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Swede Midge (*Contarinia nasturtii* Keiffer) Phenology and Management in Minnesota Community Gardens

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Abstract. **Swede midge is a major insect pest of brassicas, including broccoli (*Brassica oleracea* L. var. *italica*), cauliflower (*B. oleracea* L. var. *botrytis*), collards (*B. oleracea* L. var. *viridis*), and kale (*B. oleracea* var. *sabellica*). The insect infests and feeds on the growing tips of plants, resulting in distorted leaves or lack of heading of broccoli and cauliflower. Since 2014, when continuous trapping began in Minnesota, USA, it has primarily been found in community gardens in the Twin Cities metropolitan area. Trapping data obtained at Saint Paul community gardens over 3 years indicated that swede midge phenology in any particular garden varied from year to year. Gardeners surveyed in 2023 indicated some knowledge of swede midge, were unsure of how to recognize infestation symptoms, and were interested in collaborating to test management methods. A simple mitigation system using bamboo poles, polypropylene fabric, and weed barrier was tested for its ability to reduce infestations by blocking access to plants by adults and to soil by larvae and prevent emergence by previously pupating generations. It was 50% to 80% effective compared with unprotected controls.**

The severity and prevalence of swede midge as a pest continues to increase across North America. Native to Europe and Asia, it was detected in 2000 in Ontario, Canada, and has spread across the northeastern United States and Canada (Hallett 2017). It infests any brassica crop, such as broccoli, cauliflower, and collards, with damage caused by larval feeding. A single swede midge larva can cause enough damage to make a cauliflower plant unmarketable (Stratton et al. 2018). Results of a 2018 online survey of commercial vegetable farmers in Michigan, Ohio, New Hampshire, New York, Pennsylvania, and Vermont in the United States and Ontario and Québec in Canada indicated that the average reported loss due to swede midge in brassica crops was US$3808 per acre per year (Hodgdon et al. 2022).

The swede midge can complete a single generation in 21 to 44 d, and research in Ontario shows that there are 4 to 5 overlapping generations within a season (Hallett et al. 2009). Swede midge pupates within the top 1 cm of soil and require 25% to 75% soil moisture content for successful emergence (Chen and Shelton 2007). They can overwinter for 2 years below the soil surface (Des Marteaux et al. 2015). Ground barriers used for weed control may influence the ability of swede midge to use soil for pupation by providing a physical barrier to the soil and modifying the microclimate required for pupation. Landscape fabric, tarp, and biodegradable fabric prevented the emergence of swede midge after soil infestation compared with bare ground (Hodgdon et al. 2024).

Swede midge are not strong flyers and are unable to fly long distances or cross over large barriers (Hoepting and Vande Brake 2020). Exclusion fencing has been studied as means to reduce swede midge feeding damage. Evans (2017) found that ~2.5 times more midges were trapped on yellow sticky cards set at 60 cm from the ground compared with 120 cm or greater heights, suggesting that exclusion methods may prevent midge infestations. However, 85-cm-tall mesh fencing installed around broccoli plots did not prevent swede midge damage, whereas 150-cm-tall fencing delayed the onset of damage, reduced damage severity, and increased the number of marketable plants (Hodgdon et al. 2024). Also, midge damage can still occur if midge numbers are high, winds blow midges over tall barriers, or the midges access brassicas through holes in fencing.

Organic farmers are especially disadvantaged when combating swede midge because there are few available and effective organic certified insecticides (Hodgdon et al. 2024). Currently, organic management of the insect includes 1) not planting brassica crops within 152 m of areas known to be infested if separated by a barrier, for 2.5 to 3 months with no brassica planting from May to mid-July (Hoepting and Vande Brake 2020) and combine with crop rotation; 2) removing brassica weeds and cover crops; 3) planting brassicas with some resistance to swede midge; 4) using insecticides such as spinosad, kaolin clay, and azadirachtin; and 5) using exclusion netting (Hodgdon et al. 2024). Of these practices, crop rotation, varietal resistance, and exclusion netting were the most efficacious in on-farm field tests (Hodgdon et al. 2017). Although the use of exclusion netting was rated highly effective by growers in the 2018 online survey, many respondents commented that netting was expensive and laborious to move when weeding and harvesting crops (Hodgdon et al. 2022).

Swede midge has been detected by Minnesota Department of Agriculture Plant Protection Division personnel at multiple community gardens, but not on commercial farms in Minnesota (Philips et al. 2017). This pattern was repeatedly observed up to 2022, when trapping was discontinued. Similarly, the insect had not yet been detected on canola farms in the northern Great Plains as of 2022, which includes Minnesota's neighboring state, North Dakota (Vankosky et al. 2023). The uneven distribution of swede midge is puzzling, and more information on practices and environmental conditions that may affect swede midge infestation is needed. Even if swede midge is mainly localized to community gardens in the Twin

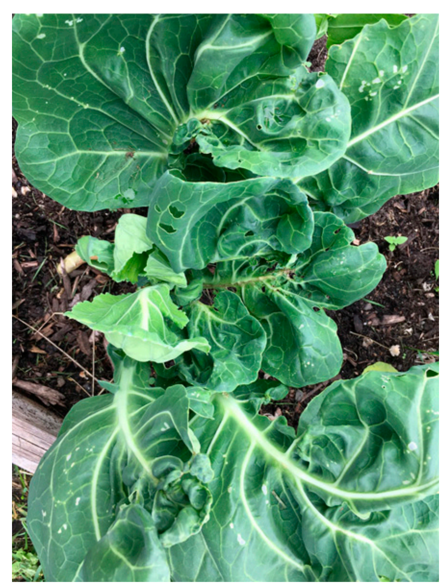

Fig. 1. Distorted leaves typical of swede midge damage on a collard plant. Photo courtesy of Jennifer Nicklay.

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Cities in Minnesota, the insects may eventually spread to commercial farms and cause economic damage. Educating and assisting community gardeners on how to manage swede midge could help slow the potential spread of the insect to farms. However, before effective educational programming can be developed, the levels of awareness of swede midge and abilities of gardeners to recognize damage need to be assessed. The goals of this project were to map locations of swede midge outbreaks in Twin Cities community gardens, determine brassica gardeners' educational needs related to swede midge, and develop a method to manage insect infestations within the gardens.

Materials and Methods

Trapping and damage mapping. Trapping was done during 25 May to 24 Oct 2022, 23 May to 17 Oct 2023, and 8 May to 11 Oct 2024. Jackson traps baited with a *Contarinia nasturtii* sex pheromone lure (Alpha Scents, Inc., Canby, OR, USA) were placed about 15 m apart along the lengths of four community gardens and at the Student Organic Farm on the University of Minnesota Saint Paul campus (44.9869°N, 93.1781°W). All locations are in St. Paul, MN, USA: 1) EG, 44.9439°N, 93.1566°W; 2) MGS, 44.9679°N, 93.1584°W; 3) MS, 44.9536°N, 93.1834°W; and 4) SAP, 44.9727°N, 93.2004°W. The numbers of traps differed among sites due to the particular layout of each garden. The numbers of traps were six at EG, eight at MGS, 15 at MS, and 11 at SAP. Sticky cards were replaced once a week, and card contents were examined under a microscope. Swede midges were identified according to Hoepting (2024) and Eder et al. (2005). Gardens were marked as positive for swede midge damage in Jul and Aug 2024 if at least 10 brassica plants exhibited distorted leaves typical of swede midge damage (Fig. 1). Gardens were mapped using ArcGIS (Esri, Redlands, CA, USA).

Survey of gardeners. An online survey (Supplemental Fig. 1) that targeted community gardeners in Minnesota was distributed in 2023 using Google Forms. The survey was distributed using snowball sampling, through local networks to gardeners at the community gardens collaborating on swede midge trapping. The Urban Farm and Garden Alliance, the Twin Cities Metro Growers Network, and Master Gardeners of Hennepin and Ramsey counties were asked to send the survey to their listservs. The project was deemed exempt from institutional review board approval. The survey included questions on length of time at the particular location, types of brassicas grown, current knowledge of swede midge, observed damage due to swede midge, preferred strategies used to manage swede midge, and interest in collaborating

Fig. 2. Interior (**A**) and exterior (**B**) views of the swede midge mitigation system. Brassicas were transplanted into small holes in weed barrier stapled to the ground. Bamboo stakes were placed around the periphery of the plot. Polypropylene fabric was attached to the stakes using clothespins, allowed to drape over the ground, stapled to the ground, and left open above the transplants.

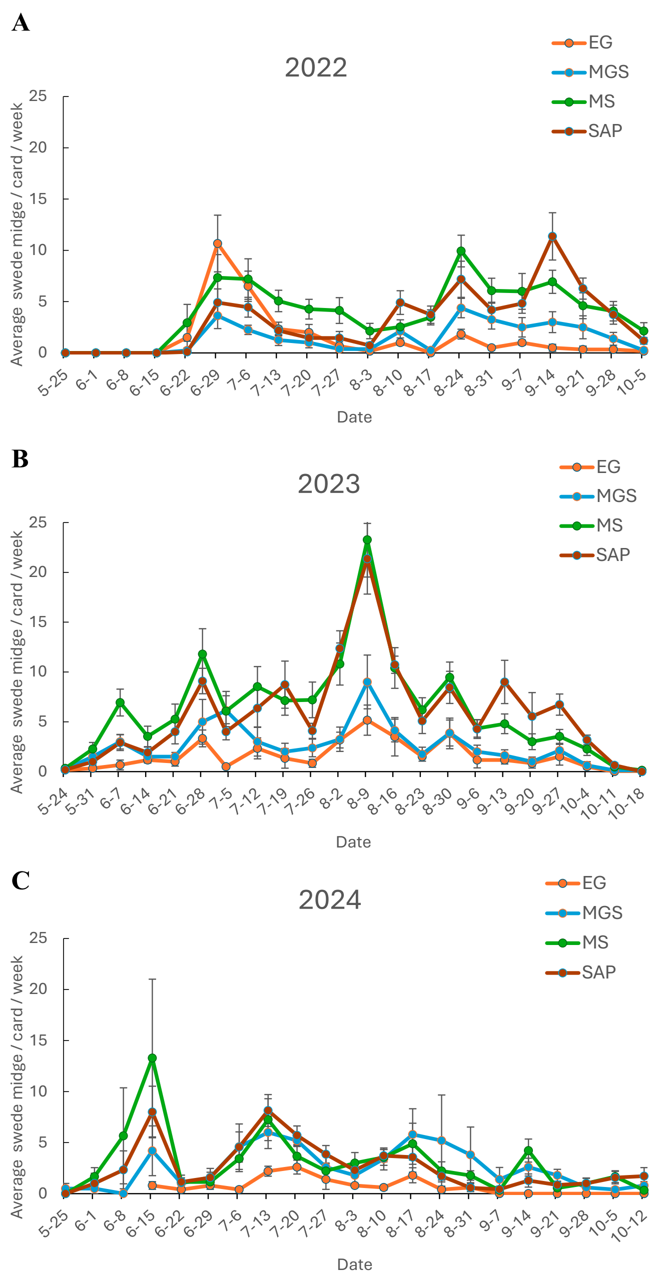

Fig. 3. Numbers of swede midge trapped per week in 2022 (**A**), 2023 (**B**), and 2024 (**C**) at four community gardens in Saint Paul, MN, USA. Traps were installed 15 m apart along the length of each garden, except at EG, where traps were installed in a cross pattern due to the layout of the garden. Error bars show standard errors of the means.

with researchers to develop or test management strategies.

Mitigation system testing. In 2023, broccoli (‘Diplomat’) transplants were grown from seed (Harris Seeds, Rochester, NY, USA) in Performance Organics All Purpose Container Mix (ScottsMiracle-Gro, Marysville, OH, USA) under mist, and planted in 1.1-m^2 plots at the MGS, MS, and SAP gardens on 25 and 26 May. Each garden site had three plants in each of three replicate plots. A mitigation system including 42.5-g weed barrier (Standard Weed Control, DeWitt, Sikeston, MO, USA) pinned to the ground with staples, and polypropylene fabric (Agribon+AG-15, Johnny’s Selected Seeds, Winslow, ME, USA) clipped with clothespins to bamboo poles (A.M. Leonard, Piqua, OH, USA) surrounding a plot containing broccoli was tested at three community gardens (Fig. 2). The height of the fabric was at least 1.5 m and draped over the soil around the plot. Broccoli seedlings were planted outside and next to the mitigation system as controls. Transplants that suffered herbivory were replaced with ‘Lieutenant’ broccoli plants sourced from a local market on 10 and 14 Jun. Data on numbers of broccoli plants that produced heads were collected on 31 Jul 2023 at MS and SAP and 20 Aug 2023 at MGS (which is shadier than other two sites).

In 2024, kits containing components of the mitigation system [90.7-g woven weed barrier and staples (Ag Resource Inc., Detroit Lakes, MN, USA), bamboo poles, polypropylene fabric, and clothespins], along with instructions, were distributed to volunteer testers at three of the community gardens (MGS, MS, and SAP) that were involved in the trapping study. The testers included 18 gardeners, who were allowed to plant any brassica plants of their choosing but were asked to plant at least two to three replicate plants inside and outside (controls) the barrier. None of the gardeners had previously used any mitigation against swede midge. The numbers of undamaged plants inside and outside the barriers were rated on 22 Jul 2024. The brassicas grown by gardeners varied from plot to plot, and included broccoli, Brussels sprouts (*B. oleracea* var. *gemmifera*), cabbage (*B. oleracea* var. *capitata*), collards, and kale (*B. oleracea* var. *viridis*), so the success rate of the mitigation system in any particular plot was calculated as (numbers of plants with no damage/the total numbers of plants) × 100. Damage ranged from mild twisting of leaves and swollen petioles to severe twisting of leaves, crumpling of leaves, and petiole scarring; meristem death; and blind heads. Plot sizes varied based on the gardener and type of brassicas grown. There were 20 plots in total.

Statistical analyses. All the 2023 replicated plots and individual 2024 gardener plots included a control and a treatment, which were directly compared with each other. Paired *t* tests were separately applied to mitigation system data of 2023 and 2024, using RStudio statistical software. Bartlett’s test was used to determine homogeneity of variances before *t* test use.

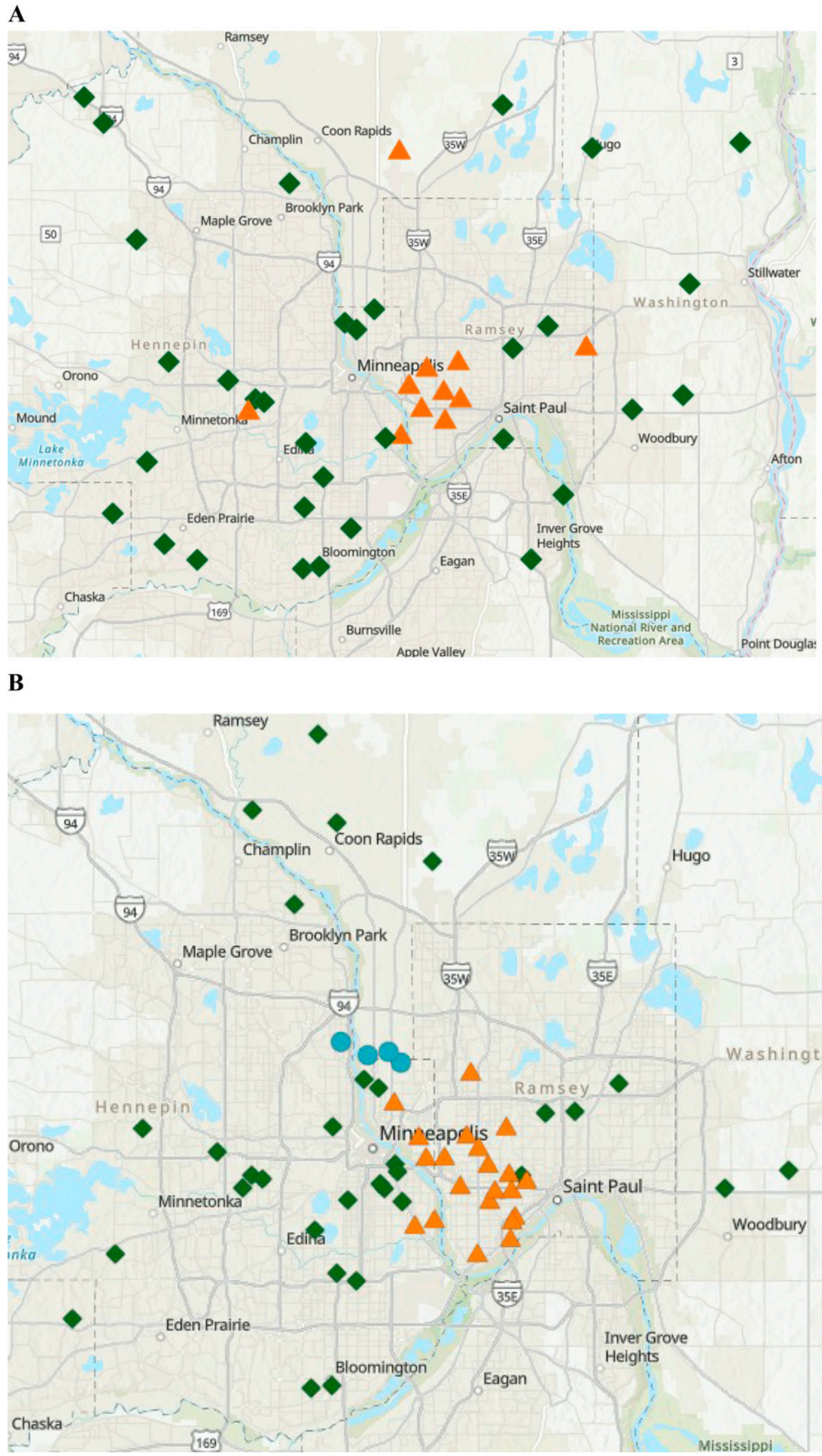

Fig. 4. Locations of gardens with positive identifications of swede midge infestation before (**A**) and in 2024 (**B**) in the Twin Cities area. Data used for (**A**) were from Minnesota Department of Agriculture pheromone lure trapping work. Data used for (**B**) were based on visual damage assessments, where at least 10 brassica plants exhibited swede midge-related distorted leaves. Green diamonds = gardens with plants having no detectable swede midge damage, orange triangles = gardens with plants showing detectable damage in early (old) growth, and blue circles = gardens with large, healthy plants with distorted leaves in the youngest growth. The distance between Minneapolis and Saint Paul (white dots) is 15 km.

Results and Discussion

Weekly trapping. Graphs of trapping data showed distinct population peaks across the season, indicating the occurrence of multiple generations of swede midge. Generally, peaks occurred at the same time in all the gardens. In 2022, swede midge emergence was not

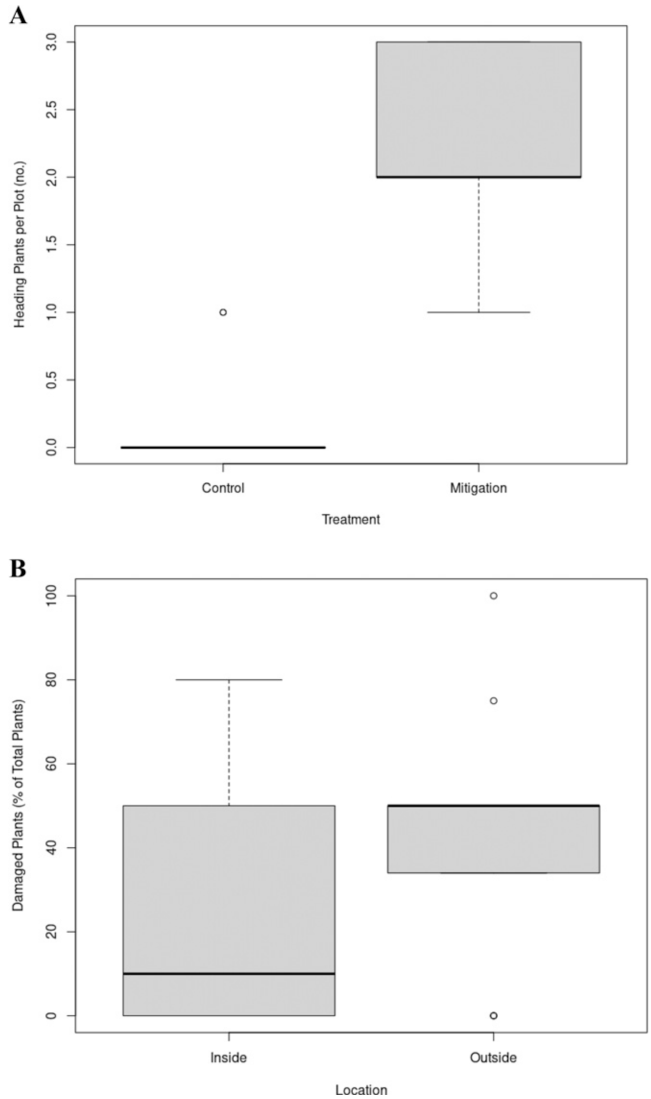

Fig. 5. Effectiveness of the mitigation system in 2023 (**A**) when managed by researchers and in 2024 (**B**) when tested by gardeners. In 2023, only broccoli was grown in test plots (three plants per treatment in each of three replicated plots) at three community gardens with known swede midge populations, thus numbers of heads per replicate plot were counted. In 2024, volunteers who gardened at the same three community gardens used in the 2023 study were asked to grow two to three replicates of any types of brassica plants inside (protected from midges) and outside (control, no protection) the mitigation system. Gardeners grew different types of brassicas, so the percentage of damage due to swede midge was documented.

observed until late June, with the first peak occurring on 28 Jun. The greatest number of midges at the first peak was detected at a garden that had banned brassicas for the previous 3 years (Fig. 3), suggesting that the ban was not effective in eliminating the insect within 3 years. However, gardeners at this location during these years were growing radishes (*Raphanus sativus* L.), a species that suffers less damage than other types of brassicas, and shepherd's purse [*Capsella bursa-pastoris* (L.) Medik], a weedy species that can be a host for swede midge (Chen et al. 2009) grew in the garden, providing means for swede midge survival.

In 2023 and 2024, midges were trapped on our earliest sampling date on 30 May, so we were not able to establish if this was an indication of the initial activity of midges for the growing season or if midges were already active before the start of sampling for those years. The early emergence in Spring 2023 and 2024 might be explained by snowfall, snow cover, and precipitation in the preceding winters; however, the conditions before 2022 were more similar to that of 2024. Total snowfall in Winter 2023–24 was 71.9 cm (Minnesota Department of Natural Resources 2024), and the lack of snow cover during the winter months in 2023 to 2024 may have allowed for earlier midge emergence in the Spring. However, Winter 2022–23 snowfall total was 210.1 cm, greater than the 10-year average of 137 cm, suggesting that lack of snowfall in 2023–24 may have been only one factor in the earlier emergences observed in 2023 and 2024. Before the emergence in 2022 and 2024, precipitation from December through April was 25% lower than before emergence in 2023, but both 2022 and 2024 had exceptionally high May precipitation, more than 11 cm compared with 2.8 cm for May 2023.

Due to a cool April in 2022, the degree day (7.2 °C base temperature) accumulation reached 344, a minimum that Corlay and Boivin (2008) identified for swede midge emergence, 1 week later than in 2023 and 2024. This may have contributed to the later emergence of midges in 2022 than in 2023 and 2024. The Corlay and Boivin (2008) model for predicting emergence may not work well for our data because traps and/or lures led to a delay in captures or the populations may be extremely low compared with those in Québec.

Two gardens in 2016 and one garden in 2018 where swede midge had been trapped did not have swede midge detections in subsequent years (compare Fig. 4A and 4B). Swede midge damage assessed in 2024 was mostly observed in gardens on the western side of St. Paul and east of the Mississippi River in Minneapolis (Fig. 4B). The exceptions were two gardens west of the Mississippi River in south Minneapolis and one St. Paul garden less than 400 m from another with no swede midge-damaged plants, which were primarily mustards and therefore not preferred hosts for these insects (Chen et al. 2011). We have observed brassica plants with swede midge damage in a campus plot located only 250 m from a brassica variety trial where no swede midge damage occurred (data not shown), indicating that swede midge emergence can be highly localized. Possible contributing factors to localization, such as prevailing wind direction and use of plastic mulch, may be examined in future studies.

Survey of gardeners. Twenty-eight gardeners responded to the survey. According to the responses, collard greens and/or kale were the most popular brassica vegetables grown, with 64% of respondents reporting growing these in 2023, followed by cabbage (43%) and radish (36%). When asked to assess current knowledge on swede midge, the majority of the respondents (57%) indicated that they knew a little about this pest, with no respondents indicating that they knew a lot, and the remainder (43%) fell somewhere in between. When asked if swede midge was observed during the 2023 season, with example photos provided, 39% of gardeners reported symptoms, 32% reported maybe or that they were unsure if symptoms were present, 21% responded that symptoms were not observed, and the remainder reported that brassicas were not grown in 2023. This suggests that further educational programming around this topic would be helpful to gardeners. The top three management strategies respondents were most interested in were crop selection to reduce damage (79%), using row covers or nets to exclude swede midge adults (75%) and using botanical-based products to repel swede midge from plants (64%). More than 89% of respondents indicated interest in collaborating with researchers in mitigating damage from swede midge.

Mitigation system in gardens. In 2023, mitigation systems with broccoli were installed at three community gardens and maintained by University of Minnesota researchers. At first, polypropylene fabric was pinned to short hoops placed over the transplants. However, high temperatures in late May led to continual wilting of transplants, so the fabric was rearranged and pinned to poles surrounding plots. This allowed heat to escape and made it easier to irrigate the plants. A paired *t* test of the results (Fig. 5A) confirmed that more heads developed with the mitigation system than without ($t = -5.375$, $df = 8$, $P < 0.001$).

In 2024, gardeners testing the mitigation system experienced problems with wind tearing the polypropylene fabric barrier, rodent herbivory, and high humidity within the covered area due to abnormally wet summer weather. The total precipitation from Mar to Aug 2024 (Minnesota Department of Natural Resources 2024) was 78.13 cm, whereas the 30-year average (1991 to 2020) was 54.48 cm. Ten gardeners were able to grow brassicas, which included broccoli, Brussels sprouts, cabbage, collards, and kale. The percentage of undamaged plants recorded outside the mitigation systems averaged 46%, ranging from 0% to 100%, while the percentage of undamaged plants inside the mitigation systems averaged 31.5%, ranging from 20% to 100%. Paired *t* test analysis indicated that the polypropylene fabric-based system was not able to mitigate swede midge damage compared with unprotected controls ($t = -1.55$, $df = 9$, $P = 0.155$, Fig. 5B). However, the median value of damage within the mitigation system was ~10%, whereas it was 50% outside the system. Variation within the system skewed toward more damage, which we surmise was mostly due to lack of attention to holes in the polypropylene fabric that developed after high winds. Also, under high-humidity conditions, the polypropylene fabric was unable to dissipate excess moisture, and crops were susceptible to rotting, a problem that might be avoided with the use of exclusion netting. Outside the mitigation system, lack of swede midge damage may be attributed to the choice of brassicas that were grown because we did not require gardeners to plant crops highly susceptible to swede midge damage. For instance, some gardeners planted cabbage and curly kale, which typically suffer less damage from swede midge than some other brassicas such as 'Red Russian' kale or broccoli (Hodgdon et al. 2024). Overall, the mitigation system seemed promising when used with brassica crops attractive to swede midge in combination with protection against rodents but required some attention from gardeners to be effective. Gardeners could not install the system and neglect it, as might be more possible with exclusion netting. Informal discussion with gardeners indicated that they were interested in testing exclusion netting, especially with collard crops. Future research may include a direct comparison of the polypropylene fabric system with exclusion netting. Such a comparison could include the cost and ease of use because the exclusion netting is expected to be more expensive but easier to install and maintain than the polypropylene fabric. Experimenting with these materials can help gardeners decide which system is most cost-effective for their purposes.

References Cited

Chen M, Shelton AM. 2007. Impact of soil type, moisture, and depth on swede midge (Diptera: Cecidomyiidae) pupation and emergence. Environ Entomol. 36(6):1349–1355. https://doi.org/10.1603/0046-225X(2007)36[1349:iostma]2.0.CO;2.

Chen M, Shelton AM, Hallett RH, Hoepting CA, Kikkert JR, Wang P. 2011. Swede midge (Diptera: Cecidomyiidae), ten years of invasion of crucifer crops in North America. J Econ Entomol. 104(3):709–716. https://doi.org/10.1603/ec10397.

Chen M, Shelton AM, Wang P, Hoepting CA, Kain WC, Brainard DC. 2009. Occurrence of the new invasive insect *Contarinia nasturtii* (Diptera: Cecidomyiidae) on cruciferous weeds. J Econ Entomol. 102(1):115–120. https://doi.org/10.1603/029.102.0116.

Corlay F, Boivin G. 2008. Seasonal development of an invasive exotic species, *Contarinia nasturtii* (Diptera: Cecidomyiidae), in Quebec. Environ Entomol. 37(4):907–913. https://doi.org/10.1093/ee/37.4.907.

Des Marteaux LE, Schmidt JM, Habash MB, Hallett RH. 2015. Patterns of diapause frequency and emergence in swede midges of southern Ontario. Agr For Entomol. 17(1):77–89. https://doi.org/10.1111/afe.12083.

Eder R, Samietz J, Baur R. 2005. Identification of Swede midge males (Contarinia nasturtii) on sticky papers of pheromone traps. https://ira.agroscope.ch/en-US/publication/2662. [accessed Aug 2024].

Evans BG. 2017. Implications of swede midge biology in the development of population management alternatives (PhD diss). University of Guelph, Guelph, Canada.

Hallett RH. 2017. The challenge of swede midge in canola, p 44–67. In: GVP Reddy (ed). Integrated management of insect pests on canola and other *Brassica* oilseed crops. CABI, Boston, MA, USA. https://doi.org/10.1653/024.100.0428.

Hallett RH, Goodfellow SA, Weiss RM, Olfert O. 2009. MidgEmerge, a new predictive tool, indicates the presence of multiple emergence phenotypes of the overwintered generation of swede midge. Entomol Exp Applicata. 130(1):81–97. https://doi.org/10.1111/j.1570-7458.2008.00793.x.

Hodgdon EA, Campbell AEM, Conner DS, Hoepting CA, Galimberti AK, Chen YH. 2022. Farm-level losses and grower willingness to try management strategies for swede midge in vegetable crops. HortTechnology. 32(5):471–478. https://doi.org/10.21273/HORTTECH05063-22.

Hodgdon EH, Chen YH, Hoepting CA, Hallett RH. 2017. Organic management of swede midge. http://hdl.handle.net/1813/55087. [accessed 24 Oct 2024].

Hodgdon EA, Stratton CA, Hoepting CA, Campbell AEM, Gradish AE, Evans BG, Hallett RH, Chen YH. 2024. Organic management of the invasive swede midge (Diptera: Cecidomyiidae) on Brassica vegetables: Multiple dead ends necessitate novel approaches. J Integr Pest Manage. 15(1):17. https://doi.org/10.1093/jipm/pmae010.

Hoepting C. 2024. Monitoring and identification. https://blogs.cornell.edu/swedemidge/monitoring-and-identification/identification. [previous version accessed 18 May 2022].

Hoepting C, Vande Brake S. 2020. NEW crop rotation recommendations for swede midge. Cornell Coop Ext Integrated Pest Manage Veg Fact Sheet.

Minnesota Department of Natural Resources. 2024. Past climate data. https://www.dnr.state.mn.us/climate/historical. [accessed 26 Oct 2024].

Philips C, Ambourn A, Christianson L. 2017. First detections of swede midge (Diptera: Cecidomyiidae) in Minnesota. J Entomol Sci. 52:297–300. https://doi.org/10.18474/JES17-32.1.

Stratton CA, Hodgdon EA, Zuckerman SG, Shelton AM, Chen YH. 2018. A single swede midge (Diptera: Cecidomyiidae) larva can render cauliflower unmarketable. J Insect Sci. 18(3):1–6. https://doi.org/10.1093/jisesa/iey062.

Vankosky MA, Hladun S, Williams J, Soroka JJ, Andreassen L, Meers S, Beauzay PB, Prochaska TJ, Lubenow L, Chirumamilla A, Calles-Torrez V, Knodel JJ, Mor BA. 2023. Pheromone trap monitoring reveals the continued absence of swede midge in the northern Great Plains. Can Entomol. 155:1–7. https://doi.org/10.4039/tce.2022.38.