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Editorial

Diseases of Oilseeds Crops: Challenges and future management strategies

There are nine major oilseeds crops cultivated in India. Out of these, rapeseed & mustard (Raya [*Brassica juncea* (L.)Czern. & Coss.], *B. campestris* L. viz., toria, brown sarson and yellow sarson, gobhisarson (*B. napus* L.), Ethiopian mustard (*B. carinata* Braun.) and taramira (*Eruca sativa* Mill.); groundnut (*Arachis hypogaea* L.); sunflower (*Helianthus annuus* L.); Soybean (*Glycine max* (L.) Merrill); Sesame (*Sesamum indicum* L.); Safflower (*Carthamus tinctorius* L.); Niger (*Guizotia abyssinica* (L.) Cassini) are edible oilseeds crops while castor (*Ricinus communis* L.) and linseed (*Linum usitatissimum* L.) are non-edible oilseeds crops.

All India Area, Production and Yield of seven edible oilseeds crops were: 271.39 m. ha, 332.19 m. tons,and 1224kg/ ha, respectively; the highest being the Soybean (120.90, 112.20, 928); rapeseeds and mustard (67.80, 91.20, 1345); followed by Groundnut (48.9, 101, 2065); Sesame(16.23, 6.58, 405); sunflower (2.4, 2.2, 891); niger (1.36, 0.41, 303); Safflower (0.52, 0.44, 843); and two non- edible oilseeds crops viz. Castor were (10.46, 18.49, 1761) and linseed (1.80, 1.21, 671) during the year 2019-20. The oil extracted from seeds of edible oilseeds form an important item of human diet while Oil-cake are used for cattle-feed and manure and the oil of non-edible oilseeds can be used for manufacturing paints, varnishes, hydrogenated oil, soaps, perfumery, lubricants, etc. The country exports soybeans, mustard seeds, groundnuts, sesame seeds, niger seeds, cotton seeds, castor seeds and sunflower & safflower seeds. In FY 2021-22 India exported Rs. 8,310 crore (US$ 1,003.99 million) worth of Oilseeds.

The diseases of **Rapeseed and mustard** crops are Alternaria Leaf Spot / Blight (*A. brassicae*(Berk.) Sacc. and *A. brassicicola* (Schw.) Wilts.); White Rust (*Albugo candida*(Pers.) Kuntze); Downy Mildew (*Peronospora parasitica* Gäum. (*P. parasitica* subsp. *brassicae* (Gäum.) Maire); Powdery Mildew (*Erysiphe cruciferarum* Opiz ex L. Junell); Sclerotinia Stem Rot (S. *sclerotiorum* (Lib.) de Bary). Except powdery mildew, all the other pathogens are necrotrophs. Infections are caused by airborne spores. Host resistance is an important attribute to avoid the seed yield losses in the crops. Yield loss ranged from 3.16 to 31.87% due to Alternaria blight. Except Divya, which was found slightly tolerant, all the other varieties were susceptible. *B. juncea*, varieties PRB-2008-5, PRE-2009-12 and PRB-2004-3-4 were found slightly tolerant to white rust disease. Cool and humid climate i.e. 12-14°C and 60-80% relative humidity was found favourable for the disease development. Good agricultural practices viz. field sanitation, crop rotation, sowing certified healthy disease-free seeds, treating seeds with 2.5 g of thiram or mancozeb/ kg of seed, and spraying the crop with mancozeb, 0.2 %were found good for the disease management. White rust and downy mildew both occurring together are also serious disease of mustard crops grown in temperate climatic conditions. Therefore, both the diseases can be managed by dressing the seed with metalaxyl (Apron 35SD)@6g/kg followed by spraying with metalaxylmz, (metalaxyl 8% + mancozeb 64% WP), 0.2%. Generally occurrence of Powdery mildew is sporadic in timely sown crops, but in late sown crops it affects the seed yield. It can be managed by one or two sprays of wettable sulphur, 0..2% or hexaconazole, 0.005%.

Groundnut is very important edible oilseed crop, the seeds and its oil is used in human diet and fodder and de-oiled cake as animal feed. Though many fungi have been reported to infect the crops, but early and late leaf spots, rust, collar rot, stem rot and seed rot and aflatoxin are important disease problems affecting the yield and quality of the crop. Early leaf spot (*Cercospora arachidicola* Hori) and late leaf spot (*Phaeoisariopsis personatum* (Berk & Curt)) are the most damaging diseases worldwide, which adversely affect the yield and quality of pod, and haulm. An early or timely sowing of crop, inter-cropping with non- host crops, and spraying the crop with fungicides viz. carbendazim, 0.05%; mancozeb, 0.2%, Chlorothalonil, 0.2%, hexaconazole, 0.005% were found effective in the management of both the leaf spots. The rust of groundnut is caused by *Puccinia arachidis* Speg. The Uredial stages are produced abundantly on the plants, which causes the yield losses. High relative humidity >85%, heavy rainfall and low temperature of 20–25ÚC, favour the rust development. Spraying a mixture of

carbendazim, 12% and mancozeb, 63% at the initiation of the disease was effective to manage the disease. Stem rot caused by *Sclerotium rolfsii* Sacc. causes wide spread and serious losses. The propagules i.e. sclerotia, survived for years in soil on crop debris and on various other hosts. Therefore, the cultural practices such as field sanitation, seed selection, crop rotation, and early sown crops, help to escape infection. Seed treatment with talc based formulation of *Trichoderma harzianum* or T. viride@ 4 g/ kg seed and soil application of the same @ 2.5–3.5 kg/ha reduce the disease incidence. Collar rot caused by *Aspergillus niger* is the serious disease of crops sown in light or sandy loam soils. The plants up to 50 days of age are affected the most. The crop is affected much under moisture stress in its early crop stage. The seed treatment with carbendazim @ 5 g/ kg seeds or with talc based *T. viride* @ 5g/ kg seeds were found effective to manage the disease.

The crop of groundnut is also affected by the viruses viz. Bud necrosis virus (BNV) and tomato spotted wilt virus (TSWV) all over the world, and is transmitted by thrips. Use of resistant/tolerant cultivars viz. ICGS 11, ICGS 4–4, ICGV 87141, ICGV87187, ICGV 87119, ICGV 87121, ICGV 87160, ICGV 8–7 1–5 7, or ICGV 86590; adjusting date of sowing to avoid the peak disease incidence; sowing groundnut at a high plant density and maintaining a good plant stand; Intercropping of groundnut with cereals, for example, pearl millet was found to restrict the spread of the virus.

Besides, “groundnut chlorotic rosette” (GCR) “groundnut green rosette” (GGR), and “groundnut mosaic rosette” (GMR) are the wide spread virus diseases in Africa. *Aphis craccivora* is mainly responsible for the spread of rosette disease. Spray of insecticides viz. demeton-s-methyl, 72–96 ml a.i./ ha was found effective to manage the aphids and minimize the disease.

Among the nematode diseases, the root-knot nematodes (*Meloidogyne* spp.) are the serious as causing yield losses ranging from 2–0% to 9–0% . The management practices viz. crop rotation of cereal-cereal-groundnut , using nematicides like fumigant i.e. ethylene dibromide (EDB) 18 cm deep at a soil temperature between 15 and 21°C @ 18 or 19 L ha–1, or non-fumigant viz. aldicarb, carbofuran, and phenamiphos at sowing @ 2–3 kg a.i. ha–1; Soil solarization during the hot dry season, and growing of resistant cultivars viz. NC 343, NC 3033, NCAC 17090, or ICGS 2 also helps to control nematodes.

Soybean crop is affected by many fungal pathogens which cause Collar Rot, Cercospora Leaf spot, Septoria Brown Spot, Downy Mildew, Charcoal Rot, Anthracnose Stem Blight, Fusarium Wilt and Root Rot, Soybean Rust, Powdery Mildew, Phytophthora Root and Stem Rot, Pod and Stem Blight and Phomopsis Seed Decay, Pythium Root Rot, Rhizoctonia Root Rot; Bacterial Diseases: Bacterial Pustule; Viral Disease: Soybean Yellow Mosaic; Nematode Disease: Soybean Cyst nematode, etc. Some of the important disease are Collar rot caused by *Sclerotium rolfsii*, which is polyphagous,destructive soil borne fungus, overwinters mainly as sclerotia and spread by contaminated tools, infected transplants seedling, moving water, infested soil., etc. The management practices discussed above should be adopted to avoid yield losses in soybean due to this disease. Downy mildew (*Peronospora manshurica* (Naumov) Syd.) is a common foliar disease, but rarely causes serious yield losses. Management practices as in mustard can be followed in this disease too. Frogeye leaf spot (*Cercospora sojina* K.Hara) is a prevalent disease in north hills zone of India. It survives in crop residue and infected seed. Warm, humid weather promotes spore production, infection and disease development.Crop rotation and tillage reduce survival of the pathogen. Brown spot (*Septoria glycines* Hemmi) is the most common foliar disease of the crop throughout the crop season. The fungicides used to manage the other leaf spots can be used for this disease. Soybean rust (*Phakopsora pachyrhizi* Syd. & P. Syd.) is capable of causing defoliation and significant yield loss. The uredial stage is damaging to the plants and can be managed by application of fungicides viz. hexaconazole, 0.1% or propiconazole, 0.1%. Charcoal rot (*Macrophomina phaseolina* (Tassi) Goid.) is an important disease and can be damaging to the crop during hot and dry weather with less moisture. The pathogen survives in soil or the crop residues as micro-sclerotia, which infect the crops. The disease can be managed by seed treatment of talc based *Trichoderma viride* @ 10g/ kg seeds and soil application of *Trichoderma* enriched FYM. Anthracnose stem blight (*Colletotrichum truncatum* (Schwein.) Andrus & W.D. Moore) occurs mainly during the reproductive stage of the crop, but also affect plant stand due to early season infection. The fungus overwinters as mycelium in crop residue or infected seed. The pathogen can be managed by selecting pathogen free seeds from dry areas; crop rotation and tillage and spraying the fungicides or application of *Trichoderma* spp. Similarly, root and stem rot (*Phytophthora sojae* Kaufm. & Gerd.), Pod and stem blight and Phomopsis seed decay (*Diaporthe phaseolorum* var.*sojae* (Lehman) Wehm.; *Phomopsis longicolla*); *Pythium* root rot, Rhizoctonia root

rot (*Rhizoctonia solani*) are some of the important diseases of the soybean, which can be managed by the measures as discussed above in other diseases.

Besides fungal diseases, Bacterial pustule (*Xanthomonas axonopodi* spv. *glycines*) occurs mid- to late season when temperatures are warmer and more favorable for disease development. The disease can be managed by spraying streptomycine sulphate, 0.005% solution. Soybean Yellow mosaic (SYMV) and Soybean Mosaic virus (SMV) are important viral diseases of soybean causing huge yield losses to seeds. SYMV is caused by bipartite begomoviruses (genus:Begomovirus, family:Geminiviridae) and transmitted by *Bemisia tabaci*. The management of the vector through systemic insecticides viz.metasystox, 0.1% can help to reduce the disease.

Sunflower is an important edible oilseed crop, which contribute to a greater extent in human diet. The crop is heavily suffered by the fungal pathogens individually and in combination to other pathogens. The diseases viz. Alternaria leaf blight, stem spot and head rot (*Alternaria alternata*, (*A.tenuis)*, *A. helianthi*, *A. helianthicola*, *A. leucanthemi*, *A. tenuissima*, *A. zinniae*), Botrytis head rot / graymold (*B. cinerea*), Charcoal rot (*M. phaseolina),* Downy mildew (*Plasmopara halstedii , P. helianthi* f.sp. *helianthi),* Fusarium stalk rot (*F. equiseti, F. solani*, *Microdochium tabacinum/ F. tabacinum, Monographella cucumerina*), Fusarium wilt (*F. moniliforme*, *F. oxysporum*), Myrothecium leaf and stem spot (*Myrothecium roridum, M. verrucaria*), Phoma black stem (*Phoma macdonaldii, Leptosphaeria lindquistii, P. oleracea var. helianthi-tuberosi*, Phomopsis brown stem canker (*Phomopsis* spp. *P. helianthi*), Phytophthora stem rot: (*Phytophthora* spp., *P. drechsleri*), Powdery mildew (*E. cichoracearum, Oidiumasteris-punicei* , *E. cichoracearum* var. *latispora, Oidium latisporum*, *L. compositarum* f.sp. *helianthi, L. taurica, Oidiopsis sicula*, *S. fuliginea*), Rhizoctonia seedling blight (*Rhizoctonia solani*), Rhizopus head rot (*Rhizopus arrhizus, R. nodosus, R. microsporus, R. stolonifer*), Rust (*Puccinia helianthi, P. xanthii, Uromyces junci*), Sclerotinia basal stalk rot and wilt, mid-stalk rot, head rot (*Sclerotinia sclerotiorum*, *S. minor*), Sclerotium basal stalk and root rot (*S.rolfsii*),Septoria leaf spot (*Septoria helianthi*), Verticillium wilt (*Verticillium albo-atrum, V. dahliae*), White rust (*Albugo tragopogonis*), Yellow rust (*Coleosporium helianthi, C. pacificum/ C. madiae*) are the important diseases of the sunflower, which take a heavy toll of the crops yield losses in favourable conditions.

Nematodes parasitic diseases viz. Dagger, American (*Xiphinema americanum*), Pin (*Paratylenchus projectus*), Lesion (*Pratylenchus* spp.; *P. hexincisus*), Reniform (*Rotylenchulus* spp., *R. reniformis*), Root knot (*Meloidogyne arenaria, M. incognita, M. javanica;*), Stunt (*Tylenchorhynchus nudus, Quinisulcius acutus*) have been reported to cause considerable yield losses to sunflower. Similarly, sunflower is also affected by viral diseases viz. Aster yellows, Sunflower mosaic(Cucumber mosaic virus), Sunflower virus (Tobacco mosaic virus), Chlorotic Mottle (Sunflower Chlorotic Mottle virus - SuCMoV), and Bacterial leaf spot (*Pseudomonas syringae* pv. a*ptata, P. cichorii; P. syringae* pv. h*elianthi, P. syringae* pv. *melle*a) and Bacterial wilt (*P. solanacearum*), Crown gall (*A. tumefaciens),* Erwinia stalk and head rot: (*E.carotovora* sub. sp. *carotovora*).

Sesame is annual edible oilseeds crop grown for seeds from which oil is extracted for human consumption in various ways. The crop is affected severely with many fungal diseases viz. Alternaria leaf blights (*A. sesami*), Charcoal rot / Dry Root rot / Stem rot (*M. phaseolina*), Fusarium wilt (*F. oxysporum* f. sp. *sesame*), White spot (*Cercosporasesame*), Phytophthora leaf blight (*P. parasitica* var. *sesami*), Powdery mildew (*Erysiphe cichoracearum),* Alternaria leaf blight (*A. sesami*); Bacterial blight (*X. campestris* pv. *sesami*), Bacterial leaf spot*(P. syringae*pv. *sesami)* Leaf curl (Tobacco leaf curl virus) and Phyllody(Phytoplasma).

Seed treatment with *Trichoderma viride* @ 4 g/ kg seed and soil application of *T.viride* @ 2.5 kg/ha, spraying of carbendazim + mancozeb, 0.2%) along with Imidachlorprid17.8SL(0.25ml/lit) was found effective to minimise Alternaria leaf spot, powdery mildews and Macrophomina stem rot, and obtaining maximum seed yield with higher cost benefit C:B (1:4.5) ratio. For managing bacterial diseases, seed treatment with Streptomycin sulphate at 250 ppm, followed by its spraying was found good to manage the disease. Similarly, seed treatment with Imidacloprid followed by foliar spray with Thiomethaxam, was found better for managing vector as well as phyllody of Sesamum.

Safflower is also an important oilseeds crop grown in marginal land. The oil extracted from its seeds is good for heart due to its oil characteristics. The crop is affected adversely by Alternaria leaf spot (*Alternaria carthami*), Cercospora leaf spot (*Cercospora* spp.), Powdery mildew (*Erysiphe cichoracearum*), Head rot and wilt (*Botrytis cinerea*), Ramularia leaf spot (*Ramularia* spp.), Rust (P*uccinia calcitrapae var. centaureae* = *P. carthami* , *P.*

verruca), Wilt (*F. oxysporum* f. sp. *carthami*), Root rot (*R. solani*, *Thanatephorus cucumeris*), Mosaic, etc. These diseases have been found to infect crops in mild to severe form in all the crop growing regions. However, disease prevalence was less in fields with late as compared to early sown crops. Intercropping safflower with chickpea, cotton, sorghum alone and with chickpea and sorghum together have decreased the disease incidence in comparison to cultivation of safflower alone. Early and accurate diagnosis of the disease through regular monitoring and surveillance will help in taking up control measures in the initial stage of the disease to reduce the loss. It is advised to follow integrated plant health management practices comprising host-plant resistance, cultural, biological and chemical control.

Linseed is an important non edible oilseeds crop, grown for seeds and stem fibre. The oil extracted from seeds is used in formation of paints, varnishes, etc., and the fibre is used in textile industry. The crop suffers heavily with Wilt (*Fusarium oxysporum* f. sp. *lini*), Rust (*Melampsora lini*), Alternaria leaf spots and blights (*Alternaria linicola*) and powdery mildew(*Oidium lini* Skoric).Wilt is caused by *Fusarium oxysporum* f. sp.*lini* , which is primarily a soil-borne and may persists for many years in the soil. High temperatures and low moisture are favourable for the disease. Use of wilt resistant varieties viz. RR 9, NP 12, 124, RR 5B, RR 80, etc., bioagents: Arbuscular mycorrhizal (AM), *Trichoderma* spp. as discussed earlier and later can be very useful to manage the wilt. Flax rust (*Melampsora lini*) occurs in the major flax production areas of the world. It is an autoecious long cycle rust, produces all stages on the flax plant. Crop rotation, spraying of triazole group of fungicides viz. hexaconazole, propiconazole, mancozeb, etc. can be useful to manage the rust. Alternaria blight (*Alternaria linicola)* of linseed is prevalent in all the crop growing regions of India, and survives in crop debris and in contaminated seeds. Seed treatment with *T. viride* @ 4 g/kg seed or with seed dressing fungicides, followed by foliar spraying of mancozeb, 0.2% at the time of flowering and at 15 days intervals are effective to control this disease. Powdery mildew (*Oidium lini*Skoric) appears as small, circular or irregular dirty white powdery patches on leaves, and spreads quickly to cover the whole plant parts. Foliar spray of wettable Sulphur, 0.25% as per need can be done to manage the disease.

Castor (*Ricinus communis* L.) crop is severely infected by wilt incited by *F. oxysporum* f.sp.*ricini*. The pathogen survives in soil through chlamydospores, therefore, *Trichoderma viride* and *T. harzianum* have been found quite effective in the management of the wilt. Application of *Trichoderma* along with FYM or castor or mustard cake gives more control to the wilt. Similarly, root rot caused by *Macrophomina phaseolina* is also a sever disease of castor. The disease was effectively managed by the application of the above bioagents with seed treatment and along with the FYM and cakes.

Future management strategies

The proper diagnosis of the pathogens infecting the crops is needed to evolve proper management strategies. Therefore, in addition to conventional method, molecular tools viz. serological and molecular methods should be used for detection of the pathogens. Research to understand the host-pathogen interactions at a molecular level, aerial surveillance& image processing technologies, artificial intelligence, to determine pest/disease status on a wide scale, need to be worked out. Drone-based target spraying of the pesticides in the oilseeds crops is useful for quick and efficient target based spraying.

Evolving bio-agents to manage biotic and abiotic stresses in the wake of climatic change is very crucial. Different speciesof *Trichoderma* viz. *T. harzianum; T. viride; T. asperellum* (endophytic), have been found to possess multi-trait characteristics viz. decomposer of organic matter by the multi- hydrolytic enzymes (cellulase, esterase, proteases, chitinases, 1,6 ß glucanases, 1,3 ß glucanases, chitobiosidases); phosphate solubilizer and releasing agent of micronutrients, NPK; producer of phyto-hormone for crop growth; competition with microbes/ pathogens for space, nutrition, Siderophore production; Mycoparasitism: through antibiosis; cell wall degradation of fungal pathogens; triggering in plants 'Induced Systemic Resistance' (ISR), 'Systemic Acquired Resistance'(SAR) by production of chemicals (alkyl pyrones, pentyl analogues, dermadin, isonitriles, poly-ketides, peptaibols, steroids, Di-ketopiperazines, etc.); which have been found quite useful for managing the biotic stresses i.e. diseases of crops. Similarly, these bioagents have also been found quite effective for management of the abiotic stresses viz. drought, salinity, heavy metals, extreme temperatures, etc. due to presence of enzymes and volatile chemicals in it. Therefore, these bioagents have been tested and found quite effective against many seed and soil borne diseases and aerial pathogens of crops, due to its SAR and ISR characteristics. Therefore, there is a need to

test these bioagents against pathogens/ diseases of oilseeds crops and recommend to farmers for the management of the diseases.The bioagents have to play a pivotal role in the management of biotic and abiotic stresses of crops, therefore, more and more soil dwelling microbes need to be tested and commercialized for the use of farmers.

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