

Improving the Germination of Celery Seeds at High Temperature

CARLOS A. BOUZO¹, JUAN C. FAVARO AND RUBÉN A. PILATTI

Department of Vegetal Production, Facultad De Ciencias Agrarias, Universidad Nacional Del Litoral. Kreder 2805. C.P. 3080. Esperanza, Santa Fe, Argentina

¹Corresponding author's e-mail: cbouzo@arnet.com.ar

ABSTRACT

The effect of the temperature, light and some growth regulators during imbibition phase on the seed germination of celery cv. 'Golden Boy' was studied. The inhibitory effect at relatively high temperature (25°C) well known as 'thermo-dormancy' was proven. In this condition, the germination was consistently improved by the use of gibberellin GA3 and 2-chloroethyl phosphonic acid. Also, the thermo-dormancy was partially removed by the use of light during the first 24 h at 25°C. These results suggest that it is possible to enhance the germination of the celery seed under high temperature conditions by adopting these treatments at the time of commercial sowing in cell trays.

Key Words: *Apium graveolens*; Thermo-dormancy; Temperature

INTRODUCTION

In recent years, the trend in vegetable transplant production is the growing of transplants in plug cell trays (Romano *et al.*, 2003). In celery (*Apium graveolens* var. *dulce* (Mill.) Pers.) and others vegetables crops this technique reduce seed costs improve seedling uniformity and diminish the time from planting to harvest (Cantliffe, 1998). High temperature has a detrimental effect on celery seed germination (Parera *et al.*, 1993) causing thermo-inhibition and affecting germination uniformity, seedling number and optimum plant stands (Corral *et al.*, 1989). Temperature causing thermo-dormant changes varies with the genotype and the position of the seed in the umbel of the mother plant (Desai *et al.*, 1996). Seeds collected from primary and secondary umbellets have been reported to be less dormant and germinate better than those from tertiary and quaternary ones (Thomas *et al.*, 1978). An increase of celery seed germination in thermo-dormancy conditions using light (Pérez García *et al.*, 1995), fluctuating temperatures (Thompson, 1974; Corral *et al.*, 1990) and growth regulators (Thomas *et al.*, 1975; Biddington & Thomas, 1978; Bravo & Andrade, 1988) has been reported. However, no study aimed to evaluate the practicable application in mechanical systems of trays sowing. The use of light is due to the existence of a phytochrome system during the formation of the seed (Casal & Sanchez, 1998) and activated after the hydration (Jain *et al.*, 2004). The phytochrome has two photo-interconvertible forms: R-absorbing form (Pr) and the FR-absorbing form (Pfr) (Casal & Sanchez, 1998). Both, Pfr and gibberellins are known to promote seed germination of many species. The connection between these two factors has been frequently reported in the literature (Smith, 1995; Casal & Sanchez, 1998).

Alternating temperatures have been reported to increase the rate of germination in celery (Thompson, 1974) and spinach (Leskovar *et al.*, 1999). In field environments, daily or weekly temperature shifts from high to low temperatures, causing changes in the dormant state of the seeds and thus releasing seeds from thermal inhibition (Leskovar *et al.*, 1999). The application of growth regulators is based on the possible existence of a hormonal balance between promoters, like gibberellins and cytokines and inhibitors, like abscisic acid (Desai *et al.*, 1996; Casal & Sánchez, 1998). Other growth regulator used in lettuce is the ethylene (Nascimento & Paiva, 2000), possibly because the most tolerant cultivars to thermodormancy produces more ethylene at high temperatures (Nascimento *et al.*, 2000). This characteristic explains the existence of genotypes with scarce dormancy (Wehner, 1999). Low temperatures could be another alternative to improve the germination in celery (Rock & Quatrano, 1995).

This study was therefore conducted to improve the germination of celery seeds at high temperature using different invigoration treatments.

MATERIALS AND METHODS

Seeds of celery variety 'Golden Boy' obtained from Asgrow Vegetable Seeds Co. were used in the study. They had an average weight of 0.285 ± 0.080 mg (0.00001 oz.) and were harvested the previous year. The experiment was carried in a growth chamber with controlled temperature and light. For germination, seeds were placed in petridishes over three Wathman No. 3 filter paper covered with a plate to diminish desiccation and previously moistened with 5 mL distilled water or solution of growth regulator. The treatments were: distilled water at 25°C as control (T₀);

distilled water with light during first 24 h to 25°C (T₁); distilled water at 6°C during 48 h and then at 25°C (T₂); gibberellin (GA₃) solution at concentration of 90 mg L⁻¹ (ppm) at 25°C (T₃) and gibberellin solution at concentration of 90 mg L⁻¹ (ppm) and 2-chloroethyl phosphonic acid (Ethephon) solution at concentration of 200 mg L⁻¹ at 25°C (T₄). Except for T₁, all the treatments were placed in darkness. A randomized complete-block design with three replications for treatment was used. The experimental units were petri dishes of 50 seeds. In T₁ the light was provided using a lamp (OSRAM HWL, 250 W) placed 0.50 m over the petri dishes whose main spectrum light emission is the red (Bickford & Dunn, 1972). To determine the germination a radicle protrusion of 1 mm (0.04 inches) was considered (Khan *et al.*, 2004) and was recorded each three days. The germination percentage (G%) was calculated according to the relationship among the number of germinated seeds (ni) and the total (N = 50) and in each date the germination rate

(GR) was calculated with the equation $GR = \sum_{t_i=0}^m \frac{n_i}{t_i}$ (Maguire, 1962), where t_i are the time (d) from beginning of the experiment.

RESULTS AND DISCUSSION

Table I shows the results of percentage germination (%G) and Table II the germination rate (GR) during the experiment. The highest germination (> 80%) was reached with the mix of gibberellins and ethephon solution (T₄ treatment) (Table I). Germination rate (GR) measure the speed of seeds germination during the experiment. The highest GR was reached again with T₄ treatment (Table II). However in the first days, the use of light (T₁ treatment) and gibberellins only (T₃ treatment) caused a early germination than T₄ treatment (Table II). The poor germination obtained with control treatment (T₀) (Table I & II) confirm the existence of a dormancy induced by high temperatures (>

20°C), which been has already demonstrated previously (Thomas, 1978; Salisbury, 1994). This thermo-inhibition of celery seeds was associated with the accumulation of an inhibitor, which could not to be abscisic acid (Whitlock, 1979). When gibberellins are included in the treatments (T₃ & T₄ treatments) a increase in the germination was obtained (Table II) probably due to a modification of the balance between inhibitors and promoters. However, the mixture with ethephon (T₄ treatment) enhanced the percentage of the germination according to the results already obtained by Thomas (1978). The use of ethephon is especially important in cultivars with high dormancy (Thomas, 1978). Although the GA₃ gibberellins has proven to be effective in other species (Soyler & Khawar, 2007) probably, a mixture of gibberellins GA₄/GA₇ could have better results that GA₃ gibberellins according to the exposed by Desai *et al.* (1996) considering that to the same concentration GA₄/GA₇ were more effective.

On the other hand, it should be considered that cytokinins promote the penetration of gibberellins (Pressman & Shaked, 1991). The light (T₁ treatment) caused an increase in germination, which confirm the behavior of positive photoblastic of the celery seeds under thermoinhibition conditions (Thomas *et al.*, 1975; Smith, 1995). As in lettuce, the light probably has a qualitative effect on the germination, while the exogenous gibberellins a quantitative effect (Lewak & Khan, 1977). This may suggest an increase of the germination when increasing the gibberellins a synergic effect to its combination with light. With cooling treatment (T₂) the germination was higher compared to the obtained with control treatment (T₀), however the percentage and rate of germination were poor. Possibly the use of low temperature (6°C) caused a partial destruction of some inhibitor like abscisic acid (ABA) (Khan, 1968). The high germination percentage obtained with mix of the GA₃ and ethephon (T₄) indicates the convenience of their use under conditions of thermodormancy. On the other hand, the seed soaked with

Table I. Effect of the treatments on the germination percentage of celery seed after 17 days

Treatment	G*
T ₀	14.0 ± 2.0 a
T ₁	62.0 ± 4.0 d
T ₂	38.0 ± 2.0 b
T ₃	48.0 ± 3.0 c
T ₄	84.0 ± 3.0 e

Germination percentage mean ± standard deviation. The letters represent mean separation within columns by Duncan test, P ≤ 0.05

Table II. Effect of the treatments on germination rates during the experiment

Treatment	Time (d)				
	5	8	11	14	17
T ₀	0.00	0.00 a	0.22 ± 0.006 a	0.23 ± 0.007 a	0.41 ± 0.020 a
T ₁	0.00	1.37 ± 0.110 d	1.45 ± 0.174 c	1.78 ± 0.107 d	1.82 ± 0.073 c
T ₂	0.00	0.12 ± 0.006 b	0.18 ± 0.011 b	0.43 ± 0.021 b	1.12 ± 0.056 b
T ₃	0.00	1.31 ± 0.118 e	1.39 ± 0.083 e	1.40 ± 0.070 c	1.41 ± 0.042 c
T ₄	0.00	0.50 ± 0.030 c	1.54 ± 0.138 d	2.35 ± 0.117 e	2.47 ± 0.074d

Germination rates mean ± standard deviation. The letters represent mean separation within columns by Duncan test, P ≤ 0.05

this solution instead of distilled water does not represent a problem for sowing of trays with mechanical systems. Further research is needed to determine: (a) minimum time of seed soaking necessary with the solution of GA₃ and ethephon and (b) if the partial drying of the seeds before of the sowing affects the germination capacity.

CONCLUSIONS

The germination of celery seeds under high temperature conditions can increase with hormonal treatment during imbibition phase. With the use of mixture of GA₃ and ethephon was obtained the highest percentage and rate of germination in comparison with the use of distilled water during seed imbibition. Also, the thermodynamicity was partially removed by the use of light during the first 24 h at 25°C.

REFERENCES

- Bickford, E.D. and S. Dunn, 1972. *Lighting for Plant Growth*, p: 221. The Kent State University Press
- Biddington, N.L. and T.H. Thomas, 1978. Thermodynamicity in celery seeds and its removal by cytoquinins and gibberellins. *Physiol. Pl.*, 42: 401–5
- Bravo, A. and P. Andrade, 1988. Efectos de tratamientos de remojo en agua y en tres reguladores de crecimiento sobre la germinación de la semilla de apio (*Apium graveolens* L.). *Ciencia e Investigación Agraria*, 15: 3–10
- Cantliffe, D.J., 1998. Seed germination for transplant. *Hort. Technol.*, 8: 499–503
- Casal, J.J. and R.A. Sánchez, 1998. Phytochromes and seed germination. *Seed Sci. Res.*, 8: 317–29
- Corral, R., F. Pérez-García and J.M. Pita, 1989. Nota sobre el efecto de la temperatura e iluminación de plántulas de cuatro cultivares de apio (*Apium graveolens* L.). *Investigación Agraria: Producción y Protección Vegetales*, 4: 219–23
- Corral, R., F. Pérez-García and J.M. Pita, 1990. Germinación de semillas de apio (*Apium graveolens* L.). *Investigación Agraria: Producción y Protección Vegetales*, 5: 217–22
- Desai, B.B., P.M. Kotecha and D.K. Salunkhe, 1996. *Seeds Handbook: Biology, Production, Processing and Storage*, p: 627. Marcel Dekker, Inc. New York
- Jain A., A.D. Sharma and K. Singh, 2004. Acid and Alkaline Phosphatase activities in the Pearl Millet seeds. *Int. J. Agric. Biol.*, 6: 960–3
- Khan, A.A., 1968. Inhibition of gibberelic acid-induced germination by abscisic acid and reversal by cytokinins. *Pl. Physiol.*, 43: 1463–5
- Khan, M.M., M.J. Iqbal, M. Abbas, H. Raza, R. Waseem and A. Ali, 2004. Loss of vigour and viability in aged onion (*Allium cepa* L.) seeds. *Int. J. Agric. Biol.*, 6: 708–11
- Leskovar, D.I., V. Esensee and H. Belefant-Miller, 1999. Pericarp, leachate and carbohydrate involvement in thermodynamicity of germinating spinach seeds. *J. American Soc. Hort. Sci.*, 124: 301–6
- Lewak, S. and A.A. Khan, 1977. Mode of action of gibberelic acid and light on lettuce seed germination. *Pl. Physiol.*, 60: 575–7
- Maguire, J.D., 1962. Speed of germination. Aid in selection and evaluation for seedling emergence and vigor. *Crops Sci.*, 2: 176–7
- Nascimento, W.M. and S.A.V. Paiva, 2000. Evolvimento do etileno na germinação de sementes de alface em condições de altas temperatura. *Revista Da Sociedade De Olericultura Do Brasil*, 18: 1038–9
- Nascimento, W.M., D.J. Cantliffe and D.J. Huber, 2000. Thermodynamicity in lettuce seeds: association with ethylene and endo-mannanase. *J. American Soc. Hort. Sci.*, 125: 518–24
- Parera, C.A., Q. Ping and D.J. Cantliffe, 1993. Enhanced celery germination at stress temperature via solid matrix priming. *Hort. Sci.*, 28: 20–2
- Pérez-García, F., J.M. Pita, M.E. González-Benito and J.M. Iriondo, 1995. Effects of light, temperature and seed priming on germination of celery seeds (*Apium graveolens* L.). *Seed Sci. Technol.*, 23: 377–83
- Pressman, E. and R. Shaked, 1991. Interactive effects of GAs, CKs and growth retardants on the germination of celery seeds. *Pl. Growth Regulation*, 10: 65–72
- Rock, C.D. and R.S. Quatrano, 1995. The role of hormones during seed development. In: Davies, P.J. (eds.), *Plant Hormones: Physiology, Biochemistry and Molecular Biology*, pp: 671–97. Kluwer Academic Publishers, The Netherlands
- Romano, D., A. Paratore and A.L. Rosi, 2003. Plant density and container cell volume on solanaceous seedling growth. *Acta Hort.*, 614: 247–53
- Salisbury, F.B., 1994. The Role of Plant Hormones. In: Wilkinson, R.E. (ed.), *En: Plant-Environment Interactions*, pp: 39–81. Marcel Dekker, Inc
- Smith, H., 1995. Physiological and ecological function within the phytocrome family. *Annl. Rev. Pl. Physiol.*, 46: 289–315
- Soyler, K. and K.M. Khawar, 2007. Seed germination of caper (*Capparis ovata* var. *Herbacea*) using α -Naphthalene Acetic acid and Gibberelic acid. *Int. J. Agric. Biol.*, 9: 35–7
- Thomas, T.H., 1978. Relationship between bolting-resistance and seed dormancy of different celery cultivars. *Sci. Hort.*, 9: 311–6
- Thomas, T.H., D. Palevitch, N.L. Biddington and R.B. Austin, 1975. Growth regulators and the phytochrome-mediated dormancy of celery seeds. *Physiol. Pl.*, 35: 101–6
- Thomas, T.H., D. Gray and N.L. Biddington, 1978. The influence of the position of the seed on the mother plant on seed and seedling performance. *Acta Hort.*, 83: 57–66
- Thompson, P.A., 1974. Germination of celery (*Apium graveolens* L.) in response to fluctuating temperatures. *J. Exp. Bot.*, 25: 156–63
- Wehner, T.C., 1999. Vegetable cultivar descriptions for North America, List 24. *Hort. Sci.*, 34: 763–806
- Whitlock, A., 1979. *Celery Grower Guide N°C*, p: 93. Grower Books, Londres

(Received 30 January 2007; Accepted 19 February 2007)