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REVIEW PAPER

Nematode disease complexes and their management

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Abstract: The interactions between plant parasitic nematodes and plant pathogenic microbes like fungi and bacteria hold a lot of significance *vis-à-vis* plant health. It is a fascinating and an emerging area of research in Plant Pathology. Disease complexes impact adversely the crop yields in agricultural as well as horticultural crops. It is imperative that disease complex situations are diagnosed well and early to devise proper management measures. A new approach involving the use and exploitation of disease 'resistance-holding' cultivars for the management of disease complexes is highlighted in this article. Proper selection of naturally occurring potent microorganisms which can inhibit *all* the participating pathogens in a particular disease complex situation to harness diseases' (due to nematode as well as fungus/bacterium) suppression (along with plant growth promotion) is emphasized. Also, the prospective role of new generation nematicides is anticipated for possible disease complex management.

Key words: Ancillary pathogens, Diagnostics, New generation nematicides, PGPM/R, Primary pathogen, Resistance-holding genotype, Synergistic interaction

Introduction

'Nature does not work with pure cultures' - a maxim propounded by biologists nearly a century ago, is very true especially, of soil ecosystems (Fawcett, 1931). 'Disease Complex' is the result of interaction between two pathogenic organisms. It is recognized that plant nematodes routinely interact with other soil biota, mainly fungi and bacteria. Under agricultural cropping conditions, such interactions often have serious implications *vis-a-vis* plant disease development. This is largely because plant parasitic nematodes usually aggravate diseases attributed to other pathogens. They also make resistant plants (to pathogenic fungi and bacteria) become susceptible to the latter. When interaction between plant parasitic nematodes and plant pathogens results in host plant damage exceeding the sum of individual damages caused by these two biota (*i.e.* nematodes and fungi/bacteria), it is a case of synergism. Arithmetically, it may be denoted as 1 + 1 = > 2. When interactions result in plant damage which is less than the sum of the effects of individual organisms, it is a case of antagonism, *i.e.* 1 + 1 = < 2. And, when the interactions do not result in any damage to host plant, the situation is termed neutralism, *i.e.* 1 + 1 = 2. Plenty of examples have been documented to illustrate the phenomenon of synergism. On the contrary, only four interaction reports so far (respectively, pertaining to hosts, citrus, sugarbeet, soybean and bell pepper), have illustrated the phenomenon of antagonism (DuCharme, 1957; Jorgenson, 1970; Gao *et al.*, 2006; and Parkunan *et al.*, 2016), wherein the activities of the plant nematodes involved are observed to be suppressed by the participating fungal pathogens. The authors, in some of these cases, were not forthcoming with a satisfactory explanation for the antagonism and only competition between participating pathogens was suspected. However, Gao *et al.* averred that such interaction studies should include a wider range of the fungal inoculum levels at planting. Neutralism situation is of extremely rare occurrence: One recent publication by Mangeiro *et al.* (2022) has demonstrated it to be happening in case of root knot nematodes - soil fungi interactions in a horticultural plant host, Passion Fruit (*Passiflora edulis*). The participating pathogens in that interaction were root knot nematodes (RKN), *Meloidogyne incognita* and *M. javanica* and soil fungi, *Fusarium nirenbergiae* and *Neocosmopara* sp. The present review concentrates mainly on synergistic interactions, for, that is the crux of the nematode-induced disease complex scenarios occurring in cultivated crops.

Primary Pathogens, Ancillary Pathogens: As mentioned already, aggravation of the plant diseases (in an interaction scenario) is a prominent 'Disease Complex' situation wherein the accentuation of the disease symptoms occurs or there may be production of different syndromes. The latter situation can very well be illustrated in the case of the well known 'Yellow Ear Rot/*Tundu*' disease of wheat and barley (and also, in case of 'Bacterial Head Blight' of Pasture grasses – caused by *Rathaybacter toxicus* in association with *Anguina* spp.- mainly, *A. festucae*). Mere production of yellow streaks coupled with production of yellow slimy material on their foliage is seen when the bacterium (*Clavibacter michiganensis* pv. *tritici)* alone is involved. Whereas, the Seed gall nematode, *Anguina tritici*, when acting singly, produces the seed galls. But, 'Yellow Ear Rot' symptom is produced when the nematode is interacting with the aforementioned plant pathogenic bacterium.

'Resistance breaking' phenomenon is also kind of Disease Complex situation/condition.

Plant disease literature is replete with examples of interactions. What is *not* emphasized in Nematode-Plant-Fungi/Bacteria/Viruses interactions is the following stark fact: ***Nematodes are the primary pathogens while Fungi/Bactera/ Viruses are ancillary pathogens***

Earliest and well documented evidence of the occurrence of disease complex phenomenon under agricultural cropping conditions dates back to 1892 when George Atkinson observed enhanced wilt disease severity in cotton crop due to interaction of root knot nematode, *Meloidogyne incognita* with vascular wilt fungus, *Fusarium oxysporum* f. sp. *vasinfectum* (Atkinson, 1892). Since then, numerous such observations and studies involving a host of crops and an array of nematodes interacting with various fungi and bacteria, have accumulated in Plant disease literature. In their review of Disease Complexes involving plant pathogenic nematodes (PPNs) and soil-borne pathogens, Back *et al.* (2002) have listed the examples of (till then) reported disease complexes (along with the participating pathogens) occurring in about a dozen different crops (*viz.* banana, betel vine, chickpea, coffee, cotton, lentil, mint, pea, peanut, potato, soybean and tomato). Further, an appreciable number of recent investigations have clearly established the widespread association of PPNs with well known soil-borne pathogens in many horticultural crops – additional crops being, ashwagandha, coleus, cucumber, peach, plum and pomegranate (Parameshwari, 2004; Mallesh and Lingaraju, 2015; Divya Bharathi *et al.*, 2018; Patil *et al.,* 2022; Regmi *et al.*, 2022; Saranya *et al.*, 2023; Naser, 2023). All these point to potential disease complex scenarios. On the whole, the interacting nematode pathogens are: root knot nematodes (*Meloidogyne* spp.), cyst nematodes (*Heterodera* spp.; *Globodera* spp.), burrowing nematodes (*Radopholus similis*), seed gall nematodes (*Anguina* spp.), lesion nematodes (*Pratylechus* spp.), reniform nematodes (*Rotylenchulus reniformis*), spiral nematodes (*Helicotylechus* spp.) and a host of other plant parasitic nematodes like sting nematodes (*Belonolaimus* spp.), stunt nematodes (*Tylenchorhynchus* spp.) and ring nematodes (*Mesocriconema* spp.). Fungi like *Fusarium* spp., *Verticillium* spp., *Ceratocystis* spp., *Pythium* spp., *Phytophthora* spp., *Rhizoctonia* spp., *Sclerotium rolfsii* and bacteria like *Ralstonia solanacearum, Xanthomonas* spp. and *Psedomonas* spp. are being increasingly documented in the interaction studies. *Fusarium* interacts with all the aforementioned plant nematodes.

At this juncture, it is worth while to mention here the kind of interactions existing between plant nematodes and plant viruses. The former ones play the role of vectors transmitting the plant viruses. It should be said that the situations that finally arise is not a case of disease complexes.

Diagnostics of disease complexes and mechanisms governing synergistic interactions: Diagnosis of disease complex condition in any cultivated crop is akin to the diagnosis of disease caused by any kind of pathogen (on any host plant) *per se*. A few instances where such disease complex diagnosis efforts are likely to be successful include: 1) If upon uprooting a *freshly* wilted or root-rot/ foot-rot/ collar-rot/crown-rot/stem-rot affected plant (due to the aforementioned ancillary pathogens), the presence of galls, cysts or lesions or other symptoms characteristic of nematode infection/damage (like stubby roots, coarse roots, or diminished root system, *etc*.) is seen, it is a clear-cut indication that there is a disease complex *situation in progress*. 2) Supplementary information about nematode density in soil/plant will strengthen disease complex diagnosis.

***Mechanisms**:* Researches into this aspect of PPN – ancillary pathogens are very few and far between. Back *et al.* (2002) have summarized the accrued information in this regard to put forth the following mechanisms. In a nutshell, the granulated explanation points are:

1) Nematode parasitism of plants begins with creation of wounds which are utilized by soil-borne, ancillary pathogens as portals for their entry and advancement in host tissues.

2) Nematode parasitism brings about physiological changes to the host plant. As a matter of fact, nematode-infected plant tissues are actively sought and selected by soil-borne, ancillary pathogens. It is observed that the giant cells, syncytia and nurse cells (which are the nematode feeding cells in respect of endo/semi-endoparasitic PPNs) formed in the roots during the nematode pathogenesis are the regions wherein the proliferation of vascular fungi (like *Fusarium* spp., *Verticillium* spp.*, Ceratocystis* spp.) is seen suggesting that the feeding cells of nematodes are the sites of interaction between the nematodes and the vascular fungi.

3) PPN infection results in the increased production of root exudates and their composition: In a detailed study into this aspect, Keshgond and Lingaraju (2016) observed in case of *Fusarium udum - Heterodera cajani* interaction on pigeon pea, production of higher quantities of biochemicals like peroxidase, polyphenol oxidase, phenyl ammonia lyase and total phenols in root exudates emanated by Fusarium wilt resistant pigeon pea genotypes than wilt-susceptible genotype. Total sugars composition although was less in both resistant and susceptible genotypes, it was least in wilt-susceptible genotype. Also, nematode parasitism could induce the production of more lateral roots which in turn lead to the production of increased quantity of root exudates which is a function of increased root volume. It is observed that the root exudates suppress the activities of antagonistic microflora present in rhizosphere (antagonistic to the ancillary pathogens) thereby resulting in a severe disease.

4) Reduction of host resistance. Zhang *et al.* (2020) have corroborated this.

Losses and further information on related aspects: Many economically important field crops (wheat, barley, cotton), vegetable crops (tomato, brinjal, cucumber), plantation crops (black pepper), medicinal crops (coleus, ashwagandha), fruit crops (pomegranate, banana) suffer heavily owing to disease-complex conditions leading to huge monetary losses, as these complex interactions can have significant impacts on crop yield and overall plant health, owing to the fact that the synergistic interactions result in the severe accentuations of the diseases inflicted by the very many ancillary pathogens. Also, the loss of the host-plant resistance to such diseases, impacts the disease complex scenario in tragic ways. While the accurate crop loss estimation data owing to the disease complex phenomenon is not available, the crop losses due to plant pathogens is documented from time to time. Global annual crop

Table 1. Greenhouse and field reaction (%) of wilt-resistant pigeon pea genotypes as influenced by F. *udum* (F) and H. *cajani* (N)

Pigeon pea genotype[$]	2001-02 Greenhouse tests				2002-03 Greenhouse tests				2002-03 Field study under natural occurrence	2003-04 Field study under natural occurrence	2004-05 Field studyunder natural occurrence
	F[a]	F+N[a]	F[b]	F+N[b]	F[a]	F+N[a]	F[b]	F+N[b]	F + N[b]	F + N[b]	F + N[b]
ICP 8859	0	0	0	40	0	0	0	0	20.00	11.77	NA
ICP 8863	0	0	0	0	0	0	40	40	37.50	11.11	NA
ICP 9174**	0	0	0	0	0	0	20	60	3.57	NA	0
ICP 12745**	0	0	0	0	0	0	0	0	2.56	NA	0
ICP 14722	NA	NA	NA	NA	0	0	0	40	16.67	18.18	NA
ICP 87119	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.83
ICP 89045	NA	NA	NA	NA	NA	NA	NA	NA	NA	20.00	NA
ICP 89048**	0	0	20	20	0	0	0	40	6.78	8.16	0
ICP 89049	0	0	0	0	NA	NA	NA	NA	NA	NA	NA
WRP-1	NA	NA	NA	NA	NA	NA	NA	NA	NA	3.45	0
GPS – 33	0	0	0	0	NA	NA	NA	NA	NA	9.26	NA
KPL – 44	NA	NA	NA	NA	NA	NA	NA	NA	NA	7.14	NA
DPPA 85-13	NA	NA	NA	NA	0	0	0	40	14.29	16.67	NA
PI 397430	0	0	0	0	0	0	20	40	14.29	14.89	NA
AWR 74-15	0	20	0	40	20	40	100	60	50.00	25.71	NA
BWR 370**	0	0	20	0	0	0	0	0	5.97	NA	NA
JS - 1*	20	0	40	60	NA	NA	NA	NA	NA	NA	NA
GS - 1*	NA	NA	NA	NA	NA	NA	NA	NA	100.00	NA	NA
Bahar*	NA	NA	NA	NA	60	60	60	60	98.00	67.93	NA
ICP 2376*	80	100	80	100	80	80	100	100	100.00	NA	NA
BDN - 1*	60	20	60	60	NA	NA	NA	NA	100.00	NA	21.74
C - 11*	40	60	40	60	20	40	60	80	61.00	NA	NA
PT - 221*	NA	NA	NA	NA	NA	NA	NA	NA	NA	100.00	82.22

Note: a: Flowering stage; b: Harvesting stage 1. Wilt percentage values above 10 is a susceptible reaction; 2. $ - Many of these genotypes are still in cultivation in different geographical locations of the country. For example: ICP 8863 and ICP 87119 in Karnataka (released as Maruti & Asha respectively). The Bahar are in cultivation in Uttar Pradesh, as well.*Susceptible Checks **Resistance Holding cultivars.

yield losses due to plant pathogenic fungi is documented to be in the range of 10-20% valued at US $ 100-200 billion (USDA ARS, 2023). Given the role of plant nematodes as disease aggravators and host resistance breakers, it can be safely said that the disease complexes result in much higher crop and monetary losses.

As mentioned already, umpteen number of references can be gleaned from plant disease literature concerning the documentation of interactions of plant parasitic nematodes with various ancillary pathogens. The gist/main information that we obtain from these interaction research/studies is: Prior inoculation of nematodes followed by fungal or bacterial inoculations have recorded a high severity of the plant diseases attributed to ancillary pathogens. (Savitha and Lingaraju, 1996; Vijayashanthi *et al.,* 2020; McKenry, 2022; Lilley *et al.,* 2024). This recurring feature of all these experiments wherein nematode inoculation precede that of fungal or bacterial inoculations is actually a simulation of the processes occurring in nature. This clearly means that the nematode is the first of the pathogens to infect the host. This is because the infective stages of the nematodes are in readiness to infect the host plant compared to fungi/bacteria in that, their resting structures (chlamydospores, sclerotia, endospores and the like) require time to become active infective propagules to initiate the infection process.

The present review paper cites a couple of the actual experimental data tables obtained through sustained field investigations to clearly understand the concepts of synergism, antagonism, resistance-breaking and resistance holding. It is worthwhile to mention here that the aforementioned field investigations were taken up in different locations spanning the jurisdictional areas of UAS, Dharwad UAS Raichur, UAS, Bengaluru and UAHS, Shivamogga of Karnataka. It is hoped that the reader can easily get the hang of the aforementioned concepts upon going through the data presented in this article (Tables 1 to 5). Diseases rampantly observed in a field crop like pigeon pea and horticultural crops like coleus, ashwagandha and betel vine are cases in point. The footnotes in some of the tables emphasize the obvious and specific findings.

***Inferences*:** Research can guide us to deploy for cultivation such pigeon pea cultivars as will hold the resistance to *Fusarium udum.* The usefulness of such results is enhanced if we deploy resistance-holding (which are also agronomically superior) varieties, already accepted and grown by the farmers.

Table 2. Cyst numbers (Final) in 100 cc soil of *H.cajani* in pigeon pea cultivars

Cultivar	Nematode alone	N + F*
ICP 2376**	16.7	25.89
BAHAR**	16.7	17.33
AWR-74/15***	9.00	25.00
C-11**	10.0	9.58

**F.udum* CFUs- Initial; $3.5x10^3$ cc^{-1}soil; Final: $4.4x10^4$ cc^{-1}soil
Wilt-susceptible; * Wilt-resistant

Table 3. Selection of efficient PGPR strains effective against different pathogens of Coleus and Ashwagandha

Fusarium (F)	*Ralstonia* (R)	*Meloidogyne* (M)	F&R	F&M	R&M	F,R&M
RB01	RB01	RB01	RB01	RB01	RB01	RB01
RB03	RB03	RB02	RB03	RB07	RB09	RB10
RB04	RB04	RB06	RB04	RB10	RB10	RB13
RB05	RB05	RB07	RB05	RB13	RB13	RB22
RB06	RB09	RB09	RB10	RB18	RB15	RB31
RB07	RB10	RB10	RB13	RB22	RB22	RB43
RB10	RB13	RB13	RB22	RB24	RB29	RB50
RB13	RB14	RB15	RB31	RB31	RB31	
RB18	RB15	RB18	RB33	RB35	RB43	
RB22	RB21	RB22	RB43	RB43	RB50	
RB24	RB22	RB24	RB50	RB50		
RB26	RB29	RB29				
RB31	RB31	RB31				
RB33	RB33	RB35				
RB35	RB43	RB39				
RB37	RB48	RB43				
RB43	RB50	RB50				
RB46						
RB50						

RB- Rhizobacteria

Sustained greenhouse studies and the subsequent verification through field investigations over years tell exactly that (Table 1). Data in the 2nd table tells us that both the biota (*Heterodera cajani* and *F. udum)* synergistically interacted as their final populations increased. Table 3 narrates the efforts needed to cull out (from rhizosphere soils) *native*, potent and uniformly efficacious Plant Growth Promoting Microorganisms/ Rhizobacteria (PGPR/M) against all the participating pathogens in a disease complex scenario. Simultaneous verification of those PGPM/R for a high plant growth promotion is an essential pre-requisite.

This aspect has been looked into in a couple of studies as well, (Mallesh and Lingaraju, 2015; Manzar *et al.*, 2015). Their rhizosphere competence is (or should be) such that those microorganisms *promote well* the plant growth and development (Tables 4, 5).

Management approaches: It goes without a say that it is pertinent to manage disease complexes in agricultural as well as horticultural crops wisely, employing eco-friendly approaches to harness many advantages. Increased crop yields; clean and healthy produce (which is toxicant residue-free); maximum monetary returns - to name a few advantages. Towards that end, managing disease complexes in various crops could include options like:

1.Use of 'Resistance holding' genotypes/cultivars: This will be of immense utility when we know which genotypes or cultivars lose their resistance to a prevailing ancillary pathogen. Also, if suitable agronomically superior nematode-resistant cultivar is available, the same may be utilized.

2.Use of Plant Growth Promoting Microorganisms/ Rhizobacteria: This essentially involves culling out *native* PGPM/R from the crop rhizospheres which is/are *commonly and highly efficacious (to nematode as well as many ancillary pathogens) in suppressing the activities of ancillary pathogens (fungi/bacteria)* as well as that of primary pathogen *(nematode)*. Such efficacious PGPM/R can be upscaled for mass production and the formulation/s (talc-based powder or liquid) can be subsequently applied: Soil/planting material, if treated with required/prescribed dose (of PGPM/R formulation) will reduce the incidence of the diseases caused by the primary as well as by ancillary pathogens.

3.Use of recommended chemicals: This option is to be judiciously exercised so as to target the primary pathogen, *i.e.* nematode. But, it must be said that the advent of new potent molecules is an encouraging development in our choice of the use of safe nematicides for the management disease-complex situations. Sound and proven eco-friendly management approaches (as illustrated above) in agriculture can practically do away with the use of nematicides. In this context, soil amendments like poultry manure, various oil-cakes, seed treatment with botanicals like neem oil or, bioagents like *Purpureocillium lilacinum* (Patil *et al.,* 2022) can be gainfully employed.

On the contrary, sometimes, such non-chemical based on-the-shelf options are not available for management of disease complex situations. Under such circumstances, judicious use of nematicides becomes inevitable. The available literature mentions the use of granular formulations of organo-phosphates and carbamates like aldicarb, phorate and

Table 4. Efficiency of talc formulations of PGPR strains on yield parameters and disease incidence in Coleus under field conditions

PGPR Strains	Tubers/ plant	Tubers			Shoot weight(g)		Total biomass (g)		RKI	Percent disease incidence	Percent decrease over control	Tuber yield (Fresh wt: kg/ plot)
		Length (cm)	Fresh wt.(g)	Dry wt.(g)	Fresh	Dry	Fresh	Dry				
RB01	15.25	22.45	209.27	36.78	755.17	109.83	964.44	127.61	1.13	16.67(24.03)*	41.05	4.18
RB10	12.87	19.33	173.30	31.50	649.83	68.05	823.13	99.55	1.60	25.00 (29.91)	11.75	3.25
RB13	16.63	23.17	230.01	50.02	786.73	119.83	1016.74	169.85	0.80	20.00 (26.44)	29.40	4.60
RB22	11.87	18.57	168.17	31.17	613.67	57.43	811.84	88.6	1.53	23.33 (28.65)	17.64	3.36
RB31	16.50	29.28	272.46	62.29	822.08	128.60	1094.54	190.89	0.73	13.33 (21.32)	52.94	5.45
RB43	14.92	19.58	198.00	36.33	643.83	76.17	841.83	112.50	1.33	18.33 (25.29)	41.05	3.95
RB50	18.00	31.68	342.02	74.17	901.00	138.10	1243.02	212.27	0.66	10.00 (18.42)	64.70	6.74
Control	10.70	17.59	145.77	30.00	584.67	48.00	730.44	80.00	2.20	28.33 (32.12)	-	3.00
S.m±	0.50	0.58	0.58	1.19	3.72	2.17	4.83	2.16	0.21	1.65	-	0.26
C.D@5%	1.52	1.75	1.75	3.59	11.32	6.59	14.66	6.55	0.65	5.02	-	0.79

Note: RB01, RB10, RB13… *etc:* Rhizobacteria *Figures in the parenthesis are arcsine transformed values (Mallesh *et al*., 2009)

Table 5. Efficiency of talc formulations of PGPR strains on yield parameters and disease incidence in Ashwagandha under field conditions

PGPR Strains	Root weight (g)			Shoot weight (g)		Total biomass(g)		RKI	Percent disease incidence	Percent decrease overcontrol	Berry wt. (Fresh wt: kg/plot)	Root yield (Fresh wt: kg/plot)
	Length (cms)	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.	Fresh wt.	Dry wt.					
RB01	15.10	13.98	5.67	152.67	58.17	166.65	63.84	1.33	13.13 (21.32)*	58.54	73.56	279.67
RB10	14.67	12.20	5.50	132.80	45.80	144.0	51.30	1.93	26.67 (31.05)	15.78	38.19	210.00
RB13	15.73	15.98	5.80	170.17	60.60	186.15	66.40	1.00	16.67 (24.03)	47.36	61.32	319.60
RB22	11.50	10.43	4.50	125.33	48.33	135.83	50.83	1.46	23.33 (28.84)	26.33	40.00	214.00
RB31	16.20	17.13	6.00	184.47	77.78	200.20	83.78	0.80	11.67 (19.87)	63.15	87.38	354.60
RB43	15.57	12.64	5.25	145.83	64.50	158.47	69.75	1.40	18.33 (25.29)	42.12	63.44	252.80
RB50	16.83	18.65	6.50	206.67	80.95	225.32	87.45	0.75	08.33 (16.59)	73.69	97.00	373.00
Control	11.00	8.53	3.25	103.33	43.57	111.86	46.92	3.06	31.67 (34.21)	-	35.13	185.60
S.Em±	0.79	0.80	0.35	2.67	1.88	6.47	2.94	0.32	1.38	-	3.01	5.91
C.D@5%	2.39	2.43	1.07	8.11	5.71	19.62	8.91	0.97	4.19	-	9.14	17.92

Note: RB01, RB10, RB13… *etc*: Rhizobacteria *Figures in the parenthesis are arcsine transformed values (Mallesh *et al*., 2009)

carbofuran for the management of nematode diseases of various crops, especially of horticultural crops. This practice can appreciably bring down the nematode inoculum in soil and thereby taking care of the damage caused by the primary pathogen. But, it is a well known fact that the use of the aforementioned nematicides have already been phased out of the market. Simultaneous application of oxathiin fungicide like carboxin proved beneficial to efficiently ward off the root-rot/collar-rot/foot-rot (culminating in wilt) incited by *Sclerotium rolfsii* or *Rhizoctonia bataticola* of betel vine in disease complex situation. Concomitant reductions in root knot index were also documented in the same crop (Parameswari, 2004; Nandeesha *et al.,* 2021). So also in crops like coleus and aswagandha (Mallesh, 2008). Competitive saprophytic ability of ancillary pathogens (like *Sclerotium rolfsii, Rhizoctonia bataticola*) have been reported to be reduced in some cases (Parameswari, 2003). With the phasing out of the use of organo-phosphates and carbamate nematicides the world over, a new generation of nematicides like fluensulfone, fluopyram and fluazaindolizine (collectively termed Next Generation Nematicides) has crept in, bringing a lot of optimism on the nematode management front. *And, this could very well include disease complexes management as well.* All these three compounds contain trifluoromethyl (-CF_3) and are, therefore called 3F or fluorinated nematicides. (Oka, 2020). Elsewhere, fluensulfone has three formulations (1.5% granules, 2.0% granules and 40% as well as 48% emulsifiable concentrates), only 2% granular formulation is available in Indian market. Fluopyram and fluazaindolizine are available as liquid formulations in India. The latter one, *i.e.* fluazaindolizine is recently launched in India. Fluopyram (available as 34.48 SC) is basically a broad-spectrum fungicide with nematicidal activity as well. Though these nematicides are proving to be efficacious in the suppression of nematode diseases of several crops with no deleterious effects on soil properties (Morris *et al*., 2016; Li *et al*., 2020; Wu *et al.,* 2020; Mahalik *et al.*, 2024), they are yet to be exploited for the management of disease complexes. It will be worth-while to focus our research efforts to evaluate these molecules in Indian context for an efficient and economic management in disease complex scenarios.

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