Managing transplant size and advancing field maturity of fresh tomatoes and peppers

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Executive Summary

Previous work using the triazole paclobutrazol (Bonzi) on processing tomato transplants involved treating the plants with a 5 ppm soil drench at the 2 leaf stage, and subsequently fertilizing heavily (up to 5 times the normal rate) to achieve the desired plant height. This treatment resulted in increased vigor in the field (measures as plant dry and fresh weight), advanced plant development (earlier bloom), advanced fruit maturity and increased yields. However, it is not presently registered on any food crops in North America, so a registration for use on tomato transplants is unlikely.

Work in 2006 included other potential growth regulators with greenhouse registrations (uniconazole- Sumagic; Nova) and food crop registrations (Apogee). Nova and Apogee were not effective, and only Sumagic was evaluated in 2007.

As noted with processing tomato transplants, Sumagic treatment reduced transplant growth in the greenhouse, and extra fertilizer was needed to produce a plant of marketable size after 6 weeks. Growth and development was advanced after field establishment, as indicated by increased plant fresh weights and advanced flowering. Late applications of Sumagic (21 days) was less effective. Little difference was seen between the 2.5 and 5.0 ppm rate.

Fruit maturity tended to be advanced at both field locations; however significant differences were not noted. A greater percentage of cull fruit (mainly shoulder check) was found in tomatoes treated with growth regulator treatments at one site. While this was unexpected, it may be useful in eliciting the cause of shoulder check.

Project Results and Milestones

The objectives of this trial included:

1. Determine optimum rates, timings of application, and subsequent fertilizer regimes for producing high quality tomato and pepper transplants using the regulator Sumagic.

2. Establish field trials using products and rates which were effective at managing transplant growth in the greenhouse, in order to document effects on plant establishment, growth, development and yield.

3. Generate data to accompany processing tomato transplant production data using growth regulators for a minor use submission to PMRA

Transplants of Mountain Fresh were grown in CanGro Foods research greenhouse in Dresden ON; transplants of Aristotle bell pepper were grown in the greenhouse facility at Ridgetown Campus **(Milestone 1)** Eleven treatments were applied to the transplants according to the following schedule, which was based on previous research completed with processing tomatoes:

1. Untreated
2. Paclobutrazol (Bonzi) @ 5 ppm - applied 14 days after seeding

3. Uniconazole (Sumagic) @ 2.5 ppm - applied 7 days after seeding
4. Uniconazole (Sumagic) @ 2.5 ppm - applied 14 days after seeding
5. Uniconazole (Sumagic) @ 2.5 ppm - applied 21 days after seeding
6. Uniconazole (Sumagic) @ 5 ppm - 2 applications of 2.5 ppm 7 and 14 days after seeding
7. Uniconazole (Sumagic) @ 5 ppm - 2 applications of 2.5 ppm 14 and 21 days after seeding
8. Uniconazole (Sumagic) @ 5 ppm - 2 applications of 2.5 ppm 7 and 21 days after seeding
9. Uniconazole (Sumagic) @ 5.0 ppm - applied 7 days after seeding
10. Uniconazole (Sumagic) @ 5.0 ppm - applied 14 days after seeding
11. Uniconazole (Sumagic) @ 5.0 ppm - applied 21 days after seeding

All treatments were applied at 100 ml per tray starting approximately 7 days after seeding unless otherwise stated.

The transplants were fertilized in the greenhouse with solutions of 60-5-65 (prepared using Plant Products 12-2-14 and 14-0-14) and solutions of 150-25-175 (prepared using Plant Products 12-2-24). Fertilizer solutions and water (when necessary) were applied to provide 1 inch of growth per week over a 6 week period. From seedling emergence to the 2nd true leaf stage, all treatments received a prepared solution of 60-5-65, after which the solutions were altered to provide the required growth.

Tomato trials were established at 2 sites; on 15 May on the Ridgetown Campus research farm (Brookston clay loam sand spot phase) and on 14 May at the Cedar Springs Research Station near Blenheim ON, (Fox gravelly loam soil). A single site was used for the pepper trials; transplants were established on 13 June on the Ridgetown Campus research farm **(Milestone 2)**.

At all sites the plots were established on raised beds with black mulch. Beds were prepared suing a Rain-Flo model 2600 bedder/mulch layer and 0.6 ml Biotelo degradable black mulch was applied. Irrigation tape (Netafim streamline - 12" spaced emitters @ 0.24 gallon/hr/emitter) was installed below the mulch. Tomato beds were spaced at 1.5 m and transplants were established 45 cm apart (5,920 plants/acre; 14, 800 plants/ha); pepper beds were at a similar spacing and pepper transplants were established in twin rows, 45 cm between rows and 45 cm between plants (12,000 plants/acre; 30,000 plants/ha)

Plant fresh weights were taken on 5 tomato plants per plot once flowers were present on the most mature treatments, and again every 5-7 days. Flowers counts on 10 tomato plants per plot were taken around 17, 30 and 36 days after transplanting. Tomato fruit were graded into large (>65 mm diameter) small (< 65 mm diameter) culls (scarred, blossom end rot, shoulder check) and cracks. Peppers were harvested when the fruit was greater than 62.5 mm diameter. Plots were harvested until the middle of October **(Milestone 3)**

The experiments were established as a randomized complete block design with 4 replications. Tomato plots consisted of 1 bed, 26' (8.0 m) in length; pepper plots consisted of 1 bed (2 rows) 26' (8.0 m) in length. A protected LSD was used to separate treatments with significant differences. Means followed by the same letter within a column do not differ significantly (P = 0.05).

While tomato transplants did not demonstrate large increases in transplant fresh weight as is seen in processing tomatoes, stem diameters were generally greater with growth regulator treatments (Table 1). This effect provides a “saltier” transplant which is more tolerant of wind

when planted outdoors

Tomato plant fresh weights were significantly increased 22 days after transplanting at both locations when Banns and Sumagic were applied. (Tables 2,6). This is assumed to be as a result of to the extra fertilizer applied to the transplants in the greenhouse after growth regulator treatment. This effect continued in treatments after 36 days at Cedar Springs (Table 2); while a similar trend was apparent, significant differences were not found after 33 days at Ridgetown (Table 6).

With increased plant growth comes advanced development, as is indicated by earlier flowering in plants treated with growth regulators. This effect was apparent after 17 days in the field at the Cedar Springs site; after 31 days all plants treated with growth regulators had significantly greater number of flowers than the untreated control (Table 3). Significant improvements in flowering were noted at the Ridgetown site after 23 days in the field (Table 7)

Plant growth and flower development data suggests that late applications of Sumagic (21 day) are not as effective at advancing plant development as earlier treatments. This supports the notion that increases in fertilizer application in the greenhouse are partially responsible for this advanced development, as late growth regulator treatments reduce the time required for additional fertilizer to be applied to produce a useable plant. The effectiveness of Sumagic was similar when comparing the 2.5 vs. 5.0 ppm rate.

Early fruit production appeared to be advanced with Sumagic treatments; large fruit and overall early yields (combination of small, large, split and cull fruit) tended to be greater at the Cedar Springs site. Average large fruit size was not affected (Table 4). Early fruit production also tended to be higher at the Ridgetown site; when all fruit was included the same trend continued (Table 8).

Total marketable fruit and total fruit yields did not appear affected by Sumagic treatments at the Cedar Springs site (Table 5). This is typical of previous research; the products advance maturity but do not increase total yields. Total marketable yields were quite variable at this site, ranging from 47 to 73 tons/ha.

Total marketable fruit did not differ among treatments at the Ridgetown site (Table 9) but total fruit yield (combination of large, small, cull and cracked fruit) tended to be greater with growth regulator treatment. There tended to be a greater percentage of cull fruit with some growth regulator treatments, which consisted mainly of fruit with shoulder check. Why this occurred is unclear and unexpected. This treatment effect did not occur at the Cedar Springs site (data not shown)

Little data was collected from the pepper trial, as it became obvious soon after application that this regime of growth regulator application was not practical for peppers. Pepper plant growth was reduced to a much greater extent than tomato transplants, and in many treatments we were not able to produce a marketable plant in the allotted time even though extra fertilizer was applied.

Once planted in the field, the plants recovered and total marketable yields were similar regardless of whether growth regulators were applied or not. Fruit numbers per plant were not affected as well.

Valenti has supported this work financially, and data will be shared with them in order to support a minor use registration of Sumagic for managing transplant growth in the greenhouse.

Table 1. Effect of growth regulators on tomato plug plant growth. Measurements made 42 days after seeding. Plants courtesy of John Lang, CanGro Foods, Dresden.

Treatments	Total Weight (g/plant)	Extended Leaf Height (cm)	Stem Diameter (mm)
1. Untreated	9.8	17	3.2
2. Bonzi @ 5 ppm (14 day)	11	17.1	4.9
3. Sumagic @ 2.5 ppm (7 day)	9.8	15.4	5.1
4. Sumagic @ 2.5 ppm (14 day)	10.2	17.2	4.7
5. Sumagic @ 2.5 ppm (21 day)	9.9	16.1	4.8
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	10.1	16.5	5
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	11.2	17.8	5.1
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	10.4	15.4	4.7
9. Sumagic @ 5.0 ppm (7 day)	10.6	17	4.7
10. Sumagic @ 5.0 ppm (14 day)	9.6	17.4	4.3
11. Sumagic @ 5.0 ppm (21 day)	9.9	17.4	3.7

Table 2. Tomato plant fresh weight in response to growth regular treatment at various times after transplanting. Ridgetown Campus, Cedar Springs Site - 2007.

Treatments	**Fresh Weight (g) 22 days**	**Fresh Weight (g) 36 days**
1. Untreated	15.2 c	320.8 b
2. Bonzi @ 5 ppm (14 day)	34.0 a	467 8 ab
3. Sumagic @ 2.5 ppm (7 day)	30.7 ab	471.4 ab
4. Sumagic @ 2.5 ppm (14 day)	27.5 ab	445.4 ab
5. Sumagic @ 2.5 ppm (21 day)	20.6 abc	492.2 ab
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	27.1 ab	553.3 a
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	29.9 ab	524.7 a
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	30.5 ab	564.6 a
9. Sumagic @ 5.0 ppm (7 day)	30.7 ab	490.2 ab
10. Sumagic @ 5.0 ppm (14 day)	29.8 ab	394.7 ab
11. Sumagic @ 5.0 ppm (21 day)	17.9 bc	375.9 ab
LSD (0.05)	8.5	121.3
C.V.	22	18.1
P-value	0.0009	0.0064

Table 3. Tomato plant flower counts in response to growth regular treatment at various times after transplanting. Ridgetown Campus, Cedar Springs Site - 2007.

Treatments	**Flowers per Plant 17 days**	**Flowers per Plant 23 days**	**Flowers per Plant 31 days**
1. Untreated	0 c	0.0 b	0.3 d
2. Bonzi @ 5 ppm (14 day)	0 c	0.5 b	2.5 c
3. Sumagic @ 2.5 ppm (7 day)	0.2 ab	1.0 a	3.2 abc
4. Sumagic @ 2.5 ppm (14 day)	0 c	0.3 b	2.8 bc
5. Sumagic @ 2.5 ppm (21 day)	0 c	0.0 b	2.3 c
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	0.3 a	1.1 a	3.6 abc
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	0 c	0.3 b	2.7 bc
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	0.1 bc	1.2 a	4.3 a
9. Sumagic @ 5.0 ppm (7 day)	0.2 ab	1.3 a	3.8 ab
10. Sumagic @ 5.0 ppm (14 day)	0 c	0.0 b	2.6 bc
11. Sumagic @ 5.0 ppm (21 day)	0 c	0.1 b	2.3 c
LSD (0.05)	0.1	0.3	0.9
C.V.		39.7	21.9
P-value	0.0001	0.0001	0.0001

Table 4. Early fruit yield in response to growth regular treatment. Ridgetown Campus, Cedar Springs Site - 2007.

Treatments	Early Marketable Fruit (large) (t/ha)	Average Early Large Fruit Weight (g)	Total Early Fruit (t/ha)
1. Untreated	23.3	255	49.0
2. Bonzi @ 5 ppm (14 day)	25.5	235	57.7
3. Sumagic @ 2.5 ppm (7 day)	30.5	239	55.0
4. Sumagic @ 2.5 ppm (14 day)	31	243	61.5
5. Sumagic @ 2.5 ppm (21 day)	28.4	246	54.7
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	41.2	237	76.3
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	31.9	227	71.3
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	20.2	231	52.2
9. Sumagic @ 5.0 ppm (7 day)	25.8	248	56.5
10. Sumagic @ 5.0 ppm (14 day)	34.4	255	68.0
11. Sumagic @ 5.0 ppm (21 day)	24.1	227	52.6
LSD (0.05)	-	-	-
C.V.	34.3	9.28	23.6
P-value	N.S.	N.S.	N.S.

Table 5. Total fruit yield in response to growth regular treatment. Ridgetown Campus, Cedar Springs Site - 2007.

Treatments	Total Marketable Fruit (large) (t/ha)	Average Large Fruit Weight (g)	Total Fruit Yield (t/ha)
1. Untreated	58.9	219	111.1
2. Bonzi @ 5 ppm (14 day)	64.9	215	129.8
3. Sumagic @ 2.5 ppm (7 day)	72.7	225	122.8
4. Sumagic @ 2.5 ppm (14 day)	71.9	218	130.2
5. Sumagic @ 2.5 ppm (21 day)	66	229	124.1
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	80	227	142.3
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	61.8	218	123.6
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	47	234	106.5
9. Sumagic @ 5.0 ppm (7 day)	52.7	229	108.9
10. Sumagic @ 5.0 ppm (14 day)	73.4	232	138.8
11. Sumagic @ 5.0 ppm (21 day)	46.8	217	101.4
LSD (0.05)	-	-	-
CV	26.4	9.3	16.4
P-value	N.S.	N.S.	N.S.

Table 6. Tomato plant fresh weight in response to growth regular treatment at various times after transplanting. Ridgetown Campus - 2007.

Treatments	**Fresh Weight (g) 22 days**	**Fresh Weight (g) 33 days**
1. Untreated	4.8 b	50.1
2. Bonzi @ 5 ppm (14 day)	12.1 ab	87.7
3. Sumagic @ 2.5 ppm (7 day)	12.5 ab	77.3
4. Sumagic @ 2.5 ppm (14 day)	11.9 ab	87.2
5. Sumagic @ 2.5 ppm (21 day)	13.6 ab	73
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	10.2 ab	77.1
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	17.4 a	83.7
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	14.3 ab	89.5
9. Sumagic @ 5.0 ppm (7 day)	10.0 ab	69
10. Sumagic @ 5.0 ppm (14 day)	17.1 a	82.2
11. Sumagic @ 5.0 ppm (21 day)	7.1 ab	62.9
LSD (0.05)	7.2	-
C.V.	41.9	36.6
P-value	0.0363	N.S.

Table 7. Tomato plant flower counts in response to growth regular treatment at various times after transplanting. Ridgetown Campus - 2007.

Treatments	**Flowers per Plant 17 days**	**Flowers per Plant 23 days**	**Flowers per Plant 31 days**
1. Untreated	0 b	0.6 b	1.7 f
2. Bonzi @ 5 ppm (14 day)	0 b	1.8 a	4.0 abc
3. Sumagic @ 2.5 ppm (7 day)	0.1 ab	2.5 a	3.5 bcd
4. Sumagic @ 2.5 ppm (14 day)	0 b	2.3 a	3.9 abc
5. Sumagic @ 2.5 ppm (21 day)	0 b	1.7 a	3.2 cde
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	0.2 a	2.7 a	3.8 abc
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	0 b	2.1 a	4.5 a
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	0.2 ab	2.3 a	2.9 de
9. Sumagic @ 5.0 ppm (7 day)	0.2 a	2.7 a	4.2 ab
10. Sumagic @ 5.0 ppm (14 day)	0 b	2.0 a	3.6 a-d
11. Sumagic @ 5.0 ppm (21 day)	0 b	1.8 a	2.5 e
LSD (0.05)	0.1	0.69	0.65
C.V.		23.4	13.14
P-value	0.0001	0.0001	0.0001

Table 8. Early fruit yield in response to growth regular treatment. Ridgetown Campus - 2007.

Treatments	Early Marketable Fruit (large) (t/ha)	Average Early Large Fruit Weight (g)	Total Early Fruit Yield (t/ha)
1. Untreated	1.7	237	9.4 b
2. Bonzi @ 5 ppm (14 day)	3.8	220	14.5 ab
3. Sumagic @ 2.5 ppm (7 day)	3.7	210	16.4 ab
4. Sumagic @ 2.5 ppm (14 day)	5.1	214	14.4 ab
5. Sumagic @ 2.5 ppm (21 day)	3.3	227	11.4 ab
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	4.2	219	19.1 a
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	3.3	230	14.9 ab
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	1.3	111	10.9 b
9. Sumagic @ 5.0 ppm (7 day)	3.4	207	14.7 ab
10. Sumagic @ 5.0 ppm (14 day)	3.1	235	15.0 ab
11. Sumagic @ 5.0 ppm (21 day)	2.8	238	13.8 ab
LSD (0.05)	-		4.8
C.V.	60		23.7
P-value	N.S.		0.0218

Table 9. Total fruit yield in response to growth regular treatment. Ridgetown Campus - 2007.

Treatments	Total Marketable Fruit (large) (t/ha)	Average Large Fruit Weight (g)	Total Fruit Yield (t/ha)
1. Untreated	62.2	202	73.1 b
2. Bonzi @ 5 ppm (14 day)	62.3	205	80.0 ab
3. Sumagic @ 2.5 ppm (7 day)	62.3	186	82.2 ab
4. Sumagic @ 2.5 ppm (14 day)	62	211	74.3 b
5. Sumagic @ 2.5 ppm (21 day)	61.8	215	74.6 b
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	62	196	81.6 ab
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	62.5	218	79.1 ab
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	62.4	210	77.4 b
9. Sumagic @ 5.0 ppm (7 day)	60.9	209	77.8 ab
10. Sumagic @ 5.0 ppm (14 day)	62.7	208	80.7 ab
11. Sumagic @ 5.0 ppm (21 day)	66	189	87.9 a
LSD (0.05)	-	-	6.6
CV	3.6	33.7	5.8
P-value	N.S.	N.S.	0.0040

Table 10. Grade components expressed as a percentage of total yield in response to transplant growth regulator treatment. Ridgetown Campus - 2007.

Treatments	% Large	% Small	% Cracked	% Cull
1. Untreated	85.1 a	2.8	0	12.1
2. Bonzi @ 5 ppm (14 day)	78.1 ab	3.8	0.2	17.9
3. Sumagic @ 2.5 ppm (7 day)	76.1 b	4.9	0.1	18.9
4. Sumagic @ 2.5 ppm (14 day)	83.6 ab	2.7	0.3	13.4
5. Sumagic @ 2.5 ppm (21 day)	83.1 ab	2.3	1	13.6
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	76.2 b	3.3	0.1	20.4
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	79.0 ab	3.3	0.3	17.3
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	80.6 ab	3.4	0.3	15.8
9. Sumagic @ 5.0 ppm (7 day)	78.6 ab	4	0.3	17.2
10. Sumagic @ 5.0 ppm (14 day)	77.9 ab	5.2	0.4	16.5
11. Sumagic @ 5.0 ppm (21 day)	75.0 b	3.8	0.2	21
LSD (0.05)	5.17	-	-	5.9
CV	4.5	49.4		24.4
P-value	0.0043	N.S.	N.S.	N.S.

Table 11. Pepper yield in response to growth regular treatment. Ridgetown Campus - 2007.

Treatments	Fruit per Plant	Total Yield (t/ha)
1. Untreated	5.7	34.3
2. Bonzi @ 5 ppm (14 day)	6.8	33.4
3. Sumagic @ 2.5 ppm (7 day)	6.7	34.3
4. Sumagic @ 2.5 ppm (14 day)	6.2	36.0
5. Sumagic @ 2.5 ppm (21 day)	5.2	37.2
6. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 14 day)	6.7	36.9
7. Sumagic @ 5 ppm (2 x 2.5 ppm; 14 + 21 day)	6.6	35.1
8. Sumagic @ 5 ppm (2 x 2.5 ppm; 7 + 21 day)	6.0	38.2
9. Sumagic @ 5.0 ppm (7 day)	6.1	38.8
10. Sumagic @ 5.0 ppm (14 day)	6.3	39.4
11. Sumagic @ 5.0 ppm (21 day)	5.6	36.9
LSD (0.05)	-	-
CV	15.3	15.8
P-value	N.S.	N.S.

Milestones

All milestones were completed as indicated in the text of the report.

Communication Plan

A vegetable research tour, which was organized in cooperation with the Ridgetown OMAFRA crop specialists, was held at the Ridgetown Campus for local fresh and processing vegetable growers on 30 July, 2007. Approximately 65 people attended this event, which included this research tour, which included viewing these plots.

While this research supports the use of growth regulators as tools to manage greenhouse plant growth, job creation numbers cannot be provided.

Acknowledgment

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The in-kind contribution of treated tomato transplants by CanGrow Foods, Dresden is acknowledged and appreciated.