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EVALUATION OF ALLELOPATHIC ACTIVITY OF EXTRACTS OF PLANT ORGANS OF VARIOUS VARIETIES OF WINTER WHEAT

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Abstract

The article presents the results of scientific studies devoted to the study of the effect of water extracts of the roots, stems, leaves and grain of winter wheat plants on seed germination and root growth of single-day watercress seedlings. Samples of plants of the studied winter wheat varieties were taken in the phase of full grain ripeness. Water extracts of plant organs at a concentration of 1:100 were prepared for the Biotest. According to the results of research, the stimulating and inhibitory effect of water extracts from the organs of winter wheat plants on seed germination and growth of single-day watercress seedlings was established, depending on varietal characteristics. Water extracts from the roots of plants of all studied varieties reduced the germination rate of test culture seeds by 4.0 up to 40.4% compared to the control, and grain extracts had a slight stimulating effect. It is established that the variety Schedrivka Kyivs'ka has a high allelopathic activity. Water extracts of organs of soft winter wheat varieties Vidrada and MIP Assol were determined to be neutral to the germination of watercress seeds.

Key words: *allelopathic action, winter wheat, varieties, watercress, seed germination.*

INTRODUCTION

The world's organic economy is constantly developing and its area is growing every year. As of 2018 yr, 1.5% of the world's agricultural land, or 71.5 million hectares, is allocated to organic agriculture, including by region: 36.0 million hectares in Oceania and 15.6 million hectares in Europe (Willer et al., 2020).

Most of the organic arable land (4.8 million hectares) is occupied by cereals, 33.9% of which is wheat. Organic agriculture in Ukraine is dominated by grain production, which is allocated 43.2% of organic land (133,440 thousand hectares). But this is only 0.9% of the total area allocated for these crops in the country, while in Austria it is allocated 15.6%, in Italy it is allocated 10.4%, in Germany it is allocated 4.8%, in Belgium it is allocated 3.8% (Willer et al., 2020). The main reason for the slow expansion of organic acreage is low yields, which is due to the cessation of the use of mineral fertilizers and chemical plant protection products.

The search for biological regulators of plant growth has become one of the promising ways to develop environmentally sustainable methods for regulating the number of weeds in agrophytocenoses (Tahir et al., 2019; França Teixeir et el., 2018; Scavo et al., 2019; Orel et al., 2005; Kyrychenko 2014).

As a process, allelopathy is of great ecological importance for phytocenoses in the context of plant growth regulator, their productivity, and the species composition of natural and cultivated coenoses (Moskalyk & Leheta, 2019; Inayat et al., 2019; Rany Das, & Kato-Noguchi, 2018).

It is known that allelopatically active substances, depending on their concentration and environmental conditions, can have a stimulating or inhibitory effect on growth and development, as well as on various metabolic processes in plants and thus can be natural regulators of plant growth (Fidelis Giancotti et. al., 2020; Salman et. al., 2017; Ozkan. et al., 2019).

Research taken by scientists has established that winter wheat has allelopathic properties for controlling weeds, pests and diseases, which can be used in plant protection and will contribute to its cultivation using organic technologies (Wu et. al., 2001; Aslam et. al., 2016; Lam et al., 2012; Amist 2019). But when studying these properties, varietal characterristics of the culture and origin are not always taken into account.

According to Derevyanko V. A. (2003) in the characteristics of the wheat variety, it is also necessary to take into account allelopathic parameters as an integral component of the variety passport, since plants show different tolerance to allelopathically active substances. Therefore, one of the promising directions for the development of allelopathy is a screening test of various varieties and varieties of cultivated plants in order to study their allelopathic potential or resistance to allelopathically active substances (Derevyanko, 2007; Wu & Pratley, 2000; Kabir, 2010).

Therefore, the aim of our work was to study the allelopathic properties of 10 varieties of soft wheat and 1 variety of spelt winter wheat varieties of domestic and foreign selection.

MATERIALS AND METHODS

We studied the allelopathic activity of vegetative and generative organs of plants of various winter wheat varieties.

To establish the allelopathic activity of various winter wheat varieties in 2019-2020 yrs, the field experiment was conducted in the experimental field of the Educational, Scientific and Practical Center of the Mykolaiv National Agrarian University, Mykolaiv, Ukraine. The technology of winter wheat growing was generally accepted for the southern steppe zone of Ukraine. Its predecessor was sown peas. The sowing period is 1st of October. The seeding rate of winter wheat seeds was 5 million germinating seeds / ha. The material for the study was 9 winter wheat varieties bred in different soil and climate zones of Ukraine (Table 1)

Table 1. Characteristics of winter wheat varieties

Variety denomination	variety	height	disease resistance	grain quality
Vidrada	*erithrospermum*	medium-sized	average	strong
Koshova	*erithrospermum*	medium-sized	above average	strong
Schedrivka kyivs'ka	*lutescense*	medium-sized	above average	valuable
Krasa laniv	*erithrospermum*	medium-sized	above average	strong
Kvitka poliv	*lutescense*	medium-sized	above average	valuable
MIP Assol'	*lutescense*	medium-sized	resistant to diseases	filler
Harantiia odes'ka	*erithrospermum*	medium-sized	persistent	strong
Schedrist' odes'ka	*erithrospermum*	half-dwarf	persistent	valuable
Centurion	*erithrospermum*	half-dwarf	persistent	filler

Variants in the experiment were placed by the split section method, the repetition was four times. The area of the accounting plot was 25 m². Soil of experimental sites was southern black soil low-humus, light loamy on the loess's of wide weakly drained water-dividing plateaus, which is typical for the Southern Steppe zone of Ukraine.

Humus content in the arable soil layer was 2.4%, easily hydrolyzed nitrogen content was 16 mg/kg, mobile phosphorus content was 160 mg/кг and exchangeable potassium content was 187 mg/kg of soil.

To establish the allelopathic properties of winter wheat varieties suitable for distribution in the steppe zone of Ukraine, the method of bioassays of Grodzinsky (1973). Watercress was selected as the test object (*Lepidium sativum* L.) in accordance to it has a high sensitivity to allelopathic substances (Islam and Kato-Noguchi, 2013). The growth of the roots of the test object in distilled water was taken as control (100%).The research was conducted in 2020 at the Department of crop production and gardening of the Mykolaiv National Agrarian University (Mykolaiv, Ukraine).

The effect of water extracts of roots, leaves, stems and seeds of winter wheat plants on root growth and germination of watercress seeds was evaluated.

The greatest number of growth inhibitors accumulates in this phase.

Since the greatest number of growth inhibitors accumulates in the phase of full ripeness of winter wheat grain, sheaf samples of each of the studied varieties were selected during this period. Roots, stems, leaves, and grains were separated in the laboratory. The selected samples of vegetative organs of soft wheat and grain plants were dried at a temperature of

+65°C to a constant mass and they were crushed. An average weight of 1 g was selected, which was extracted in 100 ml of distilled water in a thermostat during the day at a temperature of +25 °C. To remove the solid fraction of the extract, the extract was filtered through filter paper and immediately used for the experiment laying.

1-day-old watercress seed sprouts were placed in sterile Petri dishes with a diameter of 9 cm on sterile filter paper soaked in 3 ml of filtrate (seeds were considered sprouted if the root length was 1 mm. Petri dishes were placed in a thermostat at +25 °C for one day. The control variant was treated with distilled water. The root length was measured using digital caliper DIGITAL CALIPER 391110 with an accuracy of 0.02 mm.

The experiment was completely randomized. A fourfold repetition of each studies of 100 seeds was used.

The germination rate of watercress seeds was determined on the Fifth Day.

RESULTS AND DISCUSSIONS

According to Ivanytska B. O. (2008), plant leaves and their secretions are more toxic; roots and root extracts are less toxic; stems occupy an intermediate position.

Other scientists (Krumsri et. al., 2020) claim that leaf and stem extracts have a higher inhibitory effect on rice seed germination than root extracts, as they contain higher amounts of phenolic compounds. Our research only partially confirms this.

Table 1 shows the effect of water extracts of four parts of plants of different varieties of winter wheat on the germination of watercress seed (Table 2).

Table 2. Effect of various extracts of winter wheat varieties on the germination of watercress seeds, (%)

Variety	Parts							
	root	% to control	stem	% to control	leaf	% to control	seed	% to control
Distilled water (control)	92.0	100.0	92.0	100.0	92.0	100.0	92.0	100.0
Krasa Laniv	88.3	96.0	74.3	80.8	90.3	98.2	94.0	102.2
Vidrada	86.8	94.3	95.8	104.1	66.0	71.7	97.3	105.8
Kvitka Poliv	67.8	73.7	98.8	107.4	70.3	76.4	93.0	101.1
Koshova	54.8	59.6	88.0	95.7	62.8	68.3	99.3	107.9
Schedrivka Kyivs'ka	85.8	93.3	68.3	74.2	70.3	76.4	98.5	107.1
MIP Assol'	88.8	96.5	83.3	90.5	96.8	105.2	94.0	102.2
Harantiia Odes'ka	71.5	77.7	76.3	82.9	72.0	78.3	98.5	107.1
Centurion	76.0	82.6	94.0	102.2	50.3	54.7	89.5	97.3
Schedrist' Odes'ka	84.3	91.6	82.0	89.1	73.0	79.3	95.0	103.3
Average by variety	**79.6**	**86.5**	**85.3**	**92.7**	**74.4**	**80.9**	**95.1**	**103.4**
The least significant difference (LSD) at $p<0.05$: factor A and B = 2.09%								

It was found that water extract from the leaves of winter wheat plants had a greater negative impact on the germination of watercress seeds, which averaged 74.4% for varieties (80.9% of the control). It was by 5.6% less than in the version with water extract from leaves, and it was by 11.8% less than in the version with water extract from stems and by 22.5% less than in the version with water extract from seeds.

It was determined that different parts of the plants of each studied variety had different inhibitory or stimulating effects on the germination of watercress seeds. At the same time, water extracts from the leaves of Centurion plants had a more negative effect (89.5%) on the seed germination of test crops, while extract from the leaves of MIP Asol' plants had a positive effect (105.2%).

The winter wheat variety Koshova was determined, the water extract from the roots of which had a more inhibitory effect on the germination of watercress seeds down to 54.8%, which was 94.3% before the control. It was less reduced seed germination of the studied test culture varieties: such as Krasa laniv down to 88.3% (96.0% before the control), MIP Asol' down to 88.8% (96.5%), Vidrada down to 86.8% (94.3%), Schedrivka Kyivs'ka down to by 85.8% (93.3%) and Schedrist' Odes'ka down to 84.3% (91.6%).

It was found that water extracts from the stems of winter wheat plants reduced the germination rate of watercress seeds less compared to extracts from roots and leaves, which was an average of 92.7% for varieties compared to the control. The lowest seed germination rate (68.3%) was when it was treated with an extract from winter wheat stalks of the Schedrivka Kyivs'ka variety down to 74.2% before the control. Water extracts from the stems of plants of Vidrada, Kvitka Poliv and Centurion varieties had a slight stimulating effect on the germination of test culture seeds, which was 104.1%, 107.4%, 102.2%, respectively, according to the control.

It was determined that water extracts from the grain of most of the studied winter wheat varieties increased the germination rate of watercress seeds by 101.1 up to 107.9% before the control, while Centurion varieties had a slight inhibitory effect (down to 97.3% before the control).

Research results (Petcu E. at ell., 2017) show that the degree of inhibition of ryegrass roots depended on the genotype of winter wheat. Our research confirms this fact on as well as on watercress. Inhibition of watercress root growth was observed by the action of water extracts from the roots of plants of all studied winter wheat varieties, except for the MIP Assol variety, whose water extracts had a slight stimulating effect. The most inhibitory effect on the length of watercress roots (2.60±0.43 mm) was exerted by water extract from the roots of plants of the Koshova variety, which was by 69.6% less than in the control variant. The coefficient of variation of the trait was 81.6%

The coefficients of variation range from high (=21-30%) to very high (>40%). The lowest coefficient of variation in the growth of watercress roots is characteristic in the variant of action of extract from winter wheat seeds of the Harantiia Odes'ka variety as 29.4%, the largest one (97.6%) is in the variant with water extract from winter wheat roots of the Schedrivka Kyivs'ka variety (Table. 3).

Table 3. Growth of watercress Roots depending on seed treatment with water extract from various plant organs and varieties of winter wheat

Variety	Parts							
	root		stem		leaf		seed	
	M±m min-max	V, %	M±m min-max	V, %	M±m min-max	V, %	M±m min-max	V, %
Control	8,55±0,59	55,75	8,55±0,43	38,25	8,55±0,30	50,81	8,55±0,28	31,73
Krasa laniv	4,55±0,41	67,70	7,30±0,44	48,16	7,43±0,22	32,41	7,65±0,25	32,41
Vidrada	7,21±0,56	68,91	8,47±0,50	56,67	8,01±0,31	32,83	6,76±0,25	33,83
Kvitka Poliv	4,45±0,60	83,41	7,43±0,43	43,62	7,71±0,29	35,84	6,61±0,29	35,85
Koshova	2,60±0,43	81,59	10,41±0,65	56,36	6,64±0,29	59,49	7,68±0,69	63,74
Schedrivka Kyivs'ka	4,87±0,64	97,60	3,83±0,37	56,10	7,88±0,28	45,95	6,56±0,59	62,71
MIP Assol'	9,49±0,71	58,72	7,43±0,44	52,93	9,92±0,29	40,68	6,16±0,22	34,77
Harantiia Odes'ka	3,20±0,32	62,53	6,21±0,53	57,02	8,32±0,32	49,00	9,30±0,28	29,40
Schedrist' Odes'ka	3,55±0,43	85,7	7,43±0,43	50,74	8,86±0,32	44,72	7,65±0,3	37,77
Centurion	4,29±0,43	67,1	11,01±0,47	40,56	6,71±0,28	47,84	6,13±0,31	47,84

The coefficients of variation range from high (=21-30%) to very high (>40%). The lowest coefficient of variation in the growth of watercress roots is characteristic in the variant of action of extract from winter wheat seeds of the Harantiia Odes'ka variety as 29.4%, the largest one (97.6%) is in the variant with water extract from winter wheat roots of the Schedrivka Kyivs'ka variety.

The increase in the root length of the test culture was less than the effect of water extracts from the organs of winter wheat plants of the Krasa laniv, Vidrada, Kvitka Poliv and Schedrivka Kyivs'ka varieties in all the studied variants. The data are statistically reliable, with the coefficient of variation ranging from 32.4% up to 97.6%.

As can be seen from Table 2, the growth of watercress roots was stimulated by using an aqueous extract from the roots of winter wheat of only one studied variety such as MIP Assol'. The root length in this variant was 9.49±0.71 cm, which was by 11.0% higher than the control. Extract from the stems of winter wheat varieties Koshova and Centurion also had a stimulating effect on the germination of test culture seeds, the root length was 10.41±0.65 mm and 11.01±0.47 mm, respectively, which was by 21.8% and by 28.8%, respectively, more than in the control. Extracts from the leaves of winter wheat plants of MIP Assol' (9.92±0.29 mm) and Schedrist' Odes'ka (8.86±0.32 mm) slightly stimulated the germination of watercress seeds, the coefficient of variation was 40.68% and 44.72%, respectively.

Among the studied winter wheat varieties, only water extract from Harantiia Odes'ka grain stimulated the germination of test culture seeds. The length of the roots was 9.30 ±0.28 mm, which was by 8.77% higher than the control. The data is statistically reliable.

The results of our studies showed that in relation to watercress, extracts of water extracts from the roots of plants of most of the studied varieties of winter wheat (except for the MIP Assol variety) showed allelopathic activity. At the same time, the greatest allelopathic activity was characteristic of the Koshova variety (as 65.10%). A significant inhibitory allelopathic effect of water extracts from the stems of winter wheat plants of the Schedrivka Kyivs'ka variety (-55.2%) on the length of watercress roots was observed (Figure 1.)

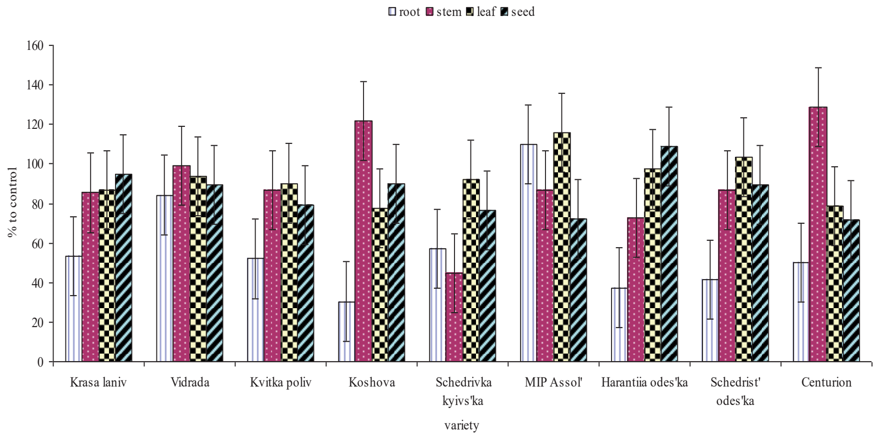

Figure 1. Allelopathic activity of water extracts of P organs of winter wheat plants depending on the variety (% to control)

Studies showed that water extracts from the leaves of winter wheat plants Koshova (-22.34%) and Centurion (-21.52%) had the greatest inhibitory effect, which was 77.7% and 78.5% before the control, respectively .

It was found that the extract from Centurion winter wheat grain had a greater inhibitory effect (-28.3%) on the growth of test crop roots. Varieties of extensive use should have a high allelopathic activity in order to create their own allelopathic regime in the crop and counteract the penetration of weeds. Varieties of intensive use should be characterized by low allelopathic activity (Derevyanko, 2007). We found that the Shchedrivka Kievskaya winter wheat variety had a high allelopathic activity in the phase of full grain ripeness (from -7.84 to -55.2%), and the lowest one were with Vidrada varieties (from -0.94 down to -13.50%) and MIP Assol' (+16.02 down to -27.95%).

The correlation between seed germination and watercress root growth under the influence of water extracts of plant organs of different varieties of winter wheat was determined. A very weak inverse relationship was typical in variants with Krasa Laniv and Schedrist' Odes'ka varieties (-0.03494 and -0.24687, respectively). A weak direct relationship was typical in variants with the varieties Schedrivka Kyivs'ka (0.144954), MIP Assol' (0.221724), Centurion (0.403765) and Kvitka Poliv (0.455515) (Figure 2).

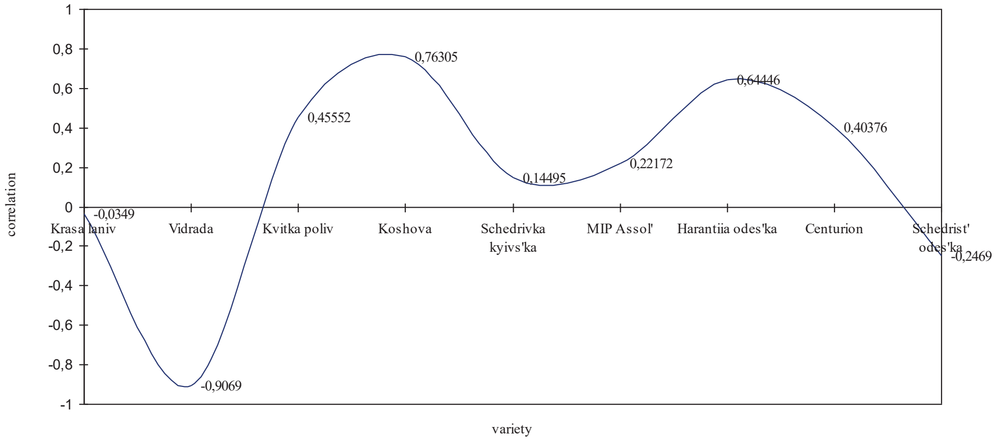

Figure 2. Allelopathic activity of water extracts of organs of winter wheat plants depending on the variety, (% to control)

In variants with water extracts of plants of Harantiia Odes'ka and Koshova varieties, a moderate dependence was observed (0.64446 and 0.763049, respectively). It was determined that only the Vidrada variety was characterized by a high relationship between seed germination and watercress root growth as 0.90691.

CONCLUSIONS

Then, the organs of winter wheat plants of the Koshova variety, in allelopathic terms, are quite active and they contain a large amount of physiologically active substances of both stimulating and inhibitory action.

Water extracts from the organs of winter wheat varieties Centurion, Koshova and Harantiia Odes'ka more suppressed the germination of test culture seeds than other varieties studied.

The most inhibitory effect on the growth of watercress roots was provided by water extract from the roots of plants of the Koshova variety.

It was found that the winter wheat variety Schedrivka Kyivs'ka had a high allelopathic activity, and the varieties Vidrada and MIP Assol were neutral to the germination of watercress seeds. A high correlation (0.90691) between seed germination and watercress root growth was determined.

In the future, the studied varieties will be subjected to more detailed testing both at different stages of development and with other test crops.

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