Chapter

Management of Root-Knot Nematode, *Meloidogyne Incognita* Dreaded Invading in Pointed Gourd (*Trichosanthes dioica* Roxb.) Crop Prone to Eastern U.P of India

Ali Anwar, Najeeb Mohammad Mughal, Efath Shahnaz, Saba Banday, Taibah Bashir, Qadrul Nisa and Gulam Jeelani

Abstract

Pointed gourd belongs to cucurbitaceae family and is extensively cultivated in eastern Uttar Pradesh (10000 Hectares), Bihar (14000 hectares), West Bengal, Assam, Orissa, Madhya Pradesh, Maharashtra and Gujrat. Its plants are perennial in nature and can survive for several years even if left uncared. This crop occupies large area of land in India. The system of cultivation varies from region to region such as trained on pandals or ardours especially during the rainy season in southern and western India. However, it is most susceptible to root-knot nematode, *Meloidogyne incognita*, the population level or density of root-knot nematodes were found in the range of 15–100 per cent of the root and soil samples. This nematode induces severe damage to pointed gourd on coarse-textured sandy soils, particularly during droughts stress. Crop failure is noticed at earlier stage of vines. In view of fact it is necessary to evolve the integrated strategies for management of root-knot nematode in this viny crop.

Keywords: Pointed Gourd, Root-Knot Nematode, Integrated management

1. Introduction

Pointed gourd (*T. dioica,Roxb.),* locally known as parwal in India is a staple vegetable of people of India and frequently used in various cuisines. Belonging to the Cucurbitaceae family, fruits of pointed gourd can be either oblong or rounded and mostly recognised with white to yellow stripings on the outer skin. The veggie has white and mushy flesh and used in various cuisines. Parwal/pointed gourd is not only consumed as a fresh vegetable but possess proven medicinal value. It is said to be useful in disorders of the circulatory system. Parwal leaves with the bark of *Azadirachta indica* are used for the treatment of leprosy. The nutritive value of parwal as reported by [1, 2] is as protein 2 g, fat 0.3 g; mineral 0.5 g, carbohydrate 2.2 g, calcium 30 mg, phosphorus 40 mg. iron 1.70 mg, carotene 153 mg, thiamine 0.05 mg, riboflavin 0.06 mg vitamin 2.0 g. Its crunchy seeds are also edible.

In India, it is stir-fried, used in stews, soups, and meat dishes. It is full fill maximum nutritional requirements of human vegetable diets which are rich in several important vitamins and minerals including it in a brilliant way to stay active and fit. Here are some of its popular health benefits.

- It is rich in fibre and promotes good digestive health by treating ailments in the digestive system.
- It improves the immunity of the body and prevents you from catching regular flu, cold and sore throat.
- According to Ayurveda, Pointed gourd is a natural blood purifier and filters out all the toxins and impurities.
- Its seeds help in controlling blood sugar levels and protect you from the verge of becoming a diabetes patient

Pointed gourd (*T. dioica*) is extensively cultivated in eastern India. Substantially, the habit of crop is perennial and vegetatively propagated through the cuttings and root-suckers, while seed propagation is avoided due to poor germination. The crop fetches more prices in the market and its demand due to everyday consumption as vegetable and stupendous nutritive value. A preliminary survey of the crop in eastern U.P. India indicated the association of root knot nematode with unthrifty growth of plants in many areas [3, 4]. It is extensively grown in eastern part of Uttar Pradesh (10000 ha), Bihar (14000 ha), West Bengal (25000 ha) and to some extent in Assam (5000 ha), Orissa, Madhya Pradesh, Maharashtra and Gujarat states in India. This crop is viny in nature and occupies large areas and hence the system of cultivation varies region wise such as trained on bamboo stack or arbours especially during rainy season. The plants of pointed gourd are perennial in habit and can survive for several years even if left uncared.

It is most susceptible to many pest and diseases resulting heavy loss of fruit yield reducing the income of marginal farmers whose are mostly cultivated in India and elsewhere. Among these, nematodes cause severe losses to pointed gourd. The extent in production of crop fruit yield by phytoparasitic nematodes depends to a large extent on the farming system employed. In general nematodes may be less injurious to the plants under more extensive and varied growing systems i.e. multiple crop farming and shifting or staking cultivation in subsistence agriculture

Figure 1.
Crop infected with root- knot nematode.

or in widely spaced rotations of commercial farming systems than in more intensive production where more cropping and narrow rotations are practiced [5].

Perennial cropping systems, promote nematode population build up with time. The extent of the increase depends on the nematodes initially present and on the percentage of susceptible plant per unit area. Intensity of damage usually increases slowly with time in the perennial cropping system, as compared to the rapid increase in damage encounter in large scale parwal production where near annual cropping is practiced (**Figure 1**).

1.1 Noxious threat to pointed gourd

Root-knot nematode caused by *M.incognita* is a serious problem associated with field production of pointed gourd and cause major losses in crop in commercial farms, green houses and home gardens elsewhere. This disease is worldwide in distribution, essentially occurring in the area where hot summer is long but winter is short and mild. Nevertheless, it is not confined only to tropics and sub-tropics. It is also found in temperate regions.

In a fortified survey conducted by [6–8] of pointed gourd cultivated area of the farmer fields of eastern U.P. and another areas of the state showed that the population level of root-knot nematode (*Meloidogyne incognita*) was the range of 15–100 J2 per cent in root and soil samples.

Root-knot nematode (*M.incognita*) induces severe damage to pointed gourd on coarse textured sandy soils, particularly during drought due to low water content of the soil. However, the nematode also occurs in sandy clay loam and loam soils.

1.2 Parasitic nematodes incidence

Important diversity presence among the polyphagous nematodes of various localities of eastern part of India including a part of U.P. Mostly pointed gourd has been recorded as a host during frequent survey made by many scientists for at least one of the most frequently occurring species of root-knot nematode, *M.incognita*. Important other nematodes like *Hoplolaimus indicus, Rotylenchus reniformis, Tylenchorhynchus vulgaris* are only a local importance in crop growing areas (**Table 1**). Conversely

Nature of feeding	Common name	Scientific name	Symptom caused
A.Ecto-Parasitic	Lance nematodes	*Hoplolaimus indicus*	Stunting the vines and foliage of crop
	Spiral Nematodes	*Helicotylenchus dihystera*	
		H.abunaami	
		H. crenacauda	
	Dagger nematodes	*Xiphinema*	Root tip swelling
		Hirschmanniella gracilis	
		Criconemella ornata	
B.Endoparasitic	Root-knot nematode	*M.incognita*	Galls on roots,twigs or vines creeped on grounds
C.Semi-endoparasitic	Reniform nematodes	*Rotylenchulus reniformis*	Yellowing of foliage

Table 1.
Diversity in plant parasitic nematodes associated with pointed gourd.

Treatment	Fruit Yield (Q/ha)	Root-knot index(1–5)	Per cent loss in fruit yield
Carbofuran 2 kg a.i./ha	69.40 (+77.90)	1.00 (+80.00)	43.80
Untreated	39.00 (−43.80)	5.00	

Figures in parentheses show, per cent increase (+) or decrease (−) over untreated.

Table 2.
Yield losses due to M. incognita in pointed gourd (T.dioica Roxb.).

root-knot nematodes that predominate in upland region are in gangatic river belt of pointed gourd prone area [7, 9].

Root-knot nematode, which increase to damaging levels within a few season in susceptible crop are so common in perennial crop production that frequently they are taken to represent "Hidden enemy "in general. The other nematodes also cause heavy losses alone or in synergistically associated with other disease causing pathogens like fungi, bacteria, viruses etc.

1.3 Crop losses

No authentic information on crop loss due to attack of root-knot nematode in available. Thus an experiment was conducted at farmer field where crop was treated with Carbofuran@2.0 kg a.i./ha to determine the avoidable yield loss by keeping untreated check. Observation revealed that Carbofuran @2 kg a.i./ha reduced root-knot infection by 43.80% and which helped to increase the fruit yield by 43.80% over untreated control [3, 8]. It has been recorded drastic decline in marketable fruit yield when initial population of J_2 had 2–3 juveniles/gm. field soil which was above threshold level. The quantitative loss in fruit yield had 43.8 per cent (**Table 2**) where field was not protected with nematode but protected field crop had markedly higher fruit yield was observed through the fruit picking period with a seven day interval. In the non-protected plants, fruit yield is suppressed and difference was marked in months of July and August picking when fewer fruits have been picked but no such difference had noticed during March and April picking of crop season [10].

2. Symptomatology of root-knot nematode, *M.incognita* in crop

2.1 Symptoms

The common symptoms of root-knot nematode on pointed gourd have been found out the general stunting which are not grown as much as plants grown in nematode free soil, low vigour, chlorosis, necrosis, defoliation and twig die back. Twig galls has also been observed along with root galls (**Figure 2**) [9]. Infected plants are more susceptible to other diseases caused by fungi, bacteria [11] and tend to stop producing early. In pointed gourd the presence of galls on the root system and on propagated vines is the primary symptoms associated with Meloidogyne infection. During the warm days of July –August, the infected plants showed unhealthy growth and severe disease symptoms and a tendency to wilt. Stunting, non-emergence of sprouts, premature drying and shedding of leaves have been found in nematode infected fields where crop was being cultivated [2, 12].

Figure 2.
Profuse gall formation on vines of pointed gourd.

2.2 Gall formation

In galls formed by the nematode swelling of the central cylinder, highly deformed vascular elements and the spherical part of the nematode surrounded by the cortical parenchyma can be easily observed at low magnification in stained roots. During warm period, gall formation on roots and twigs is more conspicuous than in colder climate. Infected plants show fewer small rootlets, reduction in aerial growth in first year, while in second year and onwards crop showed marked decline in its production with the increase in nematode population and number of gall, smaller root system to support plant growth (**Figure 2**). The stunted plants showed poor root system, sometimes with large and confluent galls on the main root and twigs. The size and form of the galls depends on the species involved, number of nematode in the tissue host and plant age. In parwal the roots forms large, fleshy galls whereas twigs and shoot-galls unlike the root galls are of woody consistency. The size of galls varies considerably with age of plant parasitized by root-knot nematode species. In such cases the examination under the microscope revealed that infected young roots are full of pearly white nematode females attached by their heads and their egg masses covered by gelatinous matrix adhering with soil particles. This nematode completed its life cycle on pointed gourd within 30–45 days (**Table 3**) during warm season [13]. When plants are severely

Penetration and development stages(J_2)	**Number, days after inoculation**												
	1	**3**	**6**	**9**	**12**	**15**	**18**	**20**	**24**	**27**	**30**	**34**	**P = 0.05**
Penetration of J_2	145	118	182	140	—	—	—	—	—	—	—	—	3.72
Spiked tail stage	—	—	—	175	95	105	95	—	—	—	—	—	2.95
Moulting of J_2	—	90	75	70	105	130	—	—	—	—	—	—	1.87
Third stage	—	—	—	—	95	115	68	37	55	—	—	—	2.05
Fourth stage	—	—	—	—	—	105	80	75	44	26	40	—	2.14
Young female	—	—	—	—	—	—	40	60	50	85	45	—	1.98
Deposition of gelatinous matrix	—	—	—	—	—	—	—	130	45	65	20	—	1.65
Emergence of J_2	—	—	—	—	—	—	—	—	—	—	40	75	0.95

Penetration = 58.5%, eggs per egg sac = 385, male formed = 0.35%, females formed = 90.12%.

Table 3.
Biology of root-knot nematode, Meloidogyne incognita, on pointed gourd.

infected by *Meloidogyne* the normal root system is reduced to a limited number of severely galled roots with a completely disorganised vascular system. Rootlets are most completely absent. The translocation of nutrient and water by roots is severely hampered. Plants wilt rapidly, especially under upland growing conditions and are often stunted. Growth is retarded and leaves may be chlorotic. In case where infection at sprouting time has taken place, numerous plants die in the field and sprouting do not survive to grow new plants and creeping. The sprouts that survive to form new plants flowering and fruit production are highly reduced. As the season advances the galls are often invaded by fungi and bacteria that induce rotting. Wherever nematode populations are very high, young sprouts may be killed over large areas even without a trace of gall formation appearing on roots. In such cases the examination under the microscope will reveal that frequently the young roots are full of females attacked their heads and their egg masses covered by adhering soil particles [14, 15].

3. Biological study of root-knot nematode on crop

3.1 Biology and life cycle of nematode

It is a perennial crop, vegetatively propagated through vine cuttings and root suckers. One of the most important limiting factors in its profitable cultivation is heavy infestation by root-knot nematode. Due to non-availability of information on biology of nematode on this crop it was ascertained and determined the biology and reported that penetration of J_2 in roots continued up to 9 days with maximum numbers penetrating on 6th day. After penetration, the juveniles oriented themselves longitudinally near the vascular area behind the root tip and started moulting in 72 hrs. Young females appeared from 18th day after inoculation. Deposition of gelatinous matrix and egg-masses started from 20 to 24 days followed by emergence of $J_{2.}$ Majority of the eggs were retained in the egg masses. The number of eggs varied from 50 to 385 per egg mass. The larval penetration in roots resulted in the formation of necrosis and irregular shaped syncytia. The infection also caused the formation of confluent round to spindle shaped galls laterally on roots [16] (**Table 3**).

The root-knot nematode is primarily root parasites. The adult females are sedentary and remain inside the root while males are vermiform and are inhabitant of soil. Sexual dimorphism is pronounced.

Several workers have been studied to determine the biology of root –knot nematode, *M.incognita* on pointed gourd. The J2 penetrated the root after 24 hour of inoculation and 58.5% penetration was recorded in roots while 90.12% penetrated J2 were moulted into different stage of juveniles however, moulting was started from third day and development of young females from 18th day after inoculation. The juvenile's stages (J3 and J4) become sedentary. Maturation of females was started from 20th to 22nd days. Deposition of gelatinous matrix and egg mass were started from 20th–24th days and emergence of J2 was initiated immediately even before the egg masses turned into brown. Whereas, number of males which were observed (0.35%) after 26th days of inoculation and eggs were 385 per egg mass. The fecundity of the nematode was not affected by the host. Thus root-knot nematode *M.incognita* is able to complete its life cycle from J2 to next generation within 30–35 days at a temperature ranged of 30-40°C(**Table 3**) [13, 17].

3.2 Ecology

The population density and damaging potential of root-knot nematode and other phytoparasitic nematode on pointed gourd vary considerably from field to

field. During field survey conducted by [5, 7, 18] assayed the population density of each plant parasitic nematode and compared with growth parameter of pointed gourd. The strongest correlation between the population densities of root-knot nematode and growth responses recorded when soil assayed for nematodes were made on first, second and third year old crop. Root-knot nematode *Meloidogyne incognita* was the most damaging parasite as evidenced by high negative correlation between population densities and plant growth responses.

3.3 Pathogenicity

There is a study on which has been worked out the damaging threshold of *M.incognita* on pointed gourd and revealed that progressive decreased on plant growth was observed with increased in nematode inoculum level. Significant reduction in length, fresh weight of shoot and root was reported at different inoculum level (100, 1000, 10000 J_2) except at 10 J_2/plant. The number of galls, egg masses and multiplication of nematode continued to increase with the increasing inoculum level for pointed gourd [19].

4. Integrated management of root-knot nematode, *M.incognita* in pointed gourd crop

Reduction in crop yield due to nematode can be greatly managed by using available management practices [20]. Crop rotation is one of the oldest and most economic methods of controlling nematodes. However, these management practices must be taken before planting or propagating the crops through its vine nature. Once the nematode are persisted inside the roots/twigs (**Figure 2**) effective and potential treatments are not available, therefore, control strategies needs to be preventive rather than curative in nature and aimed from the onset at preventing the build-up of high population densities. Many techniques used for managing root–knot *Meloidogyne* invasion [21, 22] on pointed gourd simultaneously control other phytoparasitic nematode affecting the crop [23]. Combining and effective rotational scheme and selected cultural practices and use of chemical give excellent control with little added cost. In severely affected field, chemical/nematicides may be very useful [24] in lowering down the nematode population with its threshold level [25–27].

4.1 Cultural practices

Cultural practices may be minimised root-knot nematode damage. Practices such as removing the roots of each crop as soon as harvest is being completed, followed by tilling or summer deep ploughing of the soil two to three times is very effective in reducing nematode population [20].

4.1.1 Root-knot free field and propagating material

Nematode free planting material should be used for propagation. Field must be ensured free from root-knot, nematode in order to reduce dissemination. Chemical disinfection of propagating material is a common and effective measure in large areas where as other methods must be deployed for subsistence farming [28].

4.1.2 Crop rotation

Several workers [6, 11] have already been suggested rotation designed to reduce the impact of root-knot nematodes in tropical cropping system. A number

of rotations exist in the pointed gourd growing areas which are predominantly composed of cruciferous crop, moderately resistant to tolerant against root-knot nematode. Usually farmers are grown pointed gourd perennially, it should be followed a mix cropping of inter-cropping system or companion cropping which can be reduced the susceptibility and promote tolerance of pointed gourd to root-knot nematode disease. Recommendations of a survey carried out by the various scientists [5, 18] helped to impede root-knot nematode invasion in pointed gourd by using the mustard crop in rotational cropping system.

4.1.3 Destruction of roots and vines

Practices such as removing the roots of each crop as soon as harvest is completed, followed by tilling the soil two to three times is every effective in reducing nematode levels. The tilling operations destroy the plant roots and prevent further reproduction of the nematode. It also exposes the nematodes to the drying action of the sun and wind, which reduces the level of nematode population. Maintaining optimum conditions for plant growth in terms of soil pH, fertility and soil moisture increases the tolerance of light to moderate nematode attack and makes plants less susceptible to other stresses as well. Galled roots and vines remaining in the field after harvest should be eliminated by uprooting and destruction. The spread of nematode can be retarded and the initial population density reduced because the nematode cannot survive and reproduce on the roots in the soil after harvest.

Practices such as removing the roots of each crop as soon as harvest is completed, followed by tilling the soil two to three times is very effective in reducing nematode levels. The tilling operations destroy the plant roots and prevent further reproduction of the nematode. It also exposes the nematodes to the drying action of the sun and wind, which reduces the level of nematode population. Maintaining optimum conditions for plant growth in terms of soil pH, fertility and soil moisture increases the tolerance of.

4.2 Organic amendments

In eastern U.P., India, growing areas of the crop wherein it was revealed the dreaded association of root-knot nematode, *M.incognita* infestation with unthrifty growth of vines in many areas (Verma and Anwar, 1993; Anwar, 2004). The root-knot nematodes delayed and suppressed the emergence and subsequent growth of sprouts, which had a marked influence on the performance of the host. The use of organic amendments in the soil is greatly emphasised as an alternative easy, cheap and satisfactory method of nematode control. The incorporation of chopped leaves of medicinal plants into the soil reduces root-knot densities [8, 21, 28]. The application of organic amendment as a means of biological control of root-knot disease leads to better plant growth and significant sprouting emergence, reduction in inoculum density and reduction in host susceptibility. Various oil cakes, different botanicals [3, 27, 29] and meals like neem (*Azadirachta indica*), mahuva (*Madhuca longifolia*) and castor(*Ricinus communis*) cake @ 25 qt/ha, plant parts of subabul (*Leucaena leucocephala*) and *Calotropis gigantea* are used as a source of organic amendments [29]. Further they have been revealed in their studies that powder form of cakes of mahuva (*M. longifolia)* and neem (*A. indica*) are incorporated/ amended into the soil at the rate 250 kg/ha impeded the incidence of *M.incognita* in *T. dioica* but mustard cake application with the carbofuran applied at 2kga.i./ha have completely been suppressed the nematode population in soil and significantly avoid the invasion of J2 in roots of pointed gourd (**Table 4**). Although the use of organic amendments for effective nematode control is often limited by the large

Soil amendments with	Emerged sprouts per plant pit	Infected plants/ vines(%)	Length(cm) of vines	M.incognita population density in 200 cc soil	Galls/gm of root system	Females/ gm of root system	Root-knot index
Neem cake@25Q/ha	17.00	28.00	185.50	35.00	4.00	6.00	3.00
Mahuva cake@25Q/ha	12.00	32.00	172.300	42.00	5.00	8.00	4.00
Press mud @25Q/ha	13.00	49.00	175.10	50.00	6.00	14.00	4.00
Neem leaves @25Q/ha	18.00	30.00	181.60	40.00	3.00	7.00	4.00
Carbofuran @ 5 kg a.i./ha	14.00	24.00	187.40	32.00	3.00	6.00	3.00
Unamended field	6.00	100.00	145.50	200.00	20.00	25.00	5.00

Table 4.
Management of root-knot nematode, M.incognita *on pointed gourd (*T.dioica*).*

quantities needed, they will reduce nematode population densities to different level. In addition to their suppressive effect on nematode population they improve soil structure and water holding capacity [27]. Effect of plant extract or exudates and anthelmintic drugs on nematode hatching and mortality has been studied by different workers [23, 30] which indicated the natural occurrence of anti-nematode prohibitions in extract of different plant parts of marigold (*Tagetes erecta*). Their studies have been concluded and confirmed the toxic nature of tissue extract to M.incognita by inhibiting hatching process and increased mortality. The highest toxic effect had recorded in leaf extract followed by root, flower bud and seed extract. Mortality in nematode population gradually decreased when dilution of extracts increased in contrast to hatching.

4.3 Companion crops

Pointed gourd is an important profitable cash crop which is extensively cultivated in eastern part of Indian continent. This crop has been raised along with different marigold varieties as companion crops which have been shown lowed gall formation and egg mass development in roots. The highest toxic effect due secretion of metabolites and various root amino-acids on gall formation was exhibited by marigold varieties such as Saffron Spice variety of marigold allowed to lowest gall formation than that of Yellow Gate. Whereas, lowest reproduction factor has been recorded in root-knot nematode, *M.incognita* was observed when Saffron Spice variety of marigold was planted together and maximum had been observed in the companion planting of marigold varieties, FM-561 and Yellow Gate. The highest toxic effect of Saffron Spice has been recorded in reduction of soil population of *M.incognita, while, Hoplolaimus indicus, Helicotylenchus dihystera, Tylenchorhynchus vulgaris* and *Tylenchus* spp. were also to be reduced by FM-2,Hormony Boy and Sunset Geantee Variee [30].

4.4 Resistance sources

Resistant varieties reduce the population of root-knot nematode and produce a good crop even in the presence of nematodes. The effectiveness is increased when

combined with crop rotation. By alternating root-knot resistant and susceptible crop within a given site from one year to the next, the overall nematode problem can be reduced by preventing a build-up of high populations. This practice may reduce the risk of serious damage to the susceptible crop. There are many reports of root-knot, Meloidogyne sp. parasitizing plants which have been reported non-host, an important factor in developing rotation based control system [8]. The effectiveness is increased when resistant host combined with crop rotation. By alternating resistant and susceptible crop within a given site from one year to the next, the overall nematode population can be reduced by minimising high population build-up. There is so any resistant material available in pointed gourd against root-knot nematode hitherto, Verma and Anwar, 1993 reported that except BP-2 all the germplasm of pointed gourd viz. BP-1,BP-3,BP-4,BP-5,BP-7 and BP-8 were highly susceptible to M.incognita. Variety BP-2 has some tolerance against root-knot nematode [5, 18].

4.5 Effect of potential Rhizospheric fungi

Various scientists have been revealed standard concentration of culture filtrate of saprophytes exhibited nematotoxic effect by inhibiting the hatching of root-knot nematode, *M. incognita*. Among the saprophytes, the minimum larvae had been encountered by *Aspergillus candidus* and *A. niger* while as *Verticillium albo- atrum* recorded maximum inhibitory effect on hatching [31]. Larval emergence had however inversely proportional to filtrate concentration which may be due to the differences in the nature of toxic metabolites by fungi. Species of Aspergillus [32], Penicillium and Trichoderma etc. are known to produce toxins and antibiotics like oxalic acid, malformin, penicillin and giotoxin [22]. Certain rhizospheres which are stimulated on addition of organic matter either become a part of mycoflora population for decomposing the organic matter or directly affect hatching of nematodes. It has revealed greater inhibition of root penetration by M.incognita, development of females and galling occurred with simultaneous presence of *R.solani* and *M. incognita* [33, 34]. They were confirmed with the in vitro trial wherein nematode inoculated prior and after, fungus exhibited slight to moderate inhibition of galling and female development but simultaneous presence of fungus and nematode showed linear decrease in final population of nematode in crop. Most of the fungi colonising eggs and egg masses in soil ecology where pointed crop was being cultivated [14]. Five genera of fungal fauna had been encountered from egg masses like *Fusarium(F.solani, F.oxysporum, F. dimerum); Aspergillus (A.flavus, A.niger, A. terreus); Drechslera(Drechslera sp., D. ravenelii); Rhizoctonia bataticola* and *Curvularia lunata* from crop prone areas which are exhibited toxic effect against hatching and survival of J_2 [14, 30, 33].

5. Chemical

Chemical control is the most advocated and no doubt paracticable method of root-knot nematode control. However, for pointed gourd crop of high economic value it becomes a must. The pit application of Carbofuran, phorate @ 2 kg a.i./ ha gave a satisfactory control. Application of carbofuran, oncol and hostothian @ 0.1% as vine dip treatment are also useful in increasing sprouts and suppressing nematode population. The plants vines get infected when buried in soil fields for cultivating the crop fetching remarkable fruit yields of the crop. Various chemicals including different dosages of basamid Gr have been reported as successful in controlling by significant reduction in gall formation stimulating the growth enhancements of the crop [24].

6. Conclusion

The crop fetches more prices in the market and its demand due to everyday consumption as vegetable and stupendous nutritive value. A preliminary survey of the crop in eastern U.P. India indicated the association of root knot nematode with unthrifty growth of plants in many areas. It is most susceptible to root-knot nematode resulting heavy loss of fruit yield reducing the income of marginal farmers whose are mostly cultivated in India and elsewhere. In case where nematode infection at sprouting time of pointed gourd has taken place, sprouting does not survive to grow new plants and its proper growth. The sprouts that survive to form new plants flowering and fruit production are highly reduced. As the season advances the nematode galls are often invaded by fungi and bacteria that induce rotting. Wherever nematode populations are very high, young sprouts may be killed over large areas even without a trace of gall formation appearing on roots. Reduction in crop yield due to nematode can be greatly managed by using available management practices. Crop rotation is one of the oldest and most economic methods of controlling nematodes. However, these management practices must be taken before planting or propagating the crops through its vine nature. Once the nematode are persisted inside the roots/twigs effective and potential treatments are not available, therefore, control strategies needs to be preventive rather than curative in nature and aimed from the onset at preventing the build-up of high population densities. Many techniques used for managing root–knot *Meloidogyne* invasion on pointed gourd simultaneously control other phytoparasitic nematode affecting the crop. Combining and effective rotational scheme and selected cultural practices and use of chemical give excellent control with little added cost. In severely affected field, chemical/nematicides may be very useful in lowering down the nematode population with its threshold level.

Author details

Ali Anwar*, Najeeb Mohammad Mughal, Efath Shahnaz, Saba Banday, Taibah Bashir, Qadrul Nisa and Gulam Jeelani
Faculty of Horticulture, Division of Plant Pathology, SKUAST-Kashmir, Shalimar, Srinagar, Jammu and Kashmir, India

*Address all correspondence to: zaman04@rediffmail.com; alianwar@skuastkashmir.ac.in

References

[1] Gopalan C, Ramasastri BV, Balasubramanian SC. Nutritive value of Indian Foods. I.C.M.R.:Hyderabad, India;1982. 80p.

[2] Verma A C, Anwar A. (1998). Nematode-A serious threat to pointed gourd (*Trichosanthes dioica*).In:Trivedi P C,editor. Nematode Diseases in Plants. CBS Publishers & Distributors,Daryaganj,New Delhi, India-110002;1998. P.361-368.

[3] Verma AC, Anwar A. (1995). Integrated nematode management by using leaves of medicinal plants in pointed gourd(T.dioica) field. Indian J.Nematol. 1995;25:5.

[4] Verma AC, Anwar A. Integrated management of root-knot nematode *M.incognita* on pointed gourd. Indian J.Mycol.Pl.Pathol. 1995;25:86.

[5] Verma AC,Anwar A. Second Annual Technical Report ICAR Ad-hoc Scheme Investigation on root-knot nematode on pointed gourd. Department of Nematology, NDAUAT, Faizabad, U.P. India; 1993.

[6] Page,SLJ. An assessment of the importance and control of plant-parasitic nematodes of vegetable crops in Bangladesh.O.D.M. Report of visit to Bangladesh.Ascot,Book,UK Ministry of Overseas Development. 1979;p.36

[7] Verma AC, Anwar A. Occurrence of root-knot nematode *Meloidogyne incognita* on pointed gourd(*Trichosanthes dioica* R.) in eastern UP., Indian J. Nematol. 1993;23:21.

[8] Verma AC, Anwar A. Integrated nematode management by using leaves of medicinal plants in pointed gourd (*Trichosanthes dioica*) field. Indian J. Nematol. 1994;25:5.

[9] Verma AC, Anwar A. Twig galls incited by *M.incognita* on *Trichosanthes dioica* R.. Indian J.Nematol. 1993;23 :215.

[10] Verma AC, Anwar A. (1996). Assessment of yield loss due to *Meloidogyne incognita* in pointed gourd,*Trichosanthes dioica* Roxb., Afro-Asian J. Nematol. 1996; 6:92-93.

[11] Sikora SA. Inter-relationship between plant health promoting rhizobacteria, plant parasitic nematodes and soil micro-organisms. Mededelingen van de Faculteit Landbouw wetenschappen, Rijksuni resiteit,Gent, Belgium.1988; 53:867-878.

[12] Mukherji SK, Sharma BD.1973. Root-knot disease of *Trichosanthes dioica*. Indian Phytopath. 1973 ;26:318-349.

[13] Verma AC, Anwar A.1994. Biological studies of root-knot nematode *Meloidogyne incognita* on pointed gourd (*Trichosanthes dioica* Roxb.) in eastern UP. In: Proceeding of 22nd International Nematology Symposium held at Gent, Belgium; 1994.p.72

[14] Prasad J, Anwar A, Verma AC. Fungi encountered with egg mass of root-knot nematode *M.incognita*. In: Proceeding of National Symposium on 'Rational approaches in nematode management for sustainable agriculture",Nematological Society of India,IARI,New Delhi; 1998.p.103-105

[15] Verma AC, Anwar A. (1998).Role of marigold (*Tagetes* sp.) as a companion crop against root-knot nematode, *M. incognita* in pointed gourd. In: Proceeding of National Symposium on'Rational approaches in nematode management for sustainable agriculture. Nematological Society of India,IARI,New Delhi; 1998.p.16-19

[16] Verma AC, Anwar A. (1999). Studies on Meloidogyne incognita on pointed gourd (*Trichosanthes dioica* Roxb.) in Eastern U.P., India. Indian J. Nematol. 1999; 29:190-91.

[17] Singh K. Pointed gourd (*Trichosanthes dioica* Roxb). Indian Horti.1987;34-37.

[18] Verma AC,Anwar A. 1992. First Annual Technical Report ICAR Ad-hoc Scheme Investigation on root-knot nematode on pointed gourd. Department of Nematology, NDAUAT,Faizabad,U.P.India; 1992.

[19] Verma AC, Anwar A. (1995). Pathogenicity of *Meloidogyne incognita* on pointed gourd (*Trichosanthes dioica* Roxb.).Indian J.Mycol.Pl.Pathol. 1995;25:70.

[20] Anwar A, Verma AC. 1994. How to control root-knot nematode in parwal. Farm Digest(NDUAT Supplement)1994:25.

[21] Anwar A. Effect of organic amendment on interaction between wilt disease caused by *Fusarium oxysporum f.sp.lycopersici* and root-knot nematode, *M.incognita* in tomato crop. In: Proceeding of International Seminar on Recent Trend Hi-Tech Hort. & PHT,Kanpur,U.P.India,2004. P.198-199

[22] Man kau, R.Phytopathology, 1969; 59:1170-1172.

[23] Mohammad HY,Husain SI, Al-Zarari AJ. Effect of plant extracts of some poisonous plants of Iraq on the mortality of citrus nematode, *Tylenchulus semipenitrans* Cobb. Acta. Bot.Indica.1981;9:198-200.

[24] Verma AC, Anwar A. Efficacy of Basamid Gr. Against *M. incognita* in tomato nursery. Afro-Asian J. Nematol. 1994;4:73-75.

[25] Nath RP,Haider MG, Akhter SW, Prasad H. Studied on the nematode of vegetable in Bihar I. Effect of reniform nematode, *Rotylechulus reniformis* on *Trichosanthes dioica*. Indian J. Nematol. 1976: 6:175:77.

[26] Ray S, Das SN. Nematode Fauna of Orissa Technical Bull. Published by Dept.Nematology OUAT, Bhubneswar,Orissa; 1989.114p

[27] Verma AC, Anwar A. (1997). Control of *Meloidogyne incognita* on pointed gourd. Nematol. Medit. 1997;25:31-32.

[28] Verma AC, Anwar A. (1998). Effect of organic amendments on sprout emergence of pointed gourd, in root –knot nematode, *M.incognita* infested field. Ann.Pl.Protec.Sci. 1998; 6:102-104.

[29] Anwar A, Khan FU. Effect of aqueous leaf extracts of medicinal plants on the growth of rhizospheric fungi of tomato cv.Pusa Ruby in vitro. SKUAST J. Research. 2001; 3(1):60-63.

[30] Verma AC, Anwar A. (2000).Herbal effect of marigold tagetes varieties on hatching and mortality of root-knot nematode, *Meloidogyne incognita*. In: Proceeding of Indian Phytopathology Golden Jublee;2000. P.691-692.

[31] Anwar A. Effect of rhizospheric fungi of tomato cv. Pusa Ruby on the hatching of root-knot nematode, *Meloidogyne incognita*. Agic.Sci. Digest.2004; 24:59-60.

[32] Anwar A, Saxena SK. Effect of culture filtrate of *Aspergillus niger* Van Tiegh on growth of tomato plants and development of *Rotylenchulus reniformis* linford and Olivera, 1940. Current Nematol.1993; 4(2):207-210.

[33] Anwar A, Verma AC. Interaction between *M. javanica* and *Rhizoctonia solani* on chickpea, *Cicer arietinum* L. Ann. Pl. Protec. Sci. 1993;1:137-138.

[34] Anwar A, Khan FA,Saxena SK. Interaction between *Meloidogyne incognita* and *Rhizoctonia solani* on soyabean. In: Proceeding of the Second Afro-Asian Nematology Symposium, Menoufiya, Egypt, 1996. P.110-113