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Disease problems in the cultivation of coriander (*Coriandrum sativum* L.) and their management leading to production of high quality pathogen free seed

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Abstract

Coriander is an important spice crop grown in many countries including India which has major share. The crop is attacked by several pathogens causing diseases like vascular wilt, stem rot, root rot, charcoal rot, seedling blight, stem gall, leaf blight, anthracnose, powdery mildew, seed rot, grain mould, bacterial blight, soft rot, seedling root rot, reniform and root knot nematodes, phyllody and virus diseases. Some new diseases have appeared in some countries. Resistant varieties are the best to control the diseases. Other cultural, physical and chemical methods are mentioned for their management. It is essential to produce high quality pathogen free seed for planting and export.

Key words : Bacterial, cultural management, fungal, mycoplasma, nematode, viral diseases

Introduction

Coriander is an important spice crop belonging to the family Apiaceae. It's all the tender aerial parts, stem, leaf, flower, fruits are used due to aromatic flavour. The crop is grown in almost all the states of the country but Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Orissa, Uttar Pradesh and Uttarakhand are the major coriander growing states. Rajasthan produces quality coriander and enjoys major share in area and production in the country. Coriander is also grown in Morocco, Russia, Bulgaria, Mexico, Argentina, China, Romania, Japan and Italy. From India coriander seeds and its powder are exported to several countries like Malaysia, Singapore, Srilanka, USA and gulf countries. During 2010-11, 4.82 lakh tones of coriander seeds were produced from 5.30 lakh area (Malhotra and Vashistha, 2008; Champawat and Singh, 2008; Anonymous, 2013).

Coriander contains 24 g carbohydrates, 1.3 g protein, 19.6 g fat, 5.3 g minerals and 6.3 g moisture in 100 g seed. Other compounds are linalool, α and β pinene, para cymene, α- terpenene. The oil from foliage contains aliphatic aldehydes, mainly dacylaldehyde. The seeds have 0.4 per cent essential oil. It is more in European coriander. Linalool is the main component up to 90% and up to 7% thymol. Oleresins with 90% fatty oil and 5% steam volatile oil is also obtained from seeds. These enhance aroma and flavor. Coriander seeds are used as medicine to cure indigestion, dysentery, vomiting as well as cold. The essential oil has carminative, antiseptic, bactericidal, fungicidal and muscle relaxant. The coriander plant parts and seeds are used by people as short-cut medicines for various body problems (Singh *et al.*, 2007). According to Pandey (2010) coriander is an important source of chemicals like alpha pinene, gamma terpenene, lononene, cymene, various nonlinalool alcohols, esters, flavonoids, cumarines, isocumarines, phthalides and phenolic acids. Coriander oil contains coriandrol, gireniol and vebriniol.

The crop suffers due to a number of biotic and abiotic stresses which are detrimental to plant health and seed quality. Several disease causing pathogens are seed-borne. They are associated with seeds externally, internally, extraembryal, intraembryal, as contaminant and inert matter as well as associated with inert matter. Their seed to plant transmission may be local or systemic or both. It is essential to know the actual location of the pathogen with seeds for its management. Plant to seed infection and its time of infection is a must to plan measures to check it to get pathogen free seed as produce.

1. *Vascular wilt*

The plants get infected from seedling to adult stage;

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Common diseases of coriander and their pathogens

Nature of Pathogen	Disease name	Pathogen
Fungi	Vascular wilt	*Fusarium oxysporum* f sp. *coriander*
	Stem rot	*Sclerotinia sclerotiorum* (Lib) deBary
	Root rot	*Rhizoctonia solani, Kuhn, Fusarium solani*
	Charcoal rot	*Rhizoctonia bataticola* (Taub) Butler
	Seedling blight	*Alternaria poonensis, Pythium ultimum*
	Stem gall	*Protomyces macrosporus* Unger.
	Leaf blight	*Alternaria alternata*
	Leaf spot	*Cercospora corianderi, Phoma multirostrata*
	Anthracnose	*Colletotrichum capsici* (Syd) Butler and Bisby, *C. gloeosporioides, Gloeosporium achaeniicola* Rostr.
	Powdery mildew	*Erysiphe polygoni* DC
	Seed rot	*Fusarium miniliforme, F. semitectum, F.equiseti, Aspergillus* spp.
	Grain mould	*Helminthosporium, Fusarium, Curvularia, Alternaria*
Bacterial	Bacterial blight	*Xanthomonas campestris* pv *corianderi, X. translucens* Jones, Johnson & Reddy
	Bacterial sof rot	*Erwinia carotovora* (Jones) Bergey et al.
	Seedling rot	*Pseudomonas* sp.
Virus	Carrot red leaf virus	
Phytoplasma	Phyllody	
Nematodes	Root knot	*Meloidogyne incognita* Chitwood

however the severity of the disease is more at later stages of crop growth. The foliage turns yellow and droops down, starts drying and the plant dies. On splitting the root and collar portion, brown discolouration of tissues is observed. Partial wilting is also noticed in plants when some of the branches exhibit drooping. Seeds are either not produced or if produced, they are light and immature.

The optimum temperature for disease development is 24-27 C. it is favoured by 60 -70% soil moisture. Srivastva (1972) studied the factors influencing wilt of coriander and reported slightly alkaline pH of soil to check the disease. The disease is caused by *Fusarium oxysporum* f sp. *corianderi*. The mycelium contains hyaline, septate, branched hyphae producing three types of spores, macrospores, microspores and chlamydospores. The pathogen is basically soil borne but can be transmitted through seed. The toxins produced by the pathogen reduce the seed germination and seedling vigour (Gandhi kumar and Raghuchandra, 2001).

Crop rotation is useful in checking the disease as the pathogen is specific to coriander. Adjustment of date of sowing is also useful. Amendment of soil with oilcakes checks the disease severity. Either resistant or less susceptible local types may be preferred.

2. *Stem rot*

The disease has been reported on coriander by Mehta *et al.,* (1946). The disease appears mainly around flowering under high soil moisture conditions in patches. First water soaked spots are formed on the main stem which turn brown, later the whole stem is girdled. The surface gets covered with white fungus hyphae and looks like a cottony growth. The plant gradually dries. On splitting the diseased stem black sclerotia are observed.

The disease is caused by *Scelotinia sclerotiorum* which contains hyaline, branched, septate hyphae. They are inter and intra cellular both. These hyphae form black Sclerotia within the stem. The sclerotia germinate in winter in soil where they remain from previous crop or disseminate with seed as inert matter. Stipes are formed on germination which contain apothecia and produce ascus. Each ascus produces ascospores which disseminate and attack the crop causing the disease.

The sclerotia should be removed from seed lot. Deep ploughing is helpful in burying the sclerotia deep in soil. Paddy after coriander helps in the elimination of the inoculum source.

3. *Root rot*

Mall (1968) reported stem and root rot of coriander caused by *Rhizoctonia solani*. The roots exhibit destruction of cortex. The vascular part turns reddish, later shredded. Several plants exhibit symptoms at one place in the field. The plants get pulled easily.

4. *Charcoal rot*

The disease is more prevalent in light soil and dry areas. This is a seed and soil borne disease. The pathogen remains in soil associated with crop debris. It is externally and internally seed borne. The root and stem exhibit black Sclerotia. It results in seed rot, seedling rot, dry root rot

and stem rot. The disease has been reported by Mahor *et al.,* (1982). The leaves start yellowing from the base which moves up. The stem exhibits brownish discolouration with black Sclerotia. The roots of the diseased plants also turn brown and form black Sclerotia. Pycnidia are formed when the conditions are favourable. The disease has been reported from Bulgaria (Rodeva *et al.,* 2010) caused by *Macrophomina phaseolin*a.

5. *Seedling blight*

Seedling damage is caused by *Pythium ultimum*. The tender basal parts of seedlings, root, collar, tender stem turn water soaked, brown and die. The plants rot in patches. The survived plants remain stunted with yellowish leaves. The disease has been reported from Italy also (Garibaldi *et al.,* 2010).

6. *Stem gall*

Stem gall is an important disease of coriander damaging all the aerial plant parts incurring heavy losses as the market value is reduced. It is observed in all the coriander growing areas of the country.

The stem, petiole, pedicels leaves and fruits develop tumour like hyphertrophied swellings called galls. The galls are soft and appear as if water is filled inside, later they become hard. The infected fruits are larger in size. The diseased seeds do not germinate. The disease appraisal of stem gall was done by Gupta (1954).

According to Gupta (1956) the total fat content in diseased fruits are reduced by 14%. Prasad *et al.*, (1989) reported decrease in free amino acids and sugar contents. Goel *et al.*, (1983) and Jain *et al.*, (1994) studied biochemical changes due to the disease and observed high concentration of amino acids and reducing sugars; low concentration of non reducing total sugars; increase in invertase, protease, acid phosphatase, peroxidase, a-amylase and decrease in polyphenol oxidase activities. While studying respiration activities Prasad *et al.*, (1989) reported reduction in the contents of nitrogen, starch, sugars, chlorophyll, carotene and xanthphylls and increase in glucose-1-phosphate in leaves in diseased plants. In infected leaves nitrate reductase, urease activities, exo and endo β-1, 4-gluconate and starch phosphorelase activities also increased.

The disease is caused by the fungus *Protomyces macrosporus* Unger. The hyphae grow intercellulary. They are septate. The cells swell and develop into chlamydospores. On maturity the chlamydospores develop thick, three layered wall and function as resting spores. They are ellipsoidal or globose, 50-60 μ in size. On maturity of the crop the diseased parts fall on the soils which contain chlamydospores. On threshing these diseased plant parts get mixed with the seed as inert matter and also adhere to seeds as contaminant. The chlamydospores germinate on getting moisture. The wall cracks and a vesicle come out. The nuclei divide and protoplasm gathers around each nucleus forming spores. The vesicle bursts and spores are released. They further increase by budding, finally infect the new crop. Hence the disease is soil and seed borne. The infection is followed by soil moisture and shade. The required pH range is between 4.6 and 7.4 (Mathur, 1962; Mukhopadyaya and Pavgi, 1964). Lakra (2001) estimated chlamydospore intensity in different plant parts and observed maximum number in collar portion and minimum in highly infected plants.

Early sown crop in mid September and late sown crop around first week of December have less disease severity, however the crop sown in mid November had least intensity of the disease and high seed yield (Tripathi, 2003). Potassium and nitrogen fertilizers reduced stem gall incidence while phosphorous fertilizers increased the disease (Tripathi *et al.,* 2002).

7. ***Leaf blight- Alternaria alternata***

Small dark coloured circular spots are produced on leaves and green stem. Concentric rings are also observed certain times. The disease has its negative effect on yield. High moisture favours the disease.

8. ***Leaf spot Cercospora corianderi***

The main symptoms are brown spots on leaves circular to angular usually three mm in diameter. Conidia are hyaline, acicular, 1-2 indistinct septa (Chupp, 1953).

9. *Phoma multirostrata*

The fungus attacks the base of the stem which turns pale brown and later dark brown. The lowest leaves are attacked first which develop lesions. The diseased leaves droop down. The pathogen is seed borne as well as soil borne. Black pycnidia are formed on diseased parts.

10. *Anthracnose Colletotrichum capsici, C. gloeosporioides, Gloeosporium achaeniicola*

Naik *et al.,* (1993) reported coriander blight caused by *Colletotrichum gloeosporioides* (*Glomerella cingulata*) in Dharwad district during 1985-86. Leaves and stem develop necrotic spots which later turn into lesions with dark margins and ashy grey centre. High humidity favours the disease severity. The pathogen is seed and soil borne associated with diseased plant debris. According to Bhatta and Hiremath (1989) 5-6 weeks old seedlings were most severely infected due to which they named it seedling blight.

11. *Powdery mildew*

This is a very important disease of coriander resulting in heavy losses. It appears in February-March as the disease is favoured by dry conditions with warmer days. Powdery white masses are observed sprinkled on the foliage and tender plant parts which cover the whole foliage and plant

parts. The leaves turn yellow then brown. When the disease appears early seed is not produced but in case of late infection some seeds are formed but most of them remain small in size. Kalra *et al.*, (2000) observed effect of powdery mildew on yield and yield components of early and late maturing cultivars of coriander. The disease is caused by *Erysiphe polygoni* DC.

12 *Seed rot*

Seeds rot due to seed borne as well as soil borne pathogens mostly under high moisture. *Pythium* spp., *Alternaria alternata, Fusarium* spp. *R. bataticola, R. solani*, *Sclerotium rolfsii* etc. are responsible for seed rot. Some bacterial pathogens cause soft rot of seeds.

13 ***Grain mould and seed borne microorganisms***

Rajan *et al.,* (1990) observed grain mould in coriander caused by the species of *Helminthosporium, Fusarium, Curvularia* and *Alternaria*. In screening 16 promising varieties none were found with total resistance to grain mould microorganisms.

Paul (1992) found 17 fungi associated with coriander seed of which *A. alternata, Aspergillus flavus, Cladosporium herbarum* and species of *Fusarium, Penicillium* and *Stachybotrys* predominated in Himachal Pradesh. Jain and Jain (1995) reported 13 fungal species *Alternaria alternata, Aspergillus flavus, A. niger, A. nidulans, Curvularia* sp., *C. lunata, F. chlamydosporum, F. miniliforme, F. pallidoroseum, F. solani, Phoma sorghina, Rhizopus stolonifer, Syncephalstrum recemosum,* and *Trichothecium roseum* associated with coriander seeds. *Phoma multirostrata* was found associated with coriander seed in Pakistan as reported by Hashmi and Gaffar (1991).

Bacterial diseases

Bacterial leaf spot caused by *Pseudomonas syringae* pv. *coriandricola* was reported by Gupta *et al.,* (2013) from India showing brown leaf spots 1-2 × 3-5 mm surrounded by a water soaked area. The spots were angular due to veins. On merging, the spots gave the appearance of extensive blight. In Himachal Pradesh the disease incidence was 10 percent. The disease has been reported to occur on coriander in Ontario, Canada (Cerkauskas, 2009).

Coriander plants exhibited sudden yellowing and soft rot of roots and basal parts of petioles in Brazil due to *Erwinia carotovora* sub sp. *betavasculorum* (Romeiro *et al.,* 1994). Soft rot of leaves is due to *E. arioatae* (Chakravarti and Rangrajan (1966).

Bacterial blight caused by *Xanthomonas campestris* pv. *corianderi* is a serious disease as the foliage completely rots. Bacteriosis of coriander is due to *X. transluscens*.

Nematode diseases

Moura *et al.*, (1997) described Cilantro dwarf disease caused by *Rotylenchulus reniformis* with strong stunt, leaf chlorosis plus necrosis and poor root system. The disease becomes more severe in warm weather. They have given the details of etiology, symptomatology, severity and control of the disease as it occurred in Brazil.

Meloidogyne incognita produced knots in the roots and resulted in losses up to 51% in yield (Midha and Trivedi, 1991).

Cultivars Co-1, CO-2, UD-21 are resistant to the nematode. Midha and Trivedi (1988a) reported that the number of galls and egg masses per plant increased as the inoculum level increased.

Phyllody

Prakasam *et al.*, (1988) in a survey found that phyllody is wide spread in coriander in several districts of Tamil Nadu. They could transmit the disease by side wedge grafting and not through sap inoculation.

Virus diseases

1. Carrot red leaf luteovirus caused red leaf disease in coriander in experimental plots of Tamil Nadu Agricultural University, Coimbatore. The virus did not transmit by sap inoculation or by seeds (Prakasam *et al.*, 1989).
2. Dhawan and Rishi (1992) observed chrorotic pinhead sized, raised lesions on coriander leaves in field in Hissar caused by coriander Chrorotic virus. It was transmitted mechanically.
3. Lima *et al.*, (1999) have reported the groundnut ring spot virus (GRSV) on coriander from Brazil.
4. Curly top occurs in coriander, when young plant remains dwarf, leaves are swollen, the petiole is shortened. The leaves crinkle and get puckered. The transmission of the virus is through leaf hoppers. The disease is more common in areas where light intensity is high, summer heat is prolonged, relative humidity is low and evaporation is fast (Chupp and Sherf, 1960).

Reports of new diseases in coriander

Dennis (2003) reported the occurrence of a new disease from Australia caused by *Microdochium* sp. The plants developed light grey, irregular sunken lesions up to one cm long on the stems. Where the pathogen girdled the whole stem, branches and umbels were distorted. The disease occurred in patches but got transmitted to other plants finally resulting in heavy yield losses. Usmani *et al.,* (2012) found *Plectoshaerella pauciseptata* to form soft rot symptoms on the stem and petiole of coriander where they become brown to black. The vascular portion also turned discoloured. The disease was named *Plectoshaerella* rot. This occurred in Chiba Prefecture, Japan. Wilting and root rot caused by *Macrophomina phaseolina* have been reported by Radeva *et al.*, (2010)

as new report. Garibaldi *et al.*, (2010) have reported collar and root rot of coriander due to *Pythium ultimum* in Italy for the first time. A. bacterial leaf spot of coriander was observed in Ontario, Canada by Cerkauskas (2009).

Management Resistance

To control diseases in a crop the best way is to have varieties resistant to pathogens causing diseases. Attempts have been made and success has been achieved in making available such varieties with resistance to single disease or multiple diseases (Malhotra and Vashishtha, 2008).

Singh *et al.*, (2003) found accessions PH-7, Pant Haritma, CO-17 and CO-2 highly resistant to stem gall. Naqvi (1985) reported UD-03, UD-41,UD-46 and UD-48 resistant to stem gall while Tripathi *et al.*, (1998) observed G-C-88-8, G-5365-91, Pant-1 and UD-20 moderately resistant. Keshwal and Khatri (1998) reported cultivars CS-362, CH-15 and CS-52 to exhibit resistance against powdery mildew. Midha and Trivedi (1988b) and Das (1998) have reported cultivars RCr CO-1, CO-2. UD-21 resistant and RCr-41, CO-3 and UD 20 moderately resistant to *M. incognita*. In case of grain mould Rajan *et al.*, (1990) found two coriander lines 695 and CS-7 with least incidence of 5.8 and 6.3% respectively.

Cultural control

To avoid disease pressure coriander should be grown in winter in areas free from frost, moderately cool and with dry weather. The soil medium to heavy loam with pH 6-7 is preferred. To avoid the soil borne pathogens, rotation of crop is essential. Soil Solarization keeps these pathogens under control. In case of powdery mildew early sowing is best to avoid the disease. Wilt can be managed by the application of oilcakes and keeping the soil pH 8.2 (Srivastava, 1972). According to Tripathi *et al.*, (2002) potassium and nitrogen fertilizers reduced stem gall incidence. Care is needed while deciding the fertilizer dose. The diseased portions should be removed or if needed the whole plant be uprooted and destroyed.

Chemical control

It is essential to remove diseased seeds and inert matter from the seed lots to be used as seed. Seed treatment is necessary with fungicides like Mancozeb, captan, thiram, captafol, Bavistin + thiram. For controlling powdery mildew Karathane should be sprayed. If the day temperatures are not high wettable sulphur may be sprayed. To control other foliar diseases Mancozeb may be sprayed.

For the control of seed borne bacterial pathogens dry hot air treatment at 53 C for 30 minutes gives best control (Champawat and Singh, 2008). Singh (2009) reported *Trichoderma harzianum* and *Pseudomonas fluorescence* application after 45 days of sowing was effective in controlling wilt.

Future line of action

It is essential to give priority to identify sources of resistance to important diseases and to breed to produce new varieties resistant to single or multiple diseases resistance with desired qualities of produce. The production technology needs further researches on cultural practices which may suppress the pathogens and diseases caused by them. Hot spots where the disease is endemic should be located to screen the germplasm lines against specific diseases. On the contrary disease free areas should also be known for production of high quality pathogen free seed. Work is needed to develop forecasting system for diseases. Eco-friendly management system needs to be developed leading to the integrated approach.

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