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Response of tomato to transplant drench, foliar organic-complex Ca, B, K and yield enhancement amendments

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Abstract

Field studies were established in 2004 and 2005 to determine the effects of transplant drench and foliar applications of organic-complex Ca, B, K amendments and a yield enhancement product, 'Perc Plus™', on the flowering, fruiting, fruit yield and market value of Italian-cv. 'Classica' and large-fruited cv. 'Amelia' tomato (*Lycopersicon esculentum* Mill.). Treatments were an organic yield enhancement applied as a transplant drench and then foliar 7 days later (TD); once a week foliar amendments of organic-complex Ca, B, and K nutrients beginning at first bloom for 4 weeks (FA); a combination of the drench and foliar treatments (TD+FA); and a control (CON). Fruit-set of 'Classica' was significantly higher for the FA and TD+FA than the other treatments in 2004, however there was no effect on yield and quality of harvested fruit. Flowering and fruit-set of 'Amelia' were not affected by drench and/or foliar amendments in either year. Total fruit yield and quality of the treated plots were not significantly different than the CON for either cultivar or year.

Key words: Tomato, foliar nutrient amendments, B, K, Ca, yield enhancement, fruit-set, biostimulants, *Lycopersicon esculentum*

Introduction

Commercial vine-ripened tomato producers are constantly seeking innovative and inexpensive management practices to enhance yield and quality. Various companies market supplemental nutrient and bio-stimulant products to vegetable growers that are reported to increase yields and profits. Investigations of soil applied, transplant drench and foliar applications of nutrients and various organic biostimulant compounds as a way to enhance fruit-set, growth, size, fruit quality and overall yields of tomato have produced inconsistent results. Foliar applications of Ca + B nutrients were shown to significantly decrease incidences of shoulder check defects (Huang and Snapp, 2004) and a biostimulant increased early fruit size and yields on a sandy soil when injected through the drip lines at 14 and 21 days after transplant (Cszinszky, 2002). However, foliar applications of biostimulants and nutrients have not produced consistent increases in yield or quality (Castro *et al*., 1988; Csizinszky, 1996). Foliar applied K did not increase fruit yield or quality when compared to drip-line K injection (Hartz *et al*., 2005). In apples, foliar B amendments after bloom increased fruit-set and yield (Wojcik *et al*., 1999).

The literature reflects a complicated and inconsistent response of fruit-set and growth to biostimulant application and foliar fertilization. Environmental parameters such as temperature (Peet and Bartholemew, 1996; Sato *et al*., 2000; Adams *et al*., 2001), assimilate supply and demand (McAvoy and Janes, 1989; Bertin and Gary, 1992; Bertin, 1995), sucrose synthase enzyme (D'Aoust *et al*., 1999), genotype (Abdul-Baki and Stommel, 1995) and even management practices such as planting depth of transplants (Vavrina *et al*., 1996) are other factors which have been shown to influence tomato fruit-set and growth and could possibly influence the effects of applied amendments for some cultivars. The type of organic compound could also affect plant response. Our objectives were to investigate the effects of a fulvic acid derived biostimulant and foliar applied fulvic acid complexes of B, Ca, and K on the flower, fruit-set and fruit yields of two contrasting tomato - a small-fruited Roma type, and a large-fruited commercial cultivar.

Materials and methods

Field studies were conducted at the University of Arkansas at Monticello, Monticello, Arkansas in the 2004 and 2005 growing seasons. Transplants of 'Classica', an Italian type fruited cultivar, and 'Amelia', a popular large-fruited type grown by commercial vine-ripened tomato producers in the region were planted on 6 April 2004 and 18 April 2005 in a raised bed with black-plastic mulch, micro-irrigation culture. Tensiometers at 0.15 m depth were used to schedule irrigation events when readings reached -0.25 bars. The soil was a Sacul loam and preliminary soil test data (Melich-3 extract, Mehlich, 1984) revealed high P and K nutrient levels and a favorable pH (Table 1).

Table 1. Soil pH and nutrient levels

Depth (cm)	pH	Nutrient (kg ha^{-1})			
		P_2O_5	K_2O	Ca	Mg
0-15	6.9	196	434	7665	548

The experimental design was a randomized complete block of four treatments and five replications. Treatments were a biostimulant soil transplant drench with early foliar application (TD), foliar nutrient application programme (FA), a combination of the drench and foliar programmes (TD+FA) and a control (CON). The biostimulant 'PercPlus™' (a fulvic acid based organic complex according to company literature) was applied as a soil drench at 0.1 L plant^{-1} of a solution containing 0.001135 L L^{-1}, followed by a foliar application of 'PercPlus™' at 0.454 kg ha^{-1} (mulched). The foliar programme consisted of an application of Ca+B at first cluster set followed by four, weekly applications of Ca+B+K beginning at second cluster set. The Ca, B and K sources were fulvic acid based organic complex solutions of calcium nitrate, boric acid, and potassium carbonate foliar-applied at 0.023-, 0.0055- and 0.25 kg ha^{-1} Ca, B, and K, respectively at an application rate of 187 L ha^{-1}. Within-row transplant spacing was 0.61 m and the raised bed row spacing was 1.5 m. Sub-plot size was four plants with fruit yield data harvested from the inner two plants. Number of flower clusters, flowers and set fruit of 1 cm diameter or larger were evaluated in mid-May of each year (Table 2). Fruit was hand harvested two to three times per week for four weeks and graded using current United States Department of Agriculture classification for grades of fresh tomatoes (USDA, 2006). Statistical analyses of the data were performed using analysis of variance procedures.

Table 2. Calendar of field activities

Activity	2004	2005
Transplants set	6 April	18 April
First foliar treatment	27 April	11 May
Cluster evaluations	24 May	19 May
First fruit harvest	14 June	16 June

Results and discussion

The nutrient and biostimulant treatments had little effect on the early flowering and fruiting of the ‘Amelia’ cultivar in either year of evaluation (Table 3). There was a significant treatment effect on clusters set in 2004 but it was not consistent with the treatments and numbers of flowers. The measured reproductive parameters in 2005 were less than 2004 because of a 12 day delay in transplanting. Treatment effect on the number of fruit-set for the ‘Classica’ cultivar was significant in 2004 but not in 2005 (Table 4). A one-degree of freedom contrast of the ‘treatments’ vs. ‘CON’ in a general linear model (analysis not shown) was significant at P=0.01.

Table 3. Mid-May evaluation of reproductive progress for ‘Amelia’ ($plant^{-1}$)

Treatment	Clusters	Flowers	Fruit-set	Clusters	Flowers	Fruit-set
	2004			2005		
TD	6.1	19.1	5.0	6.2	22.5	1.4
FA	6.9	20.9	5.6	5.9	24.4	1.6
TD+FA	5.0	17.5	4.4	6.1	25.3	1.5
CON	6.6	17.4	4.5	6.0	24.4	1.8
	**[Z]	NS	NS	NS	NS	NS

[Z]Not significant (NS) and significant treatment effect at P=0.05 (*) and P=0.01 (**)

Fruit yields of both types of tomatoes were not effected by treatment in either year of study (Tables 5 and 6). A general trend of higher premium grade fruit was noticed for both cultivars in 2005. With regard to the production efficiency of marketable fruit (defined here as percent of total yield meeting USDA Grades 1 and 2), ‘Amelia’ was not effected by the treatments (Table 7). There were significant effects on the ‘Classica’, but it cannot be attributed to improvements in efficiency due to the applied amendments since the untreated plots had high efficiency. The FA treatment reduced the percentage of harvestable fruit in 2005. The rainfall was much higher in 2004 than in 2005 (Table 8) which seemed to affect the percentage of harvested fruit more for the Italian fruited cultivar ‘Classica’ rather than the large-fruited ‘Amelia’. Rainfall for the month of June in 2004 was 32.8 cm compared to only 3.81 cm in 2005. This increased partial lodging of the ‘Classica’ plants more than the ‘Amelias’ during a time of rapid fruit development and resulted in a higher percentage of sun scalding and thus, lower market quality.

Table 4. Mid-May evaluation of reproductive progress for ‘Classica’ ($plant^{-1}$)

Treatment	Clusters	Flowers	Fruit-set	Clusters	Flowers	Fruit-set
	2004			2005		
TD	13.3	35.0	22.0	7.7	32.7	1.6
FA	12.1	37.9	20.0	7.5	29.8	2.4
TD+FA	11.1	32.4	18.6	7.2	30.1	2.0
CON	12.9	35.1	16.6	8.2	32.3	1.0
	NS	NS	**	NS	NS	NS

[Z]Not significant (NS) and significant treatment effect at the 0.05 (*) and 0.01 (**) level of probability.

Table 5. Harvest yields of ‘Amelia’ (kg $plant^{-1}$) under different treatments

Treatment	XL-1	L-1	No. 2	XL-1	L-1	No. 2
	2004			2005		
TD	0.64	0.12	1.64	1.64	0.33	2.90
FA	1.28	0.20	1.74	1.49	0.01	2.97
TD+FA	1.22	0.20	1.95	1.72	0.11	2.43
CON	1.16	0.22	2.28	2.12	0.07	2.74
	NS[Z]	NS	NS	NS	NS	NS

[Z]Not significant (NS) and significant treatment effect at P=0.05 (*) and P=0.01 (**)

Table 6. Harvest yields of ‘Classica’ (kg $plant^{-1}$) under different treatments

Treatment	Marketable	Total	Marketable	Total
	2004		2005	
TD	1.56	4.75	2.22	3.69
FA	2.02	5.46	1.92	4.13
TD+FA	1.83	4.55	1.79	3.19
CON	2.40	5.06	2.05	3.66
	NS[Z]	NS	NS	NS

[Z]Not significant (NS) and significant treatment effect at P=0.05 (*) and P=0.01 (**)

Table 7. Market efficiency (%) of ‘Amelia’ and ‘Classica’ cultivars

Treatment	‘Amelia’		‘Classica’	
	2004	2005	2004	2005
TD	64	68	33	60
FA	76	68	37	46
TD+FA	79	67	40	56
CON	80	74	46	56
	NS[Z]	NS	*	*

[Z]Not significant (NS) and significant treatment effect at P=0.05 (*) and P=0.01 (**)

Table 8. Water balance during 2004 and 2005

Year	Irrigation	Water received (cm)		
		Irrigation	Rainfall	Total
2004	12	11.2	61.5	72.7
2005	19	15.2	22.4	37.6

Our results did not show any consistent benefits to fruit yield and quality of a large- or Italian-fruit type tomato fruit from supplemental amendments of biostimulants and fulvic acid complex Ca, B and K. The native fertility of the soil in this study was very high and plots were well-watered. Future studies should investigate the effects of these amendments on soils that are less fertile at the beginning of the growing season. Given the extra time and expense needed to apply supplemental nutrients and biostimulants, tomato growers may be more likely to be benefitted by improving soil fertility, irrigation efficiency, pest control and general management practices.

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