

## Short Communication

# Control of Blackheart in the Celery (*Apium graveolens* L.) Crop

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## ABSTRACT

Sometimes celery can have a physiological disorder called 'blackheart', caused by calcium deficiency. The blackheart produces adverse effects on the marketability of the produce. The effect of foliar spray of calcium nitrate and chelated calcium on the blackheart reversion was investigated in celery (*Apium graveolens* L. cv. Golden Boy) plants grown under greenhouse conditions for two years. The treatments with were: calcium nitrate, chelated calcium and control (distilled water). Blackheart was reverted with calcium solutions, whilst chelated calcium was better than calcium nitrate in this regard. With chelated calcium the blackheart reversion mean was of between 58% and 68%. It is suggested that the use of different combinations of dose of calcium and frequency of application according to the environmental conditions is imperative.

**Key Words:** Physiological disorder; *Apium graveolens* L.; Calcium

## INTRODUCTION

Celery (*Apium graveolens* L.) is a biannual plant and widely grown as an annual for its nutritious leafstalks. Celery production is best in a cool, humid and long growing season with ample and uniform supply of moisture. Any time the plants are stressed for water, calcium metabolism may be disrupted and the 'blackheart', a physiological disorder begins. The plants that, severely deficient in essential nutrients such as calcium, exhibit visual deficiency symptoms (Memon *et al.*, 2005). This disorder starts when the new growth at the center of the stalk begins to die back. Leaf tips and margins turn brown and the discoloration and death of tissues can progress down the leaf into the stalk rather quickly. They occur, because calcium cannot be mobilized from older tissues and redistributed via the phloem (White & Broadley, 2003).

Although the blackheart is closely related with plant water balance and calcium levels in crown leaves, other associated factors with blackheart are less vigorous growth, varietal susceptibility, high temperature, high fertility level and high soluble salt level (Bible & Stiehl, 1986; Wahid *et al.*, 2004; Napier & Combrink, 2006). The foliar fertilizers are used throughout the world as effective, preventive and curative measure to compensate for nutrient deficiency (Kaya *et al.*, 2005) and particularly in celery the control of the blackheart with foliar applications of calcium is utilized (Pardossi *et al.*, 1999) However, information is scarce about the reversion of the symptoms when their appearance is general in the crop. The present research was designed to quantify the reversion of the disorder when it is already evident in the crops by means of foliar applications.

## MATERIALS AND METHODS

Experiments were performed in 2005 and 2006 in

greenhouse at the Horticultural Research Station, Esperanza, Argentina (31° 30' S, 62° 15' W). 'Golden Boy' celery variety (Asgrow Vegetable Seeds Co.) was used. The seeds were sown during July, every year in polystyrene trays with cell volume from 17 cm<sup>3</sup> filled with sphagnum peat in a nursery heated to 15°C. The seedlings were grown with a basic nutrient solution containing N (300 ppm), P and K (100 ppm each), Ca (95 ppm) and Mg (30 ppm) and Hoagland's concentration of microelements. The plants were transplanted in an unheated greenhouse eight weeks after sowing with a density of 10 plants m<sup>-2</sup>. The soil was loamy clay typic Argiudol with a capacity of cationic exchange of 18 meq 100 g<sup>-1</sup> of soil of which 14 meq was of calcium. Water and fertilizers was supplied with drip with a flow rate of 2 L h<sup>-1</sup>. Nitrogen (1.5 gm<sup>-2</sup>) and potassium (2 gm<sup>-2</sup>) per week were applied using potassium nitrate (N 13%, K 46%), nitrate ammonium (N 33%) and nitric acid (0.5 mL L<sup>-1</sup>) to correct the pH. Soil analysis indicated that Ca and P availability was adequate to obtain maximum yield of celery crop under non-limiting water conditions. The quantity of water supplied was based on the tensiometer readings to maintain soil water content above -30 cbar in the first 30 cm of soil. Pest and disease control were according to guidelines for normal production (Rubatzky *et al.*, 2000).

Twelve weeks after emergence the watering was withheld to induce the appearance of blackheart. The incidence of 'blackheart' was assessed 13 weeks after emergence and at harvest, which was rated for the symptoms as follows: free, 0; mild, 1; severe, 2 (Fig. 1). The treatments with foliar sprays were: (1) calcium nitrate (Ca: 24.0%) to 0.5%, (2) calcium chelated (Ca: 7.9%), at 1.25% and (3) control (distilled water). Foliar sprays were carried out every day at 19:00 h 13 weeks after emergence until harvest. The application (40 - 50 mL per plant every time) was restricted to the young innermost leaves. There were

five replications with a randomized design and each experimental unit had 100 plants. The data were analyzed by analysis of variance using Statgraphic® software.

## RESULTS AND DISCUSSION

At the beginning of the treatments for the years 2005 and 2006, withholding water supply produced high number of plants with blackheart (Table I). This was due to the fact that the calcium moves only in the xylem with the transpirational water flow (Collier & Tibbitts, 1982; Broadley *et al.*, 2003). In that moment the state of severity of blackheart corresponded to mild (1) (Fig. 1). Also no differences among plots were detected with respect to blackheart before of the beginning of the treatments.

The increase of the measure of hydric potential due to the restitution of the watering in the week 13, it seems not to have been enough to fulfill the calcium demand for new growth at the center of the stalk (Cannell *et al.*, 1959). At this time the plants presented a high growth rates, increase the risk that the tissue content of calcium fell below the critical level required for the maintenance of membrane integrity, leading to physiological disorder (Bangerth, 1979). This possibly explains the increase in the percentage of plants with blackheart in the control treatment toward the end of the experiments in 2005 and 2006 years (Table I).

The foliar applications of calcium nitrate and of chelated calcium caused some reversion blackheart compared to control (Table I). However, the reversion due to calcium treatments was different: chelated calcium was the one that presented the best effectiveness during 2005 and 2006 with a reversion of 68 and 58% respectively, while this reversion with calcium nitrate was 19% and 11% (Table I). In other studies the incidence of blackheart in young leaves was prevented by foliar application of calcium nitrate (Pardossi *et al.*, 1999), but here the effects of chelated calcium was better even with 10 times lesser concentration than the calcium nitrate. The better effect of reversion obtained with the chelated calcium can be due to an enhanced transport of calcium within the plant due to chelation of calcium (Hanger, 1979; Yang & Jie, 2005).

It is possible that the efficiency of foliar spray can be enhanced under environmental conditions that do not favor rapid dry matter accumulation and high demand for calcium in expanding leaf tissue. Also, if the crop is under heat and moisture stress, possibly the foliar sprays must begin before the appearance of a deficiency signs. This will allow carrying out fewer aspersions on the crop. Therefore, it is necessary to investigate the use of different combination of dose of calcium and frequency of application.

In conclusion, the blackheart, a common symptom of physiological disorder in celery, can be reverted by foliar sprays with calcium solutions. The chelated calcium was the one that had the greater reversion of blackheart compared to calcium nitrate. With chelated calcium the blackheart reversion was between 58% and 68%.

**Table I. Effects of treatments with foliar spray on the blackheart reversion during two years**

Treatments	2005		2006	
	Beginning	Harvest	Beginning	Harvest
Control	81.3 a	89.9 a	84.7 a	94.1 a
Calcium chelated	81.5 a	25.8 c	86.5 a	36.2 c
Calcium Nitrate	83.7 a	67.7 b	86.3 a	74.3 b

Mean values (n=100) in columns with the same letter do not differ significantly at the 5 % level as determined by ANOVA.

**Fig. 1. The severity of 'blackheart' estimated by rating young leaves for symptoms as follows: free, 0; mild, 1; severe, 2**



## REFERENCES

- Bangerth, F., 1979. Calcium-related physiological disorders of plants. *Annu. Rev. Phytopathol.*, 17: 97–122
- Bible, B.B. and B. Stiehl, 1986. Effects of atmospheric modification on the incidence of blackheart and the cation content of celery. *Sci. Hort.*, 28: 19–28
- Broadley, M.R., H.C. Bowen, H.L. Cotterill, J.P. Hammond, M.C. Meacham, A. Mead and P.J. White, 2003. Variation in the shoot calcium content in angiosperm. *J. Exp. Bot.*, 54: 1431–46
- Cannell, G.H., K.B. Tyler and C.W. Asbell, 1959. The effect of irrigation and fertilizer on yield, blackheart and nutrient uptake by celery. *Proc. American Soc. Hort. Sci.*, 74: 539–45
- Collier, G.F. and T.W. Tibbitts, 1982. Tipburn of lettuce. *Hort. Rev.*, 4: 49–65
- Hanger, B.C., 1979. The movement of calcium in plants. *Comm. Soil Sci. Pl. Anal.*, 10: 171–93
- Kaya, M., M. Atak, K.M. Khawar, C.Y. Ciftci and S. Özcan, 2005. Effect of pre-sowing seed treatment with zinc and foliar spray of humic acid on yield of Common Bean (*Phaseolus vulgaris* L.). *Int. J. Agric. Biol.*, 7: 875–8
- Memon, N., K.S. Memon and Z.U. Hassan, 2005. Plant analysis as a diagnostic tool for evaluating nutritional requirements of banana. *Int. J. Agric. Biol.*, 7: 824–31
- Napier, D.R. and N.J.J. Combrink, 2006. Aspects of calcium nutrition to limit plant physiological disorders. *Acta Hort.*, 702: 107–16
- Pardossi, A., G. Bagnoli, F. Malorgio, C.A. Campiotti and F. Tognoni, 1999. NaCl effects on celery (*Apium graveolens* L.) grown in NFT. *Sci. Hort.*, 81: 229–42
- Rubatzky, V.E., C.F. Quiros and P.W. Simon, 2000. *Carrots and Related Vegetable Umbelliferae*. CABI Publishing, Oxfordshire, U.K
- Wahid, A., M. Hameed and E. Rasul, 2004. Salt-induced injury symptom, changes in nutrient and pigment composition and yield characteristics of mungbean. *Int. J. Agric. Biol.*, 6: 1143–52
- White, P.J. and M.R. Broadley, 2003. Calcium in plants. *Ann. Bot.*, 92: 487–511
- Yang, H. and Y. Jie, 2005. Uptake and transport of calcium in plants. *J. Pl. Physiol. Mol. Biol.*, 31: 227–34

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