

Abstracts of the ASHS Northeast Region Annual Meeting

Amherst, Mass.

9–10 Jan. 1998

Hydroponic Production of Culinary Parsley in a Coal Bottom Ash Substrate

Donna Ballard* and Bradford C. Bearce, West Virginia University, Morgantown, WV 26506-6108

Production of the specialty crop, culinary (flat-leaf) parsley (*Petroselinum crispum* Mill.) offers an alternative to the traditional greenhouse crop, especially during the fall holidays. Utilizing a flow-through nutriculture bench, coal bottom ashes from three different power plants were compared to rockwool as substrates for parsley production. Full and half-strength nutrient solutions were compared in all substrates. No significant differences in dry weight occurred among treatments and there were no substrate–nutrient strength interactions. When ready for harvest, the plants were cut at substrate level and dried for nutrient analysis. This study indicates that coal bottom ash, a by-product of electricity production, has potential as an inexpensive and productive substrate for nutriculture production of parsley.

Sod Production in Composts

Allen V. Barker* and Tara A. O'Brien, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Composts of agricultural by-products (chicken manure and cranberry pomace), biosolids and woodchips, biosolids mixed municipal solid wastes, and autumn leaves were evaluated for production of turfgrass or wildflower sods. The best sods measured by establishment and growth of stands were in the agricultural compost, which was rich in N (avg. 1.7%) and low in NH_4^+ (avg. 135 mg N/kg). High NH_4^+ limited stand establishment with immature biosolids-based composts. Some of these immature composts had total N concentrations >2%. Leaf compost was too low in total N (<0.7%) to support sod production without supplemental fertilization. Aging of each compost improved its capacity to support sod production, apparently as a result of changes in the N status of the media. Growth of soilborne weeds was promoted by incorporation of composts into soil or by application of composts as mulches. A barrier mulch of paper or other materials that impeded weed emergence effected weed control. Use of a mature compost with adequate N and control of weeds are essential practices for sod establishment with composts. E-mail barker@pssci.umass.edu

Coal Bottom Ash as a Component of Floriculture Root Media

Bradford C. Bearce*, West Virginia University, Morgantown, WV 26505-6108

Our research emphasis has been on utilization of industrial by-products as components of plant root substrates. Coal bottom ash (CBA) collects at the base of furnaces of coal-fired power plants, in contrast to fly ash, which is removed from stack fumes by electrostatic precipitators. A majority of CBA is disposed in landfills. Its low cost and availability in large quantities (in 1994, >14 million tons were produced in the United States, of which only ≈5 million tons were marketed) recommend it for trial as a component of root media, which currently contain far more expensive ingredients. CBA tends to increase pH and EC and decrease water and air capacities of root

media. When used as a root medium in a closed loop nutriculture system, it caused an increase in Ca, K, and Na in the nutrient solution. Crops grown in CBA root media include pot and cut chrysanthemums, roses, rhododendrons, poinsettias, Easter lilies, peperomia, zonal and ivy geraniums, impatiens, New Guinea impatiens, and hydrangeas. In general, growth parameters such as plant dry weight and flower number tended to decline at media CBA levels of 75% or more. At CBA levels of 50% or less, these parameters tended to equal or surpass those of plants in control (0% CBA) media.

Phytoremediation of Lead-contaminated Soils

Ruby S. Beil*, A. Martin Petrovic, Thomas H. Whitlow, Wendall A. Norvell, and Leon V. Kochian, Department of Floriculture and Ornamental Horticulture, Cornell University, Ithaca, NY 14853

Lead contamination of surface soils is a frequently encountered problem of environmental concern, and Pb toxicity in humans is considered the most immediate environmental risk associated with Pb-contaminated soils. Phytoextraction, using plants to remove pollution from soil, is the subject of recent phytoremediation research. Major limitations of lead phytoextraction are low Pb availability in soil and poor Pb translocation from roots to shoots. These limitations indicate that the accumulation of Pb in shoots can be feasible only through the application of synthetic chelation agents, such as EDTA, which facilitate metal dissolution, uptake, and transport. Induced phytoextraction of Pb from contaminated soils has been demonstrated with *Brassica juncea* (Indian mustard), but *B. juncea* is not ideal for phytoextraction because of its low biomass. Inducing Pb accumulation in low-input, high-biomass perennial plants is a more practical and manageable strategy for phytoextraction. Tree and turf species have not been explored as a plant community to remove Pb from contaminated soils. The objective of this study is to induce Pb absorption from contaminated soil with low-input perennial plants, *Festuca arundinacea* (tall fescue) and *Acer rubrum* (red maple), through proper timing and application of synthetic chelation agents. This study is expected to benefit the community of scientists and environmental researchers concerned with the development of ecologically sound and economically desirable technologies for the remediation and restoration of contaminated soils. This poster presentation provides a condensed visual interpretation of the Pb phytoextraction, background information, and an update on progress of the study. E-mail rsb12@cornell.edu

A Revolution in New England: New Hampshire Develops an Annual Strawberry Production System

Charles D. Bornt*, J. Brent Loy, William G. Lord, and Otho S. Wells, Department of Plant Biology, University of New Hampshire, Durham, NH 03824

Research was conducted in New Hampshire during Fall 1995 and Spring 1996 to determine a planting schedule, rowcover type, application time, and plastic mulch type to be used in adapting the annual hill strawberry production system to New England. Treatments in Fall 1995 included two planting dates, three mulch types, and four rowcover

modifications. Yields did not differ statistically between a 18 Aug. and 1 Sept. planting date or among plastic mulches. Typar 518 floating rowcovers significantly increased branch crowns, and early and total fruit yield compared to hay mulch applied for winter protection. Research was initiated in Fall 1996 to determine the effect of runner production on yield. Plug plants (50 vs. 24 tray) were treated with different day lengths and temperatures and planted in the field on 26 Aug. or 9 Sept. All plants were covered with Typar 518 on 4 Oct. 1996. Larger, late-planted plugs treated with cool, short days produced no runners in Fall 1996 and increased branch crowns and total yield in Spring 1997. Plants set out in Fall 1995 were evaluated for 2nd year production with or without runner pruning and four rowcover treatments in Fall 1996. Runner pruning did not significantly increase total yields, but resulted in earlier fruit harvesting in Spring 1997. Typar 518 applied 4 Oct. resulted in the greatest yield of any rowcover treatment.

Relationships between Floral Morphology, Breeding Behavior, and Flower Longevity in Easter Cactus (*Hatiora xgraeseri*)

Thomas H. Boyle* and Renate Karl, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Experiments were performed to determine the influence of floral morphology and breeding behavior on flower longevity in Easter cactus. Four clones were used for this study: two clones ('Evita' and 'Purple Pride') were highly self-incompatible (SI) and diploid ($n = 11$) and two other clones were self-compatible (SC) cytochimeras (diploid epidermis and tetraploid subepidermis) that were recovered from the diploid clones. There were clonal differences in the degree of herkogamy (spatial separation between anthers and stigma) and the stage of floral development in which autogamy commenced. Autogamy commenced on the day of anthesis in the 'Evita' clones, but commenced ≈ 5 days after anthesis in the 'Purple Pride' clones. Styles from undisturbed flowers were collected at senescence, fixed, and examined with epifluorescence microscopy. The SI diploid clones contained few pollen tubes at the base of the style, whereas the SC cytochimeras contained numerous pollen tubes at the base of the style. Among the 'Evita' clones, flowers of the SC cytochimera senesced ≈ 3 days earlier than the SI diploid. However, diploid and cytochimeral clones of 'Purple Pride' were similar in flower longevity. Differences in flower longevity were attributed to clonal variation in breeding behavior and floral morphology. These data suggest that herkogamy should be used as a selection criterion when breeding for increased flower longevity in tetraploid (SC) Easter cactus.

Commercial Apple Production Information on the Internet: The Virtual Orchard and Apple-Crop Listserv

Jon M. Clements¹*, Winfred P. Cowgill², Lorraine P. Berkett¹, and M. Elena Garcia¹, ¹Plant and Soil Science Department, University of Vermont, Burlington, VT 05405; ²Rutgers Cooperative Extension, 4 Gauntt Place, Flemington, NJ 08822

The Virtual Orchard (VO) is a World Wide Web (WWW) site dedicated to dissemination of information on sustainable apple production. The VO also provides interactive forums for research and extension projects, including the 'Apple-Crop Listserv', dealing with commercial apple production and marketing issues. More specifically, the Virtual Orchard hosts the 'New Jersey Fruit Focus' sponsored by Rutgers Cooperative Extension, and the 'UVM Apple Orchard', home to the Univ. of Vermont research and Extension 'Apple Team'. A search engine provides keyword searching of the VO and other relevant WWW sites. During Jan.-Dec. 1997, the Virtual Orchard welcomed nearly 40,000 unique Internet visitors and served >500,00 requested files. VO WWW pages are served by an Apple Macintosh Workgroup Server located at the Univ. of Vermont. The Uniform Research Locator (URL) of the Virtual Orchard is <http://orchard.uvm.edu/>. The 'Apple-Crop Listserv' is an Internet discussion list that provides a forum for information exchange between university researchers, extension agents and specialists, students, commercial apple growers, wholesalers/brokers, retailers, and direct marketers of apples. 'Apple-Crop' became active in 1993 and as of Dec. 1997, had >340 subscribers throughout North America and from several foreign

countries. To subscribe to 'Apple-Crop' or for more information, send e-mail to apple-crop@orchard.uvm.edu; Univ. of Vermont (802) 656-2630; Rutgers Cooperative Extension (908) 788-1339.

Nitrogen Status of Cranberry Plants Can Be Evaluated Based on Vegetative Growth, Plant Greenness, or Tissue Nitrogen

Carolyn DeMoranville^{*1} and Joan Davenport², ¹University of Massachusetts Cranberry Experiment Station, East Wareham, MA and ²Washington State University IAREC, Prosser, WA

A standard value of 0.9% to 1.1% N in tissue has been established as the normal range for cranberry shoot tip samples collected late in the season. Recently, a survey (30 sites, four cultivars, mid-month in June, July, August) was conducted over a 4-year period comparing tissue N, SPAD Meter readings, length of new upright growth, yield, and fertilizer use. Length of new growth (from the point of budbreak on the old tissue) could be used as an indicator of cranberry N status in the month of June up until early bloom. Length at this developmental stage was positively correlated with subsequent yield. From hook stage through early bloom, recommended standard lengths were as follows: 'Early Black', 50 to 60 mm; 'Howes', 45 to 55 mm; 'Stevens', 60 to 70 mm; 'Ben Lear', 55 to 65 mm. The SPAD Meter proved to be a viable alternative to in-season monitoring of cranberry tissue N. Readings below proposed standard values indicated the need for N fertilizer if vegetative growth was normal. SPAD Meter readings could be used to determine if tissue N was in the normal range by reading old or new leaves in June and July. However, in August, only diagnostic readings on new leaves were recommended. High readings in old leaves in August were associated with poor crops the following year. DeMoranville: e-mail carolynd@umext.umass.edu; phone (508) 295-2212 ext. 25.

Effects of Plant Age on Nitrogen Uptake and Distribution by Greenhouse Plants

Touria El-Jaoual* and Douglas Cox, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Water-soluble nitrogen (N) fertilizer is used intensively in greenhouse crop production. Any N not used by a crop is subject to leaching as nitrate ($\text{NO}_3\text{-N}$), which may pollute groundwater. A close correlation between N supply and N uptake by plants would increase the efficiency of N fertilization and minimize the possibility of $\text{NO}_3\text{-N}$ pollution. The objectives of this study were to measure N uptake by American marigold (*Tagetes erecta* L. 'First Lady') and New Guinea impatiens (NGI) (*Impatiens hawkeri* Bull. 'Selenia') during growth to determine the effect of plant age on N uptake, determine if the two species have a preference for $\text{NO}_3\text{-N}$ or ammonium ($\text{NH}_4\text{-N}$), and determine the total N required for 70 days of growth. The plants were grown in solution culture using solutions supplying 120 mg each of $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$. At 10-day intervals, six cultures were chosen at random for nutrient solution analysis and plant sampling for dry weight and tissue analysis. Nitrate-N uptake was greater than $\text{NH}_4\text{-N}$ uptake throughout the experiment for both marigold and NGI. Total N uptake by marigold was greater during the first 50 days after transplanting with maximum N uptake during the period 30 to 50 days. In contrast, N uptake by NGI was greater during the period 40 to 70 days after transplanting. Maximum N uptake for NGI occurred during the period 60 to 70 days. Results of this study suggest that early N fertilization of marigold could be more important for their growth and quality than N applied later. For NGI, N fertilization later in the crop's development appears to be more important than early on. The total N absorbed by marigold during the experiment was 1.1 g N/plant; for NGI the quantity was 0.5 g N/plant. E-mail teljaoual@pssci.umass.edu; phone (413) 545-3083.

Quantifying Stem Elongation in Oriental and Asi-florum Lilies

Paul R. Fisher^{*1}, Royal D. Heins², Bin Liu², and Linda Bilodeau¹, ¹Department of Plant Biology, University of New Hampshire, Durham, NH 03824; ²Department of Horticulture, Michigan State University, East Lansing, MI 48824

Our objective was to quantify the stem-elongation patterns of

several Oriental and Asi-florum lily cultivars to develop graphical tracking charts where actual crop height can be compared visually against a target growth curve. Oriental lilies ('Mona Lisa' and 'Stargazer') were grown in research greenhouses at Michigan State Univ. (MSU) during 1994 and 1995. Asi-florum lily cultivars ('Centurion', 'LA-87', 'Non-stop', 'Salmon Queen', and 'Salzburg') were grown at MSU in 1995. Plants received constant 20 °C from emergence to flower in 1995, and constant 15, 18, 21, 24, or 27 °C in 1994. Elongation of Oriental lily plants followed a sigmoid pattern. Oriental lily cultivars elongated rapidly after emergence until 60% of the relative time between dates of emergence and first open flower, at which time plants had achieved ≈82% ('Stargazer') or 85% ('Mona Lisa') of their final height; elongation then exhibited a plateau phase. In contrast to the Oriental lilies, Asi-florum cultivars consistently exhibited a more constant elongation rate throughout the growing period. Simplified graphical tracking curves were developed based on the patterns of elongation and were programmed into a computer decision-support system ('UNH FloraTrack'). The graphical tracking curves were tested by growing 'Stargazer', 'Mona Lisa', and four Asi-florum cultivars ('Donau', 'Dream', 'Moneymaker', 'Spirit') at the Univ. of New Hampshire and MSU during 1997 to height specifications of 51 to 56 cm (including a pot height of 15 cm). Sumagic growth retardants were applied as a prebulb dip at 5 ppm and as a foliar spray at 3 ppm when plant height was above the target curve. Final height targets were achieved using this method. E-mail prf@hopper.unh.edu; phone, (603) 862-4525.

Evaluation of Tomatillo (*Physalis* spp.) Germplasm Suitable for Culture in Northern States

Rosanna Freyre* and J. Brent Loy, Department of Plant Biology, University of New Hampshire, Durham, NH 03824

The objectives of this research were to 1) evaluate and characterize existing accessions and commercial varieties of *Physalis* and 2) select desirable germplasm for future breeding attempts. Twenty-eight accessions of *Physalis* obtained from the Plant Genetic Resources Unit at Geneva, N.Y., and 11 cultivars from commercial seed companies (five tomatillos, *P. ixocarpa*; six other species) were used. Seed was sown in a greenhouse on 1 May 1997, and 20 seedlings per genotype were transplanted on 6 June at Kingman Research Farm, Univ. of New Hampshire, Durham. Two replicated plots of 10 plants each were used in a completely randomized design, with 1.8-m rows and 0.6-m spacing between plants. Plots were broadcast fertilized prior to planting, and black plastic mulch and drip irrigation were used. No pesticides were used except one application of Carbaryl early in the season to control Japanese beetle. The plants grew very vigorously and showed practically no symptoms of disease or pest problems. Manual harvests were performed continuously from 20 Aug. until 25 Sept., taking data on total weight and number of fruits per plot. After the first harvest, it was decided to limit the harvest to 12 genotypes of tomatillo with highest yields. Yields and flavor of fruits from other species were not considered satisfactory and were not harvested. A total of three harvests were performed. Average yields ranged from 16.1 to 57.7 mT·ha⁻¹. Among the commercial cultivars, the tomatillo obtained from Burpee showed the highest yields and uniformity within plots. Six accessions (two identified as *P. ixocarpa*, four as *Physalis* sp.) had yields comparable to that of commercial varieties. Selected genotypes were propagated by cuttings and are being maintained in a greenhouse. E-mail rf@hopper.unh.edu; phone (603) 862-1912.

Effect of Leaf Age and Shading on the Phenolic Composition of Apple Foliage

M. Elena Garcia*, C.R. Rom, and J.B. Murphy, University of Vermont, Burlington, VT 05404-0082

Two experiments were conducted to determine the effects of leaf age and shading on the phenolic content and composition of apple foliage. In the first study, it was determined that the phenolic content of 'Liberty', at increasing leaf developmental stages, was leaf age-dependent. Early during leaf development, there was an increase in the phloridzin (the primary glycoside identified) and in total phenolics, reaching a maximum when the leaf is 6 days from 20-mm blade length. After this stage, the phenolic content decreased with increasing leaf age. In the second study, the leaves of two cultivars, 'Liberty' and

'Starkspur Law Rome', were tagged weekly when the leaf was two-thirds unfolded. Three weeks after budbreak, the trees were placed under three shade cloth treatments (0%, 60%, and 90% shade). After 4 weeks under the shade treatments, the tagged leaves were collected to determine their phenolic content. Shade significantly affected the foliar phenolic content. Leaves in 0% shade had the highest phenolic content, whereas the lowest content was found in leaves exposed to 90% shade. There was a significant leaf age × shade interaction. The phenolic content decreased with increasing leaf age except for those leaves whose development occurred before the experiment was started. The results indicate that light and leaf developmental stage are important factors in determining the phenolic content of apple leaves, but shading appears to have a stronger influence than leaf developmental stage. E-mail mgarcia@zoo.uvm.edu; phone (802) 656-2824.

Seasonal Variation in Nutrient Uptake and Nitrate Content of Hydroponic Lettuce

M.P.N. Gent*, Connecticut Agricultural Experiment Station, New Haven, CT

In winter, lettuce grown in hydroponic solution can accumulate a high nitrate concentration in leaf tissue. We grew lettuce in spring, summer, and fall, in a standard hydroponic solution and in one that was half-strength in all nutrients, to compare growth rates, composition of leaves, and the uptake of nutrients. Lettuce reached marketable size 4 weeks after transplanting in summer but took three times longer in December. Plants grew faster when supplied with standard solution compared to dilute solution, and this difference was more significant in fall than in summer. The concentration in leaves of total reduced nitrogen did not change with time of the year, but nitrate varied from a low of 0.2% by weight in midsummer to as much as 2.2% in December. Lettuce grown in dilute solution had less nitrate in plant tissue. Uptake of nutrients during the day was faster in summer than in winter. A slow uptake of nutrients continued in the dark, although transpiration of water was negligible. The uptake of nutrients in the dark was the likely cause of nitrate accumulation in lettuce grown in winter. Phone (203) 789-7249.

Evaluation of New and Promising Apple Cultivars for New England

Duane W. Greene*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Over 225 apple cultivars grown at the Horticultural Research Center in Belchertown have been evaluated for fruit quality and fruit characteristics. Methods used to determine fruit characteristics and organoleptic assessment will be presented. The postharvest potential of the most promising apples will be presented. Two apples ripen about the first of September and show promise for early market. 'Sansa' is a medium-sized red apple that ripens about the first of September. It is a high-quality apple with characteristics similar to 'Gala'. 'Ginger Gold' is a large, firm, mild-flavored, russet-free, yellow apple. 'Honeycrisp' is a red apple that ripens in mid-September, before 'McIntosh'. It is a large, mild-flavored apple that is sometimes erratic in red color development. It maintains firmness and explosive crispness out of storage better than any other apple evaluated. 'Golden Supreme' is an extremely attractive, russet-free 'Golden Delicious' type ripening 7 to 10 days before 'Golden Delicious'. When ripe it has a very aromatic, fruity flavor. It stores better than 'Golden Delicious'. Other apples with merit that have commercial potential include: 'Hampshire', 'Shizuka', 'Cameo', 'Creston', 'Coop 25', 'Coop 29', and 'Braeburn'. 'Pink Lady' is a very late maturing, new cultivar that is being heavily planted in other areas. Although it does mature here, based upon starch rating, fruit size is small, the flesh is dry and very tart, and taste is only fair.

An Evaluation of Peach and Nectarine Cultivars for Massachusetts Orchards

Karen I. Hauschild*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003-8010

As Massachusetts apple growers look for additional sources of income from their farming operations, interest in and potential for increasing acreage of peaches and nectarines is spreading. Growers

had been relying on information from researchers in other states or from nurserymen to choose cultivars to plant. In 1990, we planted our first block of peach and nectarine cultivars to determine their suitability for our growing conditions, and to assist our growers with their choices of cultivars. Three additional plantings have been added since 1990. Fourteen yellow-fleshed and five white-fleshed peaches and eight nectarines were evaluated during the 1997 harvest period. Criteria evaluated included weight, diameter, fuzziness, split pitting, freeness of pit, color, flavor, texture, and overall quality. Average fruit size of all of the cultivars evaluated was >2.5 inches, with 13 samples reaching 3.0 inches or larger. Since the majority of the Massachusetts peach crop is sold at the retail level, our growers are looking for 3-inch or larger fruit. Of the yellow-fleshed peaches evaluated, 'Sentry', 'Flavorcrest', 'Bounty', 'Salem', 'Jim Dandee', 'Madison', 'Encore', and 'Fayette' averaged >3 inches in diameter and had acceptable fruit appearance and quality. 'Earlscarlet' and 'Fantasia' continue to be the more impressive of the nectarines, having good size, excellent color, and exceptional fruit quality. Of the white-fleshed peach cultivars evaluated, 'Summer Pearl' has been the most impressive in terms of fruit quality. It also has fruited longer. E-mail haushild@umext.umass.edu; phone (413) 545-5304.

Breeding Early Blight Resistance for Tomato in Massachusetts

David L. Holm* and Robert Bernatzky, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Early blight disease on tomato, *Lycopersicon esculentum*, is caused by *Alternaria solani*, a fungus that primarily affects plants experiencing stress due to adverse growing conditions and heavy fruit loads. *A. solani* spreads rapidly under conditions of heavy dew and humid, damp weather which frequently occur during Massachusetts summers. Early blight appears as spots and cankers on tomato fruit, stems, and foliage. Host plant resistance to *A. solani* is exhibited by several lines of wild tomato relatives, including *Lycopersicon hirsutum*. Breeding efforts at North Carolina State Univ. to incorporate this resistance by making crosses to the wild tomatoes and then making backcrosses to *L. esculentum* have resulted in advanced breeding lines. These initial lines showed some resistance but have later maturity and lower yields than current commercial cultivars. Field evaluations of yield and early blight resistance were completed for 22 cultivars and advanced breeding lines in 1992 and 20 cultivars, advanced breeding lines, and new crosses in 1993. The new crosses in the 1993 trial were made between high yielding, susceptible lines and lower yielding, resistant lines as evaluated in 1992. Two of these crosses, NC-EBR1 x JETSTAR and 88B231 x SUNRISE, were selected to be used in single seed descent and bulk breeding programs. David L. Holm phone (413) 545-2917, e-mail dholm@hamp.hampshire.edu; Robert Bernatzky phone (413) 545-5222, e-mail rb@pssci.umass.edu

Yield Response of Butternut Squash to Sidedress Application of Nitrogen at Various Soil Nitrate Test Levels

John C. Howell*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Guidelines for the use of the pre-sidedress soil nitrate test (PSNT) have been established in sweet corn (*Zea mays*). Similar guidelines should be useful to growers in optimizing nitrogen (N) use in other vegetables. The purpose of this work was to establish a soil N threshold for butternut squash (*Cucurbita moschata*), above which there is no positive crop response to additional N application. To test crop response to sidedress applications of N over a range of soil nitrate levels, plots were established in pairs in commercial butternut squash fields. Six-inch sample cores for the PSNT were taken several days prior to sidedressing, which is about the time the vines start to run. Sidedress N applications were made by the grower. In each field, one plot received no N and the other received N at 50 kg-ha⁻¹. The yield of the plot with the N treatment was compared with the nontreated plot. In fields where the PSNT values were at or above 68 mg-kg⁻¹ N, plots receiving sidedress N had lower yields than those receiving no N. In fields with N levels at 41 mg-kg⁻¹ or lower, there generally was a higher yield in the sidedressed plots. None of the fields in this study had N levels between 41 and 68

mg-kg⁻¹ at the time of sampling, but it is likely that the threshold is within this range. E-mail howell@umext.umass.edu

Reduction of Toxicity of Immature Composts

Yifan Hu* and Allen V. Barker, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Uses of immature composts are difficult due to wide C:N ratio, high NH₄ content, and phytotoxins, such as phenols and low molecular weight organic acids. This research focused on toxicity from high NH₄ content. A compost of biosolids and wood chips was used. The compost was treated with (NH₄)₂SO₄ to 2000 mg N-kg⁻¹ (dry weight) to simulate an immature compost. The same compost without any external NH₄ was used as a mature compost. Different proportions (regimes) of compost and soil provided 1/3, 1/6, and 1/12 compost (by volume). Each regime received potassium treatment at 0 or 0.6 g K-kg⁻¹ as KCl. A nitrate treatment, at the same N rate as NH₄ in immature compost, was factored into both mature and immature composts. For the mature compost, adding K generally decreased tomato (*Lycopersicon esculentum* Mill.) growth (measured by shoot mass) regardless of regimes. Adding Ca(NO₃)₂ to mature compost greatly increased plant growth for the regimes of 1/6 and 1/12. When the regime was 1/3, this increase diminished. For the immature compost, adding nitrate restricted plant growth due to excessive amount of N, including already high amounts of NH₄. This response was especially true for the 1/3 regime. Adding K to immature compost greatly increased plant growth for the regimes of 1/3 and 1/6; K suppressed plant growth at the regime of 1/12. The results indicated that using K properly can effectively reduce immature compost toxicity due to high amount of ammonium. E-mail barker@pssci.umass.edu

Heavy Metals and Seed Germination in Medicinal and Aromatic Plants

Ekaterina A. Jeliakova*, Valtcho D. Jeliakov, Lyle E. Craker, and Baoshan Xing, Department of Plant and Soil Sciences and Department of Biology, University of Massachusetts, Amherst, MA 01003

Phytoremediation has been suggested as a solution to heavy metal-polluted soils, but the choices of suitable plant species for phytoremediation have been limited. Medicinal and aromatic plants appear to be excellent selections for these plantings, since these plants are grown for economically valuable secondary products (essential oils), not for food or feed. Preliminary research indicates that heavy metals are not accumulated in essential oils, permitting the oil to be used commercially. Productivity of some, but not all aromatic plants was reduced, however, by the heavy metals. The objective of our experiment was to distinguish the mechanism of heavy metal tolerance of plants using germinating seeds of medicinal and aromatic plant species. Seeds from medicinal and aromatic plants were germinated in solutions with selected levels of heavy metals (cadmium at 6 and 10 µg-L⁻¹; copper at 60 and 150 µg-L⁻¹; lead at 100 and 500 µg-L⁻¹; zinc at 400 and 800 µg-L⁻¹) and in distilled water. Tests on *Anethum graveolens* L., *Carum carvi* L., *Cuminum cyminum* L., *Foeniculum vulgare* Mill., *Pimpinella anisum* L., *Ocimum basilicum* L., and the hyperaccumulator species *Brassica juncea* L. and *Alyssum bertolonii* established that different plant species reacted in different ways to the heavy metals. For example, cadmium did not decrease seed germination of *Alyssum*, *O. basilicum*, and *B. juncea* compared with germination in water but did decrease germination of *C. cyminum*. Lead did not affect germination of *A. bertolonii* and *B. juncea* as compared with water but did negatively affect germination of *P. anisum*, *F. vulgare*, and *C. cyminum*. Except for *B. juncea*, *F. vulgare*, and *C. cyminum*, copper had a negative effect on germination. Zinc decreased germination in all tested species except *B. juncea*.

Nitrate Uptake and Utilization in Shoots and Roots of Four Turfgrasses

Zhongchun Jiang* and Richard J. Hull, Department of Plant Sciences, University of Rhode Island, Kingston, RI 02881

Breeding programs can be developed to produce turfgrass varieties

that utilize N efficiently if metabolic traits leading to efficient N utilization are identified. To achieve this objective, we selected four turfgrass species that differ in N use efficiency and compared nitrate uptake rate (NUR) by roots and nitrate reductase activity (NRA) in shoots and roots. Grasses were grown in modified Hoagland's nutrient solutions. NUR was determined by monitoring nitrate depletion in the solutions. NRA was assayed using an *in vivo* method. NUR was significantly higher in 'Merit' Kentucky bluegrass, an inefficient N user, than in 'Cheyenne' bermudagrass, an efficient N user. 'Tribute' tall fescue and 'APM' perennial ryegrass, two grasses intermediate in N use, were in-between. Shoot NRA showed a similar pattern of variation, with 'Merit' significantly higher than 'Cheyenne'. Root NRA showed less variation. 'Cheyenne' had a significantly higher proportion of nitrate reduced in its roots (>60% of plant total) than did 'Merit' (<10%), suggesting that greater partitioning of nitrate reduction to roots might contribute to more efficient utilization of nitrate-N by bermudagrass. E-mail zjia8399@uriacc.uri.edu; phone (401) 874-5994.

Potential Role of Apple Peel Phenolics in Superficial Scald Development

Z. Ju and W.J. Bramlage*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA

Cuticle scraped from apple peel contained both free and bound phenolics, and cuticle enzymatically isolated from peel contained much greater amounts of them. Both free and bound phenolics inhibited linoleic acid oxidation, but free forms had $\approx 50\%$ higher activity. Free and bound phenolics had $\approx 75\%$ and 50% , respectively, of diphenylamine's antioxidant activity on a molar basis. Cuticle possessed little lipid-soluble antioxidant activity, but surface cells contained four to seven times the activity of cuticle. In a model system, free cuticular phenolics strongly inhibited farnesene oxidation in hexane during 4 months at 25°C , but lipid-soluble antioxidants did not. Both free and bound cuticular phenolics increased during maturation. During 0°C storage, free forms doubled during 15 weeks, then remained constant, while bound forms did not change. Cellular phenolics fell during maturation and storage, reducing browning potential in the cells. These changes all correlated with changes in C_2H_4 production. When C_2H_4 was inhibited by AVG spray and low- C_2H_4 storage, little or no change occurred; when promoted by ethephon spray or high- C_2H_4 storage, phenolic changes were accelerated. Farnesene and cuticular phenolics were positively correlated but conjugated trienes, cellular phenolics, and scald negatively correlated with C_2H_4 . We believe that C_2H_4 effects on phenolics may be closely related to scald development.

An Environmentally Modified, Vertical Growing System for Intensive Strawberry Crop Production

Nicholas G. Karakoudas*, Otho S. Wells, J. Brent Loy, and William G. Lord, Department of Plant Biology, University of New Hampshire, Durham, NH 03824

The vertical growing system consists of columns of stacked, 8-inch square polystyrene pots. Each pot was rotated 45° from the pot below, leaving the four corners open for planting. The system was a $14' \times 36'$ passive solar-heated greenhouse (high-tunnel), consisting of greenhouse plastic stretched over a metal frame. High-tunnels provide for earliness and high yields in strawberry production by capturing and storing early spring warmth. They also protect from wind, disease, and predation. The vertical growing system allows for maximum plant density by fully utilizing the area in the high tunnel. Each of four rows contained nine plant columns supported by metal rods. A total of 252 pots, of four plants each, were evenly distributed. The final planting density was 12.4 times greater than that of field-grown strawberries. Fertigation through drip emitters allowed conservative use of water and precise nutrient application in a recirculating system. Three-week-old plug plants were used in the fall planting for harvest in the following spring. Rotating column bases promoted even light distribution over the crop. A bumblebee colony ensured high pollination rates. The effectiveness of two insulating materials, Typar 518 and a $1/4''$ closed-cell polyethylene foam, were evaluated for overwintering and

spring frost protection. Overwintering methods included wrapping plant columns, covering planted pots on the tunnel floor, and a late winter-early spring planting. Black vs. white pot color effect on plant growth was examined.

Ethylene Induction of Flowering and Gel Analysis of Apex Proteins in Dutch Iris 'Telstar'

Yan-Li Li, Robert Bernatzky, and Susan S. Han*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Nonflowering-sized Dutch iris bulbs 'Telstar' were treated at 20°C in a flow-through system with ethylene-free air or air containing $10 \mu\text{L}\cdot\text{L}^{-1}$ of ethylene (C_2H_4) for 1 or 24 hours. Following the treatment, bulbs were placed in a 10°C cooler for 5 weeks before planting and subsequently forced in a 20°C day/ 18°C night glasshouse. Results demonstrated that a 24-hour C_2H_4 treatment induced earlier flowering as well as percent flowering. Flowering responses of bulbs treated with C_2H_4 for 1 hour were the same as those treated with air. The 24-hour ethylene treatment did not affect the combined fresh weight of the daughter bulb and bulblets but reduced the number of bulblets produced by each. The effects of ethylene on the protein changes in the apex were examined at two time periods: immediately after the treatment and after the cold treatment. Each sample consisted of proteins extracted from three apices. There are significant changes in one-dimensional SDS PAGE protein patterns of bulbs apices after treatment with ethylene. However, the differences are apparent after only 1 hour of ethylene treatment. The cold treatment resulted in minimal further changes in protein patterns.

Germination Procedures and Successes of the Unique Blister Run West Virginia Population of *Abies balsamea*

Carol L. McCarthy*, West Virginia University, Morgantown, WV 26506-6108

A local population of (*Abies balsamea* Mill.), referred to by growers as Canaan Fir, has become a popular variety for Christmas tree production. Germination procedures with varying stratification times are compared to X-ray and cut-test estimations of germination percentage. Recommendations for optimal stratification times are discussed.

Pregermination Methodologies Enhance Fescue Establishment and Survival on Banks and Hillsides

Annamarie Pennucci*, Northeast Turf and Ornamental Research, Milford, NH 03055

Water immersion treatments with or without nitrogen sources were evaluated for their effects on various spring-seeded turfgrass germination parameters. Doubling immersion incidence, increasing immersion time to 48 hours, increasing rinse frequency to 4-hour intervals, or prolonging dry down decreased the time required for germination and second leaf emergence in fine-leaved *Festuca* sp. Increasing time between immersion and planting from 48 hours to 2 weeks increased germination; intervals longer than 30 days decreased germination and establishment. All pregermination treatments improved seedling density, vigor, and color. Under moderate maintenance, turf quality at 4, 6, or 9 months was unaffected by pregermination treatments. Under low maintenance, pregermination treatments effects were evident for 9 months. Pregermination treatments reduced incidence and severity of soil erosion, minimized weed encroachment, and reduced incidence and severity of seedling diseases. Low levels of urea improved germination, establishment, and vigor. Any level of ammonia resulted in nearly total fatality. Pregermination techniques speed establishment of fine fescue on low-maintenance banks and hillsides or on recently disturbed sites.

Broadleaf Weed Control in Field-grown Herbaceous Perennials

Annamarie Pennucci*, Northeast Turf and Ornamental Research, Milford, NH 03055

Novel and standard herbicides were applied alone, sequentially, or tank-mixed to determine weed control efficacies and tolerances in 15

species of field-grown herbaceous perennials. Autumn applications provided excellent but short-term broadleaf (BL) and annual grass (AG) weed control. Early spring applications were equally effective and of longer duration. Mid- and late spring treatments provided moderate to poor control of AG and poor control of winter perennial BL. Single applications of prodiamine provided season-long control of AG and of spring germinating BL. Greatest number of weed species were controlled by DCPA. Increased duration occurred with tank-mixes of DCPA + pendimethalin, DCPA + quinclorac. Quinclorac provided excellent pre/post control of AG and some BL. Crop injury was minimized with directed applications. Isoxaben provided excellent preemergent control of BL. Tank-mixes improved AG control. Treatments applied prior to, or at the same time as mulch applications increased weed control and lessened drought stress. Treatments applied over mulch were less effective, suppressed fewer weed species, were of shortened duration, and increased the likelihood of crop injury.

Production of Horticultural Crops on Reclaimed Mineland

Mark D. Sherratt*, Bradford C. Bearce, Jeffry G. Skousen, and Joseph B. Morton, West Virginia University, Morgantown, WV 26506-6108

Apple, peach, blackberry, raspberry, cabbage, cantaloupe, bean, tomato, red maple, juniper, yew, viburnum, and boxwood were planted in two soils, a yellow overburden (YO) and a soil manufactured from crushed shale (MS), in a reclaimed surface mine in southern West Virginia. Treatments at planting time were 454 kg·ha⁻¹ of 10N-4.4P-8.9K fertilizer + ≈2.5 cm of sphagnum peat (F + P) or 250 mL of micorrhizal fungi inoculum + peat (M + P) mixed into the planting hole. Both soils were low in organic matter (0.9%) and N (3.0 mg·kg⁻¹). The MS had a pH of 7.7, while the YO had a pH of 5.0 and was low in Ca (16 mg·kg⁻¹). Peach grew best and tomato yielded best in the F + P treatment, while viburnums responded more to M + P. Roots of all species in all treatments including noninoculated sampled nine months after planting were found to be infected with one or more of the *Glomus* sp., with which they had been inoculated. A noninoculated species of *Glomus* was also found on some roots.

Production of Bedding and Greenhouse Snapdragons in Growing Media Containing Coal Bottom Ash

Mark D. Sherratt*, Curtis P. Gore, and Bradford C. Bearce, West Virginia University, Morgantown, WV 26505-6108

Five cultivars of greenhouse snapdragon (*Antirrhinum majus* L.) were grown in media containing 0%, 25%, 50%, 75%, or 100% coal bottom ash (CBA). Stem length of 'Winter Yellow' was reduced at 100% CBA. Spike length, number of open florets, and number of buds were reduced at 25% CBA for 'Maryland White and Yellow Bicolor'; at 50% CBA for 'Monaco White', 'Winter Yellow' and 'Maryland Plumblossom'; and at 75% CBA for 'Maryland Red'. Fresh weight was reduced at 25% CBA for 'Maryland Red' and 'Maryland White and Yellow Bicolor'; and at 50% CBA for 'Maryland White', 'Winter Yellow', and 'Maryland Plumblossom'. Number of days to harvest was increased for all cultivars at 100% CBA. L*, a*, b* color values were not affected by CBA level. Performance of all cultivars in 0% to 75% CBA fell within height and flower per spike grade standards for snapdragons, while weight per spike was within grade standards in 0% to 50% CBA. 'Apricot Floral Showers' snapdragons grown in 10-cm pots were reduced in flower bud number, height, and plant diameter at 50% to 100% CBA.

Effect of Dolomite and 'Photomag' on Nutrient Status of Lowbush Blueberry

John M. Smagula*, Walter Litten, and Scott Dunham, Horticulture Program, University of Maine, Orono, ME 04469

Two commercial lowbush blueberry fields in Washington county were used in this study. At Brook Lot, 1.5-m × 46-m treatment plots received fluid dolomite (1670 kg·ha⁻¹) or combinations of dolomite and PHOTOMAG at 5, 10, or 15 kg MgO/ha as foliar sprays when plants reached three-quarters full growth in late June 1996. At Pike Brook, 1.5-m × 23-m treatment plots received the same treatments plus

a 10 kg MgO/ha only treatment. Nontreated plots served as controls in a randomized complete-block design with eight replications at each location. At Brook Lot, leaf Mg concentrations were raised by all treatments compared to the control. At Pike Brook, PHOTOMAG alone showed little effect on soil pH and soil Mg concentration and was ineffective in raising leaf Mg concentrations in combination with dolomite to higher levels than dolomite alone, except at the highest rate (15 MgO). Although leaf Mg concentrations were raised, no measurable changes in plant growth characteristics, potential yield, or harvestable yield were found. Applying dolomite and/or PHOTOMAG to a field deficient in Mg might have resulted in different results.

Fertigation Research with Apple Trees

Warren C. Stiles*, Department of Fruit and Vegetable Science, Cornell University, Ithaca NY 14853-5909

Studies initiated in 1986 indicated beneficial effects on growth and cropping of young apple trees from trickle irrigation plus soil application of nutrient elements or fertigation with a weekly multielement complement. In 1993, an orchard facility was established to evaluate responses to alternative sources, rates, and methods of application of K, Zn, or Cu. Results of two separate experiments with K indicate the following: 1) Application of K at 112 kg·ha⁻¹ per year increased growth and yield of 'Marshall McIntosh' /M.9 and 'Royal Empire' /M.9 trees. Differences between soil surface and two fertigation regimes and between KCl and KNO₃ were nonsignificant. 2) There were no differences among three sources of K (Cl⁻, NO₃⁻, SO₄²⁻) at three rates (37, 75, or 112 kg·ha⁻¹ per year) applied in 16 weekly fertigations. All rates of K increased tree growth and yield in years 1 to 3. As cropping increased, rate effects tended to increase up to 75 kg K/ha per year. In the first 4 years, fertigation with EDTA chelates of Zn or Cu have been more effective than sulfates in increasing leaf Zn or Cu, but effects on tree growth and yield have not been significant. Results indicate no significant advantage of fertigation over conventional methods of application for K, Zn, or Cu as long as trees are irrigated adequately. E-mail wcs5@cornell.edu; phone (607) 255-1779.

Born Naked: The Development of Hull-less Pumpkin Seeds

Kelly J. Vining* and J. Brent Loy, Department of Plant Biology, University of New Hampshire, Durham, NH 03820

In Summer 1997, a field study was conducted on seed development in hull-less seeded pumpkins (*Cucurbita pepo* L.). Two hull-less seeded cultigens and a hybrid resulting from them were used to determine rates of dry biomass accumulation in developing seeds and partitioning of biomass among seed organs (embryo, endosperm, and seed coat). Developmental changes in fruit size and skin color patterns were observed and related to stages of seed maturity. Microscopic examination showed that most embryos were not fully expanded until 30 to 35 days post-anthesis (PA). Endosperm was detectable between 10 and 35 days PA. Seed coat biomass peaked at ≈20 days PA, comprising 89% to 96% of total seed dry weight at that time. Dry biomass of embryos accumulated most rapidly between 20 and 50 days PA, and at seed maturity comprised 86% to 93% of the total seed dry matter. In fruits harvested 10 to 20 days prematurely and stored in the greenhouse (18 to 30 °C) for 10 days, total seed dry biomass increased, depending upon cultigen and time of harvest.

ReTain Effects on Fruit Size, Maturity, and Storage Quality of 'Jonagold' Apples

Chris B. Watkins¹*, Randolph M. Beaudry², Terence L. Robinson³, and Alan N. Lakso³, ¹Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853; ²Department of Horticulture, Michigan State University, East Lansing, MI 48824; ³Department of Horticultural Sciences, New York State Agricultural Experiment Station, Geneva, NY 14456

ReTain™, a commercial plant growth regulator containing aminoethoxyvinylglycine, an inhibitor of ethylene production, was applied 4 weeks before normal harvest to 'Jonagold' trees and the effects on fruit maturity and quality at harvest, and quality after air and controlled atmosphere storage was investigated. When fruit were harvested from

3 to 6 weeks after treatment, fruit ripening was inhibited as indicated by lower internal ethylene concentrations, delayed starch hydrolysis, and lower levels of skin greasiness. A number of factors indicated that other aspects of fruit metabolism were affected by the compound. Treated fruit were softer than nontreated fruit at the first harvest, and the benefits of ReTain on firmness appeared only at the later harvests. Also, at each harvest date, average fruit weight of ReTain-treated fruit was lower than nontreated fruit. We have investigated the possibility the ReTain and/or the accompanying surfactant, Silwet, inhibited leaf photosynthesis, thereby leading to altered carbon metabolism. Trees were unsprayed, or sprayed with surfactant, and ReTain plus surfactant. No treatment effects on photosynthesis were detected. However, leaf photosynthesis rates were generally low and quite variable. Measurements of fruit diameter confirmed that the increase in fruit volume following treatment was $\approx 2\%$ less on the ReTain plus surfactant-treated fruit than nontreated fruit. The increase in fruit volume for the Silwet treatment was $\approx 1.5\%$ less than in untreated fruit. The data indicates a rapid change in fruit volume as fruit changed in color. Inhibition of ethylene by ReTain may be an important factor influencing fruit size.

Forecasting Scald Potential of Delicious Apples in New England

Sarah A. Weis and William J. Bramlage*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst MA 01003

Susceptibility to superficial scald on apples varies with season, orchard location, and time of harvest, and is related to seasonal weather variation. If scald potential could be forecast at the time of harvest, then appropriate antiscald treatment decisions could be made. This could result in 1) reduced use of scald inhibiting diphenylamine (DPA) dips, with their accompanying fungicides and 2) reduced loss of stored fruit due to scald. Analyses of scald-related data collected at the UMass Horticultural Research Center (HRC) from 1986 to 1993 have resulted in development of equations relating scald development to harvest date, number of preharvest days in which the temperature fell below 10°C , and harvest starch score. Equations to identify lots of fruit which were particularly scald susceptible or particularly scald resistant were also developed. These equations were tested in 1995 and 1996 on 'Delicious' apples harvested from orchards throughout New England and stored at the HRC. About 80% of the 182 lots of fruit were placed in the correct susceptibility category. DPA treatments were applied to the Massachusetts fruit in both years, and forecasts were almost 100% effective for determining the appropriate concentration of DPA needed to control scald. Effects of controlled atmosphere (CA) storage on scald development, scald forecasting, and necessary scald control measures will vary according to the atmosphere, but initial data show forecasting trends to be about the same for CA as for air-stored fruit.

Impacts of High Tunnels on Crop Production in New Hampshire

*Otho S. Wells**, Department of Plant Biology, Spaulding Hall, University of New Hampshire, Durham, NH 03824

High tunnels are unheated, walk-in greenhouse-like structures which are used primarily for season extension of high-value crops. They are relatively inexpensive to build and maintain, but require manual labor for ventilation. Research with high tunnels at the Univ. of New Hampshire began in 1987 after assessing the international use of these structures. Because of the retail value of tomatoes, this has been the primary crop grown in tunnels. The average earliness of tomatoes is 1 month compared to field tomatoes. In 1988 in New Hampshire, there were $15\ 14' \times 96'$ commercial high tunnels used for tomato production, with a gross income of $\approx \$45,000$. In 1997 the number of tunnels had increased to ≈ 160 units with a gross income of $\approx \$912,000$. Over the 10-year period, the cumulative income for commercial growers is estimated at $\$3.63$ million. Because of earliness, this represents additional income to growers. Another very

important benefit of high tunnels is the almost total reduction in diseases that are common in field production. Early blight, a serious field disease requiring several fungicide applications for control, is essentially nonexistent in high tunnels. Besides tomatoes, many other crops grow well in tunnels: pepper, summer squash, cucumbers, melons, lettuce and other salad crops, root crops, strawberries, and flowers. Although insects may be a problem, most of them can be controlled biologically. Particularly beneficial, especially for young, new-entry growers, is the relative low cost of high tunnels, $\approx \$1.50$ /square foot.

Effect of Benzyladenine on Apple Fruit Thinning and Its Mode of Action

Rongcai Yuan and Duane W. Greene*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Benzyladenine (BA) applied at the 10-mm stage at 50 and 100 $\text{mg}\cdot\text{L}^{-1}$ thinned fruit, increased fruit size, and caused seed abortion. The translocation of ^{14}C -sorbitol from leaves to fruit was promoted by BA application to the fruit, but not when BA was applied to the leaves. Therefore, it is unlikely that BA causes thinning directly by restricting photosynthate movement into the fruit. Net photosynthesis was decreased and dark respiration was increased when temperature following BA application was high (30°C), whereas there was no effect when temperature was lower (20°C). The seed number in abscising fruit was greater in BA-treated fruit than in control fruit. The number of viable seeds in BA-treated fruit was reduced. Tipping the bourse shoot increased fruit set, regardless of BA treatment. Benzyladenine thinned fruit when only one leaf was on the girdled fruiting spur, but not when leaf number was greater than two. Reduction of carbohydrates available for fruit appears to be the primary factor responsible for the thinning induced by BA. E-mail Yuan@pssci.umass.edu

Effect of Root-Applied Glufosinate-Ammonium on Free Ammonium Accumulation in Tomato Plants

Wenqi You and Allen V. Barker*, Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003

Glufosinate-ammonium is herbicidal through inhibition of glutamine synthetase in chloroplasts with the resulting accumulation of phytotoxic levels of unassimilated NH_4^+ . The herbicide is applied normally as a foliar spray at concentrations of 100 to 500 $\text{mg}\cdot\text{L}^{-1}$. Effect of root-applied herbicide on NH_4^+ accumulation was studied in hydroponics. Tomato seedlings (*Lycopersicon esculentum* Mill.) were grown in a nitrate-based solution (Hoagland no. 1) with herbicide added to active ingredient concentrations of 0, 6, 12, 25, and 50 $\text{mg}\cdot\text{L}^{-1}$. In another treatment, an ammonium-based solution was used to assess NH_4^+ accumulation from an external source. Harvest and analyses of plant tissue began with first symptoms of phytotoxicity from the herbicide and proceeded at 3-day intervals until plant death with the most extreme treatments. Free NH_4^+ was extracted by homogenization of fresh tissues in a 1-M KCl-0.02-M CuSO_4 solution. Ammonium was determined by volumetric procedures. By 6 days after treatment, NH_4^+ concentrations in tissues increased curvilinearly from nil to 1.5 mg N/g fresh tissue with increases in herbicide in the solution. Classic symptoms of ammonium toxicity were evident. The 50 $\text{mg}\cdot\text{L}^{-1}$ herbicide concentration was lethal at 6 days after treatment, and the 25 $\text{mg}\cdot\text{L}^{-1}$ concentration was lethal at 12 days when the experiment was terminated. Ammonium accumulation with the lower concentrations of herbicide or with externally supplied NH_4^+ was below phytotoxic levels at the end of the 12-day period. Amassment of NH_4^+ in foliage followed distinctly different patterns with the herbicide or external supply. Accumulation with the herbicide was mainly in the foliage, whereas with the externally supplied NH_4^+ , accumulation in roots exceeded that in shoots with no evidence of phytotoxicity. Results indicate that root-applied glufosinate-ammonium is translocated to shoots where it initiates accumulation of phytotoxic NH_4^+ levels. E-mail barker@pssci.umass.edu