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Gibberellic Acid Foliar Sprays Show Promise as Screening Tool for Tomato Fruit Catfacing

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Abstract. **Catfacing of tomato *(Lycopersicon esculentum* Mill.) fruit describes the enlarged blossom-end scar and ridged, flattened or irregular fruit shape often found on plants subjected to low temperature during ovary development. Experiments were conducted to determine if GA_3 foliar sprays could be used as a screening tool for catfacing. Concentrations of 5 to 50 μM of GA_3, applied once at transplanting, significantly increased catfacing incidence on the susceptible 'Revolution', whereas the resistant 'Valerie' was less affected. Two applications 8 days apart extended symptoms to later clusters formed on branches and may be useful for screening cultivars of a wide range of earliness. Plant apex removal may also be possible as a fruit catfacing screening tool. Chemical name used: gibberellic acid (GA_3).**

Catfacing or fascination of tomato fruit is a disorder characterized by an abnormally large blossom-end scar, usually accompanied by an irregular, ridged fruit shape. The disorder is most common in plants raised under low temperatures and has, in Cornell experiments, resulted in a 41% unmarketable yield in the susceptible 'Revolution' (H. C. W., unpublished results). Differences in cultivar susceptibility to catfacing have been described by several authors (Knavel and Mohr, 1969; Rylski, 1979), but no screening techniques to reliably identify resistant cultivars have yet been reported.

The disorder arises as a result of a proliferation of ovary tissues, particularly of the locules and style, during flower development (Saito and Ito, 1971; Sawhney, 1982). As the ovary enlarges, the abnormally large junction between the fasciated style and the ovary fails to close properly, leaving a large, irregular scar. Exposure to 17/8C (day/night), imposed for at least 6 days, has been identified as most effective for inducing the disorder (Saito and Ito, 1971). Sawhney and Greyson (1971) discovered that locule proliferation could also be brought about by application of GA_3 to the plant during ovary development. Increases in catfacing have also

Table 1. Effect of temperature, plant apex removal at transplanting, and foliar spray of GA_3 on the ratio of blossom-end scar length to fruit diameter (scar ratio) and fruit locule number in a greenhouse experiment with 'Celebrity' tomato. Each value is a mean of determinations on ≈ 80 fruits. Interactions were not significant.

Treatments	Scar ratio	Locule no./ fruit
21/l0c	0.23	10.3
21/21C	0.19	9.8
Significance	**	*
Control	0.18	9.2
Topped	0.24	10.9
Significance	***	***
GA_3 (μM)		
0	0.12 a[z]	8.8 c[z]
43	0.24 b	10.4 d
87	0.27 b	10.9 d
Significance	***	***

[z]Mean separation by Duncan's multiple range test, $P = 0.05$.
*, **, ***Significant at $P = 0.05, 0.01$, and 0.001, respectively.

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Table 2. Effect of a single foliar spray of GA_3 on catfacing incidence in 4-week-old plants of 'Revolution' and 'Valerie' tomatoes grown in the greenhouse, as characterized by fruit scar ratio.

Cultivar	GA, concn (μM)	Scar ratio[z]	Fruit with scar ratio ≥ 0.1 (%)
Revolution	0	0.069	18.0
	5	0.201	74.4
	10	0.232	78.3
	50	0.302	85.0
Valerie	o	0.047	3.5
	5	0.071	14.2
	10	0.103	22.7
	50	0.154	61.6
Statistical significance			
Cultivar		***	***
GA_3 concn		***	***
Interaction		**	***

[z]Scar ratio = (maximum scar diameter)/(maximum fruit diameter).
[**,***]Significant at $P = 0.01$ or 0.001, respectively.

been reported as a result of plant apex removal (topping) (Wien and Minotti, 1988) and after early axillary branch removal (Sikes and Coffey, 1976). The present study was conducted to determine if GA_3 foliar sprays could induce catfacing and to determine the concentration of the growth regulator and frequency of application needed to demonstrate cultivar differences.

Tomatoes were seeded in a 27/21C (day/night) greenhouse in Todd Planter flats (Speedling, Sun City, Fla.) of 80-ml individual cell volume filled with a peat-vermiculite artificial soil mix. For the greenhouse experiments, seedlings were transplanted after 4 weeks to 23-cm-diameter plastic pots (5.1 liters in volume) filled with artificial soil.

An initial greenhouse experiment compared the effects of GA_3 foliar spray, low temperature (10C), and topping on catfacing incidence in 'Celebrity'. GA_3 at 0, 43, and 87 μM was applied as a foliar spray twice weekly for 3 weeks to five plants per treatment, beginning 2 days after transplanting. Other treatments included a 3-week exposure to 21/10C or 21/21C cycles and topping at transplanting vs. art untopped control. After the temperature treatments, plants were grown in a 21/21C greenhouse until fruit on the secondary branches had become mature-green. Plants were restricted to main stem and two branches for controls and to three branches for topped plants. Catfacing was evaluated by measuring the maximum diameter of the blossom-end scar and expressing it as a proportion of the maximum fruit diameter (scar ratio). In addition, fruits were halved equatorially, and the number of fruit locules counted. Three fruits on each of three clusters per branch or main stem were evaluated per plant. A completely randomized, factorial design was used.

Cultivar differences in response to several concentrations of GA_3 were determined in a second greenhouse experiment. 'Revolution' and 'Valerie', known from previous work to be susceptible and resistant, respectively, to catfacing (H. C. W., unpublished data; J.W. Scott, personal communication), were given a single foliar spray of 0, 5, 10, or 50 μM GA_3 at transplanting. There were 10 plants per treatment. They were grown throughout at 21/21C and pruned to main stem and the primary branch. When fruits reached full size, scar ratios were measured on four fruits per cluster on up to four main stem and two branch clusters. The experiment design was completely random.

In a field experiment, we compared the effect of one or two foliar sprays of GA_3 of 0, 22, or 43 μM on the incidence of catfacing and on cluster fruit set. Sprays were applied to the seedlings 2 days before transplanting (39 days after sowing). Some plants received a second spray 47 days after sowing. Plants were grown in a gravelly loam soil (loamy-skeletal, mixed mesic, Glossoboric Hapludalf) in eight-plant, single-row plots with 46 × 152-cm spacing. A randomized complete block factorial design with four replications was used. When first-cluster fruits were ripe, main-stem clusters and first clusters on branches were harvested separately and the percentage of fruit with a scar length > 1 cm was calculated. Data from a concurrent experiment (H. C. W., unpublished data) indicated that scar ratio and this index were closely related, and the latter is much more easily determined. Clusters having one or no fruit were also counted to determine the influence of treatments on fruit set.

Topping, low temperature (10C) in the prefloral stage, and GA_3 foliar sprays all increased the amount of catfacing on fruits of 'Celebrity' in the first experiment, as measured by fruit scar ratio (Table 1). The treatments also increased the number of locules per fruit. Interactions of the treatments were not significant for both variables measured, and combinations of factors had additive effects (data not shown). There was a close correlation ($r = 0.95$, n = 12) between locule number and scar ratio across treatments. The experiment extended Sawhney and Greyson's (1971) finding that GA_3 not only increased locule number but also enlarged the blossom-end scar, and opened the possibility that GA_3 sprays could be used as a screening tool for catfacing.

The greater susceptibility of 'Revolution' than 'Valerie' to catfacing, as induced by a single foliar spray of GA_3, was demonstrated in the second greenhouse experiment (Table 2). Even 5 μM GA_3 was sufficient to cause a dramatic increase in the scar ratio in 'Revolution', but a lesser increase in 'Valerie'. Results were similar, regardless of whether catfacing was calculated by average scar ratio or percentage of fruits with scar ratios ≥ 0.1. Both main effects and their interaction were significant. These results confirm previous findings that 'Revolution' is susceptible and 'Valerie' resistant to catfacing.

In the field, as well as in the preceding greenhouse experiments, gibberellic acid sprays caused a moderate increase in stem elongation without increasing incidence of stem breakage or lodging. In the field experiment, GA_3 treatment again significantly increased catfacing incidence on both main stem and branch clusters (Table 3). Two sprays 8 days apart increased the effect, particularly on the branches, leading to a significant concentration × frequency effect. Catfacing percentage was 25, 26, and 35 for the single and 25, 42, and 50 for the double application for 0, 22, and 43 μM GA_3, respectively. Application of GA_3 increased the number of clusters with poor fruit set, particularly on the main stem (Table 3). Fruit set on branches was lower than on the main stem, and less variable.

Taken together, the results have important implications for the screening of cultivars for susceptibility to catfacing. Use of GA_3 foliar sprays appears promising as a screening tool, increasing differences between cultivars of contrasting catfacing susceptibility. Concentrations of 5 to 50 μM were effective, but cultivar differences were greater at low GA_3 rates (Table 2). The reduction in fruit set observed in the field (Table 3) would also argue for using relatively low concentrations of GA_3, e.g., 5 to 20 μM. If the lines to be screened are similar in flowering time, a single application at transplanting is adequate, but material of contrasting flowering dates may require a second application 1 week later. Since topping also resulted in increased catfacing incidence (Table 1), it may be possible to use this technique as a screening tool.

Table 3. Influence of GA, foliar spray concentration and frequency on catfacing incidence and number of clusters with ≤ 1 fruit. Treatments applied to 'Revolution' tomato transplanted to the field.

GA_3 concn (μM)	Catfacing (%)[z]		Clusters/plant with ≤ 1 fruit	
	Main stem	Branch	Main stem	Branch
0	11.7	25.1	0.10	0.88
22	49.9	34.1	0.48	0.85
43	52.3	42.5	0.60	0.92
Significance	***	***	***	*
Frequency of application				
Once	32.4	28.8	0.21	0.85
Twice	43.6	39.0	0.58	0.92
Significance	**	***	***	NS
Concn × frequency Interaction significance	NS	*	NS	NS

[z]Catfacing percentage = [(no. of fruit with scars longer than 1 cm)/(total fruit)] × 100.
[NS,*,**,***]Nonsignificant or significant at $P = 0.05$, 0.01, or 0.001, respectively.

However, the practicality of removing the growing points of individual plants of large breeding populations is questionable.

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