2,4-D Rate Response, Absorption, and Translocation of Two Ground Ivy Populations
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Objective

The objectives of this study were to determine 1) the response of two ground ivy populations to various rates of 2,4-D, 2) absorption and translocation of 2,4-D in populations that vary in their tolerance to 2,4-D, and 3) whether differential 2,4-D absorption contributes to variation in 2,4-D tolerance in ground ivy.

Rationale

Ground ivy is a stoloniferous, perennial weed that can persist in turf. Growing at soil level, stolons infiltrate surrounding vegetation and establish new populations, which result in non-uniform turf. Approximately 62,000 lbs of 2,4-D were applied to Indiana homelawns in 1992.. A 2001 survey of Indiana lawn care operators (LCO) found 79% of respondents used 2,4-D either alone or in combination with another herbicide to control ground ivy. Most LCO (86%) indicated that repeated herbicide applications were necessary for acceptable ground ivy control, suggesting chemical control of ground ivy is challenging for the lawn care industry. Widespread use and repeated applications of 2,4-D on turf sites could encourage development of 2,4-D-resistant ground ivy. Determining 2,4-D absorption and translocation patterns in 2,4-D-resistant and -susceptible ground ivy populations could ascertain whether these factors affect resistance and susceptibility, which could possibly lead to better control methods.

How It Was Done

Selection and Maintenance of Ground Ivy Populations
Samples of ground ivy in eight U.S. states and one Canadian province was sampled and brought to the greenhouse in West Lafayette, IN. The stolons were separated and planted into individual 7-inch diameter pots (5:3 soil:peat mix) and maintained in the greenhouse with daily irrigation. Our earlier experiments have identified a 2,4-D-resistant ground ivy population from NE and a 2,4-D-susceptible population from OH, and experiments focused on these two populations (Table 1).

2,4-D Dose Response of NE and OH Ground Ivy Populations
Ground ivy was treated with 0, 1, 2, 3, 4, 6, 8, 10, or 12 lbs ai/A 2,4-D-amine in 4 gal/1000 ft^2 using an air-pressured spray chamber with a single nozzle (Tee Jet LF8002E) boom. Injury ratings were taken at 25 days after treatment (DAT) on a scale of 0 to 100% with 0 being uninjured and 100% being dead.

Absorption and Translocation of ^{14}C-2,4-D in NE and OH Ground Ivy Populations
Ring-labeled ^{14}C-2,4-D acid was dissolved in a 2,4-D-amine formulation and diluted in distilled water to simulate a field application of 2 lbs ai/A 2,4-D in 4 gal/1000 ft^2 water when applied to 1 cm^2. Four plants from each population were harvested at 6, 12, 24, 48, or 72 hours after treatment (HAT). At each harvest, the treated leaf was washed twice with 0.14 fl oz of methanol:water (1:1 v/v) to ensure any unabsorbed radiolabel was completely removed. Plants were sectioned into the treated leaf, treated leaf's petiole, opposite leaf, opposite leaf's petiole, and treated node plus roots, and the rest of the stolon was harvested in 2-inch segments. All harvested plant parts were burned in a biological oxidizer. Percent absorption was determined from the sum of ^{14}C recovered in all plant parts. Percent total translocation was determined from the sum of ^{14}C recovered in all plant parts except the treated leaf. Percent acropetal (up) translocation was

determined from the sum of ^{14}C recovered between the treated node and the apical meristem of the stolon. Percent basipetal (down) translocation was determined from the sum of ^{14}C recovered between the treated node and the cut end of the stolon.

2,4-D Exposure to Roots of NE and OH Ground Ivy Populations
Stolons were cut into individual ramets consisting of an internode and a node having healthy white roots, two axillary buds, two petioles, and two leaves. In the greenhouse, ramets were transferred into test tubes where roots were placed in solutions of 0, 0.12, 0.24, or 0.36 oz ai/gal 2,4-D-amine. The roots remained in 2,4-D solution for two hours after which ramets were removed and roots washed. Ramets were then placed in centrifuge tubes containing water, which was refreshed daily and replaced every 3 days. Percent injury was rated 0.75, 1, 2, 3, 6, 9, 12, and 15 DAT based on the amount of senesced leaf tissue.

Results

2,4-D Dose Response of NE and OH Ground Ivy Populations

- The OH population was more severely injured than the NE population at all 2,4-D rates (Figure 1). Injury symptoms consisted of epinasty, leaf cupping, and senescence of leaf and petiole.
- Regression analysis of the injury data at 25 DAT indicates 50% injury to the OH and NE populations occurs at 2.9 ± 0.3 and 4.9 ± 0.4 lbs ai/A 2,4-D, respectively. Therefore, the OH population was 1.7 times more susceptible to 2,4-D than the NE population.
- The full-labeled rate for 2,4-D for broadleaf weed control in Kentucky bluegrass is 2 lbs ai/A. Based on the regression analysis, the full-labeled rate would result in 43% injury on the OH population but only 16% injury on the NE population.
- The NE population was severely injured with 12 lbs ai/A 2,4-D, which is six times the labeled rate for use on Kentucky bluegrass. However, green tissue capable of regrowth was still present on these plants after this treatment demonstrating that slightly increasing the rate of 2,4-D will not significantly increase control of this population.
- These results suggest that multiple applications of 2,4-D may be necessary for improved ground ivy control, which was also indicated by our LCO survey. A different herbicide either alone or mixed with 2,4-D may provide better postemergence control of ground ivy.

Absorption and Translocation of ^{14}C-2,4-D in NE and OH Ground Ivy Populations

- The amount of radiolabel absorbed varied by population with the 2,4-D-susceptible OH absorbing 16.8% and the 2,4-D-tolerant NE absorbing 12.3%, indicate the difference in 2,4-D sensitivity between these two populations may be due in part to a difference in foliar absorption.
- Rate of absorption was similar for both populations and was rapid during the first 6 hours of the experiment and declined over time (Table 2). Most of the ^{14}C-2,4-D (12.5%) was absorbed by 6 HAT but 16.3% was absorbed by 48 hours. This suggests delaying mowing or irrigation for 48 hours after application to allow for maximum absorption may improve ground ivy control. Since IN law requires posting after lawn care applications, most

homeowners will not water or mow within 48 hours of application. Therefore, homeowner practices may not play a large role in poor ground ivy control.

- Total translocation of ^{14}C out of the treated leaf was similar for both populations (Table 2). Our results suggest that translocation alone does not contribute to the difference in response to 2,4-D between these two ground ivy populations.
- Acropetal translocation varied by population and over time (Table 2). Acropetal translocation of ^{14}C was 1.7% and 1.2% for the OH and NE populations, respectively (Table 2). Since almost one-third more 2,4-D is translocated acropetally in the OH population than in the NE population, this may contribute to the variation in response to 2,4-D. If one assumes this ^{14}C is herbicidally active, even slightly more being translocated towards the apical meristem in the OH population may be enough ^{14}C-2,4-D to contribute to the OH population's increased susceptibility, considering younger tissue is typically more susceptible to herbicide than older tissue.
- There was no difference in basipetal translocation between the two populations, but it did increase over time from 0.4% translocated at 6 HAT to 1.5% translocated at 72 HAT.
- Complicating successful herbicidal control of ground ivy is the arrangement of vascular tissue within the plant. For example, when a leaf on a node was labeled with ^{14}C-2,4-D, almost no ^{14}C (0.02% of applied) was found in the opposite leaf on the same node at 72 HAT. Therefore, depending on where 2,4-D is absorbed, it is not translocated to all parts of the plant due to the arrangement of vascular bundles within the stolon. Since ground ivy control is dependent on controlling the developing ramets along the primary and secondary stolons, complete herbicide spray coverage is extremely important. However, as ground ivy stolons infiltrate turfgrass, there are nodes that have rooted but have not pushed leaves above the turf canopy, making complete spray coverage impossible.

2,4-D Exposure to Roots of NE and OH Ground Ivy Populations

- Since OH ground ivy absorbs 4.5% more 2,4-D than NE ground ivy, removing any potentially complicating factors such as cuticle quantity, cuticle composition, or trichome density would help clarify if differences in foliar absorption account for difference in susceptibility. When we did this, we found that differences in 2,4-D-susceptibility were maintained between the two populations (Figure 2).
- Considering there is no waxy cuticle on the surface of the roots, the roots of both populations should absorb similar amounts of 2,4-D. Yet when the roots of the OH and NE populations were exposed to 2,4-D, response differences were maintained and thus differential foliar absorption is not a major factor in the differential response to 2,4-D.

Table 1. Ground ivy population collection sites, their environment, and the number of stolons collected from each population.

Population ID	Sampling location	Location description	Mowing height	Sunlight	Size of patch	Regular irrigation	Stolons collected
			inches		ft^2		number
NE	Mead, NE	Home lawn	2.5	Full	250	Yes	29
OH	Columbus, OH	Research plots	2.0	Shade	100	No	23

Table 2. Percent absorption, and total, acropetal, and basipetal translocation of ^{14}C-2,4-D in two ground ivy populations between 6 and 72 HAT.

		Translocation		
Measurement	Absorption	Total	Acropetal (up)	Basipetal (down)
		% of applied[a]		
Population				
NE	12.3 a	4.7 a	1.2 a	1.0 a
OH	16.8 b	5.3 a	1.7 b	1.2 a
Time (HAT)				
6	12.5 a	3.5 a	0.7 a	0.4 a
12	12.3 a	3.5 a	1.1 ab	0.9 a
24	13.4 a	4.7 ab	1.1 ab	1.3 b
48	16.3 b	6.0 b	1.7 b	1.5 b
72	18.2 b	7.3 c	2.5 c	1.5 b

[a] Within variables, means followed by the same letter are not significantly different according to Fisher's protected LSD test at P = 0.05.

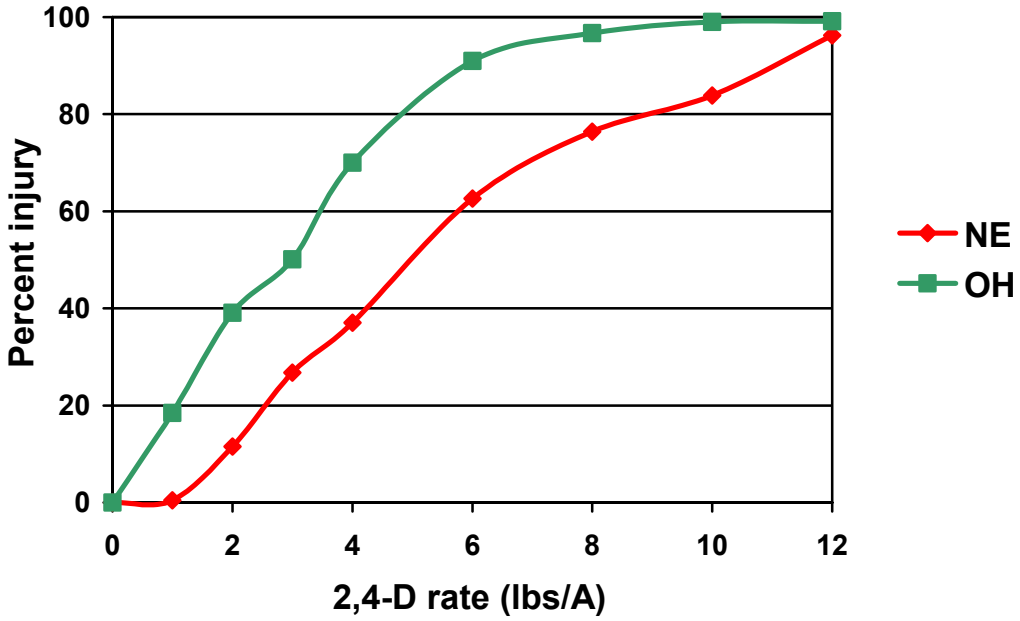

Figure 1. The response of two ground ivy populations to 2,4-D at 25 days after treatment. Points represent a mean of six ratings.

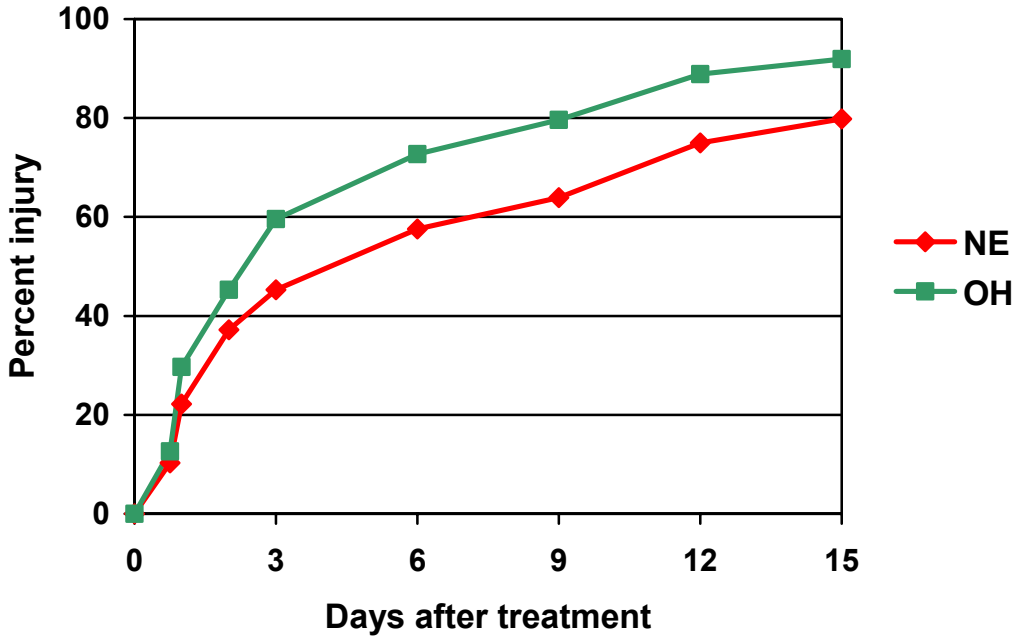

Figure 2. Percent injury on two ground ivy populations after roots were exposed to 2,4-D for two hours. Data are averaged over three 2,4-D rates. Points represent a mean of 54 ratings.