Nematodes are small worm-like organisms which are present in almost all agroecosystems where they interact directly and indirectly with plants and other microfauna, regulating decomposition and release of nutrients to the plants. Nematodes are ubiquitous and have diverse feeding behaviors and life strategies ranging from colonizers to persistors. Due to their diversity in biological and particularly feeding habits, nematodes are an integral part of the food webs in soil ecosystems. In almost every soil sample, nematodes from five trophic levels namely bacteriovores, fungivores, herbivores, predators and omnivores are usually represented. Phytophagous nematodes (Herbivores) are the most intensively studied group because of their economic importance as biotic constraints to crop production. However, as the role of soil nematodes in regulating soil bacterial and fungal populations and thus cycling of major soil nutrients becomes clear, a more positive view of nematodes is becoming established.

Role of Nematodes in Soil Health

Direct contribution to nitrogen mineralization and distribution of biomass within plants. The itrogen is available in the ammonium form when bacterivorous and fungivorous nematodes are present than when they are absent. Nitrogen mineralized through microbial grazing is available subsequently to plants. Under field conditions, bacterivorous and predatory nematodes are estimated to contribute (directly and indirectly) about 8% to 19% of nitrogen mineralization in conventional and integrated farming systems, respectively. Nematodes contribute to nitrogen mineralization indirectly by grazing on decomposer microbes, excreting ammonium, and immobilizing nitrogen in live biomass. Predatory nematodes also regulate nitrogen mineralization by feeding on microbialgrazing nematodes.

Uses of Nematodes as Indicators

- Nematodes have a permeable cuticle, which allows them to respond with a range of reactions to pollutants and correspond with the restorative capacity of soil ecosystems.
- Some nematodes have resistant stages such as cryptobiosis or cysts that allow them to survive inactively during environmental conditions unfavorable to growth and(or) development. However, some

nematode taxa such as Dorylaimidae have no resistant stages, which may make them more sensitive to environmental change.

- Since the 1970s, nematodes have been used as environmental biomonitors for aquatic systems. For example, *Panagrellus redivivus* has been used as a biomonitor to detect toxin concentrations that affect molting and organism size.

PRINCIPLES OF NEMATODE CONTROL

Avoidance: This involves choosing or selecting a site with very low or zero inoculum.

Exclusion: This principle tends to limit the spread of nematode pathogen from on place to another. This is aimed at reducing initial inoculum of the nematodes.

Suppression of nematode reproduction: This involves the use of resistant varieties and supplemental chemical nematicide.

METHODS OF NEMATODE PEST MANAGEMENT

Physical Method: This involves the use of heat either in form of sterilization or solarization.

Chemical method: This involves the use of nematicides

Cultural methods: This includes – Good site selection, Farm sanitation and hygiene, Ploughing, Use of trap crops, Crop rotation, Soil amendments, Flooding etc.

Resistance : Resistant cultivars offers the most effective and economic control of plant-parasitic nematodes. The use of crops resistant to the most destructive pathogenic nematodes remains an attractive, effective and economical management strategy for minimizing crop losses

Biological control: Biological control can be defined as the direct accurate management of common components of the ecosystems to protect crops against pathogens. In this regard, microbial diversity is a key natural resource. Biological control preserves environmental quality by reduction in chemical inputs. It is thus characteristic of sustainable management practices. Biological control involves the use of biological agents such as parasites, predators, phytophagous insects, pathogenic microbes and competing species to suppress and repulse pest species.

A large number of biocontrol agents have been tested to control plant-parasitic nematodes with encouraging results. These include bacteria, such as, *Burkholdera cepacia*, *Pasteuria penetrans*, *Pseudomonas florecens*. Fungi like *Verticillium chlamydosporium*, *Paecilomyces lilacinus*, *Gliocladium* spp., *Trichoderma* spp, *Athrobotrys oligospora* have also been used. Similarly, predatory nematodes and entomopathogenic nematodes have been reported to control root – knot nematodes and other nematodes such as *Steinernema carpocapsae* and *Mononchus acquaticus*.

Nematode trapping fungi utilise either sticky pads or constricting rings to immobilise nematodes. The fungus then digests the internal organs of the nematode and form reproductive cells. The main fungi in this group are Arthrobotrys and Duddingtonia. These fungi are found in soil where they live on readily-available organic carbon, in the absence of nematodes. They are generalist feeders, being able to trap and digest many nematodes, not just those that infest plants. Thus, the fungi are rare, unable to exist at sufficiently high densities to control nematode populations, and parasitic on beneficial as well as pest species of nematode. Because of these difficulties, exploration of the use of trapping fungi in the field has largely ceased, though see below for a case study of animal pests and Duddingtonia.

Parasitic fungi have been isolated from eggs, larvae or adults nematodes. Several of these have been found to preferentially parasitise the nematode and thereby reduce the size of the nematode population. Research efforts in some crops are now concentrating on using fungi found locally to control local pests. The general approach is to go to locations where nematodes have reached high densities. Parasitised individuals are extracted from soil, the fungi cultured and then tested as parasites of the pest nematode. The theoretical basis for this approach is that high densities of nematode will enable fungal parasites to increase population size dramatically. Thus by selecting fungi adapted to the host (nematode) and environment, inundative inoculation will control the pest nematode. Biocontrol in problem fields has been achieved in a surprising number of cases. The species used include Paecilomyces lilacinus, a fungus that appears to have a wide range of potential hosts, both insect and nematode, and yet isolates have a degree of specificity for host.

HOST PARASITE INTERACTION

This is based on crop yield, reproduction of the nematode on the host and crop damage in terms of gall index. The status of the host could be:

Resistant: is considered as the ability of the host plant to prevent the entry, establishment and reproduction of the pathogen.

Tolerant: The ability of the host plant to accommodate the nematode, cause considerable damage on the host but the yield not significantly affected.

Susceptible: is considered as the ability of the host plant to allow the entry, establishment and reproduction of the pathogen. A significant yield loss is attributable to the nematode.

Hypersusceptible: The host plant thus not allow the nematode to reproduce but the initial population establishes on the host to cause considerable yield loss.

Host plant resistance will also be related to mechanism of resistance.

Nematodes are small worm-like organisms which are present in almost all agroecosystems where they interact directly and indirectly with plants and other microfauna, regulating decomposition and release of nutrients to the plants. Nematodes are ubiquitous and have diverse feeding behaviors and life strategies ranging from colonizers to persistors. Due to their diversity in biological and particularly feeding habits, nematodes are an integral part of the food webs in soil ecosystems. In almost every soil sample, nematodes from five trophic levels namely bacteriovores, fungivores, herbivores, predators and omnivores are usually represented. Phytophagous nematodes (Herbivores) are the most intensively studied group because of their economic importance as biotic constraints to crop production. However, as the role of soil nematodes in regulating soil bacterial and fungal populations and thus cycling of major soil nutrients becomes clear, a more positive view of nematodes is becoming established.

Role of Nematodes in Soil Health

Direct contribution to nitrogen mineralization and distribution of biomass within plants. The itrogen is available in the ammonium form when bacterivorous and fungivorous nematodes are present than when they are absent. Nitrogen mineralized through microbial grazing is available subsequently to plants. Under field conditions, bacterivorous and predatory nematodes are estimated to contribute (directly and indirectly) about 8% to 19% of nitrogen mineralization in conventional and integrated farming systems, respectively. Nematodes contribute to nitrogen mineralization indirectly by grazing on decomposer microbes, excreting ammonium, and immobilizing nitrogen in live biomass. Predatory nematodes also regulate nitrogen mineralization by feeding on microbialgrazing nematodes.

Uses of Nematodes as Indicators

- Nematodes have a permeable cuticle, which allows them to respond with a range of reactions to pollutants and correspond with the restorative capacity of soil ecosystems.
- Some nematodes have resistant stages such as cryptobiosis or cysts that allow them to survive inactively during environmental conditions unfavorable to growth and(or) development. However, some nematode taxa such as Dorylaimidae have no resistant stages, which may make them more sensitive to environmental change.
- Since the 1970s, nematodes have been used as environmental biomonitors for aquatic systems. For example, *Panagrellus redivivus* has been used as a biomonitor to detect toxin concentrations that affect molting and organism size.

PRINCIPLES OF NEMATODE CONTROL

Avoidance: This involves choosing or selecting a site with very low or zero inoculum.

Exclusion: This principle tends to limit the spread of nematode pathogen from on place to another. This is aimed at reducing initial inoculum of the nematodes.

Suppression of nematode reproduction: This involves the use of resistant varieties and supplemental chemical nematicide.

METHODS OF NEMATODE PEST MANAGEMENT

Physical Method: This involves the use of heat either in form of sterilization or solarization.

Chemical method: This involves the use of nematicides

Cultural methods: This includes – Good site selection, Farm sanitation and hygiene, Ploughing, Use of trap crops, Crop rotation, Soil amendments, Flooding etc.

Resistance : Resistant cultivars offers the most effective and economic control of plant-parasitic nematodes. The use of crops resistant to the most destructive pathogenic nematodes remains an attractive, effective and economical management strategy for minimizing crop losses

Biological control: Biological control can be defined as the direct accurate management of common components of the ecosystems to protect crops against pathogens. In this regard, microbial diversity is a key natural resource. Biological control preserves environmental quality by reduction in chemical inputs. It is thus characteristic of sustainable management practices. Biological control involves the use of biological agents such as parasites, predators, phytophagous insects, pathogenic microbes and competing species to suppress and repulse pest species.

A large number of biocontrol agents have been tested to control plant-parasitic nematodes with encouraging results. These include bacteria, such as, *Burkholdera cepacia*, *Pasteuria penetrans*, *Pseudomonas florecens*. Fungi like *Verticillium chlamydosporium*, *Paecilomyces lilacinus*, *Gliocladium* spp., *Trichoderma* spp, *Athrobotrys oligospora* have also been used. Similarly, predatory nematodes and entomopathogenic nematodes have been reported to control root – knot nematodes and other nematodes such as *Steinernema carpocapsae* and *Mononchus acquaticus*.

Nematode trapping fungi utilise either sticky pads or constricting rings to immobilise nematodes. The fungus then digests the internal organs of the nematode and form reproductive cells. The main fungi in this group are Arthrobotrys and Duddingtonia. These fungi are found in soil where they live on readily-available organic carbon, in the absence of nematodes. They are generalist feeders, being able to trap and digest many nematodes, not just those that infest plants. Thus, the fungi are rare, unable to exist at sufficiently high densities to control nematode populations, and parasitic on beneficial as well as pest species of nematode. Because of these difficulties, exploration of the use of trapping fungi in the field has largely ceased, though see below for a case study of animal pests and Duddingtonia.

Parasitic fungi have been isolated from eggs, larvae or adults nematodes. Several of these have been found to preferentially parasitise the nematode and thereby reduce the size of the nematode population. Research efforts in some crops are now concentrating on using fungi found locally to control local pests. The general approach is to go to locations where nematodes have reached high densities. Parasitised individuals are extracted from soil, the fungi cultured and then tested as parasites of the pest nematode. The theoretical basis for this approach is that high densities of nematode will enable fungal parasites to increase population size dramatically. Thus by selecting fungi adapted to the host (nematode) and environment, inundative inoculation will control the pest nematode. Biocontrol in problem fields has been achieved in a surprising number of cases. The species used include Paecilomyces lilacinus, a fungus that appears to have a wide range of potential hosts, both insect and nematode, and yet isolates have a degree of specificity for host.

HOST PARASITE INTERACTION

This is based on crop yield, reproduction of the nematode on the host and crop damage in terms of gall index. The status of the host could be:

Resistant: is considered as the ability of the host plant to prevent the entry, establishment and reproduction of the pathogen.

Tolerant: The ability of the host plant to accommodate the nematode, cause considerable damage on the host but the yield not significantly affected.

Susceptible: is considered as the ability of the host plant to allow the entry, establishment and reproduction of the pathogen. A significant yield loss is attributable to the nematode.

Hypersusceptible: The host plant thus not allow the nematode to reproduce but the initial population establishes on the host to cause considerable yield loss.

Host plant resistance will also be related to mechanism of resistance.