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Taxonomy and Nomenclature in Citrus

MANY HORTICULTURISTS are inclined to question the utility of knowledge concerning the botanical classification of the plants with which their studies or work are concerned, and for those engaged in certain fields of horticultural research this attitude may have some justification. On the other hand, such knowledge is almost indispensable to the breeder and finds important applications in certain other fields. An illustration is afforded by the problem of rootstock-scion relations in general and graft compatibility and virus reactions in particular. In both of these cases, knowledge of natural relationships, as reflected in botanical classification, provides a basis for both understanding and predicting rootstock-scion relations and virus reactions.

Indeed the tristeza virus rootstock-scion reactions so extensively reported by virologists and horticulturists in recent years have provided information of great value concerning the degree of natural relationship between the rootstocks employed. Likewise the colorimetric identification tests developed a few decades ago and considerably extended and refined in recent years have contributed useful information in this connection. An example is afforded by the rough lemon, which commonly has been grouped with the true lemons and assigned to *Citrus limon*. Its reactions to the tristeza virus and colorimetric tests cast extreme doubt on the validity of this classification and suggest that the rough lemon may deserve species standing, a belief long held by some botanists and horticulturists. Indeed these reactions actually indicate possible relationship to the Rangpur lime, likewise a conclusion reached by several botanists.

Whatever their opinion of the value of taxonomic botany, plant scientists in general and horticulturists and plant pathologists in particular, in reporting research results, are confronted with the question of the botanical nomenclature to be used in describing the plant materials with which they have worked. Obviously the objective should be to employ that nomenclature which indicates most accurately and precisely the species or botanical and horticultural varieties involved so that the reader may recognize them as discrete entities (taxa) with which he is acquainted or can become so by consulting authoritative reference works.

Standardized botanical nomenclature, while a highly desirable objective, has not yet been achieved however. The practical problem, therefore, to which this discussion is addressed, is to select and use that system of nomenclature which most nearly attains the objective in question.

The Systems of Citrus Taxonomy and Nomenclature Currently Available

There are only two modern systems available, of sufficient comprehensiveness to deserve consideration, namely those of W. T. Swingle (4) and Tyozaburo Tanaka (5), and hence choice is restricted to one or the other. Both represent the culmination of studies spread over approximately four decades during which each author published extensively. Swingle's final and complete system of classification and nomenclature appeared in 1943; that of Tanaka became available in English in 1954. For obvious reasons, the former is that best known and currently most widely used, at least in the English-speaking world.

The Comparative Backgrounds and Experience of the Originators

Swingle's interest in citrus taxonomy was an outgrowth of the breeding program of the U.S. Department of Agriculture, established by him and H. J. Webber in Florida following the great freeze of 1894-95. In pursuit of this interest, he travelled widely—principally in Japan, China, the Philippines, and the Mediterranean—and assembled extensive study collections of citrus materials from nearly all parts of the world. Prior to the appearance of his monograph he had published 30 taxonomic papers on plants of the orange subfamily. In addition to his work on citrus, however, he made many other contributions of great horticultural importance, notably those relating to the fig and date industries of the

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Pacific Southwest. He was essentially a subtropical horticulturist with a special interest in citrus breeding and taxonomy.

Tanaka became interested in citrus taxonomy while still a student in the Imperial University, just prior to World War I, and has continued to work actively in that field ever since. At various times during the period 1915-1930, he was associated with Swingle, both in this country and Japan. In following up this interest, he has travelled more widely than any other worker and has become better acquainted with the original literature and herbarium materials. He has assembled what is probably the best library in existence in this field, now sequestered in the University of Taiwan. He is undoubtedly acquainted at firsthand with a wider range of citrus materials than anyone else. Prior to the appearance of his monograph he had published at least 30 papers on citrus taxonomy. He is primarily a systematist, who has specialized in *Citrus*, and secondarily an economic botanist.

Despite the early association and long collaboration of Swingle and Tanaka, their respective systems reflect widely divergent viewpoints and conclusions.

THE TWO SYSTEMS BRIEFLY SUMMARIZED.—According to the system of Swingle, the citrus fruits are assigned to 3 genera; namely *Fortunella* (kumquats) with 2 subgenera and 4 species, *Poncirus* (trifoliolate orange) with 1 species and 1 botanical variety, and *Citrus* (citrus fruits) with 2 subgenera, 16 species and 8 botanical varieties. The citrus fruits of current economic importance are assigned to 8 of the 10 species which constitute the subgenus *Eucitrus*. *Papeda* is the other subgenus. Thus his classification involves a total of 3 genera, 21 species, of which 16 are in *Citrus*, and 9 botanical varieties.

Tanaka's treatment of the genera *Fortunella* and *Poncirus* corresponds approximately to that of Swingle but he treats the genus *Citrus* quite differently. He recognizes 2 subgenera, 8 sections, and 144 species. The subgenus *Archicitrus* contains the following sections: *Papeda*—12 species, *Limonellus*—16, *Citrophorum*—21, *Cephalocitrus*—21, and *Aurantium*—28, a total of 98 species. The subgenus *Metacitrus* consists of the following sections: *Osmocitrus*—9 species, *Acrumen*—36, and *Pseudofortunella*—1, a total of 46. Thus his classification of the citrus fruits involves a total of 3 genera and 151 species, of which 144 are in *Citrus*.

VALID CRITICISMS OF EACH SYSTEM.—While the writer does not claim special competence in the field of citrus taxonomy, during the past 30

years he has made two trips to the Orient, involving nearly a year's residence in India and visits to the principal collections there (1, 3), and brought in and studied a large number of introductions from many parts of the world (2). Additionally, he enjoyed the privilege of close association with Tanaka for the better part of the year, the latter spent recently as a Fulbright research scholar in the United States. From the background of these experiences, it is his conclusion that each of these systems is subject to valid criticisms. Most certainly, insofar as their treatment of the genus *Citrus* is concerned, they represent extremes.

The justifiable criticisms of Swingle's treatment include the following:

1. It is not sufficiently comprehensive to cover the materials with which horticulturists and plant pathologists are concerned, not to mention the known gamut of the genus. Thus numerous ancient forms of the Orient are ignored, some of which are of economic importance. Illustrative of the Indian forms not treated are gajanimma, kichili (vadlapudi), amilbed, attani, kimb, and sadaphal.

2. It denies species standing to many ancient, well-known, and highly distinctive forms, some of which are of great economic importance. Among these are the rough lemon, Indian (Palestine) sweet lime, Satsuma and kunembo mandarins, Rangpur lime, natsudaïdai, and yuzu.

3. Its treatment of certain distinctive and important forms is complicated, speculative, and cumbersome. This arises from denial of species standing and the consequent necessity for their inclusion under the most appropriate species. This in turn involves speculation as to probable or hypothetical parentage. The result is that the user, if he wishes to be exact and accurate, must employ a terminology which is speculative—in that the parentage indicated cannot be proved—or cumbersome, or both. Thus the rough lemon is indicated as *C. limon* hybrid, the Indian sweet lime *C. aurantifolia* hybrid, the King mandarin *C. reticulata-sinensis* hybrid, the Rangpur lime *C. reticulata* var. *austera* hybrid, and the calamondin *C. reticulata* var. *austera-Fortunella* sp. hybrid.

4. It is lacking in consistency to a remarkable degree. Separate species standing is not questioned for certain forms which are obviously closely related but others equally obviously much less closely related are placed in a single species. Examples of the former are provided by the pummelo and grapefruit, the sour and sweet oranges, and the oval and round kumquats. Illustrations of the latter are the placing of all the kinds of mandarin—Satsuma, kunembo, Nagpur, Mediterranean, tangerine, etc.—in a single species, and similar treatment for the limes and lemons.

Wolfe (6) has recently called attention to the validity of some of these criticisms.

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In the writer's opinion, the principal valid criticism of Tanaka's system is concerned with what appears to be an excessive number of species in the genus *Citrus*—certainly more than the range of known citrus materials seems to require. Thus he recognizes 35 species in the mandarin group alone. Obviously these must be based on very minor differences—so small in fact as to be detectable with great difficulty if at all. It is doubtful that some of these constitute valid species. Additionally, he has granted species standing to numerous cultigens, some of which are undoubtedly justifiable but others of questionable validity. Likewise species standing has been given to some natural hybrids and forms for which such treatment seems unnecessary or inappropriate.

Discussion

It seems clear that the basic difference which led these two investigators to such divergent conclusions relates to their respective concepts as to what constitutes a *Citrus* species. Essentially one is a "lumper" whereas the other is a "splitter." In the writer's opinion, the major reason for this difference arises from their respective experiences and interests.

Swingle's interest in citrus taxonomy was an outgrowth of his participation in the first citrus breeding program ever undertaken, which involved materials belonging to what are now agreed upon as 3 genera and early gave rise to a series of hybrids of striking variety and interest. Indeed he soon faced the problem of nomenclature for his hybrids, which he solved by the coinage of a series of new names indicating their general parentage—citrange, tangelo, tangor, etc.

Because of his awareness of the rich variation which could arise from citrus crosses, Swingle early reached the tentative conclusion that any citrus form which exhibited characters similar to those observed in another must be considered to be a probable hybrid relative, and hence should be assigned to the species it most closely resembled. As he became acquainted with the literature and when he visited the Orient and later studied his numerous introductions, he encountered many forms with characters which to him suggested hybrid origin. Indeed, he found some which somewhat resembled hybrids created in his breeding program. As a consequence, he was led to reject a large number of species established or accepted by other workers. Still other species he appears to have ignored.

Swingle's assumption that citrus forms which exhibit characters found

in other forms cannot be considered for species standing unless it can be established that they are not of hybrid origin, while understandable in the light of his experience as a citrus breeder, is not in accord with the views of most botanical taxonomists. Hybridization is generally regarded as one of the important modes of origin of new species. Many existing species which the taxonomists do not hesitate to recognize and accept are considered to have arisen from natural intercrossing at some time in the past. Indeed, in recent decades a number of plant species have been subjected to cytogenetic analysis, their component parentage determined, and then resynthesized.

Tanaka, on the other hand, approached the problem of citrus classification and nomenclature from the strictly botanical viewpoint. In the writer's opinion, however, a dominating influence, almost from the outset, was his interest in and desire to determine the facts concerning the center of origin, dissemination, and evolutionary development of *Citrus*. It would appear that the latter objective has caused him to search for the connecting links and to refine his species treatment to an unnecessary degree, which, together with acceptance of cultigens and certain hybrids, has led to the establishment or recognition of an excessive number of species.

Since these two systems reflect such extreme divergence in species concept, the possibility clearly exists that an intermediate system might be developed which would not be subject to their valid criticisms and hence of maximum utility to all concerned. For some years past, as the details of the two systems have become available and the opportunity to study the materials in the field has permitted, this has been an objective of the writer. His conclusions to date are set forth below.

*Citrus Species not Accepted by Swingle but Considered
to be Valid*

ACID MEMBERS GROUP

Citrus bergamia Risso—bergamot

Citrus jambhiri Lushington—rough or Mazoe lemon, citronelle, jamburi

Citrus latifolia Tanaka—Tahiti or Persian lime

Citrus limetta Risso—Mediterranean sweet lemon

Citrus limettioides Tanaka—Palestine sweet lime, mitha nimbu

ORANGE GROUP

Citrus myrtifolia Rafinesque—chinnoto, chinois, hazara

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MANDARIN GROUP

- Citrus deliciosa* Tenore—Mediterranean or Willowleaf mandarin
Citrus nobilis Loureiro—King mandarin, kunembo
Citrus reshni hort. Tanaka—Cleopatra mandarin
Citrus sunki hort. Tanaka—sunki
Citrus tangerina hort. Tanaka—tangerine
Citrus unshiu Marcovitch—Satsuma mandarin

OTHERS

- Citrus junos* Siebold—yuzu
Citrus karna Rafinesque—karna, kharna khatta, khatta nimbu, id nimbu
Citrus limonia Osbeck—Rangpur lime, Canton or cravo lemon, Otaheite orange, mandarin-lime
Citrus macrophylla Wester—colo, alemow
Citrus maderaspatana hort. Tanaka—kichili, vadlapudi, Guntur sour orange
Citrus madurensis Loureiro—calamondin
Citrus natsudaidai Hayata—natsudaidai, dai dai mikan, Japanese summer grapefruit
Citrus pennivesiculata Tanaka—gajanimma. Identical with *C. Moi*.

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