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PHYTOSANITARY STATUS OF GERANIUMS COLLECTION AT VYTAUTAS MAGNUS UNIVERSITY BOTANICAL GARDEN

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Vytautas Magnus University Botanical Garden has a rather rich collection of geraniums. These are mainly perennial, decorative herbaceous plants, which are characterized by the fact that they are relatively undemanding, they can grow both in sunny places and in the shade. In addition, geraniums tolerate drought quite easily and suppress weeds well. However, the most important feature of decorative plants is their resistance to diseases and pests. Even the most decorative plant will lose its value if it is constantly damaged by diseases or pests. The geraniums grown in the Botanical Garden are monitored throughout the growing season and their phytosanitary status is assessed. It was found that powdery mildew was the most common disease in the collection of geraniums and geranium sawfly was the most common pest. The aim of the conducted research was to define the phytosanitary status of the geranium collection, to assess the resistance or susceptibility of cultivated geranium species and varieties to the most important pests and diseases.

Keywords: *Geranium*; powdery mildew; geranium sawfly, resistance, damage.

INTRODUCTION

Geranium is a genus of herbaceous plants that includes more than 400 species distributed throughout the world. Some species and more than 1000 varieties are used in horticulture (Aedo, 1998). Geraniums are appreciated for their long decorativeness, abundant flowering and easy care (Iannotti, 2023). Despite being undemanding to environmental conditions, sometimes they can be injured by some pests and diseases. Slugs might attack young geranium plants, while powdery mildew (Figure 1 A) and rust can infest foliage, especially in partial shade and humid conditions.



Figure 1. Geranium stems damaged by powdery mildew (A) and leaf damaged by geranium sawfly larva (B). Photos made by authors.

Shearing back and disposing of the infected leaves will help. To avoid powdery mildew, the plants should be planted with a plenty of space to improve air circulation and the watering through ground soaking rather than overhead spraying should be performed. Powdery mildew spores are spread from water splashing against the soil (Iannotti, 2023). Powdery mildew diseases are caused by fungi in several genera, including *Erysiphe*, *Leveillula*, *Golovinomyces*, *Podosphaera*, *Microsphaera*, *Oidium*, and *Sphaerotheca*. Each genus contains several species. Most powdery mildew species are specialized to infect only hosts in one plant genus or one family; it is rare that more than one family is affected by a single species (Dicklow, Madeiras, 2019). Powdery mildew may have little or no effect on the plant (other than aesthetic) or it may cause infected leaves to distort, discolour, wither, and defoliate prematurely. Most Powdery mildews have evolved to avoid killing their hosts because they can only survive in living plant tissue. Symptoms and their severity depend upon the cultivar or species of host plant, the powdery mildew species, environmental conditions, and the age of plant tissue (Dicklow, Madeiras, 2019).

Geranium sawfly (*Ametastegia carpini*) belong to Hymenopteras (suborder Symphyta). It is a monophagous parasite of Geraniaceae plants. *Geranium palustre*, *G. pratense*, *G. robertianum*, *G. sanguineum*, *G. sylvaticum* are the most susceptible species to this pest (Willem, 2020). Larvae of the sawfly parasitize geranium leaves (Figure 1 B). It is known that the pest is widespread in Great Britain, it is also found in some European countries, therefore there is no systematic knowledge of its prevalence.

The purpose of the conducted research was to determine the main diseases and pests of the geraniums and to distinguish their species and varieties with natural resistance.

RESEARCH METHODS

Botanical names of plants have been checked according to the systems of taxonomic standardization of names of plant species: The World Flora Online, Euro+Med PlantBase. Lithuanian species names have been verified in the term bank of the Language Commission of the Republic of Lithuania. Varietal names have been calibrated using RHS Plant Finder (Cubey, 2012), and a register of Geranium varieties published on the International Geraniaceae Group website (Victor, 2017).

The research was carried out in the VDU Botanical Garden in 2023. The collection of geraniums is one of the largest in Baltic region - 141 collection numbers (Table 1). Observations were performed according to methodology prepared by J. Vaidelys (2005) "Methodology of phenological observations, biometric measurements and formation of the assortment of ornamental herbaceous plants".

Table 1. Collection of geraniums in Vytautas Magnus University Botanical Garden.

Species	Variety
<i>G. × cantabrigiense</i>	'Berggarten', 'Biokovo', 'Cambridge', 'Crystal Rose', 'Intense', 'St Ola', 'Harz', 'Hilary Rendall', 'Karmina'
<i>G. cinereum</i>	'Ballerina', 'Purple Pillow'
<i>G. dalmaticum</i>	'Stade's Hellrosa'
<i>G. endressii</i>	
<i>G. himalayense</i>	'Plenum', 'Derrick Cook', 'Baby Blue', 'Die Sensation', 'Gravetye'
<i>G. ibericum</i>	
<i>G. ibericum</i> var. <i>platypetalum</i>	
<i>G. macrorrhizum</i>	'Czakar', 'Album', 'Bevan's Variety', 'Ingwersen's Variety', 'Jördis', 'Lohfelden', 'Olympos', 'Sandy's Smile', 'Spessart', 'Variegatum', 'White-Ness'
<i>G. maculatum</i>	'Espresso'
<i>G. × magnificum</i>	'Anemoniflorum', 'Rosemoor'
<i>G. nodosum</i>	'Svelte Lilac'
<i>G. × oxonianum</i>	'Frank Lawley', 'Wageningen', 'Wargrave Pink', 'Königshof', 'Claridge Druce'
<i>G. palustre</i>	
<i>G. phaeum</i>	'Blauwvoet', 'Calligrapher', 'Golden Spring', 'Lady in Mourning', 'Lily Lovell', 'Rachel's Rhapsody', 'Raven', 'Samobor', 'Springtime', 'Album', 'Walküre'
<i>G. platyanthum</i>	'Russian Giant'
<i>G. pratense</i>	'Azure Skies', 'Cloud Nine', 'Cluden Sapphire', 'Dark Reiter', 'Double Jewel', 'Hocus Pocus', 'Kaya', 'Laura', 'Midnight Clouds', 'New Dimension', 'Purple Ghost', 'Storm Cloud', 'Galactic', 'Sabani Blue', 'Mrs. Kendall Clark', 'Splish Splash'
<i>G. psilostemon</i>	'Johnson's Blue'

<i>G. reflexum</i>	
<i>G. renardii</i>	
<i>G. richardsonii</i>	
<i>G. sanguineum</i>	'Alan Bloom', 'Apfelblüte', 'Canon Miles', 'Compactum', 'Feu d'Automne', 'Inverness', 'Pink Pouffe', 'Vision Pink', 'Album', 'Little Bead', 'Max Frei'
<i>G. sanguineum</i> var. <i>striatum</i>	
<i>G. sylvaticum</i>	'Baker's Pink', 'Angulatum', 'Mayflower', 'Ice Blue'
<i>G. soboliferum</i>	
<i>G. swatense</i>	
<i>G. thunbergii</i>	
<i>G. tuberosum</i>	
<i>G. versicolor</i>	
<i>G. wallichianum</i>	'Havana Blues', 'Rise and Shine', 'Azure Rush'
<i>G. wlassovianum</i>	'Typ Crūg Farm', 'Lakwijk Star'
<i>G. yesoense</i>	
<i>Geranium</i> L.	'Blue Blood', 'Blue Sunrise', 'Dilys', 'Dreamland', 'Fay Anna', 'Kashmir Blue', 'Khan', 'Laurence Flatman', 'Nimbus', 'Orkney Cherry', 'Philippe Vapelle', 'Red Admiral', 'Rozanne', 'Terre Franche', 'Traupis', 'Black Crown', 'Brookside', 'Chantilly', 'Criss Canning', 'Istrica', 'Ivan', 'Kelly-Anne', 'Orion', 'Pink Penny', 'Tiny Monster', 'Blue Cloud'

The phytosanitary status of the geraniums collection was monitored and assessed continuously throughout the growing season. Pests and diseases observed in the collection were identified using reference books for the description of diseases and pests (Pirone, 1978; Трейвас, 2014) and microscope VWR.

RESEARCH RESULTS AND DISCUSSION

During observations of the geraniums, it was defined that the plants were mostly affected by downy mildew and geranium sawfly larvae.

The first symptoms of geranium sawfly larvae damage were recorded at the end of June - beginning of July. The larvae of the pest occurred on the underside of the leaves. At first, they nibbled the soft tissues of the underside of the leaf, often without even damaging the upper epidermis. As a result, the leaves near to the area of lesions begin to turn brown, dry, roll up, and crumble. Later, the larvae of the pest make oval-shaped elongated holes between the veins of the leaves. Fortunately, most of the collection was not affected by this pathogen. The results of the assessment of the intensity of geranium sawfly larvae damage of the geranium species and varieties grown in the VMU Botanical Garden geranium collection are presented in Table 2.

Table 2. Species and varieties of geraniums intact and damaged by the geranium sawfly and the intensity of the damage.

Intact plants
'Berggarten', 'Crystal Rose', 'Intense', 'St Ola', 'Ballerina', 'Purple Pillow', <i>G. dalmaticum</i> , 'Stade's Hellrosa', <i>G. endressii</i> , 'Plenum', <i>G. macrorrhizum</i> , 'Czakov', 'Album', 'Bevan's Variety', 'Ingwersen's Variety', 'Jördis', 'Lohfelden', 'Olympos', 'Sandy's Smile', 'Spessart', 'Variegatum', 'White-Ness', <i>G. maculatum</i> , 'Anemoniflorum', <i>G. nodosum</i> , 'Frank Lawley', 'Wageningen', <i>G. palustre</i> , 'Blauwvoet', 'Calligrapher', 'Golden Spring', 'Lady in Mourning', 'Lily Lovell', 'Rachel's Rhapsody', 'Raven', 'Samobor', 'Springtime', 'Russian Giant', 'Azure Skies', 'Cloud Nine', 'Cluden Sapphire', 'Dark Reiter', 'Double Jewel', 'Galactic', 'Hocus Pocus', 'Kaya', 'Laura', 'Midnight Clouds', 'New Dimension', 'Purple Ghost', 'Splish Splash', 'Storm Cloud', 'Johnson's Blue', <i>G. renardii</i> , <i>G. richardsonii</i> , 'Alan Bloom', 'Apfelblüte', 'Canon Miles', 'Compactum', 'Feu d'Automne', 'Inverness', 'Pink Pouffe', 'Vision Pink', <i>G. sanguineum</i> var. <i>striatum</i> , <i>G. sylvaticum</i> , <i>G. swatense</i> , <i>G. tuberosum</i> , 'Havana Blues', 'Rise and Shine', <i>G. wlassovianum</i> , 'Typ Crūg Farm', 'Lakwijk Star', 'Blue Blood', 'Blue Sunrise', 'Dilys', 'Dreamland', 'Fay Anna', 'Kashmir Blue', 'Khan', 'Laurence Flatman', 'Nimbus', 'Orkney Cherry', 'Philippe Vapelle', 'Red Admiral', 'Rozanne', 'Terre Franche', 'Traupis', <i>G. yesoense</i>
10-40% damaged plants
'Biokovo', 'Harz', 'Hilary Rendall', 'Karmina', <i>G. himalayense</i> , 'Derrick Cook', 'Baby Blue', 'Die Sensation', 'Gravetye', <i>G. ibericum</i> , <i>G. ibericum</i> var. <i>platypetalum</i> , 'Espresso', <i>G. magnificum</i> , 'Rosemoor', 'Svelte Lilac', 'Claridge Druce', 'Wargrave Pink', <i>G. phaeum</i> , 'Album', 'Walküre', <i>G. pratense</i> , 'Mrs Kendall Clark', <i>G. reflexum</i> , <i>G. sanguineum</i> , <i>G. sanguineum</i> 'Album', 'Little Bead', 'Baker's Pink', 'Angulatum', 'Mayflower', <i>G. soboliferum</i> , <i>G. thunbergii</i> , <i>G. versicolor</i> , 'Azure Rush', 'Blue Cloud', 'Sabani Blue'
70-100% damaged plants
'Cambridge', 'Königshof', 'Max Frei', 'Ice Blue', 'Black Crown', 'Brookside', 'Chantilly', 'Criss Canning', 'Istrica', 'Ivan', 'Kelly-Anne', 'Orion', 'Pink Penny', 'Tiny Monster'

Some species and varieties of geraniums were defined to be particularly resistant to geranium sawfly, namely the species and varieties of *G. macrorrhizum* and *G. phaeum*. A significant part of the collection was moderately damaged by geranium sawfly larvae. The intensity of damage to these plants varied from 10-40 %.

Geranium sawfly larvae mostly (70-100 %) damaged leaves of geranium varieties 'Cambridge', 'Königshof', 'Max Frei', 'Ice Blue', 'Black Crown', 'Brookside', 'Chantilly', 'Criss Canning', 'İstrica', 'Ivan', 'Kelly-Anne', 'Orion', 'Pink Penny', 'Tiny Monster'.

The first lesions of powdery mildew were recorded at the end of June - beginning of July. The leaves and/or only the stems of the plants become covered with white coating. Later, these coatings darken, cover larger and larger areas of plant parts, which begin to deform and dry. Damaged plants lose their decorativeness. However, it must be recognized that plants do not die due to powdery mildew damage.

During the observations, it was determined that powdery mildew did not damage the majority of the geranium collection. Thus, the composed collection of geraniums contains quite a number of geranium species and varieties, the plants of which are resistant to powdery mildew. The obtained research results are presented in Table 3. *G. pratense* and varieties derived from this species appeared to be the most susceptible to powdery mildew.

Table 3. Species and varieties of geraniums intact and damaged by powdery mildew and the intensity of the disease.

Intact plants	
'Berggarten', 'Crystal Rose', 'Intense', 'St Ola', 'Ballerina', 'Purple Pillow', <i>G. dalmaticum</i> , 'Stade's Hellrosa', <i>G. endressii</i> , 'Plenum', <i>G. macrorrhizum</i> , 'Czakar', 'Album', 'Bevan's Variety', 'Ingwersen's Variety', 'Jördis', 'Lohfelden', 'Olympos', 'Sandy's Smile', 'Spessart', 'Variegatum', 'White-Ness', <i>G. maculatum</i> , 'Anemoniflorum', <i>G. nodosum</i> , 'Frank Lawley', 'Wageningen', <i>G. palustre</i> , 'Blauwvoet', 'Calligrapher', 'Golden Spring', 'Lady in Mourning', 'Lily Lovell', 'Rachel's Rhapsody', 'Raven', 'Samobor', 'Springtime', 'Russian Giant', 'Azure Skies', 'Cloud Nine', 'Cluden Sapphire', 'Dark Reiter', 'Double Jewel', 'Hocus Pocus', 'Kaya', 'Laura', 'Midnight Clouds', 'New Dimension', 'Purple Ghost', 'Storm Cloud', 'Johnson's Blue', <i>G. renardii</i> , <i>G. richardsonii</i> , 'Alan Bloom', 'Apfelblüte', 'Canon Miles', 'Compactum', 'Feu d'Automne', 'Inverness', 'Pink Pouffe', 'Vision Pink', <i>G. sanguineum</i> var. <i>striatum</i> , <i>G. sylvaticum</i> , <i>G. swatense</i> , <i>G. tuberosum</i> , 'Havana Blues', 'Rise and Shine', <i>G. wlassovianum</i> , 'Typ Crüg Farm', 'Lakwijk Star', 'Blue Blood', 'Blue Sunrise', 'Dilys', 'Dreamland', 'Fay Anna', 'Kashmir Blue', 'Khan', 'Laurence Flatman', 'Nimbus', 'Orkney Cherry', 'Philippe Vapelle', 'Red Admiral', 'Rozanne', 'Terre Franche', 'Traupis', <i>G. yesoense</i> , 'Biokovo', 'Harz', 'Hilary Rendall', 'Karmina', <i>G. himalayense</i> , 'Derrick Cook', 'Baby Blue', 'Die Sensation', 'Gravetye', <i>G. ibericum</i> var. <i>platypetalum</i> , 'Espresso', <i>G. × magnificum</i> , 'Rosemoor', 'Svelte Lilac', 'Wargrave Pink', <i>G. phaeum</i> 'Album', <i>G. reflexum</i> , <i>G. sanguineum</i> , <i>G. sanguineum</i> 'Album', 'Little Bead', 'Baker's Pink', 'Angulatum', 'Mayflower', <i>G. soboliferum</i> , <i>G. thunbergii</i> , <i>G. versicolor</i> , 'Azure Rush', 'Sabani Blue', 'Cambridge', 'Königshof', 'Max Frei', 'Ice Blue', 'Black Crown', 'Brookside', 'Chantilly', 'Criss Canning', 'İstrica', 'Ivan', 'Kelly-Anne', 'Orion', 'Pink Penny', 'Tiny Monster'	
Leaf damage	
10-20% damaged	90-100% damaged
<i>G. ibericum</i> , 'Walküre'	'Galactic'
Stem damage	
30-50% damaged	70-100% damaged
'Claridge Druce', <i>G. pratense</i> , 'Mrs. Kendall Clark', 'Splish Splash', 'Blue Cloud'	'Galactic'

Geraniums of the variety 'Galactic' were particularly susceptible to powdery mildew. Both leaves and stems of plants of this variety were 70-100 % covered with powdery mildew coatings.

Several cases of powdery mildew damage were observed in September as well. *G. pratense*, *G. himalayense* and *G. soboliferum* were the most affected. Powdery mildew damaged all the leaves of these species of geraniums.

CONCLUSIONS

1. The first symptoms of powdery mildew appeared in late June - early July. Powdery mildew lesions were particularly evident in September.
2. *G. pratense* and varieties derived from this species were most susceptible to powdery mildew: 'Galactic', 'Mrs. Kendall Clark', 'Splish Splash'.
3. Geranium sawfly larvae mostly (70-100 %) damaged 'Cambridge', 'Königshof', 'Max Frei', 'Ice Blue', 'Black Crown', 'Brookside', 'Chantilly', 'Criss Canning', 'İstrica', 'Ivan', 'Kelly-Anne', 'Orion', 'Pink Penny', 'Tiny Monster' plants.
4. *G. macrorrhizum* and *G. phaeum* species and their cultivars were particularly resistant to geranium sawfly.

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