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DYNAMICS OF SOIL NEMATODES IN VEGETABLE BASED CROP SEQUENCES IN WEST BENGAL, INDIA

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Abstract: Diversity and dynamics of soil nematodes were observed in okra based crop sequences in West Bengal, India. The major nematode species identified were: *Rotylenchulus reniformis, Meloidogyne incognita, Hoplolaimus indicus, Tylenchorhynchus mashhoodi* and *Criconemoides onoensis*. *R. reniformis* and *M. incognita* were found to be the most abundant. The okra-cowpea-cabbage and okra-cucumber-mustard sequences were found to have maximum suppressive effect on *M. incognita*. The cabbage, mustard and rice in the sequence had a suppressive effect on *M. incognita* while okra, brinjal, cowpea and tomato supported nematode multiplication. Okra-rice-fallow suppressed *R. reniformis.* Low populations of *H. indicus* and *C. onoensis* were found in okra-cowpea-cabbage, okra-brinjal-okra and okra-cucumber-mustard. The populations of *H. indicus* and *C. onoensis* were found maximum in okra-rice-tomato and okra-rice-fallow. *T. mashhoodi* was suppressed under okra-cowpea-cabbage, okra-rice-fallow, okra-cucumber-mustard and okra-brinjal-okra. Plant parasitic and free living nematodes in an okra based system were estimated and their ratio was determined. The saprozoic nematode index (SNI) was found high (0.45) in okra-rice-fallow.

Key words: crop sequence, nematode suppression, dynamics, vegetable, West Bengal, India

INTRODUCTION

Plant parasitic nematodes are greatly influenced by the various biotic and abiotic factors in the ecosystems of crops. Among the biotic components, the crop host has a major impact on the build-up of the nematode population and consequently crop losses occur. Considering the adverse effects of the pesticidal approach to nematode control, there is hardly any choice left the for growers to reduce the nematode population in crop fields. The cropping sequence has a major role to play in the managing of phytonematode problems in economic crops under a sustainable production system. Nusbaum and Ferris (1973) documented well the importance and possibilities of adoption of crop rotation in nematode management. Subsequently, several attempts (Khan *et al.* 1975; Alam *et al.* 1976, 1980, 1981; Khan and Banerjee 2003) have been made to determine the host effects and to identify the nematode suppressive crop sequences under Indian conditions. In West Bengal, vegetable based crop sequences are the most predominant ones and cause a substantial nematode problem in the crops in the sequence (Anonymous 2005). Considering the importance of the crops with this local nematode problem, a pre-determined okra based crop sequence was grown. The purpose was to determine the effect of crops in the sequences on the diversity and dynamics of the soil nematode population in field plots. The purpose was also to identify crops or crop sequences and their likely impacts on soil nematodes.

MATERIALS AND METHODS

The experiment was conducted for two consecutive years (2005–2007) at the Central Research Farm, Bidhan Chandra Krishi Viswavidyalaya (BCKV), in the New Alluvial Zone of West Bengal (India) at 22°58’19’’N latitude 88°32’E longitude and at an elevation of 9.6 m above mean sea level. The community diversity and dynamics of soil nematodes were studied under predetermined vegetable based cropping sequences (under the All India Coordinated Research Project on Plant Parasitic Nematodes at Central Research Farm, Gayeshpur, Nadia, India). The crop sequences followed were: okra (cultivar: arka anamika) – rice (cultivar: IET4094) – tomato (cultivar: patharkuchi), okra-cowpea (cultivar: bidhan barbati-1) – cabbage (cultivar: Green express), okra-rice-fallow, okra-cucumber-mustard (cultivar: B-9) and okra-brinjal (local cultivars) – okra (cultivar: Arka anamika). The crops were raised throughout the year on fixed plots of 4x2.5 m size each, from 2005–2007. Soil along with root samples were collected from the rhizosphere of crops using a tool called a *khurpi*. Samples were collected at monthly intervals from June 2005 to May 2007. The samples were collected randomly from 10 points of each plot. A composite sample of 200 cc soil along with root (5 g) was taken in a polythene bag, tied with a rubber band and labeled properly. All the collected samples were brought to the laboratory and stored in a refrigerator at 10°C until their extraction. Nematodes from each soil sample were extracted by Cobb’s decanting and sieving (Cobb 1918)

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followed by modified Baermann's technique (Whitehead and Hemming 1965). For extraction of the nematode root population, samples were cut into small pieces and incubated over a double layer tissue paper supported on an aluminum wire gauge which was kept over a glass Petri plate of 10 cm diameter. The Petri plate was filled up with tap water and left undisturbed at room temperature. The nematode population was collected from the Petri plate at 24 h intervals for 2–3 consecutive days and then concentrated in a beaker for further processing. The infested root materials were processed and stained by the NaOCl-Acid Fuchsin method (Byrd *et al.* 1983). The species of the root-knot nematode species was identified on the basis of the perineal pattern of mature female. The nematode specimens were killed by the hot-water-bath method and then fixed in a 3% formaldehyde solution in order to preserve them in a specimen bottle. The nematodes obtained in a water suspension were counted under a stereoscopic binocular microscope with the help of a multi-chambered counting disc. The required number of fixed nematodes from each population were hand-picked. The nematodes were processed using the Seinhorst's glycerol-ethanol method (Seinhorst 1959) for permanent mounting on a glass slide for identification. The meteorological parameters (temperature, rainfall and relative humidity) were procured from the All India Coordinated Research Project on Agrometeorology, the Kalyani centre.

RESULTS AND DISCUSSION

The major plant parasitic nematodes consistently found in this vegetable based crop sequence were: *Meloidogyne incognita, Rotylenchulus reniformis, Hoplolaimus indicus, Tylenchorhynchus mashhoodi* and *Criconemoides onoensis*. Among these plant parasitic nematodes, *M. incognita* and *R. reniformis* were the most important and abundant in the field. The other free living nematode groups encountered were: *Tylenchus*, *Aphelenchus avenae*, rhabditid, mononchid and dorylaimid nematodes. The effect of crops on nematode dynamics and diversity is shown on figures 1–5. The results clearly indicated that among the crop sequences, okra-rice-fallow was most effective at suppressing the nematode population of *R. reniformis*, although its peak population was recorded during June–July 2006 (Fig. 1). This was followed by okra-rice-tomato, okra-cowpea-cabbage, okra-cucumber-mustard and okra-brinjal-okra.

The okra-cowpea-cabbage and okra-cucumber-mustard were found to have a maximum suppressive effect on *M. incognita* (Fig. 2). Among the other crop sequences, okra-rice-fallow had an almost similar effect but during February 2007 only a high population of the nematode was recorded. Jain *et al*. (2002) also found okra-wheat-fallow-okra as most effective to reduce root-knot nematode. The okra-rice-tomato enhanced the nematode population except in the rice growing period (July–October 2006). Similarly, okra-brinjal-okra stimulated the *M. incognita* population in the field. The population of *M. incognita* probably had agreeable conditions from July–October 2006 in order to have maintained high densities in soil. The results clearly showed that cabbage, mustard and rice in the crop sequence had a suppressive effect on *M. incognita* while okra, brinjal, cowpea and tomato supported nematode multiplication in the field. Mojtahedi *et.al.* (1993) also found suppression of nematodes in soil by using mustard and other *Brassica* crops. In West Bengal, the population of *M.incognita* was enhanced by the jute in the rice-jute-vegetable crop sequence but incorporation of mustard in the sequence reduced the soil nematode population (Khan and Banerjee 2003). It was evident that rice alone was not able to reduce the build up of *M. incognita* in the okra-rice-tomato sequence. This is presumably because rice is also a host (Jairajpuri and Baqri 1991) on which the nematode could multiply in certain conditions. *Brassica rapa*-okra reduced *M. incognita* and several other nematodes (Alam *et al.* 1981). Siddiqui and Alam (2001) proved that fallow-cauliflower-sorghum-coriander and sorghum-wheat-horsegram-turnip were beneficial in reducing the *M. incognita* and *R. reniformis* populations.

The population of *H. indicus* was found in low densities in okra-cowpea-cabbage, okra-brinjal-okra and okra-cucumber-mustard while its population build-up was

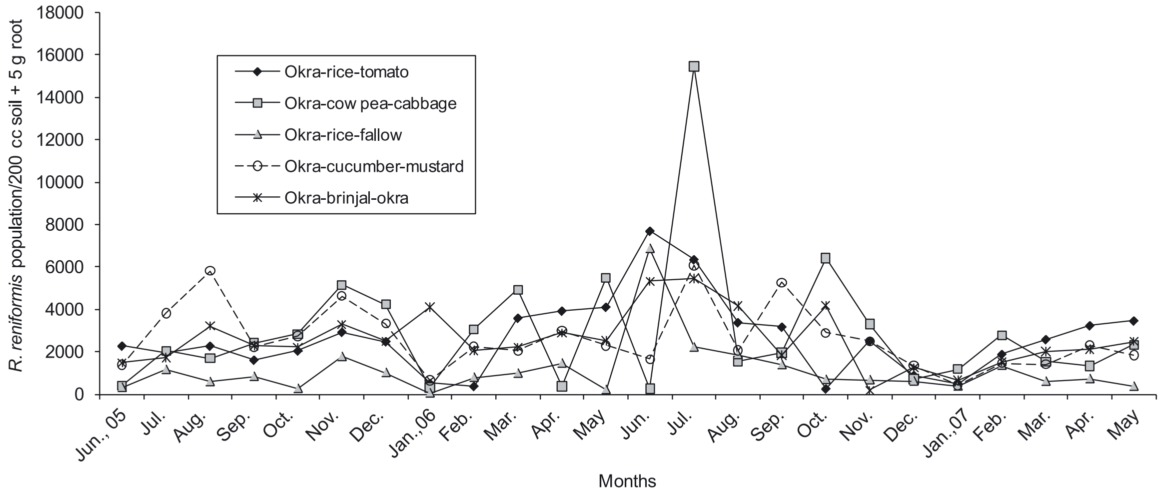

Fig. 1. Population fluctuations of *R. reniformis* in vegetable based crop sequences

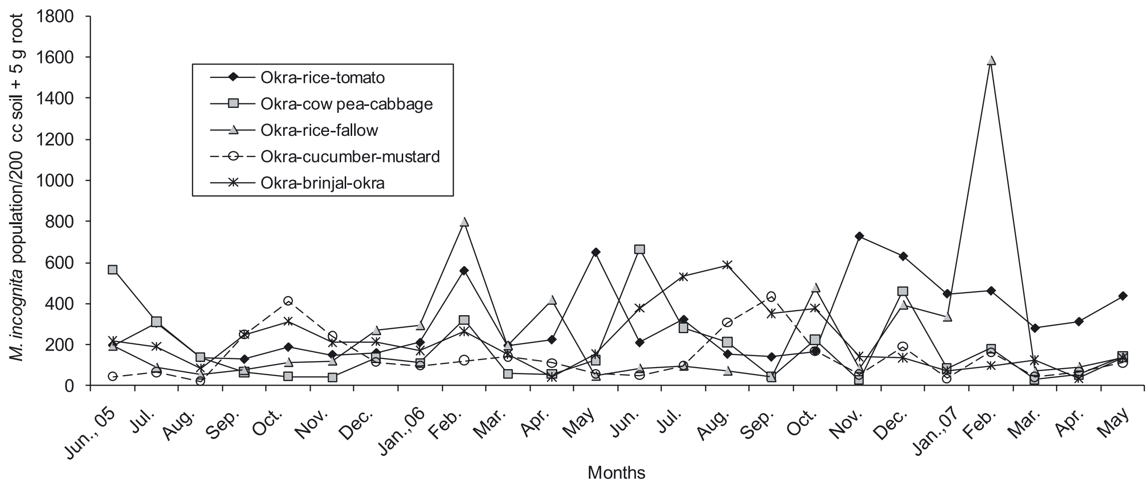

Fig. 2. Population fluctuations of *M. incognita* in vegetable based crop sequences

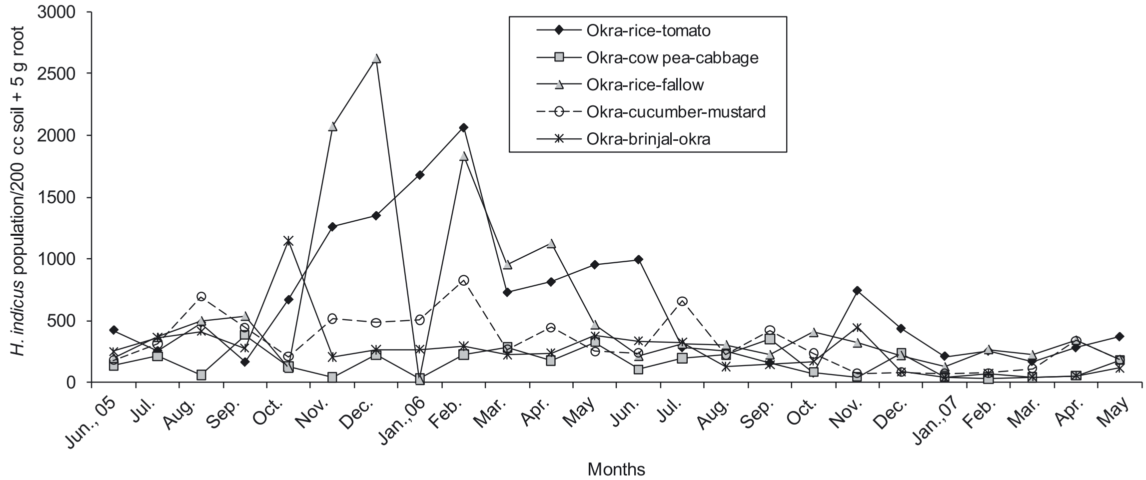

Fig. 3. Population fluctuations of *H. indicus* in vegetable based crop sequences

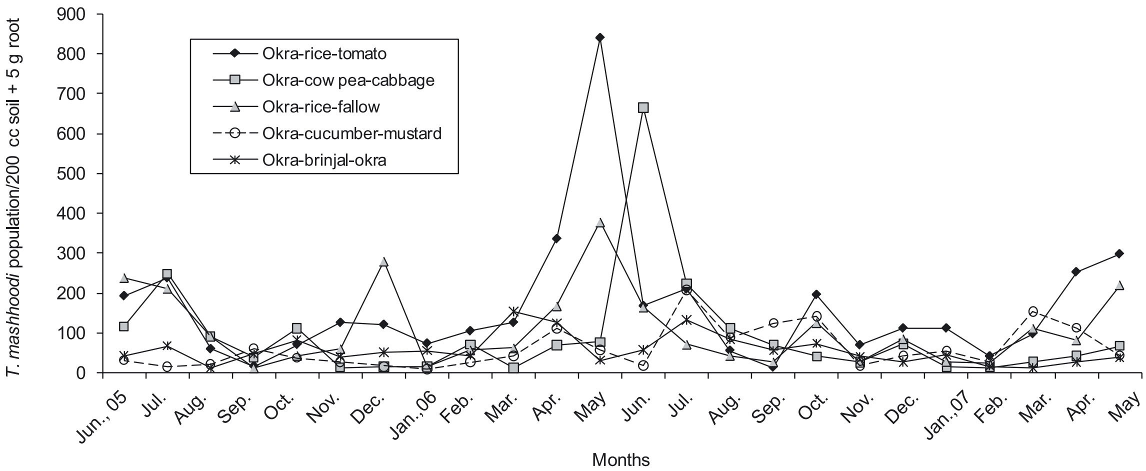

Fig. 4. Population fluctuations of *T. mashhoodi* in vegetable based crop sequences

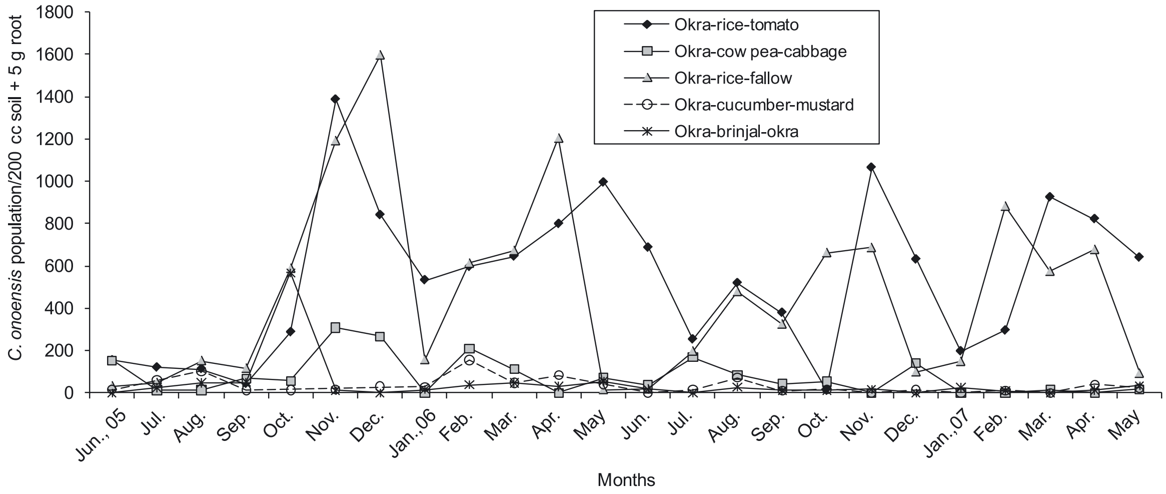

Fig. 5. Population fluctuations of *C. onoensis* in vegetable based crop sequences

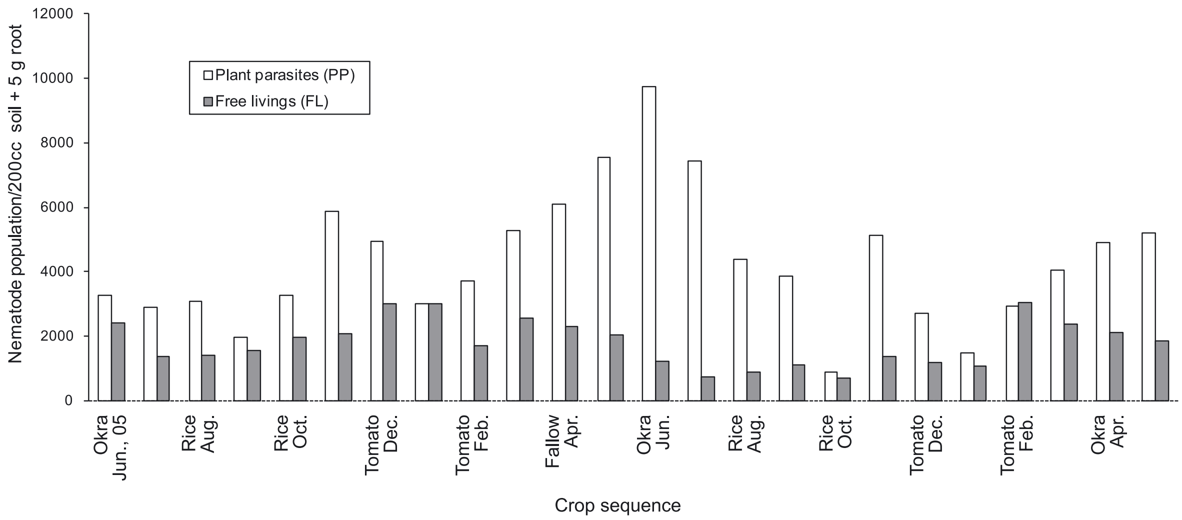

Fig. 6. Ratio of the population of plant parasitic and free living nematodes in okra-rice-tomato crop sequence at Gayeshpur, West Bengal

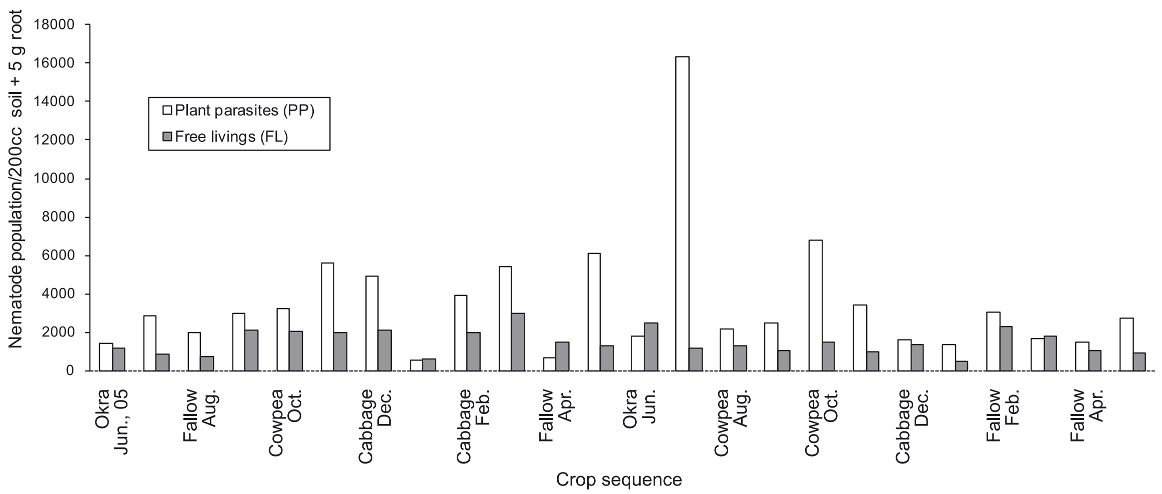

Fig. 7. Ratio of the population of plant parasitic and free living nematodes in okra-cowpea-cabbage crop sequence at Gayeshpur, West Bengal

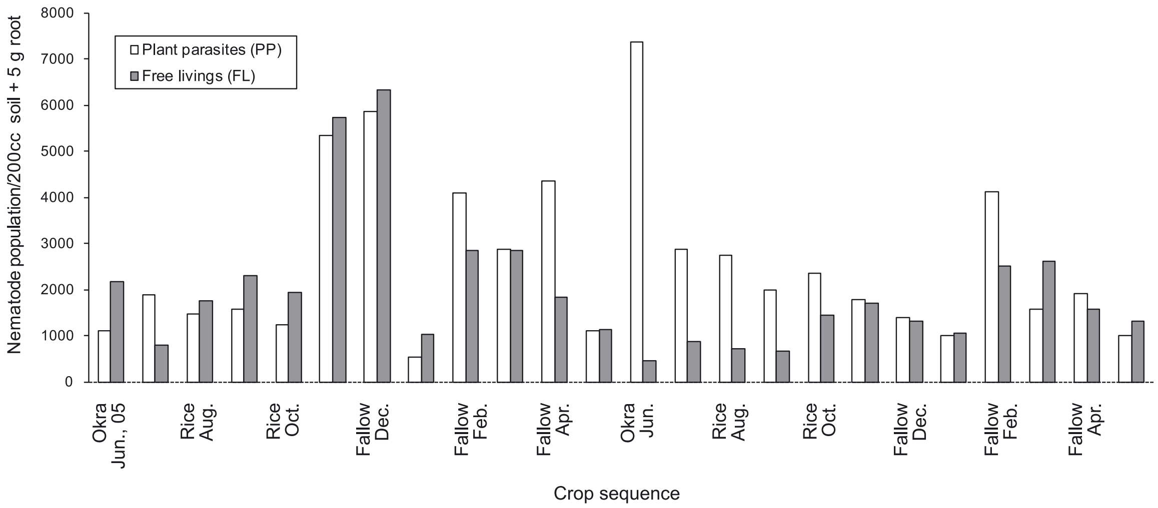

Fig. 8. Ratio of the population of plant parasitic and free living nematodes in okra-rice-fallow crop sequence at Gayeshpur, West Bengal

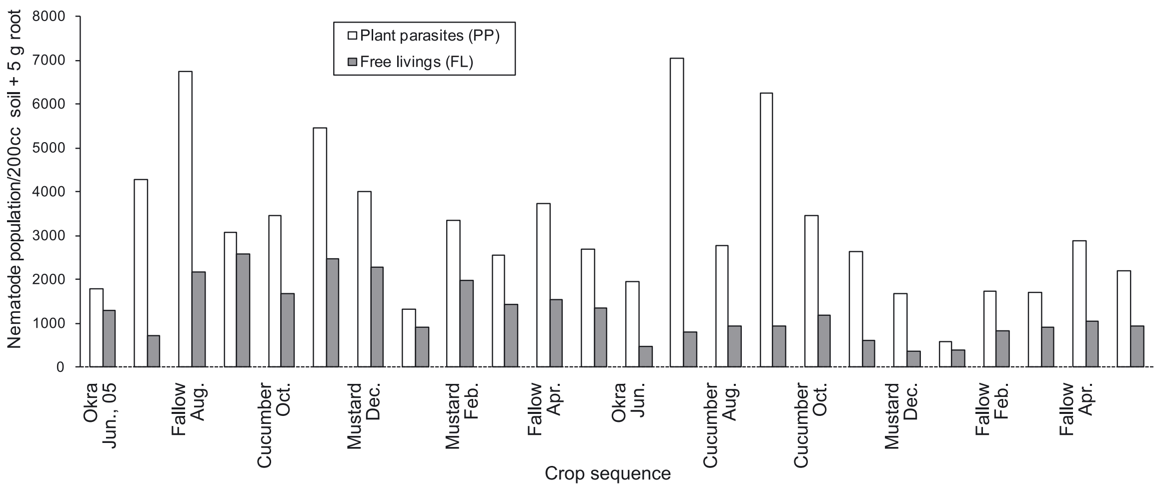

Fig. 9. Ratio of the population of plant parasitic and free living nematodes in okra-cucumber-mustard crop sequence at Gayeshpur, West Bengal

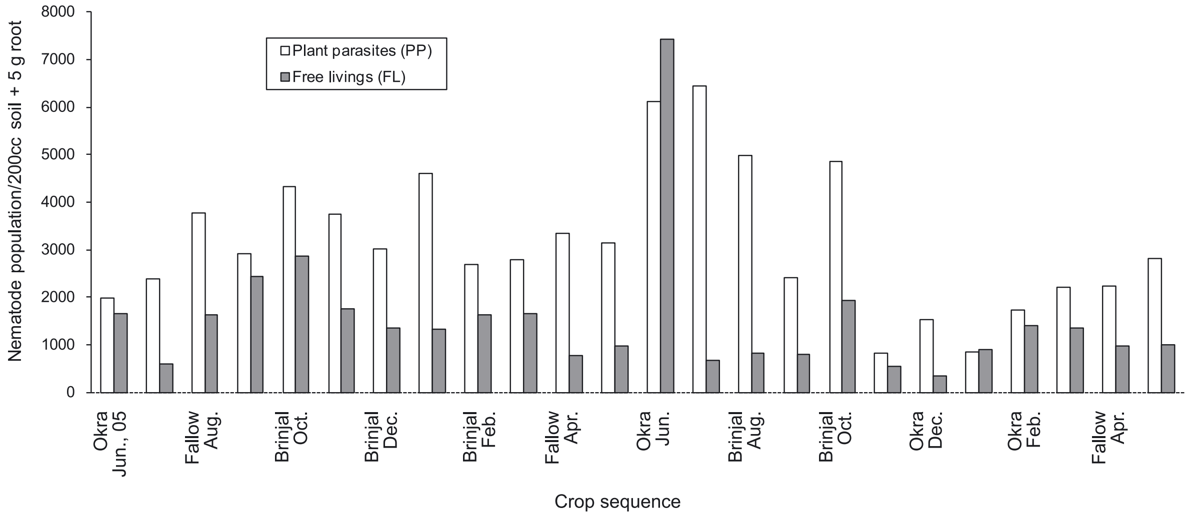

Fig. 10. Ratio of the population of plant parasitic and free living nematodes in okra-brinjal-okra crop sequence at Gayeshpur, West Bengal

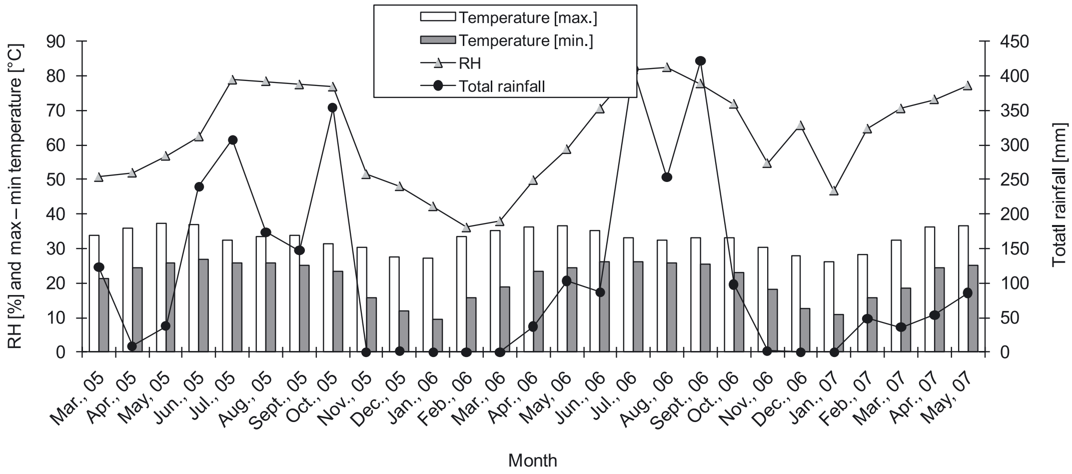

Fig. 11. Weather parameters during the period of March 2005 to May 2007 at Nadia, West Bengal

found to be maximum in okra-rice-tomato and okra-rice-fallow (Fig. 3). Similarly, okra-cowpea-cabbage, okra-rice-fallow, okra-cucumber-mustard and okra-brinjal-okra were found to have nematode suppression but okra-rice-tomato encouraged the build up of *T. mashhoodi* in the field (Fig. 4). The population of *C. onoensis* was found to be suppressed under okra-cucumber-mustard and okra-cowpea-cabbage crop sequences (Fig. 5).

In the okra-rice-tomato crop sequence, the total abundance of plant parasitic nematodes (PP) was found to be consistently higher than that of the total of free living nematodes (FL) except in February 2007 (Fig. 6). The population of PP increased steadily from January 2006 to June 2006 in tomato and okra crop. Consequently, the PP: FL ratio reached a maximum (3.69) in May 2006 in okra and 10.00 in July 2006 in okra. The total nematode count in the samples from rice fields was found to be relatively low in the rice growing season. In most of the samples in okra-cowpea-cabbage PP outnumbered FL (Fig. 7). In most of the samples in okra-rice-fallow during 2005–2006, PP was also found to be relatively lower than FL, although it turned out to be quite the opposite in 2006–2007 (Fig. 8). It was further evident from their ratio, which remained less than 1.0 in all the samples of rice 2005–2006 and slightly greater than 1.0 in 2006–2007. In the same crop sequence, the PP ratio was quite high in July 2005 (2.38) and in June 2006 (16.34) in okra.

Plant parasitic nematodes outnumbered FL in most of the samples in okra-cucumber-mustard (Fig. 9). Plant parasitic nematodes were recorded very high (16341/200 cc soil + 5 g roots) in comparison to FL from July–August immediately after harvesting of okra which had a higher (5.95 to 14.21) PP: FL ratio.

In the okra-brinjal-okra crop sequence, PP was consistently found to be higher than that of FL except in okra where FL outnumbered PP in June 2006 and in January 2007 (Fig. 10). In addition, the mean population density of PP on brinjal was recorded to be higher than on okra. Both, PP as well as FL in okra, was also very high in June 2006, with their ratio at 0.83. The ratio went high (4.0) in July 2005 in okra; 4.26 in April 2006 after harvesting of brinjal; 9.40 in July 2006 after harvesting of okra; 6.01 in August 2006 in brinjal and 4.37 in December 2006 in okra. The density of total nematodes (PP + FL) was very low during November 2006 to January 2007 possibly due to low temperatures. The weather conditions prevailing during the period of investigation are presented in figure 11.

The Saprozoic nematode index (SNI) was determined by dividing free-living nematodes (FL) with total nematodes (FL + PP) and multiplied by 100. The SNI was found highest (0.45) in okra-rice-fallow whereas it was 0.32, 0.35, 0.29 and 0.32 in okra-cowpea-cabbage, okra-rice-tomato, okra-cucumber-mustard, and okra-brinjal-okra, respectively. Gaur (2005) considered that the relative abundance of saprozoic nematodes could serve as a soil health parameter predicable by the SNI. A high SNI value indicates production systems rich in organic matter with a greater abundance of free-living nematodes playing an important role in the decomposition process in soil.

In summary, among the crop sequence tested for their suppressive effect on soil, nematodes, okra-rice-fallow, okra-cowpea-cabbage, okra-cucumber-mustard had the greatest effect on *R. reniformis, M. incognita, T. mashhoodi*, and *C. onoensis*. This was probably due to the incorporation of nonhost, poor host or antagonistic crops in the crop sequences. In most of the samples in vegetable based crop sequences PP consistently outnumbered FL and their ratio or SNI value could be a determinant for gauging soil health conditions. The information generated through this investigation may be used by farmers so that they can adopt the crop sequence for checking the population of plant parasitic nematodes and maintain free-living nematode populations for better soil health conditions.

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POLISH SUMMARY

DYNAMIKA NICIENI GLEBOWYCH W NASTĘPSTWIE ROŚLIN OPARTYM NA WARZYWACH W ZACHODNIM BENGALU, INDIE

W zachodnim Bengalu (Indie), obserwowano różnorodność i dynamikę nicieni glebowych w uprawach opartych na piżmianie jadalnym (orka). Stwierdzono najczęstsze występowanie nicieni: *Rotylencinus reniformis, Meloidogyne incognita, Hoplolaimus indicus, Tylenchorhynchus mashhoodi* i *Circonemoides onoesis*. Stwierdzono, że *R. reniformis* i *M. incognita*, występowały najliczniej. Ustalono, że następstwa roślin: piżmian–wspięga pospolita–kapusta i piżmian–ogórek–gorczyca, wykazywały najbardziej ograniczające działanie na *M. incognita*. Następstwa: kapusta, gorczyca i ryż, wykazywały działanie ograniczające *M. incognita*, a piżmian, brinjal, wspięga i pomidor, podtrzymywały rozmnażanie się nicieni. Zmianowanie: wspięga–ryż–ugór, ograniczało *R. reniformis*. Niskie populacje *H. indicus* i *C. onoesis* stwierdzono w zmianowaniu: piżmian–wspięga– *C. onoesis*, piżmian–brinjal–kapusta, piżmian–brinjal–wspięga i wspięga–ogórek–gorczyca. Populacje *H. indicus* i *C. onoesis*, były maksymalne w zmianowaniach: piżmian–ryż–pomidor i piżmian–ryż–ugór. *T. mashhoodi* był ograniczany przez zmianowanie: piżmian–wspięga–kapusta, piżmian–ryż–ugór, piżmian–ogórek–gorczyca i piżmian–brinjal–piżmian. Obliczono nicienie pasożytnicze dla roślin i nicienie wolno żyjące w systemie bazującym na pizmianie oraz ustalono ich występujące proporcje. Saprozoiczny wskaźnik ilości nicieni (SNI) był wyskoki (0.45) w systemie: piżmian–ryż–ugór.