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Neonicotinoids against sucking pests on winter wheat stands in the Forest-Steppe Zone of Ukraine

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A B S T R A C T

Saturation of crop rotation with grain cereal crops (corn, winter wheat) leads to the creation of favorable conditions for the development of sucking pests and, consequently, increasing of their density of population and harmfulness on winter wheat crops. The comparative evaluation of the effectiveness of neonicotinoids against the group of sucking pests (Sun pest (Eurygaster integriceps), wheat aphids, thrips) on crops was done in 2016-2017. Insecticide Engeo 24.7% SC was the most effective against the Sunn pest. His maximum technical efficiency reached 100.0% and was obtained on 7th and 14th day after treatment. The most effective for spraying against aphids were Engeo 24.7% SC and Actara, 24% SC, that shown 99.7% and 98.3% reduction of aphids number on 7th day compared to the control respectively. The application of investigated insecticides significantly reduced the population of aphids, trips and Sun pest, that results in increasing in quantitative and qualitative indices of winter wheat yield.

Keywords: Wheat, Sucking pests, Aphids, Bugs, Insecticides, Crop.

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Introduction

In recent years, there has been a violation of the agricultural crops alternation in the crop rotation of most farms, when one crop is grown in the same field for two or more years in a row. In the Forest-Steppe Zone of Ukraine, a situation is characterized when 3-5 crops (corn, soybeans, sunflower, winter rape, winter wheat) prevail in the farm. In some cases, the area under the corn takes up 50-75% of the total area of the plowed land of the farm. Due to the excessive saturation of the crop rotation with one culture, the favorable conditions for the pest proliferation and the infection spread are created [1].

More than 360 species of insects and other animal organisms, including nematodes, rodents, birds and representatives of other fauna classes damage cereals in Ukraine [2]. Sucking pests are especially dangerous. In particular, mass outbreaks of the sunn pest (*Eurygaster integriceps*), wheat aphids, thrips, cicadas cause significant damage of winter wheat plants. This leads to a shortage or full loss of grain yield. Thus, according to the Institute of Plant Protection of the National Academy of Agrarian Sciences of Ukraine, damaging the stem of culture with a sunn pest can reduce yield by 50-54% [3].

New chemicals against pests appear every year in the State list of pesticides and agrochemicals authorized for use in Ukraine. With the implementation of modern agricultural technologies, there is a tendency to increase the use of highly effective insecticides with low application rates, that minimizes their influence on the environment. Preferably, these chemicals are from the group of

neonicotinoids that are highly effective against pests and, at the same time, are low toxic for the humans and animals [4].

Neonicotinoids are a relatively new class of insecticides. One of the success factors of these plant protection products is that their application is affecting pests with developed resistance to insecticides from other chemical groups. The prevalence of neonicotinoids is due to the variety of methods of their application (spraying, pre-sowing seed treatment, introduction into irrigation water in drip or irrigated systems). In addition, these chemicals have opened new opportunities in the development of products for protection of seeds and seedlings [4, 5].

The mechanism of action of neonicotinoids shows itself in disturbance of the central nervous system of insects. Active ingredients act as a competitor to acetylcholine of the postsynaptic membrane receptor. In this case, excessive excitation of the nerve cells occurs and thereby disturbs the normal conduction of the nerve impulse through the synapses, which is a consequence of a violation of the functional activity of the acetylcholine receptor. As a result, convulsions and paralysis developed in insects, which leads to their mortality [6, 7].

In the Ukrainian market, insecticides from the group of neonicotinoids are most widely represented on the basis of the following active ingredients: imidacloprid, thiamethoxam, thiacloprid and acetamiprid (Table 1). Their combinations with pyrethroids are also used in order to increase their effectiveness against crop pests: Engeo 24.7% SC (thiamethoxam, 141 g/l + lambda-cyhalothrin, 106 g/l); Borey 20% SC (imidacloprid, 150 g/l + lambda-cyhalothrin, 50 g/l); Connect 11,25% SC (imidacloprid, 100 g/l + beta-cyfluthrin, 12.5 g/l); Proteus 11% OD (thiacloprid, 100 g/l + deltamethrin, 10 g/l); Inasuma 13% WG (acetamiprid, 100 g/kg + lambda-cyhalothrin, 30 g/kg) and others.

Therefore in 2016-2017 to optimize winter wheat protection measures, a comparative assessment of the effectiveness of neonicotinoids against the group of sucking pests (sunn pest, wheat aphids, thrips) was made on stands of this crop.

Materials and methods

Field trials were carried out in 2016-2017 in the Kyiv region conditions. For investigations, the registered chemicals from the neonicotinoid group were used: Actara, 24% SC and Mospilan, 20% SP In addition, for the comparison of efficacy, the complex insecticides Engeo 24,7% SC, Connect 11,25% SC and Proteus 11% OD were used. In the experiments, the winter wheat sort Myronivska 65 was grown, the seed planting rate was 4,5 millions per hectare. The size of the experimental plots is 50 m^2 (10,4 x 4,8 m), replication – 4 times. Allocation of plots is randomized.

Scores of pests, sampling and analysis were carried out in accordance with generally accepted methods [8]. The number of larvae and adult insects of the sunn pest was counted for 1 m^2, while the insects were counted on 8 test sites of 50x50 cm (0.25 m^2) size. For the scores of the thrips, 5 spikelets were selected in 10 places of the plot. Samples were placed in paper bags. Then the number of thrips and their average number per spikelet was counted in the laboratory. The score of the wheat aphids was counted on each site for 100 stems (5 stems in 20 places), imago and larvae were observed on leaves, stalks and spikelets.

Table 1. *The main active ingredients of neonikotinoids in Ukraine*

Active ingredient	Name of insecticide	Manufacturer	Rate of application
Imidacloprid	Confidor, 20% SL	Bayer Ag, Germany	0,1-0,35 l/ha
Acetamiprid	Mospilan, 20% SP	NIPPON SODA CO., LTD, Japan	0,05-0,50 kg/ha
Thiacloprid	Calypso, 48 % SC	Bayer Ag, Germany	0,15-0,30 l/ha
	Biscaya, 24% OD		0,20-0,40 l/ha
Thiamethoxam	Actara, 24 % SC	Syngenta Crop Protection Ag, Switzerland	0,15-0,16 l/ha

Research results

The occupation of winter wheat crops by pests was determined from the tillering phase. In the species composition of the aphids, the Grain aphid (*Sitobion avenae* F.) was most common, the Sunn pest was dominated among the shield bugs (Scutelleridae), *Eurygaster austriaca* Schrank occurs sporadically, *Aelia acuminata* L. and other species of bugs were found. The number of larvae and imago of wheat aphids reached 50.0-80.5 / plant, thrips – 23.3-27.0 / spikelet, imago of the Sunn pest – 5,3-8.3 /m^2 during the observations before the application of insecticides in the early-medium milk stage of winter wheat.

The treatment of crops with insecticides contributed to a decrease of the occupancy of plants by pests (Table 2). The highest effectiveness against Sunn pest was provided by insecticide Engeo 24.7% SC. Thus, on average, on the 3rd day after its application, the death of this pest reached to 92.5%,

and 100.0% – on the 7th and 14th day.

On average, over two years, the effectiveness of the Actara, 24% SC was 88.6% and 95.8% on the 3rd and 7th day after spraying respectively. Somewhat lower was an efficiency of Proteus 11% OD, that on the 3rd day after spraying reached to 86.9%, on the 7th – 89.7%. With the application of insecticide Mospilan, 20% SP the mortality rate of these phytophages was lower and reached only 69.8% and 84.6%, respectively (Table 3).

Also, on the 3rd day after spraying in the variant with the insecticide Actara, 24% SC the population of larvae and imago thrips was decreased by 93,8%, and on the 7th day – by 99.1%. Application of the Mospilan, 20% SP ensured the mortality rate of these phytophages on the 3rd day at the level of 88.2%, on the 7th – 93.0%. Insecticide Engeo 24.7% SC showed the effectiveness against the thrips slightly higher, compared with the Actara, 24% SC. Thus, on the 3rd day after application of Engeo 24.7% SC the death of the thrips reached to 98.0%, on the 7th day – 99.0%. Somewhat lower was an efficiency of Proteus 11% OD, that on the 3rd day after spraying reached to 96.2%, on the 7th – 98.2%.

At the observations on 14th day after spraying, the increasing of the effectiveness of insecticides was noted. So, in variants with the use of Actara, 24% SC, Proteus 11% OD and Engeo 24.7% SC efficiency was almost the same and reached to 99.1-99.6%. In the variant with the application of Mospilan, 20% SP this indicator was only 94.4%.

During the research period it was found that the use of insecticides provided high effectiveness against wheat aphids. Their mortality rate on the 3rd day after application of the Mospilan, 20% SP was 85.4%, on other variants with insecticides it reached 89,3-92,6%. On the 7th and 14th days the preparations Actara, 24% SC, Proteus 11% OD, Connect 11,25% SC and Engeo 24.7% SC were most efficient, supply the mortality of wheat aphids at level – 95.4-99.7%.

At harvesting it was found that protection of winter wheat plants by spraying with insecticides contributed to the preservation of quality indicators of the yield. So, the mass of 1000 grains in the variant with Actara, 24% SC, Proteus 11% OD and Engeo 24.7% SC reached 46.3, 46.4 and 46.5 g, respectively, that was on 4.9-5.1 g higher than control. Application of the Mospilan, 20% SP and Connect 11,25% SC provided the increasing of the mass of 1000 grains up to 46.0 g, that was on 4.6 g higher than the control indicator (Table 4).

The higher yield of wheat grain was obtained on all variants of the experiment with application of insecticides, in comparison with the control. So, the yield on variants with the Actara, 24% SC, Proteus 11% OD and Engeo 24.7% SC exceeded the control by 0.49 and 0.51 mt / ha, and by 0.03-0.05 mt/ha in comparison with the variant with Mospilan, 20% SP and Connect 11,25% SC.

Table 2. *The number of winter wheat pests in the early-medium milk stage of winter wheat (Kyiv region, 2016-2017)*

Variant	Application rate, kg (l)/ha,	Year	Number of pests before treatment			Number of pests on … day after treatment								
						3rd			7th			14th		
			Sunn pest, exemplars/ m^2	thrips larvae, exemplars /spikelet	wheat aphids, exemplars /plant	Sunn pest, exemplars/ m^2	thrips larvae, exemplars /spikelet	wheat aphids, exemplars /plant	Sunn pest, exemplars/ m^2	thrips larvae, exemplars /spikelet	wheat aphids, exemplars /plant	Sunn pest, exemplars/ m^2	thrips larvae, exemplars /spikelet	wheat aphids, exemplars /plant
Control	-	2016	7,8	27,0	50,0	8,0	32,5	68,0	8,3	44,5	96,5	8,5	51,8	134,3
		2017	5,5	24,5	80,5	6,0	29,3	107,8	6,3	36,5	132,3	6,8	42,0	162,8
		average	**6,7**	**25,8**	**65,3**	**7,0**	**30,9**	**87,9**	**7,3**	**40,5**	**114,4**	**7,7**	**46,9**	**148,6**
Actara, 24% SC	0,15	2016	8,3	24,5	53,8	0,5	1,8	8,0	0,3	0,5	4,8	0,0	0,3	2,8
		2017	5,3	23,3	76,5	1,0	2,3	10,0	0,3	0,3	5,3	0,3	0,5	2,3
		average	**6,8**	**23,9**	**65,2**	**0,8**	**2,1**	**9,0**	**0,3**	**0,4**	**5,1**	**0,2**	**0,4**	**2,6**
Mospilan, 20% SP	0,12	2016	7,5	24,3	52,5	2,0	3,3	13,3	1,0	2,3	11,0	1,0	2,0	6,5
		2017	6,0	24,0	78,5	2,0	4,3	11,3	1,0	3,5	9,0	0,8	3,3	2,0
		average	**6,8**	**24,2**	**65,5**	**2,0**	**3,8**	**12,3**	**1,0**	**2,9**	**10,0**	**0,9**	**2,7**	**4,3**
Engeo 24.7% SC	0,18	2016	8,0	26,5	51,5	0,3	0,5	6,8	0,0	0,3	2,8	0,0	0,0	0,5
		2017	5,3	23,5	75,0	1,0	0,8	5,3	0,0	0,5	1,5	0,0	0,3	0,5
		average	**6,7**	**25,0**	**63,3**	**0,7**	**0,7**	**6,1**	**0,0**	**0,4**	**2,2**	**0,0**	**0,2**	**0,5**
Connect 11,25% SC	0,5	2016	8,0	27,0	53,0	0,8	1,5	7,4	0,5	1,2	3,9	0,3	2,0	2,0
		2017	7,0	24,4	81,0	1,2	1,4	9,0	1,0	1,7	3,5	0,8	2,4	1,5
		середнє	**7,5**	**25,7**	**67,0**	**1,0**	**1,5**	**8,2**	**0,8**	**1,5**	**3,7**	**0,6**	**2,2**	**1,8**
Proteus 11% OD	1,0	2016	7,0	28,0	54,4	0,5	0,8	7,8	1,0	0,9	3,0	0,5	0,5	1,0
		2017	6,8	25,4	79,5	1,0	1,4	6,5	0,5	0,5	2,1	0,0	0,3	0,8
		середнє	**6,9**	**26,7**	**67,0**	**0,8**	**1,1**	**7,2**	**0,8**	**0,7**	**2,6**	**0,3**	**0,4**	**0,9**

Table 3. *Efficiency of insecticides against winter wheat pests in the conditions of the Central Forest-Steppe of Ukraine (Kyiv region, 2016-2017)*

Variant	Application rate, kg (l)/ha,	Year	Efficacy on … day after treatment, %								
			3rd			7th			14th		
			Sunn pest	thrips larvae	wheat aphids	Sunn pest	thrips larvae	wheat aphids	Sunn pest	thrips larvae	wheat aphids
Actara, 24% SC	0,15	2016	93,3	95,0	87,3	96,2	99,0	94,6	100,0	99,5	97,8
		2017	83,9	92,5	91,2	95,4	99,2	96,2	95,7	98,9	98,7
		average	**88,6**	**93,8**	**89,3**	**95,8**	**99,1**	**95,4**	**97,9**	**99,2**	**98,2**
Mospilan, 20% SP	0,12	2016	76,0	90,9	79,5	88,4	95,3	88,0	88,7	96,5	94,9
		2017	63,6	85,6	89,8	82,7	90,6	93,4	87,2	92,3	98,8
		average	**69,8**	**88,2**	**84,6**	**85,5**	**93,0**	**90,7**	**87,9**	**94,4**	**96,9**
Engeo 24.7% SC	0,18	2016	96,2	98,5	89,7	100,0	99,3	97,0	100,0	100,0	99,6
		2017	83,9	97,4	95,4	100,0	98,7	98,9	100,0	99,3	99,7
		average	**90,0**	**97,9**	**92,6**	**100,0**	**99,0**	**98,0**	**100,0**	**99,7**	**99,7**
Connect 11,25% SC	0,5	2016	89,7	95,4	88,5	93,8	97,3	95,7	96,4	96,1	98,4
		2017	74,5	95,2	91,6	79,8	95,4	97,3	85,0	94,3	99,1
		average	**82,1**	**95,3**	**90,0**	**86,8**	**96,3**	**96,5**	**90,7**	**95,2**	**98,7**
Proteus 11% OD	1,0	2016	94,4	97,4	87,5	89,2	97,9	96,6	94,7	99,0	99,2
		2017	79,4	95,0	94,0	90,2	98,6	98,4	100,0	99,3	99,5
		average	**86,9**	**96,2**	**90,8**	**89,7**	**98,2**	**97,5**	**97,4**	**99,1**	**99,4**
SSD_{05}			**7,6**	**3,8**	**3,5**	**2,7**	**1,5**	**1,4**	**1,6**	**1,5**	**1,1**

Table 4. *Yield of winter wheat in dependence on application insecticides (Kyiv region, 2016-2017)*

Variant	Application rate, kg (l)/ha,	Year	Yield, t/ha	Mass of 1000 grains, g
Control	-	2016	5,08	41,8
		2017	4,46	41,0
		average	4,77	41,4
Actara, 24% SC	0,15	2016	5,65	47,3
		2017	4,81	45,3
		average	5,23	46,3
Mospilan, 20% SP	0,12	2016	5,61	47,0
		2017	4,79	45,0
		average	5,20	46,0
Engeo 24.7% SC	0,18	2016	5,68	47,5
		2017	4,82	45,5
		average	5,25	46,5
Connect 11,25% SC	0,5	2016	5,5	46,9
		2017	4,7	45,0
		average	5,1	46,0
Proteus 11% OD	1,0	2016	5,6	47,3
		2017	4,8	45,5
		average	5,2	46,4
SSD_{05}			0,38	3,9

Conclusions

1. Saturation of crop rotation with grain crops (corn, winter wheat, barley) leads to the creation of favorable conditions for the development of sucking phytophages and, accordingly, to increase their density of population (larvae and imago wheat aphids (50,0-162,8 / plant), trips (23.3-51.8 / spikelet), imago of the Sun pest (5.3-8.5 / m2) on winter wheat stands.
2. Preparations from the neonicotinoids group were highly effective against sucking wheat pests for 2 weeks. The maximum technical efficiency against them was noted in the variant using insecticide Engeo 24.7% SC and reached 99.6-100.0%. Somewhat lower efficiency was shown by Actara, 24% Cp (97.9-99.2%) and Proteus 11% OD (97.4-99.4%).
3. The application of insecticides significantly reduced the occupation of plants by aphids, thrips and Sun pest, resulting in increased wheat yield and a mass of 1000 grains.

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