IODOMETHANE PHYTOTOXICITY: POTENTIAL ROLE OF PLANT NUTRIENT UPTAKE

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In the spring of 2006 multi-year studies were initiated to evaluate the efficacy of Midas™ (iodomethane:chloropicrin 50:50, Arysta LifeScience Corp., Cary, NC) for production of ornamental cockscomb (*Celosia argentea* var. *cristata*) in Martin County, Florida. Treatments were untreated check, Midas™ at 224 kg/ha (200 lb/A), and methyl bromide:chloropicrin (MeBr, 98:2) at 224 kg/ha (200 lb/A). All treatments were covered with metalized film (Canslit, Inc., Montreal, Quebec, Canada) following fumigation. Each plot was 1.8 m x 30 m, with four replications in a randomized complete block design. Plastic was removed 15 days after fumigation and cockscomb ('Chief Rose', VIS Seed Company Inc., Arcadia, CA) was seeded five days later. Although Midas™ application required equipment modifications, it provided adequate weed, nematode, and disease control and yields comparable to MeBr (Rosskopf et al., 2006: Kokalis-Burelle, et al., 2006). In fall 2006, the experiment was repeated with treatments remaining in exactly the same locations. After two seasons of Midas treatments in the same blocks, plants began exhibiting symptoms of iron (Fe) toxicity, particularly the Bombay cultivars. Symptoms included interveinal chlorosis and necrosis, with severely reduced internodes, and significant stunting in the most severe cases. In addition to the standard sampling procedures including nematode populations, weed incidence and weights, fungal colony forming units, and plant growth, leaf tissue and soil samples were taken to compare symptomatic and asymptomatic plants. Symptoms were not observed in untreated controls or MeBr. Fertilizer application during this season was a standard 6N-6P-6K (nitrogen-phosphorous-potassium) with Fe oxide. Once symptoms were identified as Fe toxicity, this fertilizer was discontinued and calcium nitrate was applied for the remainder of the season. However, affected plants did not recover.

Soil samples taken from all areas of the field indicated that water-extractable Fe levels were consistent throughout the field regardless of fumigant treatment (Table 1). Leaf tissue levels of Fe were greater in symptomatic tissue (Table 1). Leaf Fe levels in both asymptomatic and symptomatic tissue; however, were considered "toxic" based on nutrient guidelines for the production of cut flowers (Mills and Jones, 1996) (Table 1). Albano et al (2006) working on Fe toxicity in marigold, however, reported that levels of leaf Fe considered toxic were not always associated with the occurrence of Fe toxicity. Many biotic and abiotic factors influence Fe nutrition in plants including soil chemistry and microbiology (Lindsay and Schwab, 1982); cellular levels of other nutrients (Somers and Shive, 1942); a cultivar's susceptibility or tolerance to Fe toxicity (Albano and Miller, 1998; Verkleij and Schat, 1990) or the ability to express Fe-efficiency; a set of physiological reactions that occur when soil Fe availability is low that increases root zone Fe solubility and enhance Fe uptake and distribution in the plant (Albano and Miller, 1996); or a combination of these factors. Considering these factors together with the plant tissue data, the use of Fe oxide, a relatively insoluble Fe source, and the higher soil pH observed in symptomatic soils, (pH 4.17 ± 0.45 and 5.44 ± 0.28, in asymptomatic and symptomatic, respectively), it appears that the Midas treatment affected soil chemistry, soil microbiology, and/or the plant to cause excessive accumulation of Fe in leaf tissue. The high levels of Fe in both asymptomatic and symptomatic leaf tissue suggest that plants responded to Fe oxide by enhancing plant physiology associated with Fe acquisition. Other abiotic and biotic factors may have contributed to the observed disorder including irrigation water alkalinity (i.e. liming agents) and soil microbial populations. Soil microorganisms release various organic substances that improve Fe solubility/availability in soils; a change in microbes or the death and decay of microbes, could alter soil-solution Fe levels (Basel, 2004).

Based on the hypothesis that fertility plays a role in the observed phenomenon, 2007 spring and fall field trials were designed with the Midas-treated blocks in the same locations as the two previous seasons. All fumigant plots were split into two fertilizer sub-plots. Both fertilizers were formulated as 10N-4P-10K, but one contained no Fe and one contained a higher level of slow release Fe, relative to Fe oxide, in the form of Fe sucrate. Although there were significant interactions between fertilizer and fumigant efficacy, particularly with regard to nematode populations, the previously observed symptoms could not be recreated, even with two seasons of applications.

Based on the information that has been collected thus far, it appears that: Fe plays a significant role in the phytotoxicity symptoms observed in Midas treated fields; the symptoms appear to be plant mediated, ie. conditions may be present for phytotoxicity to develop, but cultivar genetics play a role in expression; bicarbonates and resulting changes in soil pH may play a role in phytotoxicity; and bacterial population changes may play a role in development of symptoms. Additional analysis is being done on existing samples to evaluate shifts in soil microbial populations. Also, further chemical analyses of tissue and soil samples collected from this field trial are underway.

Recently, phytotoxicity occurred in areas where Midas was applied in commercial production of bell peppers and tomatoes on sloped fields using seep irrigation. Of the 12,000 acres of vegetable production land that has been treated with Midas since the fall of 2008, approximately 196 acres of plants have exhibited symptoms of phytotoxicity that appear to be related to the phenomenon seen previously.

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Table 1. Leaf tissue and soil analysis from symptomatic and asymptomatic celosia plants.

		Macro Nutrients (% - Leaf; ppm -Soil)					Micro Nutrients (ppm for both Leaf and Soil)							Non Essential (ppm)
Source	C	Ca	K	Mg	N	P	B	Cu	Fe	Mn	Mo	Ni	Zn	Al
							Leaf Tissue							
Asymptomatic		2.784	6.036	1.174		0.981	26.428	19.174	1105.1	182.30	0.712	2.424	157.52	67.11
Symptomatic		2.153	5.112	0.904		0.694	31.488	19.580	1609.6	235.48	0.786	2.365	160.76	120.94
Statistics (*Pr* > *F*)	---	0.0031	0.0080	0.0002	---	0.0169	0.0087	0.7941	0.0190	0.2793	0.3672	0.9292	0.8666	0.1182
Nutrient Sufficiency Range	---	1.00 – 2.00 Dianthus field[z]	1.17 – 6.00 Dianthus field	0.19 – 0.70 Dianthus field	2.80– 5.20 Dianthus field	0.19 – 0.80 Dianthus field	22 – 100 Dianthus field	6 – 30 Dianthus field	50 – 200 Dianthus field	33 – 302 Dianthus field	0.12 – 2.00 Snapdragon greenhouse	---	20 – 200 Dianthus field	10 – 100 Snapdragon greenhouse
Evaluation[y]	---	S	S	E	---	S	S	S	T	S	---	---	S	---
							Soil (2:1)							
Asymptomatic	---	7.196	7.095	0.2858	---	4.848	0.010	BDL[x]	0.3909	0.084	BDL	BDL	0.019	0.313
Symptomatic	---	12.182	3.999	0.9158	---	4.633	0.006	BDL	0.3390	0.061	BDL	BDL	0.020	0.248
Statistics (*Pr* > *F*)	---	0.1967	0.0682	0.3469	---	0.8482	0.6145	---	0.7535	0.4664	---	---	0.9371	0.2312

[z]Nutrient range, Cut Flower Crop, and Production System. Source: Plant Analysis Handbook II, Mills and Jones, 1996, ISBN: 1-878148-052.

[y]Evaluation based on published sufficiency data: S, sufficient; E, Excessive; T, toxic.

[x]BDL: Below Detection Limit