The Effects of Shoot Age on Root Formation of Cuttings of *Eucalyptus grandis* W. Hill ex Maiden

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Root formation on cuttings of *Eucalyptus grandis* is influenced by the age of the shoots on the donor plants. Cuttings taken from 8-week-old shoots rooted more frequently and with a larger number of roots per cutting than did cuttings from 16 week old shoots. The difference in rooting patterns is primarily attributed to rapid leaf senescence on the older shoots as shoots which lost more than 75% of the original leaves failed to root. Propagators should avoid using older shoots with leaves that will not remain functional during the first 2 weeks of root initiation. Roots were visible on the younger shoots within 2 weeks of their being set and the number of primary roots had reached a maximum within 4 weeks. Percentage rooting reached a maximum by the 8th week after setting. This time sequence has implications for management of cuttings production in nurseries. It indicates that there is an optimal time to change from a root initiation regime to a root development regime.

INTRODUCTION

Adventitious root formation on cuttings is influenced by the age of the stock plant. The effect of stock plant maturity on rooting of cuttings is widely known. Studies with ivy have shown that cuttings taken from plants with juvenile morphology will root easily but cuttings from plants of flowering age have a much reduced ability to root (Hackett, 1988). Similarly, cuttings from eucalypt seedlings or basal coppice growth root easily whereas shoots taken from the crown of a mature tree will root poorly or not at all (Paton et al., 1981).

Root formation on cuttings of woody plants is also influenced by the age of the shoots of the stock plant. Staff in nurseries cloning eucalypts for forest plantations in the Congo, Brazil, and South Africa collect cuttings when the shoots on the stock plants are approximately 8 to 10 weeks old (Chaperon and Quillet, 1977; Adendorff and Schon, 1991). Although this technique is common, there is little published evidence of the responsiveness of rooting to differences in shoot age. Part of the trial reported here investigated the impact of shoot age on rooting cuttings of *Eucalyptus grandis*.

Movement of cuttings from a misting to a watering and fertilizing environment should be done once primary root initiation is complete. To assist in defining the time of this event, our studies closely monitored root development.

MATERIALS AND METHODS

The experiment was conducted in the spring of 1989 at the Plant Culture Facility, the Australian National University, Canberra. Stock plants were of a single clone of *E. grandis* and in the two years since their establishment as rooted cuttings they had been hedged at regular intervals to encourage multiple shoot formation on a central stem 30 cm high. They were grown in containers in a glasshouse with an air temperature maintained at 25°C day and 15°C night and received natural light and photoperiod.

Forty stock plants were used. The age of the shoots taken for use as cuttings was organized by firstly removing all shoots except one which remained as a lateral feeder shoot. As soon as axillary shoots had developed on the main stem the feeder shoot was removed. All the cuttings were taken at the one time from plants which had been hedged either 8 or 16 weeks previously. Twenty stock plants were hedged for each treatment.

The cuttings were prepared as four-node cuttings. On each cutting the two basal leaf pairs were removed, while the upper pairs had the leaf area reduced by 50%. The base of each cutting was treated with IBA (80 mg/liter in ethanol) for 10 seconds and then allowed to dry. Cuttings were inserted into Kwik pot trays with 42 cells, each of 70 ml and filled with a medium containing 1 peat, 1 perlite, and 1 sand (by volume). Four hundred and forty cuttings were arranged in pairs, each consisting of an 8- and a 16-week-old shoot. There were thus 220 pairs randomly set throughout a single block of trays.

The trays of cuttings were placed in the propagation facility under a misting system which operated for 5 sec every 5 min. Air temperature was in the range 20 to 30°C and the trays were set on a sand bed heated to 20°C.

Each week for 9 weeks and in the 11th and 13th week, 20 pairs of cuttings were selected at random, harvested, and the following features recorded: (1) the number of primary roots, (2) the dry weight of the root mass, (3) the number of original leaves retained, and (4) whether the cutting was alive or dead. A dead cutting was defined as showing no green pigmentation in the stem or leaves.

RESULTS

There were differences between the shoot types in the number of cuttings with roots, the number of primary roots produced, the weight of the roots, the retention of leaves and death of the cuttings.

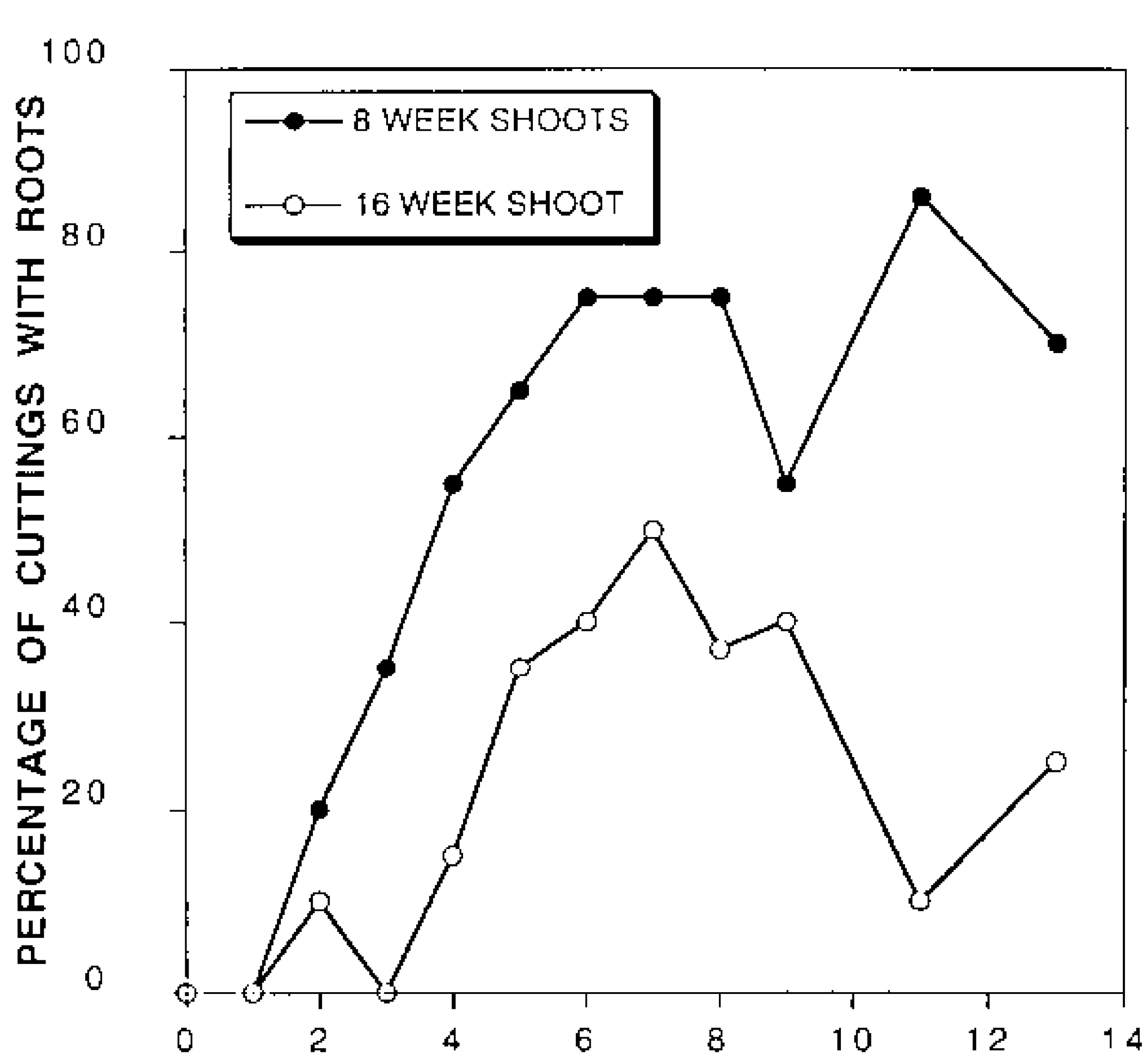

Figure 1. The percentage of cuttings to form roots.

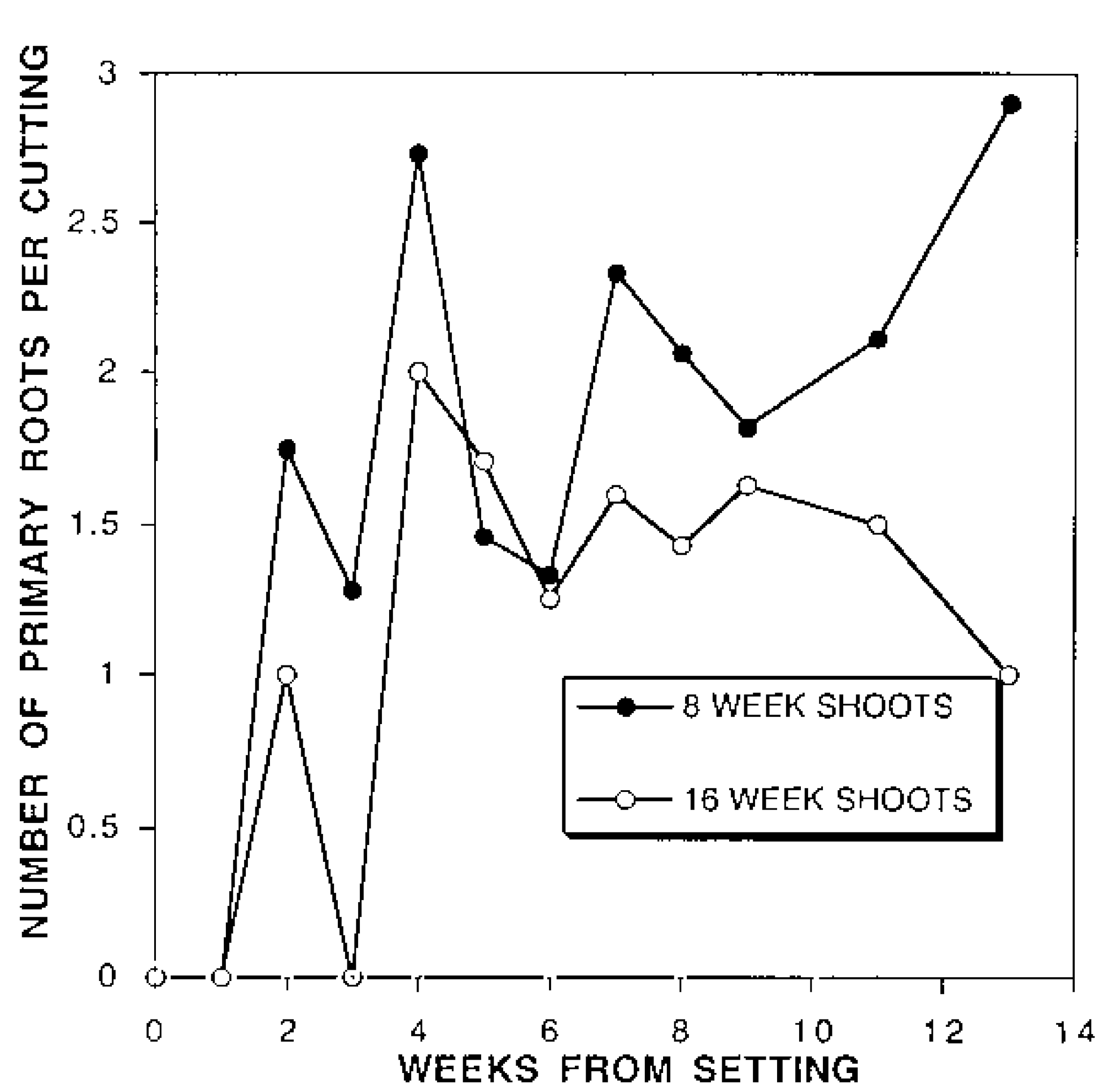

Figure 2. The number of primary roots per cutting.

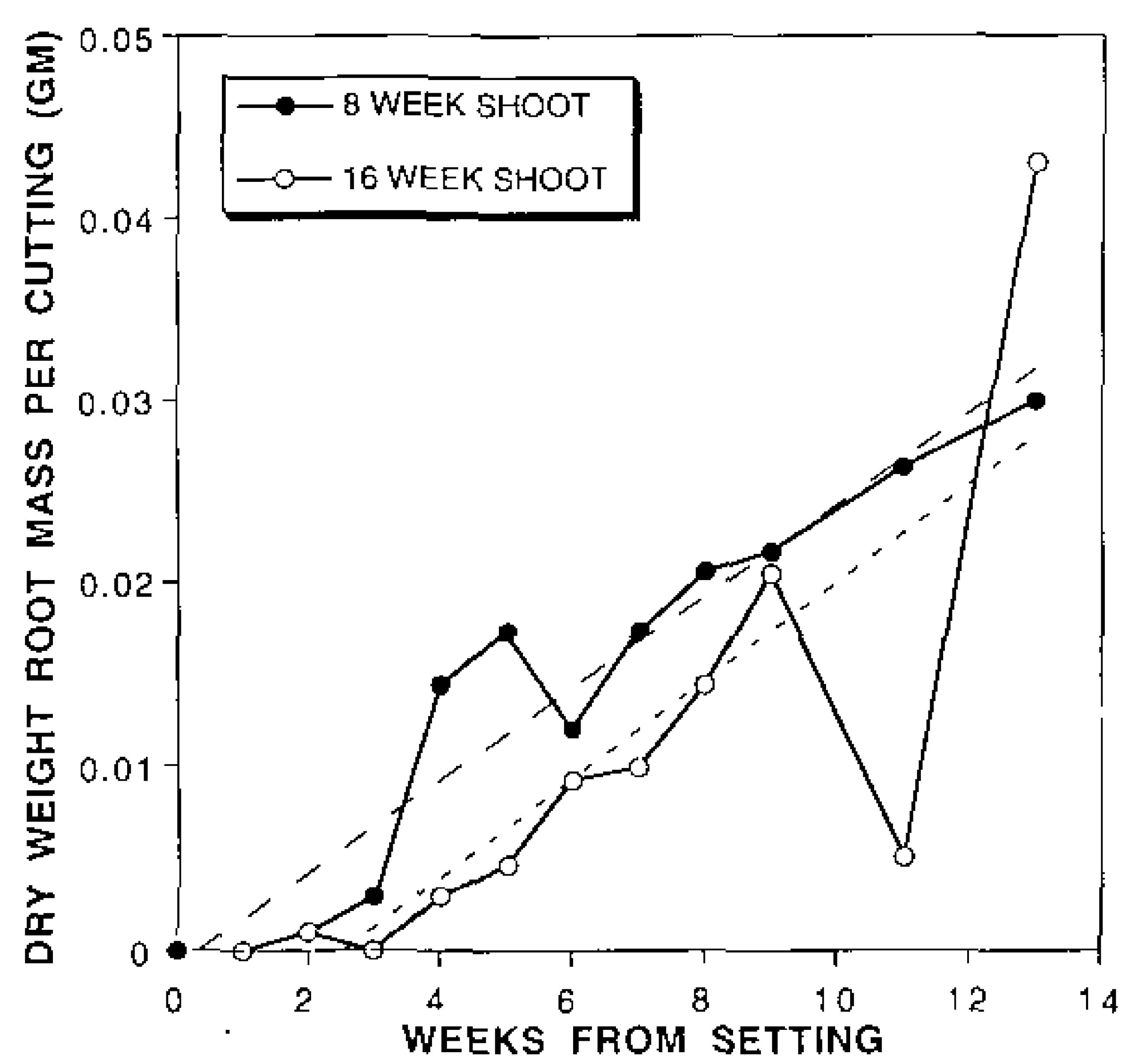

Figure 3. The dry weight root mass per cutting.

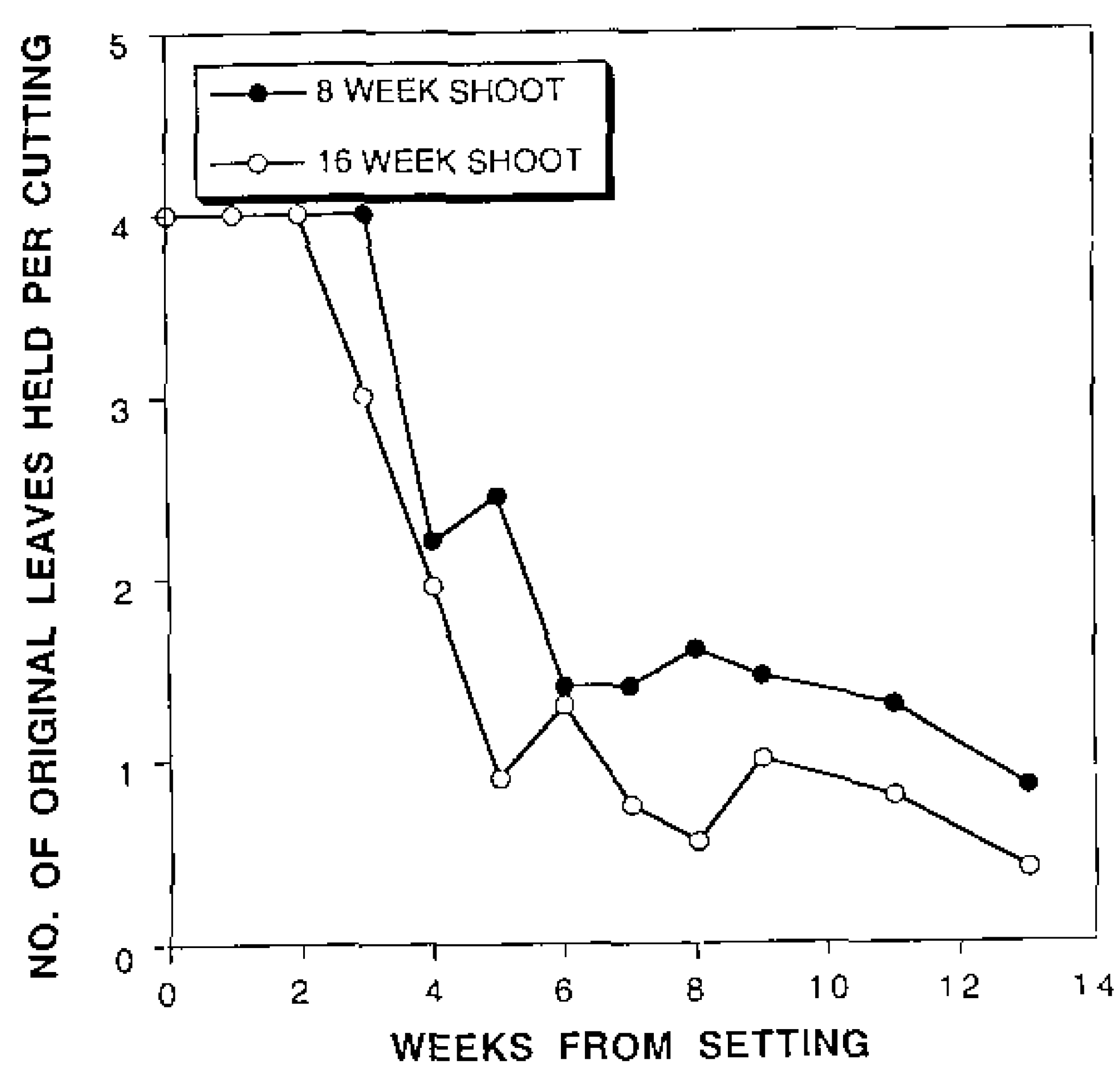

Figure 4. The number of leaves retained on each cutting.

The number of harvested cuttings with roots increased until week seven (Fig. 1). At that time 75% of the 8-week shoots had rooted but only 50% of the 16-week shoots had done so.

Primary roots were visible by the 2nd week after setting and they continued to increase in number per cutting until the 4th week (Fig. 2). After that time no new primary roots formed and root development continued as secondary roots.

The number of primary roots was greater on the 8-week shoots than on the 16-week shoots; the respective means at the 4th week were 2.7 and 2.0 (Fig. 2). Also, the root mass on the younger shoots was almost five times that of the older, suggesting that roots on the younger stems have been initiated earlier (Fig. 3).

Leaf abscission was more rapid on the cuttings from the older shoots (Fig. 4). These showed yellowing of leaves by week 2 and had retained only one of the original four leaves by week 5. The cuttings from the younger shoots also lost leaves but always retained more than did the older shoots. This leaf drop was due to senescence, as the leaves turned yellow and abscised.

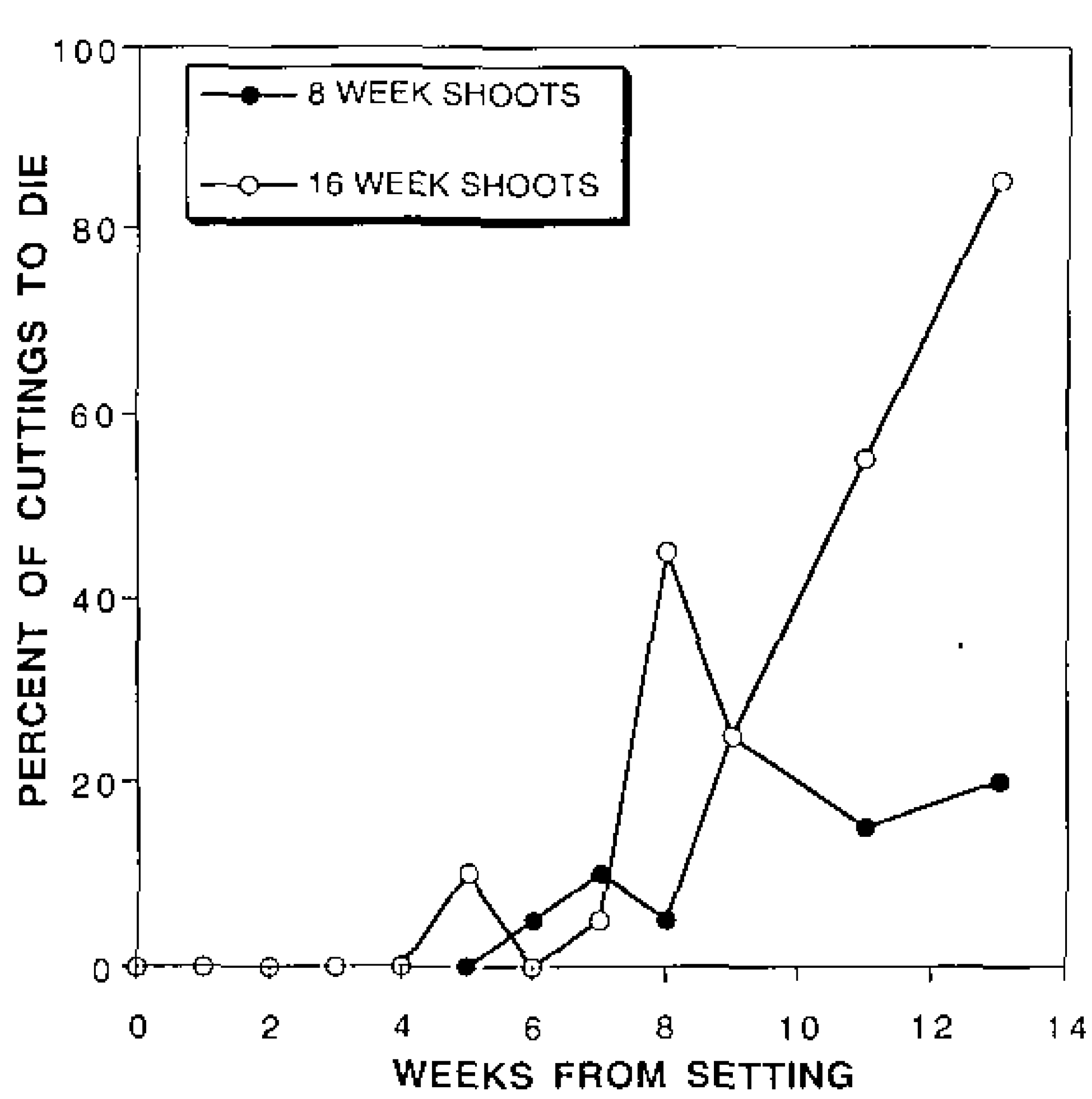

Figure 5. Percentage of cuttings to die.

The cuttings taken from 16-week shoots showed a higher mortality than their 8-week counterparts (Fig. 5). Cuttings of both groups had begun to die within 6 weeks from setting, and at week eight, 5% of the 8-week shoots and 50% of the 16-week shoots had died. At the time of the final observation, 13 weeks from setting, 20% of cuttings from 8 week shoots, and 80 % of the 16 week shoots were dead. The cuttings that died were leafless and over 90% did not have roots.

DISCUSSION

Cuttings from 16-week-old shoots showed a reduced ability to form adventitious roots compared to those from 8-week-old shoots. The older shoots produced fewer successful cuttings and those that were produced had fewer and smaller roots than those from the younger shoots. The cuttings from the older shoots also lost their leaves more rapidly than did those from the younger shoots.

Reasons for the reduced rooting behavior may include differences in shoot morphology and physiology. Haissig (1974) suggested that for some woody species, older stems with more differentiated tissues contain fewer root initiation sites. They may also have bands of sclerenchymatous tissue which act as a barrier to root primordia emergence (Williams et al., 1984). Also, they can have strongly suberized epidermal tissues and this may make the shoots less responsive to exogenous applications of auxin (Maynard and Bassuk, 1988). Younger shoots have less pigmentation and more succulent stems, features which are also characteristic of etiolated shoots of *E. grandis*, shown to be more responsive to adventitious root formation than non-etiolated shoots (Carter and Slee, 1991).

Shoot physiology is important in the rooting process. Variations in the absolute amount and ratio of carbohydrate and nitrogen pools in the leaf and stem tissues influence root formation (Haissig, 1986). Root promoters, inhibitors, and cofactors also vary with leaf age and undoubtedly a part of the response in our trials was due to those variations.

The differences in the rate of leaf senescence may explain the different rooting behavior of the 8- and 16-week-old shoots. Bachelard and Stowe (1963) reported that *E.camaldulensis* cuttings without leaves did not root and Geary and Harding (1984) also working with *E. camaldulensis* demonstrated that removal of more than 75% of the leaves from 4-leaf cuttings reduced rooting of these cuttings. In our trials it is possible that cuttings that had not developed root initials in the short period when leaves were fully functional were unable to do so after commencement of leaf senescence. This suggests that for optimal rooting response, shoot age must be such that the cutting will have leaves that are fully functional and will remain so for the duration of the propagation phase. Furthermore even basal segments of young shoots should be avoided if leaves are likely to senesce. Our trial has confirmed nursery practices for cutting propagation of *E. grandis* in Brazil and South Africa where 8-week-old shoots rather than older are used as cuttings.

The study has also provided guidelines for the schedule of operations. Primary root formation and emergence were completed within 4 weeks from setting the younger shoots. Therefore, cuttings at that time can be moved from an environment favoring root initiation to one encouraging root growth. High frequency misting could be replaced by a watering programme and fertilizer applied via the irrigation system.

By the 8th week from setting the cuttings, the propagation phase can be considered complete as potentially rootable cuttings have done so. After this time the rooted cuttings can be moved fully into the growing-on phase. These recommendations are in accordance with nursery practices observed by us in South Africa.

The results also provide practical guidelines for the assessment of rooting of cuttings of species with a pattern of adventitious root formation similar to *E. grandis*. Selection of species and clones for their rooting capacity as cuttings is based on criteria such as percent rooting, root numbers, and root mass. In the trial reported here, the first two of these criteria were fully expressed within 6 to 8 weeks of setting the cuttings, suggesting that assessment of rooting patterns can be carried out with accuracy at that time.

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