanent, non-moldboard, mixed-depth 20-22 cm for grain crops and 25-27 cm for soybeans, combined (moldboard-non-moldboard and (moldboard-surface) with plowing for soybeans, non-mouldboard and surface tillage for grain crops.

The main treatment in all variants was carried out against the background of preliminary disk loosening of 8-10 cm.

For each soil treatment option, three levels of mineral nutrition were applied: $N_{60}P_{60}K_{60}$; $N_{30}P_{30}K_{30}$ and $N_{10}P_0K_0$ kg a.v. fertilizers per 1 hectare of arable land and two levels of plant protection system: seed treatment - background and background + herbicides, fungicides and insecticides during the growing season of crops. Azophoska (with an element ratio of 16:16:16) was used as a fertilizer. Objects of research: winter wheat - Scepter, spring barley - Chakinsky 221 and soybean - Avanta.

The soil cover of the experimental plot is represented by typical chernozem, heavy loamy. The humus content in the arable layer is on average 6.9%. The supply of mobile phosphorus and exchangeable potassium is high and increased - 150-170 and 130-150 mg/kg of soil, respectively, pH (sol) - 6.6-6.8.

Weed infestation of field crops in crop rotation was determined before harvesting using the quantitative-weight method [14].

The yield of crops in grain-fallow crop rotation was taken into account by direct threshing using a small-sized SAMPO-500 breeding combine, followed by conversion to standard humidity.

The experimental data were assessed using the dispersion method according to Dospehov [15].

Weather conditions during the growing seasons during the years of research varied and had deviations from the long-term average. Thus, the growing seasons (May – August) in 2021 and 2022 were characterized by insufficient precipitation, less by 86 and 102 mm, and increased air temperature, more by 3 and 1.9 ° C compared to the long-term average. In 2023,

during the growing season, precipitation fell 78.5 mm above normal, and the air temperature was at the level of the long-term average.

In agrocenoses of field crops of crop rotation, the species composition of weeds was typical for the Tambov region, which can be classified into three ecological and biological groups and characterized as young-root-sprouting. At the same time, more than 85% of the total number of weeds accounted for the share of annual species, among which the dominant species were: common barnyard grass, bird's knotweed, convolvulus knotweed, blue cornflower, common pikeweed, field lily, medicinal fume grass, green bristle grass, tenacious bedstraw, upturned acorn grass, white pigweed, field violet, bindweed buckwheat, odorless chamomile. Root shoots were found in smaller numbers - field bindweed, which to a greater extent infested crops against the backdrop of surface tillage in crop rotation. Field thistle plants were present in separate clumps in the crops.

## 3 Results and discussion

An analysis of the weed infestation of crops in crop rotation at the time of harvesting showed that the number of weeds and their weight depended on the technological methods of cultivation. Counts carried out in crops revealed certain patterns in the formation of the numerical composition and mass of weeds depending on the main tillage in the crop rotation (Fig. 1).

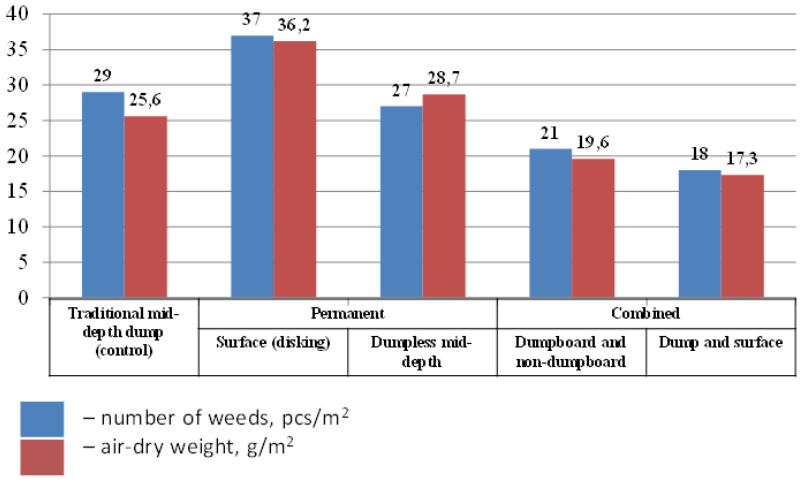


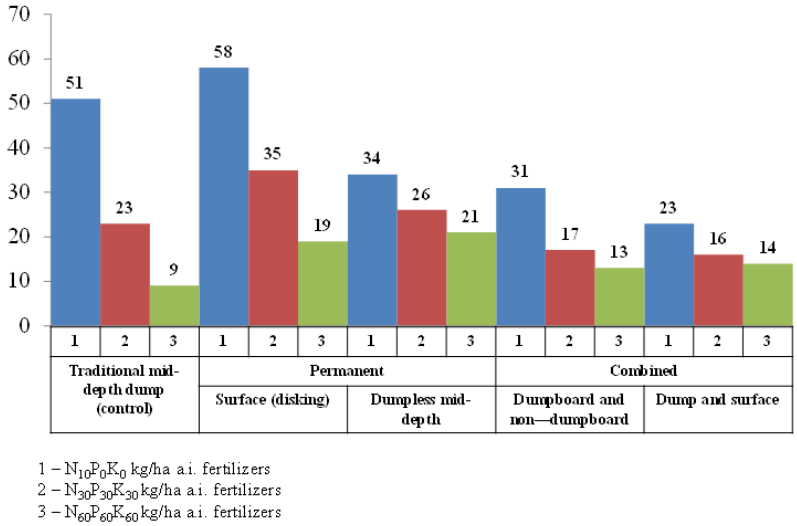

**Fig. 1.** Infestation of agrocenoses in grain-fallow crop rotation depending on the main tillage systems on average for 2021-2023.

Thus, the use of a non-mouldboard, multi-depth tillage system in crop rotation did not have a significant effect on either the number or mass of the weed component compared to the control (traditional mouldboard, multi-depth tillage system). At the same time, with the surface system (disking 10-12 cm), an increase in the density and air-dry mass of weeds was observed. The number of weeds increased by 27.6%, air-dry mass by 41.4%.

The use of technological complexes for cultivating crops in crop rotation based on combined (moldboard-mouldboard-less and dump-surface) cultivation systems contributed to a reduction in the number of weeds by 27.6 and 37.9%, the biomass of the weed component - by 23.4 and 32.4% compared with control.

The use of fertilizers against the background of various soil treatments had a certain impact on the weediness of agrophytocenoses in grain-fallow crop rotation. The results of

counting weeds clearly demonstrated that with an increase in the level of mineral nutrition, the infestation of crops decreased (Fig. 2).




1 – $N_{10}P_0K_0$ kg/ha a.i. fertilizers
2 – $N_{30}P_{30}K_{30}$ kg/ha a.i. fertilizers
3 – $N_{60}P_{60}K_{60}$ kg/ha a.i. fertilizers

**Fig. 2.** Weed infestation of agrocenoses of grain-fallow crop rotation depending on the level of mineral nutrition under different soil cultivation systems on average for 2021-2023.

Increasing the dose of mineral fertilizers from $N_{10}P_0K_0$ до $N_{60}P_{60}K_{60}$ kg a.i./ha of arable land in crop rotation contributed to a reduction in the number of weeds before harvesting by 5.7 times in technologies with a traditional moldboard mixed-depth tillage system, by 3.1 times in technologies with surface tillage. For other soil treatment options, weed infestation from increasing the dose of fertilizer application decreased by 1.6-2.4 times. The decrease in weediness with an increase in the level of mineral nutrition can be explained by the more powerful development of cultivated plants and a stronger suppressive effect on weeds.

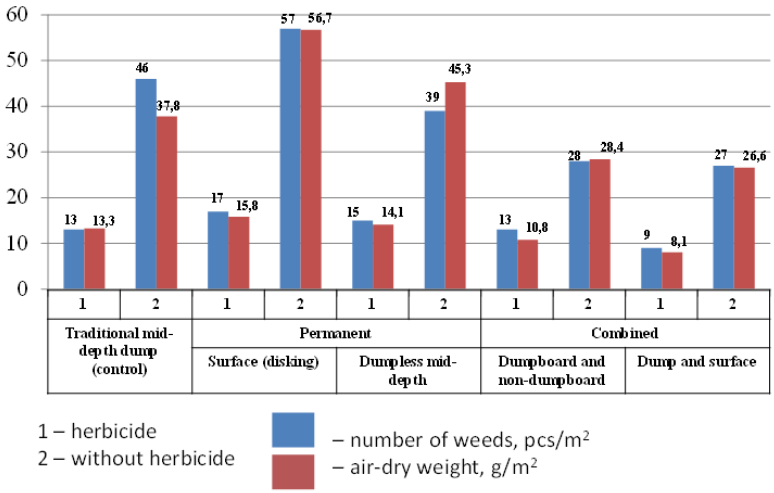



**Fig. 3.** The effectiveness of chemical weeding of crops in grain-fallow crop rotation against the background of various systems of primary soil cultivation on average for 2021-2023.

A comparative analysis of the infestation of agrocenoses in crop rotation during the harvesting period, in variants with and without chemical weeding of crops from weeds, showed that treatment with herbicides helped to significantly reduce the infestation of crops (Fig. 3).

In general, it should be noted that chemical weeding of crops under grain-fallow crop rotation in all variants of the experiment provided a high biological effect, reducing the number and weight of weeds. Moreover, the greatest reduction in the number of weeds from chemical weeding of crops (71.7 and 70.2%) was observed in variants with traditional moldboard and surface tillage systems. In technologies with no-moldboard, mid-depth and combined (mouldboard-no-moldboard and mouldboard-surface) treatment systems, the number of weeds from the use of herbicides decreased by 61.5, 53.6 and 66.7%, respectively.

Chemical weeding of crops against the backdrop of surface tillage ensured a reduction in the air-dry mass of weeds by 72.1%. For other tillage options, this figure varied between 62.0-69.5%.

In technologies based on a surface tillage system in combination with chemical weeding, the infestation of crops in crop rotation before harvest remains higher compared to traditional moldboard and other systems of primary tillage.

The effectiveness of technologies in agriculture is assessed by the yield of cultivated crops and the productivity of arable land. The studied technological methods for cultivating field crops in grain-fallow crop rotation differ in the productivity of arable land (Table 1).

**Table 1.** Productivity of arable land in grain-fallow crop rotation, depending on technological methods of cultivating field crops, on average for 2021-2023.

| **Tillage system (factor A)** | **Mineral nutrition level (factor B)** | **Plant protection (factor C)** | **Product output from 1 hectare of arable land, thousand tons of grain, units** | **Increase against the background of +.- thousand t/ha** | | |
|---|---|---|---|---|---|---|
| | | | | **Soil treatment** | **fertilizers** | **Plant protection** |
| Traditional mid-depth dump (control) | $N_{60}P_{60}K_{60}$ | 1* | 2.93 | – | 0.28 | – |
| | | 2** | 3.32 | – | 0.38 | 0.39 |
| | $N_{30}P_{30}K_{30}$ | 1 | 2.75 | – | 0.10 | – |
| | | 2 | 3.05 | – | 0.11 | 0.30 |
| | $N_{10}P_0K_0$ | 1 | 2.65 | – | – | – |
| | | 2 | 2.94 | – | – | 0.29 |
| Average for tillage | | | 2.94 | – | – | 0.33 |
| Permanent surface (disking 10-12 cm) | $N_{60}P_{60}K_{60}$ | 1 | 2.77 | -0.23 | 0.32 | – |
| | | 2 | 3.17 | -0.15 | 0.41 | 0.40 |
| | $N_{30}P_{30}K_{30}$ | 1 | 2.59 | -0.16 | 0.14 | – |
| | | 2 | 3.03 | -0.02 | 0.27 | 0.44 |
| | $N_{10}P_0K_0$ | 1 | 2.45 | -0.20 | – | – |
| | | 2 | 2.76 | -0.18 | – | 0.31 |
| Average for tillage | | | 2.79 | -0.19 | – | 0.38 |
| Permanent dumpless mid-depth | $N_{60}P_{60}K_{60}$ | 1 | 2.83 | -0.10 | 0.26 | – |
| | | 2 | 2.99 | -0.33 | 0.13 | 0.16 |
| | $N_{30}P_{30}K_{30}$ | 1 | 2.61 | -0.14 | 0.04 | – |
| | | 2 | 2.99 | -006 | 0.13 | 0.38 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | $N_{10}P_0K_0$ | 1 | 2.57 | -0.03 | – | – |
| | | 2 | 2.86 | -0.08 | – | 0.29 |
| Average for tillage | | | 2.81 | -0.13 | – | 0.28 |
| Combined dump-dumpless | $N_{60}P_{60}K_{60}$ | 1 | 2.89 | -0.04 | 0.31 | – |
| | | 2 | 3.21 | -0.11 | 0.24 | 0.32 |
| | $N_{30}P_{30}K_{30}$ | 1 | 2.77 | 0.02 | 0.19 | – |
| | | 2 | 3.03 | -0.02 | 0.06 | 0.26 |
| | $N_{10}P_0K_0$ | 1 | 2.58 | -0.07 | – | – |
| | | 2 | 2.97 | 0.03 | – | 0.39 |
| Average for tillage | | | 2.91 | -0.03 | – | 0.32 |
| Combined dump-surface | $N_{60}P_{60}K_{60}$ | 1 | 2.96 | 0.03 | 0.37 | – |
| | | 2 | 3.27 | -0.05 | 0.40 | 0.31 |
| | $N_{30}P_{30}K_{30}$ | 1 | 2.81 | 0.06 | 0.22 | – |
| | | 2 | 3.05 | 0 | 0.18 | 0.24 |
| | $N_{10}P_0K_0$ | 1 | 2.59 | -0.06 | – | – |
| | | 2 | 2.87 | -0.07 | – | 0.28 |
| Average for tillage | | | 2.92 | -0.02 | – | 0.28 |

$HCP_{05}$: for average private- 0.08 t/ha; for factor A - 0.09 t/ha; for factor B - 0.07 t/ha; for factor C - 0.06 t/ha.
Note: 1* - seed dressing – background; 2** - background + herbicides, fungicides, insecticides

The best options turned out to be traditional mouldboard, mixed-depth and combined (mouldboard-non-mouldboard and mouldboard-surface) tillage in crop rotation, providing the highest productivity of crop rotation - 2.91-2.94 thousand t/ha of grain units. Options with surface (discing at 10-12 cm) and non-mouldboard multi-depth tillage systems caused a significant decrease in the productivity of arable land in crop rotation, amounting to 0.19 and 0.13 thousand t/ha of grain units ($HCP_{05}$ = 0.09 thousand t/ ha). The use of fertilizers and increasing their application rates had a positive effect on the productivity of arable land, which, on average, for soil treatment options against the background of $N_{60}P_{60}K_{60}$ in relation to the low level of mineral nutrition $N_{10}P_0K_0$ increased by 0.31 thousand t/ha of grain units. Chemical weeding of crops ensured an increase in the productivity of arable land in crop rotation according to the main tillage options by 0.28-0.38 thousand t/ha of grain units.

## 4 Conclusion

Thus, the studies conducted on the influence of basic tillage systems, fertilizers and herbicides on the formation of the weed component in agrocenoses of grain-fallow crop rotation and the level of its harmfulness allow us to conclude that the surface tillage system (discing at 10-12 cm) increases the weed infestation of crops. crop rotation in terms of weed numbers by 27.6%, air-dry mass by 41.4%. At the same time, treatment of crops with herbicides, against the background of surface treatment, ensured high efficiency; the number of weeds decreased by 70.2%, but remained the highest compared to the control (traditional mouldboard, mixed-depth) and other tillage options.

The highest effectiveness against weeds is characterized by combined (moldboard-non-mouldboard and moldboard-surface) soil cultivation systems, which contributed to a reduction in the number and weight of weeds at the time of harvesting by 27.6 and 37.9% and 23.4 and 32.4%.

When applying mineral fertilizers, a decrease in the weed component was noted in agrocenoses of grain-fallow crop rotation, which is largely due to the more powerful development of cultivated plants.

The use of herbicides reduced the infestation of crops under various soil treatment options by 53.6-71.2% in terms of numbers and by 62.0-72.1% in terms of air-dry mass of weeds.

In grain-fallow crop rotation, as primary tillage systems, it is possible to use combined ones (moldboard-non-moldboard and mouldboard-surface), ensuring the productivity of arable land at the level of traditional moldboard mixed-depth.

The use of chemical agents (mineral fertilizers and chemical weeding) helps to increase the productivity of arable land in crop rotation.

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