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SUSCEPTIBILITY OF ECHINACEA TO ONION THRIPS DAMAGE: A CASE STUDY IN VYTAUTAS MAGNUS UNIVERSITY BOTANICAL GARDEN

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Onion thrips (*Thrips tabaci* Lind.) are increasingly recognized as economically significant pests of Echinacea species cultivated for ornamental and medicinal purposes. This study assessed the susceptibility of Echinacea accessions maintained at the Vytautas Magnus University Botanical Garden during the 2024-2025 growing seasons. A total of 108 accessions, including wild species and horticultural cultivars, were evaluated under open-field conditions using standardized morphological assessment and damage scoring methods. Results demonstrated substantial inter- and intra-specific variation in susceptibility to *T. tabaci*. The most resistant accessions across both seasons were *Echinacea paradoxa* and its derived cultivars, which exhibited ≤20% damage and retained high ornamental quality. In contrast, *E. purpurea* and many of its hybrids consistently belonged to the highly susceptible group (70-100% damage), showing extensive leaf deformation, discoloration, and reduced aesthetic value. Yearly climatic differences influenced pest intensity: warmer and drier conditions in 2024 coincided with more severe thrips damage, whereas cooler and wetter periods in 2025 corresponded with a larger proportion of resistant responses. Overall, the findings confirm that susceptibility to onion thrips in Echinacea is genotype-dependent and environmentally modulated. Resistant accessions, particularly those with *E. paradoxa* lineage, represent valuable material for breeding programs aimed at enhancing pest tolerance in ornamental and medicinal cultivation systems.

Keywords: *Echinacea, coneflower, collection, damage.*

INTRODUCTION

The genus *Echinacea* (Asteraceae) comprises several perennial, herbaceous species native to the prairies and open grasslands of North America. Classical morphological treatments describe the genus as having a short, thickened rhizome, erect stems reaching 50-150 cm, lanceolate to ovate rough leaves with serrated margins, and large capitula with a prominent conical disk of tubular florets surrounded by showy ligulate rays (McGregor, 1968). Recent genomic and phylogenomic studies have refined species delimitations and supported the monophyly of *Echinacea*, while revealing substantial interspecific genetic divergence that has practical implications for conservation, breeding and pharmacognosy (Ahmadi et al., 2024; Jordan, Leebens-Mack, 2025).

Echinacea species have broad cultural importance in both ornamental horticulture and phytotherapy. Their attractive inflorescences have driven widespread cultivation in botanical gardens and private landscapes, while extracts - most notably from *E. purpurea*, *E. angustifolia* and *E. pallida* - are used in herbal medicine and pharmacological research (Baskin, Baskin, 1988). Agronomic studies and reviews summarizing bioactive constituents and cultivation practices have emphasized the need to monitor genetic identity, phytochemical variation and phytosanitary status across collections used for breeding or medicinal production (Barker et al., 2012; Cardinale et al., 2021; Ahmadi et al., 2024).

Among arthropod pests affecting ornamental and medicinal herbs, thrips (Thysanoptera: Thripidae) rank among the most damaging groups because of their feeding mode and vector potential. Thrips feed by puncturing epidermal cells and sucking their contents, producing characteristic symptoms such as silvering, stippling, necrotic streaks, deformation of leaves and flowers, and deposition of dark fecal specks; heavy feeding reduces aesthetic value and plant vigor and may indirectly affect secondary metabolite profiles in medicinal plants. In addition, several thrips' species are efficient vectors of viruses and other pathogens, amplifying their economic and phytosanitary importance (Van Driesche, et.al., 1999).

The onion thrips (*Thrips tabaci*), is one of the most polyphagous and widely distributed thrips species and has been documented on hundreds of host species, including ornamentals and medicinal herbs. Recent surveys and experimental work demonstrate that *T. tabaci* can inflict direct feeding damage and may interact synergistically with other stressors or pathogens to increase disease severity. For example, observational and experimental studies in ornamental and crop systems show that *T. tabaci* feeding can exacerbate symptoms of viral or fungal infections and that large populations can rapidly reduce plant quality. Reports from greenhouse and field studies underline the species' importance in both open-field and indoor cultivation systems (Gagnon et al., 2024; Saini et al., 2024; Jandricic et al., 2024).

Climatic and weather conditions strongly influence thrips population dynamics and resultant damage levels. Multiple studies across crops and regions report positive correlations between thrips abundance and high temperatures, low rainfall, and reduced relative humidity; conversely, heavy rainfall and high humidity suppress population growth and dispersal. Modelling and empirical work indicate that warming trends and altered precipitation regimes can extend activity periods, accelerate development rates, and increase the number of generations per season for many thrips species, including *T. tabaci*, thereby raising the risk of severe outbreaks in susceptible crops and ornamentals (Bergant et al., 2005; Cagáň et al., 2022; Garrick, Liburd, 2017).

Evidence specifically addressing thrips on medicinal and aromatic plants is accumulating: targeted surveys and host-association studies report a diversity of thrips species on herbs and ornamentals, and highlight that plant architecture, phenology and cultivar traits influence local infestation levels. While direct experimental comparisons of cultivar susceptibility are still limited for many herbaceous ornamentals, the literature supports the need for systematic phytosanitary monitoring within germplasm collections and experimental plantings to identify tolerant material and to inform integrated pest management (IPM) strategies (Pobożniak, Sobolewska, 2011; Elekcioğlu, 2020).

Management studies for *T. tabaci* emphasize integrated approaches: cultural practices (e.g., irrigation management, removal of alternate hosts), biological control (predators and parasitoids), and selective chemical or biorational options when thresholds are exceeded. However, the effectiveness of chemical control varies by crop and region, and there is growing concern regarding resistance development in thrips populations. Consequently, cultivar selection based on demonstrated tolerance or resistance - ideally validated under local climatic conditions - remains a valuable component of long-term management in both ornamental and medicinal *Echinacea* collections. The aim of this study was to determine the susceptibility of different *Echinacea* species and cultivars grown in the collection of the Vytautas Magnus University Botanical Garden to *Thrips tabaci* infestation across different years.

RESEARCH METHODS

The study was conducted during the 2024–2025 growing seasons at the Botanical Garden of Vytautas Magnus University (VMU), located in Kaunas, Lithuania (55°52′N, 23°54′E). The site hosts a diverse collection of *Echinacea* accessions representing multiple species and cultivars, comprising a total of 108 accessions. The research was carried out under open-field conditions in Kaunas, which is situated in central Lithuania and characterized by a temperate transitional climate between maritime and continental types. This climate features moderately warm summers and cold winters, with an average annual temperature of approximately 7 °C and annual precipitation ranging from 650 to 700 mm, distributed relatively evenly throughout the year. The frequent alternation of air masses contributes to a high variability in weather conditions typical for the region.

Meteorological data, including air temperature and precipitation were obtained from the Meteostat (2025) to assess the influence of climatic conditions on pest occurrence and damage intensity.

According to the data presented in Figure 1, the mean air temperatures in Kaunas during the 2024 growing season (April–September) were consistently higher than the long-term averages. In April, the average temperature reached 9.1 °C, exceeding the long-term mean of 7.7 °C. The warmer early-spring conditions likely promoted an earlier onset of vegetation. In May, the mean temperature increased to 15.8 °C (long-term mean – 13.4 °C), creating favourable conditions for the intensive vegetative growth of *Echinacea* plants and for the development of the root system. June remained warm (18.0 °C, +1.2 °C above the long-term average), and July was the warmest month of the season, averaging 20.1 °C, slightly higher than the long-term mean (19.2 °C). Such conditions were favourable for floral stem formation and the initiation of flowering. In August, the temperature remained high (19.8 °C), while September was also warmer than usual (17.3 °C compared to the long-term 13.7 °C), which contributed to a prolonged vegetation period.

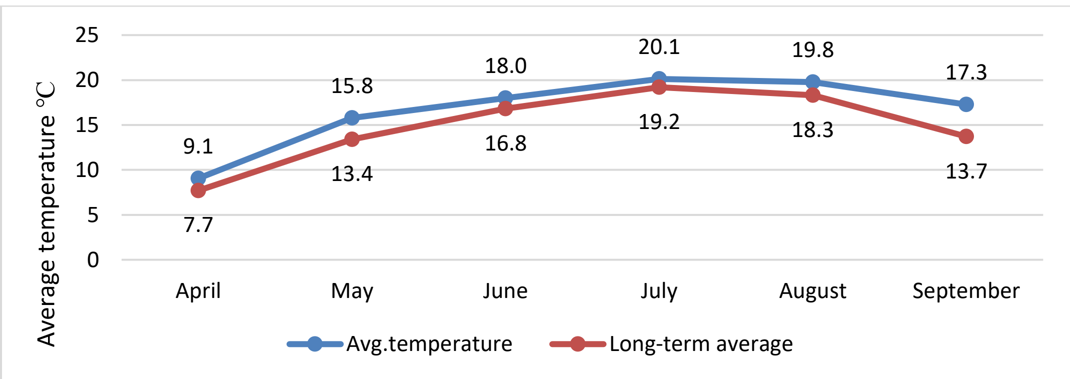

Figure 1. The average air temperatures in Kaunas during the 2024 growing season (Meteostat, 2025)

Overall, the 2024 season in Kaunas was characterized by above-average thermal conditions, which favoured *Echinacea* growth and development throughout the growing period. The extended period of warm weather likely enhanced both vegetative and generative phases, leading to abundant flowering. However, such conditions were also conducive to the proliferation of pests, particularly *Thrips tabaci*, which tends to thrive under warm and dry weather patterns.

According to the data presented in Figure 2, precipitation levels in Kaunas during the 2024 growing season (April–September) showed considerable deviations from the long-term averages, with a general trend toward drier conditions, especially in late spring and summer. In April, the total precipitation amounted to 67.6 mm, exceeding the long-term average of 48 mm. The wetter early spring likely provided adequate soil moisture, supporting the initial regrowth and early vegetative development of *Echinacea* plants. However, from May onward, a marked decline in precipitation was observed. In May, rainfall reached only 10.7 mm, which is approximately six times lower than the long-term mean (63 mm), and this pronounced deficit continued into June (27.7 mm compared to 75 mm).

The prolonged dry conditions during May and June likely restricted vegetative growth and could have temporarily slowed biomass accumulation, particularly in young plants. Although precipitation in July (75 mm) approached the long-term mean (91 mm), the following months were again extremely dry - August received only 7.7 mm of rainfall (compared to the long-term 84 mm), and September only 21.4 mm (long-term mean 59 mm).

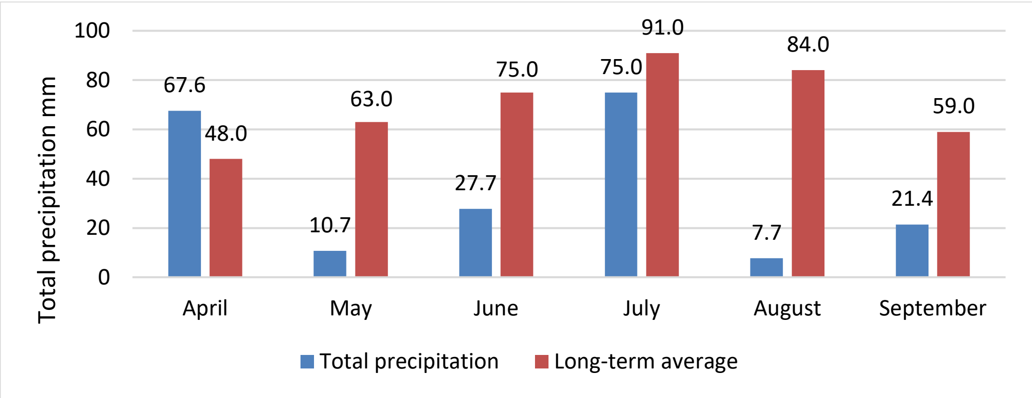

Figure 2. Total precipitation in Kaunas during the 2024 growing season (Meteostat, 2025)

Finally, the 2024 season was characterized by significant rainfall shortages, particularly during the main flowering and seed formation stages of *Echinacea*. The combination of low precipitation and elevated temperatures created warm and dry conditions favourable for the development and spread of *Thrips tabaci*. Such climatic conditions are known to enhance thrips population density and feeding activity, as the pest thrives under dry and warm weather, leading to increased plant damage and reduced ornamental quality.

In 2025, temperature conditions in Kaunas showed considerable fluctuations throughout the growing season, with values slightly above the long-term average in early spring but cooler than average conditions during the main growth period (Figure 3). April was notably warm, with an average temperature of 9.4 °C compared to the long-term average of 7.7 °C, which favoured early sprouting and initial vegetative growth of *Echinacea* plants. However, May and June were relatively cool (10.4 °C and 15.8 °C, respectively) compared to their long-term averages (13.4 °C and 16.8 °C), which slowed down plant development and delayed the onset of flowering. July was close to the long-term average (19.3 °C vs. 19.2 °C), providing optimal thermal conditions for flowering and biomass accumulation, while the subsequent months of August and September were slightly cooler than average (16.7 °C and 15.6 °C).

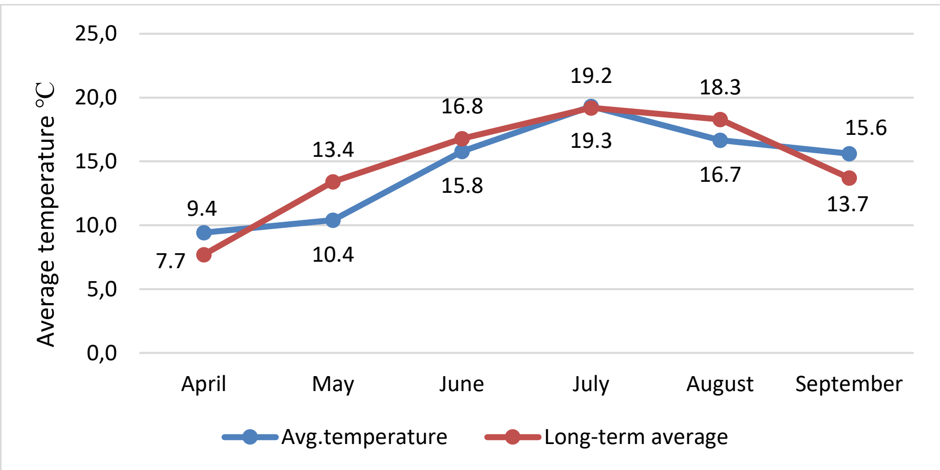

Figure 3. The average air temperatures in Kaunas during the 2025 growing season (Meteostat, 2025)

Such a temperature pattern - with a cooler mid-season - likely limited the intensity of *Thrips tabaci* population growth, as the pest develops more slowly under lower temperature regimes. Consequently, *Echinacea* plants may have experienced reduced pest pressure and less visible damage compared to warmer and drier years, while the moderate thermal conditions supported stable physiological development and prolonged flowering.

As shown in Figure 4, precipitation levels in Kaunas during the 2025 growing season fluctuated considerably compared with the long-term averages, showing distinct periods of drought alternating with short, intense rainfall episodes.

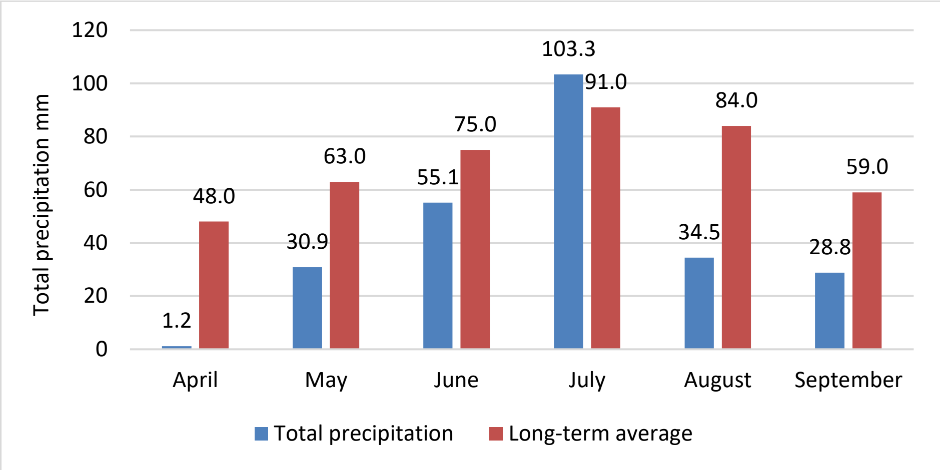

Figure 4. Total precipitation in Kaunas during the 2025 growing season (Meteostat, 2025)

In April, the total precipitation was extremely low - only 1.2 mm, compared to the long-term average of 48 mm - indicating a severe moisture deficit at the beginning of the vegetation period. Such exceptionally dry conditions likely delayed *Echinacea* regrowth and reduced early-season soil moisture availability. In May, rainfall slightly increased to 30.9 mm (still below the long-term mean of 63 mm), and by June, total precipitation reached 51.1 mm (compared to 75 mm). Although still lower than average, this gradual increase in rainfall partially alleviated soil drought stress and supported moderate vegetative growth. In contrast, July was markedly wetter than usual, with 103.3 mm of rainfall, exceeding the long-term average of 91 mm. The higher precipitation during this period was likely beneficial for *Echinacea* flowering and biomass accumulation. However, the subsequent months again turned drier: in August, total precipitation dropped to 34.5 mm (long-term mean 84 mm), and in September to 28.8 mm (long-term mean 59 mm). These below-average rainfall values toward the end of the season may have shortened the flowering duration and accelerated plant senescence.

In summary, the 2025 growing season in Kaunas was characterized by uneven precipitation distribution, with pronounced early-season drought followed by a single wet peak in mid-summer. Such weather patterns likely stressed *Echinacea* plants during early growth stages but supported recovery and flowering during July. However, the predominance of warm and dry conditions in most of the season created favourable conditions for *Thrips tabaci* population growth, as dry and warm weather enhances the pest's feeding activity, survival, and reproductive success. The wetter period in mid-summer, however, likely had a suppressive effect on *Thrips tabaci* populations, reducing their abundance and thereby mitigating the level of damage to *Echinacea* plants.

The botanical names of *Echinacea* species were verified according to the taxonomic standardization system of The World Flora Online (WFO) (2025), while cultivar names were confirmed using the Royal Horticultural Society database (RHS, 2025).

Observations and measurements followed the methodological guidelines developed by J. Vaidelys (2005), "Methodology for Phenological Observations, Biometric Measurements, and the Compilation of Herbaceous Ornamental Plant Assortments". Data were collected at regular intervals throughout the vegetation period to document plant growth dynamics and visible pest damage.

The assessment of *Thrips tabaci* damage was based on visual inspection of aerial plant parts, including leaves, stems, and inflorescences. Damage severity was estimated as the percentage of affected tissue area, and plants were grouped into three categories according to their level of infestation:

- up to 20% – slightly damaged plants (resistant);
- 30–60% – moderately damaged plants;
- 70–100% – severely damaged plants (susceptible).

Each plant infested with onion thrips underwent careful inspection, photographic documentation, and comparative evaluation of its aesthetic characteristics.

RESEARCH RESULTS AND DISCUSSION

The evaluation of *Echinacea* accessions conducted in 2024 focused on assessing the degree of damage caused by onion thrips (*Thrips tabaci*) (Table 1). The plants were divided into three categories according to the extent of infestation: resistant (≤20% damaged), moderately damaged (30–60%), and susceptible (70–100%). The assessment included both *Echinacea* species and numerous cultivars, totalling all 108 accessions.

Resistant group comprised 18 accessions, which exhibited minimal damage symptoms and maintained high aesthetic quality. Among these were species such as *Echinacea paradoxa* and *E. tennesensis*, as well as cultivars including

'Flame Thrower', 'SunSeekers Salmon', 'Lakota Orange', and others. These accessions demonstrated a clear tolerance to onion thrips attack, suggesting the presence of morphological or biochemical traits associated with resistance. Consequently, these genotypes may be considered valuable for future breeding programs aiming to enhance pest resistance in ornamental *Echinacea*.

Table 1. Onion thrips damage in the *Echinacea* collection at Vytautas Magnus University Botanical Garden in 2024

Damaged up to 20%	Damaged 30-60%	Damaged 70-100%
Echinacea paradoxa, *E. tennesensis*, *E.* 'Flame Thrower', *E.* 'SunSeekers Salmon', *E.* 'SunSeekers Mineola', *E.* 'SunSeekers Golden Sun', *E.* 'Lakota Orange', *E.* 'Strawberry Shortcake', *E.* 'SunSeekers Mango Sunrise', *E.* 'SunSeekers Sweet Fuchsia', *E.* 'Sensation Wild Romance', *E.* 'Pink Skipper', *E.* 'Julia', *E.* 'SunSeekers White Beauty', *E.* 'Guava Ice', *E.* 'Cleopatra', *E.* 'Mistral', *E.* 'SunSeekers Bubblelicious'	*Echinacea sanguinea*, *E.* 'Magenta Pearl', *E.* 'Nuotaka', *E.* 'Pusnelė', *E.* 'Purpurinė Žvaigždė', *E.* 'Summer Cocktail', *E.* 'Ugnelė', *E.* 'Liepsna', *E.* 'Vyšnaitė', *E.* 'Vestina', *E.* 'Cinamoninė', *E.* 'Avietėlė', *E.* 'Apelsinukė', *E.* 'Pink Pearl', *E.* 'Delicious Candy', *E.* 'Pretty Parasols', *E.* 'Supreme Cantaloupe', *E.* 'SunSeekers Apple Green', *E.* 'Secret Glow', *E.* 'Southern Belle', *E.* 'Green Jewel', *E.* 'Fountain Pink Eye', *E.* 'SunSeekers White Perfection', *E.* 'SunSeekers Rainbow', *E.* 'Mis Lietuva', *E.* 'Sielos Akys', *E.* 'Sweet Sandia', *E.* 'Fountain Light Purple', *E.* 'Fountain Orange Bicolour', *E.* 'Summer Salsa', *E.* 'Butterfly Kisses', *E.* 'SunSeekers Red', *E.* 'SunSeekers Blush', *E.* 'Cheyenne Spirit', *E.* 'Fountain Yellow', *E.* 'Papallo Semi-double White', *E.* 'Papallo Semi-double Pink', *E.* 'Marmalade', *E.* 'Glowing Dream', *E.* 'Funky White', *E.* 'Bravado', *E.* 'Prima Ginger', *E.* 'Hula Dancer', *E.* 'Meditation Orange', *E.* 'SunSeekers Purplecious', *E.* 'Raspberry Truffle', *E.* 'Leilani', *E.* 'Irresistible', *E.* 'Pink Tip', *E.* 'Green Twister', *E.* 'Milkshake', *E.* 'Amazing Dream', *E.* 'White Swan', *E.* 'SunMagic Vintage Ruby', *E.* 'Virgin', *E.* 'Orange Pearl', *E.* 'Double Scoop Cranberry'	*Echinacea angustifolia*, *E. purpurea*, *E.* 'Mamos Atminimui', *E.* 'Sandra', *E.* 'Snieguolė', *E.* 'Funky Yellow', *E.* 'Evolution Colorific', *E.* 'Alba', *E.* 'Liliput', *E.* 'Fatal Attraction', *E.* 'Puff Vanilla', *E.* 'SunSeekers Magenta', *E.* 'Sensation Pink', *E.* 'Razzamatazz', *E.* 'Pink Poodle', *E.* 'Yellow Pearl', *E.* 'Aloha', *E.* 'Blueberry Cheesecake', *E.* 'Meditation Lime', *E.* 'Tomato Soup', *E.* 'Strawberry and Cream', *E.* 'White Double Delight', *E.* 'Sombrero Bianco', *E.* 'Mars', *E.* 'Dark Pink Pearl', *E.* 'Meringue', *E.* 'Carrot Cake', *E.* 'Parrot', *E.* 'Big Kahuna', *E.* 'Greenline', *E.* 'Pink Sorbet', *E.* 'Rainbow Marcella', *E.* 'Purple Emperor'
In total 18 accessions	In total 57 accessions	In total 33 accessions

A total of 57 accessions were classified within this intermediate category. This group included *E. sanguinea* and a wide range of cultivars such as 'Magenta Pearl', 'Summer Cocktail', 'Green Jewel', 'Cheyenne Spirit', and others. Plants in this group showed moderate susceptibility to onion thrips, with partial leaf damage, discoloration, and minor deformations observed. The diversity of cultivars suggests significant genetic variability in resistance, even among related hybrids. These findings are important for selecting breeding lines that combine both ornamental value and moderate pest tolerance.

The most severely affected group contained 33 accessions, including *E. angustifolia*, *E. purpurea*, and several widely cultivated hybrids such as 'Razzamatazz', 'White Double Delight', and 'Tomato Soup'. These plants displayed extensive thrips damage - necrosis, leaf deformation, and loss of ornamental quality – indicating high susceptibility to infestation. Such genotypes are less suitable for commercial cultivation in thrips-prone environments but may still serve as a reference material for studying susceptibility mechanisms in *Echinacea*.

The 2025 evaluation examined onion thrips (*Thrips tabaci*) infestation across a wide range of *Echinacea* accessions, including both species and cultivars (Table 2). The results revealed significant inter- and intra-specific variation in susceptibility, highlighting the complex interactions between plant morphology, physiology, and the environmental conditions during the 2025 growing season.

A total of 37 accessions were assigned to resistant group, indicating a considerable proportion of genotypes exhibiting high tolerance to thrips attack. Among them were again *Echinacea paradoxa* and *E. tennesensis*, together with a number of cultivars including 'Flame Thrower', 'Summer Cocktail', 'Green Jewel', 'Secret Glow', 'SunSeekers Golden Sun', and others. Plants within this category exhibited minor feeding traces, limited chlorotic spotting, and maintained strong ornamental appeal throughout the growing season. The predominance of *E. paradoxa* derived hybrids suggests that this species continues to play a pivotal role in transmitting resistance traits. Furthermore, the broader range of accessions in this group compared to 2024 implies a potential enhancement of plant resilience, possibly influenced by environmental conditions such as temperature and humidity that year.

The intermediate category comprised 35 accessions, among which were *E. sanguinea* and numerous hybrids such as 'Magenta Pearl', 'Cheyenne Spirit', 'SunSeekers Blush', and 'Green Twister'. These plants manifested moderate injury symptoms - partial leaf deformation, discoloration, and a slight decline in visual quality - yet remained viable and continued to flower normally. The presence of both wild species and modern hybrids in this category highlights genetic heterogeneity in partial resistance mechanisms. The relative reduction in accession number compared with the previous year may indicate year-specific environmental moderation of thrips population pressure, leading to a narrower intermediate damage range. This group represents genotypes of intermediate breeding value, combining ornamental attractiveness with moderate pest tolerance.

Table 2. Onion thrips damage in the *Echinacea* collection at Vytautas Magnus University Botanical Garden in 2025

Damaged up to 20%	Damaged 30-60%	Damaged 70-100%
Echinacea paradoxa, *E. tennesensis*, *E.* 'Flame Thrower', *E.* 'Summer Cocktail', *E.* 'Ugnelė', *E.* 'Liepsna', *E.* 'Vyšnaitė', *E.* 'Vestina', *E.* 'Cinamoninė', *E.* 'Avietėlė', *E.* 'Apelsinukė', *E.* 'Green Jewel', *E.* 'Fountain Pink Eye', *E.* 'SunSeekers White Perfection', *E.* 'SunSeekers Rainbow', *E.* 'SunSeekers Salmon', *E.* 'SunSeekers Apple Green', *E.* 'Secret Glow', *E.* 'Southern Belle', *E.* 'SunSeekers Mineola', *E.* 'SunSeekers Golden Sun', *E.* 'Lakota Orange', *E.* 'Strawberry Shortcake', *E.* 'SunSeekers Mango Sunrise', *E.* 'SunSeekers Sweet Fuchsia', *E.* 'Sensation Wild Romance', *E.* 'Pink Skipper', *E.* 'Summer Salsa', *E.* 'Butterfly Kisses', *E.* 'SunSeekers Red', *E.* 'Julia', *E.* 'SunSeekers White Beauty', *E.* 'Purple Emperor', *E.* 'Guava Ice', *E.* 'Cleopatra', *E.* 'Mistral', *E.* 'SunSeekers Bubblelicious'	*Echinacea sanguinea*, *E.* 'Magenta Pearl', *E.* 'Nuotaka', *E.* 'Pusnelė', *E.* 'Purpurinė Žvaigždė', *E.* 'Mis Lietuva', *E.* 'Sielos Akys', *E.* 'Sweet Sandia', *E.* 'Fountain Light Purple', *E.* 'Fountain Orange Bicolour', *E.* 'SunSeekers Blush', *E.* 'Cheyenne Spirit', *E.* 'Fountain Yellow', *E.* 'Papallo Semi-double White', *E.* 'Papallo Semi-double Pink', *E.* 'Marmalade', *E.* 'Glowing Dream', *E.* 'Funky White', *E.* 'Bravado', *E.* 'Prima Ginger', *E.* 'Hula Dancer', *E.* 'Meditation Orange', *E.* 'SunSeekers Purplecious', *E.* 'Raspberry Truffle', *E.* 'Leilani', *E.* 'Irresistible', *E.* 'Pink Tip', *E.* 'Green Twister', *E.* 'Milkshake', *E.* 'Amazing Dream', *E.* 'White Swan', *E.* 'SunMagic Vintage Ruby', *E.* 'Virgin', *E.* 'Orange Pearl', *E.* 'Double Scoop Cranberry'	*Echinacea angustifolia*, *E. purpurea*, *E.* 'Mamos Atminimui', *E.* 'Sandra', *E.* 'Snieguolė', *E.* 'Supreme Cantaloupe', *E.* 'Funky Yellow', *E.* 'Evolution Colorific', *E.* 'Alba', *E.* 'Liliput', *E.* 'Fatal Attraction', *E.* 'Pink Pearl', *E.* 'Delicious Candy', *E.* 'Pretty Parasols', *E.* 'Puff Vanilla', *E.* 'SunSeekers Magenta', *E.* 'Sensation Pink', *E.* 'Razzamatazz', *E.* 'Pink Poodle', *E.* 'Yellow Pearl', *E.* 'Aloha', *E.* 'Blueberry Cheesecake', *E.* 'Meditation Lime', *E.* 'Tomato Soup', *E.* 'Strawberry and Cream', *E.* 'White Double Delight', *E.* 'Sombrero Bianco', *E.* 'Mars', *E.* 'Dark Pink Pearl', *E.* 'Meringue', *E.* 'Carrot Cake', *E.* 'Parrot', *E.* 'Big Kahuna', *E.* 'Greenline', *E.* 'Pink Sorbet', *E.* 'Rainbow Marcella'
In total 37 accessions	In total 35 accessions	In total 36 accessions

The group most affected by thrips infestation consisted of 36 accessions, including *E. angustifolia*, *E. purpurea*, and multiple hybrids such as 'Razzamatazz', 'Tomato Soup', 'White Double Delight', and 'Pink Poodle'. These plants displayed severe chlorosis, necrosis, and flower deformation, leading to substantial deterioration of aesthetic quality and, in some cases, inhibited growth. Such pronounced susceptibility is often associated with large-flowered ornamental cultivars, where intensive breeding for colour and flower form may have diminished inherent pest resistance. The consistent presence of *E. purpurea* and its derivatives among the most damaged plants across both years supports the hypothesis that this species possesses lower intrinsic defence capacity against *T. tabaci* feeding.

The 2025 data confirm that significant variation in thrips susceptibility persists within the *Echinacea* genus. However, compared to 2024, there was a broader distribution of resistant genotypes - particularly within the low-damage group - suggesting that environmental conditions or phenological timing during 2025 may have favoured reduced pest activity or enhanced plant defence responses. The most tolerant accessions (≤20%) were largely derived from *E. paradoxa* or its hybrids, reaffirming its importance as a genetic donor of resistance traits. The moderately affected group (30–60%) demonstrated reduced heterogeneity compared with the previous season, potentially reflecting stabilization of pest pressure. The highly damaged group (70–100%) remained dominated by *E. purpurea* and ornamental hybrids, confirming their continued vulnerability despite their horticultural appeal.

Overall, these findings underscore that resistance to onion thrips in *Echinacea* is genotype-dependent and environmentally influenced. Integrating both field data and phenotypic evaluations across multiple years is essential for identifying stable resistance sources for breeding and for understanding seasonal variation in pest dynamics.

CONCLUSIONS

The comparative evaluation of *Echinacea* accessions conducted in 2024 and 2025 provides a comprehensive insight into the variation of resistance to onion thrips (*T. tabaci*) within this genus. Across both growing seasons, substantial inter- and intra-specific differences in susceptibility were observed, indicating that resistance to thrips is a genetically controlled and environmentally modulated trait. In both years, *Echinacea paradoxa* and its hybrids consistently demonstrated the highest tolerance to thrips feeding, exhibiting minimal visible damage and maintaining good ornamental quality. This suggests that *E. paradoxa* may serve as a key donor species for breeding programs aimed at enhancing pest resistance. In contrast, *E. purpurea* and its derivatives were repeatedly classified among the most susceptible genotypes, suffering extensive foliar damage and loss of decorative value, particularly under high pest pressure conditions. Between the two seasons, a shift in the distribution of resistant accessions was observed. The proportion of plants classified within the resistant category (≤20%) increased from 18 accessions in 2024 to 37 in 2025, whereas the number of highly damaged accessions remained relatively stable (33 in 2024 and 36 in 2025). These dynamics may reflect annual climatic variations, influencing both thrips population density and plant defense activation. The overall pattern suggests that environmental conditions in 2025 were less favorable for pest development or more conducive to plant resilience. The moderately affected group (30-60%) exhibited the greatest genetic diversity in both years, indicating the presence of intermediate tolerance mechanisms across a wide range of hybrid cultivars. This category represents the most valuable material for breeding, as it combines desirable ornamental traits with moderate resistance, allowing for targeted selection toward improved pest tolerance.

Overall, the two-year dataset confirms that *Echinacea* responses to onion thrips are multifactorial, depending on both genetic background and environmental context. The integration of multi-year observations is therefore essential for distinguishing stable genetic resistance from transient, environment-induced tolerance.

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