The deterioration of our well water probably occurred gradually over a period of years thus not causing us to suspect it as the source of trouble. I would urge the States to establish water quality standards, if they have not already done so, and encourage growers to have their propagation water, in particular, checked if they are showing any salt injury on the leaves or roots of cuttings. The problem is severe under mist because of the nature of application. Most all of the salts in the water end up concentrated on the leaves due to evaporation, as there is little or no leaching, such as you would get under an irrigation system.

MODERATOR PINNEY: I imagine your paper will go on record as one of the shortest we have had but we appreciate the information very much. I know of one instance in Wisconsin in which a considerable amount of money was spent over a two year period trying to determine what was wrong and the trouble turned out to be the source of water. At this time I'd like to introduce the next speaker, Dr. Harold Pellet, who will speak on the relationship of rootstock to maturity and cold hardiness of the scion variety in apples.

RELATIONSHIP OF ROOTSTOCK IN THE APPLE TO MATURITY AND COLD HARDINESS OF THE SCION VARIETY

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INTRODUCTION

Even though the art of graftage has been known and used in plant propagation for centuries relatively little is known about stock-scion relationships. There has been quite a bit of work done to study the influence of rootstock on plant growth and some on nutrition but very little work has been done to study the influence of rootstock-scion interactions as they might affect hardiness.

The rootstock could affect scion hardiness in one of several ways. Hardy rootstocks might induce hardier scions strictly through their use. The root system of certain rootstocks may have the ability to survive or escape root injury where other rootstocks cannot. In studies at Minnesota we have found that there is quite a range in hardiness capabilities of the various Malling and Malling-Merton stocks. Other workers have reported similar results (1, 2). Certain rootstocks may, due to earlier maturity or later bud-break, enable a scion variety to escape early and late winter injury by hardening earlier or dehardening later. The rootstock may enable the scion to develop greater hardiness than it could if grown on its own roots. Perhaps the rootstock does not influence the scion hardiness in

anyway, or only in such a minor way, as not to be of much importance in the well being of the whole plant during the winter.

MATERIALS AND METHODS

In order to study the influence of rootstock on scion hardiness in apple the following study was initiated at the University of Minnesota Horticultural Research Center in 1965.

The scion varieties, 'Delicious', 'Haralson', and 'Columbia Crab', were budded to 'East Malling 26' and *Malus robusta* '5' rootstocks. Throughout the remainder of this paper, 'East Malling 26' and *Malus robusta* '5' will be designated 'EM26' and 'MR5' respectively and grafts will be designated 'H/EM26' or 'D/MR5' to indicate 'Haralson' scion on 'East Malling 26' or 'Delicious' scion on *Malus robusta* '5', respectively. The scion varieties were selected to give a wide range in hardiness: 'Delicious' being tender, 'Columbia Crab' being extremely hardy, and 'Haralson' being one of the hardiest apple varieties grown in the upper Midwest. The rootstocks were chosen to give a comparison of hardy and tender rootstocks. 'MR5' is vigorous and hardy; 'EM26' is dwarfing and, at the time the study was initiated, was not really characterized for hardiness but was believed to be much less hardy than 'MR5'.

The hardiness of the current season's scion growth and roots of the rootstock was determined by controlled freezing tests at 5 times during the fall, winter, and spring of 1967-68 and 1968-69.

For the freezing test, small sections of stems or roots were placed in thermos bottles with a thermocouple to record temperature. The thermos bottles were placed in a freezer that was programmed to drop 3 degrees per hour. The thermos bottles were then removed at 3 degree intervals. The stem and root sections were kept in polyethylene bags at room temperatures for one week before rating; each sample was rated visually for damage using a 1 to 5 scale with 5 being no injury and 1 being dead. The mean injury ratings of 3 plants of each graft combination was used to plot the tables. A mean injury rating of less than 3 was felt to be too seriously damaged to survive.

Maturity was evaluated in three ways: date of terminal bud formation in the fall, percent leaf fall and rating of leaf color change in the fall, and date of bud break in the spring. In all cases evaluation was made at 4 to 8 day intervals in order to note the periodic changes that occurred, since the varieties varied greatly in all of these characteristics. Bud break in the spring was recorded at the time the leaves had emerged about ¼ inch. The date of bud-break is based on the average date of 12 different plants of each combination. Likewise, the mean percent leaf-fall data that is presented is the average leaf-fall of 12 different plants of each combination. Only the 1968-69 data are given since the results of the 1967-68 season were very similar.

I would like to compare each of the varieties separately to

show how each reacted on the two different rootstocks. For each, I have plotted the mean percent leaf-fall as a gauge of maturity and the hardiness level of each combination during the period of leaf abscission. In the spring, I recorded the average date of bud-break, and the hardiness level of each combination after they had leafed out.

RESULTS AND DISCUSSION

'Haralson' on 'EM26' lost its leaves sooner than 'H/MR5'. There was about 4 days difference between 'H/EM26' and 'H/MR5' in the date fifty percent leaf fall occurred. This difference was apparent throughout the period of terminal bud formation and leaf fall (Fig.1).

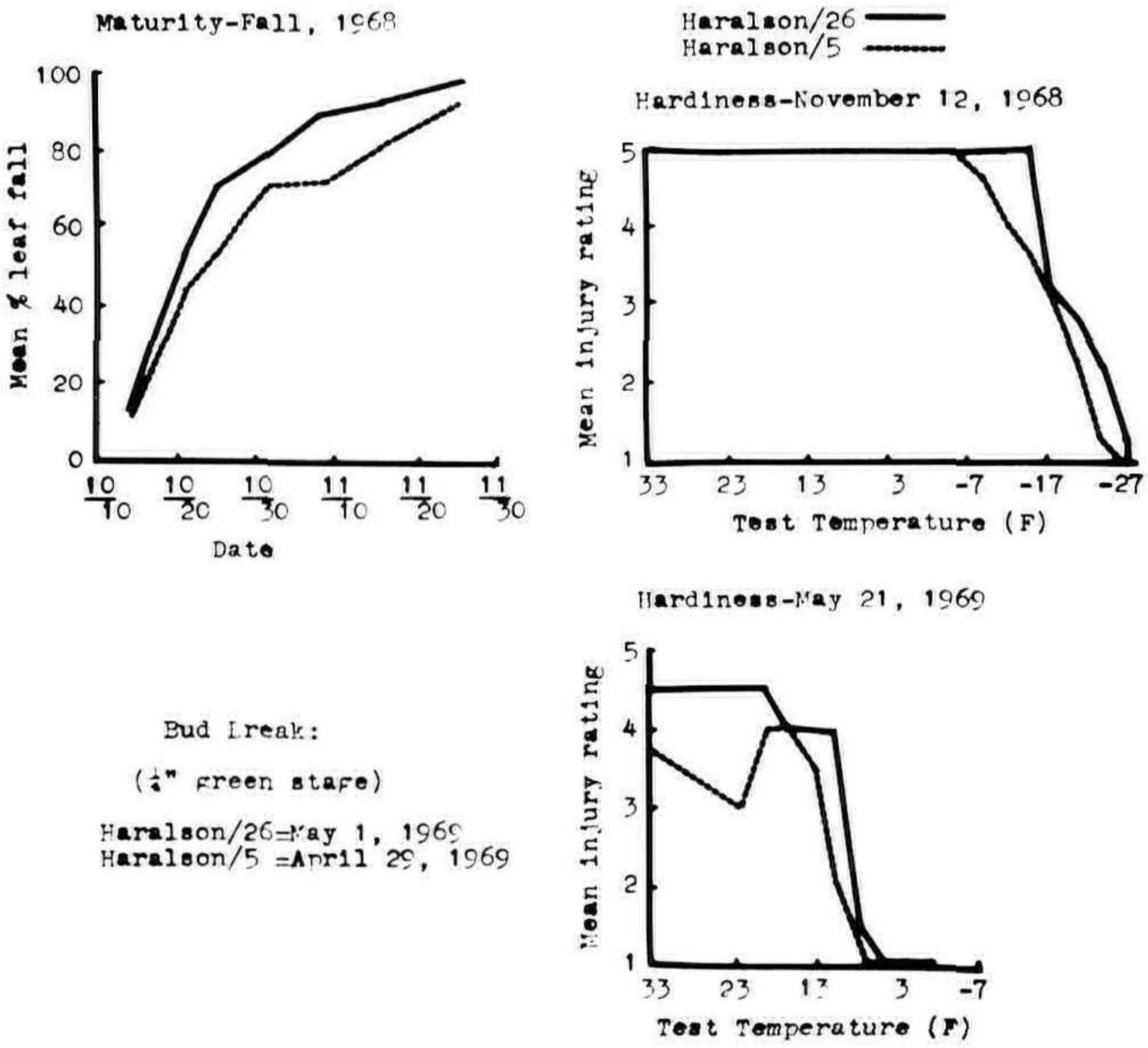


Fig. 1. Comparison of maturity and hardiness with 'Haralson' budded to 'EM 26' and *Malus robusta* '5'.

Earlier maturity of 'H/EM26' was also reflected in the mean injury ratings of hardiness on Nov. 12. 'H/EM26' showed no damage at -15° F whereas on 'MR5' it started to show some browning at -6°F. There was about 3 degrees difference in the killing point of 'Haralson' on the two rootstocks. Thus 'H/EM26' matured earlier and was also hardier in the fall than 'H/MR5'. In the spring 'H/EM26' broke bud about 2 days later than 'H/MR5'. This difference was reflected in a difference in the hardiness level between 'H/EM26' and 'H/MR5'. Because 'H/EM26' remained dormant slightly longer, it also apparently retained a higher level of cold resistance longer than 'H/MR5'. There was more field damage to 'H/MR5' than 'H/

EM26' on May 12 and there was about a 3 degree difference in the killing point of 'Haralson' on these rootstocks at this time. Thus, both in the spring and in the fall, maturity seemed to influence the hardiness of 'Haralson' budded to 'EM26' and 'MR5'.

With 'Delicious' the same trend was apparent although the differences were not as great. 'D/EM26' matured 2 to 3 days before 'D/MR5' and was 2 to 3 degrees hardier in the fall. In the spring 'D/EM26' was about 2 days slower to break bud than 'D/MR5' and was somewhat more hardy (Fig. 2).

'Columbia Crab' displayed the same characteristics in spring and fall as 'Haralson' and 'Delicious' (Fig. 3).

Next, we wanted to compare the unbudded rootstocks themselves for maturity and hardiness. It was found that while 'EM26 and 'MR5' started to lose their foliage about the same time, 'MR5' matured much more rapidly than 'EM26'. 'EM26' was earlier than 'MR5' in forming its terminal buds. This change in maturity is reflected in hardiness comparisons of the two rootstocks. In September, shoot growth of 'EM26' was slightly more hardy than 'MR5', but by Nov. 12 'MR5' was considerably more hardy (3 to 8 degrees difference) than 'EM26' and remained so throughout the winter (Fig. 4).

In the spring 'MR5' was extremely early in breaking bud, being about 12 days earlier than 'EM26'. Spring freezing tests also reflected the difference in ultimate hardiness and earli-

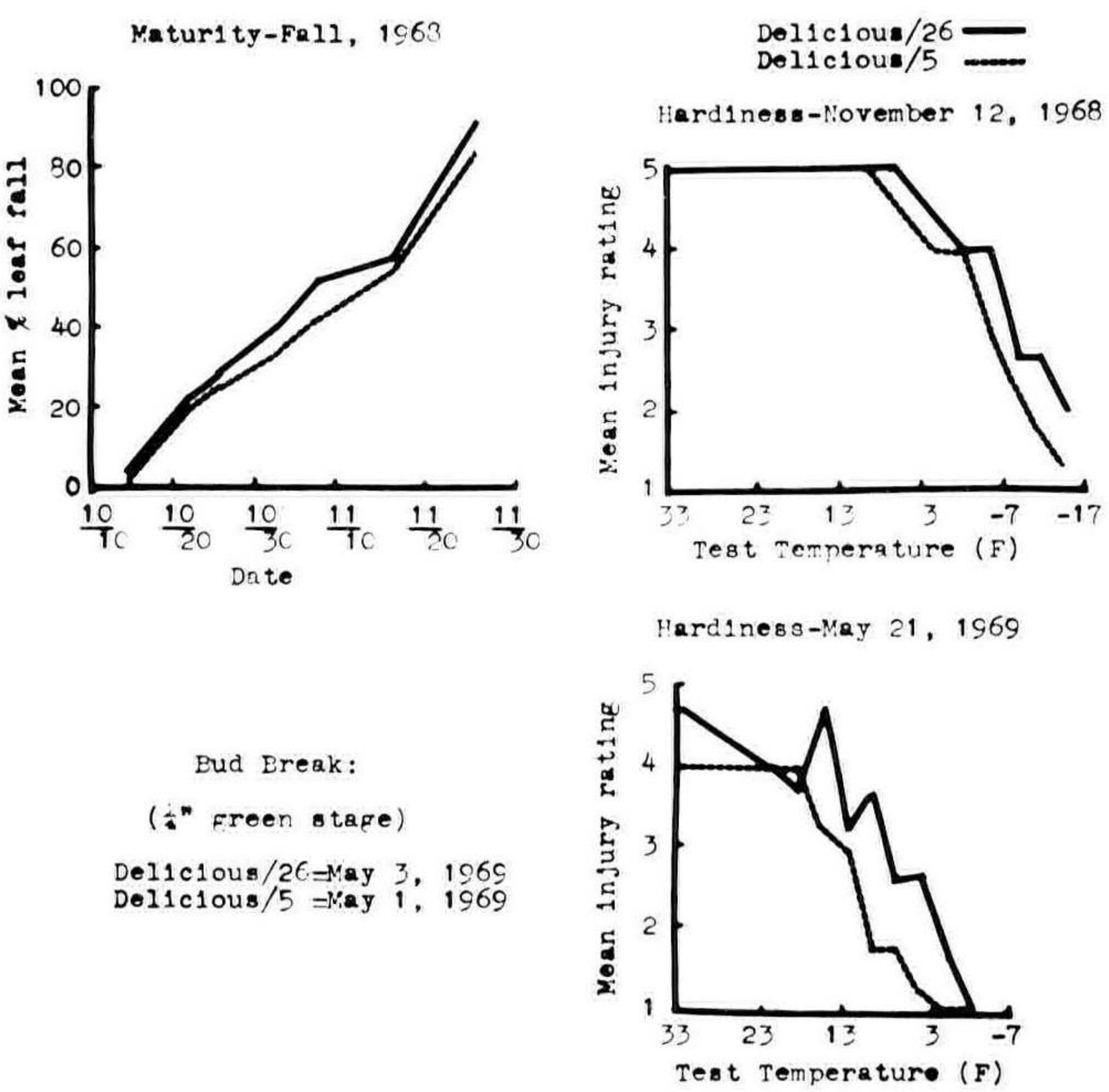
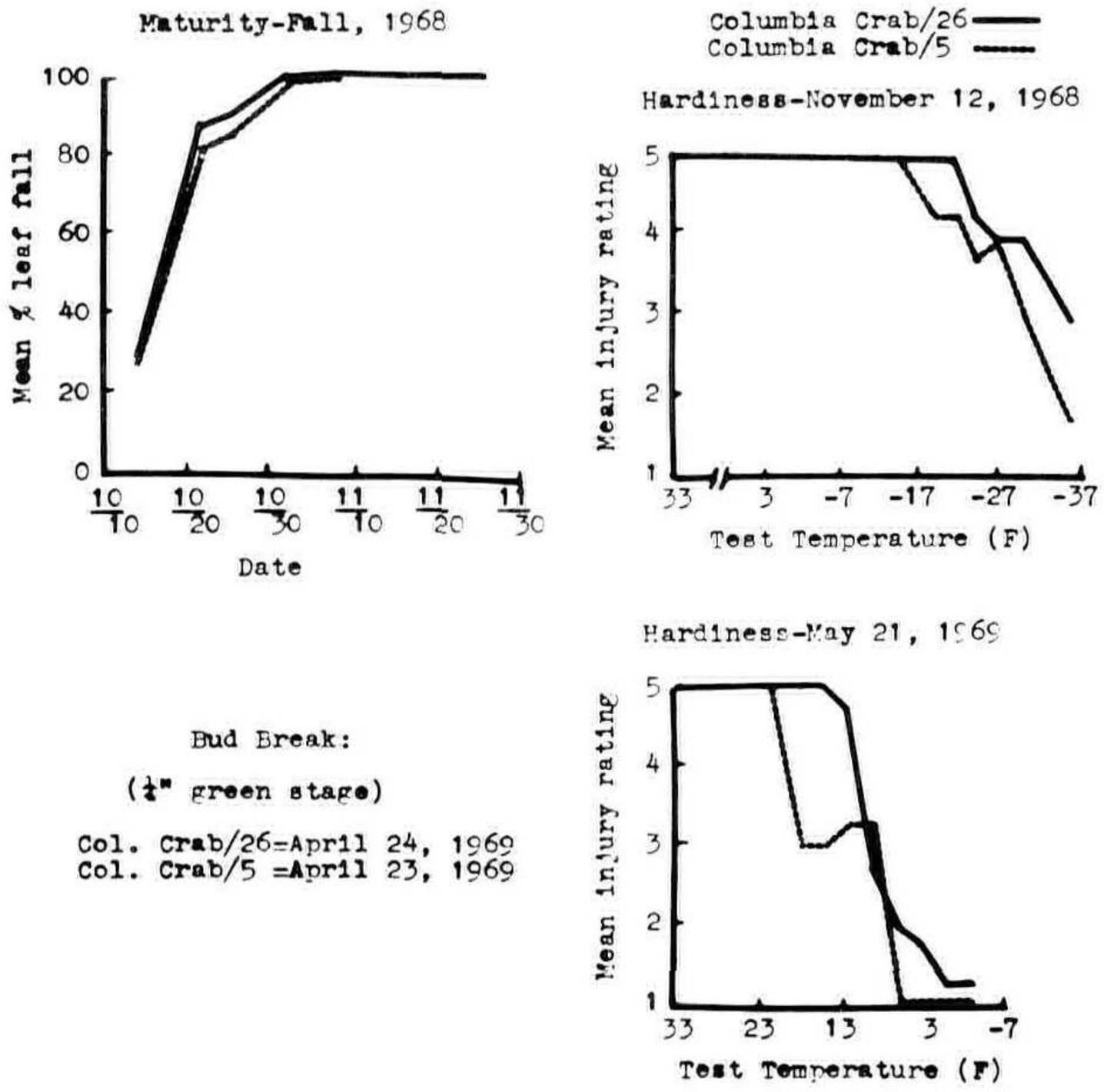


Fig. 2. Comparison of maturity and hardiness with 'Delicious' budded to 'EM 26' and *Malus robusta* '5'.



Bud Break:

(¼" green stage)

Col. Crab/26=April 24, 1969
Col. Crab/5 =April 23, 1969

Fig. 3. Comparison of maturity and hardiness with 'Columbia Crab' budded to 'EM 26 and *Malus robusta* '5'.

ness to break bud. Field damage, as reflected by the 33°F, or check temperature, was greater on 'EM26' than on 'MR5', showing that 'MR5' was better able to withstand winter temperatures than 'EM26'. However, its level of hardiness on May 21 was not as great as 'EM26', reflecting the earlier bud break date of April 21 for 'MR5'.

Comparison of the rootstocks themselves thus shows that while shoot growth of 'MR5' is ultimately much more hardy than 'EM26', 'MR5' matures slightly behind 'EM26' early in the fall and then matures very rapidly later in the fall. This difference is reflected in the hardiness changes of the two rootstocks during the hardening cycle in the fall. Likewise, in the spring 'MR5' breaks bud extremely early and loses its cold resistance much faster than 'EM26'.

In every case, the earlier maturing combination was hardier than the later maturing combination. Likewise in the spring, the combination that remained dormant the longest also remained the most cold resistant. In order to determine if the increased hardiness of the budded combinations was due to the capacity of 'EM26' to mature earlier in the fall and break bud later in the spring, or if 'EM26' imparted some degree of hardiness to the scion varieties budded to it, we compared the hardiness of these varieties in mid-winter on both rootstocks.

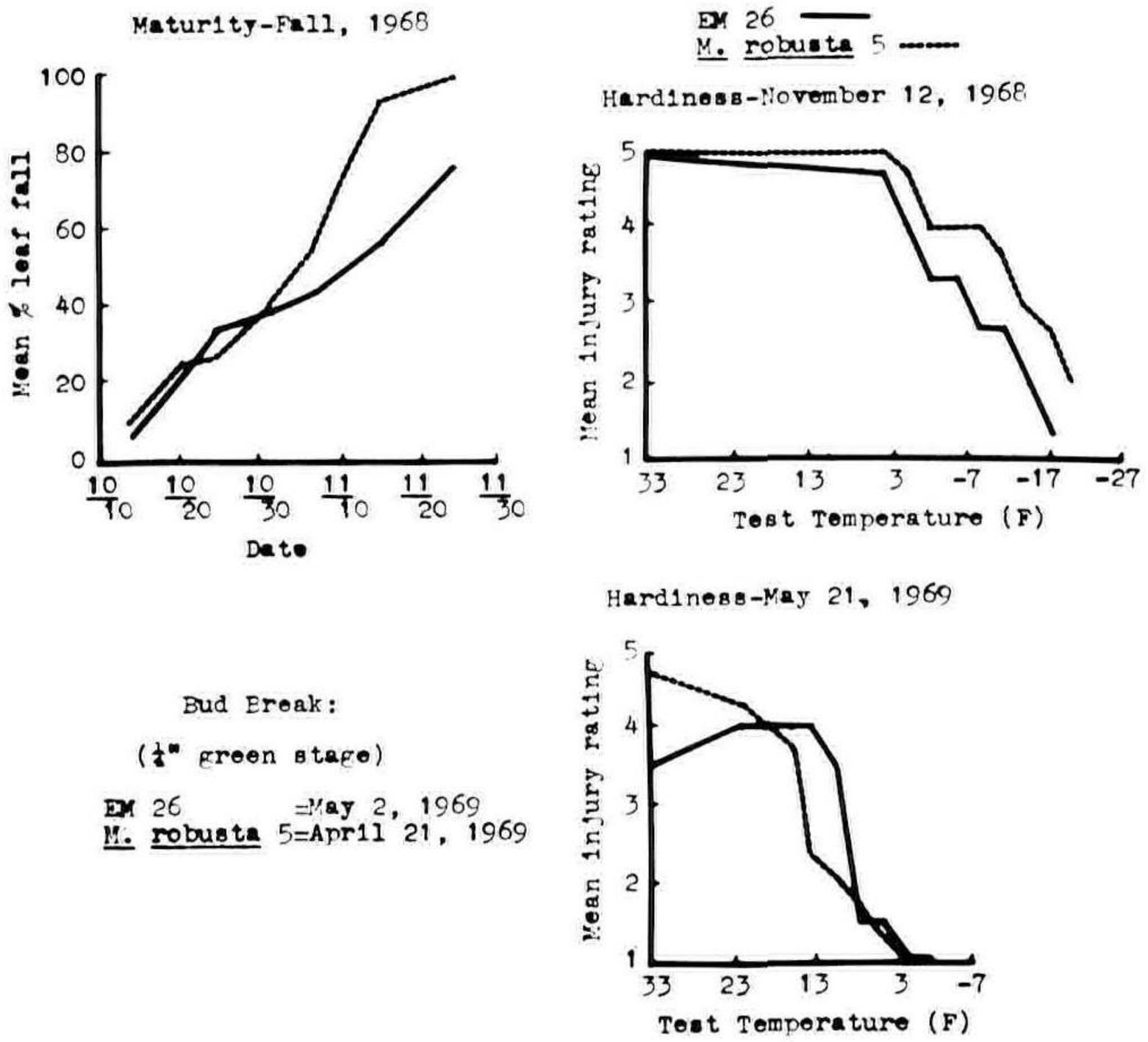


Fig. 4. Comparison of maturity and hardiness of unbudded 'EM 26' and *Malus robusta* '5' rootstocks.

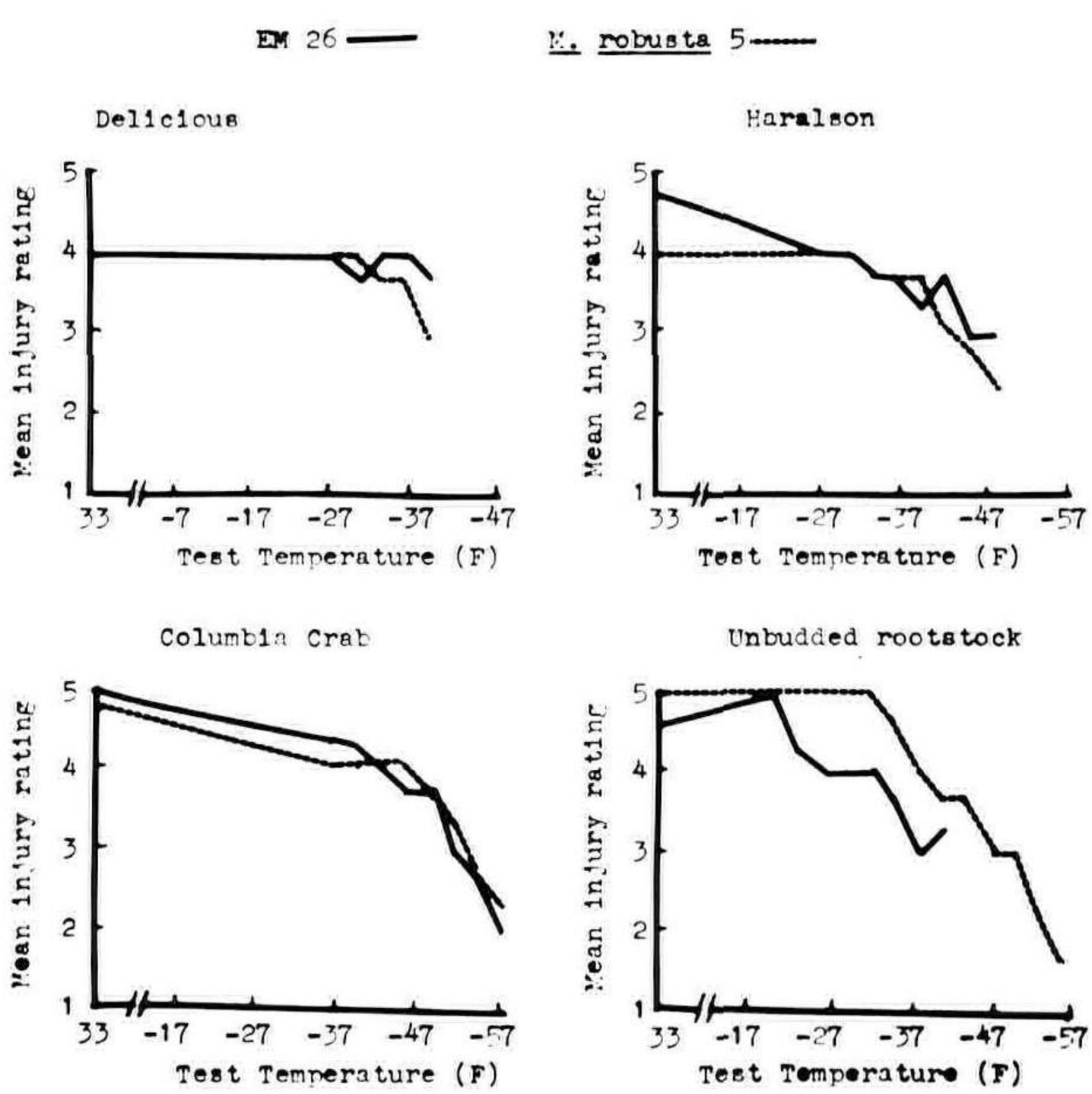


Fig. 5. Comparison of hardiness in mid-winter, 1968, with 'Delicious', 'Haralson', and 'Columbia Crab' budded to 'EM 26' and *Malus robusta* '5'.

In February, 1968, when this material was sampled, the differences in hardiness between the varieties on the two rootstocks was not apparent as it was in the fall and spring (Fig. 5.).

'Delicious', while suffering some field damage, was not killed at -39°F on either rootstock. 'Haralson' also suffered some field damage, slightly more on 'MR5' than on 'EM26', but was not killed at -48°F. 'Columbia' crab reacted the same way. Perhaps if lower test temperatures were used on these varieties, differences in the rootstocks would have become apparent, but for the temperatures tested, there was no difference in the hardiness of the variety on the two rootstocks. As in previous late fall and early winter tests, shoot growth of 'MR5' displayed the capacity to become more cold resistant than 'EM26' and was more hardy than 'EM26' in mid-winter.

Comparison of root hardiness between the two unbudded rootstocks reveals that the root hardiness was about the same at each date of sampling except in December, when 'MR5' was considerably more hardy than 'EM26'. The roots of 'MR5' apparently also have the capacity to harden to a greater degree than 'EM26' roots (Fig. 6).

Thus, while both shoot growth and root growth of 'MR5' have the capacity to become more cold resistant than 'EM26' in mid-winter, varieties budded to 'MR5' were no more hardy than when they are budded to 'EM26'. From this study, it appears that the rootstock can influence the hardiness of the

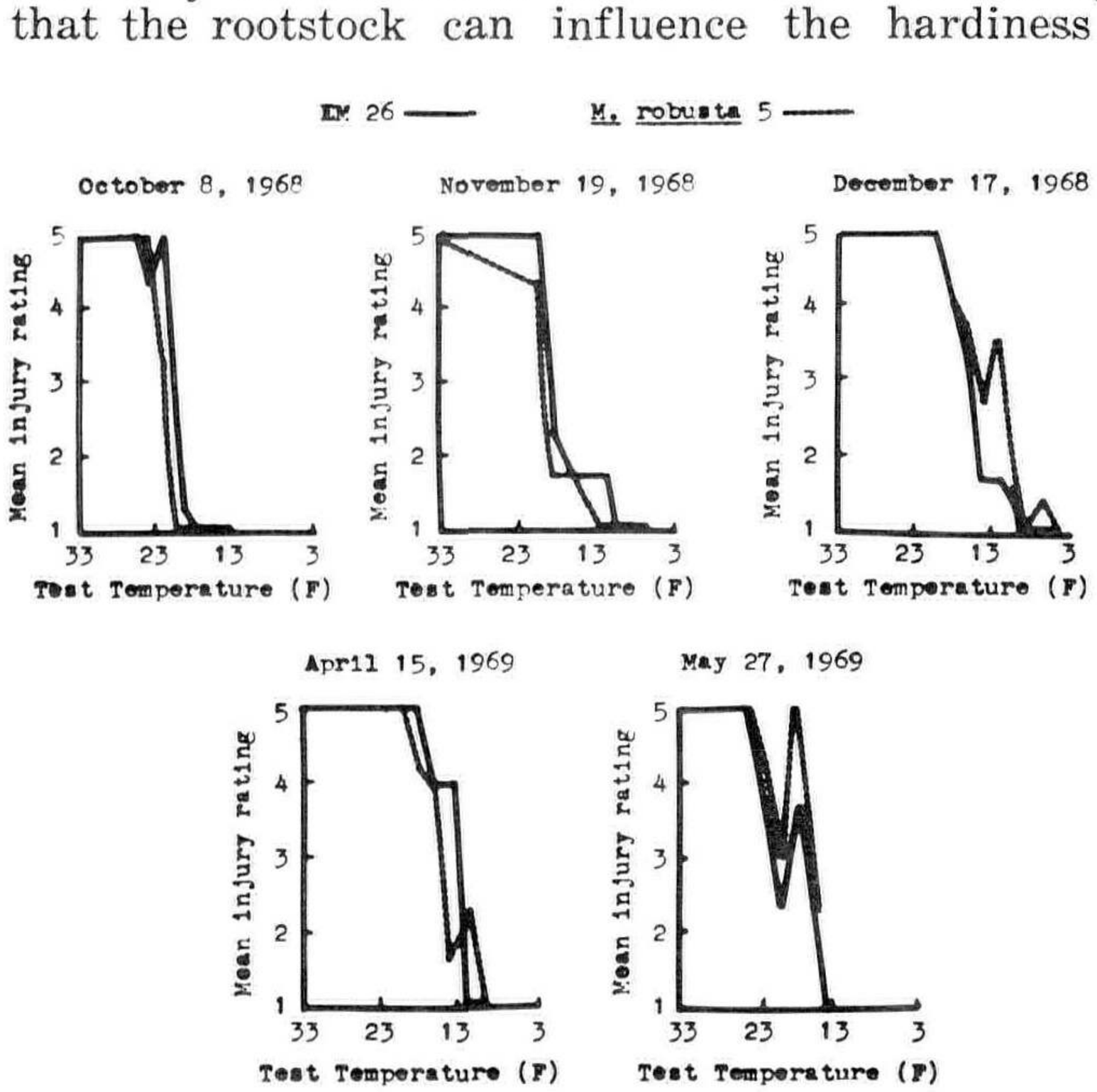


Fig. 6. Comparison of root hardiness in unbudded 'EM 26' and *Malus robusta* '5' rootstocks.

scion variety. Further, it appears the rootstock may exert its effect on scion hardiness by speeding maturity in the fall or by delaying bud break in the spring, as 'EM26' did, rather than by increasing scion hardiness by use of a rootstock which has the inherent capacity to become more cold resistant in mid-winter.

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2. Stuart, N. W. 1940. Cold hardiness of Malling apple rootstock types as determined by freezing tests. *Proc. Amer. Soc. Hort. Sci.* 38:311-314.

MODERATOR PINNEY: Thank you very much, Harold. Are there any questions?

JOHN MCGUIRE: How long were the tissues held at the temperatures you mentioned?

HAROLD PELLET: They were just brought down to the temperature and then they were removed from the freezer. They were not held at this temperature.

CASE HOOGENDOORN: Are the dwarf rootstocks as hardy as your Minnesota seedlings?

HAROLD PELLET: No they are not, but 'EM 26' can be used quite successfully in Minnesota. 'EM 7' and 'EM 9' give us problems unless we mulch.

MODERATOR PINNEY: To continue this afternoon's program, we next have Dr. Elwin Orton who will speak to us on breeding woody ornamental plants.

HYBRIDIZING WOODY ORNAMENTALS

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The development of new and superior cultivars is the primary objective of the breeding program with woody ornamentals at Rutgers University — The State University of New Jersey. For the most part, the improvements sought are increased winter hardiness, increased resistance to insect pests, and improved foliage and fruiting characteristics and, in some cases, decreased plant size. Work is also being devoted to the development of plants that exhibit characteristics quite novel for the plant material in question.

The plant species currently receiving most attention in the breeding program belong to the genera *Ilex* and *Cornus*. The starting point of the breeding project with each species has been the initiation and maintenance of a cultivar performance trials. Such trials are important as they make it possible