RED ROOT OF CHRYSANTHEMUM CUTTINGS RESULTING FROM UNFAVORABLE SODIUM: CALCIUM RATIOS

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Red root, a disease of chrysanthemum cuttings, first appeared at a nursery following the change of water supply from a well about 400 feet deep to a well about 800 feet deep. A comparison of analyses of water from the two wells is given in the following table:

Test for	Old Well	New Well
pH (Saturation paste)	7.2	8.1
Electrical conductivity (millimhos/cm)	2.02	0.60
Ca + Mg (meq/liter)	13.8*	1.2*
Na (meq/liter)	5.0	4.3
Co_3 + HCO_3 (meq./liter)	1.2	4.2

*approximately half Ca, half Mg

The symptoms of the disease appeared first as a loss of root hairs and small rootlets, followed by a slight reddening of portions of the roots. As severity increased, the redding became more intense and the tips beyond the reddened areas died. Additional roots were produced which in turn became deep red to brown and failed to elongate. On severely injured cuttings, only a tuft of short reddish-brown roots was produced. Affected cuttings failed to elongate but other than that, there were no above-ground symptoms.

No causal organism could be detected by culturing or with a microscope so experiments were started in cooperation with Dr. James Vlamis of the Soils and Plants Nutrition Department at Berkeley to see if the cause could be determined. Various salts were added to rooting media of different types and red root was found to appear whenever certain sodium salts and peat were used together.

Further experiments showed that in addition to sodium, potassium also caused the disease but it was not as severe as sodium when compared on a millequivalent basis. It was found that only the bases or basic salts of sodium and potassium such as the carbonates and bicarbonates caused red root while the nitrates, phosphates and chlorides did not cause the disease.

The injury of the cuttings with sodium and potassium hydroxides, carbonates or bicarbonates was found to be related to the sodium:calcium or potassium:calcium ratios in the rooting media. Determination of the amounts of sodium, potassium and calcium in the rooting media showed that as the

concentrations of hydroxides, carbonates and bicarbonates increased, the ratios of sodium:calcium and potassium:calcium also increased. With this there was an increase in disease severity. The sodium and potassium:calcium ratios changed very little with an increase in the phosphates, nitrates or chlorides and with this there was no or only a slight increase in the disease severity.

The increase in severity with the hydroxides, carbonates or bicarbonates is explained by their reaction with the peat portion of the rooting medium. When added, the sodium or potassium exchanged with the hydrogen on the peat. These reactions went to completion, the end products being water or carbonic acid which disappeared by leaching or volatization, thus allowing the sodium or potassium to accumulate. With the addition of nitrates, phosphates and chlorides, the reactions did not go to completion but only as far as the equilibrium constants allowed. Because of the drainage, many of these salts were then leached from the medium and the sodium or potassium did not accumulate.

The appearance of the disease following the changing of wells also can be explained by the sodium:calcium ratio. In the old well, the ratio was 5.0:6.9, whereas in the new well, the ratio was 4.3:06. Although there was more sodium in the old well than in the new well, the calcium-magnesium level in the old well was very high, resulting in a low sodium:calcium ratio.

The addition of calcium to the rooting medium increased the number of roots produced, even when added with high levels of sodium or potassium. This is explained in that calcium is higher than either sodium or potassium in the lyotropic series and thus a higher percentage of calcium was absorbed or exchanged on to the peat. As a result, the sodium or potassium was not adsorbed and was leached from the medium. Calcium is known to favor root growth and hence where it was used, better root systems were produced.

Because of the effect of calcium, it was added either as lime or gypsum and was found to correct the disease in the nursery when used at the rate of 2 tons per acre. Gypsum has been the cheaper of the two so it has been used at regular intervals and red root has no longer been a problem.

MODERATOR LEISER: Thank you Bob. Our next speaker is Dr. Jack Paul of the Department of Environmental Horticulture on the Davis Campus. Jack is a soil chemist with a sound training in basic soil problems. This training gives him the background to solve many of our problems in the nursery industry. Dr. Paul.