Agronomic assessment of the herbicides application on winter wheat crops

O.A. Savoskina*, *S.I.* Chebanenko, *I.A.* Zavertkin, *A.V.* Shitikova, and *S.A.* Zapivalov

Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, 49 Timiryazevskaya str., 127434, Moscow, Russia

Abstract. In modern conditions of agricultural production, it is important to obtain a high yield of good quality, which may be limited by a high degree of contamination of crops. At the same time, it is necessary to search for new approaches to the weed control problem, which involves solving a number of issues: determining and analyzing the floral composition of weeds with constant monitoring of contamination to make forecasts and make operational decisions. This work is devoted to the study of these issues. It reveals the features of winter wheat agrophytocenosis formation with the analysis of weed species composition, and shows the effectiveness of the use of herbicides recommended on the basis of mapping. The biological efficiency of the spray mixture of herbicides Verdict + Dinat was 84.1% (by the number of weeds) and 94.9% (by air-dry weight). The agronomic effectiveness of herbicides was expressed in obtaining an increase in yield of 2.67 t/ha, and the profitability level was above the threshold of economic feasibility of the weed management and amounted to 141.8%.

1 Introduction

Winter wheat is a valuable food crop and at the moment the issue of improving the technology of its cultivation through the optimization of individual parts of the farming system does not lose relevance: scientifically based crop rotation, rational use of fertilizers, control of harmful objects, etc. [1].

In terms of the area of grain crops, Russia occupies one of the first places in the world, but this cannot be said about the yield. According to the data for 2016-2020, the yield of winter wheat averaged 2.75 t/ha. It could be attributed basically to the low level of agricultural culture, nevertheless, still there are points that are not obvious to everyone, but understandable to agronomists. Now more than 70% of grain crops are heavily and moderately weeded. The annual potential losses of grain harvest from weeds amount to a total of 10-12 million tons. Considering the importance of grain farming in the country's economy as a whole and winter wheat in particular, the control of weeds in crops is put in the first place to ensure food security [2, 3, 4].

In the current situation, weed control has become a priority in the field of plant protection, since without its successful solution it is pointless to carry out all other measures aimed at improving soil fertility and increasing crop productivity [5].

* Corresponding author: osavoskina@rgau-msha.ru

In production conditions, it can be quite time-consuming to choose an effective herbicide. This process is associated with consideration and in-depth analysis of various factors, such as, for example, biological features of crops and weeds, phenological phases of their development, soil and climatic conditions, characteristics of preparations. Moreover, these factors should be compared with the crop cultivation technology adopted in the farm, its provision with appropriate equipment and resources [6, 7, 8].

It is known that the choice of preparations for application can be carried out in several ways: using crop protection systems developed by pesticide manufacturers; technological protection maps and crop cultivation technologies; specialized information published in the journal "Plant Protection and Quarantine". In addition, the selection of pesticides is also practiced using information search engines in the Internet space [9].

Nevertheless, it is not enough to choose a preparation considering the crops contamination type, it is important that the herbicide shows high efficiency both biological and agronomic one [10].

2 Materials and Methods

The research was carried out in the Non-Chernozem zone of Russia at the Golovkovo Collective Farm LLC (2020-2022), located in the Naro-Fominsk district of the Moscow region (latitude - 55.450, longitude - 36.595). The region belongs to the taiga soil-climatic zone with a temperate climate. The land use area of the farm is represented by a complex of sod-medium-podzolic loamy soils on the moraine and sod-strong-podzolic loamy soils on the cover loams. In the field, when cultivating winter wheat, soil agrochemical indicators were close to optimal values, as evidenced by the consolidated quality indicator, which was equal to 84.5 points (Table 1).

Table 1. Soil agrochemical characteristics.

Indicator	Value
Acidity pH KCI	6.0
Organic matter content, %	
P_2O_5 content, mg/kg of soil	180
K_2O content, mg/kg of soil	100
Amount of absorbed bases, mg. eq. per 100 g	10.1
Degree of base saturation, %	90.0
Ca content, mg. eq. per 100 g	7.9
Mg content, mg. eq. per 100 g	2.2

Our research was carried out in winter wheat crops grown in feed grain-grass-row crop rotation:

- 1. Barley with undersowing of perennial herbs,
- 2. Perennial herbs of 1 year of use,
- 3. Perennial herbs 2 years of use,
- 4. Winter wheat,
- 5. Corn for silage.

Meteorological conditions during the years of the research were characterized by uneven provision of natural moisture supply to the soil with precipitation in comparison with the average long-term nature of their precipitation.

The object of the study was winter wheat plants and weeds. The farm cultivates winter wheat of the Moskovskaya 40 variety (breeding work participants: E.T. Varenitsa, B.I. Sandukhadze, and G.V. Kochetygov), which was bred in 1999, and it was included in the State Register of Breeding Achievements in 2011. This variety is recommended for the Central region of Russia (Figure).

Weeds were represented by specimens from various biological groups growing on the farm territory.

For chemical weeding, the spray mixture of selective herbicides was used: Verdict (water-dispersible granules) with a spectrum of action against juvenile and some perennial dicotyledons, as well as some juvenile monocotyledons (oatmeal, bluegrass, foxtail, apera) weeds. The active substance is Iodosulfuron-methyl-sodium (6 g/kg) + Mesosulfuron-methyl (30 g/kg) + Mephenpyr-diethyl (90 g/kg); Dinat (aqueous solution) against juvenile dicotyledons, including resistant to 2,4-D and 2M-4X, and some perennial dicotyledons, including species of thristle (Cirsium, etc.), weeds. The active substance is Dicamba (dimethylamine salt) (480 g/l) with a rate of application of 0.4 kg/ha and 0.2 l/ha, respectively.

The treatment was carried out in the spring tillering phase by a single continuous ground spraying (OP 2000) of vegetating plants with operating fluid consumption of 200 l/ha.

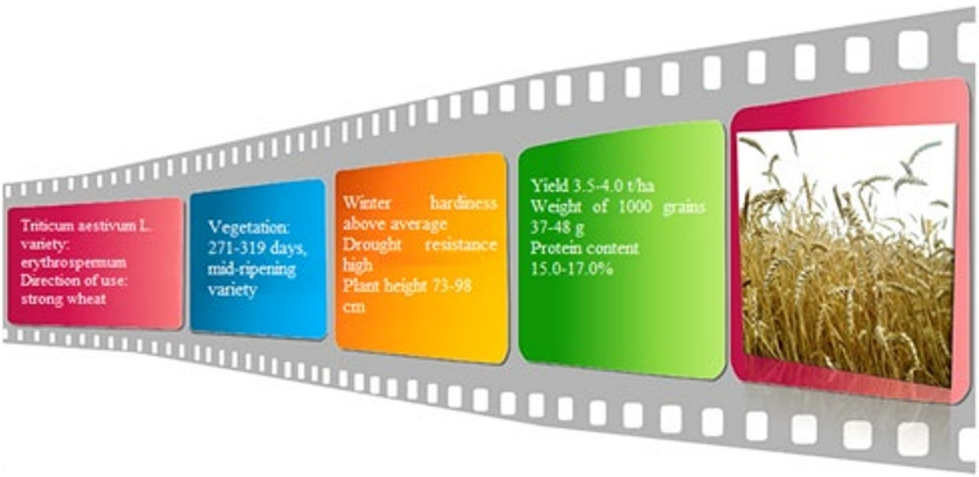

Fig. 1. Brief description of the winter wheat variety Moskovskaya 40.

Accounting for the contamination of crops was carried out by quantitative-specific and quantitative-weight methods. The route ran along the field diagonal. Along the movement, 10 frames with an accounting area of 0.25 m² were applied at regular intervals.

The technical (biological) effectiveness of herbicides was assessed by reducing the number and mass of weeds relative to control in each accounting period. For these herbicides, it was calculated according to the following formula:

$$BE = 100 – Co/Ck \times 100,$$

where BE is a decrease in the number of weeds in % of the control; Co and Ck are the number of weeds per 1m² in the experiment and in the control, respectively, at the first and subsequent counts, pcs/m² or g/m².

The indicator of the economic efficiency of any plant protection technique, including the use of herbicides, was calculated by assessing the level of the preserved (protected) crop by the difference between the actually observed values in experimental and control (without herbicide) options. A week before harvesting, sheaves were selected to determine the crop structure.

The yield was collected by a continuous method with a Polesie combine harvester at a cut height of 14-16 cm. The grain weight was determined after sorting on a laboratory winnowing machine of the SN-16PM brand to 100% purity in terms of 1 ha and 14% humidity.

3 Results

The flora of the Central region of the Non-Chernozem zone is represented by over 600 species of higher plants. From an agronomic point of view, segetal weeds are of interest, of which there are about 160 species in the district.

Within one field where the research was carried out, the species composition of weeds consisted of 22 species that belonged to 12 families. Weeds of the Asteraceae family dominated (24.9%), including 3 species, while the Amaranthaceae and Boraginaceae families accounted for only 1.8% each.

The floristic composition of weeds included 5 biogroups. Juvenile weeds were represented by a biogroup of early spring (8 species) - Chenopodium album, Fumaria officinalis, Galeoopsis speciose, Poa annua, Polygonum spp., Raphanus raphanistrum, Spergula arvensis; late spring (2 species) - Amaranthus retroflexus, Echinochloa crus-galli; wintering (6 species) - Capsella bura- pastoris, Lamium purpureum, Matricaria spp., Myosotis arvensis, Thlaspi arvense, Viola arvensis. Perennial weeds belonged to 2 biogroups: soboliferous (3 species) - Cirsium arvense, Convolvulus arvensis; rhizomatous (1 species) - Erytrigia repens.

Chenopodium album (10.1%), Viola arvensis (10.1%), and Matricaria spp. (13.6%) dominated among juvenile weeds, and Cirsium arvense (8.9%) dominated among perennial weeds.

The species composition was dominated by representatives of dicotyledon (broad-leaved) plants, the proportion of which was 88.8%.

The total number of weeds before herbicide treatment of crops was 169 pcs/m², which is 5.6 times higher than the economic threshold of harmfulness (Figure 2).

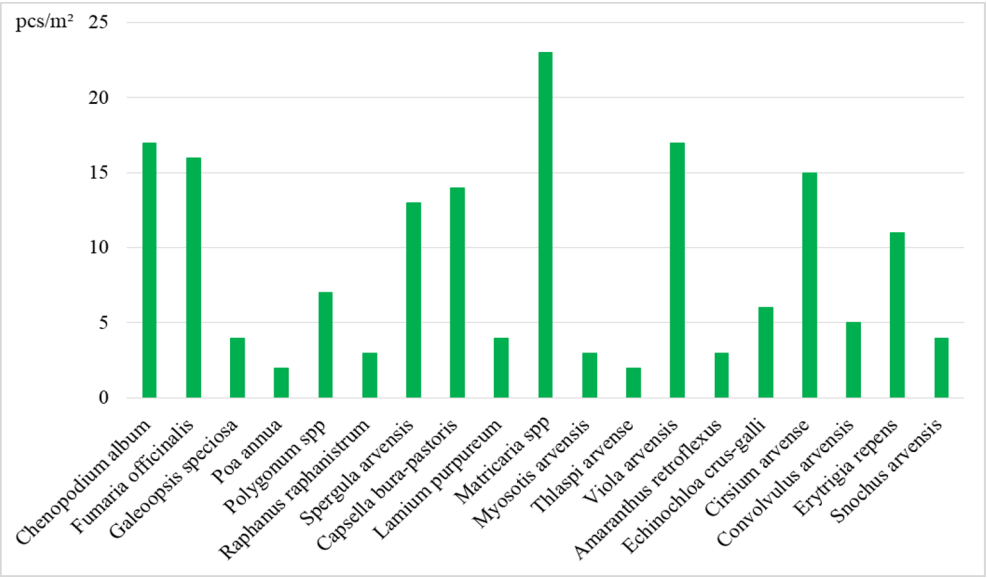

Fig. 2. Quantitative and specific composition of weeds before treatment of crops with herbicides.

Winter wheat crops were treated with a pesticide in the phase of tillering end. After 30 days, an accounting was carried out, which made it possible to determine the biological effectiveness of the herbicide Verdict. The number of weeds was also considered 45 days after treatment and before harvesting the crop to track the dynamics and identify the prolongation of the herbicide protective effect (Figure 3).

As a control, there was a plot of crops untreated with a pesticide – a "production fault".

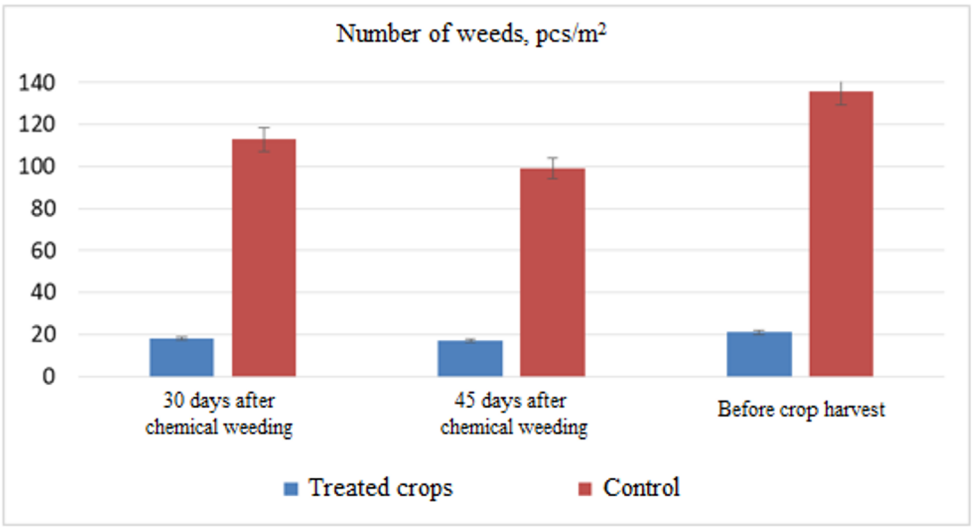

Fig. 3. The dynamics of the number of weeds.

The number of weeds does not fully reflect their harmfulness. In this regard, we also carried out the determination of the air-dry mass of weeds (Figure 4).

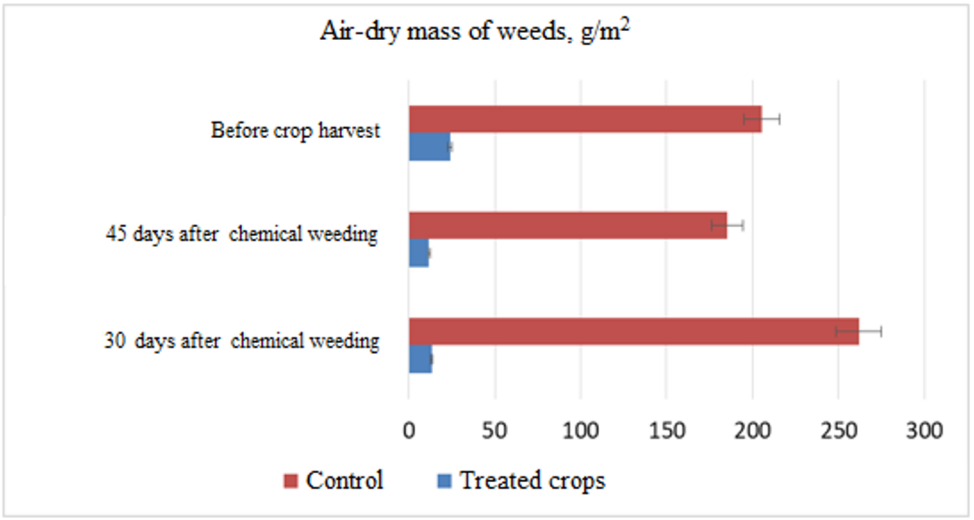

Fig. 4. Dynamics of accumulation of air-dry mass of weeds.

Under the prevailing soil and climatic conditions, the yield of winter wheat was 4.49 t/ha on herbicidal background and 1.82 t/ha on control.

4 Discussion

Winter wheat is a strong competitor for weeds and under optimal conditions, especially in the early stages of development, it is able to block weeds. A lot of work has been done for the appearance of friendly seedlings and rapid growth – pre-sowing tillage, seed disinfection, fertilization, etc., which made it possible to form an optimal density of plant stand and be phytocenotically strong in relation to weeds.

Nevertheless, winter wheat plants come out weakened when the spring vegetation resumes, in addition, "bald spots" appear due to the loss of plants and a favorable environment for the development of weeds appears.

Quantitative and species analysis of weeds showed that before chemical weeding, the crops were clogged mainly with wintering and spring early weeds.

The harmfulness of wintering species is determined by the fact that they are able to germinate together with winter wheat, vegetate until late autumn, overwinter in any growth phase and in the future, having accumulated a large phytomass, have a negative impact on grain growth and formation. For example, it is known that Matricaria indora has strong allelopathic activity and reduces seed germination energy and slows down the growth processes of winter wheat.

The greatest problems for farmers are perennial weeds, of which there were 35 pcs/m², where 24 pcs/m² are malicious hard-to-root weeds.

Thus, it was decided to treat crops with the spray mixture of herbicides for better control of weeds.

During the 2nd accounting (30 days after the application of herbicides), there is a decrease in the number of weeds by 151 pcs/m², compared with the initial one. On an untreated with herbicide site (production "fault"), a high density of weeds remains – 113 pcs/m².

There were no significant changes in the species composition at the control compared to 1 accounting.

The spray mixture of herbicides completely suppressed such weeds as Fumaria officinalis, Poa annua, Polygonum spp., Capsella bura-pastoris, Myosotis arvensis, Snochus arvensis, and others. Single specimens included Chenopodium album, Matricaria indora, Cirsium arvense, Convolvulus arvensis, and Erytrigia repens.

The total biological effectiveness of herbicides (for all types of weeds) was 84.1%. A more pronounced effect of the spray mixture is noted in the reduction of the air-dry mass of weeds with an efficiency of 94.9%.

Similar trends were observed 45 days after the treatment. Only before winter wheat harvesting there was an insignificant increase in the number of weeds. Thus, on the treated crops it was 21 pcs/m², and on the control – 136 pcs/m², which is respectively 3 and 23 pcs/m² more than during 2 accounting.

The agronomic effectiveness of the use of herbicides is expressed in yield increase. Chemical processing allowed to obtain an additional (save) yield of winter wheat 2.67 t/ha relative to untreated control.

Another important aspect in the application of chemical plant protection products is their payback, which in agriculture is regulated by the threshold of fight economic expediency and with it the profitability level from the use of herbicides should be higher than 25%. The calculation of the economic efficiency of the use of the spray mixture of herbicides in winter wheat crops showed that with an actual yield of 4.49 t/ha, the profitability level was above the threshold of fight economic expediency and amounted to 141.8%.

5 Conclusion

Recently, much attention has been paid to organic farming based on the rejection of the use of any pesticides. Nevertheless, the intensity of the development of harmful objects does not yet allow to completely abandon chemicals. Although the farm tends to carry out crop processing only on the basis of monitoring data when the number of economic harm thresholds is exceeded.

As previously noted, during the tillering phase, the contamination of crops was recorded, significantly exceeding the EHT, which necessitated the use of spray mixture of herbicides for weed control. Dicotyledon broad-leaved weeds dominated the structure of weeds.

The biological efficiency of the spray mixture of herbicides Verdict + Dinat was 84.1% (by the number of weeds) and 94.9% (by air-dry weight).

The agronomic effectiveness of herbicides was expressed in obtaining an increase in yield of 2.67 t/ha, and the profitability level was above the threshold of economic feasibility of the weed management and amounted to 141.8%.

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References

1. N.M. Afonin, R.A. Titov, Development of a comprehensive plant protection system for winter wheat in the Tambov region, *Science and Education* **3(3)** (2020)
2. G.Z. Ibiev, *Effective development of the grain sub-sector of crop production as the basis of Russia's food security in the conditions of agriculture digitalization*, Innovative directions of integration of science, education and production: Collection of materials of the III International Scientific and Practical Conference, Kerch, May 11-15, 2022 (Kerch: Kerch State Marine Technological University, 2022) 224-229.
3. S.I. Voronov, et al. Agricultural Scientific Journal **7,** 10-14 (2020)
4. S.V. Soroka, et al. Agriculture and crop production **2,** 30-32 (2022)
5. A.V. Solomatin, S.Yu. Novikov, N.Yu. Garmash [et al.] Fertility **6(129),** 29-32 (2022) DOI 10.25680/S19948603.2022.129.08.
6. E.V. Tokarev, V.A. Khilevsky, *Combined herbicide for weeding winter wheat crops,* Protection of plants from harmful organisms 280-282 (2019)
7. M.I. Smirnykh, I. A. Babkina, E. V. Malysheva, *Assessment of the effect of herbicides on winter wheat productivity*, Biotechnological methods of production and processing of agricultural products: materials of the All-Russian (National) Scientific and Practical Conference, Kursk, February 08, 2021. Volume Part 1 (Kursk: Kursk State Agricultural Academy named after I.I. Ivanov, 2021) 7-11.
8. A. Al-Gailani, The effect of different Agricultural applications on the number and types of weeds associated with crops, June 07-09, 2021 **1** 358-360 (2021)
9. V.I. Dolzhenko, A.B. Laptiev, N.R. Goncharov, Certificate of state registration of the database No. 2020622424 Russian Federation. Application of winter wheat protection products against pests, diseases, and weeds: No. 2020622266: application 16.11.2020: publ. 27.11.2020; applicant Federal State Budgetary Scientific Institution "All-Russian Scientific Research Institute of Plant Protection" (FSBSU VISR), Limited Liability Company "Innovative Center for Plant Protection" (LLC "ICPP").
10. A.S. Filippov, V.V. Nemchenko, A.Yu. Kekalo, N.Yu. Zargaryan, Agrochemistry **11,** 28-34 (2020) DOI 10.31857/S0002188120090045.