RESENAS – REVIEWS

NEMATODE PROBLEMS AFFECTING POTATO PRODUCTION IN SUBTROPICAL CLIMATES

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ABSTRACT

Greco, N. 1993. Nematode problems affecting potato production in subtropical climates. Nematropica 23:213–220.

Globodera rostochiensis and *G. pallida* are the principal nematodes affecting potato in subtropical regions and are responsible for considerable yield losses; *Meloidogyne* spp. and *Pratylenchus* spp. are of local importance. The tolerance limit of potato to both cyst nematodes is 1.3–2.1 eggs/g soil and the relative minimum yield at high nematode densities ranges from 0 to 40%. Short-cycle potatoes planted in summer and harvested in the fall minimize nematode reproduction and yield loss. Long-cycle potatoes planted in the fall and harvested in spring suffer greater yield loss than short-cycle potatoes and allow a significant proportion of the nematodes to reach the cyst stage. Potato crops sown in spring and harvested in summer suffer the heaviest crop losses and allow maximum reproduction of the cyst nematode (39–65 ×). Nematode population buildup is influenced by the number of generations completed per year, the length of the potato growing season, and the soil temperature. Thus, appropriate cropping systems can be used to control nematode populations. Quarantine regulations and crop rotations are major control measures. The use of resistant cultivars is effective if the pathotype of the nematode is known. Soil solarization is effective but costly. The use of chemical nematicides is also expensive and may cause environmental contamination.

Key words: Globodera rostochiensis, Globodera pallida, Meloidogyne arenaria, Meloidogyne hapla, Meloidogyne incognita, Meloidogyne javanica, potato, potato cyst nematodes, *Pratylenchus mediterraneus, Pratylenchus penetrans, Pratylenchus thornei, Solanum tuberosum,* subtropics.

RESUMEN

Greco, N. 1993. Problemas de nematodos que afectan la producción de papa en los climas subtropicales. Nematrópica 23:213–220.

Globodera rostochiensis y *G. pallida* son los principales nematodos que afectan a la papa en las regiones subtropicales y son responsable de pérdidas considerables en el rendimiento; *Meloidogyne* spp. y *Pratylenchus* spp. son de importancia local. El límite de tolerancia de la papa a estos nematodos formadores de quistes es de 1.3–2.1 huevos/g de suelo y los rangos de rendimiento mínimo de 0 a 40% a las densidades más altas de nematodos. Las papas de ciclo corto que se plantan en verano y se recogen en otoño reducen la reproducción de los nematodos y las pérdidas. Las papas de ciclo largo que se plantan en otoño y se recogen en primavera sufren mayores pérdidas en el rendimiento si se compare con las papas de ciclo corto y permiten que una proporción significante de los nematodos se desarrollan a formar quistes. Las papas sembradas en primavera y recogidas en verano producen las pérdidas más grandes en el cultivo y permiten la reproducción máxima de los nematodos formadores de quistes (39–65 ×). El incremento de poblaciones de los nematodos esta influído por el número de generaciones completadas por año, la duración del cultivo de la papa, y la temperatura del suelo. De este modo, con sistemas apropriados de cultivo se puede contribuir a mantener los nematodos controlados. La introducción de medidas de cuarantena y las rotaciones de cultivo son las medidas más eficaces de control. El empleo de cultivares resistentes es eficaz si se conoce el patotipo del nematodo. La solarización del suelo es eficaz pero cara. El uso de nematicidas químicos es también caro y puede causar contaminación ambiental.

Palabras clave: Globodera rostochiensis, Globodera pallida, Meloidogyne arenaria, Meloidogyne hapla, Meloidogyne incognita, Meloidogyne javanica, nematodos formadores de quistes, papa, *Pratylenchus mediterraneus, Pratylenchus penetrans, Pratylenchus thornei, Solanum tuberosum,* subtropical.

INTRODUCTION

Several plant-parasitic nematodes have been reported to be noxious to potato crops worldwide (13) and have stimulated extensive investigation (14) to elucidate their biology and pathogenicity, evaluate their role in potato production, and develop methods for their control. Some species cause damage in almost all major potato growing regions while others have only local importance.

Subtropics are characterized by warm summers and mild winters. In these regions, especially in coastal areas, frost is rare and most rainfall occurs from fall to early spring. This unique situation allows potato crops to be grown in very different seasons. For instance, in the Mediterranean basin potatoes can be planted in August (summer) to be harvested in November (fall), in November to be harvested in March–April (spring), in February to early March (winter) to be harvested in May–June (late spring), or planted in April (spring) and harvested in September–October (fall). In the 4th and 5th geopolitical regions of Chile, potatoes are grown year-round and potato crops at all developmental stages can often be seen in the same area at the same time. The season in which potato is grown affects the population dynamics and development of the different nematode species in different ways and, therefore, affects their impact on potato yield differently.

NEMATODES AFFECTING POTATO IN THE SUBTROPICS

With the exception of *Meloidogyne chitwoodi* Golden, O'Bannon, Santo & Finley all major nematode pathogens of potato occur in the subtropics. Fortunately, few of them cause severe yield losses.

Although *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans Stekhoven and *P. thornei* Sher & Allen are distributed worldwide and significantly affect potato production in temperate regions, their effect on potato production in the subtropics is virtually unknown. However, another root-lesion nematode, *P. mediterraneus* Corbett, formerly reported as *P. thornei,* has been shown to increase the severity of Verticillium wilt (12) in Israel. These root lesion nematodes all appear to be common in the Mediterranean basin (3,9), but their importance to potato production in this area has not been investigated.

Root-knot nematodes, *Meloidogyne incognita* (Kofoid & White) Chitwood, *M. javanica* (Treub) Chitwood, *M. arenaria* (Neal) Chitwood, and to a lesser extent *M. hapla* Chitwood, are common in subtropical areas and cause severe damage to many vegetables cultivated in summer in sandy soils. Although these nematodes are reported to damage potato in tropical countries (13), their effects on potato production in the subtropics are not well understood. The physical characteristics of the soils in which potatoes are cultivated in the subtropics and the cool growing season in which potatoes are usually grown (mostly from mid fall to spring), probably account for the absence of, or negligible damage caused by the major root-knot nematode species. However, potatoes are sometimes planted in midsummer in sandy soil where severe damage can be expected when these nematodes are present. This has been observed on summer sown potatoes infected by *Meloidogyne* spp. in Greece (27) and in soil infested with *M. arenaria* in Tunisia (B'Chir, personal communication).

The potato cyst nematodes *Globodera rostochiensis* (Woll.) Skarbilovich and *G. pallida* Stone, despite being less widespread than the previous nematode groups, appear to be the most damaging nematodes of potato in the subtropics (13). They are adapted to a wide range of soil texture (sandy to 35% clay) (4,5,6,8) and temperature (5,8,15); *e.g.*, they infect potato and develop well at 20 °C as well as 27 °C. The most common root-knot nematode species develop poorly if soil temperature is below 25 °C. Therefore, this review concentrates on *G. rostochiensis* and *G. pallida*.

POTATO CYST NEMATODES

The potato cyst nematode species that is most frequently reported in the subtropics is *G. rostochiensis*. This species occurs in the Mediterranean basin, including north African countries (Algeria, Morocco, and Tunisia) and islands such as Crete (28), Cyprus, Malta, and Sardinia, as well as in the southern hemisphere, *viz.* in Bolivia, Chile, Peru, South Africa, and New Zealand (17). *Globodera pallida* is present in Chile (16), Greece (28), and Italy (2), often mixed with *G. rostochiensis*.

Investigations undertaken in Chile (5), Cyprus (20), and Italy (8) showed that *G. rostochiensis* developed only one generation per growing season on early potato. Second-stage juveniles emerged from a certain proportion of eggs of the first generation. These juveniles were able to invade potato roots but, because of unsuitable soil temperature (usually above 25 °C) and (or) unavailability of suitable potato roots, the juveniles did not reach the adult stage. However, a second generation could be completed on potato planted in May and harvested in September in central Italy, if susceptible potato roots were available. Although this confirmed findings in temperate climates, the percentage of nematodes reaching the adult and cyst stages varied with the growing season. In Italy (8), 85–87% of the nematodes reached the cyst stage by harvest of potatoes sown from February to April while only 22% reached the cyst stage before harvest of potato planted in November. In the 4th and 5th geopolitical regions of Chile, where only early potatoes are cultivated, 10, 20, and 41% of the nematodes reached the cyst stages at harvest of crops planted in February (summer), June (winter), and September (spring), respectively (5). The potato growing season in Chile also influenced the reproduction rate of the nematode. In Italy, populations increased by a factor of 58–65 on potatoes planted in February-April (6). In Chile populations increased by 39× on spring potatoes but by only 8–9× on potatoes planted in February (summer) or June (winter) (5). The day degrees above 10 °C, required to reach the cyst stage in different countries and seasons, differ. In Chile, 358, 266, and 125 day degrees were required to reach the cyst stage on potatoes planted in February (summer), September (spring), and June (winter), respectively (5). In Italy, the day degrees required to reach the cyst stage with embryonated eggs were in the range 275–450 (8). These findings suggest that harvesting potatoes as early as possible minimizes nematode reproduction, thereby keeping nematode populations low.

Hatching tests with a Chilean population revealed no periodicity of hatching in *G. rostochiensis*, although more eggs hatched from February to April (maximum 84.4%) than thereafter (maximum 60%) (5).

As with most cyst nematodes, the population decline of *G. rostochiensis* in the absence of a host crop is rather slow. However, an annual egg decline of nearly 100% was reported from Morocco (21), probably due to a hot summer, and one of 80% was observed in Chile, compared with an average annual decline of 50% in temperate countries.

YIELD LOSS

Information on yield losses caused by plant-parasitic nematodes is prerequisite to advice for their management. Unfortunately, most current information is derived from nematicide experiments in fields with nematode infestations that are not uniform.

Seinhorst (22,24) demonstrated that the relationship between the population density at sowing or planting (P) of a nematode and yield of an annual host plant can be characterized by the equation

$$y = m + (1-m)\, z^{P-T}$$

in which: y (the relative yield at P) is the ratio between the yield at P and that at P $\leq$ T; T (the tolerance limit) is the population density up to which no yield loss occurs; m (the minimum yield) is the value of y at very high nematode population density; and z is a constant such that $z^{-T} = 1.05$. Microplot experiments in three different areas of Italy (6) and in two different seasons in Chile (4) provided data relating population densities of *G. rostochiensis* and *G. pallida* at planting to the relative yield of potato. Fitting the above equation to the data gave tolerance limits of potato to *G. rostochiensis* of 1.4 and 2.1 eggs per gram of soil for potatoes planted in spring in central and southern Italy, respectively, and of 1.3 and 1.56 eggs per gram of soil for winter and spring sown potato in the 4th geopolitical region of Chile. The tolerance limit of potato to *G. pallida* in Italy was 1.7 eggs per gram of soil. These data are close to the average tolerance limit of 1.9 eggs per gram of soil reported in temperate countries (23) and are useful to estimate the yield losses of potato in fields infested with potato cyst nematodes in subtropical regions. According to these relationships, average potato yield losses of 20, 50, and 100% would occur in Italy in soil infested with 12, 32, 128 eggs of the nematode per gram of soil. Similar yield losses can be expected in Chile in spring potato, but less would be expected in potato sown in summer (February) since the minimum yield (m) obtained from summer sown potatoes (0.3) was higher than that from spring sown potato (0.07). This suggests that at population densities >T summer sown potatoes are less damaged than spring sown potatoes, even though tolerance limits are similar, and is in agreement with Seinhorst's observation (23,24) that environmental conditions should have little effect on the tolerance limit, but might affect the minimum yield. Thus, although specific information on the yield of potato as affected by population densities of potato cyst nematodes is lacking for most countries, the information available can be of general use.

The relationship described here can be used to predict yield loss at the farm level, but can not provide the estimates of yield losses at province and country levels, which are needed to set priorities in allocating funds for research. Such estimates require extensive surveys to determine the percentage of fields infested at various population levels, and are not available for most subtropical regions. In Italy, the estimated annual yield loss of host crops due potato cyst nematodes is very high (up to 100%) at the farm level, but decreases with the size of the geographical area considered, being 17% and 5.2% at the province and region level, respectively (11).

CONTROL

For proper advice on the management of nematodes information is required on *i*) the nematode species and pathotype present, and their soil population densities, *ii*) relationships between nematode population densities and yields of host crops, *iii*) nematode biology, *iv*) nematode host range, *v*) nematode population dynamics, *vi*) relationships between control treatments and nematode mortality, and *vii*) economics of the available means of control. Unfortunately, in most subtropical regions little of this information is available. However, from the work reported in this review, general recommendations can be given. Because of consumer concern about environmental pollution, methods of control should be based primarily on cultural (non-chemical) means. Potato cyst nematodes have narrow host ranges and, therefore, crop rotations have proved satisfactory in keeping nematode soil population densities at non-damaging levels. There is clear evidence that nematode population densities are greater and crop damage is more severe where short (1 to 2 year) rotations are used. Compared to the 4 to 5 year rotations recommended in temperate climates; however, a 3 to 4 year rotation would provide good control of these nematodes in the subtropics because of their lower reproduction rate and greater annual population decline. In the subtropics, cultivation of potato from fall to early spring should be encouraged. This greatly limits reproduction of cyst and root-knot nematodes and permits an even shorter rotation.

Nematodes can develop on volunteer potatoes and on several weeds that are common in potato growing areas. Failure to control weeds properly during fallow or during crop rotation can greatly reduce the benefits of either practice.

High summer temperatures in the subtropics causes the top soil to become hot enough to kill eggs within cysts. In the Canary Islands, where both potato cyst nematode species are present, rotavating the soil in summer has proved useful to control populations (1).

Pathotype Ro_1 of *G. rostochiensis* seems to be prevalent in the subtropics (2) and most potato cultivars possessing resistance to potato cyst nematodes are resistant to this pathotype. However, some *G. rostochiensis* populations contain specimens that reproduce on resistant cultivars; hence continuous use of resistant cultivars might select for virulence in *G. rostochiensis* populations. In Chile, resistant cultivars are currently used specifically to control *G. rostochiensis*, and in other countries are used irrespective of the presence of the nematodes, simply because they ensure good production.

Most investigations on chemical control of nematodes in potato have been conducted in temperate countries. Very often great reductions of nematode populations and impressive yield increases have been obtained by treating the soil with fumigant (100–300 kg/ha) (7) and nonfumigant (5–10 kg a.i./ha) (7,19,25,29) nematicides. Unfortunately, insufficient information is available on the relationship between nematicide rate and nematode mortality to reliably estimate the rate required to reduce the nematode population to the economic threshold. Therefore, more nematicide than is required is often applied. This increases the cost of soil treatments to a level that might not be affordable by potato growers in many countries, and also increases the risk of environmental pollution. Moreover, the effectiveness of nematicides can be influenced by soil properties. In the subtropics, the soil pH is usually well above 7 (mostly between 7.5 and 8.6) and chemicals that are effective in temperate and tropical regions (where soil pH is often below 7) might fail to control nematodes.

Summer fallow is often practiced in the subtropics, providing an ideal situation for using soil solarization to control plant-parasitic nematodes. Although there is little information on the effect of soil solarization on potato nematodes, the experience gained with similar nematodes on other crops shows promise (18). Investigations have been undertaken in our institute to ascertain the effect of different temperatures and exposure times on the survival of several nematode species, including cyst nematodes. Our findings clearly demonstrate that *G. rostochiensis* is much more sensitive to temperatures in the range 35–45 °C than are other cyst forming nematodes. This suggests that soil solarization could be a satisfactory control method. Solarization is also effective against other soil borne pathogens, insects, and various weed species. Its efficacy can be increased significantly if combined with low rates of fumigant nematicides (10,26).

FURTHER CONSIDERATIONS AND CONCLUSIONS

Although nematodes affecting potatoes have been extensively investigated in temperate countries, their impact in many subtropical areas needs more study. Root-knot nematodes (*Meloidogyne* spp.) are widespread in the subtropics but no information is available on the relationships between potato yield and soil population densities of root-knot nematodes in different growing seasons, making it difficult to formulate management recommendations. The root rot nematode, *Ditylenchus destructor*, is a severe pest of potato in temperate European countries and also occurs in some Latin America countries. *Nacobbus aberrans* (the false root-knot nematode) is common in Bolivia and Perú and causes extensive damage to potato. *Ditylenchus destructor* and *N. aberrans* both have rather wide host ranges, thus making their control by crop rotation difficult. Quarantine regulations should therefore be adopted to limit their spread in non-infested areas.

Several nematode parasites of potato have races and (or) pathotypes that differ greatly in virulence, and in their ability to reproduce on potato. Their identification is a prerequisite for proper use of resistant cultivars and, therefore, should be encouraged. Moreover, geographically isolated populations within other nematode species, such as *Pratylenchus* spp., may also differ in their virulence and more information is needed regarding this genetic variability.

The most damaging nematodes to potato crops in subtropical regions are *G. rostochiensis* and *G. pallida*. The information currently available regarding these species can be used to design an integrated management program in most cases. This will usually be based on crop rotations, choice of the most appropriate potato growing season to limit the buildup of the nematode populations, and the use of resistant cultivars. However, satisfactory control can be achieved only if the nematode species and their infestation levels can be ascertained and if proper advice reaches the farm level.

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