Seasonal fluctuations of nematode populations in three Spanish vineyards

Jorge PINOCHET and Tomas CISNEROS

Centro Agronómico Tropical de Investigación y Enseñanza, Apartado 6-3786, El Dorado, Panamá and Actividades Agrícolas Aragonesas, Zaragoza-14, Spain.

SUMMARY

A study on nematode population fluctuations was carried out during a one year period in three Spanish vineyards located in Castilla, Cataluña and La Rioja. The populations of the three most important plant parasitic nematodes encountered in each region were related to temperature and rainfall conditions for the same period. In Castilla, *Criconemella xenoplax* was the most abundant nematode species found, followed by *Xiphinema mediterraneum* and *Helicotylenchus dihystera*. Population of *C. xenoplax* was highest in summer followed by a second peak in autumn that was correlated with high precipitation. Seasonal fluctuation also was high. Populations of *X. mediterraneum* and *H. dihystera* were low throughout the year. In Cataluña, *Criconemella sphaerocephala* was the predominant species. Population increase was observed in spring and autumn. As in Castilla, maximum nematode levels were also related to high precipitation during the months of autumn. Other nematodes encountered were *X. mediterraneum* and *Pratylenchus* sp., although their population levels were low. Slight increase of *Pratylenchus* sp. was observed during the summer. In La Rioja, nematode populations were lower than in the two other regions. The three most common nematodes were *Helicotylenchus dihystera, Xiphinema index* and *Zygotylenchus guevarai*. The first two reached maximum increase during the summer months. *X. index* appears to have one life cycle per year.

RÉSUMÉ

Fluctuations saisonnières des populations de nématodes dans trois vignobles espagnols

Les fluctuations des populations de nématodes de trois vignobles espagnols situés en Castille, Catalogne et à La Rioja ont été comparées pendant une année. Les populations des trois plus importants nématodes phytoparasites de chaque région ont été mises en corrélation avec la température et les précipitations durant cette même période. En Castille, *Criconemella xenoplax* est l'espèce la plus abondante, suivie de *Xiphinema mediterraneum* et de *Helicotylenchus dihystera*. La population de *C. xenoplax* est plus abondante en été, suivie en automne d'un second pic en corrélation avec des précipitations élevées. Les fluctuations saisonnières sont également importantes, tandis que les populations de *X. mediterraneum* et *H. dihystera* se maintiennent à un niveau bas tout au long de l'année. En Catalogne, *Criconemella sphaerocephala* est l'espèce dominante. On a observé une augmentation de la population au printemps et en automne. Comme en Castille, le niveau maximum était en relation avec les précipations élevées des mois d'automne. *X. mediterraneum* et *Pratylenchus* sp. sont également présents, mais en faible nombre; une légère augmentation de la population de *Pratylenchus* sp. a été observée durant l'été. A La Rioja, les populations de nématodes étaient inférieures à celles des deux autres régions. Les trois nématodes les plus communs sont *Helicotylenchus dihystera, Xiphinema index*, et *Zygotylenchus guevarai*, les deux premiers étant les plus abondants pendant les mois d'été. Il semble que *X. index* n'ait qu'un cycle par an.

The area dedicated to grape culture in Spain is approximately 1.8 million hectares. As a wine producing country, it ranks third after Italy and France with an estimated annual production of 6 050 926 Tm. (Anuario de Estadística Agraria 1980, 1981). In the last decade exports have multiplied six fold while the ratio of wines exported in bottle has gone up even faster. Vineyards are of special economic importance in the regions of La Mancha, La Rioja, Cataluña, Valencia, Andalucia and Galicia.

The presence of many known nematode pathogens that commonly occur in other grape producing areas of the world, have also been detected in Spain (Arias, Lopez Pedregal & Jiménez Millan, 1963; Tobar Jiménez & Peman Medina, 1970). Economic losses caused by nematodes in Spanish vineyards are unknown, although it is estimated that they are similar to those that occur in other countries that share similar environmental conditions (Cohn & Orion, 1970; Mc Elroy 1972; Meagher, 1960; Mojtahedi *et al.*, 1980).

Several authors in different parts of the world have studied the spatial distribution, population dynamics on a short and long term basis of plant parasitic nematodes on grape host (Bird & Ramsdell, 1985; Ferris & Mc Kenry, 1974; Ivezic, Samota & O'Bannon 1984). Similar studies are useful and not available in Spain.

Information on the seasonal behaviour of nematodes on grape host in different regions, that have different climates, soil conditions, and sometimes different cultural practices, would certainly contribute to a better understanding of potential nematode problems and consenquently, the adoption of appropriate control measures, if necessary.

The objective of this study was to obtain information on the seasonal fluctuation of nematode populations in established vineyards, and to determine the major environmental factors affecting population changes in three vineyards located in Castilla, La Rioja and Cataluña, all very important wine growing regions of Spain.

Materials and methods

A total of 332 composite samples were collected from three vineyards in the localities of Quintanilla de Arriba, Province of Valladolid, region of Castilla; La Guardia, Province of Alava, region of Rioja Alavanesa; and Villa Franca del Penedés, Province of Barcelona, region of Cataluña (Fig. 1). In each vineyard, samples were taken from two sites and from each site, five composite samples were recollected from five vines chosen at random. These vines were labeled for future samplings. Indicator stickers were used in the area surrounding vines in order to avoid sampling in the same position. Soil recollection was made from the first 40 cm of depth and from a distance of approximately 30 to 40 cm from the base of the plant with a 25 cm diameter soil auger. Sampling took place every 28-32 days for a one year period. Nematodes in the soil were extracted by differencial sieving and sugar flotation method (Jenkins, 1964). In La Rioja and Cataluña root samples were taken during the first three and four months respectively. Endoparasitic nematodes were not found in Castilla. Nematodes in roots were extracted by macerating tissue and placing contents on Baermann funnels. Root and soil material recovered in the three regions were processed within 36 hours after sampling. Nematodes recovered from 500 cm^3 of soil were killed and stored in vials containing 5 % formalin. Counts generally were made within a month after extraction.

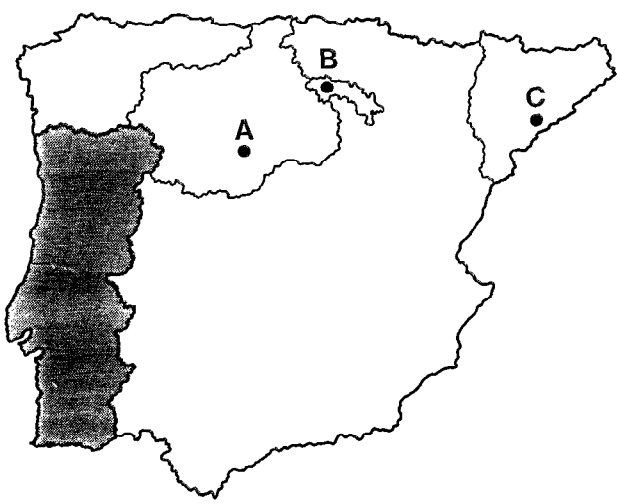

Fig. 1. Diagram of Spain showing location of the three vineyards. A : Quintanilla de Arriba, Province of Valladolid, Region of Castilla; B : La Guardia, Province of Alava, Region of Rioja Alavesa; C : Villafranca del Penedés, Province of Barcelona, Region of Cataluña.

The population of the three most important plant parasitic nematodes present in each locality were correlated with the mean monthly temperature and rainfall for twelve months. Meteorological information was obtained from the Weather Forecast Service. The criteria for choosing the most important nematodes were based on the known pathogenicity or virus transmitting capabilities of certain species on grape host, such as *Xiphinema index* (Hewitt, Raski & Goheen, 1958; Cohn & Orion, 1970; Raski, Hart & Kasamatis, 1973) and *X. mediterraneum* (Lamberti *et al.*, 1973) and in other cases, the high numbers of lesser known pathogens like nematodes of the genera *Criconemella* (Raski & Lider, 1959; Raski, Hart & Kasamatis, 1973; Santo & Bolander, 1977) and *Helicotylenchus* (Pinochet, Raski & Jones, 1976). During this study, vineyards were not supplemented with irrigation, since this is not a normal practice in Spain for grapes used in winemaking. Cultural practices were considered to be standard for each region, although more rigorous in the vineyard in La Rioja. Sanitary conditions in the vineyard located in Cataluña was better than in the other two. The vineyard in Castilla was located on the margins of the river Duero. This aluvial formation is very high in active lime where poor growth in the form of patches within the field were visible. Incidence of fan leaf in the vineyard in La Rioja was evident although production was considered to be acceptable. None of the three vineyards had a history of use of nematicides. Tillage with discs or rotovator and fertilization with nitrogen-based compounds seem to have been the main agronomic practices that might have influenced nematode population variation. Rainfall during the same period was slightly lower than normal in La Rioja and Cataluña, but dry in Castilla where rainfall was approximately 80 mm lower than in a normal year. Environmental, agronomic and soil conditions that prevailed in each vineyard are presented in Table 1.

Results

In the vineyard located in Castilla (Fig. 2), the three most important nematodes were *Criconemella xenoplax*,

Table 1

Agronomic and environmental conditions that prevail in three vineyards located in Valladolid, Castilla; Alava, La Rioja; and Barcelona, Cataluña.

General Information	*Castilla (Valladolid)*	*La Rioja (Alava)*	*Cataluña (Barcelona)*
Denomination of Origin	Ribera de Duero	Rioja	Penedes
Cultivated area (ha)	17,000	42,000	25,000
Climate	Continental	Cantabric	Mediterraneum
Annual precipitation (mm)*	480	590	530
Average year temperature (°)*	11.5	12.3	16.1
Active veg. period	198 days	210 days	315 days
Soil Texture at site	Sandy clay loam	Sandy loam	Loamy
pH	8.7	8.3	8.1
Organic matter (%)	0.5	1.0	1.4
Active lime (%)	12.8	4.0	7.2
Potassium in ppm	206	108	232
Phosphorus in ppm	12	4	—
Age of vineyard	50-60 years	37 years	10 years
Variety	Malbec	Tempranillo	Xavel-lo
Rootstock	Berlandieri	Rupestris de Lot	110 Richter

* *Average for twenty years.*

Xiphinema mediterraneum and *Helicotylenchus dihystera*, all ectoparasitic forms. *C. xenoplax* was the most abundant and active nematode throughout the year. Fast multiplication of this species was recorded in the months of August and November, reaching maximum level of 1 900 and 1 280 nematodes in 500 cm³ of soil, respectively. Both population increases were related to periods of rainfall that exceeded 50 mm per month, following a rather dry period. The mean monthly temperature for August was 19.6°. *Helicotylenchus dihystera* achieved highest numbers in the summer months of June, July and August, although, never exceeding more than 320 nematodes in 500 cm³ of soil. The population of *X. mediterraneum* was low and erratic showing no relation with temperature or precipitation, larval and adult forms being present throughout the year.

In La Rioja (Fig. 3), nematode populations were considerably lower than in Castilla and Cataluña. The nematodes of major interest found in that vineyard were *Helicotylenchus dihystera*, *Xiphinema index* and *Zygotylenchus guevarai*. The spiral nematode *H. dihystera* was more abundant than the other species and was active year around, reaching several peaks during this period. Fluctuations presented little relation to temperature or rainfall. However, *X. index* was active only during summer where it reached its highest levels during July, adults being recovered in very low numbers in the remaining seasons. The population of *Z. guevarai* increased during summer and early autumn. A second peak was recorded in February at a time when temperature conditions were opposite to those of summer, although high rainfall was present in both of these periods. Nematode multiplication of the three populations in La Rioja was active during July and August, although none of them reached more than 600 nematodes in 500 cm³ of soil.

In Cataluña (Fig. 4), the most important nematodes encountered were *Criconemella sphaerocephala*, *Xiphinema mediterraneum* and an undetermined species of *Pratylenchus*. The ring nematode *C. spherocephala*, was the predominant species. High numbers were present in spring, autumn, and part of winter, reaching a maximum of 810 nematodes in 500 cm³ of soil during November which was also the month of highest precipitation in that locality. The lowest population of this nematodes was recorded during the hot and dry summer in the absence of rain. The population of *X. mediterraneum* was low throughout the year with a slight rise in November and December, adult and larval stages being recovered in every month's sampling. The lesion nematode species encountered in Cataluña showed slight population increases in July and August under hot and dry conditions and then later in December and March with cold and rainy weather. Seasonal fluctuation of soil populations of *Pratylenchus* sp. presentend no correlation with climatic conditions.

Discussion

In Castilla, *Criconemella xenoplax* was the predominant nematode population and could also be

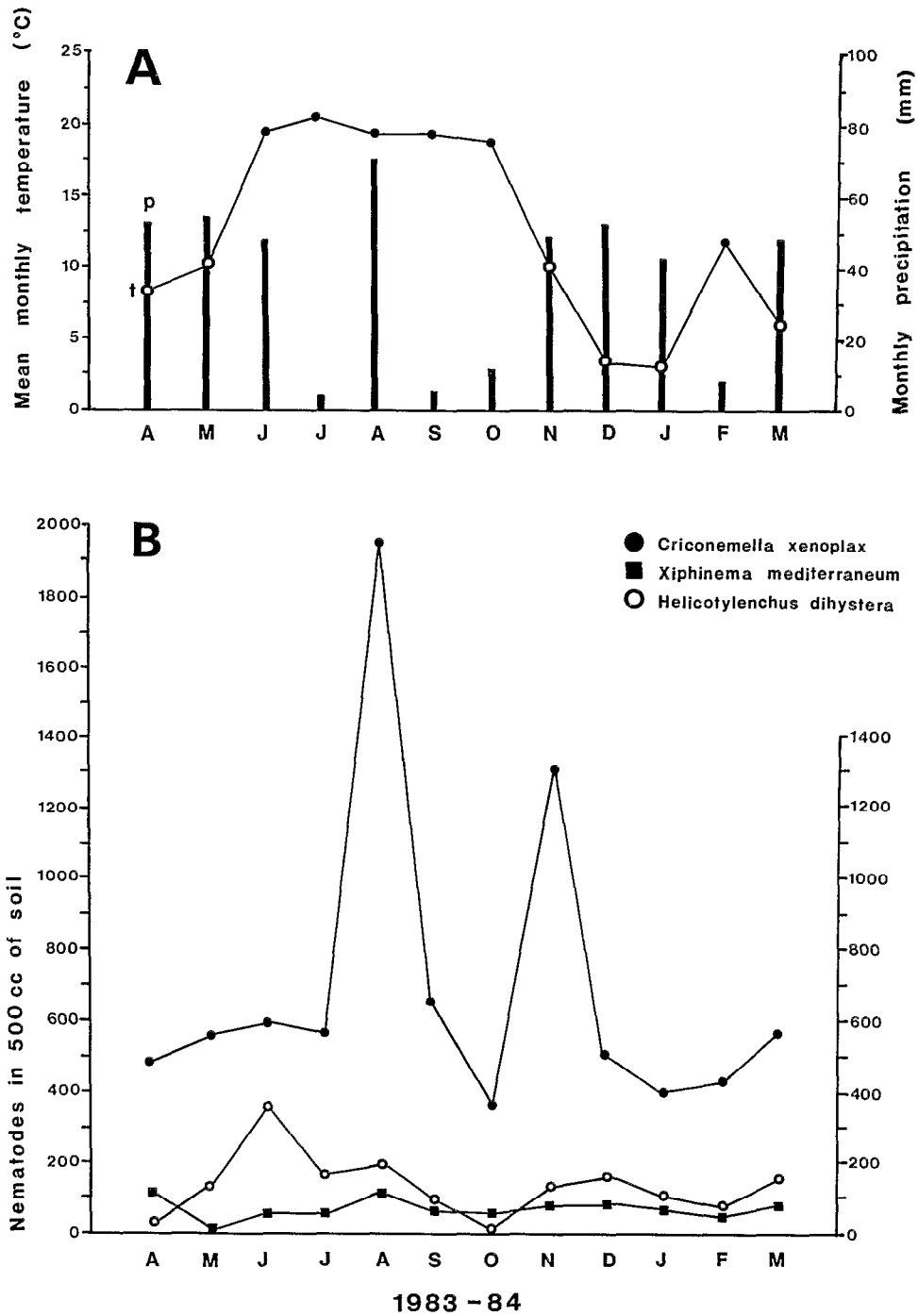

Fig. 2. Nematode population dynamics in a grape vineyard in Castilla. A : Mean monthly temperature and monthly precipitation during a one year period. B. : Seasonal fluctuation of three nematode populations for the same period.

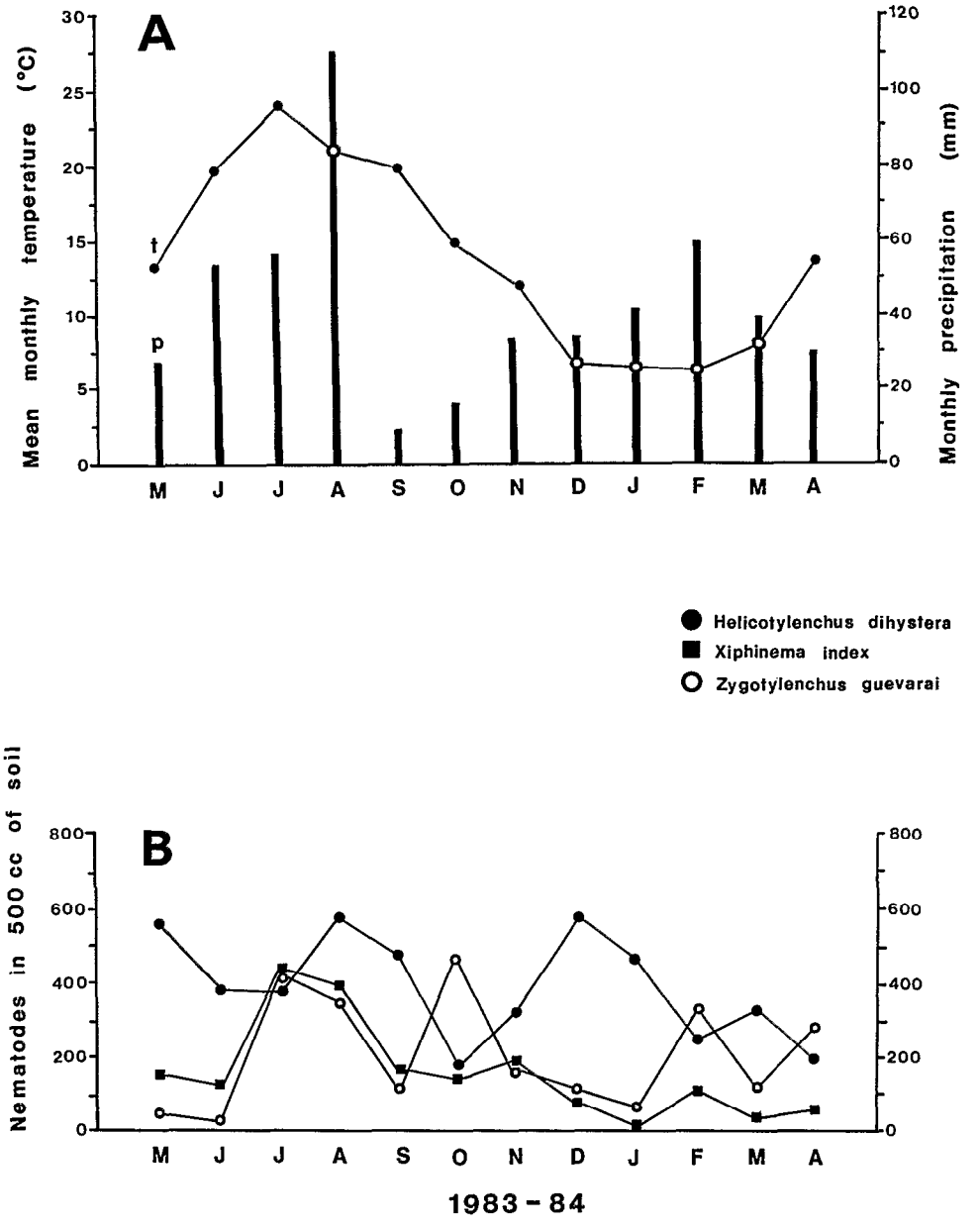

Fig. 3. Nematode population dynamics in a grape vineyard in La Rioja. A : Mean monthly temperature and monthly precipitation during a one year period. B : Seasonal fluctuation of three nematode populations for the same period.

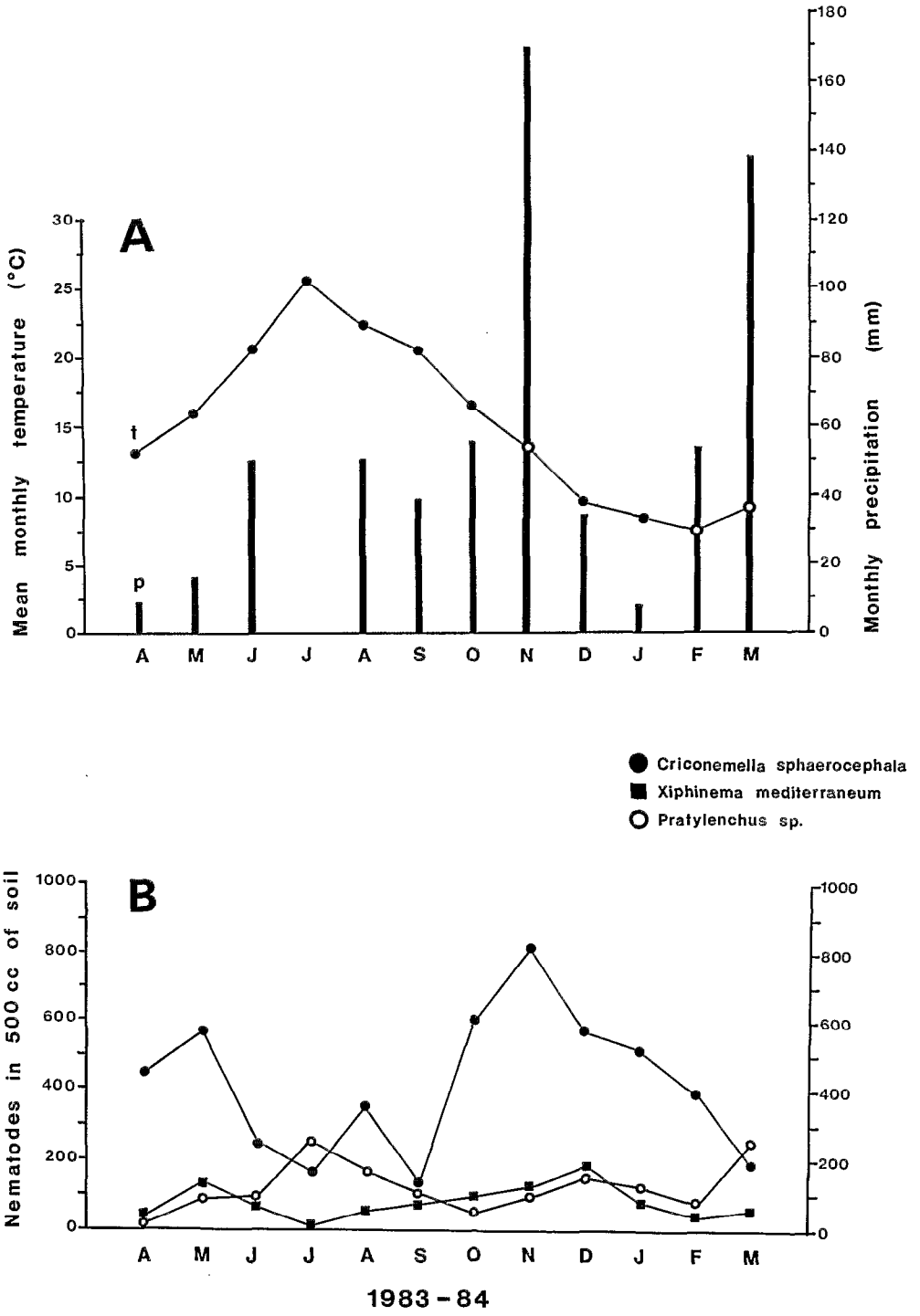

Fig. 4. Nematode population dynamics in a grape vineyard in Cataluña. A : Mean monthly temperature and monthly precipitation during a one year period. B : Seasonal fluctuation of three nematode populations for the same period.

considered the most significant species due to its large numbers found during late summer and autumn. Such high levels can cause growth retardation in established vineyards or stunting to young replants (Raski & Lider, 1959; Santo & Bolander, 1977). Rainfall seems to be the main climatic factor on which population increase depends. Optimum conditions for reproduction occurred with high rains and temperatures recorded during August. Similar situations were observed in November, but one month later, in spite of high rainfall, temperature of 5° was accompanied by limited nematode multiplication. Nevertheless, *C. xenoplax* was active in lower populations throughout the rest of the year. In Cataluña, another ring nematode, *Criconemella sphaerocephala*, showed a similar pattern to that of *C. xenoplax* in Castilla where it reached its highest levels during October and November, months of high rainfall and temperatures that fluctuated between 11° and 16° (Fig. 4). With temperatures below 7° multiplication of *C. sphaerocephala* was affected in spite of abundant rains during the following months of February and March. The life cycle of *C. xenoplax* is 15 to 20 days under favourable conditions reaching high populations in a brief period of time (Jenkins & Taylor, 1968). This seems to be case for *C. spherocephala* since population increase of this nematode and *C. xenoplax* ocurred generally during the same months that registered high precipitations. Also noteworthy was the rapid decrease in nematode populations for both criconematids in their respective localities during peak hot months that registered little or no precipitation.

Xiphinema mediterraneum was found in Castilla and Cataluña. In both cases populations were low and presented little seasonal changes in relation to climatic conditions (Figs 2 and 4). Larval and adult stages were present in all seasons suggesting it has several cycles per year. This is the most frequent of *Xiphinema* species detected in Spanish vineyards, especially in the eastern half of the peninsula (Arias & Navacerrada, 1973). Its economic importance has not been determined. In contrast, *X. index* was the most important nematode encountered in La Rioja. Typical symptoms of root malformations were observed in a few samples. Also, some vines with fanleaf symptoms were visible in the vineyard. This species was active during the warm and rainy summer but low during the remaining months of the year (Fig. 3). The absence of adult stages during most of the year suggests this nematode has only one cycle per year. Similar findings have been reported by Harris (1979) in a more detailed study on seasonal population fluctuation of *X. index* in Australian vineyards, Cohn (1969) in Israel and Protta and Garau (1973) in Sardinia.

Zygotylenchus guevarai has been found associated with grapes in Spain, Cyprus and Germany (Pinochet & Bergua, 1983; Antoniou, 1981; Tarjan & Weischer, 1965). It also has been reported to be a migratory endoparasite in many herbacious and woody hosts (Vovlas, Inserra & Lamberti, 1976; Tobar Jiménez, Guevara Benitez & Martinez Sierra, 1968). This nematode was not extracted from the roots during the recollections of the first three months from La Rioja (Fig. 3), indicating that perhaps this species might have fed ectoparasitically on grape host. It is also possible that this nematode might have been associated with weeds, although weed control practices were very good in this particular vineyard. The host parasite relationship of *Z. guevarai* on grape host under the present conditions is not well understood. A similar situation was found with *Pratylenchus* sp. in Cataluña. In this case, nematodes were not extracted from the roots in the first four months. This species conformed closely to the taxonomic features of *P. pratensis*. Weeds were abundant in this vineyard during certain times of the year and it seems more likely that this nematode might have been associated with adjacent weeds.

The vineyard located near the town of Quintanilla de Arriba in Castilla, was situated over an alluvial formation on the margins of the river Duero. These soils were chalky, light greyish in color and with an abnormally high content of active lime of 12.8 %. Patches with poor growth due to excessive lime were visible in the vineyard, mainly on hilltops and low spots surrounded by elevations. Rootstocks used in this area must have resistance or tolerance to these conditions. Despite adverse soil conditions for grape culture, nematode population increase was higher in this site than in the other vineyards located in La Rioja and Cataluña. The high lime content in the soil does not appear to have been a limitation for nematode reproduction, especially that of *Criconemella xenoplax*.

In general, the optimum conditions for nematode reproduction occurred with warm to hot temperatures and high rainfall for the majority of the nematodes in the three regions. Temperature became a limitation for nematode increase below 5° in some cases and so did the lack of rain during hot months for others. Despite variations in climatic conditions on which seasonal fluctuations mainly depend, nearly all the nematode populations studied remained active in varying degrees during the year.

ACKNOWLEDGEMENTS

The authors wish to thank M. Garcia, Enologist of the winery Vega Sicilia in Quintanilla de Arriba, Valladolid; S. Minguez, Viticulturist of INCAVI, Villafranca del Penedés, Barcelona; and A. Martinez, Agronomist of La Casa del Vino, La Guardia, Alava, for their assistance in this study, and to Prof. D. J. Raski for reviewing this manuscript.

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Accepté pour publication le 1er avril 1986.

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