Nematol. medit. (1986), 14: 207-215.

Instituto de Edafología y Biología Vegetal - C.S.I.C.
Madrid - 28006 - Spain

ON THE DISTRIBUTION AND ECOLOGY OF *XIPHINEMA INDEX* AND *X. ITALIAE* IN SPAIN

by
A. NAVAS and M. ARIAS

Xiphinema index Thorne *et* Allen and *X. italiae* Meyl are vectors of grapevine fanleaf virus (GVF) (Hewitt *et al.*, 1958; Cohn *et al.*, 1970). They are typical longidorid Mediterranean species and, with *X. pachtaicum* (Tulaganov) Kirjanova, are similarly distributed throughout Spain (Arias, 1979). *X. index* and *X. italiae* usually occur together on *Vitis vinifera* L., which is their most common host (Arias *et al.*, 1985); the transmission of GVF by *X. index* was first demostrated in Spain by Alfaro García (1971). The two species are not so frequently found together on other cultivated crops and their distribution has not so far been investigated in natural habitats.

Material and Methods

As part of a survey of the geographical distribution of plant parasitic nematodes in Spain, 1230 soil samples were collected (722 from arable soils and 508 from soils with natural vegetation) in two widely separated areas, Region Central and La Rioja. Both areas have a long grape growing tradition and exhibit a wide range of physiographic, climatic, edaphic and botanical features. Species distribution was analysed in relation to such features using χ^2, Student t-test, analysis of variance and Pearson's correlation index.

Results

In our study, *X. index* occurred in La Rioja (7 records) and the Region Central (4 records) but *X. italiae* was only present in the Region Central

Table I - *Distribution of* X. italiae *and* X. index *in the Region Central according to environmental factors.*

HIGH ALBERCHE BASIN			
	X. italiae		
	PRESENCE	MEAN ABUNDANCE (lg)	SAMPLES
CLIMATE			
C_1	1	2.004	39
C_2	5	1.70±0.01	128
B_1	6	1.19±0.07	116
B_2	2	1.04	47
POTENTIAL VEGETATION			
EC	4	1.61±0.40	112
RLE	5	1.31±0.36	76
RC	5	1.36±0.33	121
PSA			21
HABITAT			
CEREAL	1	1.70	80
HORTIC.	1	1.04	
(N) SHRUB	2	1.04	221
(N) TREES	10	1.49±0.35	
DEGRADATED			29
ALTITUDE (m.)			
<1000	1	1.04	101
1000—1200	6	1.48±0.34	67
1200—1400	6	1.35±0.40	128
>1400	1	1.70	34
SOIL TYPE			
TPH	10	1.33±0.32	211
TPM	4	1.61±0.40	119
TEXTURE			
S			9
LS	5	1.63±0.35	105
SL	8	1.29±0.34	172
L			7
SCL			5
SAND (%)			
< 50	1	1.32	6
50—60	1	1.04	19
60—70	2	1.04	71
70—80	9	1.48±0.33	147
>80	1	2.004	55
CLAY (%)			
<10	13	1.44±0.35	221
10—20	1	1.04	69
>20			8
SILT (%)			
<10	1	1.32	26
10—20	7	1.55±0.36	171
20—30	6	1.26±0.34	86
30—40			12
>40			3
pH			
<5	6	1.20±0.27	78
5 - 6	3	1.58±0.49	153
6 - 6.5	4	1.53±0.33	50
6.5 - 7.6	1	1.70	27
>7.5			5
ORGANIC M. (%)			
<0.5	2	1.85±0.21	13
0.5—2.5	6	1.30±0.32	58
2.5—4.5	4	1.53±0.33	80
4.5—9.5	2	1.04	162
>4.5			

LOW ALBERCHE	
	X.
	PRESENCE
CLIMATE	
C_1+C_2	6
POTENTIAL VEGETATION	
RLE	1
EC	5
HABITAT	
VINEYARD	1
FRUIT T.	4
SHRUB.	1
ALTITUDE (m.)	
400—500	1
>600	5
SOIL TYPE	
TPM	5
OTHERS	1
TEXTURE	
S	1
SL	5
SAND (%)	
50-70	4
>70	2
CLAY (%)	
<10	
10-20	6
SILT (%)	
10-20	3
20-30	3
pH	
<5	1
5-6	2
6-6.5	2
6.5-7.5	1
ORGANIC M. (%)	
<0.5	1
0.5-2.5	1
2.5-4.5	1
>4.5	3

C_1 DRY SUBHUMID
C_2 SUBHUMID
B_1 HUMID I
B_2 HUMID II
B_3 HUMID III
B_4 HUMID IV
A. PERHUMID

S. SANDY
LS. LOAMY SAND
SL. SANDY LOAM
L. LOAM
SCL. SANDY CLAY LOAM

BASIN		TIETAR VALLEY				
italiae	*X. index*		*X. italiae*		*X. index*	
MEAN ABUNDANCE (lg.)	PRESENCE (1.20)		PRESENCE	MEAN ABUNDANCE (lg)	PRESENCE	MEAN ABUNDANCE (lg)
		CLIMATE				
1.70±0.41	1	B_1	2	1.85±0.21		
		B_3			1	1.301
1.04		B_4			2	1.85±0.21
1.60±0.40	1	A	1	1.30		
		POTENTIAL VEGETATION				
1.04	1	RLE	2	1.65±0.49	2	1.85±0.21
1.68±0.35		EC	1	1.69		
1.70		ELE			1	1.30
		HABITAT				
1.04		FRUIT T.	3	1.67±0.35	3	1.67±0.35
1.90±0.17	1	ALTITUDE (m.)				
		400-600			1	1.30
1.90±0.17	1	600-800	3	1.67±0.35	2	1.85±0.21
1.04		SOIL TYPE				
		TPH	1	1.30	2	1.86±0.21
1.70		ALU	2	1.85±0.21	1	1.30
1.60±0.40	1	TEXTURE				
		SL	3	1.67±0.35	3	1.67±0.35
1.44±0.48		SAND (%)				
1.52±0.68	1	50-60			1	1.30
		60-70	3	1.67±0.35	2	1.85±0.21
	1	CLAY (%)				
1.70±0.41		<10	2	1.65±0.49		
1.52±0.68	1	10-20	1	1.69	3	1.67±0.35
1.85±0.21		SILT (%)				
		10-20	3	1.67±0.35		
1.49		20-30			3	1.67±0.35
1.04	1	pH				
1.52±0.68		<5	1	1.30		
2.004		5-6	1	1.69	2	1.85±0.21
		6-6.5	1	2.004		
1.04		>7.5			1	1.30
2.004	1	ORGANIC M. (%)				
1.04		0.5-2.5	2	1.85±0.21		
1.58±0.49		2.5-4.5	1	1.30	3	1.67±0.35

ELE. SANGUISORBO QUERCETUM SUBERIS
EC. JUNIPERO QUERCETUM ROTUNDIFOLIAE
RLE. LEUZEO QUERCETUM PYRENAICAE
RC. LUZULO QUERCETUM PYRENAICAE
PSA. CYTISO ECHINOSPARTETUM BARNADESII

N. NATURAL HABITAT
TPH. BROWN HUMID SOIL
TPM. BROWN MERIDIONAL SOILS
ALU. ALLUVIAL

although its occurrence is more widespread there (23 records). Distribution of the two species in relation to habitat, climate and soil factors is given in Tables I and II. The relationship of such factors was analysed for *X. italiae* with data from Alberche Alto (330 samples), one of the three river basins of Region Central, and for *X. index* with data obtained from La Rioja (367 samples). The statistical analyses are summarised in Tables III and IV.

To apply correctly the χ^2 (Table III), qualitative variables have been simplified, so that types of climate have been reduced to two (humid and less humid), potential vegetation to Mediterranean and Atlantic, habitats to arable and natural soils, soil types to brown meridional and soil textures to less sandy or more sandy.

Discussion and Conclusion

Xiphinema italiae occurred more or less uniformly in the Region Central. Climate does not appear to be significant in relation to its distribution although it was not found in the semiarid climate. No preference was apparent for either potential vegetation or host plant, in spite of higher numbers in wooded areas of natural environments. In general, *X. italiae* can be considered to be associated with sandy-loam or loamy-sand soils with low percentages of fine particle fractions; with acid soils (pH=5-5. 5) and those with a normal organic matter content (2.5-4.5%) (Buol *et al.*, 1973) as can be deduced from its *presence* and *abundance*, as well as the correlations between sand and silt ($r = -0.36^{***}$) and silt and organic matter ($r = 0.377^{**}$).

Xiphinema index distribution shows a wider climatic range than *X. italiae*, appearing in potential Mediterranean vegetation (8 records in *Quercus ilex* climax, 2 in *Q. pyrenaica* climax and one in *Q. faginea* climax). In La Rioja it was only recorded on grapevine and in Region Central also on apple and peach trees. In the former zone it occurred more frequently at low altitudes (<600 m), was not significantly associated with soil texture, which is very uniform, but was more influenced by pH and organic matter, not only in its presence but also in its abundance. Organic matter could be a limiting factor for *X. index* as shown by its correlation in La Rioja and its presence in the Region Central; while for pH it was associated with high values in La Rioja but it was found in acid soils in Region Central.

Xiphinema italiae has not been recorded in those European countries

Table II - *Distribution of* X. index *in La Rioja according to environmental factors.*

	PRESENCE	MEAN ABUNDANCE (lg)
CLIMATE		
D	3	1.82 ± 0.46
C_1	4	2.02 ± 0.62
POTENTIAL VEGETATION		
E	6	1.79 ± 0.43
Q	1	2.70
HABITAT		
VINEYARD	7	1.92 ± 0.52
ALTITUDE (m.)		
<400	6	2.08 ± 0.48
400-600	1	1.30
SOIL TYPE		
SPC	3	2.004 ± 0.6
ALU	4	1.87 ± 0.45
TEXTURE		
CL	2	2.04 ± 0.42
L	1	1.30
SCL	2	2.08 ± 0.12
SAND (%)		
<50	6	1.88 ± 0.51
>60	1	2.17
CLAY (%)		
10-20	1	2.17
20-30	2	1.65 ± 0.49
30-40	4	1.75 ± 0.42
SILT (%)		
<20	1	2.17
20-30	1	2.004
30-40	3	2.004 ± 0.42
>40	2	1.45 ± 0.38
pH		
7.5-8	3	2.08 ± 0.12
>8	4	2.15 ± 0.15
ORGANIC MATTER (%)		
0.5-2.5	7	1.92 ± 0.52

D - SEMINARID
C_1 - DRY SUBHUMID

E - EVERGREEN OAKS
Q - *QUERCUS FAGINEA*

SPC - CALCAREOUS BROWN SOILS
ALU - ALLUVIAL

CL - CLAY LOAM
L - LOAM
SCL - SANDY CLAY LOAM

Table III - *Relationship of* X. italiae *with environmental factors of High Alberche Basin*

a) ASSOCIATION

QUALITATIVE VARIABLES		*QUANTITATIVE VARIABLES*					
			mean of variables				
	χ^2		presence species	absence species	variance ratio	t	t'
Climate	0.74 (NS)	Altitude	1264 ± 206	1187 ± 234	1.29 (NS)	1.29 (NS)	
Potential Veg.	0.52 (NS)	Sand	73.76 ± 6.28	73.26 ± 9.02	2.06 (NS)	0.20 (NS)	
Habitat (plant)	1.52 (NS)	Clay	5.92 ± 2.62	8.52 ± 4.49	2.92*		3.35**
Soil type	0.09 (NS)	Silt	20.30 ± 5.18	18.21 ± 7.34	2.01 (NS)	1.01 (NS)	
Texture	0.04 (NS)	pH	5.47 ± 0.81	5.49 ± 0.75	1.18 (NS)	0.08 (NS)	
		O. matter	5.12 ± 3.44	6.29 ± 4.44	1.66 (NS)	0.98 (NS)	

b) ABUNDANCE

QUALITATIVE VARIABLES	F	*QUANTITATIVE VARIABLES*	r
Climate	11.99**	Altitude	0.221 (NS)
Potential Veg.	0.86 (NS)	Sand	0.569*
Habitat(plant)	1.63 (NS)	Clay	—0.329 (NS)
Soil type	1.53 (NS)	Silt	—0.523*
Texture	2.98 (NS)	pH	0.563*
		O. matter	—0.458*

NS. not significant; * $P < 0.05$; ** $P < 0.01$

Table IV - *Relationship of* X. index *with quantitative variables of La Rioja*

a) ASSOCIATION

	mean of variables presence species	absence species	variance ratio	t	t'
Altitude	414.28 ± 37.79	642.31 ± 316	70.1***		10.47***
Sand	43.60 ± 13.63	36.01 ± 14.61	1.15 (NS)	1.15 (NS)	
Clay	26.2 ± 5.76	29.01 ± 10.94	3.61 (NS)	0.57 (NS)	
Silt	30.20 ± 11.27	34.96 ± 8.50	1.76 (NS)	1.24 (NS)	
pH	8.04 ± 0.26	7.51 ± 0.95	13.36*		4.14**
O.matter	1.32 ± 0.55	3.42 ± 2.85	26.9***		7.25**

b) ABUNDANCE

	r
Altitude	—
Sand	0.434 (NS)
Clay	0.274 (NS)
Silt	—0.665 (NS)
pH	0.944**
O.matter	—0.805*

NS not significant; * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

(Britain, Germany, Netherlands and Belgium) which are subject to the North-Atlantic influence. Dalmasso (1970) considered that the French populations of this species to be an island in the Northern part of its area of distribution, and hence it can be considered as a Mediterranean species. Most of the records of occurrence are from cultivated plants (Cohn, 1977), but it has been also found in uncultivated soils (Heyns, 1974) and has a wide host range (Lamberti, 1981). In our study there were no differences in the distribution of *X. italiae* in natural and cultivated soils, although a preference was shown for natural woodland, as indicated by Lamberti *et al.* (1985).

Xiphinema index appears in most of the soil sample records from vineyards, which could be the main means of its dispersal. Dalmasso (1970) considers that the Mediterranean basin represents the distribution centre of *X. index* which provides an explanation of our results in relation to climate and potential vegetation. Taking into account our thorough sampling, the restriction of *X. index* distribution to vineyards in La Rioja (Navas, 1984) can be due to edaphic factors, particularly soil texture, which is considered to be of great importance for plant parasitic nematodes (Rebois and Cairus, 1968). This could explain the low frequency of occurrence in La Rioja, which is an area of heavy soils. This accords with the views of Antoniou (1981), but not with those of Harris (1979), Coiro (1980) and Pietler *et al.* (1981). Nevertheless, the association of *X. index* with soils of pH > 7 and poor in organic matter, which are generally representative of the Mediterranean area, seems logical.

The environmental characteristics of the Region Central probably represent the optimal environment for the occurrence and distribution of *X. italiae* in Peninsular Spain. These characteristics are a Mediterranean or supra-Mediterranean vegetation on siliceous soils with acid or moderately acid pH and an organic matter content of 2.5 to 4.5%; a semiarid climate would be a limiting factor for its distribution. These ecological characteristics combined with the absence of specific association with particular hosts, provide the basis of an explanation of the actual distribution of *X. italiae* in Peninsular Spain. Selective sampling would be necessary to confirm this.

Xiphinema index tolerates major variations of pH and a lower organic matter content. It shows an opposite pattern of behaviour and distribution from *X. italiae* with respect to climate and altitude. It is usually associated with lower altitudes but humid climate is generally a limiting factor for its distribution.

Acknowledgements: We thank Dr. A. Bello for his suggestions as well as the valuable help of Prof. C. E. Taylor and Dr. J. Rey.

SUMMARY

A study has been undertaken on the ecological factors that influence *Xiphinema index* and *X. italiae* distribution in Spain. An analysis has been made of the influence of climate, altitude, potential vegetation and soils factors on their presence and abundance, taking into account a previous review of their distribution and host plants. The analysis was based on 1230 soil samples collected from Region Central and La Rioja, 722 from arable soils and 508 from uncultivated areas. *X. italiae* was found in arable soils but more often in uncultivated areas, in subhumid climates, acid or slightly acid sandy soils and at relatively high altitudes within the areas investigated. *X. index*, on the contrary, only appeared in arable soils, mostly in vineyards, at lower altitudes and in Mediterranean environments. *X. index* is considered to be less limited in its geographical distribution by such environmental factors than is *X. italiae*.

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Accepted for publication on 14 May 1986.