INTRODUCTION

Weather of sufficiently low temperature to cause injury or retardation of growth of some vegetables occurs most every winter in Florida. Vegetable growers should understand the possible effects from cold and know ways to minimize this damage.

TYPES OF COLD INJURY

A - Injury without frost: On a number of crops this may occur at temperatures anywhere below 70°F, depending on the crop and the stage of development. Symptoms vary and may appear immediately or weeks later.

Examples: Tomatoes - Reduces plant growth and plants exhibit phosphorus deficiency. Fruit set reduced or fruit deformed or "cat-faced", puffy and misshapen. Fruit near maturity may not ripen properly after harvest and will bruise easily and soften prematurely if harvested and handled at low temperatures. The lower the temperature and the longer the duration the more severe these conditions will be.

Several other crops express similar symptoms to tomatoes, i.e. eggplant, peppers, squash and beans.

Bolting - Celery is a good example of bolting or premature seeding caused by exposure to cold temperatures during the growing season. Young plants will grow normally for a long period then shoot up to seed. The later in the growing season the cold occurs the quicker bolting will begin. Varieties differ greatly in their susceptibility to bolting. Lettuce and several other crops require high temperatures to cause bolting.

Seed Germination - On most warm season crops seed planted during cold periods will germinate slowly and erratically or not at all even with optimum conditions following cold.

Wind burn - Plants and leaves tend to dessicate and appear to be burned with cold winds. Plants take up water more slowly than it is transpired and evaporated in cold weather.

Pollination: Pollen may not be as viable or stigma as receptive or both during cold weather. For crops needing cross pollination, the necessary insects are not as active particularly bees.

Diseases - Cold tends to predispose a number of crops to certain diseases.

B - Frost Injury: Injury due to radiation cooling may occur when the air temperature is as high as 40°F above the plant. The plant surface, however, must drop to 32°F for frost injury to occur. The acute symptoms are the killing of
the exposed plant surfaces. The symptoms described for cold injury may also appear.

Ice crystals form outside and inside the plant tissue, which ruptures cells and evaporation and thawing dessicates cells. This gives the watery appearance of leaves immediately following frost. Plants vary in their susceptibility to frost. Some very tender plants are able to recover and regrow depending on their stage of development and severity of the cold. Examples are: Potatoes, peppers, tomatoes and eggplant. Some cold hardy plants may be injured by frost so that they become unmarketable or require excess trimming depending on their stage of development. i.e. lettuce, cabbage or other cold hardy leaf crops.

C - Freezing Injury: Freezing air below 32°F which moves in is the most destructive. The symptoms described for cold injury and frost will occur. Usually all but the most hardy crops will be destroyed. Even the most hardy can be destroyed with intense cold of long duration.

VEGETABLE GROUPING IN COLD HARDINESS:

A Cool season crops tolerant of slightly freezing weather.
- Cabbage, broccoli, spinach, beets, brussel sprouts, kohlrabi, parsnips, radishes, rutabaga, turnips, watercress.

B Cool season crops damaged near harvest by freezing weather.
- Cabbage (Chinese), cauliflower, lettuce, English peas, potatoes, celery, carrots, celeriac, chicory, endive, mustard, parsley, strawberries.

C Cool season crops that are tolerant of FROST.
- Onion, chives, garlic, leek shallots, asparagus.

D Warm season crops intolerant of FROST.
- Sweet corn, snap beans, lima beans, tomatoes, peppers, summer and winter squash, cucumbers, cantaloupes, chayotes, pumpkins.

E Warm season crops requiring continuous warm weather.
- Watermelons, sweet potatoes, eggplant, okra, hot peppers.

PROTECTIVE AND CONTROL MEASURES

1. Site selection. Avoid planting susceptible crops in known cold or frosty areas during season of the year when cold weather is imminent.

2. Crop selection. Grow crops that will tolerate cold during cold seasons of the year.

3. Timing. Know the average frost-free dates for your area. Specifically know the particular air drainage, and frost characteristics of your fields and locations in the fields. Time the planting and subsequent harvest of crops to try to avoid coldest periods.

4. Covering. There are a number of ways to cover plants to reduce danger of cold. They are usually used only on young plants but may be used on older plants such as strawberries.

(a) Hot Caps or Hot Tents: Individual waxed paper plant covers have been used quite successfully for many crops such as tomatoes, cantaloupes, watermelons, and peppers. They also create problems that must be coped with. If the weather suddenly turns warm when covers are in place, they may have to be removed or the tops opened to prevent plants from becoming too soft or being killed by excessive temperatures inside the cover. Weeds germinate and grow more rapidly under the covers and may be more difficult to control when covers are removed. Insects and diseases may
be more prevalent under covers, particularly cut worms, and are difficult to control. Finally, covers may be removed or opened for a warm period and a killing frost may follow.

(b) Row Covers: Recently continuous row covers using waxed paper or clear polyethylene plastic have been used to protect plants from cold and wind. In cold sections of the country, complete coverage of plants using wire wickets to support the cover along the row are used. The edges are covered with soil. The covers may be applied and removed with machines either hand drawn or tractor mounted. The same disadvantages exist as for Hoth-Caps. California growers have used the same types of covers, except the cover is applied only two-thirds to three-fourths of the way over, leaving the south side or the leeward side open. This allows good air movement and minimizes the problems of weeds, insects and overheating associated with complete covers.

5. Cultivation: Never cultivate the soil if frosts are anticipated. Bare, compact soil will give greater protection for plants than freshly cultivated or straw-mulched soils. High moisture content soils give more protection than dry soil. Loose, dry soil is a good insulator. It retards the rate at which the soil will absorb heat when the air temperature is warmer than the soil and it slows down the release of heat from the soil when the air temperature is lower than the soil temperature. Water has a greater capacity for both absorption and release of heat than soil. So, compact, undisturbed, high moisture soil gives greater cold protection than loose, dry soil or compact, dry soil.

This is of greater importance on organic soils than on mineral soils. Organic soils (muck & peats) are better insulators than mineral soils and damage is usually most severe, because they are usually in low areas where cold air drainage is into them.

6. Chemical Weed Control: Where chemical weed control eliminates cultivation, it reduces cold damage.

7. Water: Water may be used very effectively for frost control. With subsurface, surface or ditch irrigation, the water table should be kept as high as possible without causing crop injury during frost danger periods.

Overhead Sprinklers: Overhead sprinkler systems designed or modified for cold protection are quite effective if water is continuously sprayed on the plants. When air temperatures approach 32°F begin application of water. This water gives off heat as it falls and freezes. One pound of water turning to ice releases 144 B.T.U. Applying 0.10 acre inches per hour will release 3,257,136 B.T.U. per acre per hour, if all the water turns to ice. The beginning water temperature is of little benefit. The latent heat of freezing water released to plants gives the protection.

System requirements are:

- Apply the minimum amount of water for maximum protection with good coverage. This is 0.08 to 0.12 inches per hour.
- Pump requirements for 0.10 acres inches per hour is 45 G.P.M. per acre.
- Keep ice load to a minimum.
- Prevent water-logging of soil.
- Keep equipment and operational costs reasonable.
Type sprinkler required and pressure at nozzle: One single nozzle sprinkler with approximately 2.50 G.P.M. capacity at 50-60 psi for 50 feet by 50 feet spacing to give 0.10 inches per hour. For 60 feet by 60 feet sprinkler spacing use 3.60 G.P.M. sprinklers at 50-60 psi. Sprinklers making one revolution every two minutes or less are satisfactory.

For irrigation and frost protection a 25 feet by 50 feet, 25 feet by 60 feet or 30 feet by 60 feet spacing is more desirable. For frost protection every other sprinkler would be shut off, which will make it a staggered 50 by 50 or 60 by 60.

This system works best on low growing crops; however, it has been used on staked tomatoes with success.

Flooding: Field flooding may be used on some crops where land is level and water and pumping facilities are adequate. Water may be run down every 3 to 10th middle and allowed to stand in the field until frost danger is past. This works well with potatoes.

A complete covering of plants with water gives excellent protection from frost and freezing. Water must be removed immediately following frost danger. This may require pumping water in and out several days in a row. Some crops such as peppers and beans will tolerate immersion better than others, such as celery.

5. Plowing Under: Plowing young crops under is used extensively and works quite well with crops that will withstand rough treatment or crops that are field-seeded thick enough that some destruction does not affect yields. Young beans, potatoes, and even tomatoes can be completely covered with soil without causing excess injury. Plants must be uncovered as soon as frost danger is over. The uncovering usually involves considerable labor.

9. Succession Planting: This is a general practice with watermelons and cantaloupes. Seed are planted in the same rows at weekly intervals up to four or five times so that if an early planting emerges and is killed a second planting is ready to emerge shortly. With these crops the use of peat pots has worked quite well. The pots are placed adjacent to each other and filled with good potting soil, and seeded with three or four seeds. The area is covered with clear plastic over a frame to increase the temperature and hasten germination. The cover is removed when plants emerge. If frost is expected, the plants are covered with clear plastic. The plants are held until danger of frost is past before setting in the field.

10. Black Plastic Mulch: The black plastic absorbs more heat than bare soil and much more than straw mulch. It releases this stored heat slowly at night which reduces frost injury to open strawberry flowers which are very susceptible to frost. Black plastic mulched strawberries recover more quickly and produce fertile flowers and fruit more quickly following frosts than straw-mulched or un-mulched plants.

11. (Heat) Many forms of heat are used extensively. These include old tires alone or filled with sawdust and saturated with oil, wind-rows of pine needles, straw, sawdust, wood, palmetto roots, etc. are placed on the windward or north side of fields and sometimes throughout the field. They are then fired up. This creates much smoke (which is of little value) and some heat. This heat creates an air turbulence over fields and reduces frost damage. Several small fires dispersed over an area is much better than one large fire.

Open smudge pots and stack-type, oil-fired heaters are used extensively in citrus groves and are used some in vegetable fields. The economic value and stage of maturity of the crops involved determine whether a grower should use heaters. An open pot burner of nine gallon capacity will consume about one gallon of fuel per hour. With wind, this is increased to 4-5 gallons per hour. From 40 to 50 heaters of this type may be necessary per acre and cost nearly $20 each.
With the high initial cost for equipment and an average fuel and labor cost of $50 per acre per night, it is doubtful whether this type of protection is economical. With high value crops, such as staked tomatoes near harvest maturity, and when only two to three degrees Fahrenheit must be overcome for only a short time, then it may be economical. When the temperature drops well below freezing and stays there, the risk of still losing the crop is great.

12. Wind Machines: These machines have gained wide usage among citrus grower, however, only a few are used with vegetables. The reasons for this are that the machines must be permanently installed and are difficult to move and are expensive. Vegetable growers move from area to area and usually operate on leased land. Wind machines work best with only light frost and where there is a warm air inversion above an area. With cold, clear, still weather their value is reduced.

13. Wind plus Heat Machines: Recently, portable and stationary rotating blower type machines with an oil heat source have been perfected. At this time, none have been used on vegetable crops in Florida. They appear to have distinct advantages over wind alone or heat alone.

14. Foam: In 1959, a United States Patent was awarded for a foam treatment for shielding plants from frost. Bean and tomato plants were sprayed with a Saponin, 2.5 parts, Methocel, 7.5 parts with 1,000 parts of water. This was spumed (foamed) over the plants just prior to anticipated frost. In one test, the temperature went down to -24°F and foam-covered plants survived while uncovered plants were killed. This method has considerable promise, but requires more research on practical application equipment and reduction in costs of the ingredients to be economical.

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REFERENCES


References continued...


MEMORANDUM

TO: County Agents

RE: Vegetarian Newsletter No. 58
Effects of Cold Weather and Protection Techniques on Vegetable Crops

Wind Machines: The last sentence in this paragraph should read: With cold, clear, still weather, machines are most likely to be of value.

On exceptionally cold nights, the inversion of warm air above the earth is usually small and is considered a weak inversion. The rate of cooling of the earth's surface becomes much slower once it reaches the freezing point, especially if frost forms. Very cold air is usually very dry, and the air density is greater than warmer, more moist air and should be more resistant to displacement, thus rendering the machines less effective.

Machines are least effective when winds exceed 6 mph and should not be operated both to prevent possible injury to the crop and to the machine.

More detailed information on this subject may be found in Florida State Horticultural Society Proceedings, Volume 71, page 92, 1958. Wind Machines for Frost Protection in Florida by James G. Georg.

Sincerely,

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