

THE EFFECT OF THE BASIC TILLAGE SYSTEM on soybean weediness in the right-bank Forest-Steppe of Ukraine

Goal. To improve the system of soybean crops weed control under different methods of tillage. **Methods.** Field and laboratory experiment, mathematical and statistical method to assess the reliability of the obtained results. **Results.** The researched species composition of weeds in soybean crops included 12 species of 7 families, with a predominance of dicotyledonous species (80.1—93.3%), regardless of the tillage method the proportion of the monocotyledonous species made up 6.7—19.9%. The following species were most common: *Chenopodium album* L., *Amaranthus retroflexus* L., *Polygonum lapathifolia* L., *Galinsoga parviflora* Cav., *Echinochloa crus-galli* (L.) Pal. Beauv. and *Setaria glauca* (L.) Pal. Beauv. The maximum weediness of soybean crops before herbicides application was observed under the moldboardless main tillage use (to a depth of 10—12 cm) and amounted to 481.5 pcs./m², of which dicotyledonous species made up 81.7% and monocots — 18.3%. The lowest number of weeds (at the level of 254 pcs./m²) was observed under the No-till technology, the share of dicot species made up 80.1%. With the use of the moldboard tillage in soybean crops before herbicides use, the total number of weeds was 425.5 pcs./m², where annual dicotyledonous species predominated (93.3%). Soybean crops subject to herbicides use on the moldboard tillage variant formed a 2.49 t/ha yield, which was 50% higher than that of the weeded control variant. The use of the moldboardless tillage and No-till technology ensured productivity in the range of 2.34—2.40 t/ha. **Conclusions.** Regardless of the soil tillage method, dicotyledonous weed species occupied from 80.1 to 93.3% of the soybean crops, with the predominance of *Chenopodium album* L., the share of which was 66.6—77.3% and *Polygonum lapathifolia* L. — 17.6—24.9%. The use of various methods of soil tillage and weed control ensures elimination of weeds at the level of 91.0—91.5% and maintaining productivity in the range of 45—50%.

types of weeds; methods of soil tillage; efficiency

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Soybean *Glycine hispida* (Moench) Max belongs to the most common leguminous and oilseed crops, which are grown in more than 60 countries all over the world. This valuable protein-oil crop has a wide range of uses in the food processing industry, medicine and feed production. Therefore, it seems natural that soybean cultivated areas are increasing.

Thus, the soybeans growing technology needs improvement, specific elements efficiency increase, in particular, through the basic tillage methods enhancement and a balanced, scientifically substantiated system of weed control.

The choice of a specific type of tillage depends on the soil and climatic conditions, as well as on the

general level of land cultivation, for example, the degree of weeding of the fields. Experience shows that there exist three main tillage technologies that can be used to grow soybeans: the classic system; surface one (both with and without soil layer turnover) and No-till technology. According to the certain soil and climatic conditions and specific features of the crop, main tillage may be different [1, p. 222].

According to foreign researchers, the tillage system of different intensities affects the diversity, thickness and dry biomass content of weed plants in agricultural crops. In particular, the main advantage of traditional tillage system is a significant reduction in the number of perennial weed species and a decrease in their dry biomass. Regardless of the tilling method, annual broad-leaved weeds are definitely the dominant species [2].

Tillage that includes the topsoil loosening can provoke weed seeds germination and eliminate competition from agricultural crops. When the time of soil loosening corresponds to the optimal conditions for the weed seedlings emergence, they begin to grow and develop readily in favorable conditions. There are also populations of certain types of weeds that can sprout massively under any conditions, using all opportunities for growth and development that makes impossible growing crops without herbicides use [3].

Since soybean has low competitive ability to weeds, especially at the beginning of the growing season, protection from weeds is one of the decisive factors for increasing its productivity. Yield losses due to the harmful effects of weeds can reach 30—50% or even more [4, 5, 6].

Reducing the competitive in-

teraction and thus weed infestation of crops by means of introduction the system of agrotechnical measures and use of herbicides significantly changes conditions of the crop growth and development and its productive potential realization. Due to the chemical protection of soybean crops from harmful weeds, interspecies competition for the area of nutrition and lighting disappears in favor of the crop [7].

Main tillage system plays a leading role in improving agricultural practices and is an important lever for controlling weediness, it is carried out taking into account the specific features of soil and climatic conditions, the first crop, crop rotation and biological characteristics of the plant, as well as the nature and extent of weed infestation. The factors listed above define and determine the expediency of using certain methods and systems of basic soil cultivation [8, 9, 10, 11].

The rational and effective use of herbicides on agricultural crops must simultaneously take into account the interaction of many factors: the specifics of the environment, crops, weeds, the characteristics of the preparations, the methods of applying the working liquid, the possible effect of the preparations on subsequent crops, the weather in the period before and at the time of herbicides application and after it. There are about 50 such factors in total [1, p. 313].

Therefore, weed control will be successful if it is scientifically substantiated, in particular, with regard to establishing information about the species composition and quantitative indicators of the crops weediness for various soil and climatic conditions, which cause zonal differences in weeds [12].

The aim of the research is to improve the system of weed control of soybean crops under different methods of tillage.

Materials and methods. Field experiments were conducted at the research field of the Institute of Feed Research and Agriculture of Podillia of the National Academy of Sciences, which is located in the right-bank Forest-Steppe of Ukraine. The soils of the experimental area

are gray forest podzolic, prone to waterlogging and crust formation. The content of humus in the 0–30 cm soil layer is 2.21–2.40%, of readily hydrolyzed nitrogen — 9.5–11.2 mg/100 g of soil, labile phosphorus — 14.2–18.4 mg/100 g of soil, exchangeable potassium — 8.1–12.1 mg/100 g of soil.

Methods of basic tillage:

1. Moldboard plowing to a 20–22 cm depth;
2. Shallow disking to a 10–12 cm depth;
3. No-till technology.

Basic tillage was carried out after harvesting the precursor crop according to the scheme of the experiment. The spring complex of works consisted of tilling to a depth of 10–12 cm and pre-sowing treatment — to a depth of 5–6 cm. In the variant with No-till technology, continuous action herbicides were applied 10 days before sowing.

Background fertilizers were applied in the rate of $N_{30}P_{30}K_{30}$.

Soybeans were sown in the third decade of April, in a quadruple repetition, on a 25 m² accounting area. In the spring and summer period, the following weed protection system was used: Galaxy ultra, e.c. — 2.5 l/ha (bentazon, 352.4 g/l + acifluorfen, 161.7 g/l) + Miura, e.c. — 1.0 l/ha (hyzalofof-P-ethyl, 125 g/l) in the phase of 2–3 trifoliolate soybean leaves. Application of herbicides was carried out with a PL2 «System Agrotop» sprayer with a 250–300 l/ha flow rate.

During the soybeans growing season, records and observations were carried out in accordance with the generally accepted methods [13, 14].

Research results. Studies of the species composition of weed plants in soybean crops revealed 12 different species of 7 families. The annual and biennial dicot type of weed vegetation was represented by plants of the *Chenopodiaceae*, *Amaranthaceae*, *Asteraceae*, *Polygonaceae*, *Brassicaceae*, *Solanaceae* family; monocotyledonous type — by the plants of annual species of the *Poaceae* family.

In the structure of actual weed infestation of soybean crops, plants of dicotyledonous weed species

made up 80.1–93.3%, monocotyledonous annual species were represented mainly by the *Poaceae* family in the amount of 28.5–88.0 pcs/m², or 6.7–19.9%.

The following species were most common on soybean crops: *Chenopodium album* L., *Amaranthus retroflexus* L., *Polygonum lapathifolia* L., *Galinsoga parviflora* Cav., *Echinochloa crus-galli* (L.) Pal. Beauv. and *Setaria glauca* (L.) Pal. Beauv.

Under the use of the moldboard ploughing for the soybean crops before herbicides application, the total number of weeds was 425.5 pcs./m², where annual dicotyledonous species prevailed (93.3%).

The highest number of weed plants before spraying crops with herbicides (481.5 pcs./m²) was recorded in the variant where shallow disking was used. The least amount of weed plants were counted in this period under No-till technology, the total number of which was 254.0 pcs./m².

It should be noted that, regardless of the tillage method, annual dicotyledonous weed species were predominant in the crops (80.1–93.3%). Among them *Chenopodium album* L. and *Polygonum lapathifolia* L. prevailed, the share of which was 66.6–77.3% and 17.6–24.9% respectively, depending on the variant of the basic tillage.

The maximum weed infestation of soybean crops was recorded under the use of moldboardless basic tillage (to a depth of 10–12 cm) and totaled to 481.5 pcs./m², of which 81.7% were dicotyledonous species, the rest (18.3%) — monocotyledonous ones. Application of herbicides ensured a decrease in weediness by 92%, monocotyledons — by 89.0, dicotyledons — by 92.0% (Fig. 1).

The lowest number of weeds (at the level of 254 pcs./m²) was observed under the use of No-till technology, the share of dicotyledonous species was 80.1%, monocotyledonous — 19.9%.

To control weediness of soybean crops, spraying with Galaxy ultra, e.c. 2.5 l/ha (bentazon, 352.4 g/l + acifluorfen, 161.7 g/l) + Miura, e.c. 1.0 l/ha (hyzalofof-P-ethyl, 125 g/l) herbicides in the phase of 2–3 trifoliolate soybean leaves was

carried out. The use of herbicides provided control of weed plants at the level of 91.0–91.5%, depending on the method of soil tillage (Table).

Pre-harvesting weed control of the crops showed that the wet weight of weed plants on the weeded control variant ranged from 1665 to 1835 g/m². The largest weight of weed plants was formed on the moldboardless variant of tillage — at the level of 1835 g/m². At the use of moldboard tillage to a 20–22 cm depth, the wet weight of weeds on the control variant without herbicides use was 1665 g/m², and under the No-till technology — 1750 g/m².

Spraying soybean crops with herbicides provides 88.8–92.2% reduction in the weight of weeds — to 130–196 g/m².

Under the condition of using herbicides on the moldboard tillage variant, soybean crops formed a 2.49 t/ha yield, which was 50% higher than that of the weeded control one.

At using moldboardless tillage and No-till technology productivity was almost the same and amounted to 2.34–2.40 t/ha, which is somewhat lower compared to traditional moldboard tillage. The level of the preserved yield was 45–46%.

Thus, it was established that in growing soybeans in a two-field crop rotation under moldboard tillage, favorable conditions for the effective weed control are created. It is worth noting that the number of weeds and their weight were the largest at the use of shallow disking compared to moldboard tillage and No-till technology, which resulted in a decrease in soybean productivity.

CONCLUSIONS

The species composition of weed plants in soybean crops was represented by 12 species of 7 families. The following species were most common on soybean crops: *Chenopodium album* L., *Amaranthus retroflexus* L., *Polygonum lapathifolia* L., *Galinsoga parviflora* Cav., *Echinochloa crus-galli* (L.) Pal. Beauv. and *Setaria glauca* (L.) Pal. Beauv.

In the structure of actual weed

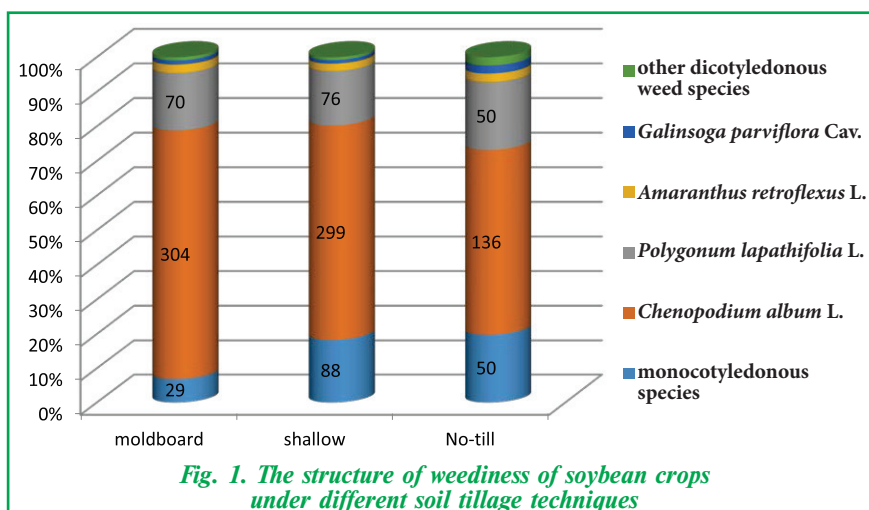


Fig. 1. The structure of weediness of soybean crops under different soil tillage techniques

infestation of soybean crops, plants of dicotyledonous weed species made up 80.1–93.3%, monocotyledonous annual species were represented mainly by the *Poaceae* family in the amount of 28.5–88.0 pcs/m², or 6.7–19.9%. Among the dicotyledonous species, *Chenopodium album* L. (the share of which amounted to 66.6–77.3%) and *Polygonum lapathifolia* L. (17.6–24.9%) were predominant.

The maximum extent of soybean crops weediness before herbicide application was recorded at the use of mouldboardless primary tillage (to a depth of 10–12 cm), that amounted to 481.5 pcs/m², of which dicotyledonous species made up 81.7%, monocots — 18.3%. Mouldboard cultivation (plowing to a depth of 20–22 cm) ensured reduction of the total number of weeds to 425.5 pcs/m² with predominance of annual dicotyledonous species (93.3%) compared to boardless tillage. The

least number of weed plants was recorded on the no-till variant, their total number was 254.0 pcs/m² with predominance of dicotyledonous species as well.

Pre-harvesting weed control of the crops showed that the wet weight of weed plants on the weeded control variant ranged from 1665 to 1835 g/m². The largest weight of weed plants was formed on the moldboardless variant of tillage — at the level of 1835 g/m². Spraying soybean crops with herbicides provides 88.8–92.2% reduction in the weight of weeds — to 130–196 g/m².

Thus, it was established that weediness of soybean crops depends on the method of main soil cultivation. The use of mouldboard, mouldboardless or no-till soil tillage technology, provided that crop weed control is accomplished, makes it possible to reach 2.34–2.49 t/ha productivity. Carrying out pro-

The influence of different tillage methods and weed control measures on soybean productivity, average for 2019–2020

Tillage methods (factor A)	Herbicide protection variants (factor B)	Plant thickness, thousand pcs./ha	Productivity, t/ha	Preserved productivity	
				t/ha	%
Moldboard	Control without herbicides	765.5	1.67	-	-
	Miura, e.c. — 1.0 l/ha + Galaxy ultra, e.c. — 2.5 l/ha	767.1	2.49	0.83	50
Shallow	Control without herbicides	762.9	1.60	-	-
	Miura, e.c. — 1.0 l/ha + Galaxy ultra, e.c. — 2.5 l/ha	764.1	2.34	0.74	45
No-till	Control without herbicides	760.5	1.65	-	-
	Miura, e.c. — 1.0 l/ha + Galaxy ultra, e.c. — 2.5 l/ha	762.2	2.40	0.75	46
Least significant difference — 0.5 t/ha			A — 0.04; B — 0.04; AB — 0.07		
Factor A — tillage methods Factor B — herbicide protection variants					

tective measures allows achieving 91.0—91.5% elimination of weed plants, ensuring soybean productivity at the level of 45—50%.

Financing: the research was carried out as part of the task 02.03.00.12.P «To improve the system of integrated management of weed resistance to herbicides under different methods of soil cultivation in the corn-soybean crop rotation in conditions of the Right-Bank Forest Steppe of Ukraine», state registration No. 00119U100229 PSR 2 «The newest systems of land cultivation and land use».

Conflict of interest: the authors declare no conflict of interest.

REFERENCES

- Ivashchenko O. O., Ivashchenko O. O. (2019). Zahalna herbolohiia : monohrafiia. [General herbology: monograph] Kyiv: Feniks. 752 p. <https://doi.org/10.36495/ISBN978-966-136-649-6/2019.752s> (in Ukrainian).
- Demjanová E., Macák M., Čalovič I., Majerník F., Týr Stefan, Smatana Jozef. (2009). Effects of tillage systems and crop rotation on weed density, weed species composition and weed biomass in maize. [Effects of tillage systems and crop rotation on weed density, weed species composition and weed biomass in maize]. *Agronomy Research*, 7(2), 785-792 URL:https://www.researchgate.net/publication/288958455_Effects_of_tillage_systems_and_crop_rotation_on_weed_density_weed_species_composition_and_weed_biomass_in_maize (in Slovakia).
- Schonbeck M. Keep the Weeds Guessing with Crop Rotations. [Keep the Weeds Guessing with Crop Rotations] <https://eorganic.org/node/2496> (in USA).
- Tkalich Yu.I., Tsyliuryk O.I., Rudakov Yu.M., Kozachko V.I. (2021). Efektyvnist strakhovykh herbitsydiv u posivakh soi Pivnichnoho Stepu Ukrainy. [Effectiveness of insurance herbicides in soybean crops of the Northern Steppe of Ukraine]. *Agrology*, (4), 165-173 <https://doi.org/10.32819/021019> (in Ukrainian).
- Marchenko D.I. (2020). Konkurentni vzaemovidnosyny soi ta burianiv v ahrotse-nozakh. [Competitive relationships between soybeans and weeds in agrocenoses]. *Tavriiskyi naukovyi visnyk*, (114) 84-90 <https://doi.org/10.32851/2226-0099.2020.114.12> (in Ukrainian).
- Zadorozhnyi V.S., Karasevych V.V., Movchan I.V., Kolodii S.V. (2014). Kontroliuvannia burianiv u posivakh soi v Pravoberezhnomu Lisostepu Ukrainy. [Weed control in soybean crops in the Right Bank Forest Steppe of Ukraine]. *Naukovi pratsi Instytutu bioenerhetychnykh kultur i tsukrovykh buriakiv: zb. nauk. Prats*, (20), 25-31. <http://www.bioenergy.gov.ua/uk/content/vipusk-20-2014> (in Ukrainian).
- Zherebko V.M. (2014). Khimichniy metod kontroliu zaburianenosti posiviv v intensyvnnykh tekhnolohiiakh vyroshchuvannia silskohospodarskykh kultur. [A chemical method of controlling weediness of crops in intensive technologies of growing agricultural crops]. *Karantyn i zakhyt roslyn. [Quarantine and Plant Protection]*, (2), 22-24. <http://kr.ipp.gov.ua/index.php/journal/issue/view/44/2-2014> (in Ukrainian).
- Myroshnychenko M.S. (2020). Vplyv systemy udobrennia ta obrobitku gruntu na zaburianenist posiviv tsukrovykh buriakiv v korotkorotatsiinykh sivozminakh. [The influence of the fertilization and tillage system on the weediness of sugar beet crops in short-rotational crop rotations]. *Naukovi pratsi Instytutu bioenerhetychnykh kultur i tsukrovykh buriakiv: zb. nauk. Prats*, (28), 29-36 <http://www.bioenergy.gov.ua/sites/default/files/articles> (in Ukrainian).
- Tsvei Ya.P., Tyshchenko M.V., Filonenko S.V. (2018). Monitorynh zaburianenosti posiviv silskohospodarskykh kultur u lantsi zernoburiazakovoivo sivozminy u vyrobnychkykh umovakh. [Monitoring of weediness of agricultural crops in the beet crop rotation chain under production conditions]. *Visnyk Poltavskoi derzhavnoi ahrarnoi akademii*, (1), 23-30. <https://doi.org/10.31210/visnyk2018.01.03> (in Ukrainian).
- Masliiov S.V., Stepanov V.V., Zinovy O.B. (2020). Vplyv osnovnoho obrobitku gruntu na produktyvnist soniashnyka v umovakh Luhanskoi oblasti. [The influence of the main tillage on the productivity of sunflower in the conditions of Luhansk region]. *Tavriiskyi naukovyi visnyk*, (112), 111-115. <https://doi.org/10.32851/2226-0099.2020.112.15> (in Ukrainian).
- Len, O.I., Totskyi, V.M., Hanhur, V.V., Yeremko, L.S. (2021). Vplyv systemy udobrennia ta osnovnoho obrobitku gruntu na produktyvnist hibrydiv kukurudzy. [The influence of the fertilization system and the main tillage on the productivity of corn hybrids]. *Visnyk Poltavskoi derzhavnoi ahrarnoi akademii*, (2), 52-58. <https://doi.org/10.31210/visnyk2021.02.06> (in Ukrainian).
- Kryvenko A. I. (2018). Vydovyi sklad burianiv ta yikh biolohichni hrupy u korotkorotatsiinykh sivozmini pviddennoho stepu Ukrainy. [The species composition of weeds and their biological groups in the short-rotational crop rotation of the southern steppe of Ukraine]. *Young Scientist* 8 (60), 13-17. URL:<https://molodyvchenyi.ua/index.php/journal/article/view/4103/4034> (in Ukrainian).
- Trybel S.O. (Ed.). (2001). *Metodyka viprobuвання i zastosuvannia pestytsydiv. [Test methods and application of pesticides]*. Kyiv: Svit., 448 (in Ukrainian).
- Veselovskiy I.V., Lysenko A.K., Manko Yu.P. (1988). *Atlas — vyznachnyk burianiv. [Atlas is a weed finder]*. Kyiv: Urozhai. 72 (in Ukrainian).

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Вплив системи основного обробітку ґрунту на забур'яненість сої у Правобережному Лісостепу України

Мета. Удосконалення системи контролювання забур'яненості посівів сої за різних способів обробітку ґрунту. **Методи.** Дослідження польові, лабораторні, математично-статистичний для оцінки достовірності отриманих даних. **Результати.** За досліджень видового складу рослин бур'янів у посівах сої налічували 12 видів із семи родин, з перевагою двосім'ядольних видів (80,1—93,3%). Незалежно від варіанту обробітку ґрунту частка односім'ядольних видів становила 6,7—19,9%. Найпоширенішими були види: *Chenopodium album* L., *Amaranthus retroflexus* L., *Polygonum lapathifolia* L., *Galinosa parviflora* Cav., *Echinochloa crus-galli* (L.) Pal. Beauv. та *Setaria glauca* (L.) Pal. Beauv. Максимальною забур'яненість посівів сої перед застосуванням гербіцидів була за використання безполіцевого основного обробітку ґрунту (на глибину 10—12 см) і становила 481,5 шт./м², з яких 81,7% припадали на двосім'ядольні види, односім'ядольні займали 18,3%. Найменша кількість бур'янів (254 шт./м²) була за No-till технології обробітку ґрунту, частка двосім'ядольних видів становила 80,1%. За використання полицевого обробітку ґрунту у посівах сої перед використанням гербіцидів загальна кількість бур'янів сягала 425,5 шт./м², де переважали однорічні двосім'ядольні види (93,3%). Посіви сої за умови застосування гербіцидів на варіанті полицевого обробітку ґрунту формували урожайність на рівні 2,49 т/га, що на 50% перевищувало показник забур'яненого контролю. Використання безполіцевого обробітку ґрунту та No-till технології забезпечувало урожайність в межах 2,34—2,40 т/га. **Висновки.** Незалежно від варіанту обробітку ґрунту у посівах сої двосім'ядольні види бур'янів займали від 80,1 до 93,3%, з перевагою лободи білої, частка якої становила 66,6—77,3%, та гірчака шорсткого — 17,6—24,9%. Застосування різних способів обробітку ґрунту та захисту посівів від бур'янів забезпечує загибель бур'янів на рівні 91,0—91,5% збереження урожайності від 45 до 50%.

види бур'янів; способи обробітку ґрунту; ефективність

It was sent to the editors: 11.05.2023

Approved for publication: 25.05.2023

Printed: September 2023

Published online: October 2023