UMASS EXTENSION

VEGETABLE NOTES

For Vegetable Farmers in Massachusetts

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Greenhouses are an important part of vegetable production. Most vegetable growers use greenhouses for starting plants for field production and many also use them to raise plants for sale. Greenhouse production of tomatoes and other vegetables is increasing. Success requires attention to details. Articles in this newsletter address some of the important aspects of greenhouse management. Please let us know how you used the information.

John Howell
Vegetable Team

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TIPS FOR TROUBLE-FREE USE OF SOILLESS MIXES FOR BEDDING PLANTS AND TRANSPLANTS

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Which soilless mix is best? This is a common question from bedding plant and vegetable transplant growers, but one that is not easy to answer. How well a mix "performs" depends on the watering and fertility practices of the individual grower and the particular fertility requirements of the plants being grown. This article covers the major characteristics of soilless mixes and some of the problems growers have which contribute to their apparent success or failure for growing bedding plants and transplants.

Major Components of Soilless Mixes

Organic components

Sphagnum peat moss. In my opinion, peat moss probably has the greatest effect on the physical and chemical properties important to bedding plants and transplants. Peat moss is very acidic (pH 3.0-4.0), has high moisture retention capabilities, and is very low in natural fertility. The acidic nature, high moisture retention, and low long-term fertility characteristics of soilless mixes is mainly a reflection of the sphagnum peat moss base of these mixes.

Composted pine bark. This component has a higher pH (5.5-7.0) and has much lower moisture retention compared to sphagnum peat moss. Pine bark is a useful addition to improve drainage and aeration of soilless mixes.

Coir fiber. Coir is a recent addition to the list of choices of components for soilless mixes. It is a byproduct of the coconut processing industry. Coir is unique because the fiber structure increases both aeration and moisture retention at the same time. In my experience, the most noticeable effect is an increase in the water-holding capacity when it is blended with other materials. The pH ranges between 5.5 and 7.0. There have been a few cases of high soluble salts with coir due to its sodium content, but this problem seems to have been greatly reduced in recent years.

Inorganic components

Vermiculite. Expanded vermiculite clay is a common component of soilless mixes. Vermiculite promotes aeration, but also increases moisture retention because water is held on the surface and within the structure of the particle. Unfortunately vermiculite is the least durable of the major components - the particles come apart due to excess handling and mixing, root penetration, and expansion/contraction caused by wetting and drying. If the particles fall apart, their effectiveness at increasing moisture retention and aeration is greatly diminished.

Perlite. This material is often substituted for

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vermiculite to promote drainage and aeration. Perlite retains very little moisture compared to vermiculite. It is more durable than vermiculite, but the particles can be eroded by too much mixing, particularly when sand is present.

Sand. The weight of sand is the main reason it is included in soilless mixes. Coarse sand increases drainage and it may improve aeration. Too much sand will make the mix too heavy and in some cases may impede drainage.

Drainage, Water Retention and Aeration

Many growers decide which soilless mix is best based how it performs in terms of moisture retention and drainage. Does the mix stay too wet or does it dry out too fast? Mixes comprised of relatively small, uniform particles have smaller pores than media formulated with larger, more irregular particles. Small pores retain more water and consequently less air than large pores. When moisture retention is increased it is generally done at the expense of aeration. Peat moss, coir fiber, and vermiculite increase moisture retention while pine bark, perlite, and sand increase drainage.

Other factors in addition to particle size and pore space determine whether a mix stays too wet or dries out too fast. Excessive mixing, handling, or packing into containers results in compaction. In compacted mixes the particles are pressed tighter together, slowing drainage, reducing aeration, and increasing moisture retention. These conditions are unfavorable for optimal plant growth.

Some growers complain that their mix stays too dry. This may be caused by high proportions of pine bark, perlite, sand, or other coarse materials which increase drainage or it could be the result of the mix being too dry or not fully blended at planting. The absence of a wetting agent may cause poor wet-up before transplanting or difficult rewetting after dry downs when the plants are growing.

Container depth also affects the levels of moisture and air in a soilless mix. All mixes hold more water, and thus are less well-aerated in shallow containers compared to deep ones. This explains the observation that plug trays sometimes stay too moist. Plug cells are the smallest and shallowest containers used in bedding plant and transplant production. Much more water and much less air is held by a mix in a plug tray compared to a pot. Too much moisture, at the expense of aeration, during the seedling stage can cause poor growth.

Fertility Issues

Preplant fertilizers

Commercially bagged mixes contain dolomitic limestone, "starter charge", trace element fertilizer, and a wetting agent **(See Table 1)**. Some also contain superphosphate fertilizer, but most commonly used soilless media, such as the Metro Mixes, do not because it is assumed that the grower will apply a complete NPK fertilizer as the crop grows. Generally this assumption is correct and P deficiency is rare, but some growers using mainly calcium nitrate and potassium nitrate or 15-0-15 as their fertilizer have seen P deficiency develop.

Growers making their own soilless mix should add all the amendments in Table 1, except superphosphate if a water-soluble NPK fertilizer is applied on a regular basis. Since most soilless media are blended with significant quantities of sphagnum peat moss, dolomitic limestone is a must to offset the acidic effect of this material.

The nutritional value of the starter charge seems to vary among different brands of soilless media. Generally the starter charge is a proprietary material, so it is difficult to determine its potential effect without a soil test. Based on my experience, it seems that today's commercial mixes have a higher fertility level coming straight out of the bag than one might expect. This has resulted in a few cases of soluble salts injury to seedlings shortly after transplanting to packs. Generally, injured seedlings were those grown in open flats and weakened by root loss during transplanting rather than those started as plugs.

Table 1. Preplant amendments for soilless mixes.

MATERIAL	Lbs./cu.yd.
Dolomitic limestone	5
Starter charge (potassium nitrate)	1
Superphosphate (0-45-0)	2
Trace element fertilizer (Micromax)	1
Wetting agent (Aqua Gro 2000)	1

Note: Micromax and Aqua Gro 2000 are mentioned only as examples of products that can be used.

Low pH

Low pH (values below the optimum range) is the most common pH problem found in greenhouse crops growing in soilless mixes. Most greenhouse crops can grow satisfactorily over a fairly wide pH range. However, optimum pH ranges have been established for some crops and soilless mixes and those containing field soil. The optimum pH range for a soilless mix is 5.5-6.0 and for a mix containing 20% or more field soil the range is 6.2-6.5. The differ-

ence in optimum pH between the two types of growth media is related to pH effects on nutrient availability in each.

Trace elements such as iron (Fe) and manganese (Mn) may reach phytotoxic levels when pH is low (<5.8). A disorder sometimes called "bronze speckle" is caused by too much Fe and Mn. It occurs in marigold, geranium, New Guinea impatiens, and some other bedding plants and is characterized by a mild chlorosis accompanied by the development of numerous very small brown spots on the leaves. In addition to Fe and Mn toxicity, low pH is also associated with Ca and Mg deficiency. The pH requirements for a number of bedding plants and the reasons why are shown in **Table 2.** What action to take on pH depends on the specific requirement of the plants being grown and a knowledge of the factors which interact to affect the pH of greenhouse media. Limestone, irrigation water pH and alkalinity, acid/basic nature of fertilizer, and effects of mix components are the major influences on growth medium pH. Also, some plants are known to change the pH of the mix; geranium is the best example - the activity of its roots can significantly lower pH.

Table 2. pH ranges for bedding plant seedlings

PLANT	PH	WHY?
Most bedding plants	5.4-6.8	pH tolerant
Celosia	6.0-6.8	Prevent Fe/Mn toxicity
Dianthus	6.0-6.8	Prevent Ca deficiency & NH_4 toxicity
African marigolds	6.0-6.8	Prevent Fe/Mn toxicity
Geranium	6.0-6.8	Prevent Fe/Mn toxicity
Pansy	5.4-5.8	Prevent B & Fe deficiency
Petunia	5.4-5.8	Prevent B & Fe deficiency
Salvia	5.4-5.8	Prevent B deficiency
Snapdragon	5.4-5.8	Prevent B & Fe deficiency
Vinca	5.4-5.8	Prevent B & Fe deficiency

North Carolina State University Plug Research Group

Iron deficiency

Iron deficiency (rather than toxicity) is appearing more frequently in bedding plants and other spring crops growing in soilless mixes. The fact that reports of Fe deficiency are more common is mainly explained by the growing popularity of some crops naturally susceptible to the disorder. In particular, some of the plants in Ecke's "The Flower Fields®" series and the Pleasant View "Proven Winners®" series are known to be susceptible Fe deficiency. Sensitive crops include vegetative petunias, scaevola, calibrachoa, ivy geraniums, and some bedding plants **(See Table 2).**

The most common symptom of iron (Fe) deficiency is moderate to severe chlorosis, sometimes starting at the shoot tips, but more often occurring throughout the entire plant. The best diagnostic symptom is that in extreme cases the leaves of some plants turn almost white. However, in all but the most extreme cases, Fe deficiency can be easily mistaken for nitrogen or magnesium deficiency, so a soil or tissue test is necessary to confirm a suspected case of deficiency.

Fe deficiency can be prevented by careful control of growth medium pH and the use of an iron chelate.

pH control. Acid pH favors the availability of Fe to plants, therefore the target pH range for these crops is fairly low, 5.5 to 6.0. Most commercial soilless mixes have pHs falling in this range and in most cases the use of an acid-forming fertilizer with a balance of ammonium and nitrate will be enough to keep the pH in this range. A major exception would be if the irrigation water is alkaline and then acid injection might be needed. If a grower blends his/her own sphagnum peat-based mix, no more than 5 lbs./cu. yd.of dolomitic limestone should be added because too much limestone is a factor contributing to Fe deficiency. For most growers keeping pH in the 5.5-6.0 range will be enough to prevent Fe deficiency.

Iron chelate. Fertilizing Fe sensitive crops with Fe from time to time is probably the least complicated and most proactive way of preventing Fe deficiency. Most greenhouse supply companies in this area carry a product called Sprint 330™ or perhaps an older one called Sequestrene 330.™ Both are 10% Fe chelates and are basically the same product (Sequestrene 330 is now marketed for agronomic crops only).

The Fe chelates are applied as a soil drench or as a foliar spray at the same rate of 8 oz./100 gal. (1/2 - 3/4 tsp. gal.). The chelate is also soluble enough to make a concentrated solution for injection, but it must be mixed and injected by itself. Soil drench is the safest method of application; foliar sprays should be tried experimentally first to look for injury or residues. At the recommended rate, Fe chelate can be applied every 3 or 4 weeks if desired. □

DISEASE MANAGEMENT FOR VEGETABLE BEDDING PLANTS

Leanne Pundt, University of Connecticut Extension and Tina Smith, University of Massachusetts Extension

Diseases of vegetable bedding plants include *Botrytis* blight, damping-off, tospoviruses and bacterial diseases such as bacterial leaf spot, bacterial canker, and black rot. To effectively control diseases, it is important to properly identify them. When diseases are not successfully managed, it is often because the cause was not accurately identified. Symptoms caused by poor cultural practices can also mimic disease symptoms. Fungicides cannot correct problems caused by high soluble salts, poor aeration or a nutrient imbalance. An integrated approach to disease management involves the use of resistant cultivars, sanitation, sound cultural practices and the proper use of the correct pesticide.

Resistant cultivars

Seed catalogues often feature disease resistant and tolerant varieties of vegetables. Utilize resistant varieties where feasible, but take some time to research the diseases that are giving the most trouble, to find other strategies to incorporate into the disease management plan.

Sanitation

Pest management on vegetable bedding plants begins with a clean, weed free, disinfected greenhouse. Before growing the crop, the greenhouse should be cleared of plant debris, weeds, flats and tools. Empty benches, potting tables, storage shelves, tools and cell packs should be washed and disinfected with a sanitizing agent. After the greenhouse has been sanitized, care must be taken to avoid recontamination with pathogens. Purchase seed from reliable sources. If possible, purchase seed that has been disinfested by chemical and/or heat treatment by the seed company. Potting media is easily reinfested by dirty hose nozzles or tools and unsanitary growing conditions. The floor of the greenhouse is a good source for diseases. Use a hook to keep the hose nozzles off the floor. Grow transplants off the ground in a well-ventilated greenhouse. To prevent root rot diseases, avoid overwatering and overfertilizing. Water early in the day to help prevent foliar diseases.

Use separate greenhouses for vegetable seedlings and ornamental bedding plants. Separate greenhouses: 1) will protect vegetable seedlings from any insect pests that may migrate from ornamentals and plants that are held over 2) will protect vegetable seedlings from tospoviruses and 3) will make it easier to treat the vegetable seedlings if pesticides are needed. Avoid high humidity (see article: *Environmental Management in Greenhouses,* p.7)

Seed Treatments

Seed treatments are useful for many vegetable crops to prevent root diseases, as well as certain diseases carried on or within the seed. There are two general types of seed treatment: eradicative and protective. Eradicative seed treatments use hot water or chlorine to kill disease-causing agents on or within the seed. They are useful in controlling certain seed-borne diseases such as bacterial leaf spot on pepper and bacterial canker on tomato. Protective seed treatments use fungicides on the seed surface to protect the seed against decay and soil-borne organisms such as damping off. For more information regarding seed treatments, contact your seed sales representative, Extension vegetable specialist or plant pathologist.

Fungicides

Fungicides can provide excellent management of some diseases, but for others they may be ineffective. In general, to control root diseases, broad spectrum fungicides should be applied as a drench on a preventative basis. Read directions for application on pesticide labels. An application of additional water may be necessary. For foliage diseases, obtain thorough spray coverage and treat when disease is first evident.

Biofungicides

Biofungicides are fungicides that contain living organisms such as fungi, bacteria or actinomycetes (a group of bacteria that form branching filaments) and can work in a number of ways. Growers need to be aware of their mode of action and how to most effectively use biofungicides to suppress plant diseases. Storage conditions, soil and air temperatures, and use of other chemicals affects their efficacy. Biofungicides should be used as a preventative treatment in conjunction with a regular monitoring program where root health and crop quality is evaluated. They will not cure diseased plants. A number of products are commercially available for use on vegetable bedding plants. Rootshield and Topshield are formulations of a selected strain of a common soil saprophytic fungus, *Trichoderma harzianum*. Mycostop is a powdered formulation of dried spores and mycelia of the soil actinomycete, *Streptomyces griseovirdis* K61. SoilGard 12G is a granular formulation of a common soil saprophytic fungus, *Trichoderma virens* GL-21. AQ10 Biofungicide is a water-dispersible granule formulation of the fungus *Ampelomyces quisqualis* M-10 that parasitizes powdery mildew.

Specific Diseases

Botrytis blight

Botrytis can cause leaf blight, cankers, damping off and root rot. Plants may be attacked at any stage, but the new tender growth, freshly injured tissues and dead tissues are most susceptible.

Symptoms: *Botrytis* blight produces characteristic gray fuzzy-appearing spores on the surface of infected tissues. Air currents and splashing water can easily disseminate the spores. In general, germination of spores and infection is dependent on a film of moisture for 8 to 12 hours, relative humidity of 93% or greater and temperatures between 55˚ and 65˚F. After infection, colonization of plant tissues can occur at temperatures up to 70˚F.

Management: Management of environmental conditions such as temperature, humidity and duration of leaf wetness, sound cultural practices and fungicides will help prevent disease development.

1. Control weeds and remove plant debris between crop cycles and during production. Dispose of diseased plants and debris in a plastic trash bag. Keep the bag closed to help prevent spreading spores to uninfected plants as the bag is removed from the greenhouse.
2. Reduce humidity and leaf wetness duration to prevent spore germination. See *Environmental Control in Greenhouses.*
3. Provide good air circulation and reduce humidity within the canopy. Proper planting dates, fertility, watering and height management will prevent overgrown plants, thereby reducing humidity within the canopy.
4. Water in the morning, never late in the day. Rising temperatures during the day will cause water to evaporate from the foliage and dry the leaf surface.
5. Avoid growing ornamental hanging baskets above vegetable bedding plants. Spent flowers dropping on plants below cause *Botrytis* infection.

Damping-off of Seedlings

Damping-off is a common disease of germinating seeds and young seedlings. Several fungi are capable of causing damping-off including *Rhizoctonia*, *Alternaria*, *Sclerotinia* and the water molds, *Phytophthora* and *Pythium*. Soil borne fungi generally do not produce air-borne spores but are easily transported from contaminated soil to pathogen-free soil by infected tools, hose ends, water-splash and hands. Young seedlings are most susceptible to damping-off. However, later in the crop cycle, the same pathogens may cause root and stem rot.

Symptoms: Symptoms of damping-off include seedlings failing to emerge or wilting, often with a stem lesion that appears water-soaked or dark, necrotic and sunken at the soil line. The fungus disease usually spreads radially from a central point of origin so plants often die in a circular pattern. Vegetable seeds that are germinated in poorly drained, cool soils are especially susceptible. Young plants that do emerge are weak and often wilt at or below the soil line. Cabbage, cauliflower, tomato and pepper seedlings may be girdled by brown or black sunken cankers. Stems of these plants may shrivel and become dark and woody (wirestem or collar rot). The plants may not collapse, but remain stunted and die after transplanting.

Management: Damping-off must be prevented because it is difficult to stop once symptoms occur. There are several strategies to prevent damping-off.

- Use only certified disease-free seed from reputable seed companies.
- Use fungicide-treated seed. Certain fungicides are labeled for damping-off for selected vegetable crops.
- Use pasteurized soil, compost-based or soilless mixes.
- Disinfect all flats, cold frames, pots and tools.
- Germinate seed under conditions that will ensure rapid emergence, such as the use of bottom heat.
- Avoid overwatering, excessive fertilizer, overcrowding, poor air circulation, careless handling, and planting too deeply.
- Provide adequate light for rapid growth.
- Promptly rogue out infected plants from flats.

Tospoviruses

Tospoviruses are a group of viruses that include impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV). They may infect hundreds of plant species including tomatoes, peppers and eggplant. These viruses are primarily spread by the western flower thrips. Tospoviruses are not seedborne but are brought into the greenhouse on vegetatively propagated ornamental plants or seedlings that have been exposed to the virus. Once the thrips in the greenhouse become infected, they can transmit the virus to susceptible crops and weeds.

Symptoms: Symptoms include stunting, foliar ringspots and black lesions on stems. Symptoms of INSV and TSWV will vary depending upon the host.

Management: To manage tospoviruses, it is necessary to discard infected plant material, including weeds and to manage thrips. Infected vegetable transplants planted into the garden or field will be stunted and will not produce a harvestable crop. Since INSV and TSWV are not seedborne, vegetable transplants may be kept free of tospoviruses if they are not brought into contact with other infested crops or thrips carrying the virus. Growers attempting to concentrate all their warm temperature crops in a single house run a risk of mixing tospovirus-free vegetable seed

(continued next page)

crops with leftover ornamental stock plants or new cuttings that may carry the virus. Pre-finished or vegetatively propagated ornamentals from another producer could be infested with thrips or infected with a virus. Therefore, vegetable bedding plants should always be grown in separate greenhouses.

Bacterial diseases

Bacterial diseases of vegetable bedding plants, such as bacterial leaf spot of peppers, bacterial speck and bacterial canker of tomatoes and black rot on cole crops are introduced into a greenhouse through infected seed and transplants.

Bacterial leaf spot, Bacterial speck

Symptoms: Bacterial leaf spot is caused by *Xanthomonas campestris* pv. *vesicatoria* and is found primarily on peppers although all above ground parts of tomatoes are also susceptible. Spots on leaves are chocolate-brown and irregularly shaped with areas of dead leaf tissue. At first, the spots are less than 1/4 of an inch in diameter. Severely spotted leaves will appear scorched and defoliation may occur. This disease is most prevalent during moderately high temperatures and long periods of leaf wetness.

Bacterial speck occurs on tomato but not pepper. The bacterium, *Pseudomonas syringae* pv. *tomato*, causes small black spots to develop resulting in chlorosis (yellowing), necrosis (dead tissue) and blighting of the foliage. Bacterial speck can usually be distinguished from bacterial spot by the size of the lesions, however, in some cases, the symptoms look can look similar.

Bacterial canker

Bacterial canker of tomato is caused by *Clavibacter michiganensis* (formerly *Corynebacterium michiganense*). In New England, bacterial canker occurs less frequently than other tomato diseases but it is potentially more destructive. Peppers are another host of this highly contagious disease. The bacterium is seed-borne but may survive on plant debris in soil for at least one year. It can also survive in the greenhouse on wooden stakes and flats. Wilt, leaf scorch, canker, pith necrosis and fruit spot may occur singly or in combination depending on the circumstances. When the bacterium is carried in the seed, the vascular system becomes colonized, resulting in wilt, pith necrosis and external cankers. Wilt initially occurs on one side of a leaf or one half of a plant because only a portion of the vascular system is blocked. Cankers and pith necrosis occur in later stages of disease development. Cankers are dark and water-soaked in appearance and often exude bacteria that are easily spread to adjacent plants. Pith necrosis is first evident as a darkening of the center of the stem that soon becomes chambered or hollow. When leaf scorch occurs, the petioles usually bend downward while the leaf edges curl up. The margins of the leaves become brown with a yellow border to the inside. Scorching of the foliage often develops in the absence of wilt or stem canker. Transplants may not express symptoms until six to eight weeks after infection and initial symptoms expression is accelerated by environmental stress.

Black rot

Black rot, caused by the bacterium *Xanthomonas campestris* pv. *campestris* occurs throughout the world where cruciferous plants are grown. Cabbage, cauliflower and Chinese cabbage are often severely affected. The bacterium enters the leaves by colonizing the hydathodes (water pores) and moves from the leaf margins inward. Lesions may also begin at wounds. Diseased tissue is often V-shaped, flaccid, tan to yellow and with blackened veins. The blackened veins are diagnostic and are best seen by holding the leaf up to the sun. When the lesions reach the petiole and stem, the bacterium moves systemically through the plant, resulting in premature leaf drop. At this stage of disease, a cross-section of the stem will reveal a ring of discolored vascular tissue.

Management: These bacteria can be introduced on infected seeds, infected transplants purchased from another operation, or in the field on crop residues. These bacteria can also survive on weeds in the same family as the host crop. The management of these bacterial diseases is similar and includes the following strategies.

- Buy certified seed from a reputable source.
- Use hot water-treated seed. Ideally, the seed should be custom-treated by the seed company. Seed companies may treat the seed upon request. There is a risk that germination percentages will be reduced if the seed crop is grown under stressful environmental conditions.
- Promptly remove infected plants and adjacent plants to prevent further infection and avoid unnecessary handling of plant material.
- Avoid overhead irrigation, splashing or periods of extended leaf wetness.
- Disinfect all benches, equipment, flats and stakes.
- Follow sound practices for weed and insect control.

Prevent bacterial leaf spot on peppers by choosing resistant varieties whenever possible. There are many resistant varieties of bell peppers available, but there are few choices for resistant specialty peppers. □

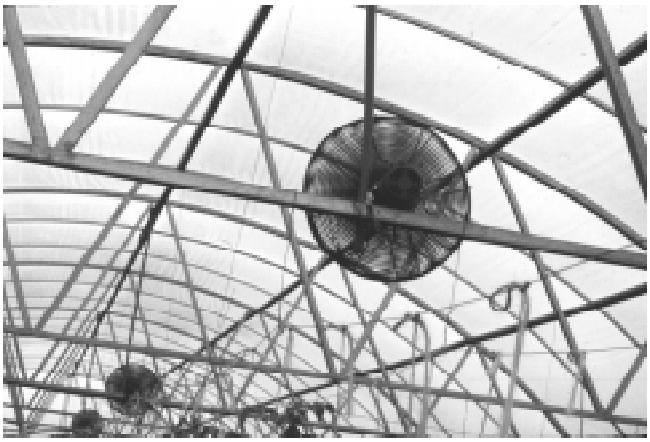
ENVIRONMENTAL MANAGEMENT IN GREENHOUSES

John Howell, University of Massachusetts Extension

Greenhouses are primarily used to start transplants or grow crops when it is too cold outside. In this regard our primary concern is temperature management. However, we should also concern ourselves with moisture and humidity management, light levels and air quality in the greenhouse.

Growers typically try to maintain day temperature at about 10 fahrenheit degrees warmer than night temperature. This can be accomplished by setting the furnace thermostat at the desired night temperature and leaving it there. A separate thermostat should activate the ventilation system when the appropriate day temperature is reached. During the day it is not necessary to raise the setting on the furnace because the sun can be expected to heat the greenhouse. On cloudy days, if there is not sufficient sun to heat the house, there will be reduced photosynthesis and so temperature should be kept near the night level to minimize stretching and carbohydrate loss through respiration. Some research has shown that plant height can be reduced by reducing temperature to 50° to 55°F for 2 to 3 hours at dawn, before the house warms to the day temperature. **CAUTION:** These temperatures may injure tender plants or cause fruit malformation in tomatoes.

Ventilation units are often set to come on in stages. Small fans such as jet fans with plastic distribution tubes mounted overhead are ideal for introducing moderate amounts of cool air from outside and mixing it with greenhouse air. This unit can be set to start ventilating at a desired temperature. If the outside air is cold enough this may be all that is needed to maintain temperature. If the outside temperature is more mild, more air will be needed and larger fans can be set to come on if temperature continues to rise a few degrees.



Fans for Horizontal Air Flow

Intake louvers should be baffled to protect nearby plants from a blast of cold air.

Thermostats should be located at plant height so they are responding to the same temperatures the plants are experiencing. Aspirated thermostats provide the most accurate reading of ambient temperature. An aspirated thermostat is one that is enclosed in a white box which reflects the suns heat. A small fan runs constantly to ventilate the box. Highly accurate electronic thermostats are available.

When we think about the greenhouse environment, we often overlook relative humidity. This can be a costly mistake. Water droplets form as humid air contacts cool surfaces. Droplets form on metal greenhouse frames and inner surfaces of plastic films and then drip onto plants. They can form directly on plant surfaces which are cooled by radiational heat loss at night. Some important diseases such as *Botrytis* and *Fulvia* require free water for their spores to germinate. By reducing relative humidity (RH) we can prevent moisture formation or dripping on plant surfaces. Control of RH is an effective disease management tool.

RH is the amount of water vapor in the air compared to the amount the air can hold at a given temperature. Warm air can hold more water vapor than cool air. A temperature increase of about 20°F will double the amount of moisture the air can hold. A decrease in temperature reduces the amount of moisture the air can hold. This happens in the evening as the greenhouse cools down. In a typical greenhouse, the RH is likely to be 90% or more. As the house cools in the evening, the RH will increase and will reach 100% with only a few degrees drop in temperature. This is the dew point. When the temperature drops below the dew point, free moisture is formed on surfaces, including plants. A drop of 10 degrees from day to night temperature would result in a great deal of free moisture. We can effectively lower relative humidity by exhausting some of the humid air from the greenhouse and replacing it with cooler outside air and heating it. It is especially important to do this as the greenhouse cools down for the evening. During the night hours, relative humidity can be effectively managed by ventilating the greenhouse for 20- to 30-second intervals two to three times an hour. This is not as expensive as it sounds because it doesn't require much energy to heat air. At $1.05 per gallon for fuel oil, this should average about 45 cents per day for 1,000 square feet of greenhouse space. **CAUTION:** Timers should be wired to lock out furnaces during the intervals exhaust fans are running

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to avoid reversing the draft and pulling fumes into the house.

Continuous air movement reduces stratification of air. This helps manage temperature and RH within the plant canopy and reduces water condensation on leaf surfaces. Many growers use a series of small fans along the sides of the greenhouse to establish a circulating pattern of horizontal air flow up one side and down the other. These fans can be angled to direct some of the warm upper air down into the plants.

Aspirated Thermostat

It is important to have heating equipment checked yearly for proper operation. Be sure vent pipes and connections are tight to prevent fumes from contaminating air in the greenhouse. Ethylene fumes from a malfunctioning unit or faulty vent pipes can cause serious plant damage and great financial loss.

Hot air heating systems are most efficient if the cold air intake is close the floor of the greenhouse. If the intake is located near the roof, as with suspended gas units, the heater brings in warm air and heats it, but does not have much effect on the colder air at plant height. This situation can be improved somewhat by angling the horizontal air fans downward to mix the upper warm air with the lower cool air. Some growers have retrofitted suspended gas units with ducts that extend from the intake down to floor level, resulting in increased efficiency. However, most of these hearing units do not lend themselves to the addition of such duct work.

GREENHOUSE ENERGY CONSERVATION CHECKLIST

John W. Bartok, Emeritus Extension Professor, University of Connecticut

Providing heat in the greenhouse during the winter months consumes a large quantity of fuel oil or gas. There are many ways to increase heating efficiencies to reduce consumption and costs. Following are ways of realizing savings.

Reduce Air Leaks

(Possible fuel saving of 3-10%)

- Keep doors shut by using a door closer or springs.
- Weatherstrip doors, vents and fan openings.
- Lubricate louvers frequently so that they close tightly. A partially open louver may allow several changes per hour using additional fuel to heat the incoming air. (Ed. Note: Although air changes are needed to manage relative humidity in the greenhouse, this should be done in a controlled manner as needed.) Shut off some fans during the winter and cover openings with insulation or plastic to reduce unnecessary air infiltration.
- Repair holes in the greenhouse covering.
- Close holes under the foundation board on plastic houses. *(continued page 9)*

DEADLINE FOR AGR CROP INSURANCE SIGN UP IS JANUARY 31.

The Adjusted Gross Revenue (AGR) insurance plan is a non-traditional approach to crop insurance that is now being offered by the USDA Risk Management Agency through private commecial insurance companies. It protects growers of all types against losses of revenue due to unavoidable causes. A huge variety of crops are included in the coverage. Instead of using an estimated value of these crops calculated by someone else, the AGR uses the last 5 years of your Schedule F tax form information as a base to provide a level of guaranteed revenue for the insurance period. This is the second year that AGR is available in Vermont, but few growers took advantage last year (many wish they had!).

YOU MUST SIGN UP BY JANUARY 31 TO GET COVERAGE FOR THE 2001 GROWING SEASON.

For more information, contact either: Arthur G. Caroll Crop Insurance Agency 800-531-4700 or Rain and Hail, LLC 800-776-4045.

Double Covering
(Possible fuel savings of 25-35%)

• Line insides of side and end walls with polyethylene plastic to achieve a thermopane effect. Install double wall polycarbonate structured sheets to achieve an insulation effect and reduce labor for recovering.
• Use double poly plastic with air inflation.
• Add a single or double inflated layer of plastic over glass houses.

Energy Conserving Blanket
(Possible fuel savings 25-50%)

• Manual and motorized systems are available.
• Tight closures should be maintained where curtains meet sidewalls, framing and gutters. Use a U-shaped heat trap to prevent heat from escaping overhead.
• Heat and water lines should be insulated or located below the blanket.

Foundation and Sidewall Insulation
(Possible fuel savings 3-6%)

• When building new greenhouses, place 1-2" polyurethane or polystyrene board to 18' below the foundation to reduce heat loss. This can increase soil temperature near the sidewall as much as 10°F during the winter.
• Use 1-2" insulation board on concrete knee walls. Insulating a 3' high knee wall on a 28' by 100' greenhouse with 2" of foam insulation will save about 400 gallons of fuel oil per year if the house is operated all winter.
• Use aluminum-faced building paper or insulation board behind heat pipes to reduce radiation heat loss, but leave air space next to the wall to prevent wall freezing.

Location
(Possible fuel savings 5-10%)

• Locate new greenhouses in sheltered areas to reduce wind-induced heat loss, if this does not block light.
• Use windbreaks on the north and northwest sides of the greenhouse area. A windbreak can be evergreen trees or plastic snow fence.

Efficient Heating Equipment
(Possible fuel savings 5-20%)

• Have furnaces cleaned and adjusted at least once a year. A 2% increase in efficiency for a 30' by 150' greenhouse will save about 200 gallons of fuel oil. Check boiler, burner and backup systems to make sure they are operating at peak efficiency by a qualified service person.
• Use electronic thermostats with a 10°F accuracy. Aspirate thermostats for more uniform temperature control.
• Clean heating pipes and radiating surfaces frequently.
• Use horizontal air flow to improve temperature uniformity.
• Insulate distribution pipes in areas where heat is not required.

Conserve Electricity
(Possible savings 1-14%)

• Have wiring inspected by an electrician for overloading, corroded parts or faulty insulation.
• Losses of energy to heating of overloaded wires can be reduced by using larger wires.
• Motor size should meet the requirements of the equipment to be operated. High efficiency motors can save 2-5%. Turn off motors when not needed and maintain proper belt tension and alignment.
• Use larger diameter fans with smaller motors. For example, a 36" fan with a 1/3 hp motor has the same output as a 30" fan with a 1/2 hp motor but will save about $3.00 per month.
• A power company voltage drop of 8% will not affect most motors if wiring to the motor is adequately sized and not overloaded. Combined voltage drop and wiring losses over 10% can cause motor overheating and damage. Use thermal overload protectors.
• Replace incandescent lights with fluorescent bulbs and/or fixtures.

Greenhouse Management

• Fuel use is reduced by about 3% for each degree the night temperature is lowered. However, this may require more time to grow the crop, negating some of the savings.
• It is easier to provide heat to plants on benches than those on the greenhouse floor.
• Delay starting the greenhouse by using a germination chamber or small greenhouse area. If you have tall, leggy plants, you may be starting them too early for your planting date.
• Root zone temperature is usually more important that air temperature. Air temperature can be 5-10°F lower than root zone temperature. Install root zone heating in floor or under benches. Editor's note: Do not allow air temperature to drop below 60°F for tomatoes and peppers.
• Keep growing areas full and use moveable benches to achieve 90% space utilization. □

Vegetable Notes is a publication of the University of Massachusetts Extension Vegetable Program, which provides research based information on integrated management of soils, crops, pests and marketing on Massachusetts farms.
Subscriptions to Vegetable Notes include the IPM Newsletter, published weekly during the growing season. For subscription information call (413)577-0712 or visit our website at ***www.umass.edu/umext/programs/agro/***. For more information about the Vegetable Team's research and UMass Extension programs call Ruth Hazzard at (413)545-3696.

551ST ALL DAY MEETING
FRIDAY, JANUARY 5, 2001
FAIRVIEW KNIGHTS OF COLUMBUS HALL, CHICOPEE, MA
PRESENTED BY NEW ENGLAND COOPERATIVE EXTENSION SYSTEM AND NEW ENGLAND VEGETABLE & BERRY GROWERS ASSOCIATION

9:30 AM	**Registration.** There is a $10.00 registration fee for those who are not members of NEV&BGA. This does not include lunch.
10:00 AM	**Organic Vegetable Culture**, John Howell, University of Massachusetts; Douglas Coldwell, Grower, Montague; Gary Gemme, Harvest Farm of Whately. John will introduce the basics of organic culture while Doug and Gary will tell about their experience in growing organically.
10:45 AM	**Vine Crop Diseases**, Meg McGrath, Cornell University Meg is doing research on diseases of vine crops and will discuss these diseases and the results of her research.
11:30 AM	**Post Harvest Handling of Vegetables and Small Fruits**, William Bramlage, University of Massachusetts. Proper handling after harvest maintains quality and increases shelf life. Bill will tell us how to do it.
12:00 Noon	**$12 Lunch** - Reservations Required. Phone reservations can be made or changed until noon on Friday, December 29th by phoning (508) 378-2546. Those who make reservations and do not show up will be billed!
1:00 PM	**Business Meeting**
1:15 PM	**Cultivators and Cultivation Equipment,** Vern Grubinger, University of Vermont.There are many new types of cultivators available and Vern will discuss these and their use in vegetable and small fruit production.
1:45 PM	**Farm Slides**, Ruth Hazzard, University of Massachusetts. Visits to farms via slides is one of the most popular topics at our meetings. Ruth will present a slide show of some of the farms she has been working with.
2:15 PM	**Shields for Herbicides,** Richard Bonanno, University of Massachusetts. Contact herbicides are useful for controlling weeds between the rows of some crops, but shields are necessary to prevent crop injury. Rich will discuss shields and their use.
2:45 PM	**Weed Management in Pumpkins,** Todd Mervosh, The Connecticut Agricultural Experiment Station. Todd received a research grant from the Association to conduct weed trials on pumpkins and will discuss the results of his research.
NOTE:	Two hours of recertification credit for certified pesticide applicators will be given for attending this meeting.

DIRECTIONS:

From Mass. Pike, take Exit 5 to Route 33, Memorial Drive, north to K of C Hall across from Abdow's Restaurant.

From north or south, take 1-91 to West Springfield exit to Mass. Pike and head east to exit 5, and proceed as above.

552 ND ALL DAY MEETING

FRIDAY FEBRUARY 3, 2001

EASTERN MASS EXTENSION CENTER
240 BEAVER STREET, WALTHAM, MA
PRESENTED BY NEW ENGLAND COOPERATIVE EXTENSION SYSTEM AND NEW ENGLAND VEGETABLE & BERRY GROWERS ASSOCIATION

9:30 AM	**Registration.** There is a $10.00 registration fee for those who are not members of NEV&BGA. This does not include lunch.
10:00 AM	**Pesticides Update:** Insects, Diseases, Weeds. Ruth Hazzard, Robert Wick, Richard Bonanno University of Massachusetts.
11:00 AM	**Butternut Squash Spray Schedule**, Anne Carter, University of Massachusetts.
11:30 AM	**Trickle Irrigation**, John Howell, University of Massachusetts.
12:00 Noon	**$12 Lunch** - Reservations Required. Phone reservations can be made or changed until noon on Friday, December 29th by phoning (508) 378-2546. Those who make reservations and do not show up will be billed!
1:00 PM	**Business Meeting,** Election, Reports, Favorite Variety Survey.
1:30 PM	**Strawberry Variety Update,** William Lord, University of New Hampshire.
2:00 PM	**Strawberry Black Vine Weevil,** Richard Cowles, University of Connecticut.
2:30 PM	**Strawberry Renovation,** David Handley, University of Maine.
3:00 PM	**Strawberry Plasticulture,** William Lord, University of New Hampshire.
3:30 PM	**Strawberry Weed Control,** Rich Bonanno, University of Massachusetts.
NOTE:	Two hours of recertification credit for certified pesticide applicators will be given for attending this meeting.

DIRECTIONS:

From the Mass Pike: Take I-95/Rt 128 north to the Totton Pond Rd Exit. Go east on Totton Pond Rd to the end. At the light, get in the middle lane, turn right and then immediately bear left at the fork. Turn left onto Beaver St. at the first light. Proceed through the rotary and past Bentley College. The Eastern Mass Extension Center (formerly the Waltham Field Station) is on the right (240 Beaver St.).

From Rt 2: Take I-95/Rt 128) south to the Totton Pond Rd. exit and proceed as above.

2001 UPCOMING EVENTS

Jan 5	**New England Vegetable and Berry Growers' Meeting.** *(See enclosed program on page 10 .)*
Jan 9,10,11	**Tri-State Greenhouse IPM Program,** Augusta, ME Jan 9; Durham, NH Jan 10; Burlington, VT Jan 11. Contact Margaret Skinner, at 802-656-5440.
Jan15-22	**North American Farmers' Direct Marketing Conference and Trade Show**. Mesa, AZ. Contact Charlie Touchette at 888-884-9270.
Jan16-18	**New Jersey Vegetable Growers Conference and Trade Show,** Atlantic City, NJ. Contact Phil Traino at 856-985-4382.
Jan 24	**Vermont Vegetable and Berry Growers Meeting,** Barre, VT. Contact Vern Grubinger at 802-257-7967.
Jan. 30	**Flower Growers' Meeting,** Townsend, MA. Contact Tina Smith at 413-545-5306.
Jan 30 - Feb 1	**Mid-Atlantic Vegetable Growers Convention,** Hershey, PA. Contact William Troxell at 717-694-3596.
Feb 3	**New England Vegetable and Berry Growers' Meeting.** *(See enclosed program on page 11.)*
Feb 3	**NOFA-MA Winter Conference,** Barre, MA. Contact Ed McGlew at 413-247-9264.
Feb 12-13	**Ontario Horticultural Crops Conference and Trade Show,** Hamilton, ON. Contact Deborah Milito at 519-763-6604.
Feb 12-15	**New York State Vegetable Conference,** Liverpool, NY. Contact Jean Warholic at 607-539-7648.
Feb 14-17	**Small Fruit Conference (strawberries, brambles and *ribes*),** Primm, Nevada. Contact Erin Griebe at 517-548-4990.