

Systematic Numbering of Vegetative Compatibility Groups in the Plant Pathogenic Fungus *Fusarium oxysporum*

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Fusarium oxysporum Schlechtend.:Fr. is a cosmopolitan fungal pathogen (4) responsible for wilt and cortical rot diseases of more than 100 economically important plant hosts (3). Genetic diversity within *F. oxysporum* has been categorized extensively by vegetative compatibility grouping in laboratories around the world. Detailed studies indicate that isolates belonging to the same vegetative compatibility group (VCG) typically possess very similar or identical multilocus haplotypes and belong to the same clonal lineage (19). VCGs, therefore, can be good predictors of genetic similarity, clonal lineage, or both. In this communication, we propose a standardization of the system currently used for categorizing genetic diversity within this taxon. Our primary objective is to make the system more understandable and useful by reducing ambiguity and increasing the rigor with which the current system is applied. A secondary goal of this undertaking is to promote international communication and cooperation in this endeavor.

In the mid-1980s, Puhalla (27) proposed a method by which various strains of *F. oxysporum* could be identified and classified based on VCGs. Since that time, numerous investigators have classified isolates of *F. oxysporum* in this manner and have adopted Puhalla's numerical system for classification. In this system, vegetatively compatible isolates are given a VCG code consisting of a four- (or five-) digit number with the first three digits corresponding to host specialization, or forma specialis, and the last digit(s) corresponding to individual VCGs within that forma specialis. Puhalla categorized 16 VCGs in his original publication and provided

specific numbers for these VCGs. Since Puhalla's original contribution, over 125 VCGs have been identified among plant pathogenic isolates of *F. oxysporum*. Currently described VCGs are summarized in Table 1 (T. Katan, unpublished data). This list will be updated periodically on the worldwide web and can be accessed by contacting H. Corby Kistler (Plant Pathology Department, University of Florida, Gainesville 32611-0680; Phone: 352/392-9241; E-mail address: hck@gnv.ifas.ufl.edu). While care has been taken to continue the system of Puhalla, problems involving duplication have arisen as VCGs have been described for newly characterized formae speciales. For example, isolates from formae speciales *basilici* (16) and *phaseoli* (35) each have been given the VCG numerical code 016.

To improve standardization, we endorse the following system for numbering formae speciales not specifically mentioned in the original publication of Puhalla and for putative nonpathogenic isolates of *F. oxysporum*. For the first described VCG in a forma specialis, the first three digits given to that VCG should be assigned by a VCG numbering coordinator (described below) and the last digit should be designated "0." VCGs described within that forma specialis should be numbered consecutively. To prevent overproliferation of VCG categories, we recommend numbering VCGs only if several independent isolates are found to be vegetatively compatible. Single-member VCGs or VCGs that are extremely localized geographically should not be numbered unless they possess other noteworthy attributes such as unusual cultural characteristics or pathogenicity, or can be shown by molecular markers to represent distinct lineages.

As more is learned about phylogenetic relationships within *Fusarium*, some VCGs may need to be transferred to related species and, thus, removed from the current listing. Baayen and coworkers (1), for example, recently discovered that some VCGs of the carnation wilt fungus originally described as *F. oxysporum* f. sp. *dianthi*

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TABLE 1. Vegetative compatibility groups (VCGs) of *Fusarium oxysporum* listed by forma specialis

forma specialis	Host	forma specialis code	Assigned numbers for VCG	Number of VCGs	Literature citations
<i>albedinis</i>	<i>Phoenix dactylifera</i>	017-	0170	1	32
<i>apii</i>	<i>Apium</i>	001-	0010 to 0012	3	5
<i>asparagi</i>	<i>Asparagus</i>	100-	1001 to 1008	8 + ^a	7
<i>basilici</i>	<i>Ocimum</i>	016-	0160	1	16
<i>betae</i>	<i>Beta</i>	... ^b	...	7 +	12
<i>chrysanthemi</i>	<i>Chrysanthemum</i>	005-	0050 to 0051	2	27
<i>ciceris</i>	<i>Cicer</i>	...	...	1	25
<i>conglutinans</i>	<i>Brassica</i>	010-	0101	1	20
<i>cubense</i>	<i>Musa</i>	012-	0120 to 0126, 0128 to 01220	21 ? ^c	26
<i>cucumerinum</i>	<i>Cucumis sativus</i>	018-	0180	1 +	15
<i>cyclaminis</i>	<i>Cyclamen</i>	015-	0151 to 0153	3	36
<i>dianthi</i>	<i>Dianthus</i>	002-	0020 to 0022, 0025, 0027, 0028	6	1
<i>elaeidis</i>	<i>Elaeis</i>	001- ^d , 014-	0011 to 0015, 0140 to 0141	5	6, 10
<i>erythroxyli</i>	<i>Erythroxyllum</i>	...	...	1	31
<i>gladioli</i>	<i>Gladiolus</i>	034-	0340 to 0343	4	24
<i>lactucum</i>	<i>Lactuca</i>	...	...	1	13
<i>lilii</i>	<i>Lilium</i>	...	...	4	22
<i>lupini</i>	<i>Lupinus</i>	...	...	2 ?+	28, 29
<i>lycopersici</i>	<i>Lycopersicon</i>	003-	0030 to 0033	4 +	23
<i>mathioli</i>	<i>Mathiola</i>	010-	0103	1	20
<i>medicaginis</i>	<i>Medicago</i>	004-	0040 to 0041	2	27
<i>melongenae</i>	<i>Solanum melongena</i>	017-	0170	1	15
<i>melonis</i>	<i>Cucumis melo</i>	013-	0130 to 0138	8 +	14, 17
<i>niveum</i>	<i>Citrullus</i>	008-	0080 to 0082	3	21
<i>phaseoli</i>	<i>Phaseolus</i>	016-	0161 to 0165	5	35
<i>pisi</i>	<i>Pisum</i>	007-	0070	6 ?+	2, 34
<i>radicis-lycopersici</i>	<i>Lycopersicon</i>	009-	0090 to 0098	8 +	18, 30
<i>raphani</i>	<i>Raphanus</i>	010-	0102	1	20
<i>spinaciae</i>	<i>Spinacia</i>	...	...	3	9
<i>tracheiphilum</i>	<i>Vigna</i>	006-	0060	1	27
<i>tuberosi</i>	<i>Solanum tuberosum</i>	...	...	6	33
<i>vasinfectum</i>	<i>Gossypium</i>	011-	0111 to 01110	10	8

^a + = Additional isolates are incompatible with the established VCGs.

^b ... = VCG code and numbers not assigned.

^c ? = Two or more of these VCGs may overlap.

^d * = forma specialis code previously given to forma specialis *apii* by Puhalla (27).

are actually members of *F. redolens* f. sp. *dianthi*. In cases such as this, VCG numbers for isolates no longer considered to belong to *F. oxysporum* should be removed from use without replacement. A similar four-digit code as used for VCGs in *F. oxysporum* has been proposed for VCGs and formae speciales in *F. redolens* (1). The latter species causes wilt and rot diseases in numerous host plants including pea, carnation, and spinach (11). Other VCGs currently placed in *F. oxysporum* may eventually prove to belong to *F. redolens* or other species of *Fusarium*.

As a rule, nonpathogenic isolates of *F. oxysporum* should not be given four-digit VCG codes. Since tests for vegetative compatibility are unlikely to be done among the many nonpathogenic isolates from different laboratories, we discourage the routine assignment of formal VCG numbers for these isolates to prevent an overabundance of VCG categories. In some cases, however, these isolates will be sufficiently important to warrant classification of their VCG. VCG numbers may be assigned when (i) isolates belonging to the same VCG are recovered from multiple locations, (ii) isolates belonging to the same VCG compose a large fraction (>5%) of the population at a single site (sample size > 100 independent isolates), or (iii) isolates belonging to the same VCG are of particular utility, e.g., biological control isolates. Nonpathogenic isolates vegetatively compatible with pathogenic isolates also should be given the VCG number of their pathogenic counterparts. Four-digit VCG codes for nonpathogens will be assigned by the coordinator as done for pathogenic VCGs. If the following recommendations for numbering are followed, duplications and inconsistencies in the system can be kept to a minimum.

To address the problems outlined here, and with the endorsement of the *Fusarium* Committee of the International Society of Plant Pathology, we hereby propose the creation of a "VCG numbering coordinator." This person should be contacted by investi-

gators prior to submission of new VCG numbers for publication. If requested by the investigator, communications with the VCG numbering coordinator will be kept strictly confidential prior to publication. Talma Katan (Department of Plant Pathology, ARO, Volcani Center, P.O. Box 6, Bet Dagan 50250, Israel; fax: 972-3-968-3543) has accepted our nomination to serve as the initial VCG numbering coordinator until the 6th International Fusarium Workshop (to be held at the International Mycological Institute from 17 to 21 August 1998), at which time a new VCG coordinator can be selected or T. Katan can be renominated to continue as coordinator.

In the coming year, representative isolates of all known VCGs of *F. oxysporum* should be deposited for storage at two or more internationally recognized fungal culture collections. Individual investigators will be contacted shortly to assemble this collection. The dual utility of such a centralized collection is that it will be able to provide reference cultures of all of the major phytopathogenic VCGs and insure long-term strain maintenance. Puhalla (27) noted that "(to) standardize the assignment of VCG, a great deal of cooperation between *Fusarium* workers will be necessary." It is our hope that the efforts begun here will promote the cooperation required to make VCG standardization possible.

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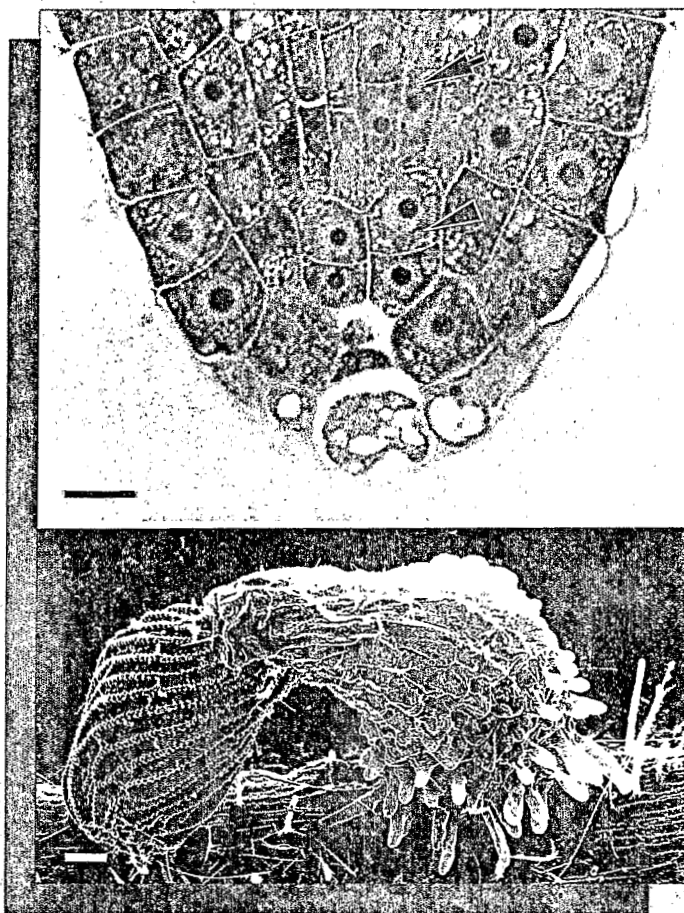
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