Vitis **45** (3), 145–146 (2006)

Research Note

Temperature exotherms of dormant buds of rootstock genotypes

C. Köse

Atatürk University, Faculty of Agriculture, Department of Horticulture, Erzurum, Turkey

K e y w o r d s : Cold hardiness, grapevine, low temperature exotherm, thermal analysis, *V. vinifera*.

Introduction: Low-temperature injury is one of the most important factors limiting the production of fruit crops, especially temperate fruit trees (Kang *et al.* 1998). It is known that rootstocks influence cold hardiness of scion tissues (Chaplin and Schneider 1974). Thus, many efforts to raise cold hardiness through breeding or by rootstock-scion combinations have been made (Rajashekar *et al.* 1982 a, b).

Exothermic events (especially low temperature exotherms, LTE) have been associated with cold injury during controlled freezing of several woody plants (Quamme 1974, Ashworth and Rowse 1982, Andrews and Proebsting 1987, Wample *et al.* 1990, Wolf and Cook 1994, Kang *et al.* 1997). The assumption that laboratory hardiness tests represent actual field hardiness is central to studies predicting plant survival or damage in response to field conditions. After it had been shown that LTE is involved in freezing injury of apple stem tissue (Quamme *et al.* 1972), thermal analysis has emerged as a simple and rapid technique for determining cold hardiness of plant tissues. Measurements of grape bud hardiness by thermal analysis were successfully performed by Quamme (1974), Montano *et al.* (1987), Rajashekar and Reid (1989) and Wolf and Cook (1994).

The purpose of this study was to determine the effect of 7 rootstocks on exotherms, especially low temperature exotherm and cold hardiness of dormant buds of the grapevine cvs Gemre and Razakı.

Materials and Methods: P l a n t m a t e r i a l : All studies were conducted on cane sections of the *Vitis vinifera* L. cvs Gemre and Razakı grafted on 7 rootstocks differing in vigor: Dogridge, Fercal and Ramsey (high vigor), Harmony and 1613 (moderate vigor) and 1616 and 41B (low vigor).

Cane sections were collected on January 8, 2001. Experiments were conducted on dormant buds of scions obtained from 10-years-old vines grown at the experimental vineyard of the Horticultural Research Institute, Egirdir, Turkey.

Vineyard soil was sandy clay loam. Vineyard climatic conditions are characterized by relatively low humidity, dry periods and a short (201 d) growing season. Long-term rainfall and mean monthly temperatures in the growing season (April-October) are 76.2 mm and 19.1 °C, respectively. The altitude of the vineyard was 1050 m.

Canes were stored between two packages of plastic gel refrigerant at -3 °C before the tests were run (Flinn and Ashworth 1994).

All wines were spaced 2.5 m apart in north-south oriented rows that were 2.5 m wide. The vines were spur-pruned and head-trained. The height of head was 0.7 m above ground. Shoot number ranged from 20-25 per vine for both cultivars.

E x o t h e r m a n a l y s i s : Thermal analysis (TA) was performed by using copper-constantan thermocouples and a programmable freezer. Exotherms of dormant buds including 2 cm long segments of nodal tissue, were determined by observing temperature recordings for sudden temperature deflections (Andrews *et al.*, 1983, Quamme 1983, Kang *et al.* 1998). The thermocouple was attached to the intact dormant buds with an elastic band. Silicon grease was used to cover the thermocouple junction to obtain maximum heat transfer; the samples were wrapped with aluminum foil and placed in Dewar Flask which was prechilled to -3 °C (Quamme 1983). The samples were prepared and thermocouples were placed at -3 °C. The Dewar flasks were placed in a programmed freezer to achieve a constant cooling rate that was 5 °C h^{-1} (Ashworh and Rowse 1982, Andrews *et al.* 1983). Cooling started at -3 °C in all freezing tests and ended at -30 °C. High temperature exotherms (HTE) and low temperature exotherms (LTE) were recorded every 15 s using a multi-channel datalogger (Montano *et al.* 1987). Determinations were carried out on 15 intact dormant buds of each graft combination.

All data were statistically treated by the analysis of variance (ANOVA), means by the Tukey's Honestly Significant Differences test.

Results and Discussion: The dormant buds of all tested graft combinations showed HTE and LTEs (Table). However, in our analysis only the first LTE was evaluated, because the first LTE temperature is closely related to cold hardiness of grapevine (Wolf and Cook 1994). Occasionally, an exotherm was observed below the first LTE, but this was not recorded. It is assumed that the latter is associated with secondary or tertiary primordia.

Both HTE and LTE temperatures were statistically different in all rootstock-scion combinations tested. TA showed that large HTEs were at -3.0 °C to -8.6 °C, followed by smaller LTE at -20.1 °C to -23.3 °C depending on the rootstock-scion combination.

In previous studies (Ashworth and Rowse 1982, Andrews and Proebsting, 1987), reported that TA of buds typically reveals two distinct exoterms (HTE and LTEs) during cooling. The HTE occurs between 0 and -10 °C. This is a large exotherm corresponding to the freezing of extracellular water in the bud axis and scales. The LTEs correspond to the freezing of extracellular water in the bud axis and scales. The LTEs correspond to the freezing of supercooled water within the primordium and are associated with injury to the flower primordia of *vitis* (Pierquet and Stushnoff 1980, Andrews *et al.* 1984).

Correspondence to: Dr. C. Köse, Atatürk University, Faculty of Agriculture, Department of Horticulture, 25240 Erzurum, Turkey. Fax: +90-442-2360-958. E-mail: cafkosetr@yahoo.com

Table

Effects of rootstocks on high temperature (HTE) and low temperature exotherm (LTE) temperatures of cvs Razakı and Gemre. Least significant differences between means (LSD) are indicated at P < 0.01

Rootstock	HTE (°C)		LTE (°C)	
	Gemre	Razakı	Gemre	Razakı
Dogridge	-4.0 c	-3.2 e	-20.9 c	-20.1 e
Fercal	-3.6 cd	-3.4 e	-20.8 c	-20.7 d
Ramsey	-3.0 e	-4.8 d	-20.5 c	-21.3 c
Harmony	-8.6 a	-8.1 a	-22.9 a	-23.3 a
1613	-5.1 b	-6.8 b	-21.6 b	-22.1 b
41B	-3.2 de	-5.7 c	-20.5 c	-21.9 b
1616	-3.5 d	-6.6 b	-20.7 c	-22.1 b
LSD < 0.01	0.428	0.366	0.471	0.383

Analysis of variance of our data showed that effects of high vigor (Dogridge, Fercal and Ramsey) and those with low vigor (1616 and 41B) showed higher HTE and LTE temperatures than rootstocks with moderate vigor (Harmony and 1613).

While the highest HTE and LTE temperatures of Razakı and Gemre were observed for Dogridge and Ramsey, the lowest HTE and LTE temperatures of both cultivars were determined from Harmony (Table). This can be associated with water content and the maturity of buds. It is well known that there is a correlation between maturity and water content of tissue and cold hardiness (Wolpert and Howell 1986, Wolf and Pool 1987). Also delayed maturity resulting in decreased hardiness has been reported (Chaplin and Schneider 1974) and LTEs were associated with the water content of flower primordia of sweet cherry (Andrews and Proebsting 1987). Kang *et al*. (1998) stated that decreases in the water content of primordia caused decreases in the exotherm temperatures.

Under the condition of short growing seasons, high vigor rootstocks delay the onset of maturation of scion cane and, low vigor rootstocks not improve necessarily the cane of scions. So, high vigor Dogridge, Fercal and Ramsey and, low vigor 1616 and 41B did not withstand the short growing season. In other words, moderate vigor rootstocks may have better effect on frost resistance of scions than high vigor and low vigor rootstocks.

Rootstocks have no direct effect on the cold hardiness of grapevines. However, indirect effects, e.g. for vigorous rootstocks a higher mutual shading of leaves, can lead to delayed maturation of fruit and canes. This can result in a significant decrease in cold hardiness (Wolpert and Howell 1986; Anonymous 1992).

In conclusion, our data show definite effects of grapevine rootstocks on scion cold hardiness. High and low vigor rootstocks, delaying the maturity of scion canes, should not be used for grapevine to avoid frost damage under the condition of a short growing season. Further studies should be made with other rootstocks under the condition of long growing seasons.

This research was supported by Agriculture Faculty of Atatürk University. The author would like to thank Dr. R. Wample, California State University, for review and suggestion.

Andrews, P. K.; Proebsting, E. L.; Campbell, G. S.; 1983: An exotherm sensor for measuring the cold hardiness of deep-supercooled flower buds by differential thermal analysis. HortScience **18**, 77-78.

Andrews, P. K.; Sandidge, C. R.; Toyama, T. K.; 1984: Deep super-cooling of dormant and deacclimating *Vitis* buds. Am. J. Enol. Vitic. **35**, 175-177.

Andrews, P. K.; Proebsting, E. L.; 1987: Effects of temperature on the deep supercooling caracteristics of dormant and deacclimated sweet cherry flower buds. J. Am. Soc. Hort. Sci. **112**, 334-340.

Anonymous; 1992: Passive Frost Protection of Trees and Vines. Coop. Ext. Univ. of California, Div. of Agric. Natural Res., Leaflet 21429e.

Ashworth, E. N.; Rowse, D. J.; 1982: Vascular development in dormant prunus flower buds and its relationship to supercooling. HortScience **17**, 790-791.

Chaplin, C. E.; Schneider, G. W.; 1974: Peach rootstock/scion hardiness effects. J. Am. Soc. Hort. Sci. **99**, 231-234.

Flinn, C.; Ashworth, E. N.; 1994: Blueberry flower-bud hardiness is not estimated by differential thermal analysis. J. Am. Soc. Hort. Sci. **119**, 295-298.

Kang, S. K.; Motosugi, H.; Yonemori, K.; Sugiura, A.; 1997: Exothermic characteristics of dormant buds of persimmon (*D. kaki* Thumb.) in relation on cold hardiness. HortScience **32**, 840-843.

Kang, S. K.; Motosugi, H.; Yonemori, K.; Sugiura, A.; 1998: Supercooling characteristics of some deciduous fruit trees as related to water movement within the bud. J. Hort. Sci. Biotec. **73**, 165-172.

Montano, J. M; Rebhuhn, M.; Hummer, K.; Lagerstedt, H. B.; 1987: Differential thermal analysis for large-scale evaluation for pear cold hardiness. HortScience **22**, 1335-1336.

Pierquet, S. K.; Stushnoff, C.; 1980: Relationship of low temperatue exotherms to cold injury in *Vitis riparia* Michx. Am. J. Enol. Vitic. **31**, 1-6.

Quamme, H.; Stushnoff, C; Weiser, C. J.; 1972: The relationship of exotherms to cold injury in apple stem tissues. J. Am. Soc. Hort. Sci. **97**, 608-613.

Quamme, H. A.; 1974: An Exothermic process involved in the freezing injury to flower buds of several prunus species. J. Am. Soc. Hort. Sci. **99**, 315-318

Quamme, H. A.; 1983: Relationship of air temperature to water content and supercooling of overwintering peach flower buds. J. Am. Soc. Hort. Sci. **108**, 697-701.

Rajashekar, C. B.; Westwood, M. N; Burke, M. J.; 1982 a: Deep supercooling and cold hardiness in genus *Pyrus*. J. Am. Soc. Hort. Sci. **107**, 968-972.

Rajashekar, C. B.; Pellett, H. M.; Burke, M. J.; 1982 b: Deep supercooling in roses. HortScience **17**, 609-611.

Rajashekar, C. B.; Reid, W.; 1989: Deep supercooling in stem and bud tissues of pecan. HortScience **24**, 348-350.

Wample, R.; Reisenauer, G.; Bary, A.; 1990: Microcomputer-controlled freezing, data acquisition and analysis system for cold hardiness evaluation. HortScience **25**, 973-976.

Wolf, T. K.; Cook, M. K.; 1994: Cold hardiness of dormant buds of grape cultivars: Comparison of thermal analysis and field survival. HortScience **29**, 1453-1455.

Wolf, T. K.; Pool, R. M.; 1987: Factors affecting exotherm dedection in the differential thermal analysis of grapevine dormant buds. J. Am. Soc. Hort. Sci. **112**, 520-525.

Wolpert, J. A.; Howell, G. S.; 1986: Cold acclimation of Concord grapevines III. Relationship between cold hardiness, tissue water content, and shoot maturation. Vitis **25**, 151-159.

Received September 15, 2005