Weed Emergence Patterns in Response to Disturbance on Two Soil Types

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Abstract:

Weeds are a major constraint to crop production in NY State and can significantly reduce the quantity and quality of harvested crops. The management of weeds also incurs substantial costs for farmers and may have negative impacts on the environment. Thus, there is an urgent need to better predict the timing of weed emergence in cropping systems and to identify those factors affecting emergence. In this research, we studied the emergence pattern of agricultural weeds in two common central NY soil types and in response to biweekly soil disturbance. Seedling emergence data and weather data (i.e. growing-degree days and precipitation) were collected at two research locations in central NY throughout the 2016 growing season. The Musgrave Research Farm (Aurora, Cayuga County, NY) has moderately drained clay-loam soils (Honeyoe/Lima soils) where grain crops are studied, while the Homer Thompson Research Farm (Freeville, Tompkins County, NY) is on very well-drained sandy loam (Howard/Phelps soils) where both vegetable and grain crops are grown. The 2016 growing season was exceptionally dry; weed emergence rates were low at both sites, but emergence was lowest at the H. Thompson site in the better-drained soils despite similar rainfall and temperatures. Data from ten weed species were analyzed; of these, only pigweed (*Amaranthus* spp.) was common at both sites. At the Musgrave site, weed emergence for all species peaked in late May/early June, with a smaller flush in late summer; the exception was Venice mallow (*Hibiscus trionum*), which had its main emergence in mid-summer. At both sites, warm- and cool-season weeds were present, as well as an annual grass; but emergence patterns were more varied. The perennial grass Kentucky bluegrass (*Poa pratensis*) emerged only in the spring, while hairy galinsoga (*Galinsoga quadriradiata*) and common chickweed (*Stellaria media*) emerged mainly in the fall with a small preliminary flush in June; common chickweed had similar emergence rates in June and September. At both sites, repeated cultivation stimulated emergence during mid-season with the exception of foxtails (*Setaria* spp.) at Musgrave, where emergence was higher mid-season in the undisturbed soil treatment.

These results provide a first data set for weed emergence patterns by date, GDD, and precipitation (which will be eventually converted to a soil moisture basis). The unusual 2016 weather provided a good opportunity to assess the limiting impact of low soil moisture on weed emergence. With additional years of data collection, this more exceptional growing season in 2016 should provide valuable data as to the impact of severe water limiting conditions on weed emergence. Findings from this work will allow better prediction of the emergence patterns of specific weed species in future years based on their response to soil disturbance (tillage) and climatic conditions. Ultimately, results from this research should lead to more effective timing of management practices which will reduce costs, increase farmer profitability, and limit the negative environmental impacts of these practices.

Background and justification:

Weed management is a priority issue for New York farmers, particularly with the increasing prevalence of organic production, the rise of herbicide resistant weeds, and the recent increase in small farms and urban farming. In the past decade, a significant body of research has accrued on weed emergence, weed/crop competition, and the response of individual weed species to environmental impacts such as weather, changing climate, and management actions. From this research, a new understanding of nuanced weed management is developing, and tools have been built to help farmers manage weeds effectively in the American Midwest and Europe. Because weeds respond differently in different regions, these tools are not necessarily applicable in other regions including New York State.

Another development in the last decade is a dramatic increase in the sophistication of climate and weather models. Detailed weather history and short and medium range weather predictions are now available to the general public. In New York State, these tools are now available by county. These provide an opportunity to consider growing degree days, precipitation, and soil moisture at the individual farm scale.

These advances in the climate and weed science disciplines provide an opportunity to develop specific and accurate weed management recommendations at the farm level. With interest in local food increasing particularly in urban areas, developing IPM methodologies for weed management in the New York with specific, regionally-focused data and tools could provide great benefits to local growers and consumers, while reducing negative impacts on the environment.

Objectives:

The objectives of this research are to: (1) determine the pattern of weed seedling emergence in two common NY agricultural soil types and in response to soil disturbance; (2) identify the emergence pattern of the most abundant weed species in each soil type; (3) relate weed emergence patterns to climatic parameters such as growing degree days (GDD) and precipitation; and (4) project evaluation.

Procedures:

Locations -Two sites were used, one near Aurora, NY (Cayuga County) at the Robert Musgrave Research Farm and one in Freeville, NY (Tompkins County) at the Homer Thompson Research Farm. Musgrave soils are Honeyoe/Lima, typical of central NY and considered prime soils for farming, while Freeville soils are Howard/Phelps glacial till more typical of the Southern Tier. The history of the Musgrave field is conventional field grains in various research programs, while the Freeville site is a fairly new organic plot that has been in vegetable trials and ryegrass (*Lolium* spp.) cover crops. The weed populations at the two sites are distinct, with more common ragweed (*Ambrosia artemisiifolia*), field bindweed (*Convolvulus arvensis*), foxtails (*Setaria* spp.) and other weeds typical of grain systems at Musgrave and pigweed (*Amaranthus* spp.), common lambsquarters (*Chenopodium album*), hairy galinsoga (*Galinsoga quadriradiata*), common chickweed (*Stellaria media*), common purslane (*Portulaca oleracea*) and other weeds typical of vegetable farms at the Freeville site.

Treatments – The field trials included two treatments. The first tracked seedling emergence after initial tillage; these plots were plowed or otherwise prepared for planting once, and then weed seedlings were removed weekly throughout the growing season. The second treatment was similar, but plots were disturbed with a stirrup hoe bi-weekly to mimic cultivation or other field operations that cause soil disturbance.

Plots – There were six replicate plots at each site for each treatment, for a total of 24 plots (12/site). Each plot was 1 m^2 with a 0.25 m^2 sampling area. The first sampling period used 0.5 m^2 sample plots, but the number of weeds per plot precluded timely sampling so the plot size was reduced to 0.25 m^2 for subsequent sampling efforts.

Sampling – Sampling occurred weekly from initial tillage in mid-May through mid-October. Plants were mostly identified to species, with the exception of species in the *Setaria* genus at Musgrave and at Freeville two grass species were combined under the *Poa* genus. Once identified and counted, seedlings were removed from the plot. If seedlings were not identifiable, they were marked and left for a week if possible for better identification (this procedure was not possible for the soil disturbance plots on weeks when cultivating). In instances where plants were still not identifiable, or where cultivation made waiting impossible, the plants were recorded as 'unknown'. Over the 20 sampling dates, 26 of 27,789 plants at Musgrave and 2 of 1,676 at Freeville were recorded under the 'unknown' category.

Climate – Climate data were recorded at each research site, including daily temperature maximums and precipitation. These data were used to correlate the weed emergence data to growing degree days and precipitation.

Data collection – Data were collected, entered, and summarized by species and site. Emergence patterns were related to climatic parameters such as growing degree days and precipitation at each site.

Results and discussion:

What is the impact of your work?

Seedling emergence data and weather data (i.e. growing-degree days and precipitation) were collected at two research locations in central NY throughout the 2016 growing season. The Musgrave Research Farm site in Aurora, NY has moderately drained clay-loam soils (Honeyoe/Lima soils) where grain crops are studied. The field used for this experiment was under conventional management in a corn/soybean rotation. The H. Thompson Research Farm site in Freeville, NY is located on a very well-drained sandy loam (Howard/Phelps soils) where both vegetable and grain crops are grown. The field used for this experiment was recently plowed from turf, and was under organic vegetable crop management with Italian ryegrass (*Lolium multiflorum*) fallow. Weather data were collected on-farm the farm weather stations; data from these stations is found at the NEWA website (http://newa.cornell.edu/). Data at Musgrave were collected from May 25 until October 5 2016, and at H. Thompson from June 8 to October 12, 2016 (Figure 1).

Weather during the 2016 growing season was exceptionally dry with weed emergence rates low at both sites. However, emergence was lowest at Freeville in the better-drained soils despite similar rainfall and temperatures.

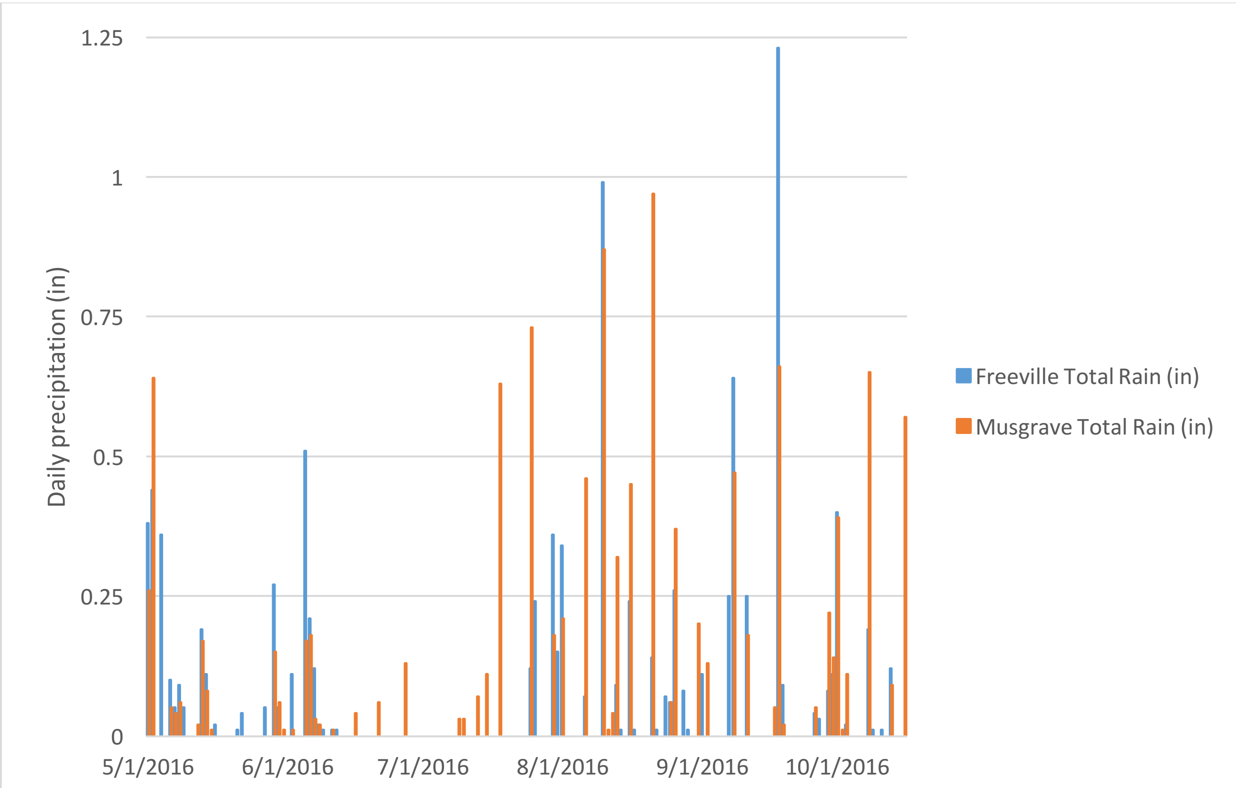


Figure 1. Daily precipitation (inches) during the 2016 growing season at the two research sites in central NY.

Weed species that were common during the experiment were selected for analysis. Data from ten weed species were analyzed; of these, only pigweed (*Amaranthus* spp.) was common at both sites. Total weed emergence was highest shortly after initial tillage at both sites; at Musgrave there was a secondary peak in the late summer, while at the Freeville site a stronger secondary peak in the fall occurred. These patterns were consistent regardless of cultivation treatment (i.e., biweekly cultivation or no cultivation).

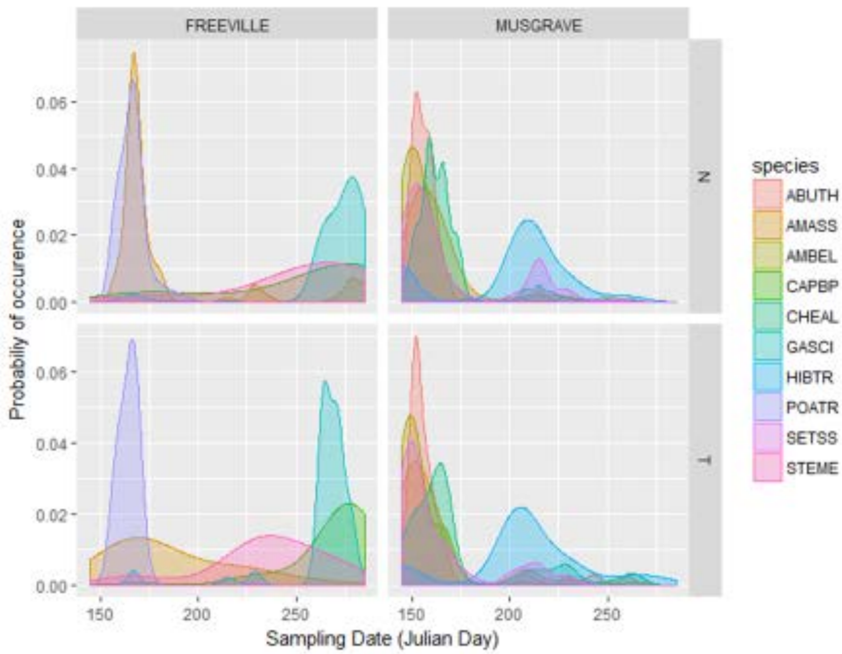


Figure 2. Probability of occurrence for ten common weed species during the 2016 growing season in tilled and control (no cultivation) plots at the Freeville and Musgrave sites in central NY. Weed species include: ABUTH = velvetleaf; AMASS = pigweed species; AMBEL = common ragweed; CAPBP = Shepherd's purse; CHEAL = common lambsquarters; GASCI = hairy galinsoga; HIBTR = Venice mallow; POATR = Kentucky bluegrass; SETSSS = foxtail species; and STEME = common chickweed.

At Musgrave, warm-season weeds common to row crop systems were found: foxtail species (*Setaria* spp.) were the most abundant, followed by common lambsquarters (*Chenopodium album*), velvetleaf (*Abutilon theophrasti*), common ragweed (*Ambrosia artemisiifolia*),and Venice mallow or flower-of-an-hour (*Hibiscus trionum*). Weed emergence for all species peaked in late May/early June, with a smaller flush in late summer; the exception was Venice mallow, which had its main emergence in mid-summer.

At Freeville, both warm- and cool-season weeds were present, as well as two perennial grasses, which were indistinguishable at the seedling stage: Italian ryegrass (*Lolium perenne*) and Kentucky bluegrass (*Poa pratensis*). The perennial grasses were most abundant in June, and their emergence tapered off early with no late-season pulse. The pigweeds, Powell amaranth (*Amaranthus powellii)* and redroot pigweed (*Amaranthus retroflexus*) which are difficult to distinguish at the cotyledon stage, emerged almost exclusively in June in the control no tillage plots, but had low emergence rates throughout the summer in the biweekly cultivation plots. Hairy galinsoga (*Galinsoga quadriradiata*) and Shepherd's purse (*Capsella bursa-pastoris*) emerged mainly in the fall, with smaller flushes in June and August; the late summer flush was stronger in the biweekly cultivation plots. Common chickweed (*Stellaria media*) had similar emergence rates in June and September. At both sites, repeated cultivation encouraged emergence during mid-season with the exception of foxtails at Musgrave, where emergence was higher mid-season in the undisturbed control plots.

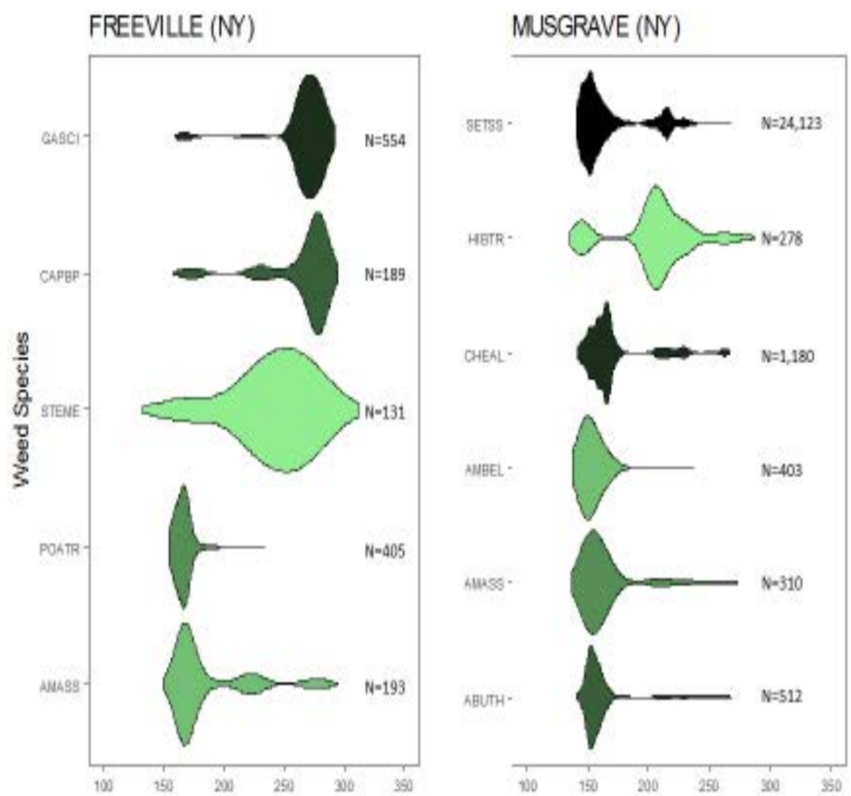
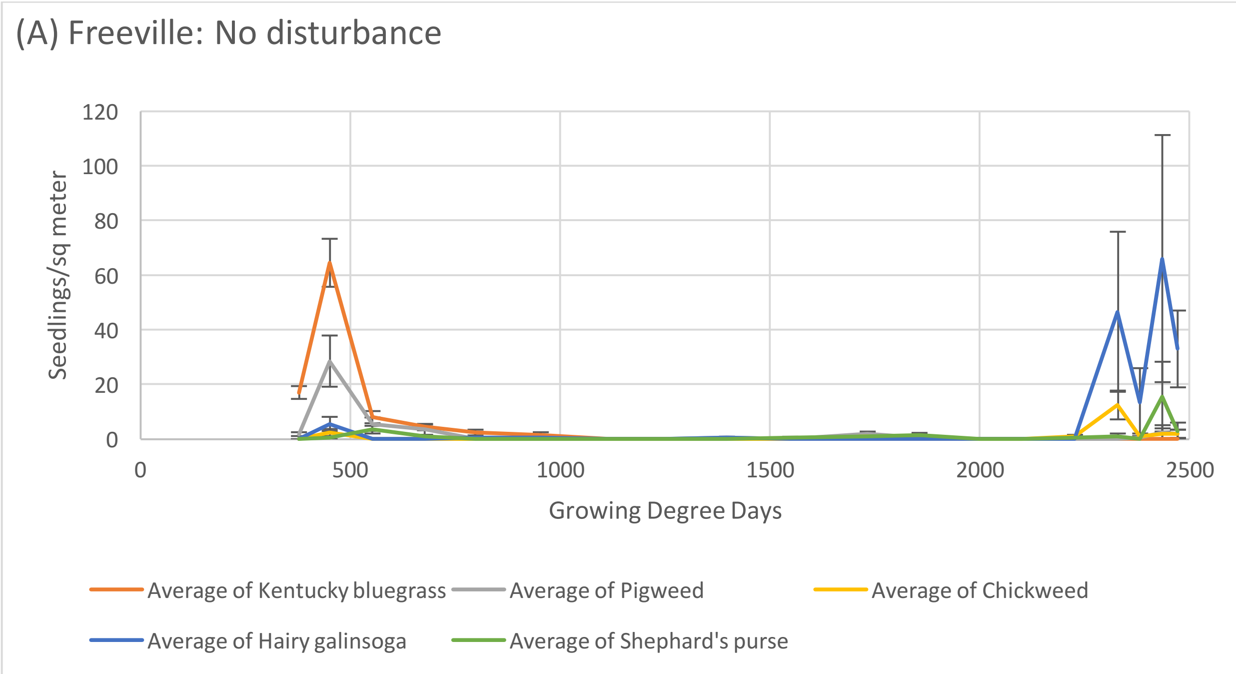


Figure 3. Emergence pattern for ten common weed species during the 2016 growing season in both tilled and control (no cultivation) plots at the Freeville and Musgrave sites in central NY. Weed species codes are as shown in Figure 2.



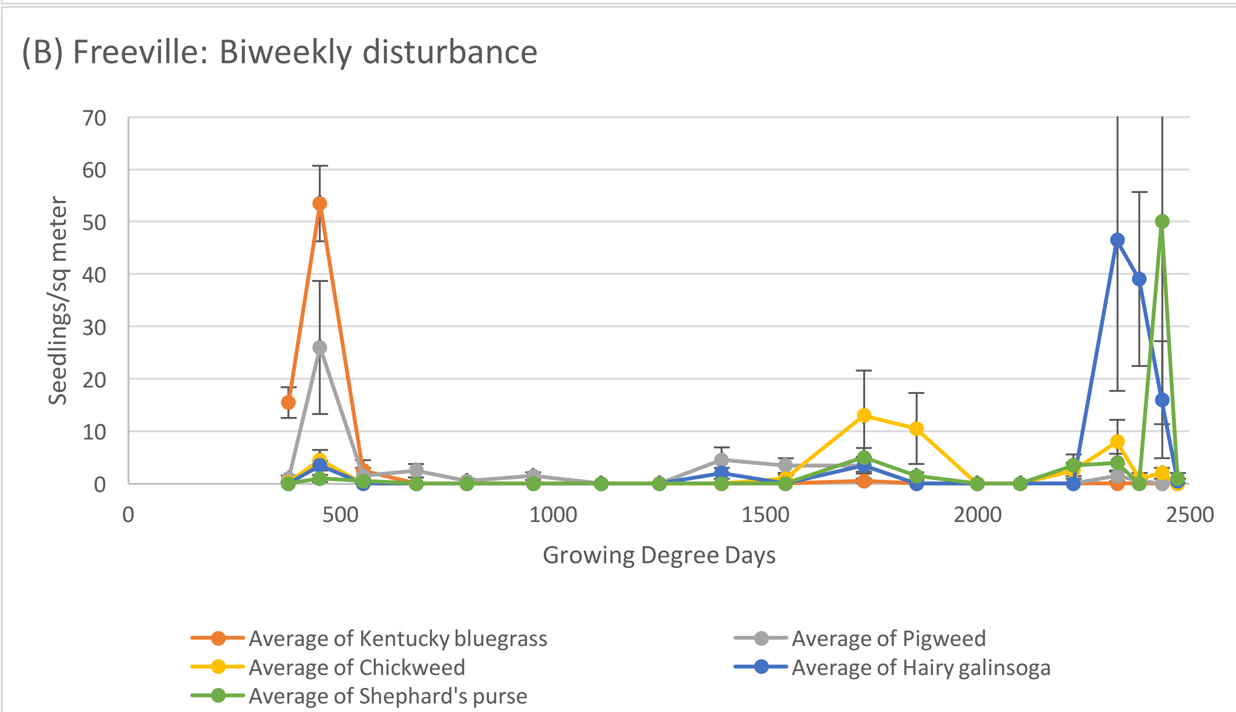


Figure 4. The number of seedlings per m^2 for several common weed species in (A) non-disturbed plots and (B) plots tilled every two weeks at the Freeville, NY site in 2016 based on growing degree days (Base 50°F).

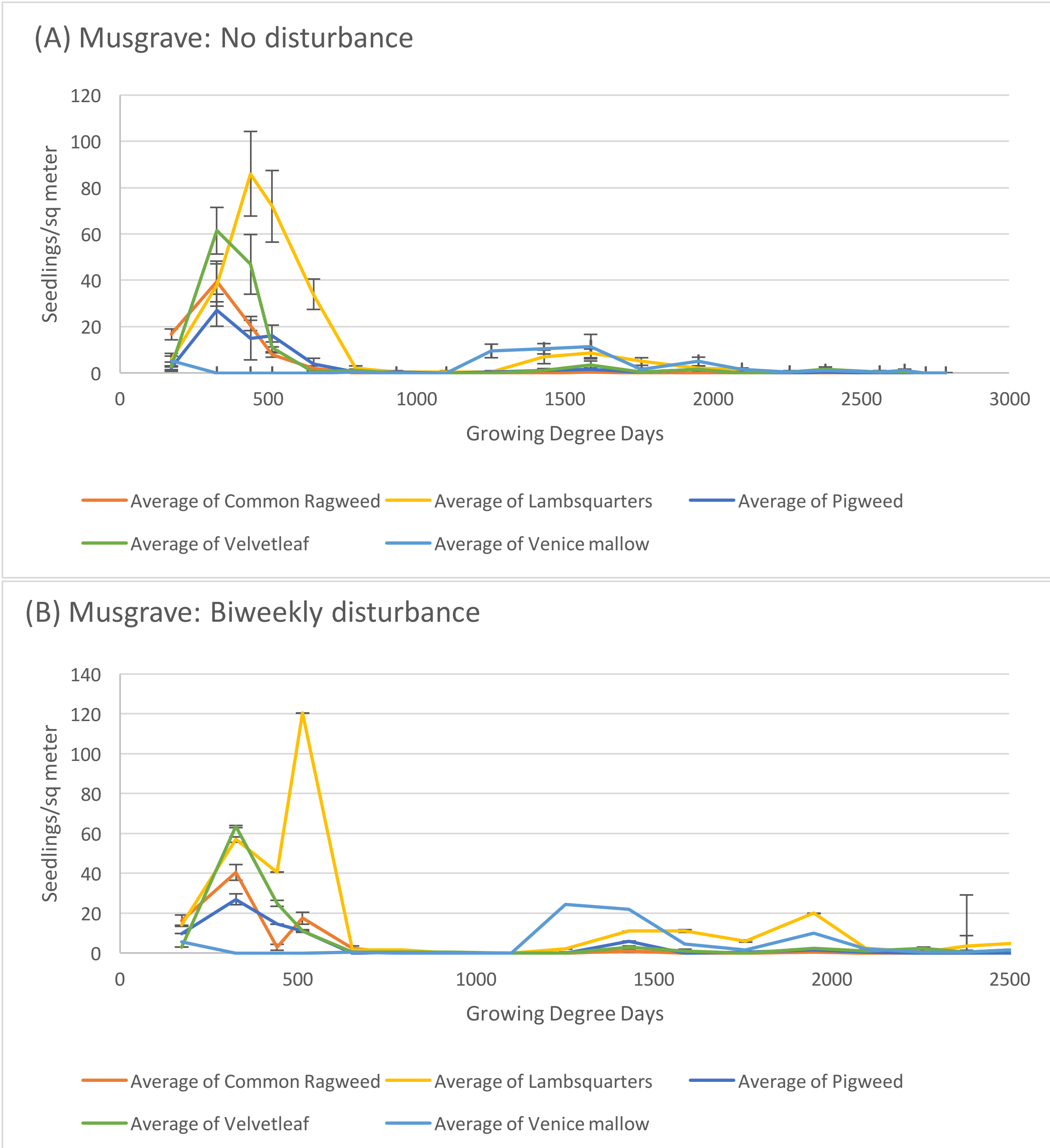


Figure 5. The number of seedlings per m^2 for several common weed species in (A) non-disturbed plots and (B) plots tilled every two weeks at the Musgrave (Aurora), NY site in 2016 based on growing degree days (Base 50°F).

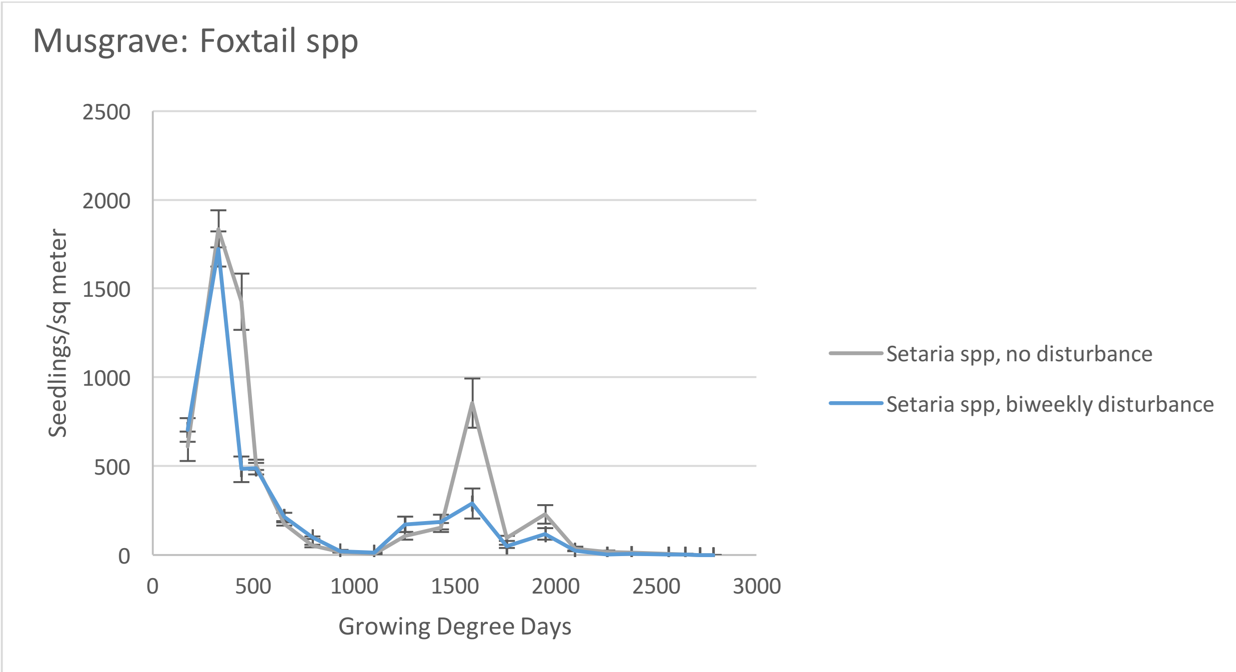


Figure 6. The number of seedlings per m^2 of foxtail (*Setaria* spp.) in non-disturbed plots and plots tilled every two weeks at the Musgrave (Aurora), NY site in 2016 based on growing degree days (Base 50°F).

These results provide a first data set for weed emergence patterns by date, growing degree days (GDD), and precipitation (which will be ultimately converted to soil moisture). The unusual 2016 weather provided a good opportunity to assess the limiting impact of low soil moisture levels on weed emergence. With additional years of data collection, weed emergence data from this unusual and extreme water-limiting growing season may be valuable for comparison purposes to more typical years. Results from this work will allow better prediction of the emergence patterns of specific weed species in future years based on their response to soil disturbance (tillage) and climatic conditions. Ultimately, findings from this research should lead to more effective timing of management practices which will reduce costs, increase farmer profitability, and limit negative environmental impacts of these practices.

Project location(s):

Research was conducted in Tompkins and Cayuga counties; the results of this experiment may be applied statewide, but will be best applicable to the central NY counties which have similar soils to those at the two research sites.

Samples of resources developed:

This work has not yet created any resources; if we secure funding to build the weed emergence model, that product will be available on the NEWA site (http://newa.cornell.edu/).