The Crop-Group and the Inconsistent Use of Linnean Names in the Taxonomy of Domesticated Plants

W.L.A. Hetterscheid[1] and R.G. van den Berg[2]
[1]WUR Botanical Garden, Gen. Foulkesweg 37, 6703 BL Wageningen, The Netherlands
[2]WUR Biosystematics, Gen. Foulkesweg 37, 6703 BL Wageningen, The Netherlands

Keywords: crop-group, ICBN, ICNCP, Linnean names, nomenclature of domesticates

Abstract

There have been several proposals for classification categories for systematic groups of domesticated plants. In the 6th edition of the International Code for Nomenclature of Cultivated Plants (ICNCP) only two main categories were included, the cultivar and the cultivar-group. The 7th edition of ICNCP saw the introduction of the Group to encompass the cultivar-group together with other kinds of groupings, also of unnamed material. Despite the existence of the ICNCP, many names for systematic groups of domesticated plants are still in purely Linnean form, following the rules of the International Code of Botanical Nomenclature (ICBN). This practice illustrates a lack of insight in the workings and logic of systematic thinking with respect to domesticated plants and muddles the borderline between the contexts of domestication and evolution. The inclusion of the Crop category in the ICNCP would accommodate the nomenclature and classification of all systematic groups of domesticated plants in one logically consistent system, setting it apart from the realm of the classical botanical classification in use for wild plants.

INTRODUCTION

The word cultonomy was introduced by Hetterscheid and Van den Berg (1996) to set systematic thinking and practice for domesticated plants apart from the systematic philosophy in place for plants exclusively influenced by evolutionary forces in the wild. Domesticated plants are by definition influenced by human activity to a lesser or larger degree. Present-day classifications of domesticated plants can be divided in two main types:

1) using ICBN-based categories, apparently based on the wish to classify domesticates within the hierarchical Linnean system, in order to provide phylogenetic information;
2) using ICNCP-based categories to produce classifications of domesticates (domesticated plants) on the basis of their agronomic traits; such “special-purpose” classifications are primarily non-phylogenetic.

CLASSIFYING AND NAMING DOMESTICATES BASED ON PHYLOGENY

The reason for creating phylogenetic classifications of domesticates is to provide hypotheses on their relationships with their wild ancestor or close relatives. Knowledge of such relationships may minimize efforts to look for favorable traits in this ancestor or these relatives in order to speed up breeding programmes and improve crops faster. Traits in close relatives of domesticates are supposed to be easier to transfer into a crop than those from more distant relatives. This idea is based on classical breeding practices involving hybridization and the assumption that closer phylogenetic affinity provides a key to more successful hybridization, which has been vindicated on many occasions, but is not generally true. Present day breeding using molecular techniques is far less dependent on knowledge of phylogenetic relationships because trait transfer can be (relatively) easily accomplished using donor-organisms which are only very distantly related to the receiving individual.

Because domesticates may have a very long history of domestication involving much hybridization, their phylogenetic affinity to any existing taxon may be unclear. The degree to which this is the case is uncertain in many domesticates and therefore the accuracy of such proposed phylogenies is suspect. Names for systematic groups of

domesticates are often proposed in pure Linnean form, using the rules of the ICBN (McNeill et al., 2006). The use of Linnean names for groups of domesticates in such classifications suggests a scientific accuracy which is, however, severely compromised by the uncertain status of the classified materials. Because many systematic groups of domesticates, 'culta' (Hetterscheid and Brandenburg, 1995) are distinguished at infraspecific level, the ICBN categories subspecies, varietas and forma are often used to accommodate them. Also, for artificial interspecific and intergeneric hybrids, nomenclature for nothospecies and nothogenera are used, following the rules in the Hybrid Appendix of the ICBN, which should be limited to the nomenclature of spontaneous hybrids occurring in the wild. The result is a Linnean-type classification of groups of domesticates, mixing entities of different historical and ontological status (evolutionary vs. intentional human-determined).

CLASSIFYING AND NAMING DOMESTICATES BASED ON AGRONOMIC CHARACTERS

The most basal category available to classify domesticated plants is the cultivar (cultivated variety). This category and its definition have proven to be unambiguous. The cultivar is a typical industrial construct. The members of a cultivar share one or more agronomical important characters and may have different means of origin and reproduction (maintenance), hence plant cultivars come in various types (e.g. hybrids, lines, F1-hybrids, cloned mutants, etc.). Most important is that a group of domesticated plants is given the status of cultivar because the group has merit in our society. Since communication concerning the cultivar is necessary, it must be given a name and this is done according to the rules of ICNCP (Brickell et al., 2004). In large assortments of cultivars, a need may be felt to group certain cultivars with shared characters into cultivar-groups. The formation of names of cultivar-groups is also dealt with in the ICNCP. The mechanism and consequences of cultivar-group classification are discussed by Hetterscheid and Brandenburg (1995), Hetterscheid (1996), Trehane (1996), and Van den Berg (1999). The last edition of the ICNCP allows groups of domesticated plants without the status of cultivar (and hence without names established following the rules of the ICNCP) to be grouped according to the Group-concept.

JOINING CULTONOMIC AND BOTANICAL CLASSIFICATION: AN ETERNAL STRUGGLE

Classifying domesticates with non-domesticated organisms in one system suggests that their nature allows for a common systematic classification philosophy to be applied to both categories. But is it logical to assume that taxa of natural origin and domesticates can be fitted in one classification system? A classification system as a means of retrieving or predicting knowledge of its members suggests at least that the members in the system are similar kinds of organism. The classification of natural taxa aims to illustrate historical phylogenetic relationships. The methods underlying such classifications are based on the premise that "evolution has occurred" and that evolution as we understand it creates a historical, nested, hierarchical pattern of phylogenetic relationships among organisms, which can be reconstructed if we use the proper tools. For that purpose, organisms are grouped into a universally applicable basic unit, the species, and then a classification of those species is proposed. The naming of species is the first classifying act, as this decides to what genus the species belongs. When dealing with a species that is new to science, this classifying act constitutes a hypothesis of phylogenetic relationships of the new species with other already named and classified species. Based on new classifications the earlier proposed names of species may be changed if necessary. Such are the basic workings of modern day biological classification.

THE NAMES OF DOMESTICATES: WHAT DO THEY MEAN?

It is not uncommon to find papers where it is stated that cultivated material of maize is called *Zea mays* L. subsp. *mays* (Iltis and Doebley, 1980) and that there are also

other subspecies, *Z. mays* subsp. *parviglumis* Iltis & Doebley as the likely progenitor of maize, *Z. mays* subsp. *huehuetenangensis* (Iltis & Doebley) Doebley, and *Z. mays* susp. *mexicana* (Schrad.) Iltis (Buckler and Stevens, 2006).

A reader would logically conclude that there is one natural species named *Zea mays* and that some taxonomist has decided that there are four natural subspecies, based on criteria in use to recognize such infraspecific units. One may wonder why a crop like maize should be classified as a natural subspecies and named accordingly. Does this mean that the three other subspecies are also cultigenic (viz. consisting only of cultivated material)? Or does it mean that maize may also be found as natural populations? And if so, does the name refer to these populations AND the cultigenic groups or exclusively to the first? None of the anwers to these questions are clear from the "scientific" name of maize. In fact, the "scientific" name of maize fails to do its basic function, providing biologically meaningful information on the nature of the indicated material in terms of its systematic and biological status. Is it a natural taxon or is it a systematic group of cultigens? Is there a one-on-one relationship between the common crop name "maize" and the scientific name *Zea mays* subsp. *mays*? It turns out that the "scientific" name is confusing because it does not tell us that maize is a cultigenic group of plants but instead suggests it to be a natural one. Extra information is needed to explain the use of this name and this is contrary to the goal of a classification system, which should in itself guarantee that its units and their names unambiguously inform the reader on their status and nature. Maize cannot be defined by any existing definition of the term "subspecies". It has no place in the exclusively evolutionary biological context because it was shaped by forces largely intentionally exerted upon it by human beings. It lacks a single uninterrupted evolutionary history based on unique interactions with its natural surroundings in natural environments. It also lacks a human- independent geographical distribution. Why then does its name suggest that maize is a biologically meaningful subspecies?

Many more examples exist in present day literature on major and minor crops, where the species level itself is also being used to denote purely or partly cultigenic entities, e.g. *Solanum tuberosum* L. (potato); *Lycopersicon esculentum* Mill. (tomato); *Lactuca sativa* L. (lettuce), *Oryza sativa* L. (rice).

Another application of scientific names to cultigenic material is the use of hybrid names. The Hybrid Appendix of the ICBN provides a mean of naming hybrid plants in general, both of natural and artificial hybrid origin. This fact in itself is not consistent with the logic of the ICBN which on one hand allows its system to be used for naming artificially hybridized (cultigenic) material, but on the other hand defers other purely cultigenic categories like the cultivar to the ICNCP, introducing ambiguity in the naming of cultigenic material. This opens the possibility of naming a cultigenic group of plants of hybrid origin under two different systems. It can surely not be the goal of systematic biological nomenclature to allow two different types of names for one and the same entity, especially when both naming systems are based on very different systematic philosophies and practices.

HOW TO RELATE SYSTEMATIC GROUPS OF DOMESTICATES TO WILD TAXA?

Classifying systematic groups of domesticated plants in a classification system widely and nearly exclusively in use for natural taxa causes serious problems. Even the use of the term "taxon" for these groups has been challenged (Hetterscheid and Brandenburg, 1995). In the view of the present authors it is basically unsound to use any of the ICBN categories in the hierarchical classification system for natural taxa to accommodate domesticated plants. This does not mean that there is no way of representing ANY historical "phylogenetic" relationship between domesticates and natural taxa. We need to adapt our system of classification categories for domesticated plants to service that goal. The present-day classification method for taxa is inappropriate for systematic groups of domesticated plants and therefore inappropriate for a sound representation of their historical relationships with natural taxa. If we are to speak about

“phylogenetic relationships” between domesticates and natural taxa at all, we have to redefine the relationship between them in order to make logically correct inferences about the extent to which both groups have common histories. In other words: what does the history of a domesticated organism (or group of organisms) have in common with the history of, say, a natural species?

This latter question needs to be answered by looking at what we know or hypothesize about the nature of the complex of processes we call “domestication”. The biodiversity of organisms in natural surroundings is dramatically different from that found in crops in cultivated fields, after and during domestication. The complex "industrial" history of domesticates produces patterns of traits that a priori do not follow the null-hypothesis for natural variation patterns, i.e. that they are inherently hierarchical and nested and as such can be used to reconstruct the suggested hierarchical pattern of phylogenetic relationships.

WHAT DOES THE "RELATIONSHIP" BETWEEN A DOMESTICATE AND AN EVOLUTIONARY TAXON MEAN?

If the industrial history of a domesticate could unambiguously be traced back to its root, it would eventually, going back in time, show the interaction with one or more taxa in an evolutionary context. By definition, the root of any domesticate lies in one or more natural populations of a species. With the first intentional actions by a human upon members of such populations the history of the targeted organisms starts to diverge from that of the co-members of the unaffected part of the natural population. With continued human manipulation, the histories keep on diverging, often quite dramatically. Human manipulation is usually directed towards "improving" a crop according to preset targets (utilization as food, ornamental, building material, medicinal plants etc.). Such improvement often includes hybridization with specimens containing favorable traits, which may or may not be closely related. The pattern of traits will diverge more and more and will also contain more and more "alien" elements. This will complicate a reconstruction of the ancestry of the resultant domesticate. In fact, in many cases a unique singular history can no longer be reconstructed because it will be highly reticulate and intertwined with the history of many other organisms with a different historical root. The pattern of traits that could be used to reconstruct the phylogenetic history becomes ever more scanty, fragmentary and "polluted".

It is therefore inappropriate to speak of a phylogenetic relationship between a domesticate and any evolutionary taxon. The actions of humans molding the histories of crops defy the formulation of a unique theory describing how to establish phylogenetic relationships between domesticates and evolutionary taxa. This would require a logical combination of the theory of Darwinian evolution with one on human interference to consistently explain the patterns of traits in domesticates. Things are even made more complex when one considers that some crops have multiple origins.

TOWARDS A THEORETICAL SOLUTION

The relation between a crop and its evolutionarily related taxa therefore is not a phylogenetic one. That leaves the somewhat meager observation that "there is always a history between a domesticate and one or more evolutionary taxa". Inasmuch as this history has a phylogenetic component, the search must be for those remaining traits that might indicate this component. However, the diversity of the domestication process (which cannot be covered by one model) will defy the logic of reconstructing the phylogenetic relationships between domesticates and evolutionary taxa. The relationship between domesticates/ crops and evolutionary taxa therefore may still be historical but is essentially non-phylogenetic. As a consequence, domesticates cannot be classified in a phylogenetic framework with evolutionary taxa. Any suggested phylogeny in such a form in literature is therefore at fault with classification logic. It contains incomparable entities that display different types of relationships. Taxa based on natural populations and "taxa" exclusively or partly consisting of domesticated organisms cannot share a phylogeny in

the sense of exclusively evolutionary relationships based on Darwinian evolutionary theory.

Despite this, we do usually recognize in domesticated organisms sets of characters that they share with existing evolutionary taxa. In trying to relate domesticated organisms to evolutionary taxa we actually hypothesize which evolutionary taxa have contributed to the domestication history of a domesticate. We usually do quite well in recognizing the genus of which one or more members may have been involved in a domestication history. However, for levels lower than genus, uncertainty increases. With the approach to these lower levels, the human influence on character sets increases and this complicates detailed statements about the relationship of such lower taxa in a domestication history.

There is overwhelming logic in declining the use of terms like "phylogeny" and "phylogenetic relationship" in discussing domestication and its results. We must look for a different kind of relationship and matching terminology if we want to express the historical ties between domesticates and evolutionary taxa.

This relationship between a domesticate and one or more evolutionary taxa is that of a shared history in terms of human driven, intentional interaction with a preset goal (improvement of the domesticate). It is a hypothesis about (part of) the origin of the domesticate, and therefore not a taxonomic relationship as it does not describe part of an evolutionary history but of a domestication history. As a logical corollary, domesticates do not originate as part of the Darwinian evolutionary context and they do not evolve themselves. Terms like "evolution", "population", "genetic drift", all developed as part of the description of an evolutionary context, should not be used in a domestication context at all, or at least not without an explicit statement as to what exactly is meant by it in the particular context of domestication.

In order to avoid confusion between domesticates and evolutionary taxa, these entities must not be classified in one and the same system. In principle all classification categories for domesticates must be different from those for evolutionary taxa. Categories like species, subspecies, variety and forma should be abandoned for the classification of domesticates. Inasmuch as they can be used, this use must be restricted to the goal of illustrating hypotheses of parts of their domestication histories. As such, taxon names should only be used in conjunction with names or epithets of the classification system for domesticates. Linnean taxon names must be abandoned as indicators or labels of systematic groups of domesticates. Such groups, when worthy of recognition, must first be classified in the appropriate categories and then named using appropriate nomenclatural rules (as described for plants in the ICNCP).

Following this viewpoint, quite a few names of important economic crops are erroneously in the form of Linnean binomials, and the scientific names of all domesticated plants contain at least an ICBN-based generic name. In our view the use of this generic name must not be seen as a hypothesis of phylogeny but as a hypothesis of domestication history, saying only that the domesticate has been domesticated from within that genus. The rules of the ICNCP with regard to the formation of the full name of a domesticated plant are not inconsistent with this; it merely requires a different interpretation of the meaning of the name.

However, it turns out that for many well-known crops, only full ICBN-names exist because there is no classification category available in the ICNCP to cover them. The Group does not suffice because it is used to classify cultivated plants in groups within a crop. What seems to be missing is a category to cover the sum of all cultivated materials, which taken together form a unit of breeding. Examples are units like "Melons", "Mandarins", "Potatoes", "Lettuce" etc. Within these units, smaller groups are often recognized that can be classified as cultivar-groups. But what is the status in the ICNCP of a unit like "Melons"?

THE CROP-GROUP

Up until today these units are identified in the literature by ICBN-based names. Examples are *Citrus reticulata* Blanco for mandarins, *Beta vulgaris* L. subsp. *vulgaris* for

beet, *Zea mays* subsp. *mays* for maize. It is here proposed that such nomenclature be abandoned in favour of a nomenclature consistent with the ICNCP, thereby emphasizing that the entities so named are of cultivated origin and are not part of a system identifying entities that play a role in the evolution of biodiversity. Where the cultivar-group is already in use to classify cultivars of a certain crop, a new category needs to be introduced into ICNCP for the crop itself.

Van den Berg (1999, 2004) suggested using the term "crop" to denote a formal category encompassing the total of all cultivars and cultivar-groups of a particular agricultural or horticultural product. The word "product" aptly implies that we are discussing the results of human industrial behaviour and not the results of evolutionary processes. Products and species are "results" of very different processes. Van den Berg (2004) argued that crops may be linked to existing taxonomic classifications but that they should not be seen as actual parts of them.

In order to use the crop as a potential classification category in the ICNCP we propose to make the combination "crop-group" to conform to the terminology of the ICNCP. The crop-group definition reads:

The crop-group embraces the total of all domesticated material derived from within a taxon and which is subject to a common domestication goal. The nomenclature of the crop-group derives primarily from the common names used in all parts of the world where it is being cultivated.

According to this definition a crop-group may contain cultivars but also other culta in a particular classification of a given crop (e.g. established cultivar-groups). The addition of the common domestication goal stresses the dependence of the existence of a given crop, recognised as a crop-group in a classification, on the intention of e.g. breeders to maintain the integrity of the original application of the crop in human society and its basic agronomic characters in that society (a vegetable, an ornamental, medicinal etc.).

In order to separate cultivated plant nomenclature as much as possible from ICBN-based nomenclature in view of the inherent instability of the latter, the names of crop-groups should be in line with how the ICNCP implements this goal, viz. by using modern languages as a basis wherever possible. For crop-groups this is not quite as daunting as it may seem, since there are internationally accepted lists of common names for crops.

Examples of these lists can be found on the following websites:

- http://www.upov.int/en/publications/taxa.htm
  UPOV list of PVR protectable crops (UPOV document C/40/6);
- http://www.ars-grin.gov/~sbmljw/cgi-bin/seedglossary.pl?language=en
  ISTA Multilingual Glossary of Common Plant Names;
- http://www.plantnames.unimelb.edu.au/Sorting/List_bot.html
  Multilingual multiscript Plant Name Database.

We suggest that under the aegis of the International Association for Cultivated Plant Taxonomy (IACPT) a central common list may be sanctioned and made available through the internet.

ICNCP-based names for crop-groups create the possibility for taxonomists to refer to crops in terminology that is specifically applicable to crops instead of using mock-scientific "names" in ICBN-based format.

Example: *Cucumis* L. (melons)

ICBN based format:

Genus	*Cucumis*
Species	*C. melo* L.
Crops	*C. melo* subsp. *melo* (melons, partly)
	C. melo subsp. *agrestis* (melons, partly)
cultivar-groups	*C. melo* subsp. *melo* var. *cantalupensis* (cantalupes)

C. melo subsp. *flexusosus* (snake-melon)
("varieties" in Decker-Walters et al., 2002)

ICNCP-based classification:

Genus	*Cucumis*
Species	*C. melo* (wild populations, if existent)
Crops	Melon Crop-group (melons)
Cultivar-groups	Cantalupe Group (cantalupes)
	Flexuosus Group (snake-melon).

It needs to be established what actually constitutes the crop in a given situation and with which taxon a crop could be associated, indicating within which taxon the crop has been domesticated. In quite some cases this might be obvious. But in the case of the situation as described by Decker-Walters et al. (2002), where ICBN-based taxon-names in melons are proposed for artificial constructs to accomodate strictly domesticated plants, the association of the melon crop with a taxon is less obvious. When it is considered that there are truly wild populations of "melon" then the use of the name *C. melo* is justified, and the full name of the crop could read: *Cucumis melo* Melon Crop-group. However, if the so-called wild populations are in fact escapes or weedy populations as a byproduct of the domestication history of the melon crop, then the use of the name *C. melo* is flawed because melons were not domesticated from within populations of a species *C. melo*. In that case the association would be with either another species of *Cucumis* if further research would indicate that, or with the genus only. In the latter case we would propose *Cucumis* Melon Crop-group.

Note that in this alternative classification, the level of subspecies is superfluous because in a classification of domesticated plants the subspecies *melo* and *agrestis*, as used by Decker-Walters et al. (2002), should not be used at all. Subspecies *agrestis* does not represent an evolutionary unit but is a purely artificial construct to accommodate domesticated plants. Subspecies *melo* is a mere autonym and would disappear if subsp. *agrestis* is no longer recognised. The fact that a minor morphological character (ovary pubescence) could be used to place the cultivar-groups in either of two larger units is of no use for the users of the classification because the resultant two groups are not defined in agronomical terms. In any case, Stepansky et al. (1999) showed that this character does not even show a distribution that consistently separates the two "subspecies".

The classification view proposed above implements the suggestion of Hetterscheid and Brandenburg (1995) of reducing the number of ICBN-based categories and names in cultivated plant classification as a prerequisite to enhance stability in their nomenclature. A lower number of ICBN-dependent categories will lead to fewer name-changes based on non-relevant, non-agronomical reasons.

Because taxonomists since Linnaeus have failed to deal critically with traditional Linnean binomials for well-known crops, such names are now in worldwide use to indicate those crops in "scientific" terms. It would not be productive to upset this heritage but we do think that all those names should be stabilised indefinitely and only used to indicate those crops. We suggest that after careful consideration by a working-party of the IACPT, a proposal should be prepared to accept the inclusion in both the ICBN and the ICNCP of an identical list of Linnean binomials for crops that will never be subject to any change through the ICBN mechanism. Those names should be considered to be mere labels for crops and not biologically meaningful species names. The list could be said to be a "list of permanently mummified names for crops". If necessary, it might be considered that the IACPT be the authoritative body to suggest changes to that list, based on well-evaluated economical or agronomical arguments.

CONCLUSION

The continuing confusion between the nature of domesticates and evolutionary taxa is exemplified by the abuse of Linnean-based nomenclature for the former category, erroneously implying that such entities belong to the latter category instead. Phylogenetic

schemes combining domesticates and evolutionary taxa under a similar nomenclature further add to the confusion by suggesting solid phylogenetic relationships between domesticates and evolutionary taxa. The introduction of the crop-group in cultivated plant systematics and nomenclature would provide a means of avoiding the use of inappropriate nomenclature for domesticated plants. Together with the introduction of the terms "culton" and "cultonomy", the introduction of the crop-group would provide a further building block for the independence of systematic thinking applicable to domesticated organisms.

Literature Cited

Brickell, C.D., Baum, B.R., Hetterscheid, W.L.A., Leslie, A.C., McNeill, J. Trehane, P., Vrugtman, F. and Wiersema, J.H. (eds.). 2004. International Code of Nomenclature for Cultivated Plants, 7th edition. Acta Hort. 647.

Buckler, E.S. and Stevens, N.M. 2006. Maize origins, domestication, and selection. p.49-66. In: T.J. Motley, N.Zerega and H. Cross (eds.), Darwin's harvest: new approaches to the origins, evolution, and conservations of crops. Columbia University Press, New York.

Decker-Walters, D.S., Chung, S.-M., Staub, J.E., Quemada, H.D. and López-Sesé, A.I. 2002. The origin and genetic affinities of wild populations of melon (*Cucumis melo*, *Cucurbitaceae*) in North America. Plant Syst. Evol. 233:183–197.

Hetterscheid, W.L.A. 1996. Cultivar-groups- a systematic approach. Hortax news 1(2):7-9.

Hetterscheid, W.L.A. and Brandenburg, W.A. 1995. Culton versus taxon: conceptual issues in cultivated plant systematics. Taxon 44:161-175.

Hetterscheid, W.L.A. and Van den Berg, R.G. 1996. Cultonomy of *Aster* L. Acta Bot. Neerl. 45(2):73-181.

Iltis, H.H. and Doebley, J.F. 1980. Taxonomy of *Zea* (*Gramineae*). II. Subspecific categories in the *Zea mays* complex and a generic synopsis. Amer. J. Bot. 67:994-1004.

McNeill, J., Barrie, F.R., Burdet, H.M., Demoulin, V., Hawksworth, D.L., Marhold, K., Nicolson, D.H., Prado, J., Silva, P.C., Skog, J.E., Wiersema, J.H. and Turland, N.J. (eds.) 2006. International Code of Botanical Nomenclature (Vienna Code). Regnum vegetabile 146. A.R.G. Gantner Verlag, Ruggell, Liechtenstein.

Stepansky, A., Kovalski, I. and Perl-Treves, R. 1999. Intraspecific classification of melons *(Cucumis melo* L.) in view of their phenotypic and molecular variation. Plant Syst. Evol. 217:313-332.

Trehane, P. 1996. Cultivar-groups- a concept in need for clarification. Hortax news 1(2):10-11.

Van den Berg, R.G. 1999. Cultivar-group classification. p.135-143.In: S. Andrews, A.C. Leslie and C. Alexander (eds.), Taxonomy of Cultivated Plants, IIIrd Int. Symp. of Cultivated Plants. Royal Botanic Gardens, Kew.

Van den Berg, R.G. 2004. The crop concept in cultonomic classification. Acta Hort. 634:141-144.