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Using Ethephon and GA_3 to Overcome Thermoinhibition in 'Jalapeño M' Pepper Seed

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Abstract. **'Jalapeño M' pepper (*Capsicum annuum* L.) seeds were soaked for 40 h in solutions of 0.0, 0.5, 1.0, 2.0, or 3.0 mM GA_3 (using Release, 10% GA_3) and 0.0, 1.75, 3.5, 7.0, or 10.5 mM ethephon in all combinations in petri dishes at 25 °C. The seeds were rinsed, dried for 24 hours, then germinated at either 25 or 40 °C. Thermoinhibition was induced at 40 °C, as nontreated seeds failed to germinate, but 99% of the seeds germinated at 25 °C after 7 days. Pretreatment with H_2O alone partially alleviated thermoinhibition at 40 °C (41% germination). Pretreatment with ethephon alone resulted in up to 50% germination and with GA_3 alone up to 79% germination. The effects of the GA_3 and ethephon were additive, as the highest germination percentage (91%) at 40 °C was obtained with 3.5 mM ethephon + 3.0 mM GA_3. The percentage of abnormal radicles was <1% in all treatments. Chemicals used: (2-chloroethyl) phosphonic acid (ethephon); gibberellic acid (GA_3).**

Thermoinhibition is a condition in which seeds fail to germinate at supraoptimal temperatures, but will germinate when temperatures return to optimum levels. Several vegetable seeds are known to exhibit thermoinhibition, including celery (*Apium graveolens* L. *dulce* Mill D.C.) (Biddington and Thomas, 1979), spinach (*Spinacia oleracea* L.) (Harrington, 1963), mustard (*Brassica oleracea* var. *italica* Plenck) (Elson et al., 1992), and tomato (*Lycopersicon esculentum* Mill.) (Abebe, 1993). Thermoinhibition was induced in several cultivars of jalapeño and cayenne pepper between 30 and 35 °C (Carter, unpublished). Further, poor stand establishment was attributed to thermoinhibition in the greenhouse in Florida when pepper seeds were planted for the fall crop (Charles Vavrina, personal communication).

Combinations of GA_3, kinetin, ethylene, or carbon dioxide (Khan, 1980/81) and K_3PO_4 or PEG (Cantliffe et al., 1981) alleviated thermoinhibition of lettuce. Ethephon overcame thermoinhibition in *Cicer arietinum* L. (Gallardo et al., 1991) and in lettuce, when used in combination with gibberellin and kinetin (Zeng and Khan, 1984). Kinetin, ethephon, and GA_3 were used on 16 ornamental species with varying results (Persson, 1993). Gibberellic acid stimulated germination of some cultivars of pepper seeds exposed to a constant 30 °C, but reduced germination in seeds of other cultivars (Sosa-Coronel and Motes, 1982). Treatment with auxin and kinetin had no effect on percentage or rate of germination at 15 or 25 °C (Watkins and Cantliffe, 1983), but gibberellins overcame thermoinhibition in pepper at 35 °C (Gonzalez et al., 1989). The objective of this study was to determine if commercially available forms of ethephon and GA_3 could be used to overcome thermoinhibition in pepper.

Materials and Methods

One commonly used commercial variety, 'Jalapeno M' (seedlot 057-014-1188; PetoSeed Co., Saticoy, Calif.), was selected because it exhibits thermoinhibition at temperatures >35 °C (Carter et al., unpublished). Each experimental unit consisted of 50 seeds. They were placed on two layers of filter paper (W&R Balston L. Genuine Whatman, Maidstone, England), wetted with 10 mL of pretreatment solution, in 9-cm petri dishes. Pretreatments consisted of GA_3 [Release (10% GA_3); Abbott Laboratories, Chicago] at 0.0. 0.5, 1.0, 2.0, or 3.0 mM and ethephon (Ethrel; Rhone-Poulenc, Triangle Park, N.C.) at 0.0, 1.75, 3.5, 7.0, or 10.0 mM in all combinations. The concentrations of GA_3 and ethephon were based on the work of Zeng and Khan (1984) with lettuce. The pH of all solutions was adjusted to 2.4 with either NaOH or HCl to ensure that the GA_3 was dissolved and that the ethephon remained stable during treatment. The petri dishes were sealed with parafilm (American National Can, Greenwich, Conn.) to avoid moisture loss, and then placed in a 25 °C incubator for 40 h. Preliminary data showed that imbibing seeds in water for periods >40 h led to 100% germination at 25 °C.

After treatment, the seeds were rinsed in double-distilled H_2O for 1 min, then air-dried at room temperature for 24 h. The final percent moisture was not calculated. The seeds were placed on filter paper in petri dishes and 10 mL of H_2O containing 0.1% Captan (Zeneca Ag Products, Wilmington, Del.) was added. Treatments were placed in incubators at either 25 or 40 °C. The experiment was conducted as a completely randomized design with four petri dishes per treatment per incubation temperature.

Germination was recorded daily (radicle ≥2 mm) until the seeds in the 40 °C treatment began to deteriorate (evidence of microbial growth or discoloration, etc., at 7 d). Total percent germination and mean daily germination (MDG) were calculated, where

$$MDG = \Sigma(N_1T_1 + \ldots N_nT_n)/\Sigma N_n$$

and N = the number of seeds germinated in a time interval T (d) (Gerson and Honma, 1978).

Results and Discussion

At 25 °C, germination in all treatments, and in the nontreated control, was between 99% and 100% (data not shown), thus showing that at optimal germination temperatures, seed treatments were not necessary for this seedlot of 'Jalapeno M'. However, at 40 °C, germination was at 0% for the nontreated controls, indicating that thermoinhibition was induced. Pretreatment with H_2O alone partially prevented thermoinhibition (41% germination; Table 1). Thus, the developmental stage sensitive to high temperature occurred in the first 40 h of soaking. In lettuce, the first 4

Table 1. Effect of pretreatments with gibberellic acid (GA_3) and ethephon for 40 h at 25 °C on percent germination of pepper seeds after 7 d at 40 °C.[z]

	GA_3 concn (mM)					
Ethephon concn (mM)	0.0	0.5	1.0	2.0	3.0	Mean
0.00	41	51	63	76	79	62
1.75	50	70	72	84	90	73
3.50	42	70	77	83	91	73
7.00	50	66	78	89	84	73
10.50	49	67	66	88	87	72
Mean	46	65	71	84	86	

[z]Effects of ethephon and GA_3 assessed by orthogonal polynomial contrasts: GA_3–linear (P = 0.0001), quadratic (P = 0.0001); ethephon–linear (P = 0.0294), quadratic (P = 0.0070). The germination of the nontreated control (no pretreatment) was 0% at 40 °C.

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h of imbibition and the phase between the beginning of mitosis and the beginning of radicle emergence is the most sensitive to high temperature (Gray, 1977). Imbibing seeds longer than 8 h at temperatures lower than a thermoinhibitory temperature can overcome the inhibitory effects of high temperature later in the germination process (Smith et al., 1968).

Pretreatment with ethephon or GA_3 promoted germination at 40 °C (Table 1). Combinations of the two chemicals were more effective than one chemical alone, but their effects were additive rather than synergistic (*P* for interaction = 0.518). The highest germination percentage obtained with GA_3 alone was only 79% while germination was 91% when 3.5 mM ethephon was used in combination with 3.0 mM GA_3.

Mean daily germination (MDG) declined with concentration of GA_3, but the concentration of ethephon had little effect (*P* for ethephon × GA_3 interaction = 0.007) (Fig. 1). When used together, ethephon increased response at all but the highest level of GA_3, but was generally linear and negative. Watkins and Cantliffe (1983) found that application of GA_3 increased the rate of germination in 'Early Calwonder' pepper at 15 °C, but GA_{4+7} was more effective than GA_3.

Gibberellic acid (GA_3) and ethephon overcame thermoinhibition in pepper as measured by radicle emergence. However, the effects of these compounds on seedling growth are not known. Lettuce seeds treated with gibberellin produced seedlings with elongated hypocotyls and cotyledons (Braun and Khan, 1976). In our study, the number of abnormal radicles was <1% for all treatments, but this still is not an indication of the quality of a fully developed seedling. Further research is needed to determine the efficacy of these treatments to overcome thermodormancy in pepper and to produce usable transplants.

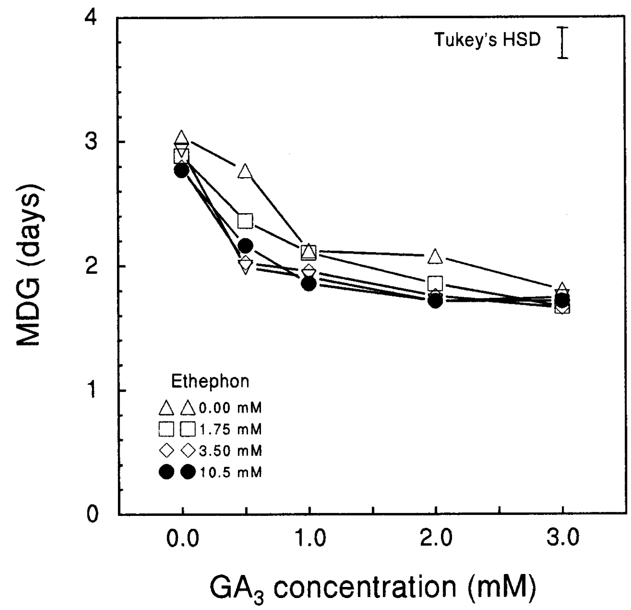

Fig. 1. Effect of ethephon, gibberellic acid (GA_3), and combinations thereof on the rate of germination (mean daily germination) of pepper seeds.

Literature Cited

Abebe, Y. 1993. Improving tomato (*Lycopersicon esculentum* Mill.) seed germination under high temperature by seed priming, scarification, heatshock, and light. MS Thesis, Univ. of Florida, Gainesville.

Biddington, N.L. and T.H. Thomas. 1979. Residual effects of high temperature pre-treatments on the germination of celery seeds (*Apium graveolens*). Physiol. Plant 47:211–214.

Braun, J.W. and A.A. Khan. 1976. Alleviation of salinity and high temperature stress by plant growth regulators permeated into seeds via acetone. J. Amer. Soc. Hort. Sci. 101:716–721.

Cantliffe, D.J., K.D. Shuler, and A.C. Guedes. 1981. Overcoming seed thermodormancy in a heat sensitive romaine lettuce by seed priming. HortScience 16:196–198.

Elson, M.K., R.D. Morse, D.D. Wolf, and D.H. Vaughan. 1992. High-temperature inhibition of seed germination and seedling emergence of broccoli. HortTechnology 2:417–419.

Gallardo, M., M. del Mar Delgado, I.M. Sanchez-Calle, and A.J. Matilla. 1991. Ethylene production and 1-aminocyclopropane-1-carboxylic acid conjugation in thermoinhibited *Cicier arietinum* L. seeds. Plant Physiol. 97:122–127.

Gerson, R. and S. Honma. 1978. Emergence response of the pepper at low soil temperature. Euphytica 27:151–156.

González, E., I. Iglesias, and T. Diaz. 1989. Effect of pre-imbibition, temperature, gibberellic acid and light on the germination of *Capsicum annuum* L. var. *acuminatum* Fingerh. Phyton. 49(1/2):83–87.

Gray, D. 1977. Temperature sensitive phases during the germination of lettuce (*Lactuca sativa*) seeds. Ann. Appl. Biol. 86:77–86.

Harrington. J.F. 1963. The effect of temperature on germination of several kinds of vegetable seeds. Proc. XVI Intl. Hort. Congr. 2:435–445.

Khan, A.A. 1980/1981. Hormonal regulation of primary and secondary seed dormancy. Israel J. Bot. 29:207–224.

Persson, B. 1993. Enhancement of seed germination in ornamental plants by growth regulators infused via acetone. Seed Sci. Technol. 21:281–290.

Smith, O.E., W.W. Yen, and J.M. Lyons. 1968. The effects of kinetin in overcoming high temperature dormancy in lettuce seed. Proc. Amer. Soc. Hort. Sci. 93:444–453.

Sosa-Coronel, J. and J.E. Motes. 1982. Effect of gibberellic acid and seed rates on pepper seed germination in aerated water columns. J. Amer. Soc. Hort. Sci. 107:290–295.

Watkins, J.T. and D.J. Cantliffe. 1983. Hormonal control of pepper seed germination. HortScience 18:342–343.

Zeng, G.W. and A.A. Khan. 1984. Regulators into lettuce seed via acetone. J. Amer. Soc. Hort. Sci. 109:782–785.