e-GRO Alert
Volume 4, Number 31 April 2015

by Neil S. Mattson
nsm47@cornell.edu

Tipburn of hydroponic lettuce

Two abiotic disorders share the same name, it is important to distinguish between them.

The lettuce literature describes two different types of abiotic disorders which share the same name, tipburn. Both disorders can severely limit a grower's ability to sell their lettuce. Understanding the difference between the two types of tipburn is imperative for hydroponic lettuce growers, because each disorder has different causes and preventative measures. The objective of this article is to clarify

Figure 1. Inner leaf tipburn of hydroponic butterhead lettuce. Symptoms appear as brown lesions on tips of young, inner leaves.

e-GRO Alert
www.e-gro.org

CONTRIBUTORS

Dr. Nora Catlin
Floriculture Specialist
Cornell Cooperative Extension - Suffolk County
nora.catlin@cornell.edu

Dr. Chris Currey
Assistant Professor of Floriculture
Iowa State University
ccurrey@iastate.edu

Dr. Kristin Getter
Floriculture Outreach Specialist
Michigan State University
getterk@msu.edu

Dan Gilrein
Entomology Specialist
Cornell Cooperative Extension - Suffolk County
dog1@cornell.edu

Dr. Brian Krug
Floriculture Ext. Specialist
Univ. New Hampshire
brian.krug@unh.edu

Dr. Joyce Latimer
Floriculture Extension & Research
Virginia Tech
jlatime@vt.edu

Dr. Roberto Lopez
Floriculture Extension & Research
Purdue University
rglopez@purdue.edu

Dr. Neil Mattson
Greenhouse Research & Extension
Cornell University
neil.mattson@cornell.edu

Dr. Paul Thomas
Floriculture Extension & Research
University of Georgia
pathomas@uga.edu

Dr. Brian Whipker
Floriculture Extension & Research
NC State University
bwhipker@ncsu.edu

this confusion by clearly describing the symptoms of each disorder, environmental causes, and corrective actions. For the purposes of distinction, we will give each disorder a separate name: inner leaf tipburn (Figure 1) vs. outer leaf marginal necrosis (Figure 3). A summary of each disorder is presented in Table 1.

Symptoms of inner leaf tipburn

This disorder is characterized by necrotic (brown) spots on the tips and edges (margins) of rapidly developing young leaves of lettuce. The young leaves are in the center (heart) of head lettuce. The necrosis can take the form of light to dark brown spots that further develop into lesions and can affect the entire margin of leaves (Figure 2). In closed head lettuce the symptoms may not be apparent until you cut through the head.

Causes of inner leaf tipburn

Inner leaf tipburn develops due to poor calcium supply to young developing leaves. Most often the symptoms are not due to lack of calcium in the root-zone but rather environmental causes leading to poor calcium supply to young leaves. An understanding of how calcium is taken up and used by the plant sheds light on the environmental causes of calcium deficiency. Calcium is a component of cell walls, acting as a binding agent to cement adjacent cell walls. Calcium is also involved in cell division and elongation. Symptoms of calcium deficiency include necrosis of young leaves and sometimes distorted or strap-like leaves. Calcium is taken up passively by young roots and is transported in the xylem. Once Ca has entered plant tissue it is not mobile. Therefore active transpiration by the plant is necessary to provide adequate calcium to developing tissues. Under low calcium conditions plant cells made by the growing point cannot form properly. As the leaves enlarge the symptoms (leaf tip necrosis) become visible to the naked eye.

Environmental conditions which limit plant transpiration result in poor calcium supply to the plant.

Cooperating Universities

Cornell University Cooperative Extension of Suffolk County

PURDUE UNIVERSITY

THE UNIVERSITY OF GEORGIA COOPERATIVE EXTENSION
College of Agricultural and Environmental Sciences
College of Family and Consumer Sciences

IOWA STATE UNIVERSITY Extension and Outreach

NC STATE UNIVERSITY

CORNELL

VirginiaTech Invent the Future

MICHIGAN STATE UNIVERSITY

UNIVERSITY of NEW HAMPSHIRE Cooperative Extension

In cooperation with our local and state greenhouse organizations

Indiana FLOWER GROWERS Association

Metropolitan Detroit Flower Growers Association

Virginia Flower Growers Association Since 1954

lifga

NC FLOWER POWER

NEW HAMPSHIRE Plant Growers QUALITY GARDEN CENTERS & GROWERS

Such conditions include high humidity, lack of air movement, and poor root system development. The disorder most frequently occurs as the head is beginning to reach maturity. The inner part of the head has locally humid conditions and less airflow due to the presence of the outer, wrapper leaves. In addition, the disorder often occurs when head lettuce is growing very quickly due to high daily light integrals (greater than 17 mol m^{-2} day^{-1} with vertical airflow, or greater than 12 mol m^{-2} day^{-1} with poor airflow) and warm greenhouse temperatures. Under rapid growing conditions, calcium supply to the growing point cannot keep up with plant calcium demands. At slower growing conditions, especially low daily light integrals, the disorder typically does not occur.

Preventing inner leaf tipburn

Once symptoms have become apparent, there is no treatment which can reverse the symptoms. Therefore management of inner leaf tipburn of lettuce relies on prevention. Rarely, is the disorder caused by lack of calcium in the root-zone. However, it is prudent to ensure that your nutrient solution contains sufficient calcium either from your water source or added fertilizer. A fertilizer recipe that has worked well for leafy greens for many years for the Cornell Controlled Environment Agriculture (CEA) group calls for 90 ppm calcium. The recipe for the Cornell CEA modified Sonneveld solution is available at: http://www.greenhouse.cornell.edu/crops/factsheets/hydroponic-recipes.pdf

Assuming sufficient calcium is supplied in the fertilizer solution; the primary tools for preventing inner leaf tip burn are promoting environmental conditions that favor plant transpiration as well as avoiding excessive daily light integrals (DLI). Low humidity and good air movement will promote plant transpiration which will promote supply of adequate calcium to the shoot tip. While supplemental light is an important tool for promoting fast crop cycles of lettuce, too much can promote inner leaf tipburn. Vertical

air flow (VAF) fans (such as paddle fans or vertically mounted horizontal airflow fans) are an important tool to promote adequate air supply to the center of each lettuce head. Extensive research by the Cornell CEA group has found that tipburn frequently occurs when DLIs are greater than 17 mol m^{-2} day^{-1} when VAF fans are used and at DLIs greater than 12 mol m^{-2} day^{-1} when VAF fans are not present.

Tipburn can be a particular problem in summer greenhouse conditions when there are naturally high DLIs. Therefore, greenhouse shading is a must when growing hydroponic lettuce in the summer. Retractable shade curtains are useful as shade can be deployed when needed, but allow natural light through on cloudy days. Carbon dioxide enrichment of the greenhouse environment is another tool which can promote growth of head lettuce. However, enrichment can also favor tipburn of heads growing too rapidly.

Symptoms of outer leaf marginal necrosis

The second disorder that is sometimes called tipburn in the lettuce literature occurs is characterized by necrotic spots/lesions on the edge of lower (older) leaves of lettuce. These lower leaves are the outer

Figure 2. Inner leaf tipburn of hydroponic lettuce. As symptoms advance, brown lesions can advance so that entire leaf margins are affected.

Figure 3. Outer leaf marginal necrosis of hydroponic lettuce. Older (outer leaves of head) are affected. Symptoms appear at margins where veins terminate.

leaves of head lettuce. The necrotic lesions can rapidly expand inward and along the length of the leaf margins. The leaf margins may also be chlorotic (yellow) in affected areas (Figure 3).

Causes of outer leaf marginal necrosis

While inner leaf tipburn has been well correlated with low calcium supply, the causes of outer leaf marginal necrosis are less clear - there may be multiple interrelated causes. Symptoms are most commonly seen under conditions of inadequate supply of water to the plant or high salts in the root-zone in combination high airflow and low humidity, which exacerbates the condition.

The symptoms are often first evident on leaf margins where vessels end in hydathodes (specialized glands that secrete water through stoma). The necrosis may be due to high salts accumulating in these regions causing cellular damage. Low humidity promotes loss of water (and thus accumulation of salts) in these regions. For example, outer leaf marginal necrosis was observed during winter, low humidity growing conditions in a hydroponic operation using vertical towers (Figure 4 and 5). The water source had elevated salts with an electrical conductivity (EC) of 1.0 mS/cm. The nutrient solution EC was greater than 2.0 mS/cm. The lettuce heads were growing in perlite and symptomatic plants were noted more often on lower portions of the vertical tower where soluble salts had accumulated. Excessive airflow can also promote outer leaf marginal necrosis. For example, symptoms have been observed on head lettuce growing in in the outer rows of nutrient film technique (NFT) channels. These outer heads were exposed to higher airflow.

Preventing outer leaf marginal necrosis

The key to avoiding outer

leaf marginal necrosis is to avoid environmental conditions which can cause high soluble salts to build up in margins of old lettuce leaves. Avoid high nutrient solution EC. For example, the EC of the Cornell CEA lettuce nutrient solution recipe is about 1.4 mS/cm. In the examples noted above, nutrient solution EC was greater than 2.0 mS/cm. Monitor root-zone EC. If plants are grown in a physical substrate, rather than in water-culture hydroponics, make sure water supply to the plant is appropriate. Leach as necessary to avoid accumulation of high soluble salts. Maintain adequate, but not excessive airflow. Finally symptoms are more common during periods of low relatively humidity, so pay particular attention to salts, water supply and airflow during these times.

Figures 4 (above) and 5 (below) outer leaf marginal necrosis was observed on hydroponic lettuce growing in a vertical tower system. Symptoms were associated with elevated salts in the nutrient solution and substrate and low relatively humidity and where outer leaves had more exposure to airflow.

Table 1. Summary of inner leaf tipburn versus outer leaf marginal necrosis of lettuce.

	Inner leaf tipburn	**Outer leaf marginal necrosis**
Symptoms	Browning of the edges of rapidly developing inner (young) leaves of lettuce, may begin as scattered spots and proceed to necrosis and collapse along entire margin	Browning of the edge of outer (older) leaves of lettuce, may be scattered spots or may be more widespread so entire margin is affected
Causes	Inadequate calcium supply to growing tip and young growing leaves	Salt accumulation at leaf margins where vessels terminate
Environmental conditions conducive to disorder	Conditions where there is insufficient transpiration of inner leaves (high humidity, poor airflow, closed heads) or environmental conditions that promote rapid growth (high light, warm temperatures)	High salts in root-zone, low relatively humidity, inadequate water supply to plant, excessive airflow
Preventative measures	Ensure adequate calcium supply and that environmental conditions promote transpiration of inner leaves (low humidity, vertical airflow fans), avoid excessively high daily light integrals	Avoid high nutrient solution EC, monitor and flush excess soluble salts if plants growing in physical substrate, provide adequate water to plants, avoid excessive airflow under conditions of low relative humidity