*Journal of Plant Protection in the Tropics* 9(2): 143-149 (1992)


# Plant parasitic nematodes associated with upland rice in the Philippines

L. M. VILLANUEVA, J. -C. PROT and D. M. MATIAS

Plant Pathology Division, International Rice Research Institute, P.O. Box 933, 1099 Manila, Philippines

**Abstract:** A survey was conducted in eight Philippine provinces to identify the major plant parasitic nematode genera associated with upland rice, determine their frequency of occurrence and abundance, and assess their potential as rice parasites. From 190 fields, 1,900 soil and root samples were collected at either pre-seeding or maximum tillering stage. Eleven genera and species of plant parasitic nematodes were found to be associated with upland rice: *Criconemella, Helicotylenchus, Hemicriconemoides, Hemicycliophora, Hoplolaimus, Meloidogyne, Pratylenchus zeae, Rotylenchulus reniformis, Rotylenchus, Tylenchorhynchus,* and *Xiphinema.* In all provinces surveyed *Criconemella, Helicotylenchus, P. zeae,* and *Xiphinema* were present. *P. zeae* was detected in all the surveyed fields with high population densities (average of 174 per g of root). Low population densities of *Meloidogyne* were observed in 35% of the fields. *P. zeae* was omnipresent and seems to be a component of the Philippine upland rice ecosystem.

**Key words:** Plant parasitic nematodes, upland rice, Philippines.

**Author citation:** Villanueva, L.M. *et al.*

## INTRODUCTION

Upland rice occupies 13%, or 19 million ha, of the world's rice areas. It makes up 76% of the rice area in Latin America and 65% in West Africa (WARDA, 1984), but only 13% in Southeast Asia (Huke, 1982). In the Philippines, upland rice is grown on 441,000 ha, or 12% of the country's total rice growing area (IRRI, 1988). The important upland rice growing areas are in Mindanao, with 52% of the country's upland area, and Southern Luzon, with 20%. Yields are low; upland rice accounted for only 3% of the country's total rice production in 1983 (Gonzaga *et al.,* 1985). Philippine upland rice ecosystems are highly diversified. Soil pH ranges from 3.8 in Leyte province to 8.5 in Bohol, with an annual rainfall ranging from 1,500 to 3,500 mm. Cropping patterns are different from one province to another. In Batangas province upland rice is usually grown in rotation with cowpea or corn. In Camarines Norte, Camarines Sur, and Sorsogon, fields are left fallow during the dry season and rice is grown every rainy season. In Samar and Leyte, fields are left fallow for two or three years, then rice is grown for two years in rotation with vegetable crops, corn, peanut or cassava. In Zamboanga del Sur, upland rice is grown every year in rotation with vegetables, corn, mungbean or cassava. Rice cultivars grown by the farmers also vary depending on provinces, soil and rainfall. Traditional varieties (Lubang, Pilit, Kalinayan, Baysilanon, Budbod, and Lingkod) are planted in Samar and Leyte while improved cultivars are grown in other provinces, IR 30716 in Misamis oriental, and UPL Ri5 and C22 in Camarines Norte, Camarines Sur, Sorsogon and Zamboanga del Sur.

According to Hollis and Keoboonrueng (1984), and Bridge *et al.* (1990), the following genera may cause damage in upland rice worldwide: *Aphelenchoides, Criconemella, Helicotylenchus, Hemicycliophora, Heterodera, Hoplolaimus, Meloidogyne, Pratylenchus, Rotylenchulus,* and *Xiphinema.*

In the Philippines, information on the occurrence of plant parasitic nematodes in the upland rice ecosystem is limited. Castillo *et al.* (1977) conducted survey in 21 farmers' fields in Batangas province. They recorded the presence of eight genera: *Criconemella, Helicotylenchus, Hemicycliophora, Hoplolaimus, Meloidogyne, Pratylenchus, Rotylenchulus,* and *Xiphinema.* Bridge (1988) indicated that, in the Pacific Islands, the most important nematode pest of rice was *Aphelenchoides besseyi,* and that *P. zeae, Meloidogyne* spp., and *Criconemella* spp. could also be important. Knowledge of the identity and prevalence of plant parasitic nematodes associated with upland rice is necessary to understand their contribution to crop yield stagnation. An extensive survey was conducted to: 1) identify the genera of plant parasitic nematodes associated with upland rice; 2) determine their frequency of occurrence and abundance; and 3) assess their potential as rice parasites.

## MATERIALS AND METHODS

The survey was conducted in eight upland rice growing provinces of the Philippines (Figure 1) from March to July 1990. A total of 190 farmers' fields, scattered all over the upland rice growing areas and representative of most of the Philippine upland rice ecosystems were surveyed. The area of these fields varied from one fourth to half a hectare. Upland rice has been grown in these areas for more than a century. Ten 500 $cm^3$ soil samples per field were collected at pre-seeding from 28 fields in Batangas and 25 in Misamis Oriental provinces. At maximum tillering stage, ten soil and root samples per field were taken from 25 fields in Batangas province, 25 in Zamboanga del Sur, 12 in Camarines Norte, 24 in Camarines Sur, 9 in Leyte, 17 in Samar, and 25 in Sorsogon. Each sample was made of one hill and 500 $cm^3$ of rhizosphere soil.

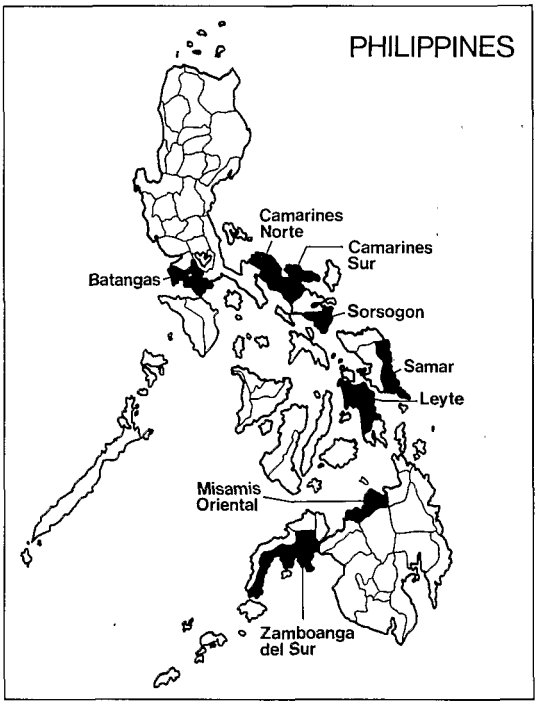


**Figure 1.** Upland rice growing provinces surveyed in the Philippines.

Each root and soil sample was processed separately. Nematodes were extracted from 200 $cm^3$ soil and 3 g root subsamples. Soil samples were processed by using a combination of sieving and modified Baermann fun-

nel methods. Root samples were shredded for 15 s in a blender and then macerated for 48 h in a modified Baermann funnel. The nematodes were identified and counted, and their numbers converted to 1,000 $cm^3$ of soil per g of roots.

To estimate their potential as upland rice parasites, two indices (Fortuner and Merny, 1973) were calculated for each nematode species and genus: 1) the frequency, which is the percentage of fields where the species or the genus was detected; and 2) the abundance, which is the logarithm of the average observed population density in fields where the species or genus was observed.

## RESULTS AND DISCUSSION

Eleven species or genera were found associated with upland rice in the areas surveyed. Table 1 indicates the mean number of individuals observed per 1,000 $cm^3$ of soil or per g of root for each species or genus at pre-seeding and maximum tillering in each province.

In the soil, the most frequently occurring nematode genera and species were *P. zeae, Helicotylenchus, Xiphinema* and *Criconemella.* They were present in all the provinces. High population densities of *P. zeae* were observed in all the fields except those in Camarines Sur and Leyte. *Hoplolaimus* occurred in low population densities in all the provinces except Camarines Norte. Low population densities of *Meloidogyne* were found in five provinces. *Tylenchorhynchus* and *Rotylenchulus* were detected in all provinces except in Leyte and Samar. High frequency of *Rotylenchus* occurred at pre-seeding but low frequency occurred at maximum tillering in Batangas. On the other hand, in the same province, the frequencies of *Hemicriconemoides* and *Hemicycliophora* were higher at maximum tillering than at pre-seeding. Only *P. zeae* was recovered from the roots with high population densities and a 100% frequency.

*P. zeae* appears to be the most prevalent plant-parasitic nematode associated with upland rice in the Philippines. When 53 fields surveyed at pre-seeding were considered, an average population density of 627 *P. zeae* per 1,000 $cm^3$ was observed (std. dev. = 723); the minimum and maximum population densities observed per field were 11 and 2731, respectively. Population densities of *P. zeae* higher than 200 per 1,000 $cm^3$ were recorded in 31 fields. At maximum tillering *P. zeae* was predominantly found within the roots. An average number of 123 *P. zeae* per g of root (std. dev. = 195) was observed when 137 fields surveyed at maximum tillering were considered. The minimum and maximum field average numbers of *P. zeae* observed per g of roots at maximum tillering were 1 and 1279, respectively. Out of 137 fields, the average root nematode populations in 100 fields were higher than 20 *P. zeae* per g of root. However, *P. zeae* was not detected in the soil in 11 fields at maximum tillering. At this stage of crop development, the field average soil population density was 123 *P. zeae* per 1,000 $cm^3$ (std. dev. = 195).

Figure 2 shows the frequency and abundance of each genus or species present in the soil based on all the surveyed fields. All the genera and species except *Hemicriconemoides* and *Hemicycliophora*

**Table 1.** Frequency (F) and average population densities (PD) per 1,000 $cm^3$ of soil and g of root of plant parasitic nematodes associated with upland rice in eight provinces of the Philippines at pre-seeding (1) and maximum tillering stage (2).

| Nematode genus or species | Batangas (1) | | Batangas (2) | | Misamis Oriental (1) | | Zamboanga del Sur (2) | | Camarines Norte (2) | | Camarines Sur (2) | | Leyte (2) | | Samar (2) | | Sorsogon (2) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F | PD | F | PD | F | PD | F | PD | F | PD | F | PD | F | PD | F | PD | F | PD |
| *Criconemella* | 36 | 2 | 90 | 12 | 48 | 2 | 12 | 1 | 67 | 18 | 25 | 2 | 11 | 1 | 18 | 2 | 84 | 5 |
| *Helicotylenchus* | 100 | 28 | 100 | 34 | 96 | 18 | 100 | 53 | 100 | 18 | 71 | 10 | 67 | 13 | 88 | 20 | 100 | 12 |
| *Hemicriconemoides* | 4 | 0.5 | 76 | 23 | – | – | – | – | – | – | – | – | – | – | 6 | 2 | – | – |
| *Hemicycliophora* | 54 | 6 | 100 | 130 | – | – | 4 | 0.5 | – | – | – | – | – | – | – | – | – | – |
| *Hoplolaimus* | 51 | 3 | 80 | 10 | 4 | 0.5 | 16 | 0.5 | – | – | 13 | 3 | 11 | 1 | 65 | 5 | 36 | 1 |
| *Meloidogyne* | | | | | | | | | | | | | | | | | | |
| soil | – | – | 64 | 22 | – | – | 6 | 2 | 17 | 1 | – | – | – | – | 24 | 6 | 40 | 4 |
| root | – | – | 56 | 5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| *P. zeae* | | | | | | | | | | | | | | | | | | |
| soil | 100 | 267 | 100 | 88 | 100 | 1072 | 100 | 117 | 100 | 88 | 58 | 34 | 89 | 7 | 100 | 52 | 100 | 371 |
| root | – | – | 100 | 240 | – | – | 100 | 62 | 100 | 159 | 100 | 72 | 100 | 113 | 100 | 50 | 100 | 415 |
| *R. reniformis* | 100 | 467 | 96 | 31 | 72 | 50 | 4 | 1 | 33 | 3 | 42 | 4 | – | – | – | – | 8 | 2 |
| *Rotylenchus* | 89 | 20 | 16 | 5 | – | – | 4 | 7 | – | – | – | – | – | – | – | – | – | – |
| *Tylenchorhynchus* | 93 | 53 | 100 | 77 | 24 | 5 | 4 | 7 | 50 | 4 | 8 | 4 | – | – | – | – | 16 | 7 |
| *Xiphinema* | 75 | 4 | 60 | 5 | 56 | 6 | 4 | 0.5 | 100 | 27 | 38 | 4 | 100 | 12 | 88 | 31 | 48 | 10 |

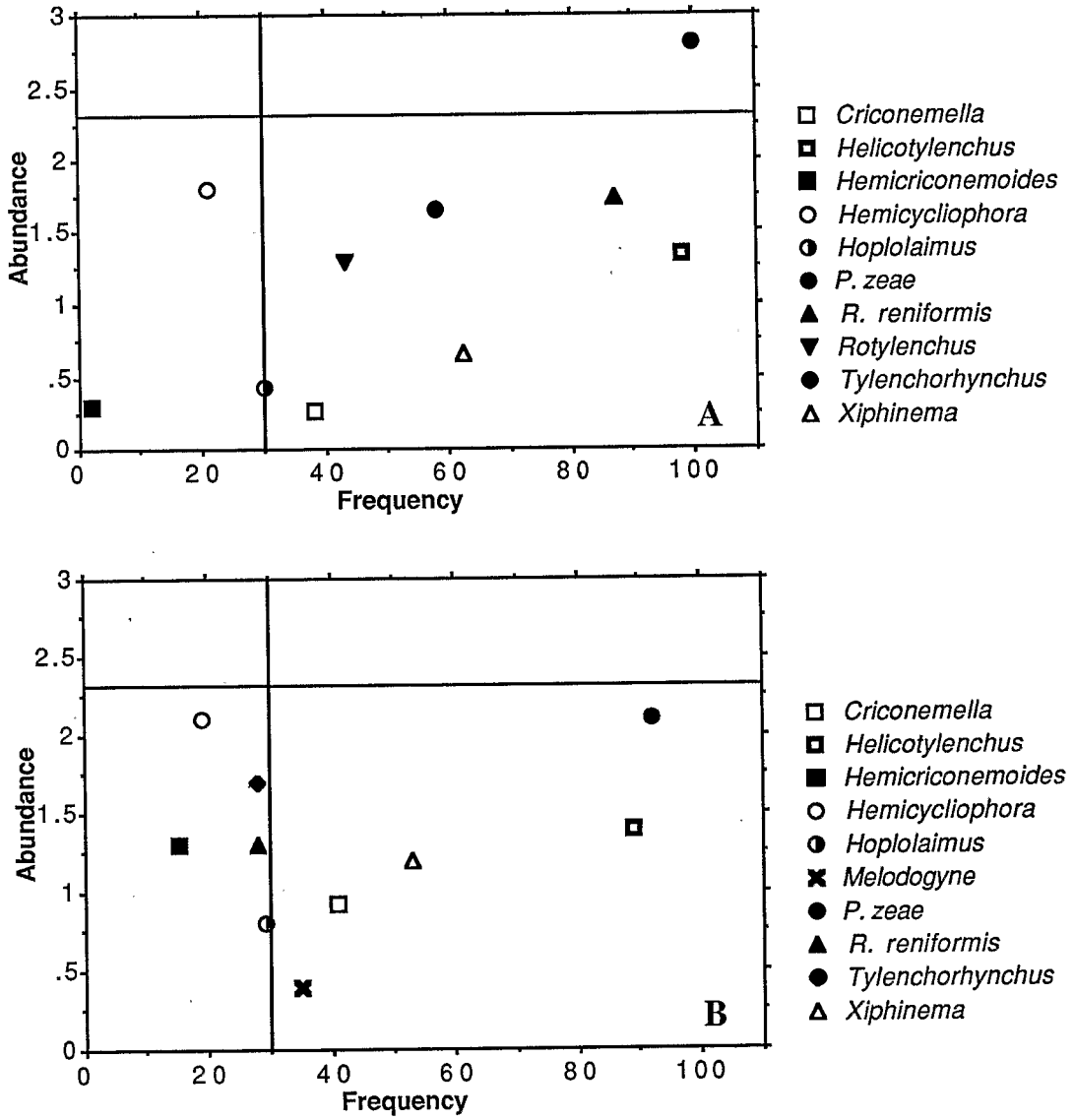


**Figure 2.** Frequency and abundance of the species and genera of plant parasitic nematodes found in the soil in the upland rice ecosystem at pre-seeding (A) and maximum tillering stage (B) in the Philippines.

were observed in more than 30% of the fields. At pre-seeding, only *P. zeae* had an abundance index of more than 2.3, while at maximum tillering stage all the nematodes had an abundance lower than 2.3. At maximum tillering stage, only *Meloidogyne* spp. and *P. zeae* were recovered from the roots (Table 1). The root knot nematodes were found in low populations (abundance = 0.7) in 7% of the samples. The frequency index

of *P. zeae* in the roots at maximum tillering was 100% and its abundance index was 2.24.

Fortuner and Merny (1973) considered that a nematode genus or species is frequent when it is detected in at least 30% of the fields. Likewise, a nematode genus or species is considered abundant when its abundance index is equal to or greater than 2.3 in the soil (corresponding to 200 individuals per 1,000 $cm^3$ of soil) and 1.3 in the roots (corresponding to 20 individuals per g of root). The same authors considered that:

– Nematodes present in more than 30% of the fields with an abundance index greater than 2.3 in the soil or 1.3 in the roots constitute the essential part of the plant-parasitic nematode fauna and are most certainly active parasites of rice.

– Nematodes present in more than 30% of the fields with an abundance index lower than 2.3 in the soil or 1.3 in the roots are ubiquitous nematodes but not active parasites of rice.

– Nematodes present in less than 30% of the field with an abundance index greater than 2.3 in the soil or 1.3 in the roots are most certainly active parasites of rice but have special environmental requirement limiting their dissemination.

– Nematodes present in less than 30% of the fields with an abundance index lower than 2.3 in the soil or 1.3 in the roots are fortuitous nematodes and are not active parasites of rice.

Based on these criteria, only *P. zeae* could be considered an active parasite of upland rice in the Philippines. All the other genera observed during this survey may be regarded as not well adapted to the ecosystem and considered as minor parasites of upland rice in the Philippines. However, *Meloidogyne* was detected in 35% of the fields (65% in Batangas province) and can cause losses in upland rice (Ibrahim *et al.*, 1972; Rao and Biswas 1974; Fademi, 1984; Babatola, 1984). *Hoplolaimus* which was present in 30% of the fields (80% in Batangas province) may also damage upland rice (Ramana and Rao, 1978). During this survey these two nematodes were observed in low population densities. No reliable information is available on the economic importance of *Criconemella, Helicotylenchus, Hemicriconemoides, Hemicycliophora, R. reniformis, Tylenchorhynchus* and *Xiphinema* in upland rice. However, the fact that *Criconemella, Hemicriconemoides* and *Hemicycliophora* were detected more frequently and with higher population densities at maximum tillering stage than at pre-seeding seems to indicate that upland rice is a host for these nematodes.

Greenhouse experiments have indicated that *P. zeae* is a pathogen of upland rice (Matias *et al.*, 1990; Plowright *et al*, 1990). Chemical control (Plowright *et al.*, 1990) and crop rotation control (Aung and Prot, 1990) experiments conducted under field conditions have indicated that the control of *P. zeae* resulted in significant increases (22-57%) in yield indicating that this nematode is probably an important pest of upland rice. *P. zeae* which occurred in high population

densities in all the fields surveyed can be considered a pest component of the upland rice ecosystem in the Philippines and a prime target for control in the country.

## ACKNOWLEDGMENTS

This research was supported by the International Rice Research Institute (IRRI) and the "Institut Francais De Recherche Scientifique Pour le Development En Cooperation" (ORSTOM).

### REFERENCES

AUNG, T. and PROT, J-C. (1990). Effects of crop rotation on *Pratylenchus zeae* and on yield of rice cultivar UPL Ri-5. *Revue de Nematologie* 13: 445-447.

BABATOLA, J.O. (1984). Rice nematode problems in Nigeria: their occurrence, distribution and pathogenesis. *Tropical Pest Management* 30: 256-265.

BRIDGE, J. (1988). Plant-parasitic nematode problems in the Pacific islands. *Journal of Nematology* 20: 173-183.

BRIDGE, J., LUC, M. and PLOWRIGHT, R.A. (1990). Parasites of rice. In *Plant Parasitic Nematodes in Subtropical and Tropical Agriculture* (eds. M. Luc *et al.*). pp. 69-108. St Albans, Herts, England: CAB International.

CASTILLO, M.B., ALEJAR, M.S. and LITSINGER, J.A. (1977). Nematodes in cropping patterns. III. Composition and populations of plant parasitic nematodes in selected cropping patterns in Batangas. *Philippine Agriculturist* 60: 285-292.

FADEMI, O.A. (1984). Influence of rate and time of carbofuran application to control root-knot nematodes in upland rice. *International Rice Research Newsletter* 9 (6): 22-23.

FORTUNER, R. and MERNY, G. (1973). Les nematodes parasites des racines associes au riz en Basse-Casamance (Senegal) et en Gambie. *Cahiers ORSTOM, serie Biologie* 21: 3-20.

GONZAGA, R.R., ROXAS, N.M. and PRICE, E.C. Jr. (1985). Subsistence upland rice cultivation systems. An economic consideration. *Proceedings of International Upland Rice Conference, Jakarta, Indonesia* 1985, pp. 38-47.

HOLLIS, J. P. Jr. and KEOBOONRUENG, S. (1984). Nematode parasites of rice In. *Plant and Insect Nematodes* (ed W.R. Nickle) pp. 95-146. New York & Basel: Marcel Dekker, Inc.

HUKE, R.E. (1982). *Rice Area by Type of Culture: South, Southeast, and East Asia.* International Rice Research Institute, Los Banos, Philippines, 32 pp.

IBRAHIM, I.K.A., IBRAHIM, I.A. and REZK, M.A. (1972). Pathogenicity of certain parasitic nematodes on rice. *Alexandria Journal of Agricultural Research* 20: 175-181.

IRRI (1988). *World Rice Statistics 1988.* International Rice Research Institute, Los Banos, Philippines, 257 pp.

MATIAS, D.M., PROT, J-C.,and AUNG, T. (1990). *Pratylenchus zeae* on upland rice and its control by crop rotation. *Proceedings of the 21st Anniversary and Annual Convention of the Pest Control Council of The Philippines, Inc., 1990, Bacolod City, Philippines,* p. 41.

PLOWRIGHT, R.A., MATIAS, D., AUNG, T. and MEW, T.W. (1990). The effect of *Pratylenchus zeae* on upland rice. *Revue de Nematologie* 13: 283-291.

RAMANA, K.V. and RAO Y.S. (1978). Evaluation of yield losses due to lance nematode, *Hoplolaimus indicus* Sher in rice. *Andhra Agriculture Journal* 24: 124-125.

RAO, Y.S. and BISWAS, H. (1974). Evaluation of yield losses in rice due to the root-knot nematode *Meloidogyne incognita. Indian Journal of Nematology* 3 (1973): 74.

WARDA, West Africa Rice Development Association (1984). Upland rice in West Africa. *Proceedings of the 1982 Bouake, Ivory Coast, Upland Rice Workshop. International Rice Research Institute, Los Banos, Philippines,* pp. 21-43.