shoots per root cutting. If these shoots are removed and treated as stem cuttings, they will also root satisfactorily.

If the tree trunks were pruned during the previous season, the short shoots which arise around these wounds will also root well. Apparently comparable short shoots taken from the main mass of the tree at the same time and placed in the same conditions will not root in reasonable percentages.

The author wishes to acknowledge the helpful advice of fellow-member Mr. Ralph Crawford concerning the propagation of the Christine Buisman elm.

MODERATOR JIM WELLS: Thank you very much, Dick. I would next like to call on Mr. James Kelley to discuss nutrition.

ROLE OF STOCK PLANT NUTRITION ON ROOTING RESPONSE OF CUTTINGS

JAMES D. KELLEY
Department of Horticulture
University of Kentucky
Lexington, Kentucky

As we have just heard, many factors influence the rooting response of cuttings. Today, considerable evidence indicates that the nutrition of the stock plants exerts a strong influence on root initiation and development. This is particularly true in the case of nitrogen, and more recent findings indicate that zinc and boron also may play a role in rooting.

Kraus and Kraybill (8) as early as 1918 demonstrated the effect of the carbohydrate-nitrogen ratio on rooting of tomatoes. Cuttings high in carbohydrates but low in nitrogen produced many roots but weak shoots, whereas those high in carbohydrates and higher in nitrogen produced fewer roots but stronger shoots. Cuttings made from succulent stems, very low in carbohydrates but high in nitrogen, all decayed without producing shoots or roots. Subsequent experiments by others have shown that a high ratio of carbohydrates to nitrogen favor rooting (3, 13, 15) in tomatoes and grapes.

Winkler (19) showed that grape cuttings highest in starch rooted better than cuttings with a low starch content. More recent work (1, 4, 9) has re-emphasized the importance of a favorable carbohydrate-nitrogen balance using geraniums, azaleas, and roses as examples.

This favorable carbohydrate-nitrogen ratio in a cutting is regulated primarily by two things: 1) the amount of nitrogen applied to the plant, and 2) the stage of development of the current season's growth.

The commercial propagator achieves this condition by 1) reducing the nitrogen supply to the stock plant in order to allow carbohydrate accumulation, 2) allowing plants to have full sunlight in order that photosynthesis may be maximum, 3) by withholding water, and 4) by a combination of the above.

Stems low in carbohydrates and high in nitrogen content are soft and flexible whereas those high in carbohydrates are firm and stiff. This is related back to time of taking the cutting. Knight (7) noted that firm cuttings which had ceased growth were much superior to actively growing shoots and attributed better rooting to a higher carbohydrate content.

The effect of zinc and boron on root initiation has also been studied. Samish (12) found that the tryptophan content of grape cuttings increased after fertilization with zinc, and he has suggested that increased auxin production from accumulated tryptophan may explain the beneficial effects of zinc applications since zinc is required for tryptophan production which in turn is required for the production of IAA. Tackett (17) showed that chrysanthemum cuttings containing less than 35 parts per million boron did not root as well as cutting containing greater amounts of boron. To date, little information is available concerning the effect of trace elements on rooting, but the effect of nitrogen on root initiation and root growth cannot be overlooked.

Even though we are well aware of the importance of the carbohydrate-nitrogen ratio, a quantitative measure of its relationship to rooting has not been worked out. In other words, the optimum ratio for maximum rooting is unknown. Researchers have shown limited interest in this area and, until they do, we will all continue to take cutting based on firmness of stems which is believed to be associated with a desirable carbohydrate-nitrogen ratio.

LITERATURE CITED

1. Brandon, R. 1939. Seasonal variations in the starch content of the genus *Rosa* and their relation to propagation by stem cuttings Jour. of Pom. and Hort Sci 14 233-253
2. Dhillon, B. S 1963 Influence of stock plants treated with various levels of nitrogen in combination with day-length on rooting of black currant stem cuttings Indian J Hort 20:34-37.
3. Garner, R J. 1944 Propagation by cuttings and layers Recent work and its application, with special reference to pome and stone fruits Imperial Bur Hort and Plantation Crops. Tech Commun 14, 80p
4. Haun, J R and P W. Cornell 1951. Rooting response of geranium (*Pelargonium hortorum*, Bailey var. Ricard) cuttings as influenced by nitrogen, phosphorus, and potassium nutrition of the stock plant. Proc Amer Soc Hort Sci 58:317-232
5. Hemberg, T 1951 Rooting experiments with hypocotyls of *Phaseolus vulgaris L.* Physiologia Plantarum 4:358-369
6. Kelley, J D. Unpublished data
7. Knight, R C 1926 The propagation of fruit stocks by stem cuttings J. Pomol 5 248-266
8. Kraus, E. J and H R Kraybill 1918 Vegetation and reproduction with special reference to the tomato. Ore. Agr Exp Sta Bul 149
9. Preston, W. H , J B Shanks, and P. W. Cornell 1953 Influence of mineral nutrition on production, rooting, and survival of cuttings of azaleas Proc Amer Soc. Hort Sci 61 499-507.
10. Richl, G 1952 Manured mother-plants do not always produce excessively well-fed cuttings Zierpflanzenbau 2.143
11. Pearse, H L 1943 The effect of nutrition and phytohormones on the rooting of vine cuttings. Ann Bot, N S 7·123-32.
12. Samish, R M. and P Spiegel 1958 The influence of the nutrition of the mother vine on the rooting of cuttings. Ktavim 8.93-100

13. Schrader, A. L. 1924. The relation of chemical composition to the regeneration of roots and tops in tomato cuttings. Proc Amer. Soc. Hort. Sci. 21:187-94.
14. Sen, P. K. and R. N. Basu 1960. Effect of growth substances on root formation in cuttings of *Justicia gendarussa* L. as influenced by varying levels of nitrogen nutrition of stock plants. Indian J. Plant Physiol. 3:72-83.
15. Starring, C. C. 1924. Influence of carbohydrate-nitrate content of cuttings upon the production of roots. Proc. Amer. Soc. Hort. Sci. 20:288-292.
16 Suntarasing, Charat. 1950. Rooting response of California Privet (*Ligustrum ovalifolium* Hassk.) cuttings as influenced by nutrition and nutrition-indolebutyric acid interaction. Unpublished Master of Science thesis. Univ. of Md.
17. Tackett, A 1962. Effect of the initial boron content of *Chrysanthemum morifolium* 'Yellow Delaware' and the interaction between boon and 3indoleacetic acid on the initiation of adventitious roots. Unpublished Master's thesis, Univ. of Kentucky.
18. Weiser, C. J. and L. T. Blaney. 1960. The effects of boron on the rooting of English holly cuttings. Proc. Amer. Soc. Hort. Sci. 75:704-710.
19. Winkler, A. J. 1927. Some factors influencing the rooting of vine cuttings. Hilgardia 2:329-349

MODERATOR JAMES WELLS: It's a wonder someone hasn't borne down on this problem yet. It is a wide open field for someone. The last and by no means the least, but in my opinion the most difficult subject for our panel to cope with, is weather. And Al Fordham of the Arnold Arboretum is going to do that.

WEATHER AS IT CONCERNS THE PRACTICE OF CUTTING SELECTION

ALFRED J. FORDHAM
Arnold Arboretum of Harvard University
Jamaica Plain, Massachusetts

Although the literature abounds with information regarding cuttings, few references are directly concerned with the relationship of weather to cutting selection and these are usually generalized or sketchy. Weather and the seasons, or timing, are difficult to separate in this context and many of the references give approximate dates with qualifying remarks such as, "depending on the season", or, "varying with the weather".

Two references dealing with the collection of lilac cuttings recommend that cutting wood be taken when the blooms first begin to open (1), and just as the terminal buds are formed (2). The dependence of these development stages upon the weather is shown by the lilac flowering dates at the Arnold Arboretum which reveal that propagators in the Boston area, using these stages as guides, would find variance up to three weeks in different years depending on the weather.

Bos (3) observed that warm days in early spring led to a start in growth on his stock plants of *Philadelphus coronarius aureus* which were later damaged by periods of cold rain or light frost. Cuttings made after this damage led to a 50% propagational loss no matter how carefully they were handled. He recommended that such stock plants be protected.

Zorg (4) in discussing Juniper cuttings pointed out the difficulty of selecting the time when cuttings were in proper condition. It was self-evident that weather had a great influ-