COLD HARDINESS OF HERBACEOUS PERENNIALS

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Abstract. Cold hardiness was determined for certain herbaceous perennials following exposure to controlled freezing temperatures. Plants of *Lythrum*, *Achillea*, and *Gaillardia* were saleable to an exposure of −11.0°C (12°F), *Campanula* and *Coreopsis* to −9.3°C (15°F) and −7.7°C (18°F), respectively, *Chrysanthemum* and *Erysimum* to −6.0°C (21°F), *Digitalis* and *Geum* to −4.4°C (24°F), and *Kniphofia* to −2.7°C (27°F). None of the species were saleable after exposure to −12.6°C (9°F), and none of the species survived exposure to −14.3°C (6°F).

REVIEW OF LITERATURE

There has been a substantial increase in the popularity of herbaceous perennials in the past several years. In an attempt to keep pace with the increasing demand for perennials, many growers are utilizing container production. Growers are striving to produce a container perennial that will bloom and give a good display in the garden the first year it is purchased. To do this vernalization requirements are being met by overwintering container plants. However, overwintering losses can be a significant problem in container production.

Container grown plants are more susceptible to freeze damage than those grown in the ground. Roots of container plants can be exposed to temperatures of −15°C (5°F) at the same time that the roots of field-grown plants (3 in. below the surface) are only exposed to −6°C (21°F) (8).

Research in overwintering container-grown perennials has not kept pace with the needs of the perennial plant industry. Grower Richard Simon of Bluemount Nurseries stated his concern, "I hope that somewhere along the line some of the research stations would do something about determining what the root killing temperature is on some of these perennials. I think it would be helpful to the industry" (7). To this date there has been no published research on root and crown hardiness of herbaceous perennials.

The amount of winter protection required depends on the root killing temperature for the species being grown and the climate of the specific production area. By combining the knowledge of root hardiness with the amount of protection afforded by various overwintering systems, growers across the nation could minimize winter losses. The purpose of this study was to determine the cold hardiness of ten selected herbaceous perennials subjected to controlled freezing temperatures.

MATERIALS AND METHODS

Ten species were selected for the controlled freezing study based on grower suggestions concerning hardiness levels and public popularity. These species were:

Hardy *Achillea filipendulina* 'Parker's Variety', *Lythrum salicaria* 'Robert', and *Campanula glomerata* var. *acaulis.*

Marginal *Digitalis* × *mertonensis, Coreopsis grandiflora* 'Sunray', and *Gaillardia* × *grandiflora* 'Monarch Strain.'

Tender *Erysimum hieraciifolium, Kniphofia uvaria,* Pfitzer's hybrids, *Chrysanthemum coccineum,* and *Geum quellyon* 'Mrs. Bradshaw'.

The ratings of hardy, marginal, and tender were those of growers who had experienced some problems with overwintering perennials. Tender species usually exhibited winter storage losses; marginal species showed losses in some years but not in others; and hardy species usually were reliably winter-hardy and rarely showed overwintering losses. These rather arbitrary classifications were used due to the lack of published research on actual hardiness levels.

One-inch plugs were transplanted on September 18, 1986, into 1-qt containers containing a soilless mix composed of equal parts river sand, sphagnum peat moss, and styrene beads. Plants were grown outside until December 12 at which time they were moved to a cooler in which the temperature was maintained at −1°C ±1°C (30.2°F) until the freezing tests were performed starting January 11, 1987.

A total of 12 plants of each species were subjected to each test temperature. Test temperatures [in Centigrade followed by Fahrenheit] were as follows:
−1.1 (30), −2.7 (27), −4.4 (24), −6.0 (21), −7.7 (18), −9.3 (15), −11 (12), −12.6 (9), and −14.3 (6).
There were three replications of each species within each of the nine temperature treatments repeated over four blocks (weeks) of time.

Thirty plants (3/species) were placed pot to pot into a low temperature freezer cabinet in a completely random design. A 15 cm (6 in.) long ungrounded copper-constantan thermocouple probe was placed approximately 5 cm into the medium in the center of 6 different containers. Temperatures were recorded every 5 minutes.

Temperatures were lowered from −1.1°C (30°F) at the rate of 2.7°C (5°F) per hour until the treatment level was reached. Once the medium in the containers reached the test temperature, plants were held at the temperature for a least 1 hour. Plants were removed from the freezer and placed in a cooler at 2°C (36°F) to thaw gradually. After thawing plants were placed in a greenhouse (20.9°C (70°F)) for forcing.

A qualitative analysis was done by a panel of 4 judges to rate saleable quality on a scale of 1 to 5, with 1 being dead, 2-alive but saleable, 3 to 5 saleable with 5 of highest quality. Analysis of covariance and simple linear regression techniques were performed. Analysis of covariance was performed with time at four levels and temperature as the covariate to predict regrowth.

RESULTS AND DISCUSSION

There was a great variation in the hardiness levels among the different species. Test temperatures that produced saleable plants ranged from −11°C (12°F) for the hardy species to −2.7°C (27°F) for the most tender species (Table 1). None of the species were saleable after an exposure to −12.6°C (9°F), and none of the species survived exposure to −14.3°C (6°F).

Table 1. Cold hardiness ratings of ten herbaceous perennials following controlled freezing tests.

Species	Temperature °C	°F
Hardy		
Achillea filipendulina 'Parker's Variety'	−11.0	12[z]
Gaillardia × *grandiflora* 'Monarch Strain'	−11.0	12
Lythrum salicaria 'Robert'	−11.0	12
Intermediate		
Campanula glomerata var. *acaulis*	−9.3	15
Coreopsis grandiflora 'Sunray'	−7.7	18
Tender		
Chrysanthemum coccineum	−6.0	21
Digitalis × *mertonensis*	−4.4	24
Erysimum hieraciifolium	−6.0	21
Geum quellyon 'Mrs Bradshaw'	−4.4	24
Kniphofia uvaria, Pfitzer's hybrids	−2.7	27

[z] Temperature exposure in Centigrade and Fahrenheit that resulted in saleable plants (at least a rating of 3 on a scale of 1 to 5 with 5 being best)

Of the ten species evaluated *Lythrum*, *Achillea*, and *Gaillardia* survived the lowest temperatures. Regression analysis of the regrowth ratings reveals that saleable plants of these three species could result if the plants were exposed to −11°C (12°F) or slightly lower. An example of the regression curves for these 3 species is shown for *Achillea* in Figure 1. The findings that *Lythrum* and *Achillea* are hardy species producing saleable plants after an exposure to −11°C (12°F) was not unexpected. Growers have reported both of these plants as being cold hardy in their overwintering systems (1, 5).

Gaillardia has been reported as being hardy in areas with minimum low temperatures of −30 to −20°F; however, growers

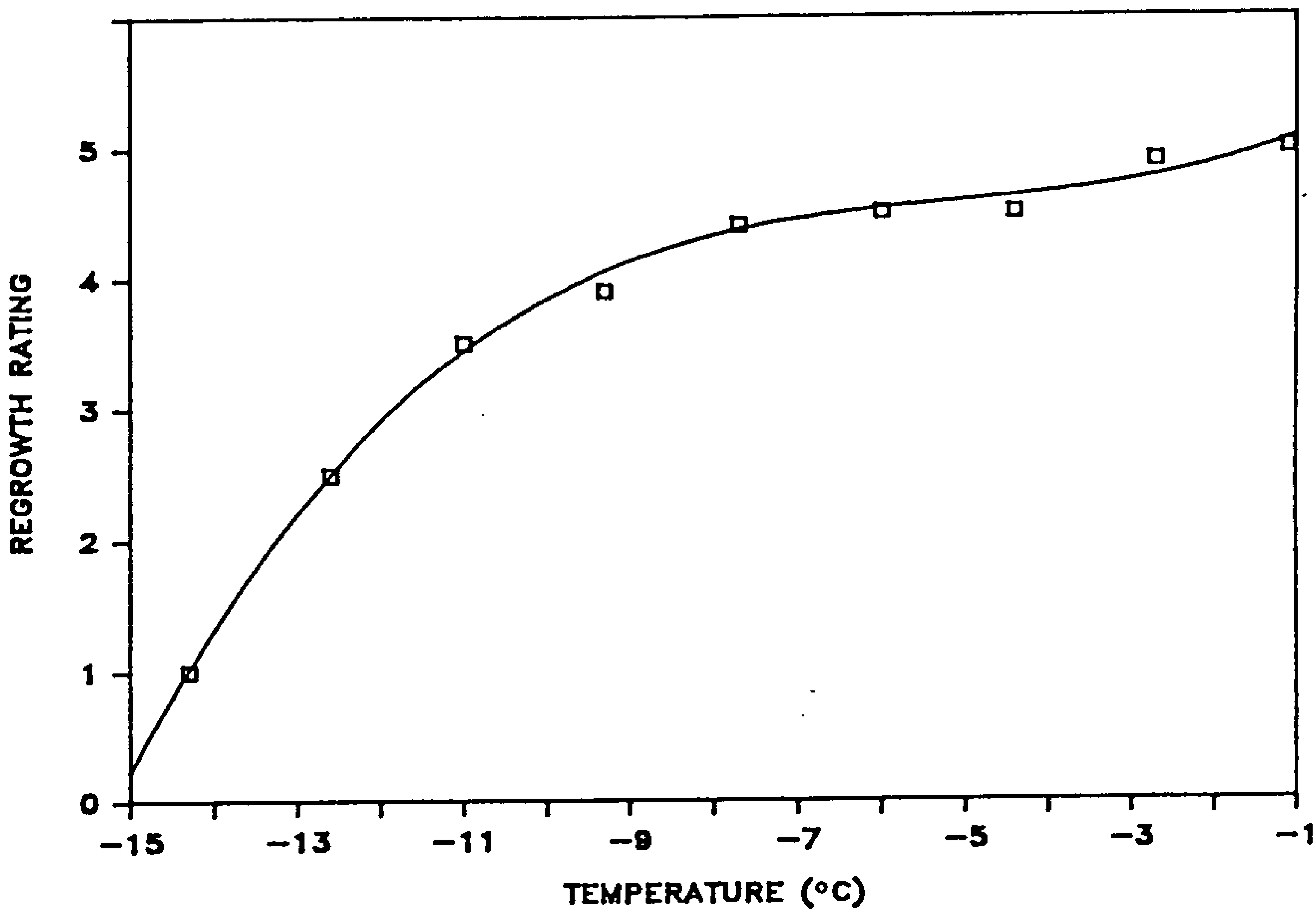

Figure 1. Influence of varying low temperature exposure on regrowth quality of *Achillea filipendulina* 'Parker's Variety.' r = .78 y=5.38768272 + (.35534847) deg + (.05876237) deg*deg + (.00386450) deg*deg*deg*.

have experienced trouble overwintering this species. DiSabato-Aust (2) reported that *Gaillardia* was damaged when stored under thermal blanket in 1985–86 even though container soil temperature never dropped below −4.9°C (23°F) which was well above the temperature in the freezing chamber. *Gaillardia* requires good drainage and wet overwintering conditions can be fatal (9). Physical storage conditions may be the reason for poor overwintering and not because of a lack of cold hardiness.

Species surviving intermediate temperatures included *Campanula* and *Coreopsis* with saleable plants occurring at −9.3°C (15°F) and −7.7°C (18°F), respectively. The regression slope for *Campanula* is indicated in Figure 2. Note that the peak of the slope moves further to the right as the hardiness of the perennials become lower.

Campanula is viewed as being hardy by the growers but *Coreopsis* has exhibited variable responses. Other research has also shown *Coreopsis* to be a variable performer. Heiden (3) tested bareroot *Coreopsis* plants at different shipping temperatures, different holding temperatures, and various holding periods. He found that this species exhibited various regrowth responses which did not show any definite trends due in part to erratic plant survival rates. Growers report losses during warm winters and variablility in survival due to the size of plants placed in storage.

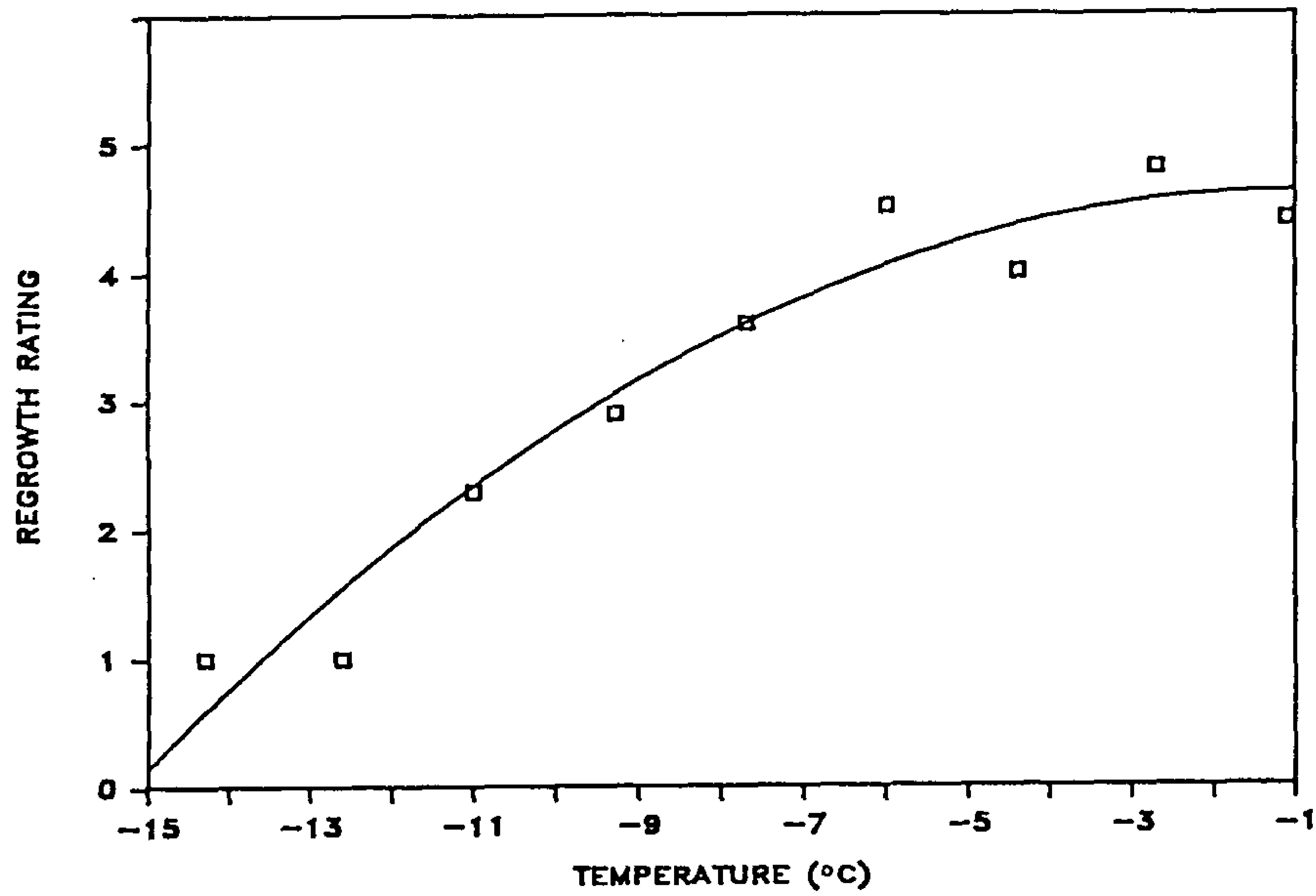

Figure 2. Influence of varying low temperature exposure on regrowth quality of *Campanula glomerata* var. *acaulis*. r = .67 y=4.58964257 + (.05028991) deg + (−.02310418) deg*deg.

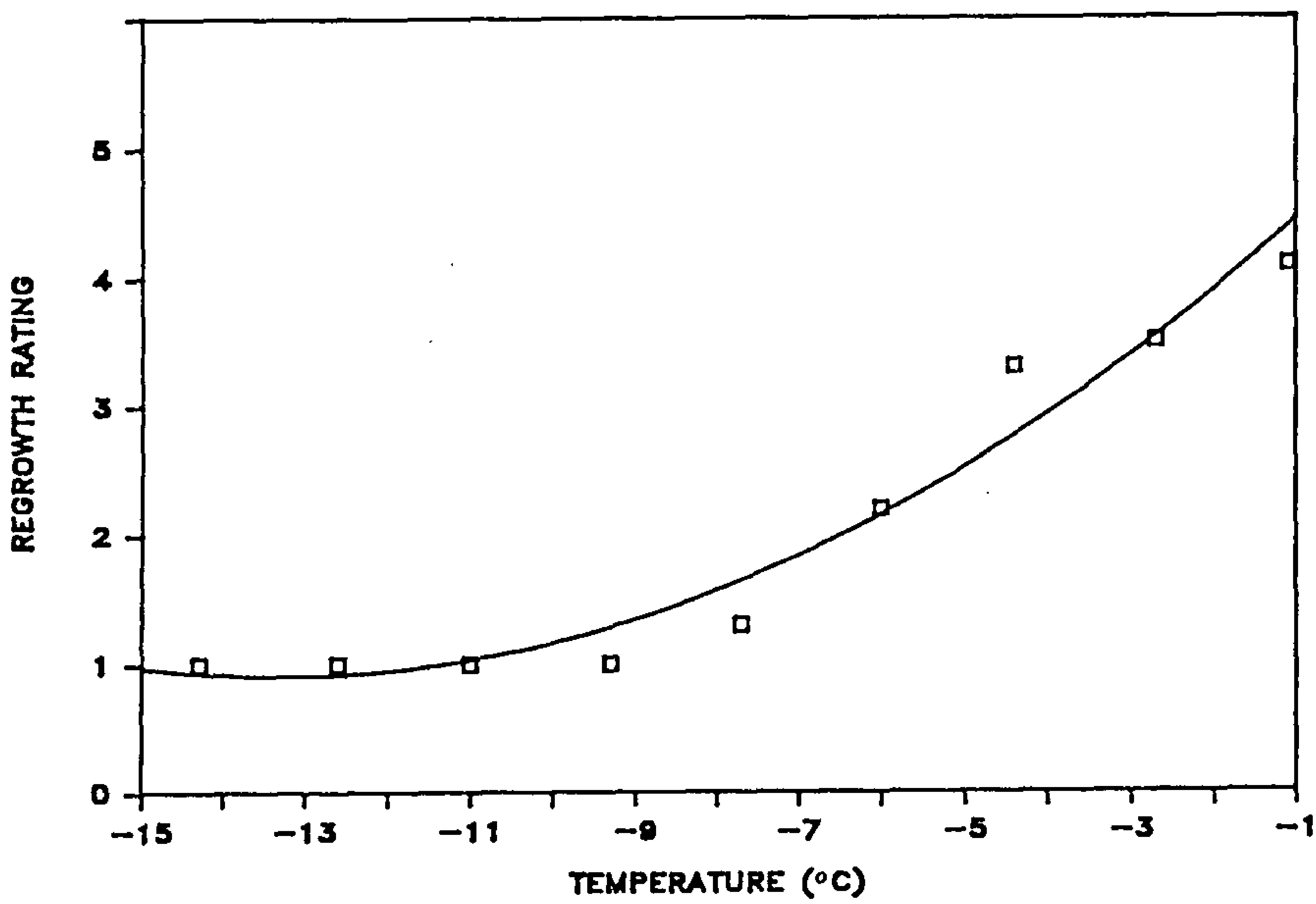

Figure 3. Influence of varying low temperature exposure on regrowth quality of *Digitalis* × *mertonensis*. r = .64 y=5.03973141 + (.61946936) deg + (.02322330) deg*deg.

There were 5 species that we considered tender due to performance after exposure to −6.0°C (21°F) or less. *Digitalis* and *Geum* are examples of plants in the mid-range of this hardiness zone with saleable plants found at −4.4°C (24°F). The regression for *Digitalis* is indicated in Figure 3.

According to DiSabato-Aust plants of *Digitalis* were not rated saleable after overwintering in a single layer poly house in 1985–86 (2). The minimum soil temperature recorded was −7.1°C (19°F). *Digitalis* is considered marginal by growers (10). It is subject to root and stem rot and growers try to avoid placing thermal blankets directly on the plants to avoid loss from these diseases.

Magbool (4) reported that bareroot plants of Geum did not have any observable growth after being stored for 6 months at −5 °C (23°F) or −10°C (14°F). DiSabato-Aust (2) reported *Geum* as unsaleable after storage in various overwintering structures where container soil temperatures were −7.1°C (19°F), −1.6°C (29°F) or −4.9°C (23°F). *Geum* is usually overwintered in a minimum heat greenhouse and moved to cold frames in the spring (1.5). It is not reliably hardy in northern areas and wet conditions can be fatal (9).

Kniphofia proved to be the most tender species studied with a saleable plant at −2.7°C (27°F). The regression curve for this species is shown in Figure 4. Growers consider it a tender species and often overwinter it in cool greenhouses (5). It is considered a tender plant

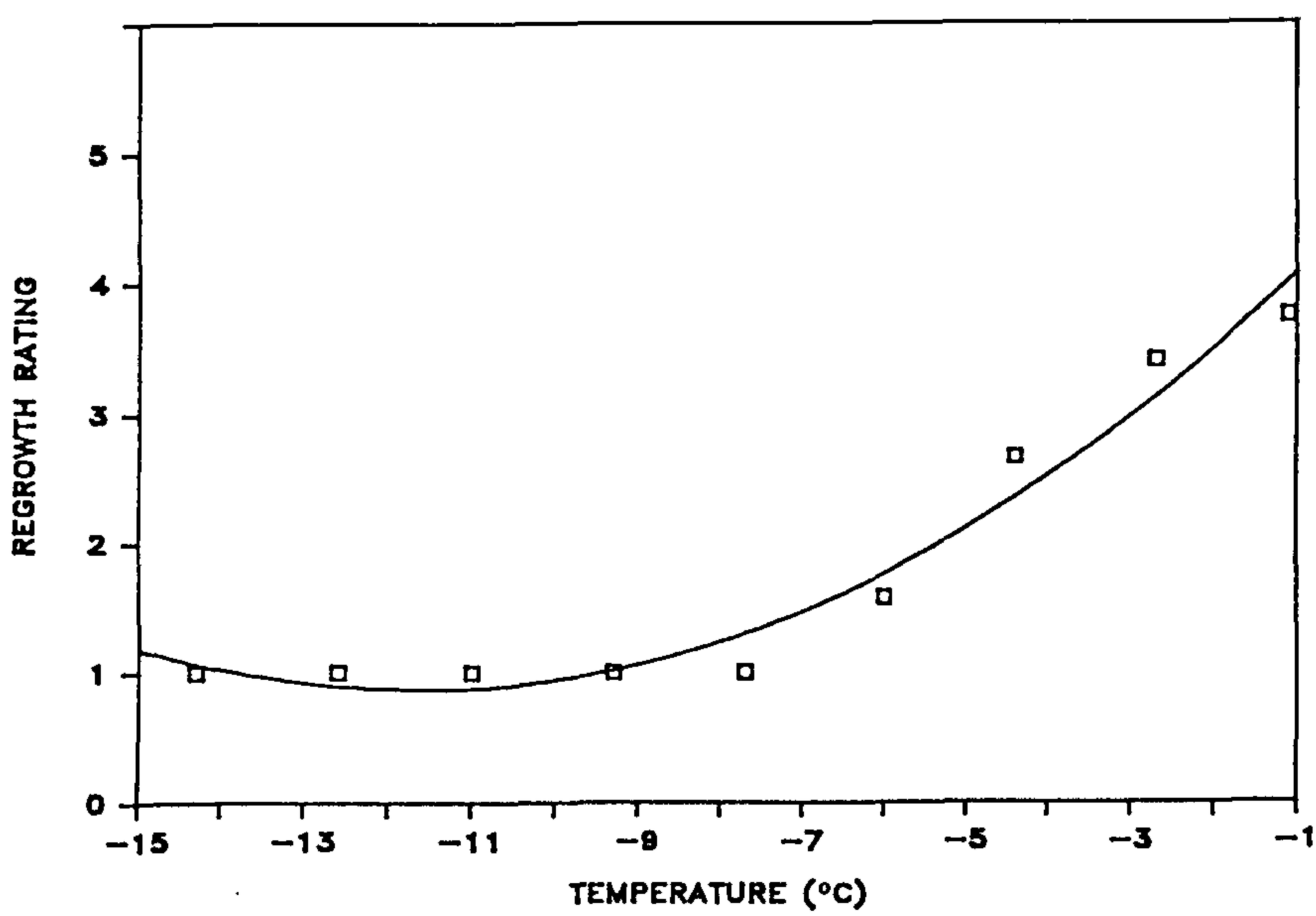

Figure 4. Influence of varying low temperature exposure on regrowth of *Kniphofia uvaria*, Pfitzer's hybrids. r = .66 y=4.696886424 + (.65743339) deg + (.02820841) deg*deg.

for northern gardens and requires mulching to overwinter when grown in the soil.

These results are only from a one-year study. Future work will be continued to survey additional species. An area of additional study might include determination of hardiness cycles. Shimizu (6) reported maximum hardiness of *Narcissus* 'White Cheerfulness' roots was reached in December followed by January and February. Roots were least hardy in March. This may be an important factor in determining the true hardiness levels of herbaceous plants. These levels could then be related to overwintering losses in the field, i.e., are losses greater if there is a period of subfreezing temperature in December or if these temperatures occur in February?

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BILL FLEMER: What type of bait are you putting under the thermal blankets?

ELTON SMITH: We are using a bait block, Eaton Bait block, that is apple scented, and available from a firm in Cleveland, Ohio. An important key is first controlling the mice outside the perimeter early in October; then bait inside the houses. This keeps them from coming into the houses.