DISEASE AND PEST MANAGEMENT IN GINGER WITH SPECIAL REFERENCE TO NORTH-EAST REGION OF INDIA

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Pests and diseases are major production constraints in all spices and ginger is no exception. Ginger is grown in almost all states in India to varying degrees, both in plains as well as in hilly terrains. It is highly productive in well-drained forest loams as well as in laterite soils. Heavy and ill-drained soils are highly prone for infection by soil-borne plant pathogens. Soil -borne pathogens are serious and take heavy toll of the crop specially when seed rhizomes are contaminated. Since it is vegetatively propagated through seed rhizomes, seed health holds key for successful production of the crop. Even though the disease profile is almost same with minor variation, the major diseases are rhizome rot/ bacterial wilt and dry rot which are virtually killers (Table 1). Shoot borer, white grub and scales are important insect pests that affect ginger.

Table 1. Major disease / pests of ginger

Diseases	Causal organisms	Disease management	
		Chemical	Biological
Rhizome rot Soft rot	*Pythium aphanidermatum* *Pythium myriotylum*	Available and effective	Available *(T.harzianum)* field tested and effective
Eye rot	*Pythium sp*		
Yellows	*Fusarium oxysporum* f. *sp zingiberi* *Fusarium solani*	Available field tested and effective	Available *(T.harzianum)*, field tested and effective
Bacterial wilt	*Ralstonia solanacearum* Bovar III	Available Not practical	Not available
Dry rot	*Pratylenchus coffeae* *Meloidogyne incognita* *Fusarium sp* *Macrophomina phaseolina* *(Rhizoctonia bataticola)*	Available	Available Not field tested
Pests	**Causal Agents**	**Pest Management** Chemical	Biological
White grub	*Holotrichia seticollis*	Available To be field tested	Available To be field tested
Shoot borer	*Conogethes punctiferalis*	Available Field tested	Available (BT) Field tested
Scales	*Aspidiella hartii*	Available	Not available

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Since pathogen profile varies considerably from place-to-place, correct identification of disease and pest problem is essential for planning and development of effective management strategies. As such integrated crop protection with minimum chemical inputs with a greater thrust on biological control would be the major focus to get optimum yield. Organic cultivation of ginger is a feasible proposition especially when plant protection is through biological control.

DISEASE AND PEST SCENARIO OF GINGER IN NORTH-EAST REGION

Ginger is a rainfed and generally grown either as an intercrop in maize or as a pure crop in dry soils as well as in paddy fields. Bacterial wilt (*Ralstonia solanacearum* biovar III), soft rot and eye rot (*Pythium* sp) and dry rot caused by fungal-nematodal complex (*Pratylenchus coffeae-Fusarium* sp) are major disease problems. In Sikkim, dry rot renders affected rhizomes unfit for marketing. White grub (*Hilotrichia seticollis*), shoot-borer (*Conogethes punctiferalis)* and scales (*Aspidiella hartii*) are important pests.

In Sikkim, adjoining North Bengal (Darjeeling and Kalimpong) and in Himachal Pradesh the disease problems are the same, viz. bacterial wilt, rhizome rot and dry rot. In Himachal Pradesh, it is 'yellows' caused by (*Fusarium oxysporum* f sp. *zingibori)* in association with *P.coffeae,* which is devastating. In Assam, rhizome rot of ginger caused by *P.myriotylum* has been reported. There is very little , information on ginger cultivation and pest and disease problems in this area especially, causal organisms, etiology and epidemiology of disease and bioecology of pests in North-east. Since in many of these areas agroclimate is the same, plant-protection problems in the region need to be tackled with an integrated approach.

At Sikkim and also in Darjeeling and Kalimpong region, farmers use large pieces of seed ginger (250-200g). Planting is done during March or early April. However, they extract the mother ('mau') rhizomes during July-August leaving the sprouts in field. The injury to spouts due to mother rhizome, extraction would create greater chances of infection and damage. Farmers though aware of this, they still continue this practice since they can get almost about 85% of the cost of cultivation through the sale of mother rhizomes especially when adequate ginger is not available in the market. The research strategy should be to evolve technology that could stop further infection in field during mother rhizome extraction.

Ecologically, little or undisturbed North-East region needs an extra effort to preserve its existing serene and sublime ecosystem by avoiding undue pesticide inputs for plant-protection measures. The efforts should be to practice integrated plant-protection measures with a greater emphasis on seed health, phytosanitation, biocontrol, botanicals and pheromones with least disturbance to existing balanced ecosystem that would support production of organic ginger. Since nematode infection is common in addition to fungal and bacterial infection, efforts should be to identify and evolve biocontrol consortia with the multiple mode of action to suppress these pathogens, ensuring better production. A brief account of diseases and posts of ginger is given for general appraisal.

Rhizome Rot

Soft rot and eye rot

Caused by *Pythium aphanidermatum,P Myriotylum* and *P.*sp., it is prevalent in all ginger growing areas with varying crop loss from place-to-place. Total crop loss is known in severe cases. Disease is noticed during early phase of crop growth (June-July) and continues at later stages also if appropriate plant-protection measures are not taken up.

The fungus infects tender sprouts causing eye rots and also pre-emergence rot so that germination is affected. When it infects tender

preudostems water-soaked patches appear at the base. Yellowing of leaves of affected pseudostems starts from lower region and progress upwards. In the advanced stages, affected pseudostem snaps off and comes off with a gentle pull. The infection spreads to rhizome causing soft or watery rot , causing total loss.

Disease occurs in patches during June-July (20-25^{0}C) period coinciding with South-West monsoon especially when the crop is in its early stages. Fungus infects tender tissues and also roots. When some of buds from developed rhizomes during later stages of crop growth are infected, they are seen as depressions on tips of rhizomes causing 'eye rot'. When such rhizomes are harvested depression on bud region is seen on mature rhizomes. Disease is soil-borne and seed (rhizome)-borne. Fresh infections in virgin soils indicate the latter. Disease appears in patches and spreads through water to the adjacent clumps.

'Yellows' or Fusarium wilt

Its causal organism is *Fusarium oxysporum* f. sp. *Zingiberi*. This is prevalent in Himachal Pradesh and has become a major production constraint. The infected plants show yellowing of leaves starting from lower region and progresses upwards. The infected stems when split open show vascular discolouration. The affected plants gradually wilt and dry up, in contrast to soft rot affected plants where the affected plant falls off. The infected rhizomes gradually rot and dry up.

The disease is seed and soil-borne. Like soft rot and bacterial wilt, this also occur in patches and spreads to adjacent rhizomes. This is typically a vascular wilt. Theassociation of plant parasitic nematodes like *Pratylenchus coffeae* with this disease has also been reported from Himachal Pradesh.

Bacterial wilt

It is caused by *Ralstonia solanacearum* biovar III, this disease causes severe damage to ginger in Kerala, Karnataka, Sikkim, north Bengal and Himachal Pradesh. Information is lacking from other North Eastern states of India. Crop loss ranges from 50 to 60% and total loss is reported in certain localities in Sikkim and Kerala.

The bacterium infects ginger right from early stage of crop to later stage of maturity. When sprouts are infected, green portion turns dark and the sprouts snap off. When pseudostems are infected, base of affected portion appears water-soaked and dark which spreads very fast. Leaves of such affected clumps show flaccidity (lack of turgour) and turn backwards without any yellowing and start dropping. Later leaves turn yellow to golden brown. Affected pseudostems come off with gentle pull, slimy to touch and emit foul smell. Infection spreads to rhizomes causing watery rot. Initially affected rhizomes show characteristics of water-soaked patches distinctly different from healthy yellowish to blue tinge of tissues. When affected rhizome bits are put in clear water, whitish bacterial ooze comes off like smoke, a feature totally absent in soft rot affected stem or rhizome bits.

The disease is soil and seed-borne. It appears during June-August in isolated patches. Temperature range of 20-25^{0}C is ideal for its initiation and spread. It is rapid through soil water to adjacent clumps. If not detected and rouged in early stages, it results in heavy crop losses.

Dry Rot

Its causal organisms are Pratylenchus coffeae, Meloidogyne incognita, Fusarium sp. and Macrophomina phaseolina (rhizoctonia bataticola). This disease is prevalent in Kerala and Sikkim but the causal organisms differ in both the places. In Sikkim, and north Bengal, stunting of affected plants and mild to severe yellowing of leaves without definite sequence and drying up of tips of leaves are aerial symptoms. Roots of such plants show varying degrees of rotting and galling. The affected rhizomes show scabs and depression on rhizomes in contrast to smooth surface of healthy rhizome. Rhizomes of severely affected plants appear shriveled and crinkled making these unfit for marketing.

In Kerala, the disease is seen in later period of crop growth during September onwards with depletion of soil moisture, showing mild foliar yellowing. Rhizomes of such affected plants shrivel and dry up.

The disease is mainly seed and soil borne. In Sikkim, it is mainly caused by *P. coffeae* and *Fusarium* sp. Contaminated seed appears to be main source of infection. Disease spread is gradual . *The P. coffeae* survives in soil even in absence of the host. Affected plants show stunting of plant, premature yellowing due to root rot and poor rhizome development with lot of scabs, results in poor marketable quality. In Kerala, it is caused by *Macrophomina phaseolina* (*Rhizoctonia bataticola*), a pathogen which infects roots and rhizomes under low soil moisture levels. The affected rhizomes when split open show dark rotten tissues with full of dark asexual structures called 'sclerotia' which further help in disease spread.

Leaf Spot

It is caused by *Phyllosticta zingiberi* , this disease is noticed in all ginger-growing . Its severity is less under shade. Yield is affected considerably because of loss of major photosynthetic area due to leaf rot.

During July-August, small whitish to necrotic spots surrounded by a chlorotic halo appear on tender leaves and adjacent spots merge causing leaf rot to varying degrees.

Disease spreads through rain splashes. From the spore-producing bodies 'pycnidia', spores come out en masse into water drop and spread fast through rain splashes during intermittent rain. However, if ginger is grown under shade, like as a mixed crop in coconut garden where the intensity of rain splashes is less, disease is totally absent or appears mild. The fungus survives on rhizomes of affected plants even though it might not infect. As such the disease is seed-borne.

Disease Management

An integrated approach involving phytosanitation, cultural practices, chemical and biological control measures is necessary. Burning of soil, soil solarization, application of organic amendments and mulching are some of the practices, which are beneficial in increasing growth and suppressing diseases.

Cultural Practices

Selection of site

Selection of a well-drained flat land or a hilly terrain with a gentle slope that ensures better drainage is ideal. Heavy soils that retain heavy moisture are prone for infection and should be avoided. Sites where ginger was grown the previous year should be avoided to reduce the chances of infection from the leftover inoculum. Sites where paddy crop is grown earlier would be safe especially to avoid bacterial wilt.

Selection of healthy seed rhizomes

Micropropagation of ginger through tissue culture is available and can be made use of. Identify ginger plots where disease incidents is not noticed during the year and select the seed material from such plots. Regular monitoring of such plots can be done both by individuals or by Govt. agencies or NGOs. Rigorous seed selection (whole rhizome) can be made from such plots. Seed should be plumpy with smooth surface. Seed should never be procured from open market. Apparently normal seed obtained from a diseased garden is prone for infection, and such seed sources should be avoided. After harvesting seed can be given dip in 0.25% Mancozeb (2.5g commercial product/litre) + (0.1%) Ekalux (4 ml/litre.) for 30 minutes. After shade drying, seed can be stored in a pit (50-75cm deep) lined with mud plaster. Seeds can be stored either in sand layers or in paddy straw layers), either in sheds or under shade of trees.

Seed treatment

Selected seed can be given hot water treatment at 51°C for 10 minutes, to eliminate parasitic nematodes like *Pratylenchus coffeae*.

Seed dip can be given in Mancozeb (0.25%) for 30 minutes.and can be shade-dried. Where Fusarium infection (Yellows') is involved, combined treatment with Mancozeb (0.25%) + Carbendazium (0.1%) is recommended.

Trichoderma harzianum, a biocontrol agent, is effective against fungal diseases especially soft rot or 'yellows'. Selected seed rhizomes can be treated with *Trichoderma* formulation before planting. This would ensure quick multiplication of *T.harzianum* either on FYM or other organics applied to planting pit, at the time of planting, ensuring protection against fungal infection. Large-scale field demonstrations with *T.harzianum* treatment conducted in Kerala are cost-effective and farmers are practising this method. However this is not effective against bacterial wilt. Rhizome solarization, a technique developed at IISR, Calicut, to disinfect seed rhizomes by keeping the seed rhizomes enclosed in polybags and exposing them to solar radiation for 2 hours, needs further testing at different elevations.

Hot-water treatment followed by biocontrol treatment would be ideal and effective. Hot-water treatment followed by fungicides would be equally effective. However, fungicides and biocontrol treatment can not be combined since they are not compatible.

Soil solarization

Soil heating up through transparent polythene tarping of the moistened beds or field, utilizing solar radiation is a technique which is effective in suppressing soil-bome plant pathogens and weeds. This is effective in ginger. This technique would be cost-effective for seed production but not for routine ginger production. The feasibility of technique especially on high ranges where prevailing temperatures are below 25°, needs testing.

Systematic removal and rouging of infected clumps in early stages and drenching the area with mancozeb (0.25%) solution (against fungal disease) or copper oxychloride (0.2% against bacterial wilt) would be effective in checking the disease spread.

For leaf spot disease, spraying the foliage with mancozeb (0.25%) is effective if given in early stage of infection. If crop is grown as an intercrop where overhead shade is available disease spread is meagre since rain splash (which is mainly responsible for disease spread) would be little or minimal.

Insect Pests

White grub is caused by *Holotrichia seticollis* , this is a serious pest of ginger, damaging 80-90.5% of the crop in certain endemic areas of Sikkim. White grubs feed on roots and tender rhizomes. Severely infested plots from distance, show yellowing symptoms like that of soft rot but when examined carefully damaged pseudostem with clear feeding marks at the base, come off with a gentle pull. Grubs tunnel into rhizomes feeding on soft tissues rendering them unmarketable.

Adult beetles are dark brown about 2.2 - 2.5 cm in length and 1.2-1.4cm in width. They emerge during late-April and reach peak during May. They congregate on trees like *Ficus* sp. Adult longivity ranges from 40 to 50 days. Females lay 20-25 eggs in soil and larvae emerge in 10-15 days. The larvae stage lasts from170 to 220 days. The last instar of grub pupated in earthen cell. Pupal duration lasts for 30-40 days.

Preliminary studies showed drenching the soil with quinalphos (0.05%) followed by chloropyriphos (0.04-0.08%). However, this should be selective and need based. Similarly soil application of entemogeneous fungus *Metarrhizium anisopliae* is also effective. However, these need to be validated by large-scale field trials. Campaigning for collection of adult beetles and destroying them is being

practised in some areas of Sikkim. Systematic investigations are needed on this pest.

Shoot borer

Its causal organism is *Conogethes punctiferalis* . It results in 'dead hearts' when central tender shoots of pseudostems turn yellow. The affected shoots come off showing the feeding marks. This is generally noticed in all ginger growing tracts during September-October .

Pseudostems are generally affected. Affected pseudostems give off frass from the bore holes. The larvae bore into tender pseudostems, and feed on softer tissues. The affected plants show withered and yellow shoots with bore holes. The economic injury levels (EIL) are determined as 0.5 plant / row of 3 m length. Reduction of 38 g of green ginger, when cumulative damage of pseudostem exceeded 50% during October.

The adult is a medium-sized moth with orange yellow wings (20mm wing span) with minute black spots, with a body length of 1 cm. The female lays eggs in tender tissues. Fully grown larvae are about 20 mm long and are light brown with sparse hair. The larvae pupates within the larval tunnels in a loose silken cocoon. The pest population is higher during September-October .

Citing the first attack of the pseudostem is important to take up control measures. Spraying during July-October at 21 days interval with 0.1% Malathion or Dipel (0.3%) (a biological product of *Bacillus thuringiensis*) is effective in checking its damage. Pruning off affected shoots at fortnightly intervals during July-August followed by spraying of 0.1% Malathion at monthly intervals during September-October is most successful in checking this pest.

Rhizome scale

Its causal organism is *Aspidella* hartiit this affects rhizomes at later stage of crop and continues during storage, affecting viability of seed. The adults appear as light brown to grey encrustations and feed on rhizomes by sucking the sap. Severely infected rhizomes shrivel, desiccate and dry up. Germination of affected seed rhizomes is severely hampered.

The adult is minute circular and light brown to grey. The insect feeds on rhizomes and multiplies both sexually and parthenogenically. Transparent eggs are oval and yellowish measuring 0.25mm X 0.17mm. Female lays about 100 eggs, crawlers emerge in a day and settle down for feeding. Male crawlers when fully mature pupate. Orange coloured adult males with transparent wings move around for mating and thus multiplication takes place.

Since this affects the crop at a very later stage and continues to seed storage, selection of seed material and treating with 0.075% Malathion for 20 minutes before storing and again before planting is effective in reducing the damage.

Damage due to plant parasitic nematode : *Meloidogyne incognita* causing root galls and *Pratylenchus coffeae* causing root necrosis and dry rot are major nematode problems. However, these generally infect in combination of other pathogens like *Pythium, Fusarium* and *Ralstonia,* thus enhancing the damage to the crop. These have been dealt earlier with disease problems.

Future Strategies

- Healthy seed production through 'seed village concept' by regular field monitoring and develop seed certification procedures.
- Impose quarantine regulation to restrict seed transportation from one state to other especially where bacterial wilt is a major problem in the region.
- Correct identification of disease/pest problem to plan appropriate management strategies.
- Development of IPM/IDM strategies

with greater emphasis on biocontrol, botanical and pheromones.

- Raising ginger in well-drained paddy fields to avoid bacterial wilt is suggested based on Sikkim experience.
- Identification of local efficient biocontrol agents suppressive to pathogen/pests of ginger and scale up production to supply farmers
- Gearing up of the extension agencies (both governmental / non governmental) to appraise the farmers the simple and appropriate production technologies to overcome disease and pest problems specially through participatory technology development (PTD) programmes.
- Developing a network of North Eastern states for a better coordination for augumenting ginger production.