FAO/IPGRI Technical Guidelines for the Safe Movement of Germplasm. No. 18

Allium spp.

edited by **M. Diekmann**

in collaboration with
the Research Institute
of Crop Production,
Prague – Ruzyne

Previously published Technical Guidelines for the Safe Movement of Germplasm

These guidelines describe technical procedures that minimize the risk of pest introductions with movement of germplasm for research, crop improvement, plant breeding, exploration or conservation. The recommendations in these guidelines are intended for germplasm for research, conservation and basic plant breeding programmes. Recommendations for commercial consignments are not the objective of these guidelines.

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INTRODUCTION

Collecting, conservation and utilization of plant genetic resources and their global distribution are essential components of international crop improvement programmes.

Inevitably, the movement of germplasm involves a risk of accidentally introducing plant pests[1] along with the host plant. In particular, pathogens that are often symptomless, such as viruses, pose a special risk. In order to manage this risk, effective testing (indexing) procedures are required to ensure that distributed material is free of pests that are of concern.

The ever-increasing volume of germplasm exchanged internationally, coupled with recent advances in biotechnology, has created a pressing need for crop-specific overviews of the existing knowledge in all disciplines relating to the phytosanitary safety of germplasm transfer. This has prompted FAO and IPGRI to launch a collaborative programme for the safe and expeditious movement of germplasm, reflecting the complementarity of their mandates with regard to the safe movement of germplasm. FAO, as the depository of the International Plant Protection Convention of 1951, has a long-standing mandate to assist its member governments to strengthen their plant quarantine services, while IPGRI's mandate *-inter alia* -is to further the collecting, conservation and use of the genetic diversity of useful plants for the benefit of people throughout the world.

The purpose of the joint FAO/IPGRI programme is to generate a series of crop-specific technical guidelines that provide relevant information on disease indexing and other procedures that will help to ensure phytosanitary safety when germplasm is moved internationally. The recommendations in these guidelines are intended for small, specialized consignments, e.g. for research, conservation and basic plant breeding programmes. Recommendations for commercial consignments are not the objective of these guidelines.

These technical guidelines are produced by meetings of panels of experts on the crop concerned, who have been selected in consultation with the relevant specialized institutions and research centres. The experts contribute to the elaboration of the guidelines in their private capacities and do not represent the organizations for whom they work.

1 The word 'pest' is used in this document as it is defined in the International Plant Protection Convention. It encompasses all harmful biotic agents ranging from viroids to weeds.

The guidelines are intended to be the best possible advice for institutions involved in germplasm exchange for research, conservation and basic plant breeding. FAO, IPGRI and the contributing experts cannot be held responsible for any failures resulting from the application of the present guidelines. They reflect the consensus of the crop specialists who attended the meeting, based on the best scientific knowledge available at the time of the meeting. The experts who have contributed to this document are listed after this introduction.

The guidelines are written in a short, concise style, in order to keep the volume of the document to a minimum and to facilitate updating. Suggestions for further reading are given at the end, along with the references cited in the text (mostly for geographical distribution, media and other specific information). The guidelines are divided into two parts. The first part makes general recommendations on how best to move *Allium* germplasm. The second part covers the important pests. The information given on a particular pest is not exhaustive but concentrates on aspects that are most relevant to the safe movement of germplasm. Only pests which may be transmitted when germplasm is moved in the recommended form *(in vitro* for garlic and shallot, seeds for onion) are described in these guidelines. *Urocystis*, *Puccinia* and other pathogens transmitted by vegetative material are not covered. The scientific and common names of *Allium* species are given in Tables 1 and 2 on the next pages.

The present guidelines were developed at an FAO-sponsored meeting held in Prague, Czech Republic from 17 to 19 July, 1995. The meeting was hosted by the Research Institute of Crop Production in Prague-Ruzyne.

Guideline update

To be useful, the guidelines need to be updated when necessary. We ask our readers to kindly bring to our attention any developments that possibly require a review of the guidelines, such as new records, new detection methods or new control methods. For your convenience, a form is provided on the last page of this publication.

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Table 1. Cultivated species of *Allium* (Hanelt 1990)

Botanical names of the designation of taxa	Synonyms	English names
A. ampeloprasum L.		
Leek group	*A. porrum* L.	
	A. ampeloprasum L. var. *porrum* (L.) Gay	Leek
Kurrat group	*A. kurrat* Schweinf. ex Krause	
	A. porrum L. var. *aegyptiacum* Schweinf.	Kurrat
Great-headed-garlic group	*A. ampeloprasum* L. var. *holmense* (Mill.), Aschers. et Graebn.	
	A. ampeloprasum L. var. *ampeloprasum* auct.	
	A. ampeloprasum var. *pater-familias* (Boiss.) Rgl.	
	A. ampeloprasum var. *bulbilliferum* Lloyd	Great-headed garlic
Pearl onion group	*A. ampeloprasum* var. *sectivum* Lued.	
	A. cepa L.	
Common onion group	*A. cepa* var. *cepa* L.	
	A. cepa var. *typicum* Rgl.	Onion
Aggregatum group	*A. ascalonicum* auct. non Strand	Shallot
	A. cepa var. *ascalonicum* Backer	
	A. cepa var. *aggregatum G.* Don	Potato onion
	A. cepa var. *solanina* Alef.	
	A. cepa var. *perutile* Stearn	Ever-ready onion
A. chinense G. Don	*A. bakeri* Rgl.	Rakkyo; Ch'iao T'ou
	A. exsertum (Lindl.) Baker non G. Don	
A. fistulosum L.	*A. bouddhae* Deb.	Japanese bunching onion; Welsh onion
A. x proliferum (Moench) Schrad.	*A. cepa* var. *viviparum* (Metzg.) Alef.	Top onion
	A. cepa var. *bulbiferum* Rgl.	Tree onion
	A. cepa var. *prolifera* (Moench) Alef.	Egyptian onion
	A. canadense auct. non L.	Catawissa onion

Botanical names of the designation of taxa	Synonyms	English names
	A. cepa Proliferum group *A. wakegi* Araki *A. aobanum* Araki *A. fistulosum* var. *caespitosum* *A. sativum* L.	Wakegi onion
Common garlic group	*A. sativum* L. var. *sativum* *A. sativum* L. var. *typicum* Rgl. *A. pekinense* Prokh.	Garlic
Ophioscorodon group	*A. sativum* L. var. *ophioscorodon* (Link) Doell *A. opkioscorodon* Link *A. sativum* L. var. *controversum* (Schrad.) Moore jr.	
A. schoenoprasum L.	*A. sibiricum* L. *A. alpinum* (DC.) Hegetschw. *A. riparium* Opiz *A. montanum* Schrank non Schmidt	Chives
A. tuberosum Rottl. ex Spr.	*A. uliginosum G.* Don *A. chinense* Maxim. et auct. non G. Don *A. odorum* auct. non L.	Chinese chives; Nira

Table 2. Wild and ornamental species of *Allium* (after Hyam and Pankhurst 1995)

Botanical name	English name
A. bourgeani Rech: Fil.	Wild leek
A. commutatum Guss.	Wild leek
A. moly L.	Moly, lily onion, yellow onion
A. oleraceum L.	Field garlic
A. scorodoprasum L.	Sand leek
A. ursinum L.	Bear’s garlic, ramsons
A. vineale L.	Crow garlic

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GENERAL RECOMMENDATIONS

- Germplasm should be obtained from the safest source possible. There is, for example, a pathogen-tested *Allium* collection accessible at the Asian Vegetable Research and Development Center (AVRDC), PO Box 42, Shanhua - Tainan 74199, Taiwan.
- If available, true seed of germplasm should be preferred for the movement of *Allium* germplasm since seed poses a minimal risk of moving and introducing pests.
- Germplasm for which true seed is not available should be moved as pathogen-tested *in vitro* cultures. If this is not possible, full quarantine measures must be taken until the vegetative material or seed is cultured *in vitro.*
- *In vitro* material should be tested for viruses known to affect *Allium* in the country of origin of the germplasm. Electron microscopy will allow the detection of all virus particles, including those not yet described.
- Indexing procedures and results should be documented, e.g. in a germplasm health statement. A sample copy is included at the end of this publication.
- The transfer of germplasm should be carefully planned in consultation with quarantine authorities and the relevant indexing laboratory.

Technical recommendations

The following ‘decision tree’ should help those who intend to move *Allium* germplasm to use the safest mode of movement possible.

Can the germplasm be moved as seed?

la If ‘yes’ follow the recommendations under A (Movement of seeds) as this is the safest method of moving *Allium* germplasm. To date, only the pests listed in Table 3 are reported to be transmitted on *Allium* seed. No virus has been reported to be seedborne in *Allium* spp.

lb If the germplasm can definitely not be moved as seed, your next decision is to determine if it can be shipped as *in vitro* material. If ‘yes’ go to **2** and follow the recommendations under B (Movement of *in vitro* germplasm); if ‘no’ go to **3**

2 The germplasm should be sent to an appropriate tissue culture laboratory in the country of origin. *In vitro* plantlets may be infected with any or all of the following viruses, which are described in these guidelines.

- Garlic common latent carlavirus (GCLV)
- Garlic dwarf reovirus
- Leek yellow stripe potyvirus (LYSV)
- Mite-borne filamentous viruses (MbFV)
- Onion yellow dwarf potyvirus (OYDV)
- Shallot latent carlavirus (SLV) and serologically related carlaviruses
- Shallot yellow stripe potyvirus (SYSV)

Other viruses that have not been characterized yet may also be present.

3 You are at this point in the decision hierarchy because the germplasm you want to ship cannot be sent as seed or shipped *in vitro.* If vegetative material is shipped, it should be submitted to quarantine. A 24-h incubation in a moist chamber and examination, e.g. for sclerotia of *Botrytis squamosa*, is recommended. Infected germplasm should be autoclaved. Pests that may be moved with bulbs and cloves include in addition to the viruses listed above:

Fungi
- *Alternaria porri*
- *Botryotinia squamosa* anamorph: Botrytis *squamosa*
- *Botrytis allii*
- *Cladosporium allii-cepae*
- *Fusarium spp.*
- *Peronospora destructor*
- *Sclerotium cepivorum*
- *Stemphylium vesicarium*

Nematode
- *Ditylenchus dipsaci*

Mites
- *Aceria tulipae*
- *Rhizoglyphus robini*, *Rhizoglyphus setosus* and *Caloglypus* spp.

Table 3. Seedborne pests in *Allium* spp.

Pest	Internally seedborne	Externally seedborne	Concomitant contamination
Fungi			
Alternaria porri	—	x	—
Botrytis allii	—	x	x
Fusarium spp.	Possibly	Possibly	x
Sclerotium cepivorum	—		x
Stemphylium vesicarium	x	x	—
Nematode			
Ditylenchus dipsaci	x	—	—

Note: no virus has been reported to be seedborne in *Allium* spp.

A. Movement of seeds

- Seeds should preferably be collected from healthy looking plants that have been tested for seed-transmitted pests.
- Donor plants should be carefully inspected to confirm the absence of insects, mites and nematodes.
- Seeds should be cleaned and surface-disinfected with 0.5% sodium hypochlorite for 10 minutes at room temperature to eliminate externally seedborne pathogens.
- Seeds should be treated with an appropriate pesticide.

B. Movement of *in vitro* germplasm

1. Sterile cultures should be obtained from meristems of pregerminated cloves according to the following procedure:
    - if required, break dormancy by subjecting bulbs/cloves to a 4°C cold treatment (shallot approx. 3 weeks, garlic 2 months)
    - remove the scales
    - surface-sterilize the cloves with 70% ethanol for 1 min, followed by three rinses with sterile distilled water, then with 1% sodium hypochlorite for 15 min, followed by three rinses with sterile distilled water
    - remove meristem (0.3-0.6 mm) and give each meristem a code for future reference

- place one meristem per tube on MS medium for 14 days, then transfer to MS medium with 50 mg/L virazole
- after 6 weeks on MS + virazole medium, excise a 0.5-cm shoot tip and transfer to MS medium with 0.5 mg/L NAA until four leaves have developed
- move test tubes to a 22°C insect-proof greenhouse for acclimatization for 1 week prior to transferring the plantlets to small plastic pots with autoclaved soil
- transfer to 15-cm clay pots
- when plants have reached maturity, withhold water for l-2 weeks and dry the first growth-cycle bulbs
- after breaking dormancy, plant the cloves for a second growth cycle
- perform virus-indexing by serological or other recently developed appropriate methods
  - on *in vitro* plantlets just before transferring them to soil
  - on mature plants at the end of the first and second growth cycles
  - several times during the two growth cycles.

2. When indexing procedures reveal that the plants are free of viruses of concern, their bulbs/cloves can be planted in the field or shipped either directly or after *in vitro* mass propagation.

3. For the movement of *in vitro* germplasm, charcoal, fungicides or antibiotics should not be added to the medium. *In vitro* cultures should be shipped in transparent tubes and visually inspected for bacteria, fungi and arthropods. Contaminated germplasm should be destroyed.

ACRONYMS AND DEFINITIONS OF TERMS AS USED IN THIS PUBLICATION

Cosmopolitan
This expression is used to describe the distribution of pathogens which are reported to occur in all continents and in many countries of these continents

FAO
Food and Agriculture Organization of the United Nations

Germplasm
A set of different genotypes conserved or used in breeding programmes

Incidence
Frequency of occurrence of a disease; usually the percentage of affected plants in an area

IPGRI
International Plant Genetic Resources Institute

MAB
Monoclonal antibodies

Scape
Leafless flower stalk

Seedborne
Carried in, on or with seeds; may be applied to pathogens and non-pathogenic microorganisms

Seed-transmitted
Refers to a pathogen's passage from seeds to seedlings or plants

Set
Small bulb for planting

Severity
Amount or intensity of disease in an individual plant

Significance
Under this heading information on the economic significance of a pest is summarized. Where relevant, information pertinent to germplasm collecting is included.

Treatment

In this publication only treatments that may be applied to germplasm are mentioned. It should be noted that treatments (e.g. fungicide for fungal pathogens, heat treatment for viruses) are rarely eradicative and that any treatment needs to be followed by extensive testing to establish the success rate.

SOURCES OF ANTISERA AND MONOCLONAL ANTIBODIES (MAB)

Recent studies provided strong evidence that the majority of vegetatively propagated *Allium* spp. are commonly infected by several distinct viruses. Former attempts to characterize viruses infecting garlic and other *Allium* spp. often led to confusing results and to an inappropriate naming of viruses, e.g. garlic yellow stripe virus, garlic yellow streak virus and garlic mosaic virus. Later studies showed that researchers coining these names had actually worked on mixtures of some of the now formally described viruses. This was also the reason that many antisera produced in the former studies against virus preparations from naturally infected *Allium* spp. contained antibodies to a range of different viruses, rendering them unsuitable for the identification of *Allium* viruses. However, provided that these antisera do not react with host components (and cryptic viruses) and, most importantly, have been examined for their suitability to sensitively detect some of the major viruses in vegetatively propagated *Allium* spp., they can be used for virusindexing in a virus elimination programme, in combination with antisera and MAB to *Allium* viruses not detected by the oligospecific antisera. High-titered antisera and MAB which are specific to clearly defined *Allium* viruses are commercially available from the sources listed in Table 4. The list is not exhaustive and listed companies are not recommended over others not listed.

Table 4. Commercially available sources of high-titered antisera and MAB that are specific to clearly defined *Allium* viruses

Company	Antisera and MAB to:
BIOREBA AG Chr. Merian-Ring 7 CH-4153 Reinach BL Switzerland	GCLV, Garlic MbFV, LYSV, OYDV, SLV (MAB), SYSV (MAB)
DSM - Arbeitsgruppe Pflanzenviren Messeweg 11-12 D-38104 Braunschweig Germany	see BIOREBA AG

IPO-DLO Dr. J. Vink PO Box 9060 NL-6700 Wageningen The Netherlands	OYDV
SANOFI DIAGNOSTICS PASTEUR 3 Bd. Raymond Poincaré - BP 3 92430 Marnes-La-Coquette France	LYSV, OYDV

DESCRIPTION OF PESTS

Viruses

Garlic common latent carlavirus (GCLV)

The filamentous particles are approximately 650 nm long and slightly flexuous. Garlic latent carlavirus *sensu* Delecolle and Lot (1981) is included in this description.

Significance
On its own it is of minor importance but in combination with other viruses it may cause serious crop losses. High incidence in garlic cultivars in Europe and many other areas of the world (South America, Central America, India, China).

Symptoms
Very weak or no symptoms in singly infected garlic and leek. Symptoms caused by potyviruses may be aggravated by the presence of GCLV (e.g. in leek) (Graichen 1991).

Hosts
- Natural: GCLV has a wide host range within the Alliaceae family. It predominantly occurs in garlic (van Dijk 1993), but has been found in more than 50 *Allium* spp. in a germplasm collection (Graichen, pers. comm.).
- Experimental: apart from the local lesion hosts *Celosia argentea*, *Chenopodium quinoa*, *C. amaranticolor*, some other *Chenopodium* spp., *Nicotiana occidentalis* and several species of the Alliaceae are systemically infected by GCLV (van Dijk 1993).

Geographical distribution
Cosmopolitan. GCLV has been detected in most garlic-growing countries but not in traditional garlic varieties of Japan, Taiwan and Thailand (Barg *et al.* 1994). In these countries, however, GCLV can be found in local markets and in garlic varieties imported for consumption or for germplasm evaluation trials (Barg *et al.* 1997).

Transmission
It is transmitted (with difficulties) by mechanical inoculation; aphid transmission is suspected (van Dijk 1993; Barg *et al.* 1994, 1997). True seed transmission has not been reported. The main mode of virus transmission in *Allium* is by vegetative propagation, particularly of garlic cultivars.

Detection

Serological methods allow easy and specific detection of GCLV by immunoelectron microscopy and ELISA. Owing to a close serological relationship between GCLV and carnation latent virus (CLV) (Barg *et al.* 1997), most antisera to CLV also permit serological detection of GCLV by either method (Conci *et al.* 1992).

For further reading, see p. 51.

Garlic dwarf reovirus

Garlic dwarf disease is associated with the presence of a reovirus named garlic dwarf virus (GDV). Particles appear icosahedral, double-shelled and 65-70 nm in diameter in pH 7.0 phosphate buffer when stained with uranyl acetate or ammonium molybdate. Several properties suggest it is a member of the Fijivirus genus. However, preliminary results show differences from the type members of the three Fijivirus groups. As the virus is not mechanically transmissible and there is no vector known, Koch's postulates are not yet fulfilled.

Significance
So far, limited distribution and low incidence in garlic crops for consumption. High potential for crop destruction.

Symptoms
Initial symptoms are red tips of the basal leaves. The majority of the affected plants do not develop normally, showing a 'tulip' or a 'fan' appearance, with all leaves originating from the same point (Fig. 1). Occasionally, the pseudostems develop normally initially, but later they develop no or very short internodes (Fig. 2). In some cases, plants are dwarfed but seem to recover, since new leaves emerge with regular internodes. The leaves of the most severely dwarfed plants assume a darker green colour. Vein swelling and, rarely, small enations may be present. The bulbs from diseased plants often appear pear-shaped, spongy and wrinkled (Fig. 3). Most cloves are small but some may be normal size.

Hosts
Garlic.

Fig. 1. Garlic cv. Thermidrome infected with garlic dwarf virus (GDV). showing. shortened internodes (right), healthy plant on the left.
(Dr H. Lot, INRA, Montfavet)

Geographical distribution
Reported only in a restricted area of southern France (eastern Rhône valley).

Transmission
No vectors are known. The incidence and distribution pattern of the disease do not suggest a very effective vector (probably a planthopper). Preliminary results suggest that the different types of symptoms described may occur from infected planting material (Lot, unpublished results).

Detection
Virus particles may be observed by electron microscope in leaf dips and more easily by ISEM. The virus is also detected efficiently in leaf extracts by standard DAS-ELISA.

For further reading, see p. 51.

Fig. 2. (above) Dwarfing of garlic cv. Thermidrome grown from GDV-infected cloves; Dl and D3 showed symptoms at an early stage, while D4 initially developed normally. (Dr H. Lot, INRA, Montfavet)

Fig. 3. (right) Cross-section through bulbs of garlic cv. Thermidrome infected with garlic dwarf virus (GDV), healthy bulb on the left. (Dr H. Lot, INRA, Montfavet)

Leek yellow stripe potyvirus (LYSV)

The flexuous and filamentous particles are approximately 820 nm long.

Significance

In western Europe, autumn and winter crops of leek are severely affected. Major outbreaks occur in all year-round cultivation areas of commercial crops. LYSV may cause yield reduction up to 50%. Quality losses by yellow striping are also reported. Recent data proved that the virus may cause a 15-50% reduction in garlic bulb yield, depending on isolates and cultivars (Lot and Delecolle, unpublished results).

Symptoms

On leek a more or less clear yellow striping on the leaf blade from its base upward is common. Rarely plants may become entirely chlorotic and slightly flaccid. Infected plants suffer from early frosts and may be killed. Symptoms are highly variable depending on susceptibility of cultivars. Aggravation of the symptoms was reported when plants were co-infected with shallot latent virus and garlic common latent carlavirus (Paludan 1980; Graichen 1991).

Fig. 4. (above) Leaf of garlic cv. Messidrome with early symptoms of leek yellow stripe potyvirus (LYSV). (Dr H. Lot, INRA, Montfavet)

Fig. 5. (right) Basal leaf and young leaf of garlic cv. Messidrome infected with leek yellow stripe potyvirus (LYSV). (Dr H. Lot, INRA, Montfavet)

On garlic, symptoms include irregular light and dark green striping on the young leaves (Fig. 4), turning to yellow on the basal and intermediate leaves (Fig. 5), especially in the distant part of the blade. The virus does not affect significantly the height of plants but reduces the diameter of the pseudostem and of the bulbs. Co-infection with OYDV accentuates the symptoms (Fig. 6), making them indistinguishable from those due to OYDV (Fig. 7), especially on very susceptible cultivars.

Hosts

- Natural: LYSV is restricted to *Allium* spp.: leek, garlic, great-headed garlic and pearl onion are affected as well as many wild species and ornamental *Allium. A. cepa* (onion and shallot) is rarely infected.
- Experimental: *Chenopodium amaranticolor, C. quinoa, C. murale* and *C. album* react with local lesions.

Geographical distribution

On leek, the virus was reported from several countries in Europe and South America, as well as from Australia and New Zealand. LYSV infecting garlic was first reported by Walkey *et al.* in 1987, but the virus has now been identified in most countries where garlic is grown.

Fig. 6. Garlic plot cv. Messidrome showing from left to right: healthy plants, plants infected with leek yellow stripe potyvirus (LYSV), plants infected with onion yellow dwarf potyvirus (OYD) and a mixed infection with both viruses. (Dr H. Lot, INRA, Montfavet)

Transmission

The virus is transmitted by aphids in a non-persistent manner and by mechanical inoculation (Bos *et al.* 1978). True seed transmission in leek does not occur. Overwintering plants are the only source of infection. The rate of infected garlic cloves depends on the time of infection.

Host specialization of isolates is reported. For instance, natural transmission from LYSV-infected garlic to leek seems quite rare. This host specificity of isolates was also demonstrated by mechanical inoculation: LYSV isolates from leek hardly infect garlic and vice versa.

Detection

ISEM decoration tests are particularly useful to detect LYSV and the possible contaminant virus(es) in plants co-infected with other viruses.

ELISA is currently used for routine tests of leaves or cloves, but the antiserum used must be carefully chosen since antibodies with narrow or wide specificity exist (Barg 1995).

An indirect dot-immunobinding assay is also effective in detecting the virus in *Allium* extracts. The virus is serologically distantly related to onion yellow dwarf virus (OYDV). Its relationship with two other potyviruses infecting *Allium*, Welsh onion yellow stripe virus and shallot yellow stripe virus depends on the strain (van Dijk 1993; Barg 1995).

For further reading, see p. 52.

Fig. 7. Severe streaks on garlic resulting from a mixed infection with leek yellow stripe potyvirus (LYSV) and onion yellow dwarf potyvirus (OYD). (Dr D.E. Lesemann, BBA, Braunschweig)

Mite-borne filamentous viruses (MbFV)

MbFV form a new, as yet unclassified plant virus group with unusually flexuous cross-banded particles of 700-800 nm in length. Phylogenetically they are between poty- and carlaviruses. Included in this group are onion mite-borne latent and shallot mite-borne latent viruses (van Dijk *et al.* 1991), shallot virus X (Kanyuka *et al.* 1992; Vishnichenko *et al.* 1993), garlic viruses A, B, C and D (Sumi *et al.* 1993) and garlic mite-borne mosaic virus (Yamashita *et al.* 1996). It is currently unclear to what extent some of these names represent synonyms.

Significance
Economic significance not yet determined

Symptoms
Generally MbFV induce no or only very mild symptoms (e.g. faint short stripes) in *Allium* spp., hence the name mite-borne latent viruses.

Hosts
- Natural: The viruses have been reported from garlic, onion, shallot, sand leek, rakkyo and several wild leek species (*A. ampeloprasum* complex). Isolates seem restricted to particular *Allium* spp.
- Experimental: Host range seems to be restricted to *Allium* spp. Crow garlic appears to be a good experimental, although symptomless host for all MbFV isolates reported so far. Local lesions are produced only on *Chenopodium murale, C. amaranticolor, C. quinoa* or *Atriplex hortensis,* with not all viruses being able to infect all these test plants (van Dijk *et al.* 1991; van Dijk and van der Vlugt 1994).

Geographical distribution
Cosmopolitan.

Transmission
The eriophyid wheat curl mite *Aceria tulipae* is a very efficient vector on crops in the field as well as on stored bulbs (van Dijk *et al.* 1991). Also through mechanical inoculation. No data are available on seed transmission. The high incidence in many vegetatively propagated *Allium* spp. in Europe and Asia, especially garlic, onion and shallot, is because the viruses spread easily with infected planting material and viruliferous mites on harvested bulbs and cloves.

Detection

Owing to high coat-protein variability, MbFV are difficult to detect by serological methods. Typical highly flexuous morphology and cross-banding of particles distinguishes MbFV from poty- and carlaviruses in the electron microscope.

For further reading, see p. 52.

Onion yellow dwarf potyvirus (OYDV)

The flexuous filamentous particles are approximately 775 nm long.

Significance

Yellow dwarf can be very damaging to susceptible crops of onion and shallot, especially where sanitation procedures are not followed. Incidence up to 50% is reported for onion in many countries. It is also commonly found on garlic.

Symptoms

Stunting is the main symptom in onion and shallot. Leaves show irregular yellow striping to almost complete yellowing and also downward curling, flattening and crinkling (Fig. 8). Also deterioration during storage and premature sprouting of bulbs may occur.

In garlic, varied symptoms of very mild chlorotic stripes to bright yellow stripes depending on virus isolate and cultivars appear. Also reduction in growth and bulb size occur. In combination with other viruses, symptoms may be aggravated.

Fig. 8. Stunting and yellow stripes on onion caused by onion yellow dwarf potyvirus (OYD). (Dr D.E. Lesemann, BBA, Braunschweig)

Hosts

- Natural: restricted to *Allium* spp.; leek does not appear to be affected.
- Experimental: An isolate of OYDV that is particularly aggressive on shallot also locally infects *Chenopodium murale.*

Geographical distribution

Cosmopolitan.

Transmission

OYDV is transmitted by over 50 aphid species in a non-persistent manner and by mechanical inoculation (Bos 1976). Seed transmission is not reported in onion (Louie and Lorbeer 1966). The main route of natural spread is by vector transmission and through vegetative propagation of infected hosts.

Detection

ELISA and decoration tests are useful to identify the virus (van Dijk 1993).

For further reading, see p. 53.

Shallot latent carlavirus (SLV)

The slightly flexuous, filamentous particles are approximately 650 nm long. Included in this description are Sint-Jan's onion latent, garlic latent *(sensu* Japanese authors) and other serologically related carlaviruses.

Significance
On its own it is of minor importance but in combination with other viruses it may cause serious crop losses.

Symptoms
Basically symptomless in singly infected garlic, shallot, onion and leek. Symptoms caused by potyviruses may be aggravated by the presence of SLV (e.g. in leek) (Paludan 1980; Graichen 1991).

Hosts
- Natural: SLV has a wide host range within the Alliaceae family. It predominantly occurs in shallot and garlic but was found in more than 80 *Allium* spp. in a germplasm collection (Graichen, pers. comm.).
- Experimental: apart from some local lesion hosts, e.g. *Chenopodium* spp., *Celosia argentea* and *Vicia faba* (van Dijk 1993), SLV systemically infects *Nicotiana occidentalis* and *N. hesperis* and a wide range of members of the Alliaceae.

Geographical distribution
Widely distributed in many countries of Asia and Europe (Bos 1982; van Dijk 1993; Barg *et al.* 1997). There is also a confirmed report for Mexico (Barg *et al.* 1997).

Transmission
Mechanical transmission and transmission by aphids in a non-persistent manner are possible means of natural spread. However, aphid transmission of SLV is less efficient than that of potyviruses (Bos 1982; van Dijk 1993). Under natural conditions, SLV is mainly disseminated and maintained by vegetative propagation which is particularly significant for garlic and shallot. True seed transmission of SLV has not been reported.

Detection
Serological methods allow detection of SLV by immunoelectron microscopy and to some extent by ELISA. Because of serological diversity among SLV strains, antisera to SLV do not generally permit highly sensitive and specific detection of all SLV strains. Monoclonal antibodies reveal at least six different reaction types (Barg *et al.* 1994, 1997). These inclu-

de SLV isolates from garlic in Japan and Sint-Jan's onion latent virus (van Dijk 1993). The latter reacts with several SLV antisera but not with any of the MABs to SLV (Barg *et al.* 1997). Additional strains of SLV-related carlaviruses may exist in traditional garlic and shallot varieties of Thailand (and other east Asian countries) which may be difficult to detect by ELISA when antisera to the more widespread strains of SLV are used.

For further reading, see p. 53.

Shallot yellow stripe potyvirus (SYSV)

The flexuous particles are approximately 700-800 nm long. Included in this description is Welsh onion yellow stripe virus *sensu* van Dijk (1993), which can be considered an isolate of SYSV (van der Vlugt, pers. comm.).

Significance

Economic significance not yet established but only mild plant symptoms occur.

Symptoms

Mild striping in young leaves of shallot plants and distinct mosaic-like yellow striping in onion.

Hosts

- Natural: shallot, multiplier onion, Chinese chive, garlic, onion and rakkyo.
- Experimental: a virulent isolate of SYSV causes severe malformation, stunting, necrosis and sometimes plant death on onion 'Stuttgarter Riesen' and yellow striping and etching on garlic and Formosan lily *(Lilium formosanum).* Welsh onion yellow stripe virus causes local lesions on *Chenopodium quinoa* and *C. amaranticolor.*

Geographical distribution

Widespread in Asia.

Transmission

Transmitted by mechanical inoculation and aphids (van Dijk 1993). Natural spread through infected planting material. No data on seed transmission.

Detection

SYSV can be detected by immunoelectron microscopy with antisera against SYSV, which are, however, unsuitable for ELISA. When these antisera are used in combination with monoclonal antibodies to SYSV in TAS-ELISA, specific detection of SYSV is possible by (Barg *et al.* 1997).

For further reading, see p. 54.

Other viruses reported to occur in *Allium* spp.

There are several other viruses which predominantly occur in other crops but which have sporadically been isolated from vegetatively propagated *Allium* spp. They appear to be of minor importance because of their restricted distribution. However, they warrant attention in areas from which they have not been reported. Some of them, such as nepo-viruses, are likely to be transmitted by true seed.

Isometric seed-transmitted cryptic viruses (tentative members of the *Partitiviridae*)
Isometric particles with a diameter of about 34 nm have been detected in onion, Welsh onion and leek by electron microscopy and immunoelectron microscopy with antisera to onion yellow dwarf and leek yellow stripe potyviruses. Such particles were also found to be co-purified with potyviruses from *Allium* spp. They were seed-transmitted in numerous onion and Welsh onion varieties at levels of almost 100%, but were not sap transmissible. They are tentatively classified as members of the family *Partitiviridae* (cryptic viruses). In spite of their high seed transmission rate and their worldwide distribution, they may have no economic importance as they do not cause symptoms or yield loss. However, antisera containing antibodies to them can give false positive reactions in virus-indexing work (Barg *et al.* 1994).

Leek yellows virus
This putative luteovirus with isometric particles approximately 30 nm in diameter was detected in leek and rakkyo *(Allium chinense)* showing symptoms of yellowing in Japan (Araki *et al.* 1981). Virus particles were observed in phloem cells, and phloem necrosis is often observed in infected hosts. The virus is not transmissible by sap and, being a luteo-virus, is expected to be not seed-transmissible.

For further reading, see p. 54.

Other viruses of minor or regional importance

	Reported from		
Virus	Host	Country	Reference
Arabis mosaic nepovirus	shallot and tree onion	Germany, The Netherlands	Graichen (1975) van Dijk (1993)
cucumber mosaic cucumovirus	garlic	former Yugoslavia	Stefanac (1980)
leek white stripe virus	leek	France	Lot *et al.* (1996)
lettuce necrotic yellows rhabdovirus	garlic	Australia	Sward (1990)
tobacco mosaic tobamovirus	garlic and onion	Russia	Vasiljeva & Mozhaeva (1978)
tobacco necrosis necrovirus	shallot	The Netherlands	van Dijk (1993)
tobacco rattle tobravirus	garlic, onion, *A. moly*, *A. ursinum* and *A. vineale*	The Netherlands, Denmark and Germany	Kristensen & Engsbro (1966) Graichen (1975) van Dijk (1993) van Slogteren (1958)
tomato black ring nepovirus	shallot and other *Allium* spp.	Northern Ireland, Germany, The Netherlands	Calvert & Harrison (1963) Graichen (1975) van Dijk (1993)
turnip mosaic potyvirus	garlic ornamental *A. ampeloprasum*	Slovenia Israel	Ravnika, pers. comm. Gera *et al.* 1997

Fungi

Alternaria porri (purple blotch)

Alternaria porri (Ellis) Cif. is a dematiaceous fungus producing very large conidia of 50-100 x 15-25 µm, with a filiform apical appendage 30-150 µm (absent in some isolates, which can be mistaken for *Stemphylium*). Most isolates of this fungus produce a purple pigment in the leaf spots as well as in culture media. Several other *Alternaria* species cause leaf spots, but not purple blotch.

Significance
A major leaf-spot agent on *A1lium* spp. under warm weather conditions.

Symptoms
Purple blotch lesions are oval, with a well-delimited margin between dry infected tissue and the healthy part of the leaf or scape. With pigment-producing isolates, the central part of the spot is purple. The fungus sporulates there, appearing as a tenuous black mould. Since conidia are very large, they can be seen with a strong magnifying glass. When several spots appear on a leaf, its apical part becomes yellow and withers. Hollow scapes can be broken at the level of a large lesion.

Hosts
Onion, shallot, leek and garlic.

Geographical distribution
Cosmopolitan.

Biology and transmission
The cardinal temperatures of 15°C -26°C -34°C are much higher than for downy mildew or Botrytis leaf blight. The conidia are very robust; they can persist more than one year on plant debris. Chlamydospores are reported to occur in the soil and only one may induce a leaf spot. Sporulation of *A. porri* is sparse (no more than one to several hundred conidia per leaf spot). *Alternaria porri* is particularly prevalent in the humid tropics where rain showers (removing sporulation inhibitors) are followed by sunshine (inducing sporulation) and dry weather (favouring conidial dissemination).

Onion and leek seeds produced under these conditions can carry mycelia and spores of *A. porri*. The necks of shallot or garlic bulbs originating from diseased plants may also be contaminated.

Detection

Microscopic examination of seeds and bulbs and isolation from seeds on culture media. Colonies of *A. porri* are dark grey and often produce the purple pigment.

For further reading, see p. 55.

Botryotinia squamosa (Botrytis leaf blight)

Teleomorph: *Botryotinia squamosa* Vien.-Bourg., syn. *Sclerotinia squamosa;* anamorph: *Botrytis squamosa* J. C. Walker (Maude 1990; Lorbeer 1992). The fungus is characterized by hyaline conidia 14-23 x 11-16 µm in size and the production of masses of small sclerotia when the fungus is grown in pure culture.

Significance
Botrytis leaf blight is an important foliar disease of onion, particularly in North America, Europe and Asia. The disease can cause significant reduction in bulb size and hence yield.

Symptoms
Initial symptoms of the disease are small elliptical white to straw-coloured lesions of l-5 mm diameter, which mostly occur on the side of the leaf exposed to sunlight. Each lesion usually is surrounded by a greenish-white halo that appears water-soaked. A lengthways sunken slit often occurs in the centre of the lesion. The older leaves are the most susceptible and they typically wilt and blight within 5-7 days of infection and lesion formation. The pathogen in some instances can infect the outer tissues of the bulb, causing a disease known as small sclerotial neck rot (Walker 1952).

Hosts
The pathogen is reported to cause disease only in the genus *Allium* (Farr *et al.* 1989). It is most important on onion *(A. cepa).*

Geographical distribution
Cosmopolitan in temperate regions (Lorbeer 1992; Brewster 1994).

Biology and transmission
Botrytis squamosa survives as sclerotia on onion bulbs, sets and transplants as well as in the soil. Conidia are produced on conidiophores either emerging from the mycelium infecting the host tissue or from sclerotia on the host tissue or in the soil. Airborne conidia are the primary form of inoculum in epidemics. Infected bulbs can transport the pathogen from one region to another. The fungus is not seed-transmitted. The apothecial stage (perfect state) of the fungus is not important in transmission of the pathogen, but serves an important role in the production of genetic diversity of the pathogen (Maude 1990; Lorbeer 1992).

Detection

Culture suspected conidia or sclerotia on media. The fungus is easily differentiated from other *Botrytis* species on the basis of conidial size and the abundant production of small sclerotia.

For further reading, see p. 55.

Botrytis allii (neck rot)

Teleomorph: *Botryotinia aclada* author ???, anamorph: *Botrytis allii* Munn. The conidial layer is shorter and more compact than that of *B. cinerea,* with a conidia size of 10-15 x 8-11 µm. Sclerotia are flat and 2-4 mm.

Significance
Prior to the widespread use of seed treatment, *Botrytis allii* was the principal cause of decay in storage of onion and shallot bulbs. Grey shallot is particularly susceptible to rot in storage.

Symptoms
Onion seedling blight can be caused by *B. allii.* Frequently the fungus remains epiphytic on the leaves of the growing plants and invades senescent tissues at the beginning of maturity. This infection induces apical bulb rot in storage, appearing successively as a grey mould, then as black sclerotia. On plants grown for seeds, *B. allii* can invade the decaying leaves at the base of the scape and then girdle the floral stem with a whitish lesion. Shallot may be invaded in the same way as onion.

Hosts
Onion and shallot.

Geographical distribution
Cosmopolitan in temperate regions.

Biology and transmission
One of the major factors that induce latent infection of growing plants and subsequent bulb rot is seed contamination: there is a strong correlation between the contamination of the seeds by *B. allii* and the amount of neck-rot decay in bulbs (Maude 1983a). Sclerotia of the fungus can survive in soil for about 2 years and longer in dry conditions, e.g. in soil mixed with stored bulbs. At harvest, infections of the section where the necks are cut are possible, thus increasing the percentage of the bulbs which will rot in storage. *Botrytis allii* is highly sensitive to temperature and is usually destroyed by temperatures over 30°C. It cannot invade dry senescent tissues.

Detection
Direct plating on agar.

Treatment

Since *B. allii* does not survive temperatures higher than 30°C, drying bulbs after harvest with hot air circulation (35°C) will eliminate the pathogen from already contaminated necks and prevent the contamination of freshly cut healthy ones.

Onion seeds are coated with a fungicide (benomyl, benomyl + thiram or iprodione at l-2 g/kg of seeds). Shallot mother bulbs from lots having shown a proportion of neck rot can be either treated with hot water (see *Ditylenchus dipsaci),* with addition of the same fungicides at l-2 g/L (for *cepa* shallots), or coated with benomyl or a dicarboximide fungicide (for grey shallots).

For further reading, see p. 55.

Cladosporium allii-cepae (Cladosporium leaf blotch)

Teleomorph: *Mycosphaerella allii-cepae* Jordan, Maude and Burchill (Jordan *et al.* 1986); anamorph: *Cladosporium allii-cepae* (Ranoj.) M.B. Ellis (syn. *Heterosporium allii cepae* Ranoj.). Considered as *Cladosporium allii* (Ellis and G. Martin) P. M. Kirk and J. G. Crompton by Farr *et al.* (1989). Conidiophores of the pathogen are solitary or in groups, brown in colour and generally 80-160 µm long. The conidia are mostly borne singularly and are pale brown and 1-septate (Maude 1990).

Significance
The disease has occurred only infrequently and mainly in temperate growing areas in the past. Severe outbreaks were reported only from Ireland and the UK (Maude 1990).

Symptoms
The fungus produces elliptical yellow to greyish lesions which run parallel to leaf veins. After the fruiting structures and conidia are produced, the lesions become brown to dark brown. The disease can occur at any time in the growth of the plant, but mostly occurs after bulbing and particularly when the leaves commence senescing. Lesions on onion leaves are 0.5 x 1.5 cm and are smaller than on other *Allium* species (Hill 1995).

Hosts
Allium spp. (including onion, shallot, Welsh onion and a number of wild species), *Sisyrinchium* spp., *Triteleia* spp. (Farr *et al.* 1989; Maude 1990).

Geographical distribution
Ireland and UK (Maude 1990); Canada and USA (Hill 1995).

Biology and transmission
The fungus can persist for 3 months on onion debris. The fungus is not seedborne (Maude 1990).

Detection
The pathogen can be detected by direct examination of potentially infected plant parts and plant debris on the soil surface after incubation in a moist chamber for l-3 days.

For further reading, see p. 56.

Fusarium spp. (Fusarium basal rot)

Fusarium oxysporum Schltdl. emend. Snyder and H.N. Hansen f. sp. *cepae* (Hanzawa). A number of synonyms are known (Entwistle 1990). The fungus produces microconidia (usually unicellular and spheroid), macroconidia (fusiform or ellipsoid and mostly 3-4 septate) and chlamydospores (7.5 to 10 µm in diameter) which form in roots and soil (Entwistle 1990).

Significance
Infected plants will have a reduced seed yield. Economic losses were reported from Italy, South Africa, Japan and the United States (Farr *et al.* 1989; Havey 1995).

Symptoms
Delayed seedling emergence, seedling damping off, stunted growth of infected plants, decay of the basal plate area in growing plants and basal rot of bulbs in storage. Infection of seedlings and enlarging plants is accompanied by leaf chlorosis and dieback resulting in the desiccation of leaves which usually remain upright. Roots of infected plants are brown to dark brown in colour (Havey 1995).

Hosts
Onion, chive, garlic and shallot.

Geographical distribution
Cosmopolitan.

Biology and transmission
Mainly transmitted by infected transplants, sets, bulbs and possibly garlic cloves. Vegetative planting material may be infected by the fungus but remain symptomless. Seed transmission has not been observed, although some reports of isolation from seed have been made (Entwistle 1990). Soil infested with chlamydospores adhering to the plant parts may also serve as a source of inoculum (Entwistle 1990; Havey 1995). These spores when close to roots germinate and penetrate healthy root cells or invade through wounds in the roots. The fungus then invades the vascular system of the plant. In mature plants the infection remains in the basal plate area for some time before spreading to the fleshy bulb scales and causing decay of the bulb.

Detection
The pathogen can be isolated from diseased roots, stem plate tissues and onion bulb scales. It can be detected in soil by the use of selective media (Abawi and Lorbeer 1972).

For further reading, see p. 56.

Peronospora destructor (onion downy mildew)

Peronospora destructor (Berk.) Casp. has pyriform to fusiform sporangia, 18-29 µm long and borne terminally on sterigmata of nonseptate sporangiophores.

Significance
The disease can be serious on onion and other *Allium* species grown for bulbs or seed, especially when relatively cool, moist weather prevails.

Symptoms
The disease is characterized by pale-green, yellowish to brownish, oval to cylindrical shaped areas on leaves and seed stalks. The fungus produces masses of sporangiophores and sporangia. The sporangia are transparent to grey in colour at first and then turn violet. The leaves become girdled in the region where the sporangia are formed, then collapse and wilt. The dead tissue typically is rapidly colonized by *Stemphylium botryosum* which forms masses of black spores on the necrotic leaf tissue. Bulb growth is reduced by the disease and the bulb tissue (especially the neck area) becomes spongy which causes the bulb to lack storage quality (Walker 1952; Maude 1990).

Hosts
Onion, shallot, leek and chive.

Geographical distribution
Cosmopolitan in temperate climates.

Biology and transmission
The pathogen overwinters primarily as mycelia in infected onion bulbs that remain in onion fields or in nearby cull piles. The pathogen can also overwinter in perennial varieties of onion in home gardens (Walker 1952). Local dissemination is primarily by airborne sporangia, which do not form zoospores but germinate directly by forming one or two germ tubes and infect onion leaves by penetrating the stoma. Long-range dissemination is primarily by systemically infected propagative material (bulbs, sets, transplants). The fungus is not seedborne (Maude 1990; Brewster 1994).

Detection
The fungus is an obligate parasite. Propagative material should be put in a moist chamber and checked for sporangia.

For further reading, see p. 56.

Sclerotium cepivorum (onion white rot)

Sclerotium cepivorum Berk. produces spherical black sclerotia 0.3-0.5 mm in diameter and aerial white mycelium. Some isolates produce larger sclerotia (up to 1 mm) and fewer mycelia.

Significance
S. cepivorum induces one of the most important *Allium* diseases, killing onion and leek plantlets in the seedbeds or in the seed furrow. At a later stage severe losses are caused by basal rot on onion, leek, garlic and shallot.

Symptoms
For plantlets as well as for maturing bulbs, the disease starts with a translucent rot of roots. On maturing bulbs of onion, shallot and garlic the symptom is a basal rot with white mycelia on which sclerotia appear later. A 'black rot' of garlic may appear in plots previously invaded by wild *AIlium* spp.

Hosts
Allium spp.

Geographical distribution
Cosmopolitan, except tropical lowlands.

Biology and transmission
Cardinal temperatures for mycelial growth are 10°C -18°C -24°C. The sclerotia can remain dormant in the soil for some years. Late infections can remain almost symptomless and are the main source of infection in garlic and shallot seed cloves or mother bulbs.

Detection
Inspection for the presence of sclerotia and white mycelium.

Treatment
No eradicative treatment available.

For further reading, see p. 56.

Stemphylium vesicarium (Stemphylium leaf blight)

Teleomorph: *Pleospora allii* (Rabenh.) Ces. & De Not., anamorph: *Stemphylium vesicarium* (Wallr.) E. Simmons. Conidia are oblong to oval, 25-42 µm, dark in colour with l-5 transverse septa and often constricted at the middle one or three most central of the septa. The conidia can be distinguished by microscopic examination from those of *S. botryosum.*

Significance

During the past 20 years this disease has become increasingly important in temperate and tropical regions throughout the world. It is a major disease of onion in Southeast Asia and India (Gupta *et al.* 1994) and epidemics have caused significant losses in Texas and New York in North America (Miller *et al.* 1978; Lorbeer 1993). It frequently occurs at the same time and on the same plants as *Alternaria porri,* the cause of purple blotch, as a disease complex.

Symptoms

The disease is characterized at first by small yellow to brown lesions which rapidly enlarge to elongated spindle-shaped to ovate-elongate lesions which, if numerous, coalesce followed by blighting of the leaves.

Hosts

The fungus occurs on a wide variety of herbaceous plants including *Allium*, *Asparagus, Eichhornia, Juncus* and *Triticum.*

Geographical distribution

Cosmopolitan.

Biology and transmission

The fungus is seedborne and airborne. It can be transmitted as conidia and mycelia on other hosts as well as *Allium.*

Detection

Standard agar-plating procedures.

For further reading, see p. 57.

Minor fungal and bacterial pathogens

Pathogen	Disease caused	Symptoms	Hosts	Countries reported	Reference
Aspergillus niger	black mould	soft rot followed by black mould	onion and shallot	Cosmopolitan	Prasad *et al.* (1986)
Botryotinia porri, anamorph: *Botrytis porri*	grey mould	rot of external leaf sheaths along the pseudostem of leek and garlic	leek and garlic	Belgium, France	Presly (1985)
Penicillium corymbiferum and *P. cyclopium*	green rot	rot of bulbs resulting in yellowing and tip-burn of the first leaves, occasionally in plant death	garlic, occasionally onion and shallot	Cosmopolitan	Bruna (1985)
Phytophthora porri	downy mildew	'white tip of leek', lesions also at the border of leaves	leek, occasionally onion	Europe	Tichelaar and van Kesteren (1967)
Pseudomonas fluorescens	maladie café au lait'	slimy, light brown lesions on the external sheaths of the pseudostem, progressing downwards	garlic	France	Samson (1982)
Pseudomonas viridiflava	leaf streak and bulb rot	water-soaked dark green lesions, developing into streaks	onion	USA	Gitaitis *et al.* (1991)
Xanthomonas campestris	Xanthomonas blight	white flecks with water-soaked margins; tip dieback	onion	Hawaii, Barbados	Alvarez *et al.* (1978)

Nematodes

Ditylenchus dipsaci (stem and bulb nematode)

Ditylenchus dipsaci (Kühn) Filipjev is an endoparasitic nematode whose adults can reach a length of 1 mm and a width of 20-35 µm. They swim actively when emerging from diseased tissues crushed in water.

Significance
A major pest of *Allium* spp. in temperate climates and the high-altitude regions of the tropics and subtropics.

Symptoms
Young infected onion plants are stunted, curved (Figs. 9 and 10), with an inflated basal part (bloat). If they survive, they produce bulbs with spongious rot of the external scales, which is the dominant symptom in shallot. On garlic attacked during bulb enlargement, *D. dipsaci* induces a reddish rot of the basal part of the bulb. The growing cloves become separated from each other. The leaves of diseased plants show a purplish discolouration and the pseudostem is stunted.

Hosts
More than 400 host plants have been described for *D. dipsaci*. The species is subdivided in races. The *Allium* race also attacks oats, sugar beet, Swiss chard, spinach and legumes (bean, pea, soyabean). Onion, garlic and shallot are affected more than leek.

Geographical distribution
Cosmopolitan, except tropical lowlands.

Fig. 9. Deformation and early senescence of leaves caused by *Ditylenchus dipsaci*. (Dr R.A. Sikora, Bonn University)

Biology and transmission

Cardinal temperatures for nematode activity and infection are 10°C -22°C -30°C. In soil, they survive as fourth stage larvae at temperatures not exceeding 35°C. In onion true seeds or garlic and shallot mother bulbs the nematodes remain in a condition of anhydrobiosis, under which they can survive a long time and become active again when rehydrated. The larvae penetrate *Allium* plants at the point of emergence of roots through the leaf sheath and can invade the short true stem of the plant, causing its disintegration, or between and inside the leaf-sheaths and the scape (Fig. 11) and move into the onion umbels.

Detection

Bulbs are cut into four pieces and macerated in water for 12 hours: rehydrated larvae move into the water and can be isolated by successive sievings following the standard nematological methods.

Treatment

Hot water treatment for elimination of *Ditylenchus* from bulbs and onion seeds. Mobile *Ditylenchus* are killed after 1 hour at 44.5°C or 2 hours at 43°C. Anhydrobiotic larvae are more resistant. The most effective method is therefore to leave the bulbs for 10 hours in cold water (20°C) to rehydrate the nematodes, then to put them in water for 1 hour at 48°C for garlic or 2 hours at 43°C for shallot.

For further reading, see p. 58.

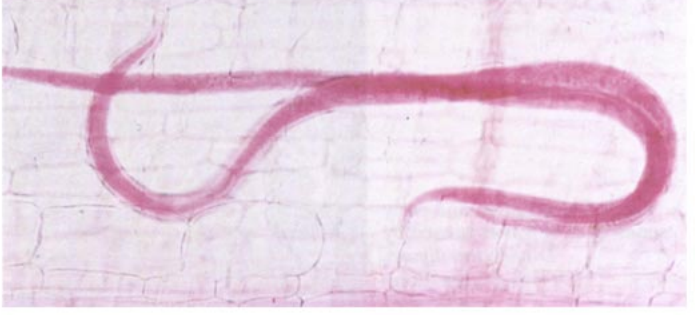

Fig. 10. (above) Deformed onions with *Ditylenchus dipsaci* infestation. (Dr R.A. Sikora, Bonn University)

Fig. 11. (right) *Ditylenchus dipsaci* in plant tissue. (Dr R.A. Sikora, Bonn University)

Arthropods

Aceria tulipae (garlic mite)

Aceria tulipae (Keifer) (Synonym: *Eriophyes tulipae),* a mite between 0.1 and 0.25 mm long, belonging to the family Eriophyidae (gall mites). They are worm-like in shape and have two pairs of legs at the anterior end of the body.

Significance
This mite is a serious pest of garlic but also occasionally damages onion and shallot. It is a vector of several viruses in the field and in storage.

Damage
Yellow streaks and twisted growth of the leaves, reduction in plant growth and shrivelling of bulbs in storage. In stored bulbs secondary rots may occur. The damage to foliage may be confused with virus symptoms. When infected cloves are planted, *Aceria* infections appear in leaves as localized distortions and mosaics. Leaves are often folded together and difficult to separate.

Hosts
Allium species, particularly garlic; other monocotyledons.

Geographical distribution
Cosmopolitan.

Biology
The females lay round, colourless eggs of 0.06 mm diameter on bulbs. There are two nymphal stages similar in appearance to the adults. Mites can mainly be found along the hollow crease of the leaf mid-vein. At maturity, the mites move down towards the bulb. Unfavourable conditions are survived by entering diapause. Transmission by infested plant material and by wind transportation.

Detection
Careful inspections of bulbs and other plant material for infestation by mites.

Treatment
No specific treatment recommended.

For further reading, see p. 58.

Rhizoglyphus robini Claparede (Synonym: *R. echinopus)* *Rhizoglyphus callae* Oudemans

Small yellow white mites with a globular body up to 0.9 mm long belonging to the mite family Acaridae (bulb mites). Adult mites with four pairs of short stout legs.

Significance
These mites attack bulbs, corms and tubers of different plant species and are occasionally serious pests on stored onion and garlic bulbs. Their virus vector status is unknown.

Damage
Heavy infestation of bulbs in storage leads to a pulpy, rotting mass. Usually, these mites feed on bulbs which have been damaged by other pests or diseases or mechanically.

Hosts
Polyphagous on many bulb-, corm- or tuber-forming plants.

Geographical distribution
Cosmopolitan.

Biology
The females lay up to 100 eggs of 0.2 mm diameter singly on bulbs, corms or tubers. Under favourable conditions it takes less than 15 days to complete the life cycle. In adverse conditions a specialized shiny brown immature stage is formed. Transmission is by insects and other animals to which the mites are attached and by infested plant material.

Detection
Careful inspections of bulbs and other plant parts for infestation by bulb mites.

Treatment
No specific treatment recommended.

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Viruses

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SAMPLE GERMPLASM HEALTH STATEMENT No.____

This statement provides additional information on the phytosanitary state of the plant germplasm described herein. It should not be considered as a substitute for the Phytosanitary Certificate.

IMPORT PERMIT

No. ______________________________
Issued by _________________________
Date ______________________________

PHYTOSANITARY CERTIFICATE

No. ______________________________
Issued by _________________________
Date ______________________________

ORIGIN OF THE GERMPLASM

[ ] The material in this package was obtained from meristems cultured *in vitro,* which were found free of viral pathogens using recommended virus-detection techniques.

[ ] The material in this package was obtained from ___[plant species]___ meristems, aseptically grown *in vitro* from the terminal buds of stakes previously subjected to thermo-therapy for ___[time]___ These stakes were originally obtained from [plant species] free from symptoms of [diseases] .

[ ] The germplasm described here has been produced under glasshouse or screenhouse conditions, in sterilized soil and in the absence of any visible pathogen or pest of quarantine significance.

[ ] The germplasm described here has been produced under intensive chemical protection in fields and regions isolated from commercial or experimental plantings of this species. These fields are exclusively used for the pest-controlled multiplication of germplasm.

[ ] The germplasm described here has been multiplied under field conditions, which do not guarantee the absence of pests or pathogens of quarantine importance.

PATHOGEN DETECTION METHODS

[ ] The germplasm described here was produced under periodic field supervision by a pathologist / virologist and it was found to be free from pathogens of quarantine significance.

[ ] Representative seed samples of the germplasm described here were assayed in the Seed Health Laboratory at ___[institute]___ , following the methods recommended in the FAO/IPGRI Technical Guidelines for the Safe Movement of _[crop]_ Germplasm:
- [ ] extraction / washing test for ___[nematodes, fungi]___
- [ ] culture on agar media for ___[fungi]___
- [ ] serological for _[viruses]__

No pathogens of quarantine significance were detected.

[ ] The plants selected as sources of meristems for *in vitro* culture were assayed using the following tests for the diagnosis of viral diseases.
- [ ] electrophoretic
- [ ] serological
- [ ] biological (grafting)

SEED TREATMENT

[ ] Seeds were treated with a solution of sodium hypochlorite.
[ ] Seeds were subjected to a dry heat treatment at _[temperature]_ °C for __[x]__ days.
[ ] Seeds were scarified with sulphuric acid.
[ ] Seeds were treated with _[fungicide(s)]______ at [rate]____.
[ ] ________[other]________

ADDITIONAL INFORMATION
FOR FURTHER INFORMATION

Please contact:

DECLARATION

We hereby declare that the information provided in this germplasm health statement was obtained in good faith, according to our technical capabilities at the time of the test. Neither ___[institute]___ nor its scientific staff assumes any legal responsibility in relation to the declaration.

Date ________________________ Signature ______________________

Comments on Technical Guidelines for the Safe Movement of *Allium* Germplasm

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I would like to bring the following

[ ] inaccuracy (ies)
[ ] new development (s)
[ ] omission (s)
[ ] concerns

to the attention of the editors:

Disease

Comments

From:

Name

Address

Date

Signature

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