

# COMPARATIVE EVALUATION OF DIFFERENT SOY PROTECTION SCHEMES

**Goal.** Evaluate the effectiveness of various soybean protection schemes using preventive measures for seedlings and control measures during the growing season. **Methods.** Field, phytopathological, herbological, mathematical and statistical. According to the first protection scheme, the seeds were treated comprehensively with Maxim XL 035 FS (fludioxonil, 25 g/l + metalaxyl-M, 10 g/l) fungicide, 0.5 l/t, Taboo s.c. (imidacloprid, 500 g/l) insecticide, 0.5 l/t and Biomag-Soya (Bradirhizobium japonicum) biological product, village, 2.5 l/t. Harnes c.e. (acetochlor, 900 g/l), herbicide was applied during sowing with a consumption rate of 2.0 l/ha. According to the second scheme during the growing season herbicides Bazagran, l.c. (bentazone, 480 g/l) with a rate of 2.5 l/ha and Panther, c.e., 1.0 l/ha (quizalofop-P-terfuryl, 40 g/l) in the phase of 3–4 true leaves in culture. Against diseases in the budding phase — the beginning of flowering and at the beginning of bean formation was sprayed with fungicide systemic contact action Amistar Extra 280 SC (cyproconazole, 200 g/l + azoxystrobin, 80 g/l), 0.75 l/ha. The quantitative and species composition of weeds in the experimental plots, the infestation of phytopathogens of soybean plants, the effectiveness of drugs in various protection schemes, crop yield were determined. **Results.** Both protection schemes effectively controlled weed infestation and disease. The first protection scheme proved to be more effective against dicotyledonous weeds: the effectiveness 60 days after herbicide application was 95.4% versus 82% according to the second scheme. Cereal weeds were more effectively controlled during the growing season. Protection of soybeans against *Alternaria* was almost equally effective in both schemes. Soybean downy mildew more effectively limited fungicidal treatments during the growing season. Under both protection schemes, soybeans yielded significantly higher yields than controls. However,

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yields, number of beans per plant and weight of 1000 grains were higher in the first scheme compared to the second protection scheme. **Conclusions.** Both protection schemes provided high weed and disease control rates during the soybean growing season. Differences in the control of different biological groups of weeds and different types of diseases are obviously related to the peculiarities of the use and toxic effects of the drugs used. However, the application of a system of preventive protection measures can reduce the pesticide load on the agrocenosis and limit the negative impact of pesticides on soybean plants during the growing season.

**protective measures; weeds; diseases; effectiveness**

Soybean (*Glycine max* (L.) Merrill.) is an extremely valuable protein-oil crop. It has an important role to play in solving the global food problem. The spread of soybeans in the world is due to high quality grain, relatively low energy consumption of its cultivation and versatility.

The main condition for increasing soybean production and reducing losses is the introduction of effective technologies for growing and protecting crops from pests. In recent years in Ukraine there is a dynamic growth of soybean acreage and, accordingly, the share of this crop in crop rotation is increasing. This usually provokes a massive accumulation of pathogens, weed seeds and pests in the soil.

Protecting crops from weeds is an extremely important step in soybean cultivation technology. Weeds are one of the most significant and controlled threats to crop production in the world. U.S. researchers point out that the weeds of soybean producers depend on the cost of weed control [1].

Cultivated plants, including soybeans, grow slowly at the begin-



Photo 1. Soy crops. Moravia variety



ning of the growing season and are less competitive than weeds. This is facilitated by low plant height, slow growth, shallow root penetration, weak shading of the soil. The critical period is the stage from the formation of the first to the third true leaf. Soybean susceptibility to weeds is usually observed before the branching phase, ie 40–50 days after germination. It is during this period that it is necessary to ensure reliable protection of soybean crops from segetal vegetation.

The fields are mostly mixed with different types of weeds, both annual and perennial, which are difficult to control by agricultural measures.

It is proved that the system of tillage, methods of sowing, fertilizing and crop rotation significantly affect the weediness of areas [2–4]. Growing soybeans in monoculture and in conditions without tillage increases weeds and fungal diseases [5]. The wide-row sowing method (37.5 m) produces 2–5 times more weeds, and their interspecific competition increases compared to the narrow-row method (12.5 cm) [6]. It is proved that the highest yield is formed in crop rotation with soy saturation up to 20% [3]. Kandeï and others report that pre-treatment of soybean crops with herbicides and seed treatment reduced disease incidence by 70% and increased crop yields by 12% [7]. Some authors point out that a significant reduction in crop weeds can be achieved by replacing one of the soybean rows with buckwheat [8]. The use of legumes in crop rotation increases the yield of other crops and improves its quality [9].

Ignificant damage to soybean crops is caused by diseases. Some scientists note that soy is vulnerable to many diseases that cause significant crop losses each year — from 20 to 50% [3, 10, 11]. Diseases reduce the energy of seed germination and their germination, weaken plants, reduce the photosynthetic surface and productivity of cultivated plants, worsen the quality of the crop. It depends on many factors: environmental conditions, production practices, susceptibility of varieties. Because soybeans are susceptible to many pathogens, it is

necessary to monitor diseases annually and develop current disease management strategies, especially in the context of climate change [12]. Due to changes in climatic conditions, diseases that did not previously pose a significant threat to soybean crops (Alternaria, Fusarium wilt, bacterial diseases) become highly harmful [13]. Increased population of soybeans by pests (acacia firefly, tuberous weevils, alfalfa bug, common spider mite, thistle, aphids) is also observed in arid hot conditions. Damaged plants dry up prematurely, beans ripen prematurely, forming a thin substandard seed [3].

Of great importance in the system of soybean protection is the treatment of seeds with insecticides and fungicides with the use of inoculation with nodule bacteria. Soybeans in symbiosis with nitrogen-fixing bacteria have the ability to form root nodules and accumulate biological nitrogen. Under optimal conditions of symbiotic nitrogen fixation, soybean-rhizobial systems can absorb up to 210 kg/ha of biological nitrogen, which makes it possible to improve the nitrogen balance in crop rotation soils and reduce the use of mineral nitrogen [14]. It is known that legumes are capable of active nitrogen-fixing symbiosis in the presence of bacteria of the genus *Rhizobium* in the root zone. However, most researchers claim that in the microflora of seeds or rhizosphere of soybean nodule bacteria *Bradurhizobium japonicum* was not detected, or this phenomenon is very rare [15, 16]. It is obvious that in order to form an effective soybean-rhizobial symbiosis, artificial bacterization of seeds with highly active strains of specific nodule bacteria, complementary to a wide range of modern varieties, must be mandatory. Such an event will contribute to the realization of the productive potential of culture. Scientists have proven that most strains of *Bradurhizobium japonicum* bacteria in mixtures with various systemic contact fungicides are not sensitive and can be used in soybean cultivation technologies [17].

To protect soybeans from pests, the modern market offers a wide

range of pesticides. There are drugs to prevent the development of pests and to destroy them during the growing season, when there is a threat to the development of culture.

The aim of the work was a comparative evaluation of different soybean protection schemes with the use of preventive measures and the use of pesticides during the growing season.

**Research methodology.** The work was performed during 2014–2016 at the State Enterprise «Experimental Base (SE EB)» «Alexandria» Bila Tserkva district of Kyiv region. The soil of the experimental field is typical low-humus coarse-grained coarse-medium-loam chernozem with a humus content of 3.15% and a hydrolytic acidity of 2.21 mg eq. per 100 g of soil, pH — 5.6. The soil is poorly supplied with nitrogen of organic compounds, which is easily hydrolyzed, and on average provided with mobile phosphorus and exchangeable potassium. The area of the research plots is 75 m<sup>2</sup>, the repetition is 4 times. Sown with a seeder with a row spacing of 25 cm soybean variety — Moravia.

According to scheme I, the seeds were treated against diseases and pests and herbicides were applied to the seedlings. Pre-sowing treatment was performed with a mixture of drugs with fungicidal and insecticidal action — Maxim XL 035 FS, t.k.s. (fludioxonil, 25 g/l + metalaxyl-M, 10 g/l), 1.0 l/ha and Taboo, hp (imidacloprid, 500 g/l), 0.5 l/t. Also applied the biological product Biomag-Soya, p. (*Bradirhizobium japonicum*), 2.5 l/t. To protect against weeds, the well-known herbicide Harnes was used during sowing. (acetochlor, 900 g/l), with a consumption rate of 2.0 l/ha.

Under the scheme II during the growing season made Bazahran herbicides, VR (bentazone, 480 g/l), with a rate of 2.5 l/ha against dicotyledonous weeds and Panther, k.e. (quizalofop-P-tefuril, 40 g/l), 1.0 l/ha against cereal weeds at plant heights of 10–12 cm in the phase of 3–4 true leaves in culture.

Against diseases in the budding phase — the beginning of flowering and the beginning of the formation

of beans (on the scale BBCH 51–61 and 71–75) was sprayed with fungicide systemic contact action Amistar Extra 280 SC, hp (tsyprokonazol, 200 g/l + azoksystrobin, 80 g/l) with normal flow of 0.75 l/ha. Soy was not treated with insecticide during the growing season because there were no pests in the crops.

Weed numbers, disease development, crop yields, and efficacy in various protection regimens were determined according to test and pesticide application methods [18]. The species composition of weeds was determined by reference books. [19] Statistical processing of research results was performed using the computer program Statgraphic plus.

**Results and discussion.** Weather conditions in the years of research mainly contributed to the growth and development of plants, although precipitation and average daily temperature by year and month were uneven, with significant deviations from the average perennial. The most wet periods for sowing crops (April and May) were in 2014 and 2016. Most seemed dry growing season 2015.

Soybean crops were dominated by mixed weeds. Weeds from different biological groups grew. The most common species of segetal vegetation were *Chenopodium album* L., *Amarantus retroflexus* L.,

*Galinsoga parviflora* L., *Convolvulus arvensis* L., *Sirsium arvense* L. The monocotyledons were dominated by the gray *Setaria glauca* L., whose share in the total number of all biological groups of weeds ranged from 40 to 51%, as well as creeping *Elytrigia répens* (L.) Gould. The number of dicotyledonous weeds in the control plots averaged 63–95 units/m<sup>2</sup>, cereals — 300–310 units/m<sup>2</sup>.

It is known that the effectiveness of herbicides is significantly influenced by many factors: weather conditions, soil characteristics, the degree of toxicity and the period of detoxification of the drug. Given that the experimental conditions were completely identical (same field, soybean variety, sowing dates, weather conditions), it is obvious that the effectiveness of protection depended on the specifics of use and toxicity of drugs.

The application of herbicides under both protection schemes ensured high efficiency of weed control in soybean crops. 30 and 60 days after application of the drugs under scheme I (pre-emergence application), the efficiency of destruction of cereal weeds was 99.7 and 90.6%, respectively, dicotyledonous — 97.9 and 95.4%. Application of herbicides according to scheme II (during the growing season) ensured the effectiveness of action after 30 days against cereal weeds at the level of 98.6%, against di-

cotyledons — 86.6%, after 60 days, respectively — 96.2 and 82.3%, (Table 1). The efficacy against dicotyledonous weeds in Scheme I was 13% higher than in Scheme II. The application of graminacid during the growing season was slightly more effective against cereal weeds.

The herbicides used in the experiments had different mechanisms of action. Harnes is an inhibitor of protein synthesis in sensitive plants. After application, the drug remains in the top layer of soil. Sprouting weed seedlings absorb acetochlor as the stem passes through the topsoil and die. Under favorable conditions, the herbicide ensures the absence of weeds for a long time (up to 12–16 weeks). Bazagran has a pronounced contact effect and is absorbed through the leaf surface of plants. The active substance bentazone blocks the process of photosynthesis, so the process of weed death occurs in 3–5 days. Controls most annual dicotyledonous weeds. Panther refers to drugs of systemic action. Within 1 hour, it penetrates all vital organs of weeds, accumulates at growth points, inhibiting the synthesis of lipids, which leads to their death. The first symptoms of toxicity appear within 3 days after application, and the death of weeds — in 10–20 days. Panther shows high selectivity and does not harm cultivated plants.

Among the diseases in the bud-

**1. The effectiveness of various schemes to protect soybeans from weeds (Kyiv region, SE EB «Alexandria», variety Moravia, 2014–2016)**

I protection scheme (preventive measures)									
Option of the experiment	Number of weeds (pcs/m <sup>2</sup> ) in... days after treatment				Efficiency (%) in... days after treatment				
	30		60		30		60		
	cereal	dicotyledonous	cereal	dicotyledonous	cereal	dicotyledonous	cereal	dicotyledonous	
Control (without processing)	308	95	310	91	–	–	–	–	
Harnes, k.e., 2.0 l/ha (application after sowing)	1	2	29	4	99.7	97.9	90.6	95.4	
SSD <sub>05</sub>	2.8	2.4	2.8	2.05	–	–	–	–	

  

II protection scheme (treatment during the growing season of plants)										
Option of the experiment	Number of weeds (pcs/m <sup>2</sup> ) in... days after treatment						Efficiency (%) in... days after treatment			
	before processing		30		60		30		60	
	cereal	dicotyledonous	cereal	dicotyledonous	cereal	dicotyledonous	cereal	dicotyledonous	cereal	dicotyledonous
Control (without processing)	300	63	308	61	310	63	–	–	–	–
Bazagran, v.r., 2.5 l/ha; Panther, k.e., 1.0 l/ha	279	85	4	12	11	15	98,6	86,6	96,2	82,3
SSD <sub>05</sub>	3,1	1,8	2,8	2,5	2,1	2,9	–	–	–	–

ding phase — the beginning of flowering, soybean plants were affected by *Alternaria tenuis* Nees and *Peronospora manshurica* Sydow. Comprehensive seed treatment provided a high protective effect against disease. Combined disinfectant Maxim XL 035 FS has a systemic contact action against a complex of phytopathogens that are on the surface and inside the seeds. Due to this, it protects plant seedlings from soil and seed infections. Biomag-Soy is a well-known bacterial nitrogen-fixing inoculant that provides nitrogen nutrition and has growth-promoting activity.

In the budding phase — the beginning of flowering, the development of *Alternaria* for soybean seed treatment was 2.8%, and for spraying plants during the growing season — 4.2% against 16.0% in the control (Table 2). Compared with the control, seed treatment and spraying of plants restrained the development of the disease by 4.2–5.7 times. The effectiveness of protection in this period was 81.2 and 73.8%, respectively, in the first and second schemes. In the bean filling phase, the protective effect was 68.4% for the first protection scheme and 73.2% for spraying plants.

Against soybean downy mildew fungicidal treatments of plants provided higher efficiency compared to seed treatment. In the control areas, the development of downy mildew in certain phases was 7.8% and 12.5% (Table 2). Seed treatment inhibited the development of downy mildew by 46.2 and 37.6%, and fungicide treatment — by 80 and 76%.



Photo 2. Symptoms of damage to soybeans by *Alternaria*

But by that time the fungicide was sprayed twice.

The most important indicator of the effectiveness of protection measures is crop yield. Under both pesticide application regimens, soybean yields were significantly higher than in the control. The soybean yield in the experimental variants was 4.8 and 4.5 t/ha, respectively, for the first and second protection schemes, in the control — 2.8 t/ha, ie increased by 71.4 and 60.7%, respectively (Table 3). The weight of 1000 grains and the number of beans on the plants were also higher than in the first protection scheme. Compared to the control, these indicators exceeded the control by 34–38% and 12.9–18.0%, respectively. The use of the bacterial inoculant Biomag-Soy, which improves nitrogen-fixing activity and crop productivity, has obviously contributed to the increase in soybean productivity.

## CONCLUSIONS

Comparative evaluation of different schemes of protection of soybeans has shown their high efficiency. Both preventive measures to control pests and treatments during the growing season provide a high protective effect and contribute to a much higher soybean yield.

However, preventive measures with the use of integrated seed treatment and application of herbicides to seedlings, in our opinion, provide a higher economic and environmental effect. After all, this reduces the cost of spraying plants during the growing season, reduces the use of pesticides, plants are less susceptible to stressful situations. Consumption of pesticides, as it was in our experiments, according to scheme I was almost 2 times lower.

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### 2. The effectiveness of soybean protection schemes against diseases (Kyiv region, SE EB «Alexandria», variety Moravia, 2014–2016)

Option of the experiment	Development, %				Efficiency of action (%) against			
	Alternaria		Peronosporosis		Alternaria		Peronosporosis	
	budding phase — flowering	phase of filling beans	budding phase — flowering	phase of filling beans	budding phase — flowering	phase of filling beans	budding phase — flowering	phase of filling beans
Control (without processing)	16.0	29.1	7.8	12.5	–	–	–	–
Integrated seed treatment (protection scheme I)	3.0	9.2	4.2	7.8	81.2	68.4	46.2	37.6
Spraying during the growing season (protection scheme II) (Amistar Extra 280 SC, hp, 0.75 l/ha), 2 treatments	4.2	7.8	1.9	2.5	73.8	73.2	80.0	72.0
SSD <sub>05</sub>	1.6	2.8	2.1	2.6	–	–	–	–

### 3. Productivity and yield of soybeans under different protection schemes (Kyiv region, SE EB «Alexandria», variety Moravia, 2014–2016)

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Option of the experiment	Number of beans		Mass 1000 grains, g	Crop capacity	
	pcs/m <sup>2</sup>	thousand pcs/ha		t/ha	% to control
Control (without drugs)	884	8840	139	2.8	–
<b>Scheme 1.</b> Seed treatment + application of pre-emergence herbicides	1216	12160	164	4.8	171.4
<b>Scheme 2.</b> Pesticide treatments during the growing season	1188	11880	157	4.5	160.7
SSD <sub>05</sub>	11.2	–	3.5	1.03	–

#### Порівняльна оцінка різних схем захисту сої

**Мета.** Оцінити ефективність різних схем захисту сої з використанням превентивних заходів до сходів культури та контролюючих заходів у період вегетації. **Методи.** Польові, фітопатологічні, гербологічні, математико-статистичні. За першою схемою захисту проводили комплексну обробку насіння фунгіцидним протруйником Максим XL 035 FS, т.к.с. (флудіоксоніл, 25 г/л + металаксил-М, 10 г/л), 0,5 л/т, інсектицидним протруйником Табу, к.с. (імідаклопрід, 500 г/л), 0,5 л/т та біопрепаратом Біомаг-Соля, с. (Bradirhizobium japonicum), 2,5 л/т. Під час сівби вносили гербіцид Харнес, к.е. (ацетохлор, 900 г/л), 2,0 л/га. За другою схемою в період вегетації вносили гербіциди Базазран, в.р. (бентазон, 480 г/л), 2,5 л/га та Пантера, к.е. (квізалофоп-П-тефурил, 40 г/л), 1,0 л/га у фазу 3–4 справжніх листків у культурі. Проти хвороб у фазі бутонізації — початок цвітіння та на початку утворення бобів посіви обробляли фунгіцидом системно-контактної дії Амistar Екстра 280 SC, к.с. (ципроконазол, 200 г/л + азоксистробін, 80 г/л) 0,75 л/га. Визначали кількісний і видовий склад бур'янів на дослідних ділянках, ураженість фітопатогенами рослин сої, ефективність дії препаратів у різних схемах захисту, урожайність культури. **Результати.** Обидві схеми захисту ефективно контролювали засміченість посівів сої бур'янами та ураженість хворобами. Проти дводольних бур'янів більш ефективно виявилась перша схема захисту: ефективність через 60 днів після внесення гербіциду становила 95,4% проти 82% за другою схемою. Злакові бур'яни більш ефективно контролювалися за обробки в період вегетації. Захист сої проти альтернативу був практично однаково ефективним в обох схемах. Пероноспороз сої більш ефективно обмежували фунгіцидні обробки в період вегетації. За обох схем захисту сої одержали суттєво вищий урожай порівняно з контролем. Проте, показники урожайності, кількості бобів на рослині та маса 1000 зерен були вищими у першій схемі порівняно з другою. **Висновки.** Обидві схеми захисту забезпечили високі показники ефективності контролювання бур'янів та хвороб у період вегетації сої. Відмінності результатів контролю різних біологічних груп бур'янів та різних видів хвороб, очевидно, пов'язані з особливостями застосування та токсичної дії використаних препаратів. Проте, застосування системи превентивних заходів захисту дозволяє зменшити пестицидне навантаження на агроценоз та обмежити негативний вплив пестицидів на рослини сої у період вегетації.

**захисні заходи; бур'яни; хвороби; ефективність**

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