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Fruit Crops

EFFECTS OF CARBON DIOXIDE ENRICHMENT AND IRRADIANCE ON EX VITRO ROOTING, ACCLIMATIZATION AND SUBSEQUENT GROWTH OF MICROPROPAGATED APPLE AND BLUEBERRY.
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Previous findings reveal that rooting and acclimatization of apple and blueberry plants is often difficult, inconsistent and inefficient. This experiment was set up in a fog chamber to investigate the effects of CO₂ enrichment (CDE) and irradiance on unrooted stage II microshoots. Two CO₂ and 3 light levels tested were: 1350 +/- 150 (+ CDE), and 450 +/- 50 (- CDE) ppm; 30 +/- 5 (low), 55 +/- 10 (medium), and 100 +/- 20 (high) $\mu\text{molm}^{-2}\text{s}^{-1}$ respectively. Cultivars assessed were Berkeley and Northsky for blueberry, G65 and NY30 for apple. Blueberry microshoots acclimatized successfully and gave between 90 to 100% rooting and survival rate. Apple microshoots acclimatized and rooted slowly, exhibited great sensitivity to *in vivo* conditions and gave between 40 to 100% rooting and survival rate. High light induced photo-inhibition which disappeared after complete acclimatization. There was a significant difference between low light and the other two light levels. The effect of CDE was dependent on cultivar. In most cases, high light (-) CDE gave the most vigorous growth (highest plant dry weight and leaf area). There was a significant difference between (+) CDE and (-) CDE at low and medium light, but none at high light. Low light (-) CDE and medium light (+) CDE were superior over low light (+) CDE and medium light (-) CDE, respectively. Stalling out in apple microshoots was corrected by GA₃ sprays.

EFFECTS OF ETHEPHON AND DIPHENYLAMINE ON ACCUMULATION AND METABOLISM OF α -FARNESENE AND ON SUPERFICIAL SCALD DEVELOPMENT IN 'CORTLAND' APPLES

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Ethephon treatments had two opposing effects on scald induction. First, synthesis and metabolism of α -farnesene were immediately enhanced, which could increase scald development. Second, during prolonged storage the relative concentrations of two conjugated triene forms (CT281 and CT258) were altered so as to increase the CT258/CT281 ratio, which could reduce scald development. The balance between these responses determined whether ethephon increased or decreased scald. DPA treatment also had two effects, immediately suppressing ethylene and α -farnesene concentrations, and over long periods, suppressing CT281 but increasing CT258 concentrations. Both effects of DPA appeared to reduce scald development. Effects of DPA, as well as of ethephon, were at least partly ethylene-mediated, and treatment with DPA counteracted effects of an ethephon treatment.

EFFECT OF FOLIAR APPLICATIONS OF FISH HYDROLYSATE FERTILIZER OR UREA ON APPLE YIELD AND FRUIT QUALITY

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A study was conducted in 1992 at Highmoor Farm, Monmouth, ME to test the effects of fish hydrolysate fertilizer on fruit set, fruit size and fruit quality of apple. Mature, semi-dwarf 'Delicious' and 'Golden Delicious' trees received 2.76g/l N, supplied by either fish hydrolysate fertilizer or urea, or received no fertilizer (control). Fertilizers were applied via three foliar sprays applied at seven day intervals, beginning at petal fall. Fish hydrolysate fertilizer reduced fruit set of 'Delicious' and 'Golden Delicious'. Foliar urea increased fruit set and yield of 'Golden Delicious'. Neither fertilizer affected mineral nutrient concentrations of leaves collected in July. Fish hydrolysate increased fruit russetting on both cultivars. Fish hydrolysate is not recommended as a foliar fertilizer for apples.

EVALUATION OF NEW APPLE CULTIVARS IN MASSACHUSETTS

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There is a general increase in interest in planting new apple cultivars. The loss of daminozide has provided an additional stimulus for growers in New England to find an alternative to McIntosh. Promising new apple cultivars have been identified from around the world and from breeding programs in Arkansas, British Columbia, New York, New Jersey and the PRI Program. Trees were propagated and planted in a cultivar evaluation block at the University of Massachusetts Horticultural Research Center. In 1992 we evaluated over 80 new cultivars. Fruit assessment consisted of laboratory analysis and visual and sensory evaluation. All cultivars were given an overall rating, and several were identified as being worthy of further evaluation. These apple cultivars include: Arlet, BC 9P 14-32, BC 8M 15-10, BC 17-30, Ginger Gold, Honeycrisp, Kinsei, NJ 55, NY 75414-1, and Sansa.

VARIABLE OXYGEN AND CARBON DIOXIDE CONCENTRATIONS DURING CONTROLLED ATMOSPHERE STORAGE OF 'GOLDEN DELICIOUS' APPLES
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In both experiments, 20-apple samples from 6 commercial orchards were harvested and stored in 208 liter containers at 0C for 4, 6, and 8 months. Additional samples were removed from CA and held at 0C for 14 days before evaluation. Gas composition was measured and controlled 6 times per day using automatic control equipment.

In the first experiment, samples were stored at constant 0.0% CO₂ and one of three O₂ regimes (constant 2.0%, 0.5 rising to 3.5%, or 3.5% falling to 0.5% O₂). Apples stored at 3.5% falling to 0.5% O₂ during the storage period were softer than apples held at

constant 2.0% or those held at 0.5% rising to 3.5% O₂ during the storage period. Variable O₂ concentrations did not influence weight loss during storage and insignificant scald, flesh browning, core browning, rot, and low O₂ injury were observed.

In the second experiment, samples were stored at constant 2.0% O₂ and one of three CO₂ regimes (constant 0%, constant 5%, or 0% rising to 6% CO₂). Constant 5% or rising CO₂ conditions did not significantly influence flesh softening or weight loss during storage. Negligible CO₂ injury was observed.

NUTRITIONAL STATUS OF NEW YORK STATE APPLE ORCHARDS

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A total of 3850 leaf samples from commercial apple orchards located throughout New York State were submitted for analysis during the 1989-1992 seasons. These included 2583 samples from mature, 968 from young bearing age, and 299 from young non-bearing orchards. Percentages of samples (all ages and all varieties combined) found to be below currently recommended levels were: Zn 75%, Cu 74%, B 68%, Ca 63%, K 60%, Mg 60%, Mn 38%, Fe 19%, N 15%, and P 8%. Percentages of samples found to be above currently recommended levels were: N 21%, Zn 16%, Mn 13%, K 6%, B 4%, Mg 2%, Cu <1%, and P <1%. Major problems consist of shortages of Zn, Cu, B, Ca, K, and Mg in 60% or more of all samples analyzed. Seasonal, varietal, pest management program, and tree age effects were apparent in the results, indicating that these factors must be considered in interpreting results of leaf sample analyses into recommendations for fertilization programs.

WARMING APPLES DURING COLD STORAGE: ITS POTENTIAL AS A NON-CHEMICAL PROCEDURE TO REDUCE LOSSES FROM SUPERFICIAL SCALD

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Seeking non-chemical alternatives to use of DPA for scald control on apples, we interrupted storage with a brief warming period. This often reduces chilling injuries of fruit. Warming 'Granny Smith' apples for 5 days at 20 C after 2 weeks at 0 C reduced scald as effectively as a 1000 ppm DPA treatment at that time. To better characterize this response, we tested other timings of the warming period, and also lower warming temperature. Warming at 10 C, or for shorter times at 20 C, or after longer periods at 0 C all were less effective. Maintaining a warm period before storage was not effective. During warming of 'Cortland' and 'Delicious' apples softening and loss of green color occurred, the extent of which increased with warming time and usually was greater if the fruit had initiated the ethylene climacteric before warming.

RELATIONSHIP BETWEEN CIELAB COORDINATES OF PEACH COLOR AND VISUAL RATINGS.

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Fruit of 34 peach (*Prunus persica* L. Batsch) cultivars were harvested at maturity and visually evaluated by panelists on a 1 to 10 scale, where 10 = excellent color. CIELAB coordinates (L* a* b*) of fruit color were measured at the midpoint between the stem and the calyx end with a Minolta CR-200b calorimeter on the blushed and ground areas of each fruit. Simple linear regressions of color coordinates with panel ratings indicated that blush chroma, blush L*, blush hue angle and E* (total color difference between ground and blush) all influence visual color evaluation. Not only does assessing fruit color with a calorimeter permit color to be reported in internationally accepted units, but the relationships indicate that instrumental values relate well to qualitative ratings.

Growth Media

A HYDROPONICS NUTRIENT SOLUTION BASED ON COMMERCIAL FERTILIZER
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Many people want to use hydroponics in production of plants but often are hobbyists with limited access to the reagents necessary to formulate a nutrient solution. Several readily available commercial fertilizers and chemicals with tomato- (*Lycopersicon esculentum* Mill.) as the test plant were used to develop a nutrient solution. A 20-8.8-16.6 IN-P-K general purpose fertilizer was added (1 g/liter) to deionized water to make a basic solution. This solution was fortified with slow-release fertilizer (approx. 17N-2.6P-8.5K with Ca, Hg, and minor elements) at 1 g/liter added directly to hydroponics vessels. Tomato developed severe foliar symptoms of Ca deficiency in this medium. Addition of CaSO₄ or CaCO₃ at 0.5 or 1 g/liter to give a solid phase of these chemicals in the vessels prevented development of symptoms of Ca deficiency; however, plants now showed symptoms of Mg deficiency. Addition of MgSO₄ at 0.25 g/liter to the basic solution prevented symptoms of Mg deficiency. Analyses confirmed that leaf N, P, K, Ca, and Mg were sufficient. This solution was as good as Hoagland's No. 1 solution for growth of tomato, marigold, and cucumber and was better than Hoagland's solution for growth of corn and wheat.

PRODUCTION OF 'SAMANTHA' GREENHOUSE ROSES IN ROOT MEDIA AMENDED WITH COAL BOTTOM ASH AND COMPOSTED HARDWOOD BARK
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Rosa x hybrida 'Samantha' plants were planted in pots of three soilless and two soil-containing media. Soilless media consisted of coal bottom ash and composted hardwood bark in 1:1, 2:1, and 3:1 ratios. Soil-containing media were equal parts soil, peat, and coal bottom ash; and a control of equal parts soil, peat, and sand. Half the pots of each media were treated with a cover crop of *Hordeum vulgare* L. 'Barsoy' to simulate weathering and incorporate additional organic matter prior to planting the roses. Physical and chemical properties of all five original media were examined, and production indices of two harvests were measured; including stem length, flower bud diameter, fresh weight, days to harvest and average number of blooms per plant. Results to date indicate satisfactory growth in all treatments. The three soilless treatments have produced more stems with larger flower bud diameters and shorter days-to-harvest than the soil-containing treatments. However, the fertilization, and electrical conductivity of all treatments remains below normal. Moisture retention data also show the soil-containing treatments to have higher container capacity and easily available water. Cover-cropped plants also had shorter days-to-harvest, but in one of two harvests produced flower buds of smaller diameter.

RESPONSE OF 'ROSEUM ELEGANS' RHODODENDRON TO ROOT MEDIUM AMENDMENTS OF PINEWOOD PEELINGS AND COAL ASH.
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Rooted cuttings of *Rhododendron catawbiense* 'Roseum Elegans' were potted on February 27, 1992, in 1 liter pots containing sphagnum peat moss:composted pine bark:sand:pinewood peelings:coal bottom ash mixed at ratios of 15:70:15:0:0, 15:70:0:0:15, 15:35:15:35:0, 15:35:0:35:15, 15:0:15:70:0 or 15:0:0:70:15 percent volume. Irrigation and fertilization frequencies were recorded from March 18-September 18, 1992. Moisture retention data showed that the high pinewood peeling mixes retained less moisture but that coal bottom ash improved moisture retention when substituted for sand in all mixes. The highest pinewood peeling:ash medium required less irrigation than the other mixes but a higher frequency of acid fertilization. The highest pine bark:sand medium required more neutral fertilization than the other mixes. Numbers of new shoots per plant in the 15:35:15:35:0, 15:0:15:70:0 and 15:0:0:70:15 media were lower than those in the high pine bark:ash mix. Plant heights were lower in the 15:0:15:70:0 mix. Flower buds per plant were higher in the 15:35:15:35:0 medium than in the 15:70:15:0:0, 15:0:15:70:0 or the 15:0:0:70:15 plants. Leaf tissue analysis showed K and Cu to be at deficiency levels in all plants. Boron was higher in all plants grown in ash containing media. Zinc was low in plants grown in high pinewood peelings media.

GROWTH AND FLOWERING RESPONSE OF 'BRILLIANT DIAMOND' POINSETTIAS IN A PEAT VERMICULITE MIX AMENDED WITH COAL BOTTOM ASH. Susan S. Myers and Bradford Bearce, West Virginia University, Morgantown, WV 26506-6108.
Rooted cuttings of *Euphorbia pulcherrima* 'Brilliant Diamond' were planted on July 27, 1992, in 15 cm standard pots containing peat:vermiculite (1:1, v/v) mixed with coal bottom ash (CBA) at 0, 25, 50, 75 and 100 percent of volume. Lime sufficient to adjust pH to an entitled range-of 5.6-6.8 was added to each medium. A 1500 mg/liter Cycocel spray was applied weekly to all plants from August 25 (pinch date) until Sept 28.) Irrigation and fertilization frequencies were recorded. At anthesis (Nov 17), plants were measured and harvested. The 100 percent CBA medium required less irrigation but more fertilization than the 0 percent CBA medium. Heights of plants in the 50, 75 and 100 percent CBA media were less than those in the 0 percent CBA medium. Bract diameters and dry weights of the 100 percent CBA plants were less than those of the 0 percent CBA plants. A quality rating placed the 75 and 100 percent CBA plants below plants in 0, 25, and 50 percent CBA. A yellowing of top leaves occurred beginning in early November and was more noticeable with increase in percent CBA.

EFFECT OF INOCULATION OF NURSERY ROOT MEDIA WITH ENDOMYCORRHIZAL FUNGI ON GROWTH OF VIBURNUM, JAPANESE MAPLE AND BOXWOOD.
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Nursery liners of *Viburnum carlesii*, Hemsl; *Acer palmatum*, Thunb., cv. 'Bloodgood'; and *Buxus sempervirens* L., cv. 'Vardar Valley' were planted in several root media at three P levels which had been inoculated or not inoculated with species of endomycorrhizal fungi. Analysis of extent of root infection (Trypan Blue staining procedure) revealed no root infection or colonization of any of the three species in any root medium. However, maples grown in an inoculated peat:sand (1:1, v/v) medium at .024 g P/liter grew taller than maples in the same non-inoculated medium at .24, .024, or .0024 g P/liter of medium. Mean height of maples in inoculated media were greater than heights of maples in non-inoculated media when height data from all three P levels in each medium were combined. Infection of *Sorghum Sudanese*, (Piper) Stapf, root: was inhibited when media was amended with composted or non-composted pine bark but was not inhibited by pine bark leachates.

KENAF AS A COMPONENT OF SOILLESS GROWTH MEDIA
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Kenaf (*Hibiscus cannabini* L.), native to east Africa, is an annual herbaceous member of Malvaceae cultivated primarily for its bast fibers. One of many potential uses of kenaf is that of a growth medium component. Kenaf stems (xylem plus phloem) were ground and sieved to 2 to 5 mm diameter particles. The particles were combined at various volumetric percentages with other components (perlite, vermiculite, calcined clay) in 70% Sphagnum peat moss which received standard preplant fertilization. To avoid growth suppression, the kenaf must be enriched with nitrogen (soaked in NH_4NO_3 solution for 5 days). Impatiens and tomato bedding plant shoot growth was proportional to both the N concentration of the soak solution and the percentage of N-soaked kenaf in the medium. The N soak solution should be $\text{f } 2000 \text{ mg N/liter}$ with 30% kenaf or $\text{f } 4000 \text{ mg N/liter}$ with 10% kenaf. Physical properties (bulk density, total porosity, air porosity and container capacity) of kenaf media were similar to those of a commercial peat-lite. The optimal medium for bedding plant production was 70% peat + 15% calcined clay + 15% kenaf soaked in 2000 mg N/liter. The N-soaked kenaf served successfully both as a medium bulking component and as a slow-release N supply.

STRAWBERRY GROWTH AND DEVELOPMENT IN THREE MINESOILS AMENDED WITH SLUDGE, HARDWOOD BARK OR A SUDAN-SORGHUM GREEN MANURE CROP.
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Strawberry (*Fragaria x Anaassa* cv. Tribute) plants were planted in 15 cm standard pots filled with overburden soils from three West Virginia surface mine sites. Initial pH levels were 6.5, 4.4, and 3.6. Prior to planting pH levels were adjusted with CaCO_3 to 6.5-6.7 in each soil. Each soil was amended by mixing in 60.85 g/pot (62.5 dry kg/ha) of sewage sludge, Sudan-sorghum hybrid green manure crop, hardwood residues, or unamended. A dry fertilizer (.10-.045-.089, N-P-K) was also mixed into the soil at a rate of 0.5 g/pot (454 kg/ha). Plants were grown from 3-6 to 10-16, 1992, on which date harvests and measurements were performed. The sludge treatments significantly increased fresh and dry weight accumulation, number of leaves, leaf area, and number of runners per plant above that of the control plants. The hardwood residues amendment delayed first date of ripe

fruit and decreased average fruit fresh weight in one of the soils. Hardwood residues also decreased leaf number in another soil. The pH levels were raised to 6.8-7.3 by the sludge in all soils and remained at or near these values during the growing period.

MUNICIPAL SOLID WASTE COMPOST AS A MEDIUM FOR SOD-GROWN CROPS
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Major compostable materials in municipal solid wastes (MSW) are sewage sludge, paper, garbage, and autumn leaves. Five composts made from these wastes separately or in mixtures and one compost made from agricultural wastes (chicken manure and cranberry pomace) were evaluated for production of grass sods. Perennial ryegrass (*Lolium perenne* L. 'Pennfine') was seeded in 3.5-cm-deep layers of compost in plastic trays and grown in a greenhouse. Seed germination was inhibited in immature sludge-based and mixed MSW composts relative to germination in the other composts. High ammonium levels in the immature sludge-based and mixed MSW composts appeared to limit germination, as these composts had ammonium-N levels ranging from 1,000 to 2,000 mg/kg. Ammonium-N in the agricultural compost was 200 mg/kg, whereas that in the leaf-based composts was 10 mg/kg. In general, germination in all media was sufficient to establish a stand. Thereafter, growth of sods in the sewage-based, mixed MSW, and agricultural composts benefitted from the rich supply of N and exceeded that in the leaf-based composts. Mixing of composts with soil gave no advantage other than slightly increased seed germination but diluted total N supply and increased weediness of the sods.

Floriculture & Ornamentals

MATRIC AND OSMOTIC PRIMING OF PURPLE CONEFLOWER
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Seeds of purple coneflower (*Echinacea purpurea* L.) Moench were osmotically primed (OSP) in polyethylene glycol (PEG) or matrically primed in expanded vermiculite No. 5 (solid matrix priming, SMP). With both OSP or SHP at 15C, 10-day exposure to -0.4 MPa resulted in lowered time to 50% germination (T_{50}) and higher germination percentage than shorter exposure (5-day) or lower water potential (-1.5 MPa). SMP- and OSP-seeds performed similarly in a greenhouse trial, resulting in 80% and 34% seedling emergence at 23C and 37C, respectively, compared to 58% and 27% for non-primed seeds. Seedling emergence rate and synchrony from primed seeds were greater than from non-primed seeds at both temperatures. An incubator study established that adding 10⁻⁶M GA₃ and 10⁻⁶mM ethephon (2-chloroethylphosphonic acid) to the PEG or vermiculite resulted in lower T_{50} and higher germination percentage than priming without these growth regulators. A further incubator study established that less-expensive trade products (Pro-Gibb Pius 2X) and Florel could substitute for the reagent-grade growth regulators. Seeds primed in PEG or vermiculite containing 10⁻⁶M GA₃ from Pro-Gibb Plus 2X and 10 mM ethephon from Floral had lower T_{50} and higher percentage emergence in a greenhouse trial than seeds primed without growth regulators. Compared to the non-primed seeds, these treated seeds had 29% greater seedling emergence and 61% less time to 50% emergence.

FERTILIZATION OF TWO WOODY SPECIES WITH FISH HYDROLYZATE FERTILIZER
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The effect of a fish hydrolyzate fertilizer product on growth of *Acer rubrum* and *Pseudotsuga menzeisii* was studied. Bare root plants were fertilized at a rate of 90, 180, and 270 kilograms of N/hectare. Soil samples were collected every two weeks throughout the summer and were analyzed for nutrient content. In addition, August leaf samples were collected and analyzed for N, P, and K content. Growth measurements on *Acer rubrum* indicate that stem caliper was significantly increased by all fertilizer treatments over the control trees. The

granular fertilizer produced a significant linear increase in caliper growth with respect to fertilizer rate. Shoot growth was also significantly increased by all fertilizer treatments; however, as with caliper growth, the granular fertilizer treatments resulted in the greatest and most consistent response. The response of *Pseudotsuga menzeisii* showed significant increases in shoot growth and stem caliper but results were not as consistent as in the case of the maple.

EFFECT OF DAMINOZIDE, ANCYMIDOL AND PACLOBUTRAZOL ON HEIGHT CONTROL OF POTTED MUSSAENDA

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Mussaenda, a tropical, hybrid ornamental plant from India and the Philippines, is being evaluated as a potential greenhouse ported crop in the United States. Showy sepals of white, picotee (White with rosy edges), light pink, dark pink, or red complemented by fragrant, yellow flowers and dark green, pubescent foliage make Mussaenda a very attractive potted plant. However, sometimes the height of Mussaenda is unsuitable for pot plant culture. With the use of chemical growth regulators, plant height is reduced thus making Mussaenda a more feasible potted crop.

In the summer of 1992, a growth regulator study was conducted to evaluate three growth regulators and concentrations capable of reducing plant height in Mussaenda. Daminozide (B-Nine SP), ancymidol (A-Rest), or paclobutrazol (Bonzi) was applied at two concentrations each. Daminozide was tested as a spray at 2500 ppm and 5000 ppm. Ancymidol was applied as a spray at 33 ppm and 66 ppm or as a drench at 0.25 mg/pot and 0.50 mg/pot. Paclobutrazol was tested as a spray at 25 ppm and 50 ppm or as a drench at 0.125 mg/pot and 0.25 mg/pot. Growth regulators were applied as a single application or a double application with two weeks separating applications.

Daminozide at 2500 ppm and 5000 ppm was most effective in controlling plant height. Ancymidol as a drench at 0.25 mg/pot and 0.50 mg/pot was also effective in plant height control. Two applications of these growth regulators were more effective in controlling plant height than a single application.

EVALUATION OF DISPLAY LIFE AND ETHYLENE SENSITIVITY OF POTTED RASTER CACTUS AND HOLIDAY CACTUS

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The display life of individual flowers was determined for 8 cultivars of Easter cactus (*Rhipsalidopsis* hybrids) and 5 cultivars of Holiday cactus (*Schlumbergera* hybrids). For Easter cactus and Holiday cactus cultivars, the display life of individual flowers ranged from 7 to 12 days and from 4 to 6 days, respectively. In a second study, flowering plants were exposed to 0, 0.4, or 1.0 $\mu\text{l}\cdot\text{liter}^{-1}$ ethylene (C_2H_4) for 48 h and were evaluated at 0 and 5 days after C_2H_4 treatments. Plant responses to C_2H_4 were dependent on C_2H_4 concentration, cultivar, and stage of floral development: Easter cactus cultivars were less sensitive to C_2H_4 than Holiday cactus cultivars. There was no correlation between display life of individual flowers and sensitivity to C_2H_4 . These studies demonstrate that: 1) there is substantial genetic variation within and between genera for postharvest performance; and 2) display life of individual flowers and plant sensitivity to C_2H_4 should be evaluated when selecting for postharvest performance.

CARBON DIOXIDE TREATMENTS FOR CONTROL OF GREENHOUSE WHITEFLY ON POINSETTIAS

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Whitefly infestation of poinsettias arises frequently from cuttings that were infested at the start of the season. Experiments were conducted to investigate the feasibility of using short-term elevated CO_2 to eliminate whiteflies on cuttings prior to planting. Results indicated that adult greenhouse whiteflies (*Trialeurodes vaporariorum*) are highly susceptible to an elevated level of CO_2 . All adult whiteflies are killed after exposure to 25% or 50% CO_2 for less than 10 hours. Eggs, however, are more resistant than adults where 80% survived 10-hr of 50% CO_2 treatment. Tests on poinsettia cuttings demonstrated that prolonged exposure to elevated CO_2 resulted in the development of toxic symptoms soon after the treatments. Tolerance of 'Lilo' exceeded that of 'Supjibi', revealing differences in susceptibility of the two cultivars to the elevated CO_2 treatment. Believing that the reduction in O_2 , rather than the elevation of CO_2 , was the main cause of mortality, we are currently testing the effects of hypoxia on survival of whiteflies.

THE EFFECTS OF LEAF PIGMENTATION ON RESISTANCE TO WHITEFLY INFESTATIONS IN *PELARGONIUM XDOMESTICUM*.

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The greenhouse whitefly (*Trialeurodes vaporariorum*) poses an acute and common production problem for growers of *Pelargonium xdomesticum*, the regal pelargonium. The main objective of this research was to ascertain whether leaf pigmentation is a feasible tool for selecting whitefly-resistant regal cultivars. Previous researchers have demonstrated that greenhouse whiteflies (GHWF) prefer yellow reflected light over all other hues. Five cultivars of *Pelargonium xdomesticum* were chosen for this study ('Country Girl', 'Grand Slam', 'Olga', 'Elsie Hickman', and 'Virginia'). Measurements of $L^* a^* b^*$ chromaticity values were performed using a Minolta Chroma Meter, model CR-100. For each experiment, $L^* a^* b^*$ measurements were taken on two leaves per plant for six plants of each cultivar. Plants were then randomized in three separate blocks and a known number of GHWF was released into each block. The numbers of eggs laid were evaluated 48 hours later. Three experiments took place between October, 1991 and April, 1992. Determinations of regression between individual chromaticity values (eg. L^* or a^*) for each cultivar and numbers of eggs laid revealed no correlations between color and whitefly preference. 'Country Girl' and 'Virginia' exhibited significantly higher levels of susceptibility at all three times. 'Elsie Hickman' was consistently the most resistant cultivar. 'Grand Slam' also demonstrated significant levels of resistance and did not differ statistically from 'Elsie Hickman'.

Cross-commodity

MANAGEMENT OF COVER CROPS FOR WEED CONTROL BETWEEN PLASTIC MULCH IN PEPPERS (*CAPSICUM ANNUUM*)

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Field research was conducted in Deerfield, Mass. to study the effects of different cover crop species seeded between plastic mulch on weed pressure and pepper yield. A complete fertilizer was applied before plastic was laid on Sept. 13, 1991. Two cover crop treatments were seeded Sept. 13, 1991: white clover (*Trifolium repens*) alone and hairy vetch (*Vicia villosa*) in combination with winter rye (*Secale cereale*). On May 27, 1992 the vetch and rye were mow-killed with the biomass left on the soil surface. Annual rye (*Lolium multiflorum*) was then seeded on the same day as the third cover crop treatment. The remaining two treatments were a weedy check and a hand-weeded check. Peppers were transplanted into the plastic on May 31. Both the annual rye and clover were mowed three times over the course of the experiment with the biomass left between the plastic mulch. The white clover and annual rye were much more competitive with weed species than the dead mulch of vetch and rye. The three cover crop treatments had pepper yields that were severely depressed compared to the hand-weeded treatment. Among the three cover crop treatments, only the annual rye yielded more peppers than the weedy check.

PRODUCTION OF POLYCLONAL ANTIBODIES AGAINST IPTASE

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Isopentenyl transferase, encoded by the *ipt* gene of *Agrobacterium tumefaciens* T-DNA, is an enzyme active in cytokinin biosynthesis. The *ipt* gene was cloned into the pMAL-c2 vector (New England Biolabs, Beverly, MA) and expressed as a fusion protein. The production of this fusion protein was induced by a 2 hour exposure to IPTG. The fusion protein was then purified by a mini-aggregate procedure and visualized by SDS-PAGE. To verify that the correct protein was purified, antibodies specific to the conserved region of the fusion protein were used to probe a western blot. Secondary antibodies were biotinylated. Rabbits were immunized to raise polyclonal antibodies against iptase. Using a slot format blotting apparatus, serum was titered. These antibodies will be used to probe western blots from transgenic plants transformed with various *ipt* constructs.

HAIL DAMAGE ON THREE VEGETABLE CROPS

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U.S. crop loss from hail damage amounted to \$246,443,391 in 1991. Premiums paid for hail insurance was \$403,742,507. Despite the magnitude of this industry, the effects of varying levels of hail injury at different stages of plant growth is largely unknown for many vegetable crops. To further evaluate the effects of hail on strawberries, watermelons, and sweet corn, several studies were established in 1991 and 1992. Simulated hail applications were made at different rates and stages of crop growth. Total yields and marketable yields of strawberries were reduced by hail applications. All hail treatments reduced the number of marketable watermelons, except for the vegetative size light hail treatment in 1991. In 1992, the early treatments caused the most total yield reduction. All hail treatments reduced the percentage of marketable ears of sweet corn, except for the light application in the 13th leaf stage (early vegetative) in 1991. In 1992, additional treatments consisting of clipping all leaves were conducted. Clipping leaves at the early silking stage reduced marketable ears, indicating the loss of foliage adversely affected the growth of the ear. Clipping leaves just prior to harvest reduced the yield of Jubilee, but not Silver Queen.

MICROPROPAGATION OF PACHYSANDRA PROCUMBENS

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Pachysandra procumbens, the Allegheny *pachysandra*, is very rare to rare throughout most of its native range. Winter color, growth habit and ease of maintenance all recommend this perennial as an alternative ground cover for shady habitats. Development of micropropagation protocols may allow for its mass distribution. Non-wild collected shoots were disinfested using conventional procedures and were cultured and maintained in an MS based stock medium. Shoots proliferated equally well on an MS, a modified MS or a DKW based medium. Shoots had significantly more swelled buds when cultured in medium gelled with Gelrite or in liquid medium on membrane rafts compared to vermiculite. Microcuttings with or without a basal node rooted equally well. Microcuttings with or without an apical bud rooted equally well; however, microcuttings with an apical bud produced significantly longer roots.

INFLUENCE OF L- OR D-PHENYLALANINE AND SUBLETHAL COLD STRESS ON RHODODENDRON LEAF DISK HARDINESS

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Leaf disks of *Rhododendron* cv. 'English Roseum' were vacuum infiltrated with buffered solutions of L- or D-phenylalanine. Controls were infiltrated with buffer. Following a 24 hour period under lights (23°C, 16 hr light: 8 hr dark), the disks were cold shocked at 0°C for one hour, then held under the same light regime for three days. Disks were then subjected to a series of cold treatments, thawed, and analyzed for damage visually and by phenolic leakage. Disks infiltrated with D-phenylalanine consistently showed greater damage at warmer temperatures than did disks infiltrated with the L isomer. We believe the inhibitory action of D-phenylalanine upon phenylalanine ammonia-lyase is responsible for this decrease in cold hardiness.

EFFECTS OF OVERWINTERING COVERS ON ALSTROEMERIA SURVIVAL
CHUNSHENG LU* AND MARK BRIDGEN, DEPARTMENT OF PLANT SCIENCE, U-67, UNIVERSITY OF CONNECTICUT, STORRS, CT06269, U.S.A.

During the winter of 1991-92, four cultivars of *Alstroemeria*: 'F-180', 'I-5', 'Parigo Pink' and 'Parigo Red' were treated with eight different overwintering covers: straw, straw with plastic covering, sawdust, sawdust

with plastic covering, hoops with plastic covering, hoops with microfoam covering, microfoam and a control with no cover. All covers had significant effects on the survival of 'Parigo Pink' and 'Parigo Red'; mulching with straw only gave the best winter protection. There were also significant genotypic differences among the four cultivars: 73% of 'Parigo Pink' and 'Parigo Red' plants survived after winter, but none of 'F-180' or 'I-5' survived. In addition, pre-winter evaluation indicated that there were significant genotypic differences among the four cultivars with cold resistance. The cold resistance was highly correlated with winter hardiness. It was concluded that: (1) pre-winter evaluation could be an efficient indicator for winter hardiness selection on *Alstroemeria* and (2) application of straw provided sufficient winter protection for zone 6 *Alstroemeria*. Other approaches of mulching need to be further identified in order to protect all *Alstroemeria* for overwintering in the northeastern United States.

Posters

CRANBERRY VARIETY FRUIT YIELD AND YIELD COMPONENTS

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Accurate estimates of yield and yield components for parental selection would facilitate cranberry breeding efforts. A study was designed to obtain value estimates for traits related to yield. Ten commonly-cultivated varieties grown in a replicated planting, were evaluated in 1991 and 1992 for fruit yield per unit area (FY), average berry weight (BW) and number of berries per unit area, or berry concentration (BC). Averaged over all varieties, FY was significantly greater in 1992. BC was responsible for higher yields in 1992. Regression analysis revealed that BC accounted for more of the variation in FY than did BW in both years. BW accounted for some variation, however, in 1991 when FY was lower. Varieties differed significantly in FY, BW and BC. Hybrid varieties had significantly greater FY and BW than wild selections. Variation for yield components exists among varieties tested, suggesting genetic gain is possible for yield with additional breeding efforts. In particular, greater fruit set should be emphasized as a breeding objective.

IMPACT OF PRE-HARVEST GROWTH CONDITIONS ON YIELD AND QUALITY OF GREENHOUSE ROSES

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The general objective of this project is to study the impact of pre-harvest growth conditions (supplementary lighting; HPS, MH; fertilization on the biochemistry and post-harvest quality of greenhouse roses. On January 25, 1991, 288 plants (*Rosa x hybrida*: 'Royalty', 'After Glow' and 'Obsession') 3X caliber were planted in pots. A split-split plot experimental design made up of four blocks was used. Light treatments (3) were in main plot while fertilization (2) and cultivars (3) were in sub-plots and sub-sub-plots respectively. The two fertilization regimes used had respectively a nitrogen potassium ratio of 150N:300K ppm (F1) and 300N:300K ppm (F2). Three light treatments (ambient light conditions (control), and ambient light conditions + PPF of 100 $\mu\text{molm}^{-2}\text{s}^{-1}$ supplied by 400 W HPS and MH lamps) were compared. Since the beginning of this experiment 14 431 flowering stems have been harvested. Only the results obtained with 'Royalty' and 'After Glow' will be presented for the following harvest periods; (1) October 6 to December 6, 1991; (2) January 30 to April 22, 1992. Yields were significantly affected by light and/or fertilization regardless of cultivar. Preliminary results indicate that stems harvested from HPS and MH light treatments combined to fertilization regime F1 had a longer vase life than those grown with F2. Preliminary results indicate that HPS lamps significantly increased vase life compared to MH. The level of ABA was higher under MH than under HPS lamps at to and this was similar for all cultivars. Furthermore, when supplemental light was combined to the F1 fertilization a lower level of ABA was obtained. Low levels of ABA are correlated to longer vase life expectancy.

ANALYSIS OF THE ESSENTIAL OIL OF THE LEAVES OF *Fragaria ananassa* DUCH

Shahrokh Khanizadeh* and André Bédanger, Plant Science Dept., McGill University, 21,111 Lakeshore rd. Ste-Anne-de-Bellevue, QC, H9X 3V9 and Agriculture Canada, Research Station, 430 boulevard Gouin, St-Jean-sur-Richelieu, QC (Canada) J3B 3E6.

Leaves of three strawberry cultivars ('Bounty', 'Honeoye', and 'Kent') were collected at random from plants growing in an experimental trial at the Agriculture Canada, Research Station farm at Lavaltrie, Quebec. Steam-distillation was carried out on 300g of leaves in 3L of distilled water in a 5L flask. The essential oils were analysed with a Varian 6000 gas chromatograph. Thirty-seven compounds were detected of which sixteen were identified. The major components were linalool and nonanal. Many of the other constituents were aliphatic in nature. Differences in oil composition among the three cultivars were observed. Essential oil composition might therefore be used as a selection criteria for insect or disease resistance. Their effect upon mites will be assayed in future studies by testing them as sex, food, or oviposition lures.

RELATIONSHIP OF PHOTOSYNTHESIS MEASUREMENTS TO FRUIT SOLUBLE SOLIDS AND SPECIFIC LEAF WEIGHT IN APPLE AND GRAPE WITH VARIOUS MEASURING TECHNIQUES

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Photosynthesis, light (PAR) and transpiration were measured with an ADC portable infrared gas analyzer on apples and grapes. Measurements were taken on north and south sides of the rows, in the morning and afternoon, on sun and shade leaves, and with the leaf chamber in a horizontal position and in a natural leaf orientation position. Measurements were made on three cloudless days in August 1990 and 1991. Subsequently, fruit adjacent to sampled leaves were harvested and soluble solids determined. Sampled leaves were then harvested and leaf areas and dry weights measured. Correlation coefficients of variables were then subjected to analysis of variance to determine which techniques gave the best correlations. Grapes and apples responded differently. For grapes, soluble solids were most closely correlated to light and photosynthesis measurements when measured on south side shade leaves, while with apples, blush side soluble solids were best correlated with measurements on south side sun leaves in the afternoon. Specific leaf weight was best correlated to photosynthesis and light with grapes when measured on north side sun leaves and with apples when measured on the south side in the morning.

AN EXAMINATION OF TARNISHED PLANT BUG FEEDING INJURY ON STRAWBERRY

David T. Handley* and James E. Pollard, University of Maine, P.O. Box 179, Nonmouth, ME 04259; Plant Biology Dept., Nesmith Hall, University of New Hampshire, Durham, NH 03824

The tarnished plant bug (*Lygus lineolaris*) is a serious pest of strawberries in North America, causing a severe malformation of the receptacle known as "apical seediness" or "buttoning". Light and scanning electron microscopy were used to assess tarnished plant bug feeding on strawberries and to determine the nature of the injury. During early fruit development stages (anthesis to petal fall) the primary feeding sites were developing achenes. Feeding sites on more developed fruit changed to receptacle tissue, usually close to an achene. The "buttoning" malformation of strawberries associated with tarnished plant bug is most likely a result of the destruction of achenes during early fruit development stages. Feeding on receptacle tissue later in fruit development causes more localized damage, such as creases and indentations.

THE EFFECTS OF TEMPERATURE, OXYGEN AND CARBON DIOXIDE ON THE STORAGE QUALITY OF 'YORK IMPERIAL' APPLES

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York Imperial is an important processing apple cultivar in the mid-Atlantic region and is often stored for up to eleven months. This experiment was designed to further examine the optimum CA storage conditions for this cultivar. Six orchards were used as statistical blocks. The factorial experiment was set up with 2 temperatures (0 and 2C), 2 oxygen (1 and 2%) and 3 carbon dioxide concentrations (2.3.5 and 5%). Sample size was 20 fruit at all analysis periods (at harvest, 4, 6, and 8 months). The apples were stored in a

recirculating CA research facility and evaluated for firmness, soluble solids and weight loss. In the overall statistical analysis, orchard blocks, harvest dates and storage times significantly influenced all 3 quality parameters. Differences between blocks at harvest were substantial with firmness ranging from 9.5 to 11.3 kg and the soluble solids ranging from 12.8 to 14.8%. At the third storage removal (8 months), low oxygen increased firmness and decreased weight loss during storage while at the lower temperature, apples were firmer, had higher soluble solids and less weight loss than at the higher temperature. Although statistically significant, the differences may not be commercially important. Block differences were generally maintained throughout storage.

CANOPY MANIPULATION EFFECTS ON VEGETATIVE AND REPRODUCTIVE GROWTH OF 'TITAN' RED RASPBERRY

Gina E. Fernandez* and Marvin P. Pritts, Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

The objective of this experiment was to determine the effects that altering the probable source-sink relationships would have on subsequent growth and yield components under field conditions. The balance between vegetative and reproductive growth was altered by imposing light stress (shading) on various growth phases, or removing primocanes, floricanes or fruit. Removal of primocanes significantly increased yield the year of removal. However, if primocane removal coincided with canopy shading, this increase in yield was not achieved. Overall, a significant negative correlation existed between 1991 and 1992 yields. Treatments with high yields in 1991 had low yields in 1992, and visa versa. This evidence suggests that: 1) primocanes and floricanes are competing for light, not photosynthates during the flowering and fruiting period and 2) altering the balance of vegetative and reproductive growth one year had a significant effect on growth the subsequent year.

ORGANIC FERTILIZERS IN SUSTAINABLE CRANBERRY PRODUCTION

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The two major determinants in sustainable cranberry production are productivity and preservation of water quality. Productivity and water quality were studied using composted chicken manure (CM) and fish hydrolysate fertilizer (FH). In whole bog field trials, soluble granular fertilizer (SG) was replaced with organic fertilizer. At all locations receiving FH, cranberry yields were maintained or improved. The yield results from bogs receiving the CM were mixed, partially due to the quality of the experimental sites. Based on water samples taken from bogs receiving FH, there was no P output and less NH output than from bogs receiving SG. Leaching properties of CM, FH, and SG in cranberry soils were investigated in the laboratory. Concentrations of NO₃⁻, PO₄⁻³, and K⁺ were greatest in the leachate from columns receiving SG, indicating that organic fertilizers are less likely to lead to the leaching of nutrients into cranberry bog water.

TISSUE-CULTURE AND PROTOPLAST ISOLATION IN ASPARAGUS *DENSIFLORUS* L.

Mustapha Benmoussa* and Yves Desjardine, Horticultural Research Center, Département de phytologie, F.S.A.A., Université Laval, Québec, Qc., Canada, G1K 7P4

We have developed tissue culture and protoplasts isolation protocols for *Asparagus densiflorus* in order to use this genetic material in the breeding of *Asparagus officinalis*. For tissue-culture of *A. densiflorus*, the conditions which optimize the induction and the production of callus are a full MS medium with 1 mg/L of both pCPA and BAP and 0.5 mg/L of thiamine. HCL in the dark. On this medium, we obtained a friable white callus. Indirect organogenesis was obtained if pCPA was omitted from the medium. Replacement of the plant growth regulators by 2,4-D and Kinetin produced a hard and compact callus which did not differentiate. Protoplast have been isolated from 10 days old friable callus. cell wall was digested with 0.3% macerase, 1% cellulase and 0.8% rhozyme for a period of 16h at a temperature of 27°C in a CPW medium. Protoplast yield was 2 X10⁶ protoplasts/g callus. osmolarity of the digestion solution was 0.8 M provided with a mixture of glucose (0.6 M) and mannitol (0.2 M). cells were then plated at a density of 1 X 10⁵ cells per ml. Microcolonies formed on a 1/2 MS medium with 0,5 mg/L NAA and ZEA and 1 g/L glutamine in the dark.

ROWCOVERS AFFECT INSECT INJURY TO STRAWBERRIES

John J. McCue* and David T. Handley, Univ. of Maine, P.O. Box 179, Monmouth, ME 04259

James E. Pollard, Plant Biology Dept., Univ. of New Hampshire, Durham, NH 03824

Rowcovers applied to strawberries have documented value for increased earliness and yield. The effect of rowcovers on insect damage to strawberries was investigated in this study. Nonwoven rowcovers were applied over strawberries in the fall with and without malathion to determine their effect on tarnished plant bug (*Lygus lineolaris*) and strawberry bud weevil (*Anthonomus signatus*) injury over two harvest seasons. Rowcovers increased the number and weight of marketable fruit. Tarnished plant bug injury was reduced by the use of rowcovers in 1990, regardless of insecticide application. In 1991, rowcovers reduced tarnished plant bug injury only when a fall insecticide was applied. Rowcovers increased the number of flower buds killed by the strawberry bud weevil where no insecticide was used in 1990, but had no significant effect on the number of buds killed in 1991. The effect of rowcovers on insect injury to strawberries appears to depend upon the overwintering habits of the insects, and the prevailing weather patterns during a given season.

THE USE OF YI-1066 AS A CHEMICAL THINNER ON GALA APPLES

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

YI-1066 is a new blossom thinner that may be useful as an alternative to the presently-used chemical thinners. It was applied as a dilute spray to 'Royal Gala' apples at either 475 or 950 ml/379 liters when about 80% of the flowers were open. Browning of flowers and leaves was noted within 1 hour of application. The 950 ml/liter rate reduced fruit set. One YI-1066 treatment was applied at the 475 ml/379 liters rate, and rain started within 10 minutes after the completion of the spray. Although flower browning was noted, fruit set on these trees was increased above that on control trees. The recommended commercial thinning combination, 3 ppm NAA and 600 ppm carbaryl, did not thin. YI-1066 at 950 ml/379 liters caused a significant amount of thinning but it also reduced seed number and increased the number of fruit with solid russet at harvest.

Symposium

ALTERNATIVE STRATEGIES FOR SMALL FRUIT PRODUCTION

Marvin P. Pritts, Department of Fruit and Vegetable Science, Cornell University, Ithaca, NY 14853

This LISA project involves four state universities and the USDA, and has the objective of developing and evaluating non-conventional production and pest management strategies for raspberries and strawberries. Production goals are divided between cropping systems and pest management. The evaluation of trellising systems for cropping efficiency, ease of harvest, and spray distribution is an example of a production related objective. Groundcover management systems for strawberries are being evaluated for their effects on both the pest complex and production system. Biological control strategies for root diseases are also being studied. Evaluations involve field performance, economics, and impacts on pesticide use. In addition, grower attitudes towards adoption of non-traditional production practices have been assessed. The project supports the publication of a newsletter that is distributed to 450 growers. The major goal of our work has been to improve production efficiency and provide growers with economical, dependable tools that can be used to prevent pest problems before chemical intervention is required.

AN OVERVIEW OF THE NORTHEAST REGION SUSTAINABLE AGRICULTURE RESEARCH AND EDUCATION PROGRAM

Beth Holtzman, Northeast Region SARE, Burlington, VT

The challenges facing horticultural production in the Northeast are many: Pests that are increasingly resistant to conventional controls; eroding profitability; increasing consumer concern about residues in food and water supplies.

The Sustainable Agriculture Research and Education Program is working

to find solutions to these problems. SARE-supported research is developing practices that will help reduce producers reliance on pesticides and other purchased inputs while maintaining farm profitability.

In the Northeast, SARE has provided about \$5 million in grants since 1983 to about 50 projects. Many focus on horticultural crops, such as apples, small fruit, sod and ornamental plants. Some strategies developed through SARE projects are already being adopted at the farm level.

Last year, the program allocated \$1.461 million to 16 projects. This year, the Northeast Region expects to distribute a similar or slightly lower amount of grant funding. In addition, the region established a new \$100,000 farmer mini-grant program to promote adoption of sustainable practices and innovations on the farm.

FUNGAL PATHOGENS FOR BIOCONTROL OF INSECTS IN GREENHOUSES.

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Western flower thrips (WFT), green peach aphid (GPA) and sweet potato whitefly (SPWF) are major pests of the greenhouse industry. Chemical control of these pests is not desirable. Alternative approaches to pest management need to be developed.

Entomopathogenic fungi hold great promise as sustainable biological control options. A broad range of indigenous fungal isolates have been screened for activity vs. WFT and GPA. Strains of *Metarhizium anisopliae*, *Beauveria bassiana* and *Verticillium lecanii* have been shown to be particularly effective. Plant and soil trials vs. WFT are now underway to permit selection of the best strains for further development. To date, assays vs. SPWF indicate that strains of *Paecilomyces farinosus* and *B. bassiana* are the most pathogenic.

USE OF COVER CROPS IN VEGETABLE PRODUCTION

Francis X. Mangan*, Stephen J. Herbert and Mary Jane Else, Dept. Plant and Soil Sciences, Bowditch Hall, University of Mass. Amherst, Mass. 01003

Cover crops have been used in agricultural systems for thousands of years and are still an important part of vegetable production in the Northeast. Winter rye (*Secale cereale*) is by far the dominant cover crop species on conventional vegetable farms in the New England states. Its use is primarily for erosion control. Winter rye is popular since it is cheap, easy to establish, can overwinter in the harsh winters of northern New England, is efficient in "capturing" excess nitrogen at the end of the cash crop season, and it can produce substantial amounts of organic matter in the spring. As many positive attributes that winter rye has, it is important to be aware of many of the other potential cover crop species that are available to us. For example, many conventional growers are exploring the use of leguminous cover crops as an alternative to chemical nitrogen fertilizers which are more readily leached and are only going to get more expensive. Cover crops can also be seeded and managed in innovative ways to suppress weeds and other pests, add organic matter and conserve soil moisture.

THE NORTHEAST SARE (LISA) APPLE PRODUCTION PROJECT

Lorraine Berkett, Terry Schettini*, Dan Cooley, Dean Polk and David Rosenberg, Project Coordinators representing: University of Vermont, Rodale Institute, University of Massachusetts, Rutgers University and Cornell, respectively

Developing sustainable production systems based on the disease resistant apple cultivars (DRACs) and IPM techniques is a key objective of this multi-disciplinary project involving 19 principle investigators across 5 cooperating institutions. Cultivar selection is a crucial decision for an apple grower which will impact the farm's competitiveness and profitability for many years. Factors that growers consider when deciding what cultivars to plant include consumer acceptance and marketability; winter hardiness; yield potential; fruit storage qualities, color, taste, and size; and potential pest management problems. These factors are being researched in this project. Disease resistant orchards will undoubtedly present new economic considerations to growers, wholesalers, and processors. A further objective is to provide economic analyses of alternative techniques and to forecast the impact of changes in production systems on the Northeast apple industry. Apple growers must have access to research-generated information that addresses the critical issues facing them. Rapid information dissemination is a high priority of this project. The Northeast Sustainable Apple Production Newsletter has over 1200 active subscribers across the United States and in 7 foreign countries. The Management Guide for Low-Input Sustainable Apple production has been well received and continues to be requested world-wide.