CONCENTRATION OF N^6 BENZYLADENINE, TEMPERATURE AND TIME EFFECTS ON RETARDATION OF SENESCENCE IN CELERY AND ENDIVE[1]

V. L. GUZMAN[2]

INTRODUCTION

Experiments conducted for the last two seasons indicated that N^6Benzyladenine, a plant hormone, retards the onset of senescence in certain vegetable crops when sprayed prior to harvest. Preliminary tests also indicated that dipping the produce in water containing 5 to 10 ppm of the hormone is effective.

Spraying with the hormone is easy, but it is one added operation to the many of the busy farmer. If the treatment could be applied during one of the routine operations that the produce undergoes in the packing houses or harvest machines, the labor and trouble involved would be minimized. The most common method of preserving vegetables for fresh market is by hydrocooling followed by storage at low temperatures. The hormone treatments might be applied either in the field harvesters washing water or in the hydro-cooling water.

The effect of N^6Benzyladenine concentration on appearance of the produce after 15 days of storage at 40°F. was studied, when simulating temperatures and length of exposure in the dipping water common in commercial operations.

MATERIALS AND METHODS

Celery (*Apium graveolens* Linn.) and two kinds of endives (*Chicorium endivia* Linn.), the broad-leaved escarole and the curled-leaved chicory (also called endive), were grown commercially by Duda and Sons in organic soil near Belle Glade.

The endives were harvested March 22 and the celery March 27, 1961. Treatments were applied after one day in storage at 40°F. The produce was stored for 15 days at 40°F. before appearance ratings were made.

A 4 x 3 x 3 factorial in a randomized block design with four replications was used. Zero, 2.5, 5.0 and 10.0 ppm of N^6 Benzyladenine concentration with dipping bath temperatures of 34°, 64° and 84°F. and with dipping time of 1 second, 900 seconds (15 min.) and 1800 seconds (30 min.) were used in all possible combinations.

Plots were three plants bundled with vegetable wrapping paper held together by rubber bands, but with the ends left open. After dipping, the plant-plots were distributed in produce boxes at random in respect to temperatures and dipping times, but concentrations were segregated to prevent contamination. Boxes comprising the first replication were randomly placed in cold storage at the bottom, the second replication was stacked over the first, and so on.

Preliminary dipping showed that with available equipment temperatures could not be properly maintained in the bathing media for 30 minutes. The 34°F. treatment rose to 38°F., the 64°F. rose to 66°F. and the 84°F. dropped to 83°F. One-second dipping temperatures were constant, while the 15 minute dipping temperatures varied, but not nearly as much as the 30 minute treatments.

The hormone effect was appraised by appearance of the vegetables after 15 days storage at 40°F. Appearance, an intangible term which is made up in part by color and turgidity or freshness of the produce, is hard to define. The rating of appearance was relative and only indicated differences among treatments. One indicates fresh looks, as when the plants are just harvested, and five is for completely deteriorated plants. Intermediate values were assigned, such as 1, 1.5, 2, 2.5, etc., giving a total nine point rating scale. The scores obtained were transformed to scores for ordinal data plus two for the analysis of variance (Fisher and Yates, Statistical Tables for Biological, Agricultural and Medical Research, Hafner Publishing Co., Inc., New York, 1953).

Scores for appearance transformed to scores for ordinal data

Original Scoring	transformed scores
1.0 (fresh appearance)	0.51
1.5	1.07
2.0	1.43
2.5	1.73
3.0	2.00
3.5	2.27
4.0	2.57
4.5	2.93
5.0 (completely deteriorated)	3.49

[1]Aided by a grant from Shell Development Company.
[2]Associate Horticulturist, Everglades Experiment Station.
Florida Agricultural Experiment Station Journal Series No. 1573.

	Concentration ppm			
	0.0	2.5	5.0	10.0
C_o			-	+
C_1		-2	+	+
C_2	-3	+	+	+
	Temperature (degrees F.)			
		34	64	84
T_o			-	+
T_1		-2	+	+
	Dipping Time (seconds)			
		1	900	1800
D_o			-	+
D_1		-2	+	+

Interactions:

C_oxT_o, C_oxT_1, C_1xT_o, C_1xT_1, C_2xT_o, C_2xT_1; C_oxD_o, C_oxD_1, C_1xD_o, C_1xD_1, C_2xD_o, C_2xD_1; T_oxD_o, T_oxD_1, T_1xD_o, T_1xD_1 and $C_oxT_oxD_o$.

Fresh produce had a score of 0.51 and the completely deteriorated 3.49, with intermediate values for the scores between.

Data were evaluated by the single degree of freedom method with the following a priori comparisons:

Results

The data are presented in tables 1 to 3.

a. Effect of concentration.

With celery there was no significant effect between 10.0 and 5.0 ppm of N^{6}Benzyladenine. A highly significant difference was found in favor of the two highest rates against 2.5 ppm, and finally all rates of the hormone were highly superior to no chemical treatment. Most effective rates of the hormone to prevent rapid deterioration in celery were 5.0 and 10.0 ppm.

Effects of the various hormonal concentrations were similar in both escarole and chicory, but different from those found in celery. The appearance scores were significantly higher with 10.0 ppm than with 5.0 ppm. Five and 10.0 ppm were also significantly less effective as compared with 2.5 ppm. All combined rates of the hormone were significantly superior to the check. Data indicate that 2.5 ppm of N^{6}Benzyladenine is the best concentration to use in endive. Five ppm may be equally effective.

b. Effect of temperature.

With celery the hormone effect decreased significantly at 34°F. as compared with 64° and 84°F.

Temperature of the dipping bath did not affect appearance scores of the endives.

c. Effect of dipping time.

Dipping celery for 1 second in the bath gave inferior appearance to 900 and 1800 seconds.

The endives reacted similarly to celery, except that in the case of escarole, 1800 seconds was significantly better than 900 seconds.

d. Combined effects (interactions)

In Celery the interaction C_oxD_1 was highly significant. With one second exposure, 5.0 ppm

Table 1. Mean appearance scores for celery as affected by various N^6Benzyladenine concentrations, dipping times and temperatures (scores = 0.51 indicating fresh appearance and 3.49, completely deteriorated).

Concentration x Temperature

Temperature degrees F.	Concentration ppm 0.0	2.5	5.0	10.0	Temperature effect
34	1.82	1.11	0.60	0.88	1.10**
64	1.84	0.93	0.74	0.56	1.02
84	1.87	0.60	0.73	0.60	0.95
Concentration effect	1.84**	0.88**	0.69	0.68	1.02

Concentration x Dipping Time

Dipping time seconds	Concentration ppm 0.0	2.5	5.0	10.0	Dipping Time effect
1	1.84	1.05	0.96	0.51	1.09**
900	1.82	0.85	0.51	0.84	1.01
1800	1.87	0.74	0.60	0.70	0.98
Concentration effect	1.84**	0.88**	0.69	0.68	1.02

Temperature x Dipping Time

Dipping time seconds	Temperature (degrees F.) 34	64	84	Dipping time effect
1	1.05	1.16	1.06	1.09**
900	1.19	0.89	0.94	1.01
1800	1.08	1.01	0.85	0.98
Temperature effect	1.10**	1.02	0.95	1.02

* Significant difference.

** Highly significant difference.

Table 2. Mean appearance scores for escarole as affected by various N^6Benzyladenine concentrations, dipping times and temperatures (scores = 0.51 indicating fresh appearance and 3.49, completely deteriorated).

Concentration x Temperature

Temperature degrees F.	Concentration ppm 0.0	2.5	5.0	10.0	Temperature effect
34	3.49	1.88	2.07	2.14	2.39
64	3.32	2.09	2.09	2.30	2.45
84	3.44	2.16	2.09	2.32	2.50
Concentration effect	3.42**	2.04*	2.08**	2.25	2.45

Concentration x Dipping Time

Dipping time seconds	Concentration ppm 0.0	2.5	5.0	10.0	Dipping time effect
1	3.44	2.38	2.16	2.30	2.57**
900	3.49	1.90	2.07	2.30	2.44*
1800	3.32	1.85	2.03	2.16	2.34
Concentration effect	3.42**	2.04*	2.08**	2.25	2.45

Temperature x Dipping Time

Dipping time seconds	Temperature (degrees F.) 34	64	84	Dipping time effect
1	2.58	2.54	2.58	2.57**
900	2.41	2.49	2.42	2.44*
1800	2.19	2.31	2.51	2.45
Temperature effect	2.39	2.45	2.50	2.45

* Significant difference.

** Highly significant difference.

Table 3. Mean appearance scores for chicory as affected by various N^6Benzyladenine concentrations, dipping times and temperatures (scores = 0.51 indicating fresh appearance and 3.49, completely deteriorated).

Concentration x Temperature

Temperature degrees F.	Concentration ppm 0.0	2.5	5.0	10.0	Temperature effect
34	3.01	1.19	1.28	2.04	1.88
64	2.57	1.41	1.86	1.95	1.95
84	2.88	1.63	1.54	2.00	2.01
Concentration effect	2.82**	1.41**	1.56**	2.00	1.95

Concentration x Dipping Time

Dipping time seconds	Concentration ppm 0.0	2.5	5.0	10.0	Dipping time effect
1	2.64	1.88	1.81	2.00	2.08**
900	3.02	1.07	1.50	2.06	1.91
1800	2.79	1.29	1.37	1.93	1.85
Concentration effect	2.82**	1.41**	1.56**	2.00	1.95

Temperature x Dipping Time

Dipping time seconds	Temperature (degrees F.) 34	64	84	Dipping time effect
1	1.94	2.21	2.10	2.08**
900	1.81	1.89	2.04	1.91
1800	1.89	1.74	1.90	1.85
Temperature effect	1.88	1.95	2.01	1.95

* Significant difference.

** Highly significant difference.

was inferior to 10.0 ppm, while at 900-1800 seconds 5.0 ppm was superior to 10.0 ppm. This could lead to the conclusion that at the highest level of the hormone with one second dipping time appearance of the celery would be similar to the next lower rate at longer dipping periods.

In escarole the interaction C_1xD_1 was highly significant. Appearance of the plants treated with 2.5 ppm and 5.0-10.0 ppm with one second dipping seemed to be inferior to the same concentrations respectively with 900-1800 seconds dipping time. This might indicate that dipping time of more than one second was necessary for best results when using 2.5 ppm. The T_0xD_0 interaction was significant. Appearance of the plants at 64°F. with 1800 seconds exposure was superior to 900 seconds, whereas at 84°F. 900 seconds was superior to 1800 seconds. This could be interpreted as the inverse relationship of temperature and time of exposure.

In chicory the C_1xD_1 interaction was significant. With 900-1800 seconds dipping, decrease in concentration from 5.00-10.0 ppm to 2.5 ppm improved appearance, while with one second dipping time appearance remained about the same regardless of the concentration used. Best appearance was obtained with 2.5 ppm and with longer dipping periods than one second.

Discussion

The mean scores for appearance seemed to indicate that celery kept better than the endives. This was probably due in part to the inherent qualities of celery. However, the endives were not at optimum condition at harvest time.

The highly significant, but relatively poor effect on the appearance of celery when the bathing water temperature was 34°F. may disqualify treating celery with the hormone in the hydro-cooling process in the packing houses. This possibility is remote, as the mean score of 1.10 although significantly different from those obtained at higher temperatures, is low enough for commercial application of the hormone at 34°F.

One second dipping time gave inferior appearance. It is possible that wrapping, in addition to such short exposure, prevented the liquid from reaching all plant parts. This could also occur in tightly packed vegetable boxes when dipped in the bathing media for a short period. Washing plants in the field harvesters takes only a few seconds, but they are thoroughly wetted. Complete coverage of the produce could possibly offset the inferior appearance attributed to one second dipping.

Usually in commercial operations, temperatures in the hydro-cooling water vary from 33°F. to 37°F. and in the field harvesters from 60°F. to 85°F. The dipping or washing period also varies from a few seconds in the field harvesters to 900 and 1800 seconds in the hydro-cooling water. It appears that the temperature and time variables in this experiment are close enough to those used by the industry.

The hormone is not commercially available at this writing. Its producer has petitioned for permanent residue tolerance.

Summary

Celery, escarole and chicory were treated with 0.0, 2.5, 5.0 and 10.0 ppm of a plant hormone (N^6Benzyladenine), a senescence inhibitor. The time of treatment in seconds varied from 1, 900 (15 minutes) to 1800 (30 minutes) at temperatures of 34°, 64° and 84°F.

Appearance of the produce was scored after 15 days of storage at 40°F.

It was found that 5.0 and 10.0 ppm of the hormone for celery and 2.5 ppm for escarole and chicory kept these vegetables with the best appearance.

A temperature of 34°F. for the dipping bath seemed to be less effective for celery than 64° and 84°F. Appearance of escarole and chicory was not affected by the temperature of the bath.

One-second dipping time was inferior to 900 and 1800 seconds dipping for the three crops.

FERTILIZER EXPERIMENTS WITH SPINACH

R. B. Forbes and P. J. Westgate

Assistant Soils Chemist and Horticulturist
Central Florida Experiment Station

Sanford

Florida Agricultural Experiment Stations Journal Series, No. 1537.

Experiments were started in the winter of 1957-58 to determine the fertilizer needs of spinach in the Zellwood muck farming district. At this time the crop was a relatively new venture. Hooper (1) described the early commercial trials at the 1956 meetings of this society. In the Zellwood area the crop is now grown to the extent of