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Growth of Garlic Mustard (*Alliaria petiolata*) in Native Soils of Different Acidity

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ABSTRACT

Garlic mustard (*Alliaria petiolata*) is a naturalized, invasive plant in North America. Its current distribution in Illinois is primarily limited to the northern two-thirds of the state. Decreased colonization by this exotic species in the southern one-third of Illinois may be related to the lower soil pH conditions found there as compared with central and northern portions of the state. The pH of soil samples taken from areas supporting populations of garlic mustard tended to be less acidic than soils obtained from southern Illinois sites. Transplanted seedlings from a population of garlic mustard in McLean County, Illinois, were grown in the southern Illinois soils and soil from their place of origin. Their growth was compared by the number of surviving plants and on a total dry weight basis. A significant positive correlation between increasing plant weight and pH suggests that lower pH conditions in the southern portion of Illinois may be a factor limiting the spread of garlic mustard in this area.

INTRODUCTION

Knowledge of soil pH is fundamental to the understanding of soil systems. Inferences regarding soil nutrient status, stage of soil genetic development, and potential toxicity of environmental contaminants, among others, can be made based upon a knowledge of soil pH (Moore and Loeppert 1987). Zollinger and Kells (1991) state that various weed species have been shown to exhibit differential growth and reproductive responses to soil pH. The effect of soil pH on growth and reproductive parameters may act to limit the geographic distribution of pH-sensitive species, thus making it possible to predict future distributional changes of such species based partially on soil pH data. Field observations of garlic mustard (*Alliaria petiolata*), a naturalized, invasive biennial species in North America, indicated that by 1991 it had not invaded most of the southern third of Illinois, where the soils tend to be more acidic than elsewhere in the state (Schwegman 1988, Nuzzo 1991, Nuzzo 1993). In the British Isles, garlic mustard distribution is reported to be associated with calcareous soils, with populations most commonly occurring in hedgerows, shady waysides, and as ground cover in deciduous woods on base-rich soils (Clapham et al. 1962, Cavers et al. 1979). Grime et al. (1988) reviewed the distribution of garlic mustard in Britain and North America and reported that the species was absent from highly acidic soils. To test the hypothesis that soil pH might play a role in limiting the plant's distribution in Illinois, the soil pH was measured at sites with and

without populations of garlic mustard. Also, the growth of seedlings transplanted from Ewing Park, Bloomington, Illinois was compared under growth chamber conditions, in soil collected from five locations from southern Illinois, and Ewing Park. None of the southern Illinois sites supported garlic mustard populations at the time the soil samples were collected.

METHODS

The southern Illinois soils were collected on 16-17 January 1991 from Fayette, Marion, Pope, and Johnson Counties. They were transported to Illinois State University, placed in plastic bags and stored at a temperature of 0-2° C in a walk-in cold room until March 21. Then they were placed in a growth chamber and air dried. Soil was collected from Ewing Park on March 29. All of the collected soils were allowed to air dry until April 2. Following air drying, the soils were broken into smaller aggregates that were less than one cm in diameter. The soils were mixed with pearlite (1:1 by volume) and for each of the six soils, seven 10 cm diameter pots were filled with the mixture.

A block of soil approximately 20 cm x 20 cm x 15 cm containing several hundred garlic mustard seedlings was collected at Ewing Park on the same day as the soil. Seedlings were placed in a growth chamber set for a 14/10 hour day/night cycle with a day/night temperature of 24/22° C and watered daily with deionized water.

On April 2, a single seedling was planted in each of the pots. Seedlings were watered and the pots were placed in trays. About one cm of water was placed in the bottom of each tray to ensure soil hydration. To reduce stress on transplanted seedlings, one-half of the lights in the growth chamber were turned off for the first two days after planting. The plants were grown until June 27 under growth chamber conditions described above. At the end of the growth period, the plants (aerial and subsurface portions) were harvested, oven dried at 80° C for 48 hours and weighed. The number of surviving plants for each soil type was recorded.

The pH of the air dried soils at the beginning of the growth experiment and of the soil-pearlite mixture at the termination of the experiment was measured. In addition, the pH of soil samples collected from sites in northern and central Illinois where garlic mustard was abundant were also measured. These sites were chosen to provide comparisons of soil pH conditions in northern and central regions of the state, where garlic mustard can be readily found, to those from the southern counties where garlic mustard is limited in range. Soil samples from these sites were air dried in a growth chamber, then a 25 g sample of each was combined with 10 ml deionized water just before testing. Soil pH was measured with a Nester Pocket pH meter with an accuracy of ± 0.1 pH units. The accuracy of the meter was calibrated before each use with pH buffers 4.0 and 7.0.

RESULTS AND DISCUSSION

Garlic mustard was found to grow in soils displaying a wide range in soil pH from a low of 5.0 at Lloyds Woods in Lake County to a pH that was slightly above neutral 7.2 at Ewing Park (Table 1). The soils from southern Illinois were generally more acidic than those in which garlic mustard was growing. All of the soils from southern Illinois used in the growth experiment had higher soil pH at the end of the experiment than they did at the beginning, as did the soil from Ewing Park (Table 2).

The number of plants surviving to the end of the experiment varied from 2 to 6 for the various soils. However, chi-square analysis indicated that there were no significant differences ($p < 0.05$) in the proportion of plants surviving in the various soils. It is of interest that the Ewing Park soil, which is the soil type from which the seedlings used in the experiment were collected, had the smallest number of plants surviving. In spite of the growth of some plants in all of the southern Illinois soils, there was a significant positive correlation (Pearson Product-Moment Correlation, r) between the average plant weight and soil pH for the five southern Illinois soils (Figure 1). These results indicate that garlic mustard is capable of growing in soils from southern Illinois but that the success of the plant, as measured by plant dry weight, increases as the soil becomes less acidic. These findings are in congruence with those of Zollinger and Kells (1991) who reported that dry weight production of perennial sowthistle (*Sonchus arvensis* L.) at pH 5.2 was 29 and 31% lower than at pH 6.2 and 7.2, respectively. It should be noted that the plants are not responding directly to the concentration of hydrogen ions in the soil. Soil pH is usually reflective of the availability of nutrient ions in the soil (especially ionic forms of bases Ca, Mg, and K). According to Schubert et al. (1990), in addition to the negative effects of low soil pH itself, increased concentrations of ionic Al and Mn and deficiencies of phosphate, sulfate, and ionic Ca and Mg may lead to decreased plant growth in acidic soils. Studies of other species in the Brassicaceae have shown soil pH to affect Ca uptake in root tissue (Myers and Campbell 1985). The decrease in plant growth associated with increased acidity is probably the result of the more acidic soil having lower availability of inorganic nutrients than the less acidic soils. Reduced growth of garlic mustard in acid soils may limit its invasion of the southern one-third of Illinois.

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LITERATURE CITED

Cavers, P. B., M. I. Heagy, and R. F. Kokron. 1979. The biology of Canadian weeds: *Alliaria petiolata* (M. Bieb.) Cavara and Grande. Canadian Journal of Plant Science. 59:217-229.

Clapham, A. R., T. G. Tutin, and E. F. Warburg. 1962. Flora of the British Isles. Cambridge University Press. 1269 pp.

Grime, J. P., J. H. Hodgson, and R. Hunt. 1988. Comparative Plant Ecology: a functional approach to common British species. Unwin Hyman, London. 742 pp.

Moore, T. S. and R. H. Loeppert. 1987. Significance of potassium chloride pH of calcareous soils. Soil Science Society of America Journal 51:908-912.

Myers, D. F. and R. N. Campbell. 1985. Lime and the control of clubroot crucifers: effects of pH, calcium, magnesium, and their interactions. Phytopathology 75:670-673.

Nuzzo, V. A. 1991. Experimental control of garlic mustard [*Alliaria petiolata* (Bieb.) Cavara & Grande] in northern Illinois using fire, herbicide, and cutting. Natural Areas Journal 11:158-167.

Nuzzo, V. A. 1993. Current and historic distribution of garlic mustard (*Alliaria petiolata*) in Illinois. The Michigan Botanist 32:23-33.

Schubert, E., K. Mengel, and S. Schubert. 1990. Soil pH and calcium effect on nitrogen fixation and growth of broad bean. Agronomy Journal 82:969-972.

Schwegman, J. E. 1988. Illinois garlic mustard alert. Illinois Department of Conservation. 1 pp.

Zollinger, R. K. and J. J. Kells. 1991. Effects of soil pH, soil water, light intensity, and temperature on perennial sowthistle (*Sonchus arvensis* L.). Weed Science 39:376-384.

Table 1. The pH of soils from various locations in Illinois supporting populations of garlic mustard.

Location	County	Soil pH
Wright's Woods	Lake	5.9
Ryerson Conservation Area	Lake	5.3
Lloyds Woods	Lake	5.0
Fermilab Site 1	Kane	7.1
Fermilab Site 2	Kane	7.2
Ewing Park	McLean	6.1
Little Mackinaw Wildlife Park	Tazewell	7.2
Indian Creek Woods	Tazewell	7.0
Mettler Woods	DeWitt	5.9
Sand Prairie Scrub Oak NP (Site 1)	Mason	6.4
Sand Prairie Scrub Oak NP (Site 2)	Mason	6.3

Table 2. Initial and final pH of soils used in growth comparison experiment.

			Soil pH[1]		
Habitat Type	County	Soil No.[a]	Intial	Final	No. Plants[1]
Brownstown Flatwoods	Fayette	1	4.2	4.7	4
Southern Till Plain Slope	Marion	2	4.2	4.3	6
Small stream floodplain	Marion	3	6.3	6.8	5
Upland Shawnee Hills	Pope	4	4.3	4.7	6
Cache River Floodplain	Johnson	5	5.2	5.3	6
Ewing Park	McLean	–	6.1	6.3	2

[a] Soil number in Table 2 corresponds with number in Figure 1

[1] Number of surviving plants out of seven planted per soil at the beginning of the study

Figure 1. Growth of garlic mustard in southern Illinois soils. Soil numbers in figure correspond to numbers presented in Table 2.
(Regression Equation - $Y = 0.1313X + 0.5281$; $r = 0.98$; $p < 0.001$)

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