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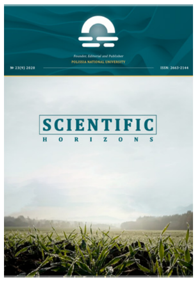

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The influence of water-soluble secretions of saffron seed on the germination of seeds of soft winter wheat varieties

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Abstract. Due to climate change, there is a need to introduce new crops into agricultural production in Ukraine, among which *Crocus sativus* L., a herbaceous perennial tuberous plant, whose allopathic properties have been insufficiently studied, can take a leading place. Therefore, the aim of the study was to determine the effect of water-soluble flower secretions and their individual elements on the initial stages of seed germination of two winter durum wheat varieties (Vidrada and Koshova). In the course of the study, generally accepted methods were used: laboratory research, analysis, synthesis and statistical. It was found that water-soluble extracts of flowers of different states and elements of *C. sativus* flowers do not have a significant effect on the morphometric and quality parameters of wheat kernels during germination. Water-soluble secretions of flowers of different states have an inhibitory effect on the development of the root system; secretions of the bud and the bloomed flower inhibit the growth of coleoptiles. The effect of water-soluble secretions of sowing saffron flowers elements has varietal peculiarities: for winter wheat seedlings of Vidrada variety, the petals have a stimulating effect on the total length of roots and their weight; for seedlings of Koshova variety, the opposite effect is observed. The water-soluble secretions of petals and stamens have a stimulating effect on the coleoptile of Vidrada plants, and the water-soluble secretions of petals have a stimulating effect on Koshova seedlings. The correlation between the length of roots and coleoptile under the influence of water-soluble secretions of flowers of different states and their elements, as well as the index of allelopathy have varietal characteristics. The obtained scientific results will contribute to the development of agrotechnical measures for the cultivation of saffron in Ukraine, selection of winter wheat varieties for joint cultivation and use of plant residues as biological stimulants

Keywords: *Crocus sativum; Triticum aestivum*; allopathic properties; seedlings; grains; allopathic index

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INTRODUCTION

Crocus sativus L., or sowing saffron, is a rare crop that is a source of the world's most expensive spices and valuable compounds used in the official pharmacopoeia. Due to the biological and ecological characteristics of the plants and their economic importance, the crop is promising for cultivation in Ukrainian agrocenoses. To this end, it is necessary to study the safety of *C. sativus* L. plant isolates on other crops and their role in soil toxin formation.

Demand for saffron is growing globally due to its use in cooking, medicine, and cosmetics, as well as new health benefits (Cardone *et al.*, 2020; Sharma *et al.*, 2020)**.** According to the National Agricultural Statistics Service (2017), in Iran, about 10-12% of the total saffron area is cultivated under intercropping systems (including cumin, sunflower, and wheat), while the remaining 88-90% of the *C. sativus* area is grown in monoculture. Over the past decade, *C. sativus* L. (perianth petals) largely has been studied for its by-products (perianth petals) in agriculture to increase yields (Lahmass *et al.*, 2018*).* According to L. Menghini *et al.* (2018)*,* about 90.0-92.6%, or 53 kg, of the production of one kilogram of spices is accounted for by perianth petals and 13.4% by stamens, which is equivalent to 150000-200000 flowers.

The perianth petals of the saffron flower contain several bioactive compounds, such as minerals, anthocyanins, monoterpenoids, carotenoids, flavonoids and flavonols (kaempferol) (Mykhailenko *et al.*, 2019; Belyagoubi-Benhammou *et al.*, 2023). Therefore, it is promising in the world to isolate biologically active compounds from saffron by-products (petals) for their use in the food, perfumery, and pharmaceutical industries (Mir *et al.*, 2022; Serda-bernad *et al.*, 2023). The study of the allopathic properties of plants is a promising area of research worldwide (Kheirabadi *et al.*, 2020; Janusauskaite, 2023). Considering the biochemical composition of various organs of *C. sativus* L., its allopathic activity has been studied for a long time. According to the results of M. Kheirabadi *et al.* (2020), it is known that saffron can be grown in one place for up to 12 years, but starting from 5-6 years, the yield of bracts decreases. I. El Aymani *et al.* (2019) found that the duration of cultivation of *C. sativus* L. also negatively affects the number of endomycorrhizal fungal species.

A minor inhibitory effect, which depended on the concentration of the filtrate, was found by Fallahi *et al.* (2018) in the effect of aqueous extracts of leaves and corms of *C. sativus* L. on seedlings of fenugreek (*Trigonella foenum-graecum* L.), chickpea (*Cicer arietinum* L.) and arugula (*Eruca sativa* Mill.) as promising related crops. According to the results of a study by M. Abbasi & A. Sepaskhah's (2022) research on combined winter wheat and saffron crops during 2013-2017 in Iran, the benefits of growing intercrops in production were found to be 74% higher, with a land equivalent ratio of 1.74. Farmers are recommended to grow saffron in wide-row crops with winter wheat to increase income and soil use efficiency.

In Ukraine, the effect of water-soluble secretions from flowers of *C. sativus* L. of different states on the germination of winter wheat has not been studied. In connection with the possible expansion of the area under *C. sativus* L., there is a need to study the interaction of a new promising crop with traditional ones. Ukraine is one of the largest exporters of wheat grain, so for agricultural production, the study of the possibility of growing saffron and winter wheat in joint crops and establishing a place in the crop rotation, considering the allopathic activity of *C. sativus* L., is an important direction of crop introduction. In addition, by-products (petals, flowers, pistils) from saffron production, such as spices, can become a biological stimulant for the germination of winter wheat seeds. The research aims to determine the peculiarities of the influence of water-soluble secretions of *C. sativus* flowers and their elements on the germination of seeds of two varieties of winter wheat.

MATERIALS AND METHODS

To establish the allelopathic activity of water-soluble extracts of *C. sativus* L. flowers grown in the Northern Black Sea region of Ukraine at the initial stages of ontogeny of plants of different varieties of winter wheat, field studies were conducted in November 2021 at the experimental field of Mykolaiv National Agrarian University, and laboratory studies were conducted in the laboratories of the Department of Plant Production and Gardening.

The determination of the allopathic activity of water-soluble secretions of individual parts of *C. sativus* L. flower on the growth of roots and coleoptiles of seedlings of Ukrainian winter wheat varieties Vidrada and Koshova was carried out according to the method of A. Grodzinskiy *et al.* (1979). Seeds of the studied soft winter wheat varieties were sown in sterile Petri dishes on filter paper moistened with distilled water and placed in a thermostat at +23-24°C for 24 hours. To determine the allopathic activity of *C. sativus* L. flower elements, freshly harvested flowers with fertile and infertile parts were used (experimental variants: "petals", "petals + stamens", "petals + pistil"). Stamens weighed 0.025±0.003 g, pistils 0.035±0.002 g, petals 0.376±0.013 and flowers 0.435±0.016 g. They were placed in distilled water in a ratio of 1 g per 100 ml (0.01%) and kept for 24 hours at a temperature of +23-24°C. The choice of concentration was based on tests conducted previously on watercress seeds (Mykolaichuk *et al.,* 2021). The solution was filtered through filter paper No. 2. A day later, 25 wheat seeds with signs of primary roots were transferred to filter paper in Petri dishes and 4 ml of filtrate was added.

To determine the allelopathic activity of water-soluble secretions of flowers of different states, buds, a blooming flower, and a flower that bloomed 1 day ago were used. The flowers were kept for a day in 100 ml of distilled water. Further development of the seedlings took place in a Petri dish in a thermostat at 20°C. Seven days later, at the beginning of the seedling development phase, the metric and qualitative parameters of seeds were determined, and the maximum and total root length, the number of adventitious roots, the length of the coleoptile and the root weight were measured. To determine the effect of water-soluble secretions of *C. sativus* L. flowers on the process of grain swelling, metric (length, width, thickness, mm) and qualitative (weight, g) parameters were measured before the experiment and on day 7. The metric parameters were measured with a calliper with an accuracy of 0.01 mm, the mass was determined using a balance with an accuracy of 0.001 g. The experiment was carried out in five replications.

Statistical processing of the results was carried out using Microsoft Excel and Statistica 7.0. Graphs were created using Excel 7.0. To quantify the allopathic effect, the allopathic activity index (AI) was used, which was determined by the formula:

$$RI=1-C/T,$$

where C – control values, T – test values. If RI>0, then there is a stimulation effect, RI<0 indicates inhibition (Williamson *et al.*, 1988).

RESULTS AND DISCUSSION

As a result of laboratory studies, an increase in the morphometric parameters of the grain: length by 1.87%, and width and thickness – on the contrary – a decrease by 5.0 and 1.1% compared to the initial values – was found during the period of germination of wheat seeds of Vidrada variety in plants of the control variant. The increase in kernel weight was 25.0% compared to the initial weight. The same peculiarity was observed for the Koshova grains, but the length increased by 6.4%, and the width and thickness also decreased by 32.1 and 18.0%. The increase in kernel weight was 33.3% compared to the initial weight.

Under the influence of water-soluble secretions of *C. sativus* L. bud, the increase in the length of the grain of Vidrada variety to the initial value was 4.0%, and to the control 2.1%. For the width, a slight increase was observed compared to the initial value, but more compared to the control (1.0 and 6.6%, respectively). The thickness, on the contrary, decreased by 2.5 and 1.5%, respectively. At the same time, the weight of the kernel increased by 50% compared to the initial and by 20% compared to the control (Table 1).

Table 1. *Influence of water-soluble secretions of C. sativus L. flowers of different states on morphometric and quality parameters of winter wheat grains of different varieties during germination*

Indicators	Water extracts from flowers in different states (Factor B)				
	Initial variable	Control	Bud	The blooming flower	The bloomed flower
	M±m min-max	M±m min-max	M±m min-max	M±m min-max	M±m min-max
	Varieties (Factor A)				
	Vidrada				
Length, mm	6.94±0.05 5.90-7.85	7.07±0.14 6.31-8.05	7.22±0.20 5.34-8.45	7.07±0.15 5.76-8.40	6.93±0.14 5.56-7.78
Width, mm	2.89±0.3 2.30-3.35	2.74±0.14 1.76-4.14	2.92±0.13 1.92-3.90	2.77±0.09 2.01-3.30	2.69±0.13 1.38-3.62
Thickness, mm	2.79±0.03 2.30-3.12	2.76±0.11 1.77-3.66	2.72±0.09 1.96-3.25	2.78±0.09 1.57-3.51	2.63±0.09 1.74-3.07
Mass, g	0.04±0.00 0.02-0.04	0.05±0.00 0.03-0.08	0.06±0.00 0.03-0.09	0.05±0.00 0.03-0.08	0.05±0.00 0.02-0.07
	Koshova				
Length, mm	6.88±0.06 5.94-7.51	7.32±0.17 5.60-8.63	7.19±0.15 6.19-8.32	6.87±0.11 5.95-7.79	6.91±0.16 5.68-8.53
Width, mm	2.87±0.04 2.04-3.44	1.95±0.11 1.00-3.04	2.55±0.12 1.70-3.41	2.46±0.11 1.69-3.66	2.29±0.10 1.56-3.05
Thickness, mm	2.67±0.17 2.36-3.03	2.19±0.11 1.25-2.97	2.55±0.11 1.39-3.25	2.27±0.09 1.71-2.87	2.28±0.08 1.34-3.05
Mass, g	0.03±0.00 0.03-0.04	0.04±0.00 0.02-0.06	0.05±0.00 0.03-0.07	0.04±0.00 0.01-0.07	0.04±0.00 0.02-0.05

Source: *compiled by the authors*

Koshova wheat grain was characterised by an increase in length of 4.5% compared to the initial one, but a decrease in this indicator by 1.8% compared to the control. There was also a decrease in width by 11.2%

compared to the original, but an increase of 30.8% compared to the control. The same trend is observed for thickness: a decrease of 4.5% compared to the initial and an increase of 16.4% compared to the control. An increase in kernel weight was recorded by 66.7% compared to the initial and 25% compared to the control.

The water-soluble secretions of the blossoming flower of *C. sativus* L. affect the morphometric parameters of the grain of the Vidrada variety: compared to the initial length, it increased slightly by 1.87%, compared to the control, there was no increase. The width and thickness are characterised by a decrease of 4.2 and 0.4% compared to the initial values. Compared to the control, there was a slight increase of 1.1 and 1.5%, respectively. Compared to the initial weight of the grain, there was an increase of 25%, but compared to the control, the weight did not increase. For the Koshova variety, there was a slight decrease in all morphometric parameters compared to the initial ones: length – by 0.2, width – by 14.3, thickness – by 15.0%. Compared to the control, the length of the grain decreased by 6.2%, and other morphometric parameters increased: width – by 26.2, thickness – by 3.7%.

The water-soluble secretions of the blossoming flower of *C. sativus* L. affected all morphometric parameters of Vidrada grain and were lower than the initial ones: length – by 0.2%, width – by 6.9%, thickness – by 5.7%, respectively. Compared to the control, a slight decrease in all morphometric parameters was observed: length – by 2.0, width – by 1.0, and thickness – by 4.7%, respectively. For Koshova grains, the length slightly increased by 0.4% compared to the initial one. Under the influence of water-soluble secretions, the weight increased by 33.3% compared to the initial weight. At the same time, width and thickness decreased by 20.2 and 14.6%, respectively. Compared to the control, the length of the kernel is 5.6% shorter, and the width and thickness are 17.4 and 4.1% larger, respectively. The grains of both varieties are characterised by a 25% increase in weight, which, in our opinion, is associated with the process of swelling during germination.

The analysis of the effect of water-soluble secretions of *C. sativus* L. flower elements on the germination of wheat kernels of the Vidrada variety shows the following: compared to the initial indicators, a slight increase in the length of the control variant kernels by 1.9% was observed, while a slight decrease in width and thickness (5.2 and 1.1%, respectively) was observed, while the weight increased by 33.3% (Table 2).

Table 2. *Influence of water-soluble secretions of C. sativus L. flower elements on morphometric and qualitative parameters of winter wheat kernels of different varieties during germination*

Indicators	Water extracts from flowers in different states (Factor B)				
	Initial variable	**Control**	**Petals**	**Petals + stamens**	**Petals + Stamens**
	M±m **min-max**	**M±m** **min-max**	**M±m** **min-max**	**M±m** **min-max**	**M±m** **min-max**
	Varieties (Factor A)				
Vidrada					
Length, mm	6.94±0.05 5.90-7.85	7.07±0.14 6.31-8.05	7.00±0.18 5.67-8.65	7.02±0.15 5.66-8.35	7.09±0.16 5.78-8.26
Width, mm	2.79±0.03 2.30-3.12	2.76±0.11 1.77-3.66	2.73±0.10 2.14-3.65	2.57±0.08 1.96-3.37	2.64±0.06 2.20-3.08
Thickness, mm	0.04±0.00 0.02-0.04	0.05±0.00 0.03-0.08	0.05±0.00 0.03-0.08	0.05±0.00 0.03-0.07	0.06±0.00 0.03-0.08
Mass, g	6.94±0.05 5.90-7.85	7.07±0.14 6.31-8.05	7.00±0.18 5.67-8.65	7.02±0.15 5.66-8.35	7.09±0.16 5.78-8.26
Koshova					
Length, mm	6.88±0.06 5.94-7.51	7.32±0.17 5.60-8.63	7.02±0.13 6.12-8.27	7.18±0.12 5.955-7.91	7.32±0.11 6.62-8.55
Width, mm	2.87±0.04 2.04-3.44	1.95±0.11 1.00-3.04	2.23±0.11 1.34-2.93	2.17±0.09 1.28-2.75	2.23±0.11 1.34-2.93
Thickness, mm	2.67±0.17 2.36-3.03	2.19±0.11 1.25-2.97	2.24±0.12 1.12-2.99	2.29±0.08 1.62-2.85	2.24±0.12 1.12-2.99
Mass, g	0.03±0.00 0.03-0.04	0.04±0.00 0.02-0.06	0.04±0.00 0.02-0.06	0.04±0.00 0.03-0.07	0.04±0.00 0.02-0.06

Source: *compiled by the authors*

Koshova grains are characterised by a 6.4% increase in length in the control variant compared to the original, but other indicators decrease in width by 32.1% and thickness by 18.0%, respectively, while weight increases by 33.3%, indicating intensive germination processes. The water-soluble secretions of *C. sativus* L. petals slightly affected the length of the grain of wheat variety Vidrada, the increase of this indicator was 0.9% compared to the initial one, other morphometric parameters were characterised by a slight decrease: width – by 1.04, thickness – by 2.2%. Compared to the control, there was a slight decrease in length and thickness by 1.0 and 1.1%, respectively, and an increase in width by 4.4%. The weight of the grain increased by 25% compared to the initial weight, and no increase was observed compared to the control. Koshova grains were also characterised by a slight increase in length by 2.0%, but a decrease in width and thickness (by 22.3 and 16.1%, respectively). The increase in weight compared to the initial weight was 33.3%, while no increase was observed compared to the control variant.

Water-soluble secretions of petals and stamens of *C. sativus* L. slightly affected the length and width of the kernels of Vidrada variety compared to the initial ones (1.2 and 0.7%, respectively), but the kernel thickness decreased by 7.9%. Compared to the control, there was a slight decrease in length and thickness by 0.7 and 6.9%, but an increase in width by 6.2%. Under the influence of water-soluble secretions of petals with stamens, the weight of the grain increased by 25% compared to the initial one, but there was no increase compared to the control. Kernels of the Koshova variety were characterised by an increase in length only, by 4.4% compared to the initial one, while other parameters showed a decrease in width by 24.4 and thickness by 14.2%.

Thus, no significant effect of water-soluble secretions of flowers of *C. sativus* L. of different states and elements of flowers grown in the Northern Black Sea region of Ukraine on the morphometric and qualitative parameters of wheat grains of the two studied varieties was found. The study of the effect of water-soluble secretions of *C. sativus* L. flower elements on the development of the root system of seedlings of the studied varieties indicates that it has varietal characteristics of the reaction (Table 3).

Table 3. *Influence of water-soluble secretions of C. sativus L. flowers of different states on morphometric and qualitative parameters of winter wheat roots of different varieties*

Water extracts from saffron flower elements (Factor B)	Varieties (factor A)			
	Vidrada			
	Max length, mm	Overall length, mm	Number of roots	Mass, g
Control	91.15±2.65 75.00-114.00	233.35±6.37 166.00-296.00	3.45±0.15 3.00-5.00	0.05±0.00 0.03-0.08
Flower state				
Bud	81.65±7.23 39.00-141.00	196.25±21.61 94.00-392.00	3.35±0.14 3.00-5.00	0.04±0.00 0.01-0.08
The blooming flower	92.89±7.15 22.00-134.00	254.32±27.82 46.00-437.00	3.89±0.19 3.00-5.00	0.05±0.01 0.01-0.11
The bloomed flower	106.25±5.76 50.00-135.00	284.48±18.98 108.00-405.00	3.40±0.11 3.00-4.00	0.04±0.00 0.02-0.08
Flower elements				
Petals	104.20±7.23 35.00-142.00	277.65±21.64 90.00-410.00	3.55±0.15 3.00-5.00	0.05±0.01 0.01-0.10
Petals + stamens	124.30±10.88 73.00-321.00	309.75±11.79 172.00-415.00	3.75±0.10 3.00-4.00	0.04±0.00 0.02-0.06
Petals + stamens	99.10±7.58 25.00-145.00	266.25±22.51 70.00-404.00	3.70±0.18 3.00-5.00	0.04±0.00 0.02-0.08
Koshova				
Control	121.75±3.63 84.00-145.00	311.25±9.23 226.00-375.00	3.25±0.12 3.00-5.00	0.05±0.00 0.02-0.08
Flower state				
Bud	75.89±8.94 15.00-130.00	174.79±25.67 17.00-388.00	3.21±0.12 3.00-5.00	0.03±0.00 0.01-0.07
The blooming flower	119.35±5.00 68.00-150.00	298.10±14.63 148.00-410.00	3.20±0.09 3.00-4.00	0.04±0.00 0.02-0.06
The bloomed flower	124.65±3.22 97.00-144.00	302.95±6.49 233.00-370.00	3.15±0.08 3.00-4.00	0.04±0.00 0.03-0.07
Flower elements				
Petals	114.80±6.17 55.00-153.00	281.60±16.34 130.00-362.00	3.40±0.13 3.00-5.00	0.05±0.00 0.02-0.08

Table 3, Continued

Water extracts from saffron flower elements (Factor B)	Varieties (factor A)			
	Vidrada			
	Max length, mm	Overall length, mm	Number of roots	Mass, g
Petals + stamens	99.55±9.00 68.00-150.00	239.75±26.13 35.00-393.00	3.10±0.07 3.00-4.00	0.04±0.00 0.02-0.06
Petals + stamens	112.80±8.05 38.00-153.00	281.15±20.82 102.00-419.00	3.15±0.08 3.00-4.00	0.04±0.00 0.02-0.08

Source: *compiled by the authors*

The water-soluble bud secretions harmed the root indices of Vidrada seedlings, especially on the total root length (-15.9%) and the number of roots (-2.9%). The negative effect on the seedlings of the Koshova variety was greater – -43.8% for the total length of roots and -1.2% for their number. The influence of water-soluble secretions of the blossoming flower on the parameters of roots of seedlings of the Vidrada plant variety has a slight stimulating effect, with the highest values also characteristic of the total length of roots, and the lowest – for the maximum length (9.0 and 1.9%, respectively). Seedlings of the Koshova variety are characterised by a negative effect on all root parameters compared to the control, with the greatest effect on the total length and a lesser effect on the number of roots (-7.1 and -1.5%, respectively). The water-soluble secretions of the faded flower stimulate the development of roots, especially the total length, with a smaller effect on their number (21.9 and 1.5%, respectively). A positive effect on the maximum length of roots (2.4%) was found for seedlings of the Koshova variety, but a slightly negative effect on other indicators (-2.7% for the total length of roots and -1.5% for the number of roots). The weight of roots of seedlings of Vidrada variety is characterised by a negative effect of water-soluble secretions of flowers of different states on the growth compared to the control: bud and bloomed flower – by 20%, and secretions of the bloomed flower have no effect.

The water-soluble secretions of *C. sativus* L. flowers of different states negatively affect the root weight of seedlings of the Koshova variety compared to the control, with a greater effect on the bud (-40%), and a negative effect on the root weight (-20%) for the bloomed and faded flowers. The water-soluble secretions of *C. sativus* L. flower elements have a positive effect on the growth of maximum and total root length (14.3 and 19.0%, respectively), as well as on the number of roots (2.9%) of seedlings of Vidrada plants. Root weight did not differ from the control. For seedlings of plants of the Koshova variety, water-soluble petal secretions negatively affect the maximum and total length of roots compared to the control (-5.7 and -9.5%, respectively), but positively – the number of roots (4.6%), no effect on root weight was found.

Water-soluble petal and stamen secretions also have a positive effect on the growth of the maximum and total root length of seedlings of the Vidrada variety (36.4 and 32.7%, respectively), and the number of roots (8.7%), but the root weight was 20% less. Water-soluble secretions of petals and stamens negatively affect all indicators of roots of seedlings of the Koshova variety: the greatest effect is observed on the total length of roots (23.0%), the least – on the number of roots (4.6%). The water-soluble secretions of petals and pistils have a positive effect on the growth of roots of seedlings of Vidrada plants compared to the control. The highest values are characteristic of the total length (14.1%), the lowest – for the number of roots (7.3%). In seedlings of the Koshova variety, a negative effect on the total length of roots (-9.4%) and the number of roots (-3.1%) was observed. The root weight of seedlings of both varieties is characterised by a negative effect of -20%. The effect of water-soluble secretions of the blossoming flower of *C. sativus* L. on the maximum and total length of roots of both wheat varieties is significant, the effect on the number of roots is insignificant. The water-soluble secretions of *C. sativus* L. flowers of different states negatively affect the length of the coleoptile of plants of the studied winter wheat varieties (Table 4).

Table 4. *Influence of water-soluble secretions of C. sativus L. flower of different state and flower elements on morphometric and qualitative parameters of collyoptile of winter wheat seedlings*

Water extracts from saffron flower elements (Factor B)		Varieties (Factor A)			
		Vidrada		Koshova	
		length, mm	mass, g	length, mm	mass, g
		M±m min-max	M±m min-max	M±m min-max	M±m min-max
Control		55.15±1.43 45.00-67.00	0.06±0.00 0.04-0.08	58.50±1.81 50.00-74	0.06±0.00 0.04-0.08
Flower state	Bud	42.50±4.52 13.00-75.00	0.04±0.00 0.02-0.09	39.47±5.88 3.00-82.00	0.04±0.01 0.01-0.09

Table 4, Continued

Water extracts from saffron flower elements (Factor B)		Varieties (Factor A)			
		Vidrada		Koshova	
		length, mm	mass, g	length, mm	mass, g
		M±m min-max	M±m min-max	M±m min-max	M±m min-max
Flower state	The blooming flower	51.84±4.62 12.00-76.00	0.05±0.00 0.01-0.08	53.05±2.81 25.00-69.00	0.05±0.00 002-0.07
	The bloomed flower	59.20±2.88 35.00-81.00	0.05±0.00 0.03-0.08	63.95±1.86 44.00-75.00	0.05±0.00 0.04-0.07
Flower elements	Petals	54.05±3.27 18.00-78.00	0.06±0.00 0.02-0.10	61.00±3.56 20.00-79.00	0.06±0.00 0.02-0.08-
	Petals + stamens	58.05±2.67 26.00-71.00	0.06±0.00 0.03-0.07	52.15±5.15 6.00-79.00	0.05±0.00 0.01-0.08
	Petals + stamens	53.80±3.60 15.00-77.00	0.06±0.00 0.02-0.08	56.90±14.02 18.00-75.00	0.05±0.00 0.03-0.07

Source: *compiled by the authors*

The Vidrada variety is characterised by an intensive decrease in the length of the coleoptiles under the influence of water-soluble secretions of the bud and the bloomed flower by -22.9 and -6.0%, respectively, compared to the control, while the water-soluble secretions of the bloomed flower have a slight positive effect of 7.3% compared to the control. There is also a negative effect on the weight of coleoptiles, ranging from -33.3% for bud secretions to -16.7% for bloomed and faded flowers. For coleoptiles of seedlings of the Koshova variety, the corresponding indicators range from -32.5%, which is typical for bud secretions, to -9.3%, which is typical for a bloomed flower, but the secretions of a bloomed flower have a slight positive effect compared to the control (9.3%). There is also a negative effect of water-soluble secretions on the weight of the coleoptile compared to the control by -33.3% for the bud secretions and by -16.7% for other variants.

Water-soluble petal secretions stimulate the growth of coleoptiles of Vidrada plants by 4.3%, and water-soluble secretions of petals and stamens and pistils inhibit growth compared to the control by 10.8 and 2.7%. For plants of the Koshova variety, a slight inhibition of growth under the influence of water-soluble petal secretions by -2.0% and stimulation by water-soluble secretions of petals with stamens and pistils compared to the control by 5.3 and 1.5%, respectively, is characteristic. There was no negative effect of water-soluble secretions of *C. sativus* L. flower elements on the weight of coleoptiles in seedlings of the Koshova variety, in contrast to the weight of coleoptiles of seedlings of the Vidrada variety, which is characterised by the absence of influence of water-soluble petal secretions and the inhibitory effect of water-soluble petal secretions and stamens and pistils (-16.7%).

The effect of water-soluble secretions on the length and weight of coleoptile of seedlings of the studied wheat varieties is significant. A high correlation ($p<0.05$) between the total length of the roots and the length of the coleoptile is characteristic of seedlings of the Vidrada variety in variants with the influence of water-soluble secretions of flowers of all states and elements of the flower (petals and petals with pistil). For seedlings of the Koshova variety, there is also a relationship between the total length of the roots and the length of the coleoptile under the influence of water-soluble secretions of buds and a blooming flower. The correlation between these parameters under the influence of water-soluble secretions of petals stamens and pistils is not very high and inverse (Table 5).

Table 5. *Correlation between root length and coleoptile length of winter wheat seedlings of different varieties under the influence of water-soluble secretions of C. sativus L. flowers of different states and their elements*

Aqueous extracts of saffron flower elements (Factor B)		Varieties (Factor A)	
		Vidrada	Koshova
Control		-0.0209	0.2794
Flower state	Bud	0.9276	0.9612
	The blooming flower	0.9298	0.3151
	The bloomed flower	0.7981	0.6933
Flower elements	Petals	0.7803	0.2863
	Petals + stamens	0.0195	-0.2672
Flower elements	Petals + stamens	0.7677	-0.0585

Source: *compiled by the authors*

For a complete assessment of the allelopathic activity of water-soluble secretions of *C. sativus* L. flowers of different states and flower elements on winter wheat, the index of allelopathic activity was used. The main indicators are the effect of *C. sativus* L. flower extracts on the maximum and total length of roots and colioptile of seedlings of the studied varieties. It was found that there is a negative effect of water-soluble secretions of *C. sativus* flower buds on the total and maximum root length of seedlings of the Vidrada variety and the total root length of seedlings of the Koshova variety (Table 6).

Table 6. *Index of allelopathy of water-soluble secretions of C. sativus L. flowers of different states and flower elements on the metric parameters of roots of plants of different winter wheat varieties*

Aqueous extracts of saffron flower elements (Factor B)		**Varieties (Factor A)**			
		Vidrada		**Koshova**	
		Max length, mm	**Overall length, mm**	**Max length, mm**	**Overall length, mm**
		M±m min-max	**M±m min-max**	**M±m min-max**	**M±m min-max**
Flower state	Bud	-0.12	-0.19	0.6	-0.78
	The blooming flower	0.02	0.1	-0.02	-0.04
	The bloomed flower	0.14	0.18	0.02	-0.03
Flower elements	Petals	0.13	0.16	-0.06	-0.11
	Petals + stamens	0.27	0.25	-0.22	-0.3
	Petals + stamens	0.08	0.12	0.08	-0.11

Source: *compiled by the authors*

The water-soluble secretions of the bloomed and faded flowers have a stimulating effect on these indicators of seedlings of the Vidrada variety. For the roots of seedlings of the Koshova variety, the inhibitory effect of water-soluble secretions of the bloomed flower and the opened flower, but the stimulating effect of secretions of the opened flower was established. The study of the influence of water-soluble secretions of *C. sativus* flowers and their elements on the coleoptile length of the studied winter wheat varieties shows certain peculiarities: the secretions of buds and bloomed flowers have an inhibitory effect on the coleoptile of seedlings of both varieties and the bloomed flower, on the contrary, has a stimulating effect (Table 7).

Table 7. *Index of allelopathy of water-soluble secretions of C. sativus L. flowers of different states and their elements on the development of coleoptiles of plants of different winter wheat varieties*

Aqueous extracts of saffron flower elements (Factor B)		**Varieties (Factor A)**			
		Vidrada		**Koshova**	
		Max length, mm	**Overall length, mm**	**Max length, mm**	**Overall length, mm**
		M±m min-max	**M±m min-max**	**M±m min-max**	**M±m min-max**
Flower state	Bud	-0.30	-0.48	-0.30	-0.48
	The blooming flower	-0.06	-0.10	-0.06	-0.10
	The bloomed flower	0.07	0.09	0.07	0.09
Flower elements	Petals	-0.30	0.48	-0.30	0.48
	Petals + stamens	-0.06	0.10	-0.06	0.10
	Petals + stamens	0.07	0.09	0.07	0.09

Source: *compiled by the authors*

Water-soluble extracts of petals and petals with stamens of *C. sativus* L. flowers have an inhibitory effect on the length of the coleoptiles of Vidrada plants, but petals with pistils have a stimulating effect. Water-soluble extracts of all elements of *C. sativus* L. flowers have a stimulating effect on the length of coleoptiles of seedlings of the Koshova variety. As a result of the studies, both stimulating and inhibitory effects were found from the treatment of seeds of different varieties of winter wheat with water-soluble secretions of the flower and parts of the flower of saffron seed. Other scientists (Murimwa *et al.,* 2019) focused their research on the identification and development of plant growth inhibitors as an alternative to the use of chemicals.

Studies (Godlewska, 2019) have shown that extracts of organs of other plants, in particular saffron flowers, can be used in agriculture as natural biostimulants. Thus, A. Khoulati *et al.* (2020) found a stimulating effect of the aqueous extract of the perianth (petals) of *C. sativus* L. at a dose of 2 mg/ml on the growth of eggplant seedlings. The improvement in plant height in this study suggests that perianth extract may act as a plant growth promoter. Higher levels of these antioxidant compounds tend to disrupt the physiological balance of the recipient plants, resulting in a corresponding inhibition of growth.

Y. Tkachova *et al.* (2022) studied the effect of the allopathic activity of aqueous extracts of hyssop leaves, stems and flowers on the growth of watercress roots, and determined the optimal concentration of aqueous extracts of the culture with a stimulating and inhibitory effect. It was found that the highest positive allopathic activity was observed in the variant with the use of hyssop flowers of the second year of vegetation at a concentration of 1:10. Thus, aqueous extracts of flowers of essential oil and medicinal crops can have both stimulating and inhibitory effects on other plants. However, the scientific literature contains almost no results of studies on the effect of water-soluble flower secretions, their state (bud, bloomed and faded flower) and parts of flowers (petals, petals + stamens, petals + pistil) of saffron on the germination of winter wheat seeds. Therefore, these studies were conducted for the first time.

Earlier studies by V. Mykolaichuk *et al.* (2022) determined that saffron flowers of different flowering stages had both inhibitory and stimulating effects on the growth of watercress roots. The highest stimulatory indicators were recorded with water-soluble secretions of the newly bloomed flower and stamens, and the lowest – from the pistils. In the experiments with the winter wheat test crop, the aqueous extract from the blooming saffron flower had a greater stimulating effect, the length of roots and colloid of seedlings of the studied varieties increased by 2.4-19.9% and 7.3-9.3%, respectively. M. Alam *et al.* (2018) suggest that different rice varieties grown in the Tanjung Karang region of Malaysia contain allelochemicals that differ in type and concentration, which is why the productivity of rice varieties varied significantly. M. Korkhova and V. Mykolaichuk (2021) determined the varietal response of water extracts from the rhizosphere of the soil of different winter wheat varieties to watercress seed germination.

The study of the influence of water-soluble extracts of *C. sativus* L. flowers on the development of the root system of winter wheat seedlings confirms the different reactions of the studied varieties. It was determined that the aqueous extract from petals and stamens of sowing saffron flowers stimulated root growth of winter wheat seedlings of the Vidrada variety by 36.4%, but inhibited root growth of the Koshova variety by 18.2%. This study is unique, as there is no scientific data on the reaction of water-soluble secretions from different states of saffron flower and its parts to the germination of seeds of different winter wheat varieties.

CONCLUSIONS

The results of studies of the effect of water-soluble secretions of *C. sativum* flowers of different states and elements of flowers grown in the Northern Black Sea region of Ukraine do not significantly affect the morphometric and qualitative parameters of Vidrada and Kosova grains during germination. No significant effect of water-soluble secretions of *C. sativum* flowers and their elements on the number of roots of seedlings of both varieties was found.

The maximum and total length of roots of soft winter wheat seedlings is influenced by varietal characteristics: water-soluble secretions of the bud inhibit the development of roots of both varieties, and the bloomed flower stimulates the development of roots of seedlings of the Vidrada variety but inhibits the development of roots of seedlings of Koshova variety; water-soluble secretions of the bloomed flower stimulate the development of roots of seedlings of Vidrada variety, and in the roots of seedlings of Koshova variety stimulates only the maximum length. The water-soluble secretions of flowers of all *C. sativus* states negatively affect the weight of the crowns of seedlings of the Koshova variety, while the secretions of the bud and flower have such an effect on seedlings of the Vidrada variety.

The water-soluble secretions of *C. sativus* flower petals have a stimulating effect on the parameters of the roots of seedlings of the Vidrada variety but inhibit the parameters of the roots of the Koshova variety. Water-soluble secretions of petals and stamens, as well as petals and pistils also have a positive effect on the roots of seedlings of Vidrada plants and a negative effect on the roots of Koshova plants. Seedlings of the Vidrada variety are characterised by a high correlation between root length and coleoptile in most variants, except for the influence of water-soluble secretions of petals and stamens. The coleoptile and root length of seedlings of the Koshova variety are characterised by a high correlation under the influence of water-soluble secretions of the bud and the blooming flower, for other variants it is low, direct, or inverse.

The allelopathy index of the effect of water-soluble secretions of buds and bloomed flowers on the length of the coleoptile for plants of both varieties has an inhibitory effect, and the secretion of the bloomed flower – a stimulating effect. There is a difference in the index of allelopathy of water-soluble secretions of flower elements: for seedlings of the Vidrada variety, the secretion of petals and petals with stamens has a stimulating effect, and petals and pistils have an inhibitory effect; for coleoptiles of seedlings of Koshova variety, it has a stimulating effect. Thus, seedlings of the Vidrada variety compared to seedlings of the Koshova variety are more resistant to the effects of water-soluble flower secretions of *C. sativus* L. The results obtained indicate that it is necessary to carefully select winter wheat varieties for compatible sowings with saffron and consider their reactions to water-soluble flower secretions. Further research will be aimed at studying the influence of weather conditions on the formation of allopathic activity of vegetative and generative organs of *C. sativus* in the Northern Black Sea region of Ukraine.

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CONFLICT OF INTEREST

None.

REFERENCES

[1] Abbasi, M.R., & Sepaskhah, A.R. (2022). Evaluation of saffron yield affected by intercropping with winter wheat, soil fertilizers and irrigation regimes in a semi-arid region. *International Journal of Plant Production*, 16, 511-529. doi: 10.1007/s42106-022-00194-4.

[2] Alam, M.A., Hakim, M.A., Juaraimi, A.S., Rafii, M.Y., Hasan, M.M., & Aslani F. (2018). Potential allelopathic effects of rice plant aquous extracts on germination and seedling growth of some rise field common weeds. *Italian Journal of Agronomy*, 13(2), 134-140. doi: 10.4081/ija.2018.1066.

[3] Belyagoubi-Benhammou, N., Belyagoubi, L., Loukidi, B., Mir, M.A., Assadpour, E., Boudhene-Stambouli, M., Kharazmi, M.S., & Jafari, S.M. (2023). Bioactivity and applications of saffron floral bio-residues (tepals): A natural by product for the food, pharmaceutical, and cosmetic industries. *Critical Reviews in Food Science and Nutrition*, 1-15. doi: 10.1080/10408398.2023.2199434.

[4] Cardone, L., Castronuovo, D., Perniola, M., Cicco, N., & Candido, V. (2020). Saffron (*Crocus sativus* L.), the king of spices: An overview. *Scientia Horticulturae*, 272, article number 109560. doi: 10.1016/j.scienta.2020.109560.

[5] Cerda-bernad, D. Pitterou, J., Tzani, A., Detsi, A., & Frutos, M.J. (2023). Novel chitosan/alginate hydrogels as carriers of phenolic-enriched extracts from saffron floral by-products using natural deep eutectic solvents as green extraction media. *Current Research in Food Science,* 6, article number 100469. doi: 10.1016/j.crfs.2023.100469.

[6] El Aymani, I., El Gabardi, S., Artib, M., Chliyeh, M., Selmaoui, K., Ouazzani Touhami, A., Benkirane, R., & Douira, A. (2019). Effect of the number of years of soil exploitation by saffron cultivation in morocco on the diversity of endomycorrhizal fungi. *Journal Article,* 54(1), 9-24. doi: 10.1556/038.54.2019.002.

[7] Fallahi, H.R., Aghhavani-Shajari, M., Branca, F., & Davarzani, J. (2018). Effect of different concentrations of saffron corm and leaf residue on the early growth of arugula, chickpea and fenugreek under greenhouse conditions. *Acta Agriculturae Slovenica*, 111(1), 51-61. doi: 10.14720/aas.2018.111.1.06.

[8] Godlewska, K., Biesiada, A., Michalak, I., & Pacyga, P. (2019). The effect of plant-derived biostimulants on White heard cabbage seedlings Grown under controlled conditions. *Sustainability*, 11(19), article number 5317. doi: 10.3390/su11195317.

[9] Grodzinskiy, A.M., Bogdan, G.P., & Golovko, E.A. (1979). *Allelopathic soil fatigue*. Kyiv: Naukova dumka.

[10] Janusauskaite, D. (2023). The allelopathic activity of aqueous extracts of *Helianthus annuus* L., grown in boreal conditions, on germination, development, and physiological indices of *Pisum sativum* L. *Plants,* 12(9), article number 1920. doi: 10.3390/plants12091920.

[11] Kheirabadi, M., Azizi, M., Faezeh Taghizadeh, S., & Fujii, Y. (2020). Recent advances in saffron soil remediation: Activated carbon and zeolites effects on allelopathic potential. *Plants*, 9(12), article number 1714. doi: 10.3390/plants9121714.

[12] Khoulati, A., Ouahhoud, S., Mamri, S., Meziane, M., Choukri, M., Asehraou, A., & Saalaoui, E. (2020). Valorization of moroccan *Crocus sativus* L. by-products: Foliar spraying of aqueous tepal extract stimulates growth and confers antioxidant properties in eggplant seedling under creenhouse conditions. *Biomed Research International*, 2020, article number 8812157. doi: 10.1155/2020/8812157.2020.

[13] Korkhova, M., & Mykolaichuk V. (2021). Allelopathic properties of winter wheat varieties of various breeding institutions of Ukraine. *AgroLife Scientific Journal*, 10(1), 116-120. doi: 10.17930/AGL2021112.

[14] Lahmass, I., Ouahhoud, S., Elmansuri, M., Sabouni, A., Elyoubi, M., Benabbas, R., Choukri, M., & Saalaoui, E. (2018). Determination of antioxidant properties of six by-products of *Crocus sativus* L. (saffron) plant products. *Waste and Biomass Valorization*, 9(8), 1349-1357. doi: 10.1007/s12649-017-9851-y.

[15] Menghini, L., Vecchiotti, G., & Locatelli, M. (2018). *Crocus sativus* L. stigmas and byproducts: Qualitative fingerprint, antioxidant potentials and enzyme inhibitory activities. *Food Research International*, 109, 91-98. doi: 10.1016/j.foodres.2018.04.028.

[16] Mir, T.G., Wani, A.K., Singh, J., & Shukla, S. (2022). Therapeutic application and toxicity associated with *Crocus sativus* (saffron) and its phytochemicals. *Pharmacological Research - Modern Chinese Medicine*, 4, article number 100136. doi: 10.1016/j.prmcm.2022.100136.

[17] Murimwa, J.C., Rugare, G.T., Mabasa, S., & Mandumbu, R. (2019). Allelopathic effects of aqueous extracts of sorghum (*Sorghum bicolor* L. Moench) on the early seedling growth of sesame (*Sesamum indicum* L.) varieties and selected weeds. *International Journal of Agronomy*, 2019, article number 5494756. doi: 10.1155/2019/5494756.
[18] Mykhailenko, O., Kovalyov, V., Goruacha, O., Ivanauskas, L., & Georgiuants, V. (2019). Bioljgically active compoands and pharmacolodgical activities of species of the genus Crocus: A review. *Phitochemistry*, 162, 56-89. doi: 10.1016/j.phytochem.2019.02.004.
[19] Mykolaichuk, V.G., Korolyova, O.V., & Korkhova, M.M. (2021). Allelopathic activity of water-soluble secretions of *Crocus sativus* L. (Iridaceae) flowers when introduced in the Northern Black Sea region. *Ukrainian Journal of Medicine, Biology and Sport*, 6(3), 340-346. doi: 10.26693/jmbs06.03.340.
[20] National Agricultural Statistics Service. (2017). Retrieved from http://surl.li/fpjvg.
[21] Sharma, B., Kumar, H., Kaushik, P., Mirza, R., Awasthi, R., & Kulkarni G. (2020). Therapeutic benefits of saffron in brain diseases: New lights on possible pharmacological mechanisms. In *Saffron* (pp. 117-130). doi: 10.1016/b978-0-12-818462-2/00010-3.
[22] Tkachova, Y., Fedorchuk, M., & Kovalenko, O. (2022). Allelopathic activity of plants *Hyssopus officinalis* L. *Ukrainian Black Sea Region Agrarian Science,* 26(4), 19-29. doi: 10.56407/2313-092X/2022-26(4)-2.
[23] Williamson, G.B., & Richardson, D. (1988). Bioassays for allelopathy: Measuring treatment responses with independent controls. *Journal of Chemical Ecology*, 14, 181-187. doi: 10.1007/BF01022540.

Вплив водорозчинних виділень шафрану насіннєвого на проростання насіння сортів пшениці м'якої озимої

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Анотація. У зв'язку зі зміною клімату постає необхідність у залученні до сільськогосподарського виробництва України нових культур, серед яких чільне місце може зайняти *Crocus sativus* L. – трав'яниста багаторічна бульбоцибулинна рослина, алелопатичні властивості якої вивчено недостатньо. Тому, метою досліджень було встановлення впливу водорозчинних виділень квіток та окремих їх елементів на початкові етапи проростання насіння двох сортів пшениці м'якої озимої (Відрада та Кошова). У ході дослідження були використані загальноприйняті методи: лабораторне дослідження, аналіз, синтез та статистичний. Було встановлено, що водорозчинні виділення квіток різного стану та елементів квіток *C. sativus* не мають істотного впливу на морфометричні та якісні показники зернівки пшениці при проростанні. Водорозчинні виділення квіток різного стану мають інгібуючу дію на розвиток кореневої системи; виділення бутону та розквітлої квітки пригнічують ріст колеоптиле. Вплив водорозчинних виділень елементів квіток шафрану посівного має сортові особливості: для проростків пшениці озимої сорту Відрада характерна стимулююча дія пелюсток на загальну довжину коренів та їх масу; для проростків сорту Кошова спостерігається зворотній вплив. Водорозчинні виділення пелюсток і тичинок мають стимулюючу дію на колеоптиле рослин сорту Відрада, а для проростків сорту Кошова стимулюючу дію мають водорозчинні виділення пелюсток. Кореляція між довжиною коренів та колеоптиле за впливу водорозчинних виділень квіток різного стану та їх елементів, а також індекс алелопатії мають сортові особливості. Отримані наукові результати сприятимуть розробці агротехнічних заходів щодо вирощування шафрану посівного в Україні, підборі сортів пшениці озимої для сумісного вирощування та використання рослинних залишків, як біологічних стимуляторів

Ключові слова*:* *Crocus sativum; Triticum aestivum;* алелопатичні властивості; проростки; зернівки; алелопатичний індекс