Integrated Management of Virus Diseases in Vegetable Crops in the Open Field

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Abstract

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Virus diseases severely reduce the productivity and quality of vegetable crops in the Mediterranean Basin. Due to the diversity of viruses affecting each crop, a global control approach is required for each cropping system. The use of healthy seeds in a clean environment should limit early infections which often are the most damaging. Adapted cultural practices may contribute to prevent, delay or slow down epidemics. Breeding for resistance is a major component of this control strategy, but depends on the presence of effective resistance genes in available cultivars. Integrated management of virus diseases affecting cucurbit, solanaceous or garlic crops is reviewed.

Introduction

Vegetables constitute one of the major cash crops in some of the most productive agricultural areas of the Mediterranean region. Cucurbitaceae (cucumber, melon, squash and watermelon), solanaceae (tomato and pepper) and liliaceae (garlic) crops are particularly important and represent a wide diversity of species and cultivars grown in a range of agroecological conditions. Virus diseases are one of the major limiting factors of vegetable production, not only by reducing the yields but also by affecting crops quality. Consequently, it is not uncommon that farmers face complete yield losses due to virus diseases.

Very often, vegetable crops in the fields are not infected by a single virus, but by several viruses forming complex and changing pathosystems (2, 5).

Evolution in virus populations in recent years has been the consequence of the occurrence of new viruses (such as TYLCV (for complete virus names see Table 1) or ZYMV) or of the introduction of new vectors (such as *Frankliniella occidentalis*, an efficient vector of TSWV). Changes in cultural practices (and in particular the important development of protected crops), in production regions and in planting dates have also contributed to changes in the relative incidence of virus diseases.

In this context, efficient control of viruses in vegetables can only be achieved through a global strategy associating environmental, cultural and genetic approaches.

Diversity of plant virus pathosystems affecting vegetable crops

The development of simple, economical and reliable diagnostic methods (such as the enzyme linked immunosorbent assay (ELISA)) and regular surveys conducted in the major production areas contributed greatly to a better understanding of the virus problems in specific crops in most of the mediterranean countries. Knowledge on virus ecology and epidemiology has also considerably improved in recent years, contributing significantly to the implementation of methods that may help to delay or prevent early virus epidemics.

A large number of viruses have been described as infecting vegetable crops throughout the world (6, 9). The major viruses occurring in the Mediterranean region are listed in Table 1. Some have a wide host range, and may infect many different crops or wild plant species (such as CMV affecting cucurbits, solanaceae as well as many other cultivated species and weeds), while others are mostly limited to only one crop and a few wild species (such as TYLCV affecting mostly tomato).

The relative incidence of the different viruses affecting one crop may depend on many factors such as the region, the season, the year and the general environment of the crop.

Basic components of integrated virus management in vegetables

The diversity of crops, cultural practices, viruses and their vectors prevents the development of an universal method which would permit an efficient control of all virus diseases. Farmers have to rely on specific, and generally only partially efficient techniques which are intended to limit virus and/or vector sources near or within the crop and to reduce or delay virus spread. When available the use of resistant cultivars or cross protected plants can be an important component of this integrated control strategy (4).

Components of mosaic virus control in cucurbits, tomato and pepper

Basically, similar strategies can be proposed to farmers to control viruses in these different crops. They should integrate a diversity of actions intended to (i) obtain healthy seedlings in a clean environment, (ii) reduce vector activities and virus spread and (iii) cultivate resistant or protected plants.

The use of healthy seeds, free of seed-transmitted viruses (TMV and PMMV for tomato and pepper; CGMMV, SqMV and MNSV for cucurbits) will limit introduction of new viruses in a region and prevent early infections within a crop. Although seed certification is generally not yet mandatory in many Mediterranean countries, informations regarding the absence of seed-transmitted viruses should be available from seed companies.

A careful weed control within and around the fields will contribute to limit virus and/or virus sources near the crop. Most of the vegetable viruses can infect a range of weeds common within or next to cultivated fields, which constitute alternative hosts for viruses (or for their vectors) in the absence of the crops. It is from these reservoirs that primary infections will come (11). Similarly, it is important to avoid plantings near old or abandoned crops; indeed such crops are often neglected by farmers and could be abundant sources of viruses and vectors (2).

Isolating and protecting nurseries will also contribute to prevent early contamination. This can be achieved by producing seedlings in insect proof greenhouses or more simply by using small shelters covered by insect-proof nets.

The use of plastic mulches (transparent, black, silvery...) proved to be particularly efficient for repelling aphid vectors and for reducing virus spread, at least until the plant growth cover their surfaces (4).

Table 1. Major virus diseases affecting vegetable crops in the Mediterranean Basin and diversity of their means of spread.

Vectors	Cucurbits	Tomato and pepper	Garlic
Aphids	CMV, WMV2, PRSV, ZYMV, CABYV	AMV, CMV, PVY	OYDV, LYSV, SLV, GCLV
Whiteflies	WCSV, CYSDV, CVYV	TYLCV	
Thrips		TSWV	
Fungi	MNSV		
Mites			Gar V type V
Unknown			GDV
Contact	CGMMV	TMV, PMMV	
Seeds	SqMV, MNSV	TMV, PMMV	All viruses

AMV: Alfalfa Mosaic alfamovirus
CABYV: Cucurbit Aphid Borne Yellows luteovirus
CGMMV: Cucumber Green Mottle Mosaic tobamovirus
CMV: Cucumber Mosaic cucumovirus
CVYV: Cucumber Vein Yellowing Virus
CYSDV: Cucurbit Yellow Stunt Disorder closterovirus
Gar V type V: Garlic V type virus
GCLV: Garlic Common Latent carlavirus
GDV: Garlic Dwarf reovirus
LYSV: Leek Yellow Stripe potyvirus
MNSV: Melon Necrotic Spot carmovirus
OYDV: Onion Yellow Dwarf potyvirus
PMMV: Pepper Mild Mottle tobamovirus
PRSV: Papaya Ringspot potyvirus
PVY: Potato Virus Y potyvirus
SLV: Shallot Latent carlavirus
SqMV: Squash Mosaic comovirus
TMV: Tobacco Mosaic tobamovirus
TSWV: Tomato Spotted Wilt bunyavirus
TYLCV: Tomato Yellow Leaf Curl geminivirus
WCSV: Watermelon Chlorotic Stunt geminivirus
WMV2: Watermelon Mosaic 2 potyvirus
ZYMV: Zucchini Yellow Mosaic potyvirus

Alternatively, physical barriers can be used to prevent vectors to reach the plants (insect proof nets, floating covers...). The main limitation for this type of protection, is the need of insects for pollination by many vegetable crops. For such crops, it is necessary to open or remove such covers for fruit setting which may reduce their efficiency and profitability (2).

Field segmentation into small blocks by using either windbreaks or intercropping can also be efficient to prevent rapid virus spread throughout a crop. However it has to fit with the requirements of mechanized agriculture.

Insecticide applications may efficiently limit vector populations in the crops, but generally they do not prevent virus transmission and dissemination, especially for viruses that are transmitted non-persistently by aphids (2). In contrast, mineral oils applications may help to prevent non-persistent virus dissemination under certain conditions (7).

The use of mild virus strains to protect plants from severe infections by aggressive strains of the same virus (cross protection) has been very successful in vegetable crops, especially for viruses inducing severe epidemics and yield losses. Cross protection of tomatoes against TMV has been very popular in the early 1970's until the release of resistant varieties (8). Presently, the use of a mild strain of ZYMV provides a good control of this severe virus in cucurbits (3).

For farmers, the use of resistant cultivars is probably the most economical and simple way to control virus diseases. However, resistant cultivars are presently available only for a few viruses and for a few hybrid cultivar types (Table 2). Breeding programs are very active to introduce more resistance genes either through classical genetics or through genetic engineering. However, this strategy faces two major limitations: resistance is generally virus specific, and breeding programs have to associate, within a same cultivar, resistance to several viruses in order to be fully effective. In some cases, virus evolution has led to the occurrence of virus isolates breaking down resistance genes, ruining the efforts of plant breeders (1).

Table 2. Examples of resistance or tolerance to viruses already available in commercial cultivars or used in advanced breeding programs.

Species	Present in commercial cultivars	Used in breeding programs
Tomato	TMV, TYLCV	AMV, CMV, PVY, TSWV
Pepper	CMV, PMMV, PVY, TMV	TSWV
Melon	Aphids, MNSV	CMV, CABYV, PRSV, ZYMV
Squash	CMV, ZYMV	WMV2, PRSV

Components of virus control in garlic

Garlic is quite different from other vegetable crops since it is only vegetatively propagated. This type of multiplication has, through the years, led to a 'degeneration' phenomena where cultivars have lost most of their productivity through accumulation of virus infections.

Therefore the first part of an efficient control strategy of virus diseases in garlic is the regeneration of cultivars through the meristem-tip culture technique (12). *In vitro* culture of these meristems can produce within 6 to 8 months regenerated plants. These plants are very carefully tested for the absence of viruses using either ELISA or immuno-sorbent electron microscopy (ISEM) and then submitted to clonal selection.

In France, certified seeds (tolerance of 1 % seeds infected by pathogenic viruses (OYDV and LYSV) (5)) are produced following a specific scheme (10). The plants of each variety are multiplied during 5 to 6 generations. The first generations (F1 and F2) are grown as lines, under insect-proof greenhouses. The following generations are now commonly grown in the fields under insect-proof nets up to the F4 (prefoundation seeds) and sometimes F5 (foundation seeds). During the multiplication process, regular observations for symptoms and ELISA tests are conducted; diseased plants are carefully rogued to ensure that the contamination level is below 1 ‰ for foundation seeds.

Foundations seeds are used for a final multiplication cycle to produce seeds certified as free of pathogenic viruses that can be used by farmers to produce high yields of good quality garlic bulbs.

Conclusion

From these examples it is clear that virus control in vegetable crops can only be achieved through the integration of a variety of methods all intended to prevent, delay or reduce virus spread in the fields.

However permanent contacts between plant pathologists, extension people and farmers are necessary in order to update these strategies when needed. This might be necessary when new resistant cultivars are released or new developments in cultural practices are proposed. This is mandatory when changes occur in the virus pathosystems, such as the introduction of a new virus or vector, or the emergence of virus strains overcoming resistance genes.

الملخص

لوكوك، هـ.، هـ. لوت وك. ج. سيلاسي. 1998. المكافحة المتكاملة للأمراض الفيروسية على الخضراوات تحت الظروف الحقلية. مجلة وقاية النبات العربية. 16(1): 32-34.

إن الأمراض الفيروسية هي من العوامل المهمة في تقليل إنتاجية ونوعية محاصيل الخضراوات في بلدان حوض البحث الأبيض المتوسط. ونظراً لتعدد الفيروسات التي تهاجم هذه المحاصيل وكذلك طرق انتشارها لذلك يفضل في مكافحتها استخدام الطرق الشاملة للنظام الزراعي للمحاصيل. فاستخدام البذور الخالية من الفيروسات في بيئة نظيفة يحد كثيراً من الإصابات التي تظهر في بداية الموسم، والتي عادة تكون الأكثر ضرراً. كما أن استخدام طرق زراعية محددة يؤدي إلى منع أو تأخير أو إبطاء الانتشار الوبائي لهذه الفيروسات. لا شك بأن استخدام الأصناف المقاومة هو أحد العوامل المهمة في المكافحة، إنما يعتمد ذلك على مدى وجود العوامل الوراثية للمقاومة في الأصناف الزراعية. وسنقدم أمثلة عن المكافحة المتكاملة للأمراض الفيروسية التي تصيب القرعيات، خضراوات العائلة الباذنجانية وكذلك محصول الثوم تحت الظروف الحقلية.

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