RESPONSE OF FOUR CELERY VARIETIES TO LEVELS OF GIBBERELLIC ACID APPLIED TWO AND FOUR WEEKS BEFORE HARVEST

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ABSTRACT

Rates of 25, 50 and 100 ppm gibberellic acid (GA) increased significantly marketable weight, petiole length and height of four celery varieties. Application of GA two weeks before harvest produced more favorable results than application four weeks before harvest with Florida 683, Florida 2-13 and Florida 2-14. In a second experiment with Florida 683 and Florimart, the latter showed a greater response than Florida 683. Application of GA four weeks from harvest increased growth in height more than at the two week interval. However, the four week interval appeared to accelerate more rapidly signs of senescence than the two week interval. Varieties responded in growth to GA, but the increments were different due to rates and application time, resulting in many interactions.

INTRODUCTION

Field testing of gibberellic acid began with celery and other vegetable crops slightly over ten years ago. Response of celery was mostly in stem elongation, increase in yields and dry matter, advanced maturity and early flower stalk initiation (1, 2, 3, 5, 7). Vegetable varieties varied in degree of response (4, 5, 6) but stem elongation occurred invariably. More consistent beneficial responses in celery resulted from rates of 20 to 100 ppm when applied two to four weeks before harvest (8). In Florida only observational tests were conducted. One test indicated an increase in petiole length and number of bolters (7). Another unreported test with a Summer Pascal variety resulted in bitterness. Grower interest in increasing petiole length under adverse growing conditions and the lack of local information on rates and time of application prompted these tests. However, since much of the initial work has already been done in Michigan and California, these tests were directed to verify results with our varieties and climate.

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METHODS OF PROCEDURE

Factorial experiments I, a 2 x 4 x 3, and II, a 2 x 4 x 2, were conducted in organic soil, the first during late fall and winter of 1967-68 and the second during early fall of 1968. Potassium gibberellate (GA) at 0, 25, 50 and 100 ppm (rate) was sprayed to the drip point two and four weeks (time) prior to harvest on 1-Florida 683, 2-Florida 2-13, 3-Florida 2-14 (varieties) for experiment I and 4-Florimart and Florida 683 for experiment II. Unit areas were three rows, each 20 x 2 feet, with a middle single-row harvest area of 15 x 2 feet. Ten random plants were measured for each observation per treatment/replication and expressed as means per plant. For pencil stripe the 24 plants per plot per replication were examined. Temperatures after GA treatment had a mean of 63°F with an average of 51°F minimum and 75°F maximum for experiment I and a mean of 68°F with an average of 54°F minimum and 76°F maximum for experiment II. Rainfall was very low for experiment I, and heavy during the early period for experiment II. No rain fell during or after application of GA for at least two days. Other relevant conditions can be ascertained from the tables.

RESULTS AND DISCUSSION

Results of experiment I are summarized in Tables 1 to 4. Responses of varieties were significantly different for all the observations except for trimmed weight, number of feather leaf and petiole width. For number of cracked stems, number of pithy petioles and plant height, the effect of variety differed with time (Table 3). Time had no effect on Florida 683 for number of cracked stems. Florida 2-13 had fewer cracked stems when the treatment was applied at four weeks, while Florida 2-14 fared better when the

Table 1. Analysis of variance - mean squares - for experiment I of those observations showing significance.

Source	df	Yield (lbs.) Total	Yield (lbs.) Trimmed	Petioles Cracked	Petioles Pithy	Petioles Length	Plant Height
Rate - Linear	1	27.50	8.26	1.04	155.62	6.94*	60.12**
- Quadratic	1	49.78	20.00	0.78	102.86	0.00	0.21
Variety - 2 vs 3	1	690.84**	3.47	180.18**	385.33	4.06	317.76**
- 1 vs 2,3	1	507.38**	31.64	50.17**	7980.44**	17.99**	50.77**
Rate x Variety	6	3.95	1.94	3.38	101.65	1.33	7.25
Time	1	305.31**	130.36**	0.46	46.30	9.51**	181.87**
Time x Rate	2	4.25	4.06	9.46*	66.24	1.78	1.87
Time x Variety	2	130.14	22.30	10.24*	2947.91**	3.20	82.57**
Time x Rate x Variety	4	24.23	11.34	4.74	34.44	1.21	1.27
Check vs Others	1	273.60**	55.41*	0.46	1213.63**	6.16*	171.91**
Error	49	31.70	9.88	2.82	134.76	1.07	5.04

* Significant at the 5% level

** Significant at the 1% level

time was held to two weeks. Number of pithy petioles for Florida 683 and 2-14 was significantly decreased by lengthening the time. On the other hand, number of pithy petioles was increased for Florida 2-13 when the time of application was prolonged. Only plant height for Florida 2-14 was affected by time of application with the greater response corresponding to the longer time. Time also significantly affected total yield, trimmed yield, petiole length and plant height. Except for the two last responses, increasing the time interval reduced the value of the response.

Rates of 25, 50 and 100 ppm of GA had a significant linear effect only on length of petiole and plant height. There was a significant interaction for cracked stem between rate and time (Table 4). When GA was applied four weeks before harvest the number of cracked stems increased with concentration. On the other hand, when application was only two weeks from harvest, increasing the rate of GA reduced the number of cracked stems. Finally, the average value of the GA treated plants was significantly greater from the untreated for total yield, trimmed yield, mean plant weight, number of pithy petioles, petiole length and plant height.

Results of experiment II are given in Tables 5 to 9. Significant variety differences were found for trimmed yield, petiole length, number of

Table 2. Main effect means when three celery varieties were treated with four rates of gibberellic acid two and four weeks prior to harvest. Plants harvested February 1-2, 1968 (experiment I).

	Variety Fla. 683	Variety Fla. 2-13	Variety Fla. 2-14	Time 2 Wks.	Time 4 Wks.	Rate (ppm) GA. 0	25	50	100
Total yield (lbs./plot)	70.28	72.12	79.71	77.54	72.79	70.66	73.51	76.31	75.67
Trimmed yield (lbs./plot)	46.19	47.32	47.86	49.19	46.08	45.61	46.65	48.37	47.87
Cracked petioles (no./plant)	0.11	0.10	0.48	0.23	0.24	0.22	0.24	0.26	0.21
Pithy petioles (no./plant)	4.27	1.75	2.32	2.92	3.11	2.07	2.71	3.16	3.18
Petiole length (cm)	21.18	23.14	24.61	22.35	24.49	21.69	22.45	23.14	24.64
Petiole width (cm)	2.34	2.24	2.24	2.30	2.24	2.29	2.32	2.25	2.24
Plant height (cm)	74.57	73.78	78.92	78.48	74.81	73.08	75.46	76.45	78.03

Table 3. Relationship between variety response and time of gibberellic acid application on three observations (experiment I).

Response	Time weeks	Variety Fla. 683	Fla. 2-13	Fla. 2-14
Cracked stem (no./plant)	2	0.10	0.15	0.40
Cracked stem (no./plant)	4	0.13	0.04	0.57
Pithy petioles (no./plant)	2	4.92	0.64	2.84
Pithy petioles (no./plant)	4	3.62	2.86	1.79
Plant height (cm)	2	74.66	73.15	75.60
Plant height (cm)	4	74.48	74.40	82.24

Table 4. Relationship between time of application and gibberellic acid rates on number of cracked stems per plant. (Experiment I)

Time weeks	Gibberellic acid ppm 25	50	100
2	0.31	0.22	0.14
4	0.18	0.29	0.29

plants with pencil stripe and plant height. Number of petioles with cracked stem was not significantly different between varieties, but there was a strong trend indicating that Florimart was very susceptible to this malady. Response to time was significantly different for yields, petiole width, number of feather leaf, pithy petioles and number of plants affected by pencil stripe. Rate had a significant effect for all observations. For total yields, trimmed yields, number of feather leaf and petiole width, the effect of rate was independent of the effect of the other factors. For the remaining responses, effect of rate depended on the variety used and/or time of application (Table 7). For instance, petiole length of Florida 683 increased up to 50 ppm of GA, whereas with Florimart it continued to increase with 100 ppm, the highest rate. Florida 683 exhibited about the same number of plants affected by pencil stripe regardless of rates; on the other hand, pencil stripe in Florimart was greatly affected by GA rates.

Number of pithy petioles and plant height in both Florida 683 and Florimart increased with GA, but the increment from zero rate was greater for Florimart. Total yield, number of petioles with feather leaf and number of plants with pencil stripe had a significant variety x time of application interaction (Table 8). For Florida 683, time of application had no real effect on the total yield. For Florimart, earlier application significantly increased total yield. In regard to number of feather leaf time effect for Florimart was insignificant, but for Florida 683 it was significantly increased at the four-week interval. Differences between the two varieties for feather leaf were found to occur only when GA was applied four weeks before harvest. Regardless of time, significantly greater amounts of pencil stripe were found for Florimart than for Florida 683. Difference between varieties was greatest when GA was applied two weeks before harvest. Time of application had no effect on the number of plants with pencil stripe for Florida 683. Application of GA two weeks before harvest significantly increased the amount of pencil stripe in Florimart.

Time x rate linear effect interaction was significant for petiole length and number of pithy petioles (Table 9). Petiole length increased with

Table 5. Analysis of variance - mean squares - for experiment II.

Source	df	Yields (lbs.) Total	Trimmed	Petioles Width	Length	Feather Leaf	Pithy	Pencil Stripe	Plant Height
Blocks	2	33.26	2.93	0.012	0.29	1.58	42.52	4.40	4.26
Variety (V)	1	181.35	129.69*	0.028	28.06*	123.52	352.08	1656.75**	490.88**
Error (a)	2	27.61	5.83	0.003	0.81	8.08	28.52	12.44	2.07
Time (T)	1	169.00**	37.21**	0.043*	1.03	300.44**	3422.25**	87.11*	17.64
T x V	1	173.36**	8.60	0.003	3.80	196.00**	38.03	121.00*	28.80
Error (b)	4	3.38	1.13	0.004	0.79	5.06	40.22	8.56	4.70
Rate									
Linear	1	243.89**	41.20*	0.002	26.03**	30.67*	5040.54**	210.02**	495.41**
Quadratic	1	83.28*	42.61*	0.007	9.85**	0.31	570.74**	58.22**	61.67**
Cubic	1	85.99*	11.54	0.018*	0.17	2.91	305.47**	35.35*	18.96
V x Rate	3	41.01	13.99	0.004	1.99**	2.02	123.81*	101.19**	31 42**
T x Rate									
Linear	1	4.98	7.88	0.003	1.16*	0.05	880.07**	2.03	10.89
Quadratic	1	18.33	2.99	0.002	1.20*	11.01	21.43	0.86	7.42
V x R x Rate	2	11.52	5.05	0.007	2.36**	8.08	45.86	2.33	10.30
Error (c)	26	19.05	5.80	0.003	0.24	6.90	36.89	6.32	4.84

Table 6. Main effect means for experiment II, harvested December 2-3, 1968.

	Variety		Time		Rate (ppm) GA			
	Fla. 683	Florimart	2 wks.	4 wks.	0	25	50	100
Total yield (lbs./plot)	59.40	55.52	56.93	61.27	52.54	59.21	58.01	60.08
Trimmed yield (lbs./plot)	34.78	31.49	32.93	34.96	30.69	34.02	33.94	33.88
Cracked stems (no./plant)	0.22	0.48	0.27	0.51	0.25	0.33	0.36	0.47
Feather leaf (no./plant)	0.48	0.15	0.06	0.63	0.23	0.24	0.37	0.43
Petiole width (cm)	1.75	1.70	1.77	1.70	1.70	1.76	1.72	1.73
Petiole length (cm)	22.05	25.93	25.58	24.71	20.57	23.57	25.96	25.88
Pithy petioles (no./plant)	2.69	1.95	1.83	3.78	0.48	2.31	2.55	3.55
Plant height (cm)	74.95	68.55	72.90	74.26	66.31	71.81	73.03	75.84
Plants with pencil stripe (no./plot)	0.83	12.58	9.67	6.56	2.50	7.67	7.50	9.17

rate regardless of time interval, but greater increment was obtained when application was two weeks before harvest. The same result was obtained with the number of pithy petioles, but the greater increment occurred when application was four weeks before harvest.

Linear yield response to rate was not significant in experiment I. This could be due to the exclusion of the zero rate in the computation of the function. As a result of GA treatment, petiole width tended to decrease at rates of 50 and 100 ppm; however, the mean values were not significantly different.

In experiment I variety response depended on the individuality of each variety. For instance, Florida 2-14 is the tallest and Florida 683 and 2-13 are about the same height. The data in Table I show differences in variety response for plant height, but since the interaction of rates x varieties was not significant, it is concluded that variety differences for plant height are due only to the characteristic of each variety or that the variety response is independent. Further, since the linear effect of rate is significant and the interaction of rates x varieties is not, it is assumed that the effect of GA rates is also independent of varieties, or that each variety increased in height in direct proportion to the concentration used. In experiment II, for plant height, variety and rate response as well as their interaction were very highly significant. The variety response was dependent on the rate of GA used. Therefore recommendation of GA rate to be used for plant height depends on the variety in this case. This seems to agree with the pedigree of the varieties in experiments I and II. Florida 683, 2-13 and 2-14 are single plant selections from tall Utah 52-70, therefore they

Table 8. Variety x time interaction means for experiment II, harvested December 2-3, 1968.

Variety	Time weeks	Yields total lbs/plot	Feather leaf no./plant	Pencil stripe plants/plot
Fla. 683	2	60.37	0.00	0.56
	4	60.31	1.04	1.11
Florimart	2	53.50	0.11	18.78
	4	62.22	0.22	12.00

Table 7. Variety x rate interaction means for experiment II, harvested December 2-3, 1968.

Variety	GA rates ppm	Petiole length cm	Petiole pithy no./plant	Plant height cm	Pencil stripe plants/plot
Fla. 683	0	19.51	0.93	71.87	0.83
	25	22.15	2.80	74.73	1.00
	50	24.08	2.35	75.07	0.67
	100	22.48	3.88	78.12	0.83
Florimart	0	21.64	0.02	60.75	4.17
	25	24.97	1.82	68.88	14.33
	50	27.86	2.75	71.00	14.33
	100	29.29	3.22	73.57	17.50

Table 9. Time x rate interaction means for experiment II, harvested December 2-3, 1968.

Time weeks	Rate GA ppm	Petiole length	Petiole pithy no./plant
2	0	20.3	0.17
	25	23.1	1.93
	50	26.9	1.60
	100	26.7	1.95
4	0	20.4	0.78
	25	24.1	2.68
	50	25.0	3.50
	100	25.1	5.15

are more likely to react to rates and time in a similar way. Since Florimart is not related to Utah 52-70, it responded differently to rate and time from Florida 683, and resulted in many more interactions in experiment II. Similar deductions can be ascertained for other observations.

The main effect of time for petiole length and trimmed yields in experiment I had opposite values from II. It is possible that a variety and season interaction may exist and explain these discrepancies.

Plant height, petiole length, trimmed yield and physiological disorders significantly increased with GA. Stems with feather leaf and cracks were counted before trimming, those pithy and with pencil stripe after trimming. Stripping and trimming eliminated some of the petioles with feather leaf and cracks. Over-maturity increases feather leaf and pithiness, and since GA seems to hasten maturity it would be advisable to harvest GA-treated celery before these disorders become serious. Cracked stem and pencil stripe are not likely to be modified by early harvest. Florida 2-14 had more cracked stems than Florida 683 and Florida 2-13, but the cracks were small and most of them difficult to see. Cracks in Florida 2-13 were very conspicuous; therefore, this disorder should be considered more detrimental in this variety than in Florida 683 and Florida 2-14.

Petiole length and trimmed yields in Florida 683, Florida 2-13 and Florida 2-14 increased with GA. It appears that most of the disorders associated with GA treatment may be reduced by timing harvest and using rates and treatment intervals appropriate to the variety. Florimart also improved with GA, but the occurrence of pencil stripe offset the benefits.

A test panel on freshly harvested celery failed to show a trend or preference in regard to the taste of celery treated with GA and the untreated check.

Conclusions

Gibberellic acid increased yield, petiole length and plant height but also accentuated the incidence of feather leaf, cracked stem, pithiness and pencil stripe in varieties susceptible to these physiological disorders. It was also found elsewhere that GA increased the number of bolters and blackheart in susceptible varieties (8). It is suggested therefore that the use of GA should be restricted to small trials and at times when serious physiological disorders are not likely to appear. The most appropriate time may be for November and June harvest, when plants tend to be short and when celery is usually cut young. Since GA tends to hasten maturity the time of harvest becomes more critical.

Varieties of the Utah type commercially used in the Everglades responded similarly to the beneficial effects of GA. For varieties susceptible to cracked stem, 25 ppm GA applied four weeks before harvest is suggested. For varieties tolerant to cracked stem, 50 ppm GA applied two weeks before harvest seems satisfactory.

Legal residue tolerance of GA in celery is 0.15 ppm.

Summary

Two factorial celery experiments were conducted to determine the effect of four levels of GA applied at two and four week intervals before harvest on Florida 683, Florida 2-13 and Florida 2-14 in experiment I and Florida 683 and Florimart in experiment II. In experiment I, varieties responded differently from each other, but the response was independent of the other factors. Rates of 25, 50 and 100 ppm GA produced significant linear effect only for petiole length and plant height. However, all GA rates increased significantly the value of all observations except for cracked stem when compared with the untreated plants. Time of application had a significant effect on marketable yield, petiole length and plant height. There were significant interactions between rate and time and variety and time for desirable observations as well as for the manifestation of physiological disorders. In consideration of all of these factors, the use of 25 ppm GA with a four-week harvest interval for varieties susceptible to cracked stem such as Florida 2-13 is suggested. For varieties less susceptible to cracked stem, 50 ppm GA with two-week harvest intervals appears satisfactory. In experiment II, main effects and their interactions exhibited in general very high significant values for both desirable and undesirable characteristics. GA increased marketable yields, petiole and plant length, but increased pithiness and pencil stripe. Increase in pencil stripe was particularly serious in Florimart. The malady was of slightly less consequence when 25 or 50 ppm GA was applied four weeks before harvest.

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CONTROL OF A LEAFHOPPER, Empoasca krameri BY VARIOUS METHODS OF APPLYING SYSTEMIC INSECTICIDES TO POLE BEANS

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ABSTRACT

Experiments conducted over a 4 year period to control a leafhopper, *Empoasca krameri* R. & M., have shown that aldicarb and carbofuran were the most effective of the systemics used. The application of granular formulations of these insecticides as a side-dress treatment after plant emergence appeared to be the most efficient method.

INTRODUCTION

Systemic insecticides have been shown by Baranowski (1, 2), Schread (3) and Wene, (4) to protect plants from insect damage for periods up to several weeks. Since young bean plants can be seriously damaged by leafhoppers in a very short time, applications of systemic insecticide at planting or shortly after the plants emerge should protect them during the most critical part of their growth.

Experiments were conducted in the period 1964-1968 to determine the most effective systemic insecticides to use in control of the leafhopper, *Empoasca krameri* R. & M., and the most efficacious method of using them.

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MATERIALS AND METHODS

The Dade variety of pole bean was used in all experiments. Each experiment was arranged in a randomized block design with 2 row plots, 30 ft. in length, replicated 4 times. Granular applications were made by distributing the insecticide in a furrow about 2 inches deep and 3 inches to the side of the row either at the time of planting or as a side-dressing after the plants emerge. Drenches were applied directly over the row in a 6 inch band either with sprinkling cans or a low pressure power take-off driven pump.

Treatment effectiveness was determined by counting the number of leafhopper nymphs on 10 leaves per plot. Data were subject to analysis of variance and Duncan's multiple range test.

Insecticides used in the various experiments were: Wepsyn(R) [P-(5 amino-3-phenyl-1, 2, 4-triazol-l-yl)-N, N, N', N' -tetramethylphosphonic diamide] ; CL 47031 [2-diethoxy-phosphinylimino)-1,3-dithiolane] ; carbofuran; dimethoate; aldicarb; phorate; and disulfoton.

The first experiment was designed to determine the relative effectiveness of 1 and 2 drench applications. Seed for this experiment was planted on February 16, 1965. Plots receiving 1