RICE ROOT NEMATODE (*HIRSCHMANNIELLA* SPP.)—A REVIEW OF THE WORK DONE IN INDIA

J. C. EDWARD, N. N. SHARMA and V. AGNIHOTHRUDU
Rallis Agrochemical Research Station, Peenya Industrial Area, Bangalore 560 058, India.

SUMMARY

In extensive survey conducted by the authors, rice root nematode species have been found associated with practically all low land rice tracts. The nematode in many instances is responsible for poor root systems, fewer tillers, stunting of the growth and reducing the yields. We hope this review will stimulate more intensive studies on this nematode leading to its effective control and checking the economic losses in rice.

RICE-ROOT NEMATODE SPECIES

In India, species of the genus *Hirschmanniella* are the most ubiquitous of the plant parasitic nematodes associated with the rice crop grown especially under lowland conditions. These have been reported practically in all the rice growing tracts of India[1,2]. A key of the species of the genus provided recently, recognizes twenty two species[3] perhaps overlooking a new species described by Maharaju[4]. The bases for creating new species under this genus appear rather arbitrary and the parameters used for their differentiation serve little purpose, for one attempting to allocate any rice root nematode specimen from a locality to a particular species already described. It may be said that the species known to occur in India considered to be ten in all[3,4] could be accommodated possibly under two species by critical study, considering the wide variations manifested in morphological characters within a population so that identification to the level of species may not pose a problem as at present.

SYMPTOMS, BIOLOGY AND HOST RANGE

The rice root nematodes are migratory ecto-endoparasites which feed on ectodermal as well as endodermal parencymatous cells of cortex of the roots with air channels. They have been found, although not frequently, in the seed, base of seedlings and coleoptile[5]. In the field, striking symptoms of the shoot system during the maturing stages are not recognized unless the root infection is heavy. Seedlings with heavy infection, however, show reduced survival, delayed tiller emergence with discoloured older leaves. Rapid regeneration of roots with tillers usually results in the recovery of plants, hence the reason for not manifesting striking symptoms of shoot system during maturity. Roots burrowed by the nematodes turn yellowish brown at the inception and eventually become dark and rot[5-7]. Dissolution of cells ofcortex penetrated by nematodes, staining of root surface with iron oxide followed by rotting of root has also been reported[6,6a]. The root system of infected plants is invariably poor, the reduction being directly proportional to the population density of the nematode in case of susceptible rice varieties[5-9].

Juveniles and adults of both sexes invade roots and the female starts oviposition a few days after penetration. Gravid females of *H. oryzae* (Soltwedel 1889) Luc & Goodey 1963 have been reported to occur only during September[10]. However, in Karnataka they have been found practically throughout the year[9]. This may be due to climatic factors. Development from egg to adult is about a month[9,10]. The population of *H. mucronata* (Das 1960) Luc & Goodey 1963 has been reported to show the highest increase at flowering stage reaching numbers equal to 9.5 folds the initial numbers[11]. In pot culture pathogenicity experiments with *H. oryzae*, initial levels of 100 and 1000 gave final populations equal to 6 and 2.4 times the initial, whereas an initial population of 10,000 decreased to half[7].

With *H. oryzae* (Soltwedel 1889) Luc & Goodey 1963 however, in Karnataka, an initial population of 1000–1200, the final population in susceptible varieties increased 0.9 to 3 folds, whereas in case of a tolerant variety (var. Halabbulu) it was as high as 5.6 fold[9]. The high population build up in tolerant variety is ascribed to its well-developed root system.

A soil temperature of 21–28°C is found to be optimal for multiplication[5]. The rice root nematode can survive in the northern rice tracts at temperatures as high as 35–45°C and as low as 8–12°C[12]. In Karnataka, Tamil Nadu and Andhra Pradesh it is found in rice tracts throughout the year. Among the weeds which serve as hosts in the rice fields the more common species are *Echinochloa crussgali*, *E. colonum*, *Eragrostis pilosa*, *Brachiaria ramosa*, *Cyperus* spp. and *Eclipta alba*[9,12,13]. In Kerala the wet land weed hosts of rice root nematodes are *Monochoria vaginalis*, *Fimbristylis miliasia*, *Cyperus iria*, *C. eleusinoides* and *Vallisneria spiralis*[14].

POPULATION DENSITIES AND DAMAGE

Paddy roots and soils around them from Punjab, Haryana, Uttar Pradesh, West Bengal, Andhra Pradesh, Tamil Nadu, Karnataka and Kerala examined for rice root nematodes revealed that their population in roots and soil at seedling stage and in the transplanting field were 3–129/1 g root and 60–780/200 ml soil and 1–159/1 g root and 10–1280/200 ml soil respectively*. From Kerala, survey has shown that in rice soils and rice roots the population may be 6–509/250 ml soil and 0–460/plant[14]. In Cauvery delta rice tract, rice nursery soils and seedling roots were found to register 6–58/250 g soil and 3–148/5 g root[14a].

Rice grain yield loss of 81% was found in pot culture pathogenicity experiments with initial *Hirschmanniella oryzae* population of 10,000 per pot[7]. Loss in grain weight of rice due to *H. mucronata* has been estimated at 25%[16]. Initial rice root nematode (*H. oryzae*) population of 1000 or 2000 per seedling affected plant growth, particularly the grain yield in rice var IR 20. Under field condition negative correlation between the nematode population and yield was noted in both IR 20 and Bhawani varieties of rice. A microplot field trial conducted on yield loss indicated that a soil population of 29–68 nematodes/500 ml soil at transplanting time could significantly reduce tiller population by 15% and final dry weight of grain by 13.8 to 19.2%[14].

In a pot culture pathogenicity experiment, sprouted rice seeds of the variety Jaya were inoculated with *Hirschmanniella oryzae* @ 0, 10, 100, 1000 and 10,000 per seedling and observations on the growth characteristics were made up to 37th day after inoculation at weekly intervals. Significant differences in the height and number of leaves of seedlings inoculated with 10,000 nematodes were recorded on the 7th day. On the 21st day the maximum number of tillers was recorded in control followed by 10, 100 and 1000 levels respectively with zero tiller in the highest level. On the 29th day, the plant height as well as the number of leaves and tillers registered inversely proportional reduction. This trend continued till the 37th day when the experiment was terminated. The leaf area and fresh weight of shoot and root recorded on the last day also indicated similar trend on reduction[16].

CHEMICAL CONTROL

Soil application of DBCP at 15–25 l/ha was found as effective as phorate at 5.5 kg a.i./ha in controlling rice root nematode[17,18]. Three applications of carbofuran or fensulfothion effectively controlled the nematode and yield increase of 32% was realised[13]. Nemaphos, Hexanema and Vapam at 11 kg/ha was found effective against *H. oryzae*[19]. Vapam at 2 kg a.i./ha was effective against *H. mucronata* but was phytotoxic[20]. Seedling root dip of rice in carbofuran 40F for 3 hr in 0.02% has been reported to be excellent in controlling rice root nematode, reducing its number, from 5 per treated plant to 41 per untreated plant[21]. Carbofuran applied at 1 kg a.i./ha to soil with standing crop has been reported to be effective against rice root nematode[22]. Soil fumigation in the nursery helped raise healthy seedlings and field application of DD and DBCP was very effective in nematode control and increasing grain yield[23]. Soil application of diazinon, fensulfothion, aldicarb, carbofuran, phenamiphos and phorate in split doses of 1.5 kg a.i./ha at planting, 40th and 60th day or at 1 kg a.i./ha on 30th day after planting, as well as dip with carbofuran WP and preplant application of DBCP decreased the nematode population significantly[8]. Fensulfothion or Nemaphos at 1.5 kg a.i./ha was found more effective than DBCP at 18–25 l/ha for controlling rice root nematode[22]. Carbofuran, aldicarb, fensulfothion or phorate at 2 kg a.i./ha were found to be equally effective in reducing *H. oryzae* populations significantly[24].

In a field trial, rice infected with *H. mucronata* treated with carbofuran (1 kg a.i./ha) at planting or at planting followed by 2 or 3 post-planting applications at intervals of 15 days indicated that application of 1 kg a.i./ha at planting and 15 days after planting was adequate in reducing populations to below economic injury level yielding about 33% increased grain over control[25]. In a field trial with natural population of *H. oryzae* and five- and ten-fold increase over natural population, soil was treated with carbofuran @ 1 kg a.i./ha at 7 and 50 days after planting. While dry weight of grain and straw per plot were reduced by 12.7 to 45.0% and 11.6 to 28.8% respectively by *H. oryzae* in untreated plots, in carbofuran treated plots grain and

* Rallis Agrochemical Research Station, Bangalore (RARS)

straw weights per plot increased by 17.9% and 14.6% respectively[26].

Reduction of rice root nematode populations was registered when roots of rice seedlings were soaked either in phenamiphos (0.04%) followed by carbofuran broadcast at 0.5 kg a.i./ha or root soak with FMC 35001 (0.04%) followed by broadcasting phenamiphos at 1 kg a.i./ha at Adutharai and Siringamasi, Tamil Nadu[27].

In a nursery treatment with either carbofuran 3G at 1 kg a.i./ha or metham sodium at 250 l/ha followed by root dip with FMC 35001, quinalphos, dimethoate, phenamiphos, phosphamidon, or aldicarb sulfone, each at 0.2% for 6 hr, carbofuran at 1 kg a.i./ha followed by root soak treatment with phenamiphos or FMC 35001 at 0.2% conc. significantly reduced rice root nematode and increased grain yield. When in another experiment carbofuran 3G was used at 1.275 kg a.i./ha in nursery, the rice root population was reduced up to 30 days after planting of rice and yield increase in treated was 7.3% over the control[27]. Nursery bed treatment at Hissar with carbofuran at 1 kg a.i./ha gave 27.2% and 40.4% increase in plant height over control in 1981 and 1982 trials respectively. Again when nursery bed was treated with 1 kg a.i./ha of aldicarb and carbofuran, both recorded significantly taller seedlings, carbofuran proving better than aldicarb, seedling height being higher over check by 41.5% and 25.5% and 32.4% and 40.4% respectively in 1981 and 1982. Nursery bed treatment with carbofuran at 1 kg a.i./ha followed by similar two doses *viz* 7 days before and 50 days after transplanting gave the maximum plant height, number of flowering tillers and grain yield (23.4%). At the same place when one-month-old seedlings (var. Jaya) were dipped before transplanting in 0.2% a.i. solution for 30 min of each of the following *viz* aldicarb sulfone, carbofuran sulfone, phosphamidon, dimethoate 30EC, carbofuran 40F, chlorpyriphos and quinalphos. Carbofuran sulfone treated plants gave the highest yield of 88.8 q/ha as against 83.6 in check whereas carbofuran 40F, aldicarb sulfone and dimethoate 30 EC gave 85.0, 83.1 and 82.1 q/ha respectively[28].

Root dip at 0.02% for 20 min on Vaigai rice variety with aldicarb sulfone, triazophos, isofenphos and carbofuran increased yield by 31.4, 28.5, 25.7 and 22.9% respectively over the control in a trial conducted at Coimbatore[28].

Seedlings raised from nursery treated with 1 kg a.i./ha and transplanted, and also those similarly treated but in addition treated with carbofuran at 1 kg a.i./ha 7 days and 50 days after transplanting were better than untreated. The latter gave 18.3% increased yield over untreated, equal to Rs. 445/ha[28].

At Bhubaneshwar, Orissa, 1 kg a.i./ha application of carbofuran in the nursery bed, followed by two applications of carbofuran at 1 kg a.i./ha, 7 days and 50 days after transplanting resulted in reduced nematode population and increased yield over control, the latter treatment being more effective, registering an increase in yield of 51.2% over the control as against 9.2% increase with nursery bed treatment alone. At Vellayani, Kerala treatment of nursery bed with carbofuran at 1 kg a.i./ha alone has been reported to reduce root population of nematode by 50E with no added advantage in the main field after nursery treatment. Further when seedlings from carbofuran treated nursery beds were given root dip with carbosulfan at 0.2% a.i. for 30 min, the grain yield per plot increased by 100% over control. A similar increase was obtained when water drench was given to nursery and the seedling roots dipped in dimethoate before transplanting[28].

Sheath blight of rice in Kerala could not be minimised by treatment with PCNB, carboxin and edifenphos. However, carboxin, Fycop (oil-based copper oxychloride) and edifenphos could reduce disease and rice root nematodes significantly when they were applied with carbofuran. Carboxin with carbofuran recorded the maximum yield[29].

Nursery bed treatment in Tiruchirapalli with carbofuran at 1 kg a.i./ha reduced the rice root nematode population of roots and increased root weight of seedlings over the untreated control by 80–100% and 22–71% respectively. (Monthly report—December 1983—of the RARS)

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NEWS

METAL SAVING METHOD OF MOULDING

This method has been proposed by researchers at the Kazakh Academy of Sciences. It consists in moulding and rolling hard alloys in a superplastic condition, and is based on the temporary ability of metals to take any shape without being destroyed.

Researchers have found that such a condition can be effected in any group of steels and alloys through selecting additives and preliminary treatment, particularly using methods of powder metallurgy. This new method is very promising. Having studied specific features of superplasticity, researchers have given recommendations to metallurgical and machine-building plants.

The determination of the threshold of superplasticity gives unlimited opportunities to make parts and blanks from hard-to-deform steels and alloys by die forging. In this case, metal wastes are substantially reduced and less electricity is consumed. Many industrial enterprises have started to forge parts in moulds under gas pressure, taking into account the threshold of superplasticity. (*Soviet Features*, Vol. XXIII, No. 185, p. 5, December 7, 1984.)