Cultivar and Calcium Management to Minimize Lettuce Tipburn in Greenhouse Hydroponics

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Abstract

Tipburn injury is an important and serious abiotic disorder most likely associated with calcium deficiency. Tipburn can severely reduce the quality and marketing value of hydroponic lettuce (*Lactuca sativa* L.). This study was designed to screen eleven lettuce cultivars (Aerostar, Annapolis, Bibb, Coastal Star, Dragoon, Fenberg, Green Forest, Holon, Outredgeous, Parris Island, and Sparx) for tipburn resistance. The influence of increasing calcium levels (187, 280 and 373 mg.L^{-1}) in reducing tipburn injury was further investigated. Lettuce seedlings were grown in greenhouse conditions under the hydroponic nutrient film techniques (NFT) for multiple growing cycles (2015-2016). Lettuce tipburn was graded in three categories following U.S. standards (injury, damage, serious damage). Significant differences in tipburn injury were found between cultivars. Annapolis, Fenberg, Green Forest, Outredgeous and Sparx cultivars were more resistance to tipburn as compared to Aerostar, Coastal Star, Holon, and Parris Island. Bibb had the highest rate to tipburn. Increased calcium concentration from 187 (recommended by growers) to 280 mg.L^{-1} reduced tipburn damage in Parris Island by 20% and Bibb by 60% in two out of three cycles. However, Dragoon, Holon and Parris Island showed inconsistent results. Higher level of calcium (373 mg.L^{-1}) eliminated the grade of serious damage in Fenberg and Bibb, in one out of three cycles, but had no effect in increasing tipburn resistance in Aerostar, Dragoon and Holon. While higher than the recommend calcium concentration reduced tipburn in some cultivars, screening for genetic resistance to tipburn appears to be the best strategy.

Introduction

Hydroponic nutrient film technique (NFT) is a system commonly used for leafy vegetable production. The use of efficient NFT systems could play a major role in agricultural environments affected by drought and heat stresses (Leskovar et al., 2014). Leafy greens such as lettuce are in great demand by consumers. However, lettuce cultivars grown in greenhouse hydroponics show tipburn injury, especially during late spring and summer. Tipburn, a physiological disorder most likely associated with calcium deficiency (Huett, 1994), can severely reduce the quality and marketing value of hydroponic lettuce. Therefore, this research was designed to screen lettuce cultivars for tipburn resistance and assess the influence of increasing calcium levels in reducing tipburn injury.

Materials and Methods

- **Lettuce cultivars**: Aerostar, Annapolis, Bibb, Coastal Star, Dragoon, Fenberg, Green Forest, Holon, Outredgeous, Parris Island and Sparx
- **Seeding**: 98 cell rockwool slabs in trays
- **Transplanting**: 3 weeks after seeding. Transplants were placed into the recirculating hydroponic NFT channels 20 cm apart
- **Nutrients solution composition** (NSC), (mg.L^{-1}): Total N 200, N-NH_4 9.3, N-NO_3 190.6, P_2O_5 133, Ca 186,6, Mg 33.3, S 73.3, Mn 3.3, Mo 0.033, with three levels of Ca: 187, 280 and 373
- **Harvest dates**: May 4, 2015 (Cycle 1); September 17, 2015 (Cycle 2); November 23, 2015 (Cycle 3) and February 16, 2016 (Cycle 4)
- **Experimental design:** CRD with four replications
- **Measurements**: Leaf fresh and dry weight, leaf number and length, stem diameter, °Brix and chlorophyll content (SPAD). Concentration of total Kjeldahl nitrogen (N) by automated, colorimetric (Systea EasyChem Analyzer); calcium (Ca), magnesium (Mg) and potassium (K) by atom-absorption spectrometer, all in the wet digest.
- **Tiburn rates**: incidence and severity of tipburn was graded following US Standards

Results

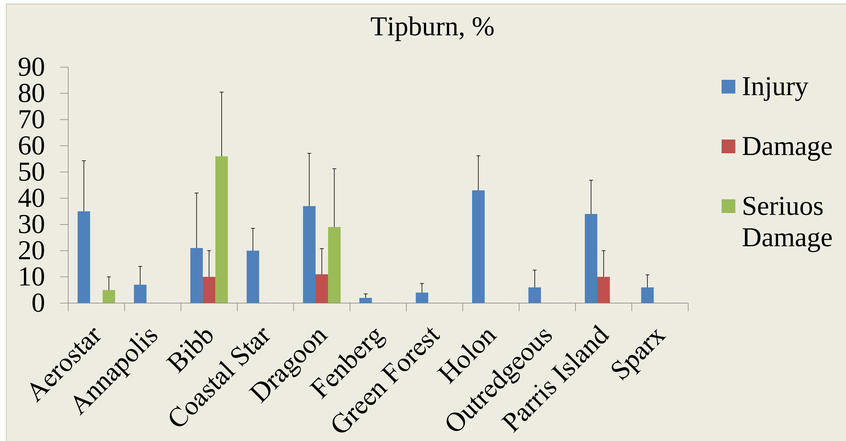

Fig. 1. Lettuce tipburn incidence and severity with Ca 187 mg.L^{-1}.

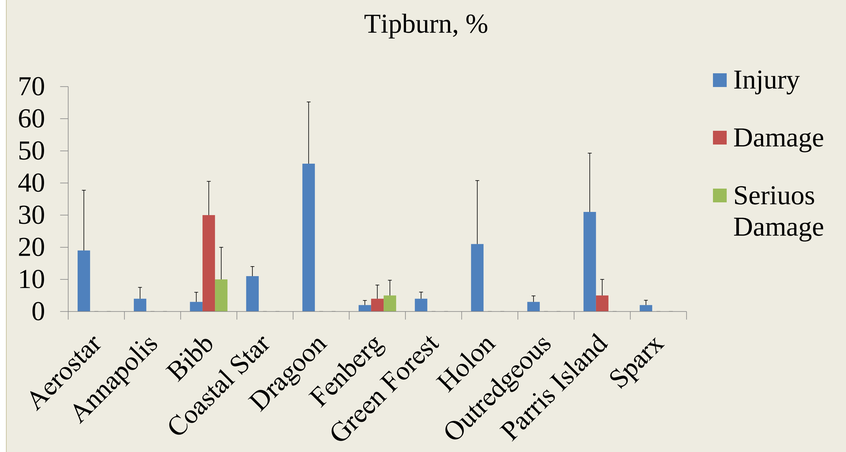

Fig. 2. Lettuce tipburn incidence and severity with Ca 280 mg.L^{-1}.

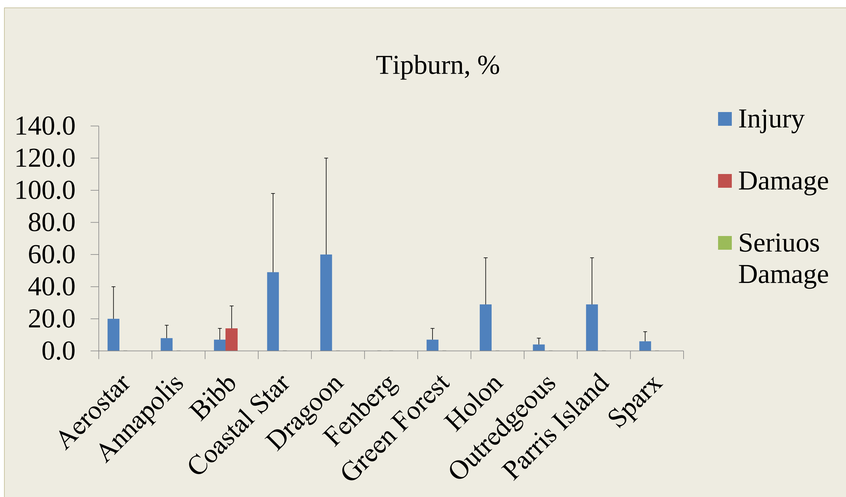

Fig. 3. Lettuce tipburn incidence and severity with Ca 373 mg.L^{-1}.

Calcium Conc.	LFW	LDW	RFW	RDW	Ca, mg g^{-1} DW			
	g/plant				Cycle 1	Cycle 2	Cycle 3	Cycle 4
187 mg.L^{-1}	76.5 a	2.63 b	5.63 b	0.50 b	13.84	14.55b	21.24	16.11
280 mg.L^{-1}	69.8ab	2.83ab	6.08ab	0.55ab	13.55	16.52a	18.21	15.60
373 mg.L^{-1}	65.3 b	3.23 a	6.85 a	0.60 a	13.81	16.67a	20.93	13.95
LSD (.05)	7.75	0.45	1.17	0.09	0.46	1.25	3.25	2.37

Table 1. Leaf fresh and dry weight (LFW, DRW), root fresh, and dry weight (RFW, RDW) and leaf calcium content of lettuce cv Fenberg as a function of calcium concentration in the nutrient solution.

Fig. 4. Tipburn in Lettuce cv. Bibb in hydroponics

The results (averaged of 4 cycles) revealed that increasing Ca concentration in the hydroponic nutrient solution can reduce lettuce tipburn incidence and severity. Annapolis, Fenberg, Green Forest, Outredgeous and Sparx cultivars were more resistance to tipburn as compared to Aerostar, Coastal Star, Holon, and Parris Island. Increased Ca concentration from 187 (recommended by growers) to 280 mg.L^{-1} reduced tipburn damage in Parris Island by 20% and Bibb by 60%, in two out of three cycles. Higher Ca levels (373 mg.L^{-1}) eliminated the grade of serious damage in Fenberg and Bibb, but had no effect in reducing slight tipburn injury in other tested cultivars. In addition, higher Ca levels increased LDW and RDW of lettuce cultivars. Importantly, plant Ca concentration significantly increased in some lettuce cultivars growing during summer (cycle 2), but not during cool seasons (cycles 1, 3, 4) (Table 1, shown for cv. Fenberg).

Conclusions

The results revealed that a higher than recommended calcium concentration may reduce lettuce tipburn incidence, a response that is highly cultivar dependent. Future screenings, including exploring changes in leaf Ca concentration under heat stress conditions will be important for lettuce crop improvements programs in hydroponic systems.

Literature Cited

1. Leskovar D. I., C. Xu, S. Agehara, S. P. Sharma and K. Crosby, 2014. Irrigation strategies for vegetable crops in water-limited environments. J. of Arid Land Studies, 24-1, 133-136.
2. Huett D. O., 1994. Growth, nutrient uptake and tipburn severity of hydroponic lettuce in response to electrical conductivity and K:Ca ratio in solution. Austr. J. Agric. Res., 45, 251-67.

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