Cold-Hardiness Response of *Ilex crenata* Thumb. cv. Hetzi Roots to Nitrogen Source and Potassium[1]

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Abstract. **Fall applications of K and NH_4^+ or NO_3^- forms of N did not significantly affect the cold hardiness of *Ilex crenata* 'Hetzi' roots. The fertilizer treatments resulted in variations in leaf total N from 1.66% to 3.26% and leaf K from 0.85% to 1.25% in Jan. Natural freezing of the container media during Dec. and Jan. did not significantly increase the cold hardiness of the roots. Hardiness test results with the triphenyl tetrazolium chloride (TTC) method agreed closely with results from survival tests with intact plants.**

Insufficient root hardiness is a serious problem in the over-wintering of container-grown nursery plants in the northern regions of the United States. The roots of some holly cultivars are killed at -7°C[2].

The effects of N, P, K and other nutrients on the development of plant hardiness have been studied with varying results (2). However, relatively little attention has been given to root hardiness. Pellett and White (4) found no effect of various levels of slow release fertilizers on root hardiness of *Juniperus chinensis* L. cv. Hetzi. Gouin[2] suggested that additional K improved hardiness of *Ilex crenata* cv. Latifolia and *Pyracantha coccinea* L. cv. Leland only if the original soil K level was very low, applications of N generally increased hardiness, although not consistently in repeated tests. The effects of N sources have not been considered in most hardiness tests. In one report (8) the subtropical plant *Litchi chinensis* Sonn. was more frost tolerant when fertilized with $(NH_4)_2SO_4$ than with $NaNO_3$.

The purpose of this study was to determine the effect of levels of K and NH_4^+ and NO_3^- sources of N on cold acclimation of roots of container-grown *Ilex crenata* 'Hetzi'.

Methods. Rooted cuttings of 'Hetzi' holly were planted in 15 cm plastic containers in May, 1970, in a medium of equal parts sphagnum peat, washed concrete sand and sandy loam. To each 0.76 m^3 (cubic yard) of the medium were added 11.35 kg ground limestone, 3.41 kg 20% superphosphate and 2.64 hl (1 bu) rotted manure. All plants were maintained under the same cultural regime during the summer. A proprietary 20-8.7-16.7 N-P-K soluble fertilizer was applied from a liquid proportioner through a tube-type irrigation system 3 times between July 1 and Sept. 1. The proportioner was adjusted to deliver 200, 250 and 300 ppm N at the successive applications.

Beginning in Sept., 6 fertilizer treatments, each with 52 plants, were applied at each irrigation on Sept. 8 and 30, Oct. 8 and 15 (Table 1).

The plants were exposed to natural weather conditions for cold acclimation until Nov. 4, when they were covered with white polyethylene. From each treatment 25 plants were removed on Nov. 20 for hardiness determinations, at which date, the media had not frozen. The remainder of the plants were left under the polyethylene for further cold acclimation until Jan. 28. Under the protective covering, the media froze for the first time on Dec. 22, and reached a low temp of approx -5.0°C on Jan. 18. Media temp was obtained from thermisters and recording equipment described by Martin and Batjer (3).

Root hardiness determinations were made on 5 plants from each treatment by the (TTC) method (5). Sections of the root ball, including roots and moist soil, were cut out and inserted into 30 x 100 mm plastic tubes, which were stoppered and placed into a temp-controlled, methanol-water bath. Mature, woody roots and young roots at the container-soil interface were not used. Temp was lowered from 3.0°C at the rate of 3.0° per hr, and samples were held at the test temp, usually at 2.0° intervals, for 1 hr. Measurements with thermocouples in the soil showed that after 30 min, the soil in the tubes was within 0.2° of the constant bath temp. We assumed that the roots were at the same temp as the moist soil. Samples were thawed at 2.0°, and unfrozen control samples were held at 2.0°.

Additional hardiness determinations were made on whole intact root systems. These tests were made in mid-Dec. on plants removed from the polyethylene structures in Nov. and stored at 2.0°C. From each treatment 15 intact plants were shifted to containers without holes and containers plunged into the methanol-water bath; 5 plants were exposed for 12 hr to: -3.9°, -5.6°, and -7.8°. After thawing, the previously frozen plants and 5 plants that had remained at 2.0° were placed in a greenhouse at 15° to 20° for 10 weeks. Visual ratings were made of viability and growth of the roots, using a rating system of 1 (entire root system dead) to 9 (totally viable).

Five random samples of leaves were collected in January from 25 plants of each treatment for nutrient analysis. Leaf samples were dried in an oven at 70°C and ground in a Wiley mill to pass a 30-mesh screen. K was determined by atomic absorption spectrophotometry (1) and N by a modified Kjeldahl procedure (6).

Results. The fertilizer treatments resulted in 3 levels of leaf total N (Table 1). The highest levels were from NH_4^+ treatments, significantly lower levels were from NO_3^- treatments, and the lowest levels were from no fertilizer N application. Two levels of leaf K were obtained, the higher being associated with fertilizer K combined with NO_3^- or K with no fertilizer N. Significantly lower leaf K levels resulted from fertilizer K combined with NH_4^+ or from no fertilizer K.

Table 2 shows the results of root hardiness tests. The TTC method estimated the killing temp to be from -5.6° to -6.7°C for the plants sampled in Nov. The killing temp for those sampled in Jan. was from -6.1° to -7.8°. There was no significant difference in killing temp among treatments or between sampling dates.

Table 1. Fertilizer treatments and resulting leaf N and K concn for *Ilex crenata* 'Hetzi' plants.

Fertilizer treatment	Salts	Total applied[y] (g/plant)	Leaf analysis[z] (% dry wt) N	K
High NO_3^- – high K	KNO_3	2.3	2.72b	1.25a
High NH_4^+ – high K	$(NH_4)_2SO_4$	2.6	3.26a	0.90b
	KCl	1.2		
High NO_3^- – low K	$Ca(NO_3)_2$	3.4	2.72b	0.95b
High NH_4^+ – low K	$(NH_4)_2SO_4$	2.6	3.17a	0.88b
Low N – high K	KCl	1.7	1.83c	1.13a
Low N – low K	---	0.0	1.66c	0.85b

[y]Total g per plant of each salt applied over the treatment period Sept. 8 to Oct. 15.
[z]Means within a column followed by unlike letters are significantly different at the 5% level.

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[2]Gouin, F. R. 1969. The influence of cultural practices and growth regulators on the overwintering of container grown woody ornamental plants. Ph.D. Thesis. University of Maryland.

Table 2. Hardiness of roots of Ilex crenata 'Hetzi' as indicated by TTC test and by visual examination.[x]

Fertilizer treatment	Killing temp (°C) estimated by TTC[y] Sampled Nov. 20, 1970	Sampled Jan. 28, 1971	Recovery from indicated temp estimated by visual rating[z] +2.0°	-3.9°	-5.6°	-7.8°
High NO_3 – high K	-6.1a	-6.1a	9.0a	9.0a	3.6b	2.4b
High NH_4 – high K	-6.1a	-6.1a	9.0a	9.0a	3.2b	2.6b
High NO_3 – low K	-6.1a	-7.8a	9.0a	9.0a	2.8b	3.0b
High NH_4 – low K	-5.6a	-7.8a	9.0a	9.0a	3.0b	1.6b
Low N – high K	-6.7a	-6.7a	9.0a	9.0a	3.0b	3.0b
Low N – low K	-6.1a	-7.2a	9.0a	9.0a	4.4b	3.4b

[x]Means within a test method followed by unlike letters are significantly different at the 5% level.

[y]Kilfing temp was estimated as that which reduced TTC to 50% of unfrozen controls.

[z]Rating of 9 (no apparent injury) to 1 (apparently dead). Intact roots of whole plants were held 12 hr at indicated temp in mid-Dec.

The visual ratings of recovery of intact roots (Table 2) show that severe damage was produced in the same temp range, -5.6°C and -7.8°, that was indicated by the TTC method. Differences among treatments were not statistically significant. Only 7 plants died of the total 60 that were frozen to either -5.6° or -7.8°. This suggests that at least a few roots survived on most of the plants.

Preliminary TTC tests showed that, in general, the larger roots with secondary thickening had the greatest cold tolerance, the young roots on the outer surface of the soil ball had the lowest, and the heavily branched roots within the ball (those used for the TTC test) were intermediate. The temp range of -5.6° to -7.8°C apparently destroyed most of the smaller roots in the test of intact plants. This was the killing temp range indicated by the TTC method.

The 2 methods of testing cold hardiness failed to show differences in root hardiness due to sources of N or level of K, even though there were differences in plant N and K as indicated by the leaf analysis. Based on these results, there would be no justification for markedly changing the fertilizer rates or formulation in the fall for the purpose of increasing root hardiness of container grown *Ilex*. Roots apparently did not increase in cold hardiness between Nov. 20 and Jan. 28 even though an increase in hardiness might have been expected as a result of freezing. Apparently, the 2nd stage of acclimation, as proposed by Weiser (7), did not occur in the roots of these plants.

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The Merbein Bunch Count, A Method to Analyze the Performance of Grape Vines[1]

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Abstract. **A method of obtaining systematic records of the growth arising at each node on grape vines (*Vitis vinifera* L. or interspecific hybrids including this species and various American species of *Vitis*) is described and illustrated. Derived variables which can be calculated from these records are listed and a code is given which enables construction of tables of the derived variables by computer.**

Grapevines are cane-pruned by retaining a no. of 1-year old mature shoots cut to more than 5 nodes (canes or rods), spur-pruned with shoots of less than 5 nodes (spurs), or rod- and spur-pruned, i.e. to have a mixture of rods and spurs. In experiments with cane-pruned vines it is often desirable to determine the no. and proportion of both the nodes which produce shoots, and of the shoots which carry fruit, as well as the variation between different parts of the vine of these and other variables such as mean no. of bunches per shoot and mean bunch wt. For instance in experiments with the cane-pruned 'Sultana' the distribution of these yield components was recorded and analyzed in detail (1, 2, 6). The "Merbein bunch count" (MBC), the method of collecting, recording, compiling and analysing these data, could be applied more widely, and is therefore presented in this paper.

The count registers in a systematic way, for each cane or spur in turn, the growth arising at each node. Because of the morphology of the grapevine, this growth may be quite complex. Many buds are formed at each node during the preceding growing season, but only rarely are more than 3 buds sufficiently advanced to have any chance of bursting. They are the *primary* bud, formed in the axil of the most basal leaf of last season's axillary shoot, and 2 *accessory* buds, formed in the axils of the first and second rudimentary leaves of the *shoot* enclosed in the primary bud (3). Thus, the eye at a node appears to carry a big central bud flanked by a smaller bud on each side.

Because of this, no more than 3 shoots will arise per node, except in rare cases. Each shoot may carry 0, 1 or more inflorescences or bunches (flowering marks the transition from inflorescence to bunch; here both forms are called bunches). In the grapevine, bunches and tendrils are homologous organs, and transition forms are not uncommon. To classify as a bunch in the MBC, such an organ must carry at least 5 – 10 berries depending on cultivar, or 4 times that no. of florets.

To describe the growth at each node, combinations of 3 symbols are used in the MBC during field recording: a dot (·) describes a node without a shoot or with a shoot which ceased growth after 1 or 2 small leaves have unfolded; a dash (–) describes a non-fruiting shoot; a cross (×) describes a fruitbearing shoot with 1 bunch. If such a shoot carries more than 1 bunch, the appropriate no. of crosses is added. Where more than 1

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