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Virus-vector nematodes in cereals and fruit crops in Spain

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Studies on nepoviruses and tobraviruses, and their relationships with their associated vector nematodes, are scarce in Spain. However, virus disease symptoms have often been detected and their nematode vectors are widespread in Peninsular Spain. Nepovirus vector nematodes (*Longidorus attenuatus*, *L. coespiticola*, *L. elongatus*, *L. macrosoma*, *Xiphinema coxi*, *X. diversicaudatum*, *X. index*, *X. italiae*, *X. pseudocoxi* and *X. vuittenezi*) have been found associated with fruit and cereal crops. All are also widespread in other crops and uncultivated areas, together with *X. rivesi*, which has not yet been found associated with fruit and cereal crops in Spain. Tobravirus vectors have been less studied in Spain. Of the five recorded species, *Paratrichodorus minor* and *Trichodorus primitivus* are present on maize and wheat respectively. The geographical and host distribution of these nematodes are given and their ecological characteristics are discussed.

Introduction

Virus vector nematodes, especially Longidorids, have been rather well studied in Spain with respect to: distribution in different areas and crops (Arias *et al.*, 1985, 1986a; Bello *et al.*, 1986; Navas & Arias, 1986; Navas *et al.*, 1988); taxonomy and morphology (Andrés & Arias, 1987, 1988a; Arias, 1978; Arias & Roca, 1986; Arias *et al.*, 1986b, 1987; Rey *et al.*, 1988; Roca & Arias, 1986). Some work also exists on biology (Andrés & Arias, 1988b), pathogenicity (Andrés & Arias, 1985, 1988a) and ultrastructure (Lopez-Abella *et al.*, 1964, 1966, 1967; Andrés *et al.*, 1988, 1989).

As regards nepoviruses, some papers have dealt with grapevine fanleaf nepovirus (Peña Iglesias & Ayuso, 1971; Peña Iglesias *et al.*, 1978; Fresno *et al.*, 1978; Romero *et al.*, 1978), artichoke degeneration virus (Romero *et al.*, 1985) and fruit trees crops (Camarasa *et al.*, 1987). There are only two papers on nematode-virus disease relationships (Alfaro Garcia, 1971; Fijo & Arias, 1976) and there is no joint work between virologists and nematologists, though some associations have been detected in the field.

The aim of this work was, therefore, to compile the information available on this subject in Spain and to discuss the problems that these nematodes could represent for cereals and fruit crops, the importance of such crops as refuges and sources of these pathogens, and their ecology and distribution. Joint studies between nematologists and virologists are needed on the epidemiology of these diseases as a basis for preventing their spread and the introduction of new viruses and/or strains.

Virus-vector nematodes in cereal growing areas

Brome mosaic bromovirus (BMV) is the only virus reported to be transmitted in cereals by nematodes, *Xiphinema paraelongatum* and *X. coxi* (Bancroft, 1970). It causes mosaic on barley, wheat, oats, rye and necrosis on maize, and probably has the widest range of grass hosts of any mechanically transmissible virus. It has been reported in USA, South Africa, Germany, Finland and Russia, but not yet in Spain (Jordá & Osca, 1987). However, *X. coxi europaeum* and *X. pseudocoxi*, components of the *X. coxi* complex (Sturhan, 1985), have been reported at 11

localities in the Región Central, and at one biotope in La Rioja and at seven points in the Región Central respectively, but have not yet been found on cereal crops.

Another nematode of this family, *Longidorus belloi*, recently described and not yet demonstrated as a virus vector, has been found in cereal growing areas, causing root tip galls in wheat, barley, lentil, vetch and rye-grass (Andrés & Arias, 1988c).

Besides, *L. elongatus* has been found on rye and wheat, *X. diversicaudatum* on oats and wheat, *X. index* on maize, and *X. italiae* on barley, oats and wheat. All these nematodes are vectors of different nepoviruses in other crops. Among tobravirus vectors, *Paratrichodorus minor* has been reported causing damage on maize (Del Moral & Martinez-Aljama, 1985) and *P. hispanus* has recently been described on wheat (Roca & Arias, 1986). Though none of these nematodes are vectors of any virus in cereal crops, they could use them as refuges.

Virus-vector nematodes in fruit crops

Some 16 nepoviruses have been reported on fruit crops in Europe and America, transmitted by seven species of *Longidorus*, five of *Xiphinema* and one of *Paralongidorus*. Only cherry leaf roll nepovirus (CLRV) has been detected in Spain, on almond, hazel and walnut, and only recently (Camarasa *et al.*, 1987). However, eight nepovirus vectors appear widespread on different host plants, five of them in association with fruit crops. Table 1 shows the virus-vector nematodes which occur on fruit trees in Spain, as well as the viruses which they have been reported to transmit in other countries.

Table 1. Nematode-borne virus diseases in Spanish fruit crops
Viroses transmises par les nématodes dans les cultures fruitières en Espagne

Nematode	Nepovirus	Host plants in which virus transmission has been proved	Spanish fruit crops concerned
L. attenuatus	TBRV English strain (tomato black ringspot)	pear	apple, fig, peach, plum, quince and medlar
L. coespiticola	AMV (arabis mosaic)	cherry, plum, strawberry	almond, apple, fig, pear, peach, plum, strawberry and walnut
L. macrosoma	CCRV (cherry chlorotic ringspot)	cherry	fig
	PNRV (prunus necrotic ringspot)	prunus	
	RRSV cherry strain (raspberry ringspot)	cherry, plum	
	RRSV English strain	mulberry, pear, raspberry and strawberry	
X. diversicaudatum	AMV	cherry, plum, strawberry	cherry, sweet cherry, fig, hazel and plum
	CCRV	cherry	
	CLRV (cherry leaf roll)	cherry, blackberry, plum	
	RMV (rosette mosaic)	peach, pear	
	RRSV English strain	cherry, mulberry, raspberry, peach, plum	
	SRV (strawberry ringspot)	peach	
X. vuittenezi	CLRV (cherry leaf roll)	cherry, blackberry, plum	apricot and pear

Vector species which have not been found in fruit crops in Spain are: *L. elongatus*, vector of CLRV and raspberry ringspot nepovirus; *X. coxi* complex, vector of arabis mosaic nepovirus (AMV) and strawberry latent ringspot nepovirus (SLRV); *X. rivesi*, vector of tomato ringspot nepovirus (TomRSV) on different fruit trees and small-fruit crops. These nematodes have, however, been reported on many other host plants.

On the other hand, Arias *et al.* (1985) have reported the presence on fruit trees of nematodes which transmit viruses to other crops: *X. index* (on apricot, fig, medlar and peach); *X. italiae* (on almond, apricot, cherry, hazel, mulberry, peach, pomegranate and walnut). In addition, *Trichodorus* spp., which are vectors of tobacco rattle tobravirus and pea early browning tobravirus, have been found on cherry, fig and pear.

Distribution and ecology

The geographical distribution of these species in Spain is illustrated in Figs 1–4. Studies carried out in Spain on the influence of environmental factors on species of the family Longidoridae show that their occurrence is greatly influenced by vegetation, climate and soil structure. So, we can distinguish two groups according to their distribution, one formed by *L. attenuatus*, *L. belloi*, *L. elongatus* and *L. macrosoma*, appearing in Mediterranean environments with a potential vegetation of evergreen oaks (*Quercus ilex*) and a semi-arid climate, and the other by *L. coespiticola*, *X. diversicaudatum*, *X. vuittenezi* and *X. coxi* complex, preferring atlantic environments with deciduous oaks and subhumid to humid climate, which is in agreement with their distribution in Europe and with the observations by Bello *et al.* (1986).

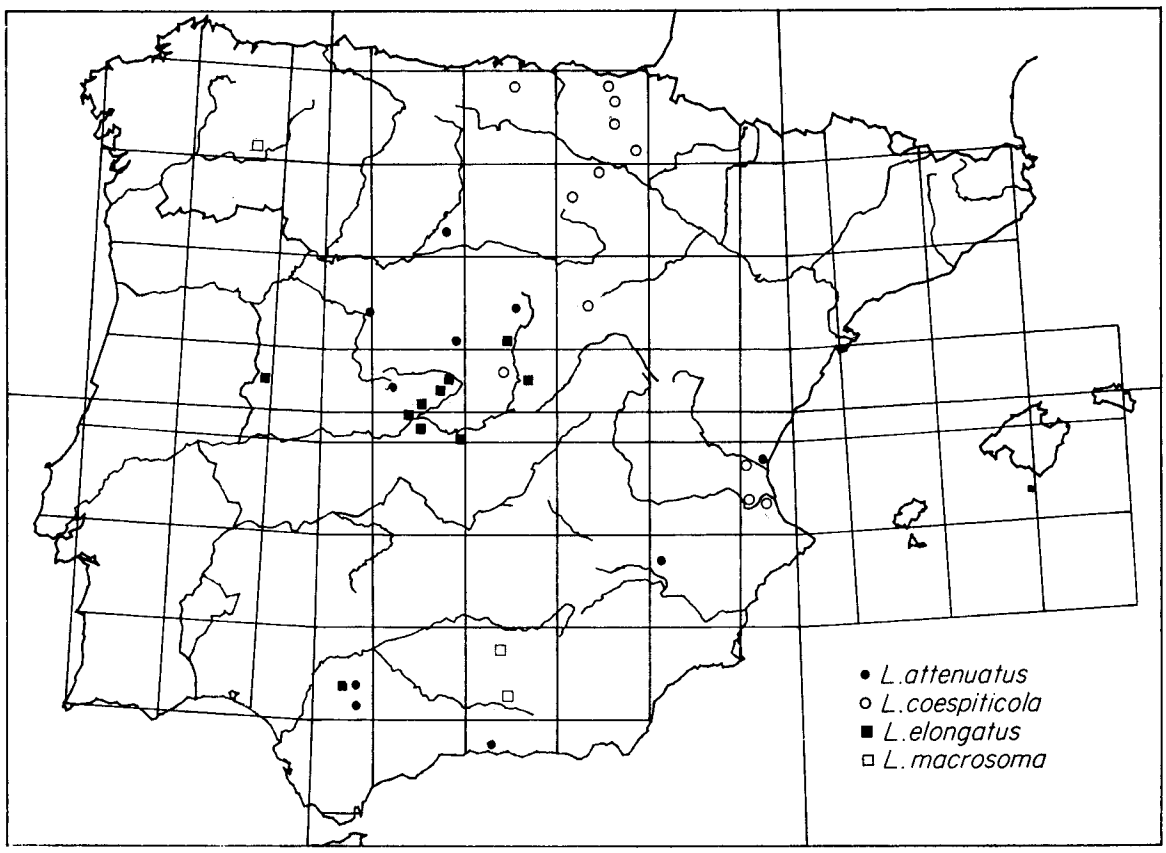

Fig. 1. Geographical distribution in Spain of *Longidorus* spp. known elsewhere as virus vectors on fruit crops.

Répartition géographique en Espagne des espèces de *Longidorus* reconnues ailleurs comme vecteurs de virus des arbres fruitiers.

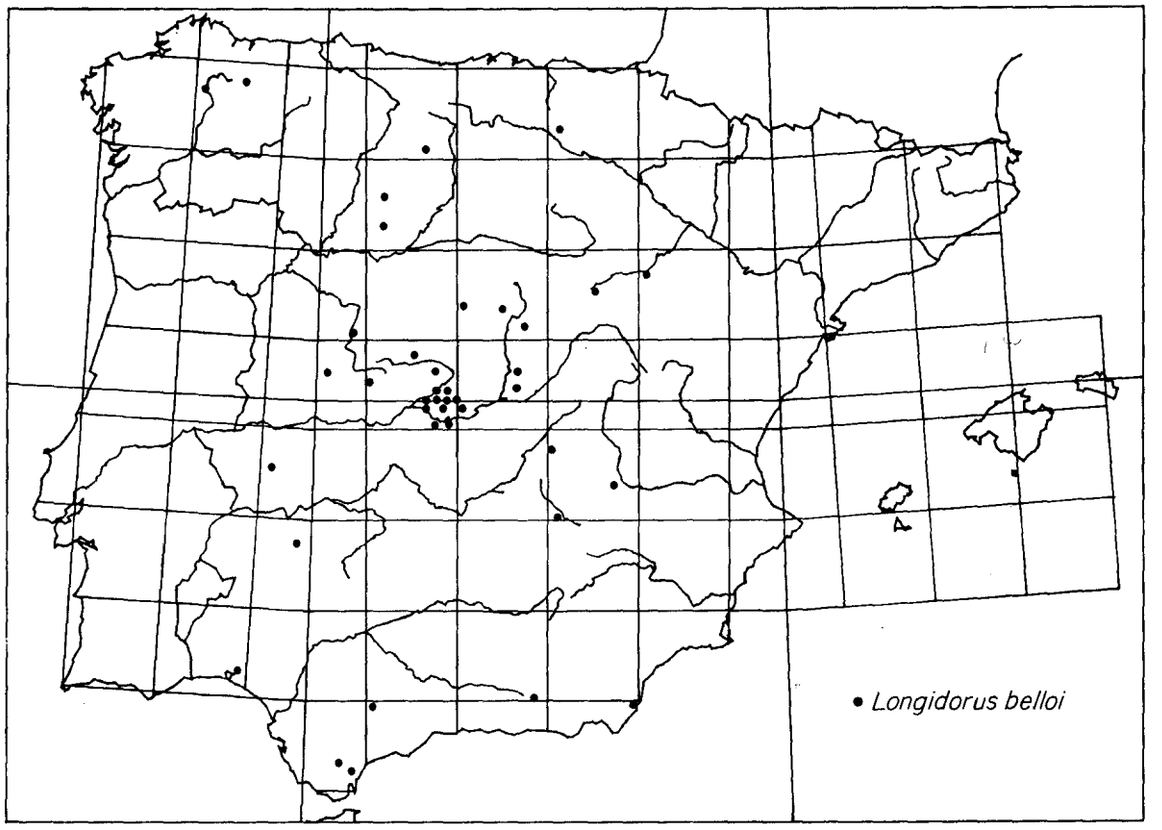

Fig. 2. Geographical distribution in Spain of *Longidorus belloi*.
Répartition géographique en Espagne de *L. belloi*.

L. attenuatus has appeared mainly in the south-western quadrant of the peninsula with some records in the Región Central and the Mediterranean coast, on cultivated land, mainly fruit crops, and on uncultivated areas on siliceous soil. *L. belloi*, previously reported as *L. profundorum* (Andrés & Bello, 1984; Arias *et al.*, 1985) is the most frequent and widespread species in the genus and occurs mainly in the Región Central in different crops, especially cereals, and also in uncultivated zones, in clay soils, often in deeper horizons (15–40 cm depth). *L. elongatus* is mainly distributed in the Región Central in uncultivated areas, while *L. macrosoma* also occurs in uncultivated areas but is much more common in crops, especially fruit crops and vineyards.

L. coespiticola has appeared in the northern central area of continental Spain and at some isolated points on the Mediterranean coast, in fruit crops and uncultivated zones with calcareous soils. *X. coxi* complex (*X. coxi europaeum* and *X. pseudocoxi*) has a distribution restricted to the Región Central, with one isolated record in La Rioja, associated with sandy-loam soils with 3–7% of organic matter and pH 6. It prefers uncultivated woodlands and pasturelands, though *X. pseudocoxi* has been found once in association with fruit trees crops and vineyards. *X. diversicaudatum* is rather widespread in the northern central area of Spain, can be considered typical of uncultivated soils with high contents of organic matter, but is also frequent in fruit crops and there are a few records in cereal areas; it is predominant in siliceous soils with coarse particles and is found in the higher altitudes, depending on climate, potential vegetation and crops. The Región Central can be considered the southern limit of its distribution (Navas *et al.*, 1988). *X. vuittenezi* is not very frequent but has appeared especially in the northern-central area of Spain in uncultivated soils and fruit crops (Navas *et al.*, 1988). Finally, *X. rivesi* has been found at one spot in the Región Central on grapevine and one in the south causing damage to roses.

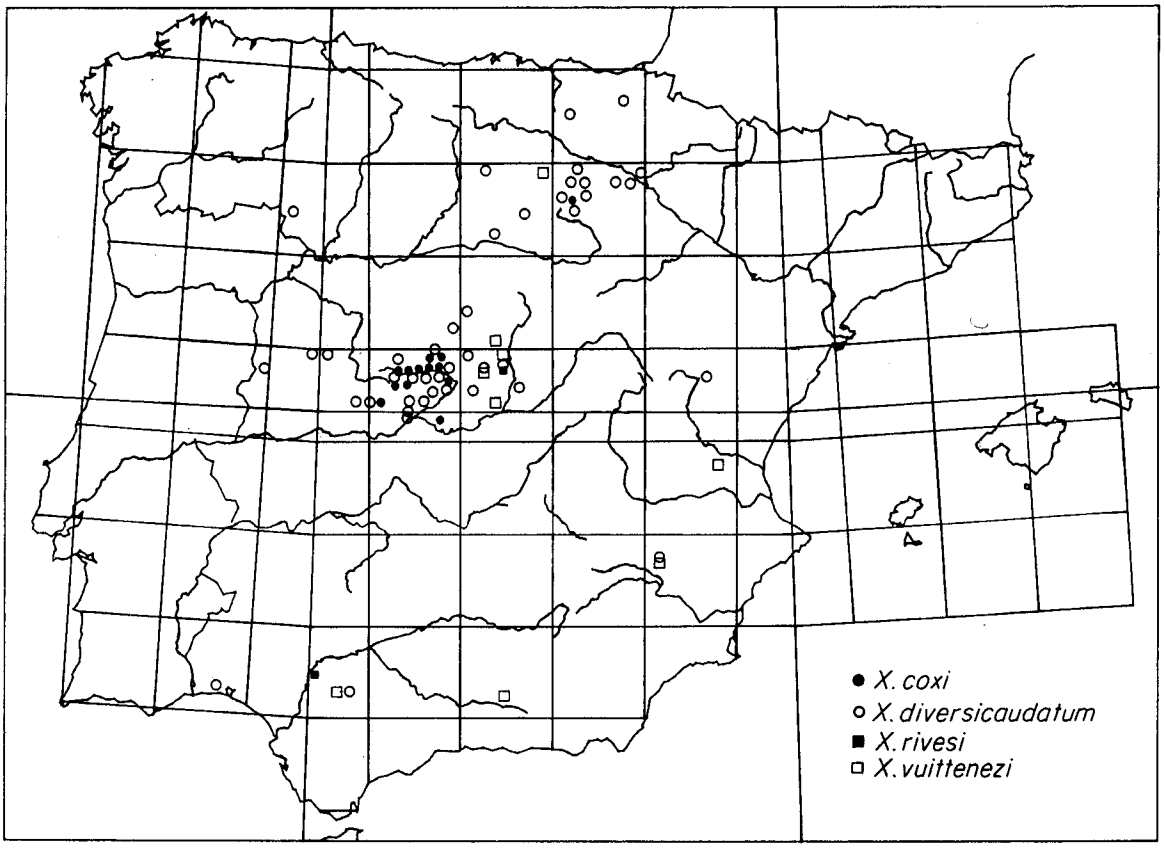

Fig. 3. Geographical distribution in Spain of *Xiphinema* spp. known elsewhere as virus vectors on fruit crops and cereals.
Répartition géographique en Espagne des espèces de *Xiphinema* reconnues ailleurs comme vecteurs de virus des arbres fruitiers et des céreales.

Tobravirus vectors, *Trichodorus* and *Paratrichodorus* spp., have been less studied in Spain. There are records of *P. minor* on maize and potatoes, *P. hispanus* on wheat, *P.* cf. *acutus* on *Quercus pyrenaica*, *Trichodorus primitivus* on *Ulmus* sp., *Trichodorus* cf. *cedarus* on *Quercus pyrenaica* and *Trichodorus* spp. on cherry, fig, pear, uncultivated woodlands and vegetable crops such as pea and potatoes.

Conclusions

Studies on nepoviruses and tobraviruses are scarce in Spain in spite of the fact that their nematode vectors are well represented in cultivated as well as in uncultivated soils. CLRV is the only nepovirus detected on fruit trees, no nematode-transmitted virus has been found on cereals and no tobraviruses have been reported.

Relationships between nematode vectors and the viruses they transmit have not been investigated in Spain in spite of the number of virus-vector species reported with this capability in fruit crops and cereals in Spain. Longidorid nepovirus vectors could have important economic influences on these crops, while tobravirus vectors could use some of these crops, especially cereals or weeds in fruit crops, as refuges.

Environmental factors have a notable influence on virus-vector nematode distribution. In Spain these nematodes can be classified into two groups according to their distribution areas, one Mediterranean (*L. attenuatus*, *L. belloi*, *L. elongatus* and *L. macrosoma*) and the other Atlantic or Continental (*L. coespiticola*, *X. diversicaudatum*, *X. vuittenezi* and *X. coxi* complex).

Joint studies by nematologists and virologists on the distribution and biology of these

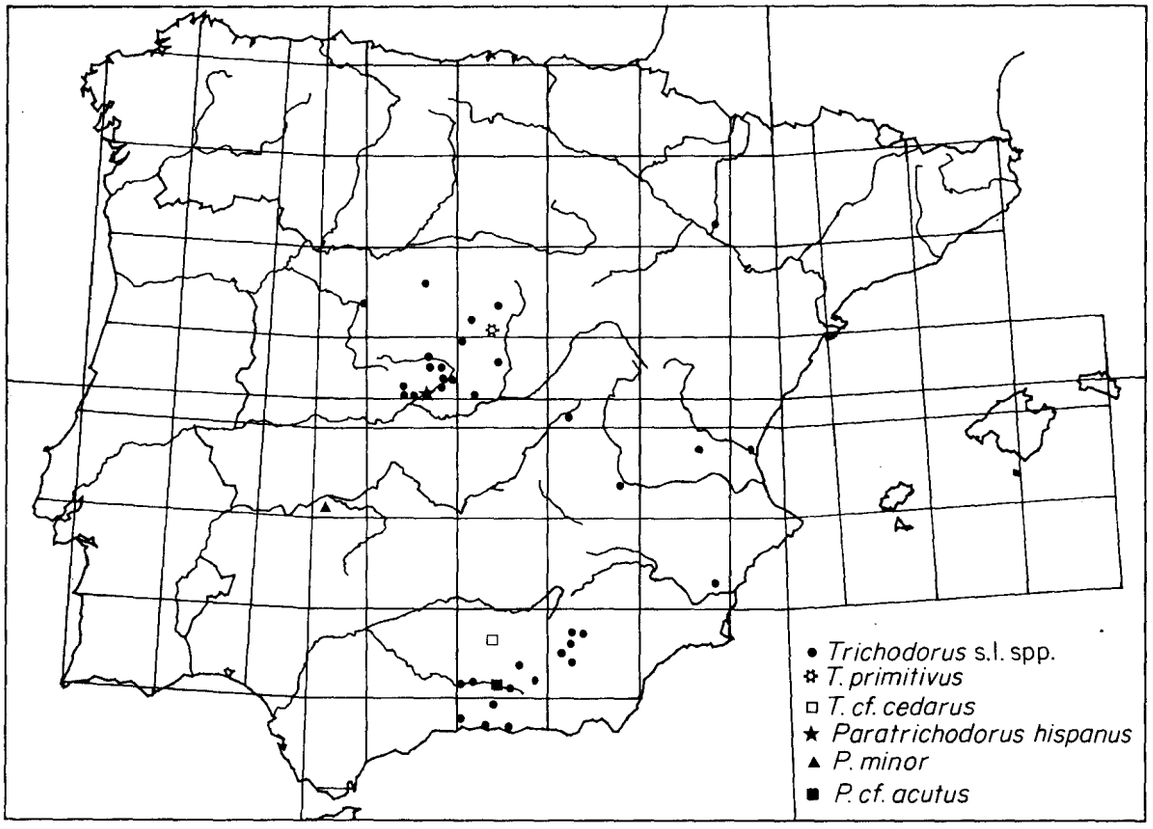

Fig. 4. Geographical distribution in Spain of *Paratrichodorus* spp. and *Trichodorus* spp.
Répartition géographique en Espagne des espèces de *Paratrichodorus* et de *Trochodorus*.

nematodes in relation to virus diseases, as well as on host/parasite relationships and virus transmission, are needed to understand the pathological and resistance phenomena generated by the direct action of the pathogens of the host plants.

Studies on the transmission capability of Spanish species for alien virus strains will be necessary to know the potential of new viruses or strains which could be introduced into our crops, as well as the role of cereal crops and weeds of fruit crops as tobravirus-vector refuges. They are needed to prevent the spread of such diseases and the introduction of new strains and to find alternative solutions to the use of chemical soils sterilizants for the control of their vectors.

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Nématodes vecteurs de virus sur cultures céréalières et fruitières en Espagne

Il manque, en Espagne, des études approfondies sur les népovirus et les tobravirus, et leurs associations avec des nématodes vecteurs. Toutefois, des symptômes probablement attribuables à ces virus sont fréquemment constatés et les vecteurs sont largement disséminés en Espagne continentale. Plusieurs vecteurs de népovirus (*Longidorus attenuatus*, *L. coespiticola*, *L. elongatus*, *L. macrosoma*, *Xiphinema coxi*, *X. diversicaudatum*, *X. index*, *X. italiae*, *X. pseudocoxi* et *X. vuittenezi*) ont été détectés en association avec des cultures fruitières et céréalières. Ils sont fréquents sur d'autres cultures, et dans les zones non cultivées, de même que *X. rivesi* jusqu'ici non trouvé sur arbres fruitiers ou céréales en Espagne. Les vecteurs de tobravirus sont moins bien connus en Espagne. Parmi les cinq espèces présentes, *Paratrichodorus minor* et *Trichodorus*

primitivus sont présents sur maïs et sur blé, respectivement. Des résultats sont présentés sur la distribution géographique et les plantes-hôtes de ces nématodes, ainsi que sur leur écologie.

Вирусоносные нематоды на злаковых и фруктовых культурах в Испании

Исследования неповирусов и тобравирусов и их взаимосвязи с соотвествующими нематодами-переносчиками в Испании до настоящего времени почти не проводились. При этом, однако, симптомы вирусного заболевания очень часть обнаруживались и переносящие их нематоды широко распространены на Пиренейском полуострове. Нематоды-переносчики неповирусов (*Longidorus attenuatus, L. coespiticola, L. elongatus, L. macrosoma, Xiphinema coxi, X. diversicaudatum, X. index, X. italiae, X. pseudocoxi* и *X. vuittenezi*) были найдены в сочетании с фруктовыми и злаковыми культурами. Все они также широко распространены на других культурах и невозделываемых площадях, вместе с *X. rivesi*, который в настоящее время еще не был найден в сочетании с фруктовыми и злаковыми культурами в Испании. Переносчики тобравирусов в Испании изучались в меньшей степени. Из пяти зарегистрированных видов, *Paratrichodorus minor* и *Trichodorus primitivus* присутствуют на кукурузе и пшенице, соответственно. Распределение этих нематод по географическим зонам и растениям-хозяевам приводится в настоящей статье с указанием их соответствующих экологических характеристик.

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