No. 1', 'Nova', and 'PSR 49087' produced low average weight fruit. Several experimental lines out performed the named cultivars suggesting that future introductions will be superior to those already available.

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SEED TREATMENTS TO IMPROVE RATE AND UNIFORMITY OF CELERY SEED GERMINATION

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Abstract. **At temperatures above 18C, celery (*Apium graveolens* L.) seeds may either fail to germinate or may exhibit problems with germination rate and uniformity. In an attempt to improve germination of celery, different priming treatments were examined. Priming with PEG at −12.5 bars at 15C for 14 to 20 days resulted in the most improvement in germination percentage and rate under both optimal and more stressful temperatures of seeds which were redried after priming. Germination was enhanced by the addition of growth regulators, especially natural cytokinin, to the priming solution. Cultivar differences were evident, which indicated a need for high quality seed lots for priming to be effective.**

All celery production in Florida is from field-grown transplants, which are grown at very high cost, partly due to the prolonged seedling stage of celery, and poor, erratic germination at temperatures above 20C resulting in nonuniform seedlings. The complexity of the germination mechanism in celery has been examined by many researchers (1, 2, 7, 13, 14). Thomas (13) found that the mechanism of thermodormancy release is phytochrome mediated, and partly controlled by endogenous growth regulators such as gibberellins (GA) and cytokinins. Temperature may control celery seed germination by affecting the level of endogenous GA. The amount of $GA_{4/7}$ required to break celery seed dormancy had to be increased as temperature was increased (1). The light requirement at temperatures greater than 18C may be related to a lowering of active phytochrome (Pfr) or products of Pfr-mediated metabolism in the dark at the high temperature extremes (1).

Priming of celery seeds was found to promote germination and overcome some of the problems mentioned above. Salter and Darby (12) reported that priming with a salt solution of KNO_3 + K_3PO_4 improved uniformity and rate of germination of celery seeds. Heydecker (6) suggested that a priming treatment which utilized PEG 6000 improved celery seed germination. Thomas (14) found that pre-sowing soak treatments with $GA_{4/7}$ stimulated celery germination at high temperatures in the dark. Benzyladenine (BA) induced germination of dormant celery seeds at 22°C (2). Addition of BA to a PEG solution enhanced the PEG treatment effect (10). Promising results were achieved by the addition of GA + ethephon to a PEG solution when priming celery seeds (5). Most of these studies had poor results if the celery seeds were redried to their original moisture content after priming. The objective of these experiments was to evaluate the effect of priming with and without the addition of growth regulators on the percentage, rate and uniformity of celery seeds redried before germination.

Materials and Methods

Earlybelle celery seeds were used in all experiments. Other celery cultivars were used in some experiments and were so noted. Seeds (0.5 g per replicate) were primed in 35 ml of treatment solution in 50 ml test tubes, under varied temperature and duration specified for each experiment. The solutions were aerated with aquarium pumps, and kept in the dark.

After priming, seeds were washed with glass distilled water and surface dried using a Buchner funnel. The seeds were then placed on Whatman #1 filter paper in Petri dishes and dried for 2-4 days at 7C and 50% R.H. All seeds were stored at 7C and 50% R.H. for the duration of the experiments.

In the first experiment, seeds were primed under all combinations of 3 factors: 3 temperature regimes [5, 15, 25C]; 3 durations [7, 14, 20 days]; 4 chemical treatments [1.5% K_3PO_4, 1.5% KNO_3 + 1.5% K_3PO_4, polyethylene gycol 8000 (PEG) at −12.5 or −10 bars]. Each treatment was replicated twice. Seeds (25) were germinated in 5 cm Petri dishes on 1 layer of Whatman #3 + 1 layer of Whatman #1 filter paper soaked with 1.5 ml of distilled water. The dishes were placed in incubators at 15 or 25C where germination was monitored for 20 days. Germination was defined as the time at which the radicle was visually observed. Mean days to germination (MDG) was used to measure the rate of germination, and was calculated as follows:

$$\text{MDG} = \frac{(\text{days to germ.}) \times (\text{no. of germ. days } T_1) + (\text{days to germ.}) \times (\text{no. germ. days } T_n)}{\text{total number of seeds germinated } (T_1 + T_2 + T_n)}$$

In experiment 2, seeds were primed at 15C for 14 days [see results of experiment 1] using PEG solutions at −12.5

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bars with the addition of growth regulators: 100 ppm benzyladenine; 100 ppm gibberellic acid; 500 ppm ethephon; 1000 ppm Enersol (extract of natural crude, humic acid, American Colloid Co., Skokie, IL); 1% "Response Extra" (seaweed extract with added nutrients, Coast Biologicals Ltd., Auckland, New Zealand), and 1% "BL9-97" (seaweed extract containing natural cytokinin, Coast Biologicals, Ltd.). Seeds were also primed in distilled water as a control to determine the effectiveness of the PEG to prevent radicle emergence. After priming, germination tests were conducted as described for experiment 1.

In experiment 3, priming was done in –12.5 bar PEG solutions with growth regulator combinations which included: $GA_{4/7}$ + BA (100 ppm + 100 ppm); $GA_{4/7}$ + ethephon (100 ppm + 500 ppm); $GA_{4/7}$ + ethephon (100 ppm + 500 ppm); $GA_{4/7}$ + BL 9-97 (100 ppm + 1%); "Response Extra" (2%). Two samples of 25 seeds each were placed between 2 layers of germination paper soaked in distilled water, and wrapped with wax paper to prevent water loss. The samples were placed at 25C in the dark. Germination was counted at 24 days and radicle and hypocotyl lengths of 10 developing seedlings per replicate were measured to evaluate the treatment effect on seedling development.

To evaluate the effect of storage on primed seeds, 4 celery cultivars, Earlybelle, Florida 2-14, Junebelle, and 683-K, were primed for 7 days at 15C with either –10 bars PEG 8000 or a 1.5% KNO_3 + 1.5% K_3PO_4 salt solution, then dried and stored at 7C and 50% R.H. Germination tests were conducted at 15C as described above, after 4 days or 4.5 months storage.

Primed seeds from experiment 2 and 3 were planted in Todd planter trays (100) in a peat + vermiculite (1:1) mix, covered with vermiculite, and placed in a plastic transplant house in Nov. 1986. Standard commercial cultural practices were used by the grower (Zellwin Farms in Zellwood, Florida) to produce transplants. Plants were harvested after 33 days, and fresh and dry weights (70C for 40 hours) were measured.

Results and Discussion

The results of the priming osmoticum, duration, temperature experiment are summarized in Table 1. For the conditions of these experiments conclusions were: a) the optimum temperature for celery seed priming was 15°C, b) PEG at –12.5 bars was the most effective osmoticum, and c) 20 days treatment duration appeared most effective. The results were generally similar for 14 and 20 days. Regardless of osmotic potential, radicle emergence was observed during priming in several treatments after 20 days, thus the experiments were terminated at this duration. The best combination of treatments was a priming treatment of –12.5 bar PEG at 15C for 14 days. This was a general priming treatment recommended by Heydecker (8). However, Heydecker reported the loss of priming advantages after drying back the seeds, but in this experiment this problem was not evident. This general priming treatment combination was the basis for subsequent experiments.

In Table 2 the germination characteristics at 15 or 25C of seeds primed with growth regulators at 15C for 14 days

TABLE 1. Summary effects of priming duration, priming temperature and priming osmoticum on percent germination and mean days to germination (MDG) of celery seeds cv. Earlybelle.

Variable	Factor or interaction	Significance level	Best variable or combination	Mean result of best variable	Control result	% of total variation
Germination at 15°C						
% germination	treatment	ns				
	duration	ns				
	temperature	ns				
	trt × temp	*	PEG, –12.5 bars at 15°C	64.7%	60%	29.6
	dur × temp	ns				
	trt × dur × temp	ns				
MDG	duration	ns				
	temperature	**	15°C	8.2 days	13.3 days	
	treatment	*	PEG at –12.5 bars	7.9 days		
	temp × trt	**	PEG, –12.5 bars at 15°C	6.5 days		29.8
	trt × dur	ns				
	temp × dur	ns				
	trt × tem × dur	*	PEG –12.5 at 15°C for 20 days	4.65 days		29.7
Germination at 25°C						
% germination	treatment	**	PEG –12.5 bars	11.6%	0	
	temperature	**	15°C	19.0%		
	duration	**	20 days	12.9%		
	trt × temp	**	PEG –10 bars at 15°C	30.0%		9.3
	trt × dur	*	PEG –12.5 bars for 29 days	20.7%		6.1
	temp × dur	**	PEG –12.5 bars at 15°C	33.5%		19.5
	trt × temp × dur	**	PEG –12.5 bars, 15°C, 20 days	56.0%		20.0
MDG	treatment	ns				
	temperature	**	15°C	12.9 days	no germination	
	duration	ns				
	trt × temp	ns				
	trt × dur	ns				
	temp × dur	*	15°C + 20 days	10.4 days		15.1
	temp × dur × trt	*	PEG –12.5 bars, 15°C	4.75 days		30.8

[z]F test significant at the 5% level (*), 1% level (**), or not significant (NS).

TABLE 2. Percent germination after 20 days and mean days to germination (MDG) of celery seeds cv. Earlybelle at 15 or 25°C as influenced by priming treatments at 15°C for 14 days with growth regulators.

Priming treatment	Germination temperature (°C)			
	15		25	
	Germination	MDG	Germination	MDG
	%		%	
Untreated seeds	66 a[z]	11.4 d	20 c	15.4 d
PEG–12.5 bars	61 ab	6.7 ab	27 b	9.1 b
PEG + BA (100 ppm)	50 b	11.8 d	43 a	14.6 d
PEG + $GA_{4/7}$ (100 ppm)	63 ab	8.2 c	11 c	14.6 d
PEG + ethephon (500 ppm)	59 ab	6.6 ab	20 bc	9.5 b
PEG + Enersol (1000 ppm)	55 ab	7.7 bc	8 c	12.9 c
PEG + "Response Extra" (1%)	53 ab	6.6 ab	28 b	8.8 b
PEG + BL 9–97 (1%)	55 ab	5.8 a	47 a	6.6 a

[z]Mean separation by Duncan's multiple range test, 5% level.

are summarized. At 15C germination temperature more uniform and rapid germination (MDG) was achieved by all seed priming treatments except the BA solution (Table 2). Total germination was unaffected by priming. The upper temperature limit for celery seed germination in the dark is generally around 18C (11). At 25°C germination temperature, priming in PEG or PEG + Response Extra improved total germination and germination rate, slightly. The addition of BA or BL 9-97 to the PEG solution further improved total germination, while only the latter additive further improved germination rate. Thus, there was a consistent improvement of celery seed germination at either temperature by the addition of a 'natural' solution of cytokinin (BL 9-97). The synthetic cytokinin, BA, did not improve germination rate or uniformity.

When imbibed in the dark at 25C, germination of either 'Earlybelle' or '683-K' was inhibited unless the seeds were primed (Table 3). Seeds of 'Earlybelle' did not germinate when primed in PEG alone. Some seeds of this cultivar germinated when primed with $GA_{4/7}$ or Response Extra. Nakamura, et al. (10) reported that adding GA_4 + BA to a PEG priming solution improved germination of celery at temperatures from 15°C to 30°C more than adding either compound alone. Seeds of the cultivar 683-K germinated (26%) at 25°C after priming in PEG alone, but germination was approximately 80% when the seeds were primed in $GA_{4/7}$ + BA or $GA_{4/7}$ + BL9-97. The BL 9-97 product contains a natural cytokinin extracted from seaweed. When BA was in the priming solution, growth of '683-K' seedlings was inhibited, whereas no growth inhibition occurred when the natural cytokinin was used. These data emphasize the response to cytokinin during germination of celery as previously reported (1, 2, 3, 13, 14, 15), and clearly demonstrate the positive effects on growth of a natural compared to a synthetic form of cytokinin. Seed quality is another important factor to be considered when priming. Seeds of '683-K' responded more favorably to priming than 'Earlybelle.' The latter cultivar had a maximum germination of 50% at 15°C in the light, while '683-K' had 94% germination under the same conditions, thus these seeds were of better quality.

The advantages of improved germination rate gained by priming were lost after storage of 4.5 months (Table 4). More importantly, the overall average germination for all 4 cultivars used was reduced from 73% to 21% if the seeds were stored for 4.5 months. Thus, primed celery seed should be sown fairly soon after treatment. Priming has been reported to adversely affect storage of celery seed (8, 9) and even the 'dry-back' process has been shown to reduce subsequent germination.

Under commercial greenhouse conditions seedling fresh weights after 33 days were improved over 2-fold by seed priming (Table 5). Dry weight was improved over 3-fold when Response Extra was added to the PEG priming solution. The addition of BA to the priming solution reduced seedling fresh weight compared to the use of Response Extra (which contains a natural cytokinin + nutrients).

TABLE 3. Percent germination in the dark at 25°C, radicle length, and hypocotyl length of celery seedlings as influenced by priming treatments in –12.5 bar PEG at 15°C for 14 days with growth regulator combinations.

Priming treatment	Cultivar					
	Earlybelle			683-K		
	Germination (%)	Radicle length (mm)	Hypocotyl length (mm)	Germination (%)	Radicle length (mm)	Hypocotyl length (mm)
Not treated	0 b	—	—	0 b	—	—
PEG –12.5 bars	0 b	—	—	26 b	9.5 a	27.0 ab
PEG + $GA_{4/7}$ + BA (100 ppm + 100 ppm)	22 a	4.5 a	11.5 b	82 a	4.0 b	10.5 c
PEG + $GA_{4/7}$ + Ethephon (100 ppm + 500 ppm)	2 b	6.0 a	11.0 b	2 b	5.5 ab	17.5 ab
PEG + $GA_{4/7}$ + BL9–97 (100 ppm + 1%)	2 b	5.0 a	23.0 ab	78 a	7.5 a	36.0 a
PEG + Response Extra (2%)	24 a	7.5 a	34.0 a	36 b	6.0 ab	29.0 ab

[z]Mean separation at the 5% level by Duncan's multiple range test, 5% level.

TABLE 4. Effect of storage duration after priming on percent germination and mean days to germination (MDG) of 4 celery cultivars germinated at 15°C.[z]

Treatment	Germination %	MDG
Primed at 15°C and stored 4 days at 7°C and 50% RH	73 a[y]	6.7 a
Primed at 15°C and stored 4.5 months at 7°C and 50% RH	21 b	12.1 b
Nontreated seeds	64 a	10.7 ab

[z]Cultivars included Earlybelle, 683-K, Florida 2-14, and Junebelle primed in PEG or KNO_3 + K_3PO_4 as separate priming solutions.
[y]Mean separation at the 5% level by Duncan's multiple range test, 5% level. Data were combined since differences between cultivars or priming solution were not significant.

TABLE 5. Effect of priming with growth regulators at 15°C for 14 days on fresh and dry weight of 33 day-old celery seedlings cvs. Earlybelle and 683-K planted in speedling trays in a greenhouse.

Priming treatment	Seedling weight (mg)	
	Fresh	Dry
PEG	113 ab[z]	7.1 a
PEG + $GA_{4/7}$ + BA	94 b	7.6 a
PEG + $GA_{4/7}$ + Ethephon	107 ab	8.6 a
PEG + $GA_{4/7}$ + BL 9-97	123 ab	8.0 a
PEG + Response extra	136 a	9.5 a
Not treated	55 c	3.1 b

[z]Data for cultivar combined. Data not available for emergence rate. Mean separation at the 5% level by Duncan's multiple range test, 5% level.

The work reported herein clearly demonstrated the beneficial effects of priming celery seed, especially when germination was at 25C in the dark. The beneficial effects were observed as an increase in total germination, germination rate, and, in the last experiment, as an increased early seedling growth rate under commercial greenhouse conditions. Clearly, only the highest quality seed should be used for priming, and regardless of cultivar or seed quality, celery seed will not store well after priming. Probably most significant was the response of celery seed to natural cytokinin in the prime solution. Cytokinins have been reported many times to promote celery seed germination, however, the negative effect of synthetic cytokinins on seedling growth have been largely overlooked. The levels of natural cytokinin in the BL9-97 prime solution were high enough to improve germination, but did not inhibit early seedling growth as evidenced with the 100 ppm BA treatment.

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SLICING CUCUMBER CULTIVAR TRIAL, FALL, 1988

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Abstract. **Eight slicing cucumbers (*Cucumis sativus* L.) cultivars were evaluated in a replicated trial at the Live Oak Agricultural Research and Education Center, Live Oak, FL in the fall of 1988. Cultivars were grown on full-bed, white-on-black polyethylene mulch with drip irrigation and were evaluated for early yield, total yield, and quality. Total marketable yields ranged from 745 to 610 bu/acre for 'Dasher II' and 'Striker,' respectively. Early marketable yields ranged from 332 to 176 bu/acre for 'Dasher II' and 'Striker,' respectively. The best overall performing cultivars, based on early yield, total yield, U. S. Fancy, and U. S. No. 1 grade, were Dasher**