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Allelopathic Effect of Cucurbitaceae Species on *Triticum aestivum* L. Cultivars

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This study investigates the allelopathic interactions between *Triticum aestivum* L. (wheat) cultivars Podolyanka and Bogdana and several Cucurbitacea*e* species, including *Cucurbita pepo* L., *Cucurbita pepo var. Giraumontia* Pang., and *Cucumis sativus* L. The experimental analysis was focused on wheat's seed germination, root length, and shoot length under the influence of aqueous extracts from these cucurbits. As the result, inhibitory effect was revealed depending on the combination of wheat variety and cucurbit species. The most substantial inhibitory impact was observed with *Cucumis sativus* on cv. Podolyanka. The aqueous extracts of *Cucumis sativus* significantly reduced germination percentage and affected early seedling growth, which indicates strong allelopathic effect. Meanwhile, with *Cucurbita pepo* and its variety *Giraumontia* variable effects were observed ranging from slight inhibition to no inhibition, depending on the wheat variety. These findings highlight the allelopathic potential of cucurbits and their possible applications in crop management, particularly for weed suppression and optimizing plant growth. Additionally, the study emphasizes the importance of understanding species-specific allelopathic influences, as these interactions can lead to improved crop rotation and intercropping strategies, ultimately enhancing overall agricultural sustainability. The results of this research can be used to optimize crop performance and develop sustainable agricultural practices that reduce reliance on chemical herbicides. The study provides insights into crop-weed dynamics and serves as a foundation for future research on the allelopathic effects, including the identification of specific allelochemicals responsible for the observed interactions, their modes of action, and their practical applications in agriculture. These results contribute to a broader understanding of plant-plant interactions and offer potential pathways for reducing chemical inputs in farming systems while maintaining productivity and ecological balance.

Keywords: allelopathy, Cucurbitaceae, *Triticum aestivum*, root, shoot

Introduction

Today, the threat of a highly negative anthropogenic impact on natural ecosystems, which leads to biodiversity loss, is reaching alarming proportions (Bogovin, 2009). Problems such as plant restoration and breeding, creation of mixed plantations, and determination of crop growing conditions can be solved by studying the allelopathic properties of plants. Allelopathy is a modern branch of science that studies the patterns of interaction between plant species during joint germination in biocenoses based on the exchange and circulation of physiologically active substances, which is important for developing the farming system (Bilyk, 2006; Basalevych, 2007).

Triticum aestivum L. is the staple food for more than 35% of the world's population (Shao et al., 2007). The high demand for this plant species and its diverse use in nutrition have led to the fact that today, *Triticum aestivum* L. is the most important cereal crop in the

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world, especially in developing countries. The study of *Triticum aestivum* allelopathy is of great importance in weed and pest management. Wheat varieties differ in their allelopathic potential due to categories of allelochemicals such as phenolic acids, hydroxybutyric acids, and short-chain fatty acids (Wu et al., 2000; Wu et al., 2001; Vidotto et al., 2008; Mengal et al., 2015). The cultivars Podolyanka and Bogdana are characterized by high reliability and adaptability to arid growing conditions and are also highly productive varieties with rapid regeneration capacity (Horbatyuk et al., 2014; Hangur et al., 2022).

The use of mono-dominant agrocenoses in the modern agricultural system leads to a decrease in biodiversity, destruction of natural connections and deterioration of crop resistance to adverse environmental conditions (Reigosa et al., 2006; Hrodzynskyi, 2012). To create sustainable and highly productive artificial phytocenoses, fundamental research is needed to determine the mechanisms of allelopathic interactions of plants with chemical secretions that affect subsequent crops in the crop rotation. An in-depth study of allelopathy makes it possible to improve strategies for regulating agricultural production and the ecological use of allelochemicals (Lambers et al., 1998; Kohli et al., 2001; Singh et al., 2006). When growing crops with wide row spacing, young plants cannot fully utilize the row spacing, especially in the early stages of development, and this leads to a decrease in the efficiency of land use. In this context, growing plants in compacted crops is becoming increasingly important, given the allelopathic relationship between compacted and compaction crops. One of the main advantages of compacted crops is an increase in overall crop yields and rational use of land resources (Kovalenko, 2012). Studying the allelopathic properties of plants allows us to find solutions to problems such as plant restoration and breeding, the creation of mixed plantations and the improvement of crop growing conditions, which, in turn, can lead to the development of new agronomic practices, which will increase yields and product quality and reduce the use of chemicals (Hrodzynskyi, 1973).

This study aimed to determine the effect of water plant extracts of the Cucurbitaceae family on the germination and development of different wheat cultivars *Triticum aestivum* under controlled conditions. *Cucurbita pepo* L., *Cucurbita pepo var. Giraumontia* Pang, and *Cucumis sativus* L. are popular vegetable crops that play an important role in people's diets and are used in various agricultural systems. The study was aimed at identifying the potential of using these extracts to improve agronomic practices by naturally regulating crop growth. Particular attention was paid to the analysis of the resistance and response of the cultivars Podolyanka and Bogdana to allelochemicals. The results obtained can be the basis for the development of new approaches in sustainable agriculture that will reduce the use of chemicals and contribute to higher yields and product quality. In the introduction part better to show why were selected Cucurbita pepo, etc.

Materials and methodology

Objects of the Study

In this study, we aimed not only to investigate the effects of allelopathic substances but also to gain a deeper understanding of how different plants can influence each other under conditions as close to natural as possible. We chose two wheat cultivars, Podolyanka and Bogdana because they have different agronomic characteristics and are commonly used in Ukrainian agricultural systems. Cultivar Podolyanka is known for its high yield and drought tolerance, while cv. Bogdana is more resistant to disease and adverse climatic conditions. Due to these features, both cultivars are interesting objects for studying the response to allelopathic effects.

In addition, extracts of plants of the Cucurbitaceae family were selected for the study: *Cucurbita pepo*, *Cucurbita pepo var. Giraumontia* and *Cucumis sativus*. These plants are known for their allelochemical properties, which can affect the growth and development of other crops, inhibiting or, conversely, stimulating their germination. The choice of these plants was driven by the need to better understand how extracts can affect the initial stages of wheat growth, which is important for the development of sustainable agricultural technologies. Plants were collected in July-August 2024 (during flowering) in Kyiv and dried in the dark at a temperature of +20–24 °C.

Preparation and conducting of the experiment

For the experimental part, the preparation of biological material and aqueous solutions was carried out according to the method of test bioassays developed by Grodzinsky (Shanda and Voroshilova, 2009; Krasnoshtan, 2015). *Cucurbita pepo*, *Cucurbita pepo* var. Giraumontia and *Cucumis sativus* were chosen as biological material. Aqueous extracts were prepared at a concentration of 1:10 (3 mg of plant material per 30 ml of distilled water). After preparation, the aqueous extracts were kept for 24 hours in a darkened room according to the method of generally accepted allelopathic studies.

Triticum aestivum seeds were placed in Petri dishes on filter paper: 10 seeds in each Petri dish. Thirty seeds were germinated in distilled water, 10 in each Petri dish. To achieve this goal, model experiments were conducted in Petri dishes in triplicate according to the following scheme for both cultivars of *Triticum aestivum*:

1. control (*Triticum aestivum* + distilled water);
2. experiment I (*Cucurbita pepo* extract + *Triticum aestivum*);
3. experiment II (extract from *Cucurbita pepo* var. Giraumontia + *Triticum aestivum*);
4. experiment III (extract from *Cucumis sativus* + *Triticum aestivum*) (Figure 1).

The study used three indicators: the number of seedlings of *Triticum aestivum* and the length of their root and shoot. By calculating the average value of a group of numbers, the significance of differences and the level of significance were determined.

Statistical analysis

Data analysis was conducted by calculating the mean alongside the standard error of the mean (S.E.M.). All statistical procedures were carried out using SPSS Statistics, version 27.

Results and discussions

On day 8 of the experiment, the number of seedlings of *Triticum aestivum* cv. Podolyanka with *Cucurbita pepo* in distilled water was 7, with *Cucurbita pepo* var. Giraumontia – 7, with *Cucumis sativus* – 10. Whereas the number of seedlings of *Triticum aestivum* cv. Bogdana with *Cucurbita pepo* in distilled water was 8, with *Cucurbita pepo* var. Giraumontia – 4, with *Cucumis sativus* – 5. In the control group, 100% of seeds germinated (Figure 2).

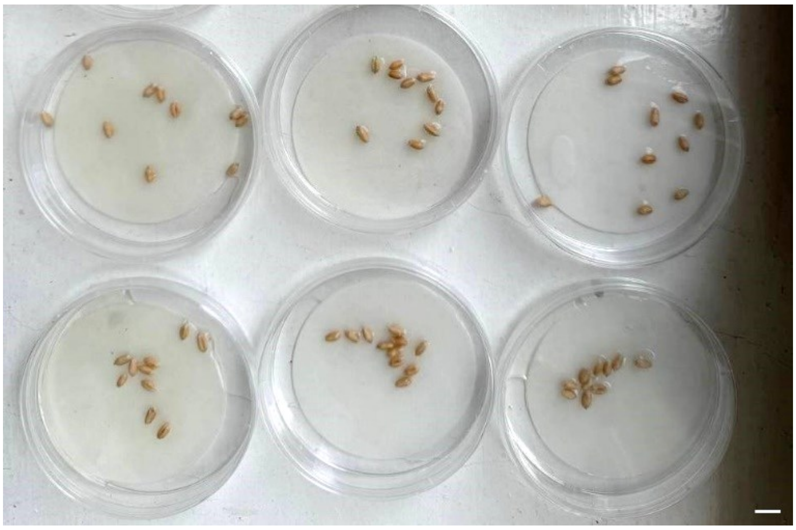

Figure 1 Test cultures in 90 mm Petri dishes. Scale bar = 10 mm.

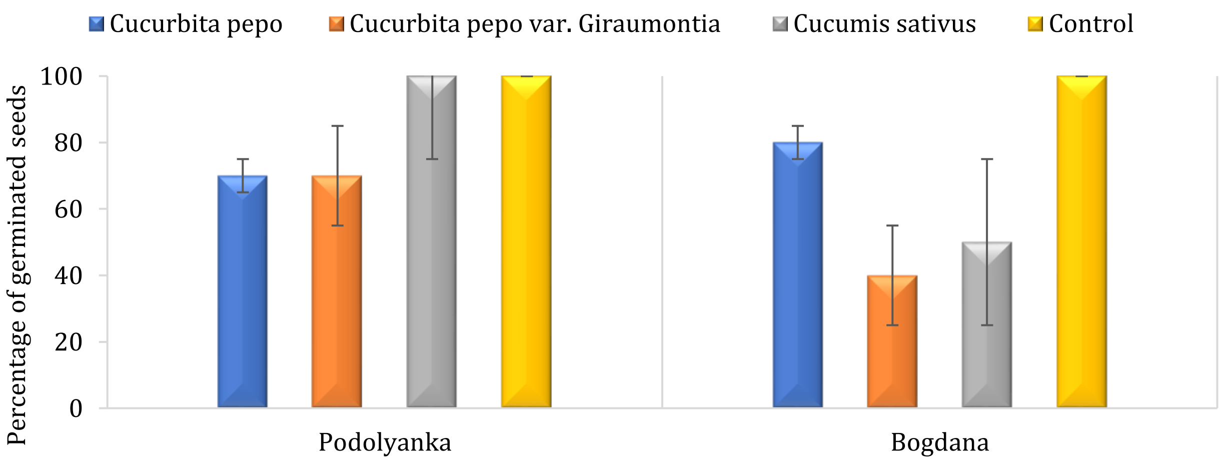

Figure 2 The number of seedlings of *Triticum aestivum L* under the influence of Cucurbitaceae plant extracts

The root length during the joint germination of *Triticum aestivum* cv. Podolyanka with *Cucurbita pepo* in solution averaged 5.69 cm, with *Cucurbita pepo* var. Giraumontia – 4.66 cm, with *Cucumis sativus* – 4.41 cm, and the root length of *Triticum aestivum* cv. Bogdana with *Cucurbita pepo* in solution averaged 7.59 cm, with *Cucurbita pepo* var. Giraumontia – 5.7 cm, with *Cucumis sativus* – 9.96 cm, while in the control cv. Podolyanka – 11.4 cm, cv. Bogdana – 6.9 cm (Figure 3).

The length of the shoot when germinating *Triticum aestivum* cv. Podolyanka with *Cucurbita pepo* in solution averaged 4.39 cm, with *Cucurbita pepo* var. Giraumontia – 3.09 cm, with *Cucumis sativus* – 3.37 cm, and the root length of *Triticum aestivum* cv. Bogdana with *Cucurbita pepo* in solution averaged 3.89 cm, with *Cucurbita pepo* var. Giraumontia – 2.54 cm, with *Cucumis sativus* – 3.57 cm. Meanwhile, in the control, cv. Podolyanka was 4.55 cm, and cv. Bogdana was 4.73 cm (Figure 4).

After a detailed analysis, we will consider the main results of the study, which aimed to investigate how aqueous extracts of Cucurbitaceae representatives affect different cultivars of *Triticum aestivum*.

The solution had a negative effect on the cv. Podolyanka with all test crops; the most significant difference with the control in the overdue plants that grew in the solution with *Cucumis sativus* was 7 cm. Regarding the effect on the cv. Bogdana, we observe a slight positive effect with *Cucurbita pepo* var. Giraumontia, with *Cucumis sativus*, the indicators are almost the same as those with *Cucurbita pepo* var. Giraumontia has a slightly negative effect because the difference is 1.9 cm from the control.

The difference between the control and the test cv. Podolyanka, which was germinated in the solution with *Cucurbita pepo*, is only 0.16 cm, so the effect of *Cucurbita pepo* on *Triticum aestivum* cv. Podolyanka is insignificant, while with *Cucurbita pepo* var. Giraumontia and *Cucumis sativus* the difference with the control is 1.46 and 1.18, indicating a negative effect. If we compare both cultivars, they are almost the same, with the control cv. Bogdana being 0.05 cm higher.

The results of our study confirm the significant inhibitory effect of *Cucumis sativus* extracts on the germination and development of *Triticum aestivum*, especially on the cv. Podolyanka. A significant reduction in root and stem length was observed, indicating a strong allelopathic effect. This is consistent with previous studies emphasizing the inhibitory effect of Cucurbitaceae on wheat (Wu et al., 2000; Basalevych, 2007; Shanda and Voroshilova, 2009).

Various studies show that the effectiveness of allelopathic effects strongly depends on the concentration of allelochemicals and environmental conditions (Cast et al., 1990; Roth et al., 2000; Ben-Hammouda et al., 2001). For example, variations in the concentration of allelochemicals in the soil can lead to different results, depending on tillage systems and growing conditions (Blum et al., 1991). Other authors (Nakano et al., 2002; Nakano et al., 2003) emphasize the importance of identifying specific allelochemicals compounds, such as phenolic acids, that are responsible for the inhibitory effect.

Positive effects of allelopathic interactions have also been documented in some cases. For example, studies by Wu et al. (2001) and Kayode (2006) demonstrate that under certain conditions, wheat allelochemicals can have a positive effect on the development of other plants. This suggests that allelopathic interactions are a complex process that is highly dependent on many factors, such as concentration, crop type, soil type, and environmental conditions.

Our results also indicate a difference in resistance between cultivars Podolyanka and Bogdana. Cultivar Bogdana was more resistant to the allelopathic effects of *Cucumis sativus*, which may be due to genetic and physiological characteristics of the variety (Inderjit and Dakshini, 1998; Bilyk, 2006). Such a difference may be important for the selection of wheat cultivars when grown together with other crops, especially Cucurbitaceae.

Given the complexity of allelopathic interactions, more research is needed to identify specific allelochemicals and analyze their mechanisms of action. The use of modern methods such as chromatography and mass spectrometry can help in the identification of active substances (Blum et al., 1991; Nakano et al., 2002). In addition, conducting experiments with different concentrations of allelochemicals will allow to better understand the dose-dependent effects on the growth and development of *Triticum aestivum* (Weston, 1996; Wu et al., 2000). It is also important to continue studying the influence of environmental conditions on the effectiveness of allelopathic interactions, which will help to optimize agronomic measures to increase the productivity and sustainability of agroecosystems (Bogovin, 2009).

In addition, findings from the study on the allelopathic effects of *Cucurbita moschata* root exudates align well with our results, offering a broader perspective on the inhibitory potential of the Cucurbitaceae family. The study demonstrated that the root exudates of *Cucurbita moschata* significantly suppressed wheat germination and reduced the growth of roots and shoots, with stronger effects observed at higher concentrations. This consistency between our results and similar research reinforces that allelopathic interactions involving *Cucurbitaceae* are notable across different species and contexts (Wu et al., 2005).

The inhibitory effects seen in our study and those of *Cucurbita moschata* reflect a common mode of action of allelopathic substances, possibly involving phenolic acids or other allelochemicals, which act to inhibit growth through various physiological disruptions. These findings provide an important foundation for future research into how these mechanisms can be harnessed or mitigated to optimize crop productivity in mixed-cropping systems. Further comparative studies across various environmental conditions and concentrations of allelochemicals will deepen our understanding of these complex interactions and contribute to the sustainable management of agroecosystems (Li et al., 2005).

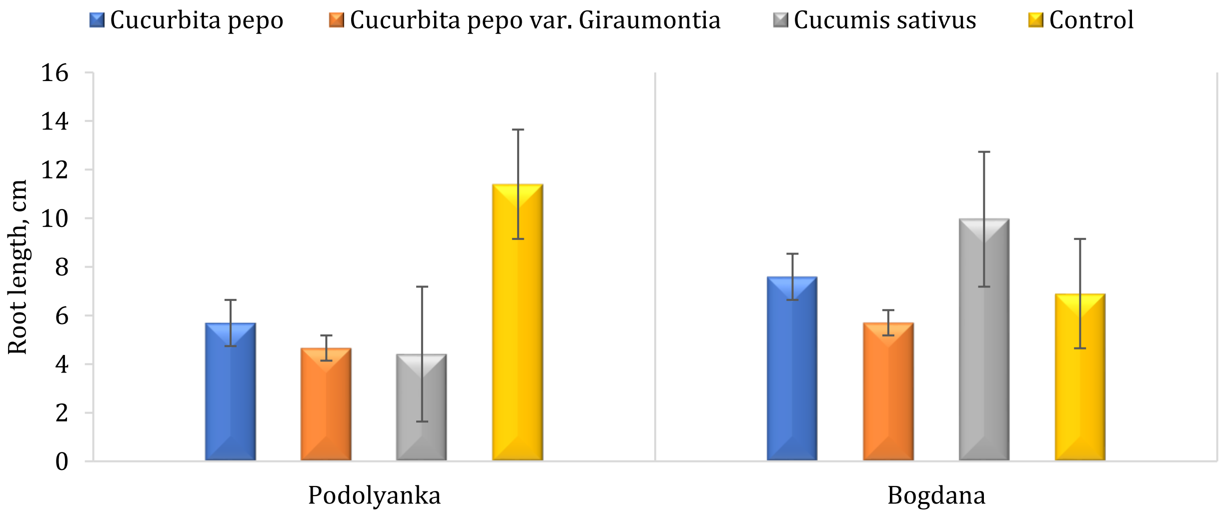

Figure 3 Root length of *Triticum aestivum* L under the allelopathic influence of Cucurbitaceae plant extracts

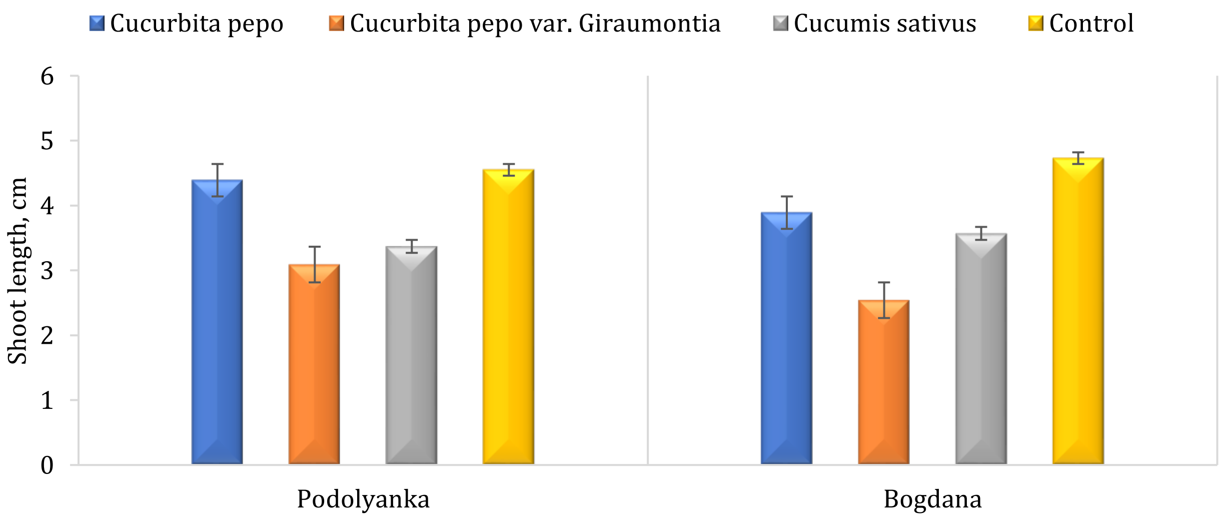

Figure 4 Shoot length of *Triticum aestivum* L as a result of the allelopathic influence of Cucurbitaceae plant extracts

Conclusions

The study demonstrates that the allelopathic effects of Cucurbitaceae species on *Triticum aestivum* vary depending on the specific wheat variety and cucurbit species. The cv. Podolyanka showed a noticeable reduction in root and shoot length when exposed to aqueous extracts from *Cucumis sativus*, indicating a strong inhibitory effect. In contrast, the cv. Bogdana exhibited more resilience, with only minor inhibitory effects observed. These findings suggest that allelopathy could be an important factor in determining compatibility between crops and can be utilized in sustainable agricultural practices for natural weed management and optimizing crop performance. Further research into specific allelochemicals and their mechanisms of action may provide deeper insights into enhancing crop resilience and productivity.

Conflict of interest

The authors declare no conflict of interest.

Ethical statement

This article does not include any studies necessitating an ethical statement.

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