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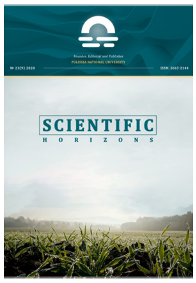

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Features of Protection of Row Crops Under Irrigation Conditions

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Abstract. Irrigation changes the ecological conditions of crop cultivation and modifies existing phytopathocenoses and entomocomplexes, having a complex and multi-vector impact, which requires significant changes in protection technologies, the development of new methods for controlling harmful organisms. It is important to select a modern range of chemicals that can be effectively used in chemicalisation. The purpose of the study was to identify promising active substances of pesticides for use in drip irrigation and develop schemes for their application. Field experiments to determine the effectiveness of certain groups of pesticides in drip irrigation were conducted in the conditions of the dry steppe of Ukraine. The studied preparations were applied on a drip irrigation system. To investigate the use of pesticides in drip irrigation, schemes were developed to protect row crops: corn, tomatoes and soybeans. The selected active ingredients, which are characterised by translaminar and acropetal movement through the plant, have a systemic nature of action and are highly effective when used in drip irrigation technologies. It was found that one of the significant disadvantages of applying plant protection products with irrigation water is the limitation of the time of application by irrigation modes. The highest effectiveness against the main pathogens was observed with the combined method of applying pesticides according to the developed schemes. This method involves the use of pesticides together with irrigation water and additional treatment with chemical preparations by conventional methods of application during the growing season. For its part, this method allows performing preventive treatments in a short time and adjust the treatment time depending on the phytosanitary situation

Keywords: drip irrigation, chemicalisation, corn, soybeans, tomatoes, pesticide efficiency, yield

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INTRODUCTION

In modern agriculture, irrigation systems are used not only for spreading water, but also for the application of fertilisers, insecticides, herbicides, fungicides, etc. The use of such technologies ensures even distribution and accurate placement of chemicals regardless of weather or field conditions, reduces the use of machinery, reduces soil compaction, and minimises operator contacts for mixing and dosing potentially hazardous materials. The cost of applying pesticides by pestigation is about one-third of the cost of conventional application methods [1].

In areas with long periods of draught, irrigation is the most important means of increasing crop productivity. It promotes the development of a denser herbage, changing the microclimate in the crop, reduces the temperature in the soil layer and increases the humidity and duration of leaf moisture, thus creating better conditions for the development of pathogens and contributing to their epiphytotic development. Irrigation affects the development of diseases by creating conditions that become more favourable for infecting plants, promotes sporulation and plays an important role in the spread of certain pathogens [1-3].

In accordance with the development of the disease, during irrigation, spores of the pathogen spread to neighbouring plants with water droplets, irrigation water, contributing to the development of epiphytotics. Plant pathogens identified from water resources include 17 species of the genus *Phytophthora*, 26 of the genus *Pythium*, 27 other genera of fungi, 8 types of bacteria, 10 viruses. Contaminated irrigation water is the main, if not the only, source of late blight inoculum for nursery gardens of fruit and vegetable crops [2-4]. In addition, irrigation promotes the development of diseases that require a warm, humid climate. In particular, the appearance of angular leaf spots, anthracnose, powdery mildew, fire blight of beans, black rot and melon anthracnose, fire blight of strawberries, late blight and bacterial diseases of tomatoes, black leg in cruciferous crops increases [4-10]. Irrigation also affects pests directly or indirectly. The use of water-charging irrigation allows regulating the number of soil pests, such as caterpillars, cut worms, bean aphids and others. The application of sprinkling irrigation contributes to the washing away and mass death of insect-like pests, namely aphids, leafhoppers, flea beetles. In addition, due to the improvement of the microclimate in plantings and optimisation of physiological processes in plants during irrigation, losses of the final crop due to damage by phytophages are minimised [11].

Changes in the soil moisture regime promote the development of leaf diseases and root rot, contribute to the spread of hygrophilic pest species, such as wireworms, corn borers, leaf aphids, ground beetles, grass sawflies. At the same time, there is a decrease in the number of locusts, bread beetles, and turtle beetles, which belong to xerophilous pest species. Therefore, by conducting irrigation by various methods, it is possible to directly or indirectly influence the number of different groups of phytophages and minimise their harmfulness on agricultural crops [2; 11]. Consequently, irrigation not only changes the ecological conditions of crop cultivation, but also modifies existing phytopathocenoses and entomocomplexes, while having a complex and multi-vector impact, which requires significant changes in protection technologies, the development of new methods for controlling harmful organisms. At the same time, the toxic load on the environment and humans is reduced, due to the fact that pesticides in drip irrigation conditions dissolve in water better than with conventional technologies. Therefore, the drift of the irrigation mixture to other non-target zones has a less toxic effect, and therefore, less pollutes the environment [12].

In particular, the use of such technologies significantly increases the production of vegetable products and reduces their cost. The use of herbicides together with irrigation water is usually effective for weed control, namely in the zone of moistening with irrigation water. Consequently, herbigation through irrigation systems is particularly effective in conditions of insufficient moisture. The movement of herbicides used in irrigation systems mainly depends on solubility, absorption, and volatility [13].

To date, the AEPA (American Environmental Protection Agency) has registered a large number of insecticides for use in drip irrigation on many crops. Their use together with irrigation water for drip irrigation provides more effective control of insect pests, compared to traditional leaf treatment, because due to root absorption, the drug is more evenly distributed throughout the plant. For vegetable crops, 1-2 single applications of insecticides by pestigation provide effectiveness at the level of several treatments by conventional methods. It was found that a single injection of chlorantraniliprole through a drip system was responsible for the effectiveness of 4 foliar treatments with lambda-cyhalothrin pyrethroid to control caterpillars that damage tomatoes [12]. G. Gidiou, T. Kuhar, J. Palumbo, D. Schuster [14] showed that 2 injections of chlorantraniliprole into the drip irrigation system had the same effectiveness as 7 standard leaf treatments, which amounted to 2 treatments with acephate (Orthene 97; United Phosphorus, Inc., Kingdom of Prussia, Pennsylvania) and 5 treatments with indoxacarb (Avaunt 30WDG; EI DuPont de Nemours, Inc., Wilmington, Delaware) to control the corn worms on bell peppers.

Fungigation is a common practice for controlling fungal diseases in regions where irrigated agriculture is widely used. In closed irrigation systems, fungigation is most often limited to the use of systemic fungicides to control soil pathogens. However, to control diseases affecting aboveground parts, I. Katz, A. Cunha, A. Sousa, and E. Herdani [15] showed that the use of fungigation can effectively reduce the development of grey rot on ornamental plants. J. Araujo, E. Furtado, H. Filho, and A. Lombardi [16] found that the introduction of fungicides with irrigation water during drip irrigation effectively protects tomatoes from diseases. Thus, the selection of a modern range of chemicals that can be effectively used in chemisation against certain harmful organisms is now one of the most relevant areas of drip irrigation and requires studies in different soil and climatic zones of Ukraine.

The purpose of the study is to identify promising active substances of pesticides for use in drip irrigation and develop schemes for their application.

MATERIALS AND METHODS

Field experiments to determine the effectiveness of the use of certain groups of pesticides in drip irrigation were conducted during 2017-2018 in the conditions of the dry steppe of Ukraine at experimental sites in SE "DH Brylivske" of the Institute of Water Problems and Land Reclamation of NAAS of Ukraine. Soil characteristics of the experimental site: dark chestnut sandy loams, humus content 1.24-1.63% (low humus), ph 5.8 (reaction close to neutral). The application of the studied preparations took place on a drip irrigation system, a multi-year irrigation pipeline of the Panplast FL 16 mills type, the level of pre-irrigation humidity – 85-75% of the lowest soil moisture capacity by crop development phases. The introduction of pesticides in the conventional way was carried out using a knapsack motor sprayer Oleo-Mac AM190. Working fluid consumption is 350 l/ha.

Tillage and technology of growing experimental crops are generally accepted for drip irrigation conditions in the dry steppe subzone of Ukraine. Drip irrigation schemes were developed to investigate the use of pesticides to protect row crops: corn, tomatoes and soybeans. The weather conditions of the growing seasons 2017-2018 were relatively favourable for the growth and development of experimental plants, and the lack of moisture reserves in the soil was compensated by drip irrigation (Table 1). During the growing season of corn, tomatoes, and soybeans, the average temperature was higher by +1.84^{0}C (2017) and +3.3^{0}C (2018), and productive precipitation was received almost 2.0 times less or -105.2 mm (2017) and +3.7 mm (2018).

Weeds were counted on fixed model sites with a size of 1 m^2 (100x100 cm). Repetition – 4 times. Records of the effectiveness of herbicides at the experimental sites were carried out 14 days and 28 days after the introduction of drugs. The ground mass of annual gramineous and dicotyledonous weeds was determined on the 28th day after treatment. The effectiveness of insecticides and fungicides was studied at experimental sites with a size of 100 m^2 (10x10 m), the placement is randomised in four repetitions [17]. The calculation to determine the effectiveness of fungicides were carried out before the first treatment; 10 days after the first treatment; before the second treatment; 10 days after the second treatment. The number of registered plants – 10 pcs. in four repetitions. The development and spread of diseases were determined at the experimental site.

***Table 1**. Characteristics of weather conditions of the growing season 2017-2018 (Khersonska Oblast, Oleshkivskyi district, Pryvitne village (SE "DH Brylivske" IWPLR NAAS)*

Main indicators	Vegetative season 2017, months						
	April	May	June	July	August	September (I-II ten-day intervals)	Total for vegetation period
Air temperature, ^{0}C a) long-time annual average	10.8	15.8	20.2	20.8	21.9	16.6	17.68
b) in 2017	10.1	14.9	21.7	23.5	25.1	21.8	19.52
Precipitation, mm a) long-time annual average	28	38	46	40	33	28	213.0
b) in 2017	9	44	22.2	32.6	0	0	107.8

Table 1, Continued

Main indicators	April	May	June	July	August	September (I-II ten-day intervals)	Total for vegetation period
	Vegetative season 2017, months						
Air humidity, % a) long-time annual average	71	68	64	60	54	66	63.83
b) in 2017	70.0	65.2	64.1	59.5	52.2	59.1	61.68
	Vegetative season 2018, months						
Main indicators	**April**	**May**	**June**	**July**	**August**	**September (I-II ten-day intervals)**	**Total for vegetation period**
Air temperature, ^{0}C a) long-time annual average	10.8	15.8	20.2	20.8	21.9	16.6	17.7
b) in 2018	15.2	19.5	21.9	22.9	25.5	21.0	21.0
Precipitation, mm a) long-time annual average	28	38	46	40	33	28	213.0
b) in 2018	0.0	12.8	8.2	112.1	62.0	15.6	216.7
Air humidity, % a) long-time annual average	71	68	64	60	54	66	63.8
b) in 2018	52	47	45	54	44	67	51.5

Studies of the effectiveness of protection systems were conducted on corn plant hybrids DKS 5276. Sowing scheme – 70+70x15 cm, plant density – 95.24 ths. pcs/ha. Irrigation of plots was carried out by drip irrigation, the level of pre-irrigation humidity – 85-90% of the lowest moisture capacity of the root-bearing soil layer (layer – 0-75 cm). In total, 29 vegetation irrigations were carried out during the growing season of corn with a rate of 135 to 165 g^3/ha (irrigation rate = 4,400 m^3/ha). The timing of vegetation irrigation was determined by the strain gauge method. Chemical protection of corn at the experimental site was carried out according to the scheme presented in Table 2.

***Table 2**. System of chemical protection of corn at the experimental sites in SE "DH Brylivske" IWPLR NAAS*

Vegetative stage on the BBCH-scale*	Object	Active ingredient	Consumption rate, l/ha
00	Annual dicotyledonous and gramineous weeds	Pendimethalin, 330 g/l	3.0-6.0
00	Annual gramineous and some annual dicotyledonous weeds	S-metolachlor, 960 g/l	1.0-1.6
00	Annual gramineous and dicotyledonous weeds	Acetochlor, 900 g/l	1.5-3.0
51-53; 60-61	European corn borer	Imidacloprid, 150 g/l+lambda-cyhalothrin, 50 g/l	0.12-0.14
16-18; 39-42	Fusarium, stem rust, helminthosporiosis	Pyraclostrobin, 62.5 g/l+epoxiconazole, 62.5 g/l	1.5-1.75
16-18; 39-42	Fusarium, stem rust, helminthosporiosis	Azoxystrobin 120 g/l+tebuconazole 200 g/l	1.0-1.2

***Note**: * – European coding system for phenologically similar development stages of all monocotyledonous and dicotyledonous plant species (BBCH-scale) [18]*

The objects of study were: beet moth (*Loxostege sticticalis*) and European corn borer (*Ostrinia nubilalis Hb.*). The caterpillars were counted once in 2 days visually and by shaking each plant on a white gauze cloth. In addition, the calculation was carried out by counting wormholes in the stems, damaged stems were opened along and caterpillar records were made. The number of registered plants – 10 pcs. in four repetitions.

The objects of study of the effectiveness of fungicides were: helminthosporiosis (*Helminthosporium spp.*), fusarium (*Fusarium spp.*), stem rust (*Puccinia sorghi*). Studies of the effectiveness of soybean crop protection systems were conducted on the Oksana variety. Scheme of sowing on experimental plots 15+15x11 cm, plant density – 605-610 ths. pcs/ha. Irrigation of plots was carried out by drip irrigation, the level of pre-irrigation humidity – 90-80% of the lowest moisture capacity of the root-bearing soil layer (layer – 0-30 cm; 0-40 cm – according to the phases of plant development). In total, 35 vegetation irrigations were carried out during the growing season of soybean with a rate of 120 to 149 m^3/ha (irrigation rate = 4,650 m^3/ha). The timing of vegetation irrigation was determined by the strain gauge method.

The system of chemical protection measures for soybeans is shown in Table 3.

***Table 3**. System of chemical protection of soybean at the experimental sites in SE "DH Brylivske" IWPLR NAAS*

Vegetative stage on the BBCH-scale*	Object	Active ingredient	Consumption rate, l/ha
00	Annual gramineous and dicotyledonous weeds	Acetochlor, 900 g/l	1.5-3.0
00	Annual dicotyledonous and gramineous weeds	Pendimethalin, 330 g/l	3.0-6.0
00	Annual gramineous and some annual dicotyledonous weeds	S-metolachlor, 960 g/l	1.0-2.0
51-53; 60-61	Bean pod borer, tobacco thrips	Imidacloprid, 200 g/l	0.2-0.25
51-53; 60-62	Powdery mildew, stem rust, septoria, anthracnose	Pyraclostrobin, 62.5 g/l+epoxiconazole, 62.5 g/l	1.5
51-53; 60-62	Powdery mildew, stem rust, septoria, anthracnose	Azoxystrobin 120 g/l+tebuconazole 200 g/l	1.0-1.2

***Note**: * – European coding system for phenologically similar development stages of all monocotyledonous and dicotyledonous plant species (BBCH-scale) [18]*

The objects of study of the effectiveness of insecticides were: bean pod borer (*Etiella zinckenella*), tobacco thrips (*Thrips tabaci*). Caterpillars *Etiella zinckenella* were counted in the BBCH phase 51-53. Thrips *Thrips tabaci* were counted by visual examination of soybean plants. The objects of the study to determine the effectiveness of fungicides were: powdery mildew (*Erysiphe communis f. glycine*), stem rust (*Uromyces sojae*) septoria (*Septoria glycines*), anthracnose (*Colletotrichum glycines*).

Herbicides were tested on tomato plants of the Lampo F1 hybrid. Scheme of planting tomato plants – 152+152x20 cm, plant density – 32.89 ths. pcs/ha. Irrigation of plots was carried out by drip irrigation, the level of pre-irrigation humidity – 80-90-75% of the lowest moisture capacity of the root-bearing soil layer (0.20-0.30-0.35 m by phases of plant development). In total, 36 vegetation irrigations were carried out during the growing season with a rate of 80 to 130 m^3/ha (irrigation rate = 3,700 m^3/ha). The timing of vegetation irrigation was determined by the strain gauge method. The system of chemical protection measures for tomatoes at the experimental site is shown in Table 4.

***Table 4**. System of chemical protection of tomatoes at experimental sites in SE "DH Brylivske" IWPLR NAAS*

Vegetative stage on the BBCH-scale*	Object	Active ingredient	Consumption rate, l/ha
00	Annual dicotyledonous and gramineous weeds	Pendimethalin, 330 g/l	3.0-6.0
00	Annual gramineous and some annual dicotyledonous weeds	S-metolachlor, 960 g/l	1.0-2.0
19-22; 30-34	Colorado potato beetle, tomato and melon aphids	Imidacloprid, 200 g/l	0.2-0.25

Table 4, Continued

Vegetative stage on the BBCH-scale*	Object	Active ingredient	Consumption rate, l/ha
19-22; 30-34	Colorado potato beetle, tomato and melon aphids	Thiamethoxam, 240 g/l	0.07-0.09
19-23; 51-53	Late blight, Alternaria blight, septoria	Pyraclostrobin, 50 g/kg+metyram, 550 g/kg	2.0
19-23; 51-53	Late blight, Alternaria blight, septoria	Azoxystrobin, 250 g/l	0.6

Note: ** – European coding system for phenologically similar development stages of all monocotyledonous and dicotyledonous plant species (BBCH-scale) [18]*

The objects of research on the effectiveness of insecticides were: Colorado potato beetle (*Leptinotarsa decemlineata*), aphids (*Aphidoidea*). Pest records were carried out at the stages of larval, adult, and reproductive stages of insect development. Accounting for the number of Colorado potato beetles (*Leptinotarsa decemlineata*) was carried out per one tomato bush, the economic threshold of harmfulness is 10% of the bushes inhabited by adults and larvae with a number of more than 10 individuals per tomato bush. Accounting for the number of tomato (*Macrosiphum euphorbiae*) and melon aphids (*Aphis gossypii*) was carried out per 100 leaves of tomato plants, the economic threshold of harmfulness is 10 individuals per 100 leaves of tomato plants. The objects of study on the effectiveness of fungicides were the pathogens of late blight diseases (*Phytophthora infestans*), alternariosis (*Alternaria solani*), septoria (*Septoria lycopersici*).

RESULTS AND DISCUSSION

Technologies for the use of pesticides in drip irrigation involve the use of chemical components that are characterised by translaminar and acropetal movement through the plant and have a systemic nature of the action. As a result of the analysis of literature sources [13-16], the following active substances were selected according to the mechanism of action on harmful organisms (Table 5).

Table 5*. Active substances of pesticides promising for use with drip irrigation*

Insecticides	Fungicides	Herbicides
Chlorpyrifos	Azoxystrobin	Bromoxanil
Zeta-cypermethrin	Pyraclostrobin	Acifluorfen
Methyl parathion	Fluopyram	Lactofen
Gamma-cyhalorin	Boscalid	Atrazine
Karbofuran	Fluoxystrobin	Chlorosulfuron
Acetamiprid	Chlorothalonyl	
Flonicamide	Copper sulphate	
Imidacloprid	Ciproconazole	
Thiamotoxam	Methyl thiophanate	
Spinosad	*Bacillus pumulis* (Ballad PLUS preparation)	
Permethrin	*Bacillus subtilis* QST 713 strain (Serenade ASO preparation)	
Esphenvalerate		
Cyflutrin		
Bifentrin		
Lambda-cyhalothrin		

Source: *compiled by the authors based on analytical data [13-16]*

As evidenced by previous studies, on vegetable crops, in particular carrots and onions, the use of fungicides of strobilurins and triazoles groups is most effective against a complex of diseases [19]. It was found that fungicides of the strobilurin group not only reliably protect crops from a complex of diseases and preserve a significant share of the crop, but are also cost-effective, and also have a pronounced physiological effect, which consists in more active use of nitrogen by plants and countering adverse environmental factors. Thus, in carrot crops, the use of mixtures of fungicides Signum VG and Skor 250 EC reduced the development of alternariosis by 93%, powdery mildew – by 60%, under this condition, the yield increased by 49%, and the yield of marketable products – by 30%. It is shown that under irrigation conditions, the optimal time for treatment against fungal diseases of onion, carrot, and soy leaves is the period of appearance of the first symptoms of the disease. Pathogen detection and monitoring, and biological and economic thresholds, are essential tools for integrated protection and should be a priority in future research. Experiments should be conducted in combination with the introduction of pesticides in a coordinated and integrated approach, since they are interrelated components.

Studies were conducted in 2017, involving the following factors: various options for applying soil herbicides, systemic fungicides and insecticides, doses of applying plant protection products to improve the technology of applying pesticides under drip irrigation conditions, which would allow using the full potential of drip irrigation methods for row crops. The conducted studies of the effectiveness of herbicides have shown that preparations with the active substance S-metolachlor (960 g/l) with consumption rates of 1.0 and 1.6 l/ha are the most promising in irrigation conditions against monocotyledonous annual weeds and show low phytotoxicity on row crops with a consumption rate of 1.0 l/ha and an average phytotoxicity of up to 4 points with a consumption rate of 2.0 l/ha.

It was found that the introduction of herbicides with active substances acetochlor (900 g/l) with consumption rates of 1.5 and 3.0 l/ha and pendimethalin (330 g/l) with consumption rates of 3.0 and 6.0 l/ha with irrigation water has certain disadvantages: weak drift over the entire area of sowing and phytotoxicity for cultivated plants. On corn, with irrigation water and using traditional application technology, insecticides with active ingredients imidacloprid, 150 g/l+lambda-cyhalothrin, 50 g/l with consumption rates of 0.12 and 0.14 l/ha provided an effective action against stem moth in the range of 75.3-84.7%. On soybeans and tomatoes, preparations with the active substance imidacloprid, 200 g/l with consumption rates of 0.2 and 0.25 l/ha had an effectiveness of 69.8-83.2% and 67.9-82.7%, respectively. On tomatoes, a higher efficiency was noted during treatment with thiamethoxam, 240 g/l (consumption rates of 0.07-0.09 l/ha) – 67.1-86.6%. Phytotoxicity was not observed. Fungicides with active ingredients pyraclostrobin, 62.5 g/l+epoxiconazole, 62.5 g/l with consumption rates of 1.5 and 1.75 l/ha and azoxystrobin 120 g/l+tebuconazole 200 g/l with consumption rates of 1.0 l/ha and 1.2 l/ha on corn showed high effectiveness against pathogens of fusarium and helminthosporiosis. At the experimental soybean sites, these drugs also showed good effectiveness of 60.9% and 70.3%, respectively, against septoria at maximum consumption rates. When applying the fungicides pyraclostrobin, 50 g/kg+metyram, 550 g/kg (consumption rate 2.0 l/ha) and azoxystrobin, 250 g/l (consumption rate 0.6 l/ha) with irrigation water, their sufficiently high technical effectiveness against pathogens of late blight (48.6% and 50.8%) and alternary fungus (42.7% and 47.3%) was established on tomatoes that were grown by seedling method and phytotoxicity was not detected.

The results obtained showed that one of the significant disadvantages of applying plant protection products with irrigation water is the limitation of the application time by irrigation regimes. Therefore, a combined scheme for the protection of row crops was applied, which provides for preventive treatment in a short time by conventional methods, depending on the phytosanitary situation of crops (Table 6). The results of the analysis of the final crop of experimental plots showed that the greatest effectiveness against the main pathogens on corn, tomatoes, and soybeans was observed with the combined method of applying pesticides according to the developed schemes. The use of this method of application provided an increase in yield in the range of 3-4% compared to other methods of application due to the share of the preserved crop (Table 7).

***Table 6**. Systems of protection of row crops (Khersonska Oblast, Oleshkivskyi district, Pryvitne village (SE "DH Brylivske" IWPLR NAAS, 2018)*

Crop	Conventional	Pestigation	Combined
Corn Soybean Tomatoes	Soil herbicides Systemic and contact insecticides Systemic and contact fungicides	Soil herbicides Systemic insecticides Systemic fungicides	Soil herbicides: conventional pestigation Insecticides: conventional+pestigation Fungicides: conventional+pestigation

***Table 7**. Influence of various systems of protection of row crops on yield (Khersonska Oblast, Oleshkivskyi district, Pryvitne village (SE “DH Brylivske” IWPLR NAAS, 2018)*

Crop	Protection system	Yield, t/ha	Increase in yield, %
Corn	Control	14.65	–
	Conventional	18.49	27.0
	Pestigation	18.26	25.4
	Combined	18.76	28.8
Soybean	Control	4.84	–
	Conventional	5.96	23.1
	Pestigation	5.67	17.1
	Combined	6.12	26.4
Tomatoes	Control	72.61	–
	Conventional	96.38	32.7
	Pestigation	95.23	31.2
	Combined	98.81	36.1

Thus, the combined scheme of protection of row crops would allow producers to use pesticides more effectively by pestigation and expand the range of effective preparations that are applied by spraying if additional crop treatments are needed.

CONCLUSIONS

Studies of the effectiveness of applying herbicides with irrigation water have shown that preparations with the active substance S-metolachlor (960 g/l) and consumption rates of 1.0 and 1.6 l/ha are the most promising in irrigation conditions against monocotyledonous annual weeds and show low phytotoxicity on row crops. Significant effectiveness against stem moth on corn was found in insecticides with active substances imidacloprid, 150 g/l+lambda-cyhalothrin, 50 g/l with consumption rates of 0.12 and 0.14 l/ha in the range of 75.3-84.7%. On soybeans and tomatoes – preparations with the active substance imidacloprid, 200 g/l (consumption rates of 0.2-0.25 l/ha). On tomatoes, the greatest effectiveness against the Colorado potato beetle and aphids was found when applying thiamethoxam with irrigation water, 240 g/l (consumption rates of 0.07-0.09 l/ha). High effectiveness against pathogens of fusarium and helminthosporiosis of corn was observed when pyraclostrobin, 62.5 g/l+epoxiconazole, 62.5 g/l (consumption rate 1.5-1.75 l/ha) and azoxystrobin 120 g/l+tebuconazole 200 g/l (consumption rate 1.0-1.2 l/ha) were applied with irrigation water. These drugs also showed good effectiveness on soybeans against septoria at maximum consumption rates. On tomatoes, the fungicides pyraclostrobin, 50 g/kg+ metyram, 550 g/kg (consumption rate 2.0 l/ha) and azoxystrobin, 250 g/l (consumption rate 0.6 l/ha) were found to have a fairly high technical efficiency against pathogens of late blight and alternariosis.

As a result of the conducted experiments, it was established that one of the significant disadvantages of the pestigation method is the limitation of the time of application of plant protection products by irrigation regimes. The tested combined scheme of protection of row crops, which provides for preventive treatments in a short time by traditional methods, depending on the phytosanitary situation of crops, the use of this method of application provided a yield increase of 3-4% compared to other methods. Therefore, further studies on improving the method of pestigation on row crops should be aimed at optimising and developing the combined application of plant protection products depending on changes in the phytosanitary condition of crops.

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Особливості захисту просапних культур в умовах зрошення

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Анотація. Зрошення не тільки змінює екологічні умови вирощування культури, але й модифікує наявні фітопатоценози й ентомокомплекси, справляючи комплексний і різновекторний вплив, що потребує істотних змін у технологіях захисту, розробки нових методів контролю шкідливих організмів. Важливим є добір сучасного асортименту хімічних речовин, які можливо ефективно використовувати у хімізації. Метою досліджень було визначити перспективні для застосування за краплинного зрошення діючі речовини пестицидів і розробити схеми їх внесення. Польові досліди щодо визначення ефективності використання певних груп пестицидів за краплинного зрошення проводились в умовах Сухого Степу України. Внесення досліджуваних препаратів відбувалось на системі краплинного зрошення. Для планування досліджень із використання пестицидів за краплинного зрошення були розроблені схеми для захисту просапних культур: кукурудзи, томатів і сої. Відібрані діючі речовини, які характеризуються трансламінарним та акропетальним рухом по рослині, мають системний характер дії і високоефективні під час застосування у технологіях краплинного зрошення. Розглянуто, що одним із вагомих недоліків внесення засобів захисту рослин із поливною водою є обмеження строків внесення поливними режимами. Найвища ефективність проти основних патогенів спостерігалась при комбінованому способі внесення пестицидів згідно з розробленими схемами. Такий спосіб передбачає застосування пестицидів разом із поливною водою та додаткову обробку хімічними препаратами традиційними методами внесення упродовж вегетації. Зі свого боку це дозволяє провести профілактичні обробки у стислі терміни та корегувати терміни обробок залежно від фітосанітарної ситуації

Ключові слова: краплинне зрошення, хімізація, кукурудза, соя, томати, ефективність пестицидів, врожайність