served in all parakeets that bear these tumors and has not been found in parakeets with other primary and transplanted tumors such as fibrosarcoma and methylcholanthrene-induced carcinoma nor has the increased protein associated with an elevated serum calcium such as has been described in estrogen-treated roosters been found (*5*).

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18 February 1957

Citrus Fruit Grafting

The grafting of a citrus fruit from one plant to another has not been reported previously, as far as I am aware. This technique should be useful in studying many problems, particularly when fruits are desired on small plants. A technique previously described (*1*) in which cuttings with fruits attached were rooted and used for experimental purposes has many useful applications but does not provide the flexibility offered by grafted plants.

For example, by employing the grafting technique, it is possible to study the influence of leaves on fruit development and composition by producing various combinations of leaves and fruits. Nitsch (*2*) suggested that organic acids are probably produced in the leaves and translocated to the fruits. On the other hand, Sinclair and Eny (*3*) and Sekhara Varma and Ramakrishnan (*4*) suggested that the large amounts of organic acids in lemon pulp are not translocated from the leaves but formed from the sugars in the juice vesicles. By grafting a sweet lemon fruit on a sour lemon plant, it was thought that information about the accumulation of organic acids in lemons might be obtained. The results of preliminary experiments of this type using sweet and sour lemons, both of which belong to the species *Citrus limon* (Linn.) Burmann (*5*), are presented here.

The Faris sweet lemon, used in these experiments, is distinguishable from sour forms in the bland, insipid taste of the juice, which has less than 1 percent acid in tree-ripened fruit in contrast with 4½ to 6 percent acid in the Ross Eureka, a commercial variety. On 25 May 1956, eight immature Faris sweet lemons were successfully grafted on Ross Eureka lemon plants growing in the greenhouse in number 10 cans. The fruits were picked and juiced when mature, between 20 July and 6 December. For comparison, Ross Eureka lemons that had been similarly grafted on 4 May were used. Vegetative branches appearing on the scions about 3 weeks after grafting (Fig. 1) were removed from half of the plants.

Analyses were made of the juice from the fruits for percentage titratable acid, *p*H, total soluble solids (refractometric reading), and sugars. The sweet lemon fruits grafted on sour lemon plants generally remained low in acid content. However, on those plants which had leaves from the sweet lemon scion in addition to leaves on the sour lemon stock, the acid content of the fruit (1.31 percent) was somewhat greater than it was on plants from which scion sprouts had been removed (0.32 percent). Whether this difference in acid content was in response to the combination of foliage, improved graft union, or some other cause remains to be determined.

Concurrently, another experiment was started in which Ross Eureka lemon plants were grafted with either Faris sweet lemon scions or Ross Eureka scions. When the vegetative shoots were about 2 to 4 feet long, sweet or sour lemon fruits were grafted on the tops in four combinations. All scion sprouts were removed as they appeared so that a single source of foliage existed on each plant. The fruits were grafted on 3 August, 1956, and on 10 September when the first fruits became yellow, one fruit of each of the four combinations was picked. At approximately monthly intervals, the remaining fruits matured and were picked, so that on 6 December the last set of four fruits was removed from the plants.

Results of analyses of the fruits showed that all the sweet lemon fruits remained low in acid concentration whether they were nourished by leaves of sour (0.52 percent acid) or sweet (0.44 percent acid) lemon plants. Also, the sour lemons remained high in acid concentration whether they were nourished by leaves of sweet (5.18 percent acid) or sour (5.18 percent acid) lemon plants. Aside from the characteristic of a lower acid concentration, the sweet lemons had a much higher reducing sugar concentration (5.17 percent) than did the sour lemons (1.45 percent).

The total soluble solids in the two types of fruits were about the same. After the acid and sugars had been subtracted from the total soluble solids only one or two percent soluble solids remained undetermined. The difference in undetermined soluble solids between

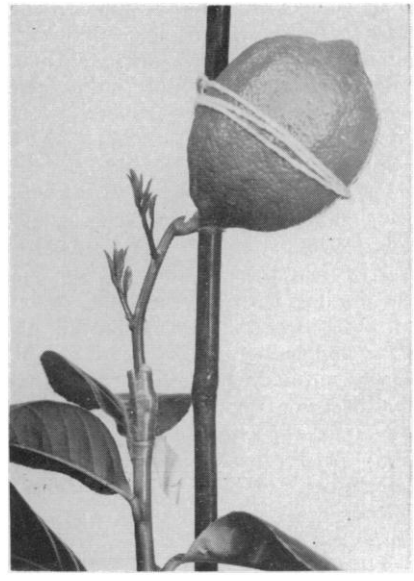

Fig. 1. Lemon fruit grafted 4 May 1956, photographed 29 May. Sprouts on the scion indicate successful graft union. Fruit was 51.4 mm in diameter when grafted and 65.2 mm when mature on 11 December; the calculated increase in volume is 63 percent.

sweet and sour fruits was only a fraction of the difference in acid concentration, thus indicating that acid was lacking in the sweet fruit rather than that it was present in a nontitratable salt form.

The failure of a sweet lemon, such as the Faris, to accumulate high concentrations of organic acids, when grafted on a sour lemon plant, such as the Ross Eureka, indicates that the high concentration of organic acids in a lemon is more complex than that which would result merely from the translocation of acid from leaves to fruit and accumulation in the latter site.

Further studies are required to determine to what extent leaves can modify fruit composition. By using the technique of grafting fruits, it will be possible to extend the study and to employ orange, grapefruit, and other foliage to produce lemons and other citrus fruits.

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