



SEED-BORNE AND POST-HARVEST DISEASES OF CASTOR BEAN (*RICINUS COMMUNIS* LINN.) AND THEIR MANAGEMENT: A REVIEW

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Castor bean (*Ricinus communis* L.) of family Euphorbiaceae is indigenous to eastern Africa and most probably originated in Ethiopia. It is widely distributed throughout the tropics, sub-tropics and temperate regions of the world. India is largest producer in the world and contributes 55-60 per cent of global production. The plant has several bioactive compounds or secondary metabolites that having medicinal and antimicrobial properties. In India, it has been documented since 2000 BC for lighting lamps and in local medicine. It is used as laxative, purgative and cathartic in Unani, Ayurvedic and other ethnomedical systems. The yield of crop reduced due to attack of several pathogens like fungi, bacteria, virus, mycoplasma and nematode diseases throughout the world which causes severe losses, reduces plating and market value of the crop. The main diseases are root rot, gray rot, seedling blight, alternaria blight, leaf blight, brown leaf spot, cotton rot, grey mold; inflorescence and stem rot, fruit rot, charcoal rot, wilt, leaf rust, powdery mildew, bacterial blight and leaf spot.

Keywords: Disease management; Seed-borne diseases; Seed-borne pathogen.

Introduction

Castor bean (*Ricinus communis* L.) of Euphorbiaceae is an important non-edible oil seed crops indigenous of eastern Africa and most probably originated in Ethiopia. The plant is widely distributed universally mainly in India, China, Eastern Africa, Ethiopia and Brazil¹. India occupies about 57 per cent of the world castor acreage with 62% production of the world. In India, major castor growing states are Gujarat, Andhra Pradesh, Rajasthan, Tamil Nadu and Orissa. India is largest producer of castor seed in the world and contributes 55-60 per

cent of total global production. In India, castor is grown in area of 12.33 lakh ha with 19.64 lakh t average productivity of 1592 kg ha⁻¹ during 2012-13. Gujarat is largest producer of castor seed with production of 14.93 lakh t followed by Rajasthan (3.41 lakh t) and Andhra Pradesh (1.05 lakh t) in 2012-13². In Rajasthan, it is grow in districts as Jalore, Sirohi, Barmer, Jodhpur, Hanumangarh, Pali and Sriganganagar³. The plant is reported to possess anti-oxidant, anti-implantation, anti-inflammatory, anti-diabetic, anti-tumor, larvicidal, anti-nociceptive and anti-asthmatic

due to the occurrence of important phytochemical constituents like flavonoids, glycosides, alkaloids, steroids etc. Castor seeds have 50–55% non-edible oil which contains steroids, saponins, alkaloids, flavonoids and glycosides⁴⁻⁷. The dried leaves have two alkaloids as ricinine (0.55%) and N-demethylricinine (0.016%); six flavones glycosides namely kaempferol-3-O- β -D-xylopyranoside, kaempferol-3-O- β -D-glucopyranoside, quercetin-3-O- β -D-xylopyranoside, quercetin-3-O- β -glucopyranoside, kaempferol-3-O- β -rutinoside and quercetin-3-O- β -rutinoside. The monoterpenoids (1, 8-cineole, camphor and α -pinene) and a sesquiterpenoid (β -caryophyllene), gallic acid, quercetin, gentisic acid, rutin, epicatechin and elingic acid are major phenolic compound isolated from leaves. Root extract contains Indole-3-acetic acid. The seeds contain 45% of fixed oil, consists glycosides of ricinoleic acid, isoricinoleic, stearic and dihydroxystearic acids, lipases and a crystalline alkaloid and ricinine^{8,9}. The fatty acid composition of the oil by gas chromatography-mass spectrometry (GC-MS) showed ricinoleic acid (74.10%) as the major constituent fatty acid. Other fatty acids are linoleic (10.32%), oleic (7.55%), stearic (2.81%), palmitic (2.59%), erucic (1.70%) and eicosadienoic (0.93%)¹⁰.

The plant of castor bean is a small tree of which most of parts are of important uses viz. root bark, leaves and flowers. Traditionally the plant is used as laxative, purgative, as fertilizer and having antimicrobial properties¹¹⁻¹⁴. Castor oil is used in the manufacture of wide range of industrial products such as nylon, fibers, jet engine lubricants, hydraulic fluids, dyes, detergents, soaps, ointments, greases, paints, varnishes, cosmetics and perfumes etc¹⁵. Castor is attacked by several pathogens like

fungi, bacteria, virus, mycoplasma and nematode diseases throughout the world causing severe losses, quality of seeds and market value of seeds¹⁶⁻¹⁸.

The fungal diseases are root rot, gray rot, seedling blight, bacterial blight, alternaria blight etc. In India, yield loss of 80–100% has been attributed to fungal diseases¹⁹ and this has affected the income of farmers in terms of foreign exchange. Many *in vitro* studies have demonstrated that some fungicides restrict or prevent the growth of fungal pathogens²⁰⁻²². The important diseases of castor bean are Phytophthora seedling blight, Rust, Alternaria leaf spot, Cercospora leaf spot, Anthracnose, Powdery Mildew, Stem rot, Fusarium wilt, Bacterial leaf spot, Bacterial wilt or Slime disease, Tobacco ring spot, Tobacco necrosis and cucumber mosaic virus²³.

The important seed-borne diseases are Leaf blight disease caused by *Alternaria ricini* (Yoshu) Hansag reported from various states as Kanpur, UP, Maharashtra²⁴, Gwalior, M.P.²⁵, Ajmer, Rajasthan²⁶⁻²⁸, spot on leaf and in seed caused by *Alternaria tenuis* Nees (= *A. alternata* (Fr.) Keissler)²⁸, *Alternaria tenuissima* (Kze. ex Pers.) Widt. Jabalpur, M.P.²⁹, *Cercospora ricinella* Sacc & Berl Pusa, Muzaffarpur, Bihar^{30,31}, Hyderabad, Andhra Pradesh³², Kokilamukh, Assam³³, *Corynespora cassicola* (Berk. & Curt.) Wei Hyderabad, Andhra Pradesh³⁴, *Leptosphaerulina ricini* Karan Hyderabad, Andhra Pradesh³⁵, *Phyllosticta bosensis* Bose & Mathur Kanpur, U.P.³⁶, *Periconia byssoides* Pers. ex Schw Hyderabad, Andhra Pradesh³⁴; spot on stem caused by *Botryodiplodia ricinicola* (Sacc.) Petrak (= *B. theobromae* Pat.) Pusa, Bihar, Bellary Tamil Nadu^{37,38}, Inflorescence and stem rot caused by *Botryodiplodia ricini* (Godfrey) Whetzel (= *Sclerotinia ricinus* Godfrey)

Banglore, Karnataka³⁹, wet rot caused by *Choanephora cucubitarum* (Berk. & Rav.) Thaxt. Gorakhur, U.P.⁴⁰; fruit rot caused by *Cladosporium oxysporum* Berk. & Curt Ludhiana, Punjab⁴¹; twig blight caused by *Glomerella cingulata* (Stonem.) Spauld. & Schrenk, Dharwar, Karnataka⁴²; root and stem rot caused by *Macrophomina phaseolina* (Tassi) Goid Nadiad, Gujrat⁴³; leaf rust caused by *Melampsora ricini* (Biv Bern.) Passerini Poona, Nagpour, Maharastra; Coimbatore, Tamil Nadu^{44,45} Hyderabad, Andhra Pradesh^{43,46}; powdery mildew caused by *Oidiopsis taurica* (Lev.) Salmon (conidial state of *Leveillula taruica* (Lev.) Arnaud.) Coimbatore, Tamil Nadu⁴⁷⁻⁴⁸; fruit rot caused by *Phytophthora colocasiae* Racib. emend. Thomas & Ramakr. T.S. Poona, Maharashtra^{49,50}; root and seed rot caused by *Phytophthora parasitica* Dast Muzaffarpur, Bihar⁵¹, *Pythium aphanidermatum* (Eds.) Fitz.⁵¹⁻⁵⁴; root rot caused by *Pythium debaryanum* Hesse⁵⁴⁻⁵⁶; on seeds in storage caused by *Pythium proliferum* de Bary., Pusa, Bihar^{52,54,57}; spot on leaf, petioles and young shoots caused by *Sphaceloma ricini* Jenkins & Cheo, Chinchwad, Maharashtra⁵⁸, Phyllody from South India⁵⁹. Bacterial blight and leaf spot caused by *Xanthomonas ricini* (Yoshi & Takimoto) Dowson is a very common in Andhra Pradesh; Tamil Nadu; Rajasthan; Gujarat; Bombay and Delhi⁶⁰.

Sahran(2005)⁶¹ reported some minor diseases viz. anthracnose caused by *Colletotrichum capsici*⁶², Bacterial Leaf spot caused by *Pseudomonas syringae*⁶³, Bacterial wilt caused by *Ralstonia solanacearum*^{64,65}, Collar rot caused by *Sclerotium rolfsii*⁶⁶; Damping-off caused by *Pythium aphanidermatum*⁶⁷; Die-Back caused by *Botryosphaeria quercuum*⁶⁸; Fruit rot caused by *Phytophthora colocasiae*; Leaf blight caused by *Phytophthora palmivora*,

Phytophthora nicotinae var. *parasitica*^{125,126}, Leaf spots caused by *Cercospora ricinella*, *Phyllosticta bosensis*, *Cladosporium* sp., *Diplidia ricinicola*, *Cercospora coffeicola*, *Alternaria tenuissima*, *Leptosphaerulina ricini*, *Periconia byssoides*, *Corynespora cassicola*, *Cochliobolus lanatus*, *Sclerotinia sclerotiorum*, *Sphaceloma ricini*, *Botryodiplodia ricinicola*, *Myrithemcium roridum*^{29,34,41,58,67,127-130}, Powdery mildew caused by *Laveillula taurica*⁶⁷, Rust caused by *Melampsora taurica*⁶⁷, Sclerotinia rot caused by *Botryotinia ricini*⁶⁷, Seed rot caused by *Cephalosporium curtipes*⁶⁷, Stem canker caused by *Botryosphaeria dothidia*⁶⁸, Stem rot caused by *Physalospora ventricosa*, *Phytophthora nicotiana*^{131,68}, Twig blight caused by *Glomerella cingulata*⁴², Twig rot caused by *Diaporthe arctii*¹³² and Verticillium wilt caused by *Verticillium alboatrum*¹³³. A number of fungal species have been reported from Pakistan on castor bean viz. *Alternaria* sp., *Aspergillus* sp., *Curvularia* sp., *Fusarium* sp., *Helminthosporium* sp., *Mucor* sp., *Nigrospora* sp., *Penicillium* sp., *Sclerotium* sp. and *Thielavia* sp.¹³⁴. The damaging pests are those attack on inflorescence such as mirids (*Helopeltis* spp.), peach moth (*Conogethes punctiferalis*) in India and throughout south-East Asia⁸¹.

In a study, 10 endophytic fungal species isolated from *Ricinus communis* namely *Aspergillus fumigates*, *Aspergillus japonicas*, *Aspergillus niger*, *Fusarium semitectum*, *Curvularia pallescens*, *Phoma hedericola*, *Alternaria tenuissima*, *Fusarium solani*, *Drechslera australien* and *Aspergillus repens*^{79,135}.

Thirty one fungal species belonging to 15 genera were isolated from 12 samples of castor bean seeds collected from different areas of Pakistan and *Fusarium solani*,

Alternaria alternata, *Cephalophora tropica* were found most predominant including saprophytic fungi as *A. niger* and *A. flavus*. Blotter method was considered to be better technique which gave maximum number of fungi followed by agar plate and deep freezing methods¹³⁶.

Nagaraja *et al.* (2009)⁷⁵ isolated 47 fungal species belonging to 7 genera from 185 samples of castor bean seeds. *F. oxysporum*, *Alternaria ricini*, *A. alternata*, *Culvularia lunata*, *Macrophomina phaseolina*, *Sclerotinia sclerotium*, *Cladosporium herbarum*, *Chaetomium globosum*, *Botryodiplodia acerina*, *Stachybotrys chartarum*, *Aspergillus ochraceus*, *A. niger*, *A. flavus*, *A. versicolor* and *Rhizopus stolonifer* were found predominant fungal species on castor seeds.

Fungi associated with the fruits and seeds of some *Jatropha* species and *Ricinus communis* were investigated in Benin City. The isolation and subculture of isolates on Potato Dextrose Agar (PDA) were identified as *Fusarium* and *Cornularia spp.* from *Ricinus communis*⁶⁹.

In a study the seeds of castor bean from China were obtained and fungal species isolated and identified as *Aspergillus flavus* Link ex Gray (56%), *Aspergillus niger* Van Themghn (48%), *Aspergillus terreus* Thom (40%), *Penicilium sp.* Link ex Fr (35%), *Fusarium oxysporum* Schlecht Emend. Sny. & Hans (30%), *Rhizopus stolonifer* (Erenb.ex Link) Lind (25%), *Curvularia lunata* (Wakker) Boedijn (25%) and *Botrytis cinerea* Pers.ex Nocca & Balb (20%). These fungal species controlled by neem leaf extracts of varying concentrations on the *in-vitro* growth isolates showed significant reduction ($P < 0.05$) at different concentrations. It is recommended that neem is effective, cheap and ecofriendly in the

control of seed-borne mycoflora of castor bean⁷⁰.

In Karnataka, it was reported that plant is affected by number of fungal diseases as wilt (*Fusarium oxysporum* f.sp. *ricini*), leaf spot and blight (*Alternaria ricini*), cercospora leaf spot (*Cercospora ricinella*), root rot, stem rot and charcoal rot (*Macrophomina phaseolina*), seedling blight (*Phytophthora parasitica*), capsule rot (*Cladosporium oxysporum*), fruit rot and Gray rot (*Botrytis ricini*), rust (*Melampsora ricini*), powdery mildew (*Leveillula taurica*), phyllosticta leaf spot (*Phyllosticta bosensis*), angular leaf spot (*Botrytis sp.*), and damping off (*Phythium aphanidermatum*)⁷¹⁻⁷⁷. These diseases reduces the yield, production and germination up to 30-50%^{34,78,79}.

Four types of methods used to detect *Alternaria ricini* and it was found that standard blotter method was more sensitive in detection of *A. ricini* than the PDA, water agar and 2, 4, Dichloro phenoxy acetic acid medium. Total nine fungal species namely *Alternaria ricini*, *F. oxysporum* f.sp. *ricini*, *A. alternata*, *Cercospora ricini*, *Macrophomina phaseolina*, *Chaetomium globosum*, *Aspergillus flavus*, *A. niger* and *A. ochraceus* were isolated and detected from local variety of castor beans. Out of nine fungal species *A. ricini* was found predominant in the seed samples sixteen districts (16.8%)⁷⁶.

A seed-borne fungi *Fusarium oxysporum* f. sp. *ricini* and its pathogenicity were studied from Karnataka by using different seed health testing methods and out of 69 10 samples show higher incidence of pathogen on various methods. The pathogen showed the symptoms of wilts were observed in 1-10 percent wilts in one, 10-30 percent in two month seedlings and 30-60 percent wilts in three month old plants, no

wilts observed in water treatment plants^{71,72,77}.

The bacterial disease of castor in Sudan has been reinvestigated. Typically the disease symptoms are brown or black, round or angular lesions on leaves; occasionally the thin succulent branches are attacked, but not the vascular tissue. The bacterium responsible for the disease was previously thought to be *Pseudomonas solanacearum* but comparative studies show that the Sudan species differs in pathogenicity and physiology from *P. solanacearum*. It closely resembles *Xanthomonas ricinicola* (Elliott) Dowson (= *Bacterium ricini* Yoshi and Takimoto) in characters, host range and pathogenic effects. In culture on solid media the growth of *X. ricinicola* is typically yellow, while that of the Sudan species is dirty white; but this difference is not considered sufficient to justify the establishment of a new species⁷⁹.

(i) MAJOR DISEASES OF CASTOR BEAN

Seed rot and seedling blights- Seedling blight disease was reported in Uttar Pradesh and Hyderabad^{80,81}. In wet soil after germination seedlings are susceptible to a number of roots and stem rot organisms. The most common fungal species which attack are species of *Fusarium*, *Rhizoctonia*, *Sclerotium* and *Phytophthora*. *P. parasitica* Dastur (syn. *P. nicotianae* Breda de Haan) is a typical root rot pathogen have wide range of host and capable to infecting over 72 plant genera^{82,83}. It is common disease of castor in India which was first reported from Pusa, Bihar. Initial stage of plant growth in moderate to severe form with seedling mortality was 30 to 40%. Root rot disease has been reported from Philippines, India, Ceylon, East Africa, Palestine, West Indies and eastern United states⁸⁴. In India,

it is reported from Andhra Pradesh, Gujarat, Maharashtra, Bihar and Tamil Nadu^{80,85,86,90,91}.

The seedling blight disease has been reported from Argentina, Brazil, Bulgaria, China, Malaya and Sumatra⁸⁷⁻⁸⁹. The root rot disease is favoured by ill drained and prolonged rainy season⁹⁰. In disease stunting accompanied by a black rot in the tap root and elongated, brown lesions on the hypocotyl was caused by *Thielaviopsis basicola*.

Seed treatment was given, independently to castor seeds with three *Trichoderma asperellum* strains (TaDOR-N13, -TV5, -7316) and one *T. harzianum* strain (Th4d) to cause the disease. When compared with untreated seedlings disease severity was reduced by 85.7% in Th4d-treated seedlings. TaDOR-7316 and -N13 showed 50% and 42.9% of disease reduction, respectively as compared to check⁹².

The diseases can be control by removal and destroy infected plant, alternate hosts and their residues, avoid low-lying and ill drained fields for sowing or treat the seeds with thiram or captan at 4g/kg before sowing. Fungicide seed treatment is recommended in areas where seedbed temperatures may be lowered after planting⁹³.

Leaf blight or Alternaria Blight-The disease caused by *Alternaria ricini* (Yoshii) Hansford in castor showed symptoms on leaves, stem, inflorescences and capsules. The disease has been reported from different areas of the country^{24, 27, 91, 94-98}. The blight disease is prevalent in Bulgaria, Brunei, Egypt, India, Jamaica, Nigeria, South Africa, Sudan, Tanzania, Yugoslavia, United States Mississippi^{24, 89, 99, 100}. Yield losses due to disease reported

up to 35% in Baker 296 variety in Texas (USA)⁹⁷. In humid years due to extensive fructification of the fungus on capsule of castor plant giving black sooty appearance with black clouds of conidia⁹⁶.

It is reported about 70 per cent of the plants affected with the disease causing serious losses in yield and oil-content⁸¹. In moist condition the conidia are produced abundantly on the diseased portions produce symptoms both externally and internally^{24, 96, 101}. The diseases grow in high humidity (85-90 %) and low temperature (16-20°C).

The pathogen survives on alternate hosts like *Jatropha pandurifolia* and *Bridelia hamiltoniana*. The diseases management can be done by treat the seeds with captan or thiram at 2g/kg, remove the reservoir hosts, plant debris periodically and spray mancozeb at 2kg/ha¹⁰²⁻¹⁰⁴.

Brown leaf spot disease- It is identified as with minute brown specks surrounded by halo caused by *Cercospora ricinella* and *Alternaria recini*. The spots coalesce form large brown patches restricted by leaf venations. Infected tissues often drop off leaving shot-hole symptoms⁹³. The diseases can be control by spraying 1% Bordeaux mixture or Copper oxy chloride @ 0.2% but where the cultures of Eri-silk worm are maintained on castor plants, spraying would not be desirable. Use of resistant varieties, spraying twice with Mancozeb 2g/lit or Carbendazim 500g/ha at 10-15 day interval or treat the seed with thiram or Captan 2gm/kg seed are another control measures^{103,105}.

Phyllosticta leaf spot- It was reported by³⁶ from Kanpur (Uttar Pradesh) caused by *Phyllosticta bosansis*. The diseases spread profusely in rainy season and appears as minute dot-like light brown spots scattered of the leaf which latter enlarge and transform into high brown circular lesions³⁶.

Within 10-16 days these spots attain the maximum size but they never cross the main veinlets⁸¹.

Powdery mildew diseases- The disease is caused by *Leveillula taurica* (Lev.) Arn characterized by typical mildew growth confined to the lower surface of lamina of leaf but in infection is severe the upper surface is also covered⁸¹. In India, the disease was first recorded by Ramakrishnan and Narasimhalu (1941)⁴⁸ and reported to be prevalent from November to March at Coimbatore (Tamil Nadu). Light green patches under leaf surface are visible on the upper side especially when the leaves are held against light. The pathogen is endophytic and hyphae found intercellular in parenchyma of leaf. The diseases can be control by comparatively dry spray (twice) with wettable Sulphur 2g/lit at 15 days interval which is starting from 3 months after sowing. Spray of 1ml hexaconazole or 2ml dinocap / litre of water at fortnight intervals and use of resistant variety, removal of plant debris and infected plants^{102,105}.

Charcoal rot or stem rot disease- It is one of the most important diseases occur worldwide caused *Macrophomina phaseolina* by of castor growing regions. In Northeastern (Brazil), the disease was concentrates 65% of the country's production. The pathogenicity and aggressiveness of the charcoal rot pathogen was assessed in 27 isolates of *M. phaseolina* obtained from 6 plant species namely *Ricinus communis* (n=21), *Gossypium hirsutum* (n=2), *Sesamum indicum* (n=1), *Helianthus annuus* (n=1), *Jatropha gossypifolia* (n=1) and *Arachis hypogaea* (n=1)¹⁰⁶. Stem rot is identified by symptoms such as small brown depressed lesions on and around nodes. Plant showed symptoms like wilting as drought and drooping of

leaves^{93,102-104}.

The diseases may be control by growing tolerant and resistant varieties like Jyothi, Jwala, GCH-4, DCH-30 and SHB-145, field sanitation, stop water logging, removal and destruction of crop debris. The selection of healthy seed or treat the seed with thiram @ 2g/kg or carbendazim at 2g/kg seed or seed treated with *Trichoderma viride* formulation at 4g/kg of seed or soil drenching with Carbendazim (1g/litre of water) 2-3 times at 15 days interval, hot water treatment of seed at 58°C to 60°C for ten minutes, spray of Copper oxychloride 2kg/ha or Streptocycline 100g/ha or Paushamycin 250g/ha are some important control measures^{93,102,103,105}.

Wilt disease- It is caused by various species of *Fusarium* and it was first time reported in morocco¹⁰⁷. Occurrence of wilt from Krasnodar, USSR was reported by Andreeva (1979)⁷¹. The extent of disease incidence was up to 80 per cent in Russia¹⁰⁸. In India, it was recorded first time from Udaipur, Rajasthan by Nanda and Prasad (1974)¹⁰⁹ and later from Gujarat during 1980-81. The extent of disease incidence was up to 80 percent in Russia¹⁰⁸.

It appears at all crop growth stages but more conspicuous during flowering and spike formation stage¹¹⁰. It showed wilting of plants, root degeneration, collar rot, drooping of leaves, necrosis and finally leading to death of plants. Losses in yield were realized in all cultivated castor hybrids in Gujrat and as high as 85 percent wilt incidence has been reported under North Gujarat conditions^{111,112}.

Reniform nematode (*Rotylenchulus reniformis* Linford and Oliveira) were found to be involved in the wilt complex of castor. The plants attacked by reniform nematode

are predisposed for the infection *Fusarium oxysporum* f. sp. *ricini*^{113,114}.

Wilt infected seeds carried out the inoculum at the micropylar end in 2-19 per cent seeds and seed infection was confined to testa, tegmen and endosperm in histology of seeds¹¹⁵. *F. oxysporum* f. sp. *ricini* was found seed-borne in 10.8 per cent seeds of castor variety Aruna collected from wilted plants^{112,114}. The disease spread severely at the time of flowering and spike formation at 13-15°C and but for symptom expression temperature is 22-25°C⁷¹. Use of resistant varieties, cultural practices, crop rotation and soil solarisation are common methods for controlling the disease. Treatment of seeds with thiram @ 2g/kg or carbendiazim @ 2g/kg seed or 4g of *Trichoderma viride* talc formulation, multiplication of 2kg of *T. viride* formulation by mixing in 50kg farm yard manure, sprinkling water and covering with polythene sheet for 15 days and then applying between rows of the crops are effective in reducing the incidence^{93,110}.

The bioefficacy of antagonist and botanical extract were tested *in vitro* against *Fusarium oxysporum* f. sp. *ricini*. *Trichoderma harzianum* (72.22%), *T. viride* (70.37%) and *Pseudomonas fluorescens* appeared potent antagonist against pathogen followed by *T. faciculatum*, *T. longibrachyatum* and *Bacillus subtilis*. Among the botanical, the extract of turmeric rhizome was effective in inhibiting mycelial growth 42.22 Per cent followed by 36.67% inhibition by leaves extract of marigold²³.

(i) MINOR DISEASES

Gray mold disease- It was first reported in the USA in 1918 by Stevens and Patterson and suggested that the causal organism of castor gray mold was an unknown *Botrytis* species^{116,117}. In India, gray mold is found in few states but in Andhra Pradesh and Tamil Nadu regarded troublesome^{118,119}.

It is serious disease effected flowers and capsules directly and yield loss up to 100% during the continue rain at the time of capsule formation. The disease occurred in epidemic form in USA during 1958 and in Andhra Pradesh during 1987. Due to attack on plant the entire group of flowers converted to a prominent cottony mass of fungal growth. Initially small, blackish spots appeared from which drops of yellow may exude. Fungal hyphae from these spots spread the infection and produce cottony on inflorescence^{93,119}.

Rust disease- It is caused by fungi *Melampsora ricini* in castor symptomatically can be identified by minute, orange-yellow coloured, raised pustules with powdery masses on the lower surface of the leaves. These pustules are grouped in concentric rings and coalesce together finally drying of leaves. The disease can be control by removing the self-sown castor, weed hosts and plant debris. The spray of fungicide Mancozeb at 2kg/ha or Propioconazole 1l/ha is effective control of disease⁹³. It is occur worldwide but in Maharashtra, Andhra Pradesh and Tamil Nadu it is a severe disease under moist conditions^{80,81}.

Capsule Mold diseases- It is caused by species of *Alternaria*, *Penicillium* and *Fusarium* attack on capsules at an early stage of development and profusely bluish color in early stages and colour become darker or black in later stages⁹³.

Cotton root rot disease- It is caused by *Phymatotrichum omnivorum* is very susceptible and should not be planted in soils where the fungus is established. By using common cultural practices disease may be control effective⁹³.

Bacterial leaf Blight- It is prevalent in USA, Korea, Japan, Russia, Brazil, Sudan, South Africa and Uganda. In India, this disease

was first reported from Gujarat (Patel et al., 1951). In India, it is reported from Bombay¹²⁰ and is similar to the one occurring in Japan, Korea and Uganda. Spots gradually turn black with dried sections of leaf tissue disintegrating and falling from leaves. Racemes are attacked under humid conditions⁹³. The disease has also been observed in Tamil Nadu, Delhi, Andhra Pradesh and Rajasthan^{121,122}.

Bacterial leaf spot- It is caused by *Xanthomonas campestris* pv. *ricinicola* syn: *Xanthomonas axonopodis* pv. *ricini* (Yoshii & Takimoto) Vauterin, Hoste, Kersters & Swings), *Xanthomonas campestris* pv. *ricini* (Yoshii & Takimoto) Dye, *Xanthomonas ricini* (Yoshii & Takimoto) Dowson in castor⁸¹. The pathogen attacks on cotyledonary leaves, lamina and veins raised numerous small rounds, water-soaked spots which later become angular and dark brown to black in colour. The diseased spots are generally aggregated towards the tip and in later stage the spots become irregular in shape, the areas around such spots turn pale-brown and brittle. Bacterial ooze is exudates on both the sides of the leaf which is in the form of small shining beads or fine scales¹²³. In Texas and Oklahoma, an average 25% castor crop was lost due disease¹²⁴.

Bacterial leaf rust- It is caused by species of *Pseudomonas* in which the leaves and branches dry up, turn black and fall. The stems may be affected turn black and plants usually die⁹³.

FUTURE STRATEGIES

The diseases occur frequently in severe form and results in heavy losses because of lack of resistant varieties/hybrids for new emerging strains/races of pathogen. Effect of inter-cropping needs to be investigated and in this regard, genetic engineering

technology may play offers great potential role for the development of transgenic resistant plant. Use of chemicals may provide an effective control. The eco-friendly technology management is not costly and comparatively non-hazardous to the environment is better option to control the disease.

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