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REVIEW

Diseases of Jute and allied fibre crops and their management

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Jute and allied fibre (JAF) crops are important natural bast fibre yielding crops with considerable commercial, environmental and socio-economic importance having multifarious end users, mostly grown in the tropical and South-East Asian countries particularly in India and Bangladesh. Incidence of different diseases is one of the limiting factors in productivity improvement of this group of crop. Ddifferent diseases of JAF crops may witness great transformation in the backdrop of climate change with respect to intensity of incidence, development of new strains and susceptibility to the existing methods of control. The information on various diseases of JAF crops are very limited and scattered. In the present review attempts are made to update the information and discuss the various aspects of JAF diseases.

Key words: Jute, roselle, kenaf, sunnhemp, ramie, disease, management

INTRODUCTION

Bast fibres are basically stem/bark fibres composed of sclerenchyma cells united together into small or large strands or bundles, arranged in the form of layer(s). In India the most important bast fibre crops are Jute (*Corchorus olitorius* and *C. capsularis*), Mesta (Roselle: *Hibiscus sabdariffa* and Kenaf: *H. cannabinus*), Sunnhemp (*Crotalaria juncea*) and Ramie (*Boehmeria nivea*). All the bast fibre crops are affected by different diseases (Fig. 1).

Major diseases of Jute

Most important disease of jute is Stem rot caused by *Macrophomina phaseolina*. Other diseases are Anthracnose (*Colletotrichum corchorum* and *C. gloeosporioides*), Black band (*Botryodiplodia theobromae*), Soft rot (*Sclerotium rolfsii*), Jute Mosaic (begomovirus) and Hooghly Wilt (*Ralstonia solanacearum*, *Meloidogyne incognita*, *Rhizoctonia bataticola* and *Fusarium* complex) (Fig. 1).

Stem rot (Macrophomina phaseolina Tassi (Goid)

Distribution and Economics

Stem rot is the most important disease of jute equally affecting both the species viz., *Corchorus olitorius* (tossa jute) and *C. capsularis* (white jute). It is prevalent in all the jute growing areas of the world. In India this disease is severe particularly in Assam, West Bengal, Bihar and Orissa. It causes significant reduction in yield and quality of the fibre. Average yield loss due to this disease is about 10%, but it can go up to 35-40% in severe condition (Roy *et al*, 2008).

Symptoms

The pathogen may cause damping off, seedling

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blight, leaf blight, collar rot, stem rot and root rot After germination deep brown spots are noticed on the cotyledonary leaves giving a blighted appearance called seedling blight. Under humid condition browning reaches to the roots and the seedling dies which is called as damping off. In the month of June-July when the plants are about more than seventy days old several small brown spots are found on the leaves that gradually increase in size and coalesce with each other to form a bigger brown colourd rotted area. The disease generally spreads from the infected leaves in two ways viz. the pathogen may enter into the stem through the petioles of the infected leaves or the infected leaves fall and adhere to stem surface where the infection may occur. The most characteristic symptom of the disease is the formation of blackish brown lesions or depressions on the stem which increase in size and several such lesions may coalesce and finally girdle the stem. The pathogen may also attack the roots causing wilting and death of the plant and on uprooting, blackish brown discoloration of the roots are seen. All the leaves fall from the infected plant and the stem looks black or dark brown. In case of seed crop late infection may cause spotting on the capsules and formation of pycnidia and sclerotia on the capsule and seed (Sarkar *et al*, 2015). The infected seeds are smaller, shriveled and light in colour. If these seeds are sown germination is found to be very less and the seedlings get infected.

Etiology

The causal organism- *Macrophomina phaseolina* (Tassi) Goid is a dreaded pathogen and it can infect more than 500 plant species in about 72 families. *M. phaseolina* is the pycnidial stage and *Rhizoctonia bataticola* (Taub.) is the sclerotial stage. The pycnidial and sclerotial stages are responsible for the disease and the perfect stage, *Orbilia obscura* is very rarely seen. It is highly variable, with isolates differing in micro-sclerotial size and presence or absence of pycnidia. The pycnida are initially immersed in host tissues, then erumpent at maturity. They are about 100-200 μm in diameter; dark to greyish, becoming black with age; globose or flattened globose; membranous to subcarbonaceous with an inconspicuous or definite truncate ostiole. The pycnidia bear simple, rod-shaped conidiophores, 10-15 μm long. Conidia (14-33 x 6-12 μm) are single celled, hyaline, and elliptic or oval. Micro-sclerotia are formed from aggregates of hyphal cells joined by a melanin material with 50 to 200 individual cells composing an individual micro-sclerotium. Colonies in culture range in color from white to brown or gray and darken with age. Hyphal branches generally form at right angles to parent hyphae, but branching is also common at acute angles.

Epidemiology

Alluvial and lateritic soils with low pH (5.6-6.5), high level of nitrogen, high rainfall and high humidity favour infection of *M. phaseolina*. Higher soil temperature and low soil moisture predispose the older plants. March sown crop suffer more than late sown crop (De, 2013). The sclerotia survives in the soil and on infected crop debris (upto three years) serve as the primary source of inoculum. These multicelled sclerotia allow the persistence of the fungus under adverse conditions such as low soil nutrient levels and temperature above 30^0C. Germination of the sclerotia occurs throughout the growing season when temperatures are between 28^0C and 35^0C. Sclerotia germinate on the root surface, germ tubes form appresoria that penetrate the host epidermal cell walls by mechanical pressure and enzymatic digestion or through natural openings. *M. phaseolina* can grow and produce large amounts of sclerotia under relatively low water potentials allowing this disease to be severe under water stress. Population of *M. phaseolina* in soil will increase when susceptible hosts are cropped in successive years. The seed borne inoculum also causes infection in jute leading to damping off or seedling blight (Sarkar *et al,* 2014). Under favourable conditions viz., cloudy weather, high rainfall and temperature of about 30-35^0C secondary spread of the disease takes place through airborne conidia .

Management Options

As the source of inoculum may be soil, seeds or infected plants, the disease management practices should be adopted well in advance. Some disease management options are discussed here.

Cultural Practices
Crop establishment
Field preparation

For growing this crop heavy soils which lack proper aeration should be avoided. The crop debris and

weeds should be removed and burnt because the pathogen may harbour therein. Proper sanitation reduces the possibility of the disease to a great extent. ***Soil pH:*** Continuous cultivation of jute crop in the same field may cause depletion of calcium, potassium and other basic elements and make the soil acidic which favours the incidence of stem rot disease. Therefore, once in 3-4 years soil pH has to be tested for liming as per requirement. Generally, lime or dolomite @ 2-4 t/h is applied about one month before sowing for correction of soil pH. ***Sowing time and Spacing :*** Sowing in the month of April reduce the incidence of stem tot than March sowing (De, 2013 and Sarkar *et al*, 2014). The incidence of stem rot disease increases under close spacing (Ghosh, 1963). Therefore, optimum spacing viz. row to row 25-30 cm and plant to plant 5-6 cm has to be maintained. ***Nutrient management :*** In organic matter deficient soil, compost or FYM @ 7-8 t/h has to be applied. Chemical fertilizer has to be applied in a judicious manner because higher dose of nitrogen (beyond 80 kg/ha) promotes stem rot disease. However, application of potash (K_2O @ 50-100 kg/ha) reduces the disease severity. ***Crop rotation :*** Jute cultivation in the same field year after year should not be allowed. Moreover, non-host crops like rice, wheat, mustard etc. must be brought in the cropping sequence to follow jute. ***Drainage :*** Although white jute can withstand waterlogging to some extent, tossa jute cannot. Waterlogging in general increases disease intensity. Therefore, proper drainage has to be made to avoid water stagnation.

Chemical control

As infected seeds are the major source of the infection, seeds must be treated before sowing with Carbendazim 50 WP @ 2g /kg or Dithane M 45 (Mancozeb) @ 5g/kg. When the disease incidence is 2% or more spraying of Carbendazim 50 WP @ 2g/l or Dithane M 45 @ 5g/l or Copper oxychloride 50 WP @ 5-7 g/l or Tebuconazole 25.9 EC @ 0.1% is recommended (Anon. 2013; De, 2014). In case of severe infection 3-4 sprays are recommended at 15-20 days interval (Sarkar *et al,* 2014).

Biological control

Bio-agents viz., *Trichoderma viride, Aspergillus niger* and fluorescent *Pseudomonas* have been reported to check the disease (Roy *et al*, 2015). Seed treatment with powder formulation of *T. viride* @10 g/kg at final ploughing and its soil application (by mixing @1kg formulation in 100kg of FYM, cover it for 7 days with polythene, sprinkle water and turn the mixture in every 3-4 days interval and then broadcast the mixture in the field at the time of final ploughing) reduced the disease incidence at various locations. Bandopadhyay *et al*, 2008). Seed inoculation with PGPR, viz. fluorescent *Pseudomonas, Azotobacter* and *Azospirillum* reduced stem rot incidence and increased the fibre yield considerably.

Varietal resistance

No Jute variety is truly resistant to the stem rot pathogen and the degree of resistance /susceptibility varies with climatic conditions and pathotypes present in a particular area. Tossa jute varieties namely JRO 524 and JRO 632 and white jute cultivars JRC 212 and JRC 321 showed differential reactions at different geographical locations Six *C. capsularis* accessions viz., CIM 036, CIM 064, CIN 109, CIN 362, CIN 360 and CIN 386 showed resistant reaction at the hot spot of the disease at Sorbhog, Assam. De and Mandal (2012) reported four *C. olitorius* accessions namely OIN 125, OIN 154, OIN 651 and OIN 853 as moderately resistant to stem rot pathogen.

Anthracnose (Colletotrichum corchorum in white jute and C. gloeosporioides in tossa jute)

Distribution and economic importance

The disease is of regular occurrence in capsularis belt of India viz. Assam, North Bengal, Bihar, and Uttar Pradesh. It is prevalent in Bangladesh also. The disease entered India during thirties along with jute germplasm from Southeast Asia, particularly from Taiwan unknowingly. The disease was first observed on “Jap-Red’ - a capsularis introduction from Formosa (Taiwan) at Dacca (Bangladesh) in 1945. From Dacca the disease spread to other parts of Bangladesh. Later it entered India through Assam. Continuous rain, high humidity and temperature around 35^0C are congenial for this disease. Epidemic of anthracnose was noticed in exotic variety, Japanese Red at Chunchura, West Bengal during 1950-51. No reports are available on the extent of loss in fibre yield. But continuous monitoring in different jute growing states showed that incidence of the disease depends on agro-climatic condition as well as crop species cultivated. Capsularis jute is mostly affected in Uttar Pradesh

whereas in Assam, olitorious jute is affected. In olitorious jute the incidence is more when the crop is about to harvest leading to negligible loss. However, when the disease appeared in early stage, numerous spot developed on the lower portion of the stem leading to development of specky or knotty fibre (cross bottom).

Symptoms

At seedling stage, the disease appeared on leaf and stem as brownish spot and streaks followed by drying up. On mature plants, initially light yellowish patches are seen on stem which turns to brown/black depressed spots. The spots are irregular in shape and size. Several spots may coalesce causing deep necrosis showing crakes on the stem and exposing the fibre tissues. The coalescing spots may often girdle the stem the plants break at that point and die. Affected plants when survived show necrotic wounds all over the stem. Fibres extracted from such affected plants are specky and knotty and fall under very low grade (cross bottom). Pods of diseased plants are also affected showing depressed spots and seeds collected from such fruits are also infected. The infected seeds are lighter in colour, shrunken and germination is poor. In *C. olitorius*, the incidence occurs at the later stage of crop growth. Generally it starts at mid-July and continues up to September (Sarkar and Satpathy, 2014).

Epidemiology

The pathogen survives in the soil, infected crop debris and in seeds. The mycelium enters through the epidermis and attacks the parenchymatous tissues between the wedges of bast fibre bundles. The entire parenchymatous tissue of cortex gradually disintegrates. Under favourable condition the mycelium attack the thin walled phloem tissue in between the phloem bundles. The phloem parenchyma disintegrates and the bundles are exposed. The mycelia often reach the cambial layer but seldom attack the wood. During humid days acervuli appear on the surface of the affected tissue and are visible with naked eye; under a magnifying lens, they appears as bristled hemispherical or slightly lenticular eruption. The disease starts in the hot and very humid months of July when the crop is about two months old. The damage is severe at harvesting time. Continuous rain, high relative humidity and temperature of around 35^0C are congenial for the faster development of this disease. White jute is more susceptible than tossa jute.

Management

Seed treatment with Carbendazim 50 WP @ 2 g/kg or Captan @ 5 g/kg and spraying of Carbendazim 50 WP @ 2 g/l or Captan @ 5 g/l or Mancozeb @ 5 g/l control the disease. Seeds having 15% or more infection should not be used even after treatment. Removal of affected plants and clean cultivation reduce the disease.

Black Band (Botryodiplodia theobromae)

Earlier this was a minor disease but gradually it is spreading. The pathogen affects both the species of jute and causes serious damage to the older crop from July onwards, from which neither fibre nor seeds can be obtained. The disease first appears as small blackish brown lesion which gradually enlarges and encircles the stem resulting in withering of epical and side branches. Stems infected at the lower portion often break at that point. The affected plants loose leaves and turn brown to black and remain standing as dry sticks. On rubbing the stem surface, unlike stem rot profuse black shooty mass of spores adhere to the fingers. Crops raised from infected seeds show seedling blight (Anon, 2009).

Management

Clean cultivation, seed treatment with Carbendazim 50 WP @ 2g/kg and foliar application of Carbendazim 50 WP@ 2g/l water or Cu-oxychloride @ 5-7 g/l water or Mancozeb @ 4-5 g/l water provides effective management.

Hooghly wilt (Ralstonia solanaearum, Meloidogyne incognita, Rhizoctonia bataticola and Fusarium complex) Distribution and economic importance

This disease was mostly prevalent in the districts of Hooghly, parts of Howrah, North 24 Parganas and Nadia where tossa jute is followed by potato or other solanaceaous crop (Mandal and Khatua 1986). It is also reported from Bangladesh. During late seventies to end eighties, more than 40 % infection was recorded in Hooghly district of India. During late forties and early fifties the disease was so severe that a new Pest and Disease Control Centre was established at Tarakeswar, Hooghly. But presently, the disease is not a serious con-

cern. On an average 30 - 34% loss of jute crop was reported during 1950-1954. During late eighties and early nineties, 5-37% disease was recorded in Kamarkundu area of Hooghly district and 2-20% in some areas of Nadia and North 24 Parganas (Mandal, 1986; Mandal and Mishra, 2001).

The pathogen

Ralstonia solanacearum (=Pseudomonas solanacearum) is primary pathogen and *R. bataticola* and *Meloidogyne incognita* are associated pathogens. Presence of these root rot pathogen (*R. bataticola/M. phaseolina*) and root knot nematode (*M. incognita*) increases the disease since they create wound in the root, and thus facilitate the entry of the primary bacterial pathogen, *R. solanacearum*.

Management

Cultural control : Common hosts like potato or other solanaceaous crops in rotation with jute are to be avoided. Jute : Paddy : Paddy or Jute : Paddy : Wheat are the most effective rotation. Where solanaceaous crop is the main crop in the rabi season, it should be replaced by paddy or wheat at least for two years. Removing wilt affected plants from the field, burning of the dead plants and rotten potato tubers are important cultural practices to keep the disease under control. By adopting cultural practices particularly the appropriate crop rotation in Hooghly district, the disease came down to 1-2% compared to above 40% in the late eighties.

Chemical control

Seed treatment with Carbendazim 50WP @ 2 g/ kg and spraying the same fungicide @ 2 g/l of water reduce root rot incidence which favours the incidence of wilt.

Jute mosaic

Geographic distribution

The diseased was first observed in undivided Bengal province of India. Since then it is variously known as jute yellow mosaic, jute leaf mosaic and jute golden mosaic. The disease was reported in capsularis jute from different jute growing belts of India and Bangladesh. In India, the disease was reported in capsularis jute from West Bengal (Roy *et al*, 2006, Ghosh *et al*, 2007) and from Assam. Recently the incidence of the disease has increased from 20-40 percent (Ghosh *et al*, 2007).

Symptoms

The disease is characterized by appearance of small yellow flecks on leaf lamina in the initial stage, which gradually increased intermingled with green patches and produced a yellow mosaic appearance. Leaves in some cases produce small enation along the mid vein. In extreme cases the infected plant gets stunted and leads to reduced plant height to the extent of 20% (Das *et al*, 2001). The incidence was about 50% on some leading cultivar such as JRC 7447 and JRC 212 (Ghosh *et al*, 2007).

Transmission

The causal virus was reported to be transmitted by white fly (*Bemisia tabaci*). Some worker also reported that the virus was transmitted by seeds. Adult whitefly can acquire the virus within 30 minutes of its access to a disease plant and acquisition is maximum after 8 hours of access. A viruliferous whitefly can inoculate the virus to the test plant within 30 minutes of its inoculation. A viruliferous vector can retain the virus upto 10 days. A typical symptom of the disease appeared on the plants of cv. JRC 7447 and JRC 212 after 10 days of whitefly transmission with 60 percent transmission efficiency when acquisition and inoculation access period were 24 h and 12 h respectively.

Detection, identification and phylogenetic relationship

Based on symptomatology and transmission, the virus was found to be a member of Begomovirus under family Geminiviridae. PCR based detection with Begomovirus group specific primer amplified a 1.2 kb DNA A fragment of the virus (Ghosh *et al,* 2008 a,b; 2009) Cloning and sequencing of this amplicon revealed that it consisted of 1263 nucleotides and shared the highest nucleotide sequence identity (91.2%) with Corchorus golden mosaic Vietnam virus. The nucleotide sequence at the origin of replication was found to be CATTATTAC instead of conventional TAATATTAC. Such unique feature was also noticed in case of Corchorus golden mosaic Vietnum virus. Phylogenetic analysis with other begomovirus revealed that the begomovirus from jute grouped with other begomovirus reported to be associated with Corchorus species and clus-

tered with new world begomoviruses. Two other primers have been designed to amply the complete DNA A and DNA B component of the viral genome which gave expected 2.7 kb amplicon in each case.

Management

In general, rouging of diseased plant and spraying of Imidacloprid 17.8 SL @ 0.3% could prevent the spread of the disease. Studies in Bangladesh revealed that a combination of collection and use of seeds from healthy plants, one insecticidal spray around 30 DAE, field sanitation with rouging several times during growth period and application of an extra booster dose of nitrogen at around 45 DAE reduced the spread of the disease .

Soft rot (*Sclerotium rolfsii*)

Symptoms

On stem, soft brown wet patch is observed at the point of infection. The bark peels off and the exposed fibre layers turns rusty brown and the affected plants wilt. White mycelial growth and brown globose to sub-globose mustard like sclerotia are also observed at the site of infection. The pathogen is soil borne and having a large number of hosts. High soil moisture with high temperature and close spacing favours the disease.

Management

Clean and weed free cultivation, summer ploughing, and spraying of Copper-oxychloride @ 5-7 g/ l water at base region reduces the disease.

B. Major diseases of mesta

Mesta (Hibiscus sabdariffa : Roselle and *H. cannabinus* : Kenaf) is the second most important bast fibre crop after jute. The principal producing countries are India, China, Thailand, Egypt, Sudan, Brazil and Australia. In India it is mostly concentrated in Andhra Pradesh, Orissa, Bihar and West Bengal. Besides fibres it has other uses as well such as production of paper and pulp and some people prepare pickle from mesta calyces. Although mesta is more adaptive to adverse soil and climatic conditions, it suffers from a number of diseases amongst which Foot and Stem Rot (FSR) (*Phytophthora parasitica* var. *sabdariffae*), Sclerotinia stem rot (*Sclerotinia sclerotiorum*), leaf blight (*phylosticta hibiscini*) and yellow vein mosaic are the important ones (Fig. 2).

Foot and stem rot
Distribution and economic importance

Food and stem rot is prevalent in all the mesta growing areas of India i.e. West Bengal, Andhra Pradesh, Odisha, Bihar. It is the most important disease of mesta in India) causing about 10 – 25% loss in fibre yield. In severe cases, more than 40% crop loss in roselle was observed; De and Mandal, 2007a). The pathogenattacks the plant at very early stage and continues upto maturity affecting quality and quantity of fibre. It is more serious in roselle (*H. sabdariffa*) than kenaf (*H. cannabinus*).

Symptoms

The symptom appears on the stem generally a few inches above the ground but the spots may be seen at higher or lower level also. The spots are deep brown to blackish in colour with variable size. Larger spots very often girdle the stem and as a result the plant breaks at the point of infection. No fibre is obtained from such plants.

Epidemiology

The disease is caused by soil borne pathogen, *Phytophthora parasitica* var. *sabdariffae*. It is favoured by high temperature (30^0-35^0C) and continuous drizzling. Water stagnation which is common during mesta growing season in West Bengal predispose the plants to infection. Continuous drizzling, high rainfall and cloudy condition from May to September may be responsible for epidemic (De and Mandal, 2007b).

Management

Varietal resistance: None of the cultivated varieties are resistant to the disease, but AMV 1, Roselle Type 1 and AP 481 were observed to be moderately resistant. Red bristled *H. sabdariffa* lines are more resistant. **Chemical control:** Seed treatment with Dithane M 45 (Mancozeb) @ 5.0 g kg/l followed by soil drenching (0.2%) and spraying of Copper oxychloride 50 WP @ 5.0–7.0 g/l or Carbendazim 50 WP @ 2.0 g/l of water (Mukherjee and Basak, 1973). De and Mandal (2007a) reported that pre-sowing seed treatment with cop-

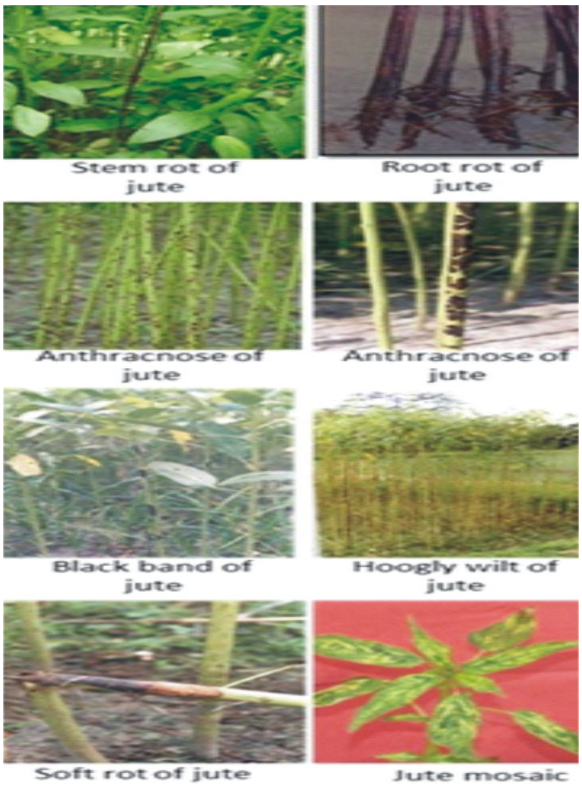

Fig.1: Major diseases of Jute

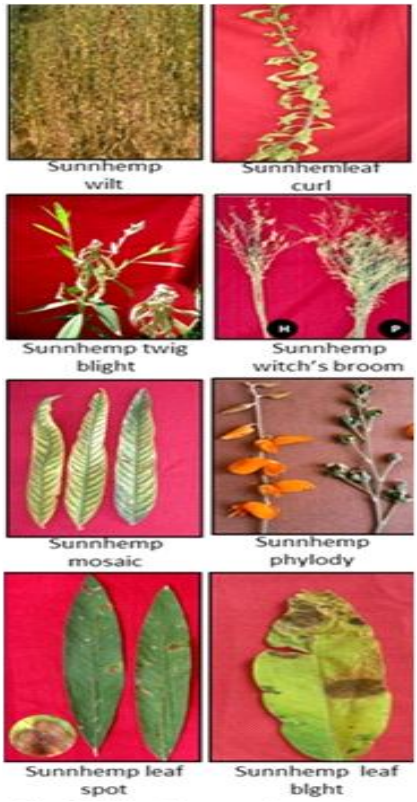

Fig. 3 : Major Diseases of Sunnhemp

Fig. 2 : Major Diseases of Mesta

Fig. 4 : Important diseases of Ramie

per oxychloride was more effective than Carbendazim, Mancozeb, Metalxyl, Ediphanphos, Carboxim, Hexaconazole and Thiophanate methyl. Copper oxychloride reduces the disease incidence by 50.3% and 45.5% at 30 days after sowing and at maturity respectively and increased 20.6 % fibre yield.

Stem rot (Sclerotinia sclerotiorum)

Stem rot of kenaf and roselle was a minor disease but during last two years (2012-14) the incidence of the disease was as high as 50 % in seed crops at CRIJAF Farm, Barrackpore. The infected plant neither yields any fibre or seeds.

Symptoms

The disease appears as water soaked areas on any parts of stem which turn into brown patches that visible from distance. Initially the portion of the stem above or below the patches looks healthy. Finally the infection girdles the stem completely which extend as much as a foot or more. The rot causes the tissues to become soft and easily peel off into shreds. The portions above the affected part may ultimately wilted, diebacked and break away. The surface of the affected parts is covered with white stands of mycelia which form cushion in the axils of the branches. Black coloured sclerotia may be observed on this mycelial mat. The pith region may be filling with these hard scleroria. The sclerotia were also noticed in bolls. The disease started in the month of December and spread with time till the boll formation.

Epidemiology

The disease appears in severe form during the cooler months of December and January. The Relative humidity for December in 2012 and January in 2013 was 76% and 72% respectively, with corresponding mean monthly temperatures of 18.0^{0}C and 17.0^{0}C. The fungus (*Sclerotinia sclerotiorum* (Lib.) de Bary) was isolated from the infected portion and pathogenicity test was positive. The sclerotia survive in the soil and with falling of temperature in the month of December-January, it germinates and developed apothecia in which asci and ascospores are formed. Upon discharge the ascospore cause infection (Tripathi *et al,* 2013).

***Mesta leaf blight* (*Phyllosticta hibiscini*)**

The disease was first reported from Nigeria. In India the incidence of leaf blight of roselle (*Hibiscus sabdariffa* L.) caused by *Phyllosticta hibiscini* has been recorded first time from Barrackpore, West Bengal, India during September, 2014 (Anon, 2014-15).

Symptoms

The disease starts as discoloured water soaked area mostly from the margin of leaf which increased towards inward direction and infect the petiole, through which it moves towards the stem. The infected leaf and petiole started yellowing and finally fall off. The infection spread very fast under high humid and rainfall condition and plants become defoliated. Under dry condition the infection become restricted and dark /black coloured dot like pycnidia developed on the leaf

Epidemiology

The disease is favoured by high humidity (75-95% RH), high temperature (30-37^{0}C) and high rainfall. Under dry condition the infection become restricted. With the increase in crop age defoliation occurs from the base of the plant making the plant sickly in appearance. The disease is caused by *Phyllosticta hibiscini,* a soil borne pathogen. The pathogen produce white coloured colony with distinguished ring like zones on which black coloured dot like pycnidia developed within 72h at 28±1^{0}C. Microscopic study revealed profuse hyaline highly branched (mostly dicotonomous) mycelia of 4-6µ. Numerous dark/black colourd pycnidia was noticed in the PDA media that produced hyaline elliptical, mostly single celled conidia measuring about 8-12 µ, circular thick walled clamydospores were also notice under the microscope (Anon, 2014-15).

Yellow vein mosaic of mesta

Yellow vein mosaic of mesta was found in a devastating form in all mesta growing areas in India. It is reported from eastern and northern part of India (Ghosh *et al*, 2007). Survey revealed that 90 percent incidence of the disease and yield loss due to this disease alone was found to be 12.78- 17.45 per cent with respect to fibre yield and 18.91-23.83 percent with respect to seed yield (Roy *et al*., 2007, 2009).

Symptoms

The disease was first observed in few plants from

Andhra Pradesh and then it was reported from West Bengal and Uttar Pradesh. The characteristic symptom of the disease is yellowing of veins and veinlets followed by complete chlorosis of leaves (Chatterjee *et al*, 2006). The flowers and fruits are malformed causing low seed yield.

Transmission

Viruliferous whitefly could effectively transmit the virus with 78-85 per cent transmission efficiency (Chatterjee *et al*, 2008). Three whiteflies per plant were found to be effective for disease transmission. Typical symptom appeared after a minimum incubation period of nine days under glass house condition. Minimum acquisition and inoculation access period for the vector was observed to be 12h and 4h respectively.

Host range

The virus has a very narrow host range. Besides the two species of mesta, it could be experimentally transmitted to *Vigna unguiculata* and *Vigna umbellate* where a mid crumpling symptom was observed (Chatterjee *et al*, 2007).

Particle morphology

Transmission electron microscopy with 2 percent uranyl acetate stains form typical symptomatic leaves of *H. cannabinus* revealed that the disease is associated with geminivirus. The size of the geminate particle is 20nm x 30nm (Chatterjee *et al*, 2005).

Detection, identification and phylogenetic relationship

Positive hybridization signal in southern blot using radio labeled probe of cotton leaf curl Rajasthan virus DNA A and α-DNA confirmed the involvement of a Begomovirus with the disease. From the northern India a strain of β DNA containing tobacco leaf curl New Delhi virus has been reported to be associated with this disease. Characterization of coat protein gene of associated Begomovirus and the satellite DNA Beta molecule from six different geographical isolates of eastern and northern India revealed that isolates obtained from eastern and northern India formed two distinct groups, indicating the existence of two distinct Begomovirus complexes associated with the yellow vein mosaic disease of mesta in two different geographical location in India (Roy *et al*, 2007). Nucleic acid based diagnostic have been developed for identification of these complexes (Chatterjee *et al*, 2007). Characterization of DNA molecule of an east India isolate revealed its close similarity with beta DNA molecule associated with cotton leaf curl disease (Chatterjee and Ghosh, 2007a). The Full length DNA A homologue (2.7 kb) of begomovirus have been characterized from two east Indian isolates which revealed that these two isolates consisted of 2728 and 2752 nucleotide respectively (Chatterjee and Ghosh, 2007a; Roy *et al*, 2007) and shared 84.3% sequence identity with cotton leaf curl Bangalore virus followed by Malvestrum yellow vein virus from china. It has been noticed that this DNA A molecule shared 89% sequence identity with any known begomovirus sequence and hence it is proposed as a new species of begomovirus with a tentative name mesta yellow vein mosaic virus (Das *et al*, 2008a,b). Individual ORF analysis revealed that this DNA A evolved as a recombinant molecule from at least three distinct begomovirus from North India, South India and China.

Management

The vector of yellow vein mosaic of mesta (*BEMISIA TABACI*) can be managed effectively by Imidaclorprid 17.8 SL @0.3% and Thiamethoxam 25 WG @0.25% (Roy *et al,* 2008).

C. Diseases of sunnhemp

Sunnhemp (*Crotalaria juncea L*) is a multipurpose Fabacious crop grown widely in India. The fibre obtained from sunnhemp is slightly lignified, light in colour somewhat course, strong and lasting. It is used for various purpose like making ropes, strings, twines, floor mat, fishing nets, handmade paper etc in cottage industries and paper pulp in paper industry. Apart from these industrial values, the plant being a legume is advantageous to grow on poor, fallow or freshly reclaimed soil playing major role as soil builder as well as deterrent to nematode. One of the major constraints of sunnhemp cultivation is the incidence of diseases especially in monsoon-sown crop which are discussed below (Fig. 3).

Vascular wilt of sunnhemp

Distribution and economics : This disease has been recorded from several countries. In India, it

is reported from sunnhemp growing areas of Uttar Pradesh, Bihar, Maharashtra and Madhya Pradesh. Generally the incidence was 10-12 % but under favourable conditions the incidence may go as high as 60-80%.

Symptoms : The affected plant gradually whither, droops, hang down, turn brown, and ultimately dies within a day or two. Usually the whole plant wilts but partial wilting is also noticed. In grown up plants the wilting parts droop at the tips and defoliation starts which consequently die. The discolouration of the tissues could be traced to the main tap root or lateral roots. In the early stage the fungus is confined to the lateral roots especially in the tip portion and subsequently attacks the vascular bundle of meristem. The sporodochium of the fungi with pinkish tinge are produced on the dead stem or the dead portion of the stem where the infection is confined to one side.

Epidemiology : The disease is caused by *Fusarium udum* (Bult) f. sp *crotalariae* (Kulkarni). The fungus survives in the soil as well as in crop residues as facultative parasite. It attacks the plant through the thinner roots and rootlets, even through the cracking in the basal portion of the stem occurs. The pathogen produces enormous spores (both macro and micro condia) in the pink coloured sporodochium that are also capable of infecting the growing crop. The fungus was also noticed on the pod and in many cases in the seed of diseased pod. The infected discoloured seed also may initiate the infection in the field. The incidence of this disease declined with high temperature in different parts of the country. At Sunnhemp Research Station, Pratapgarh, Uttar Pradesh, wilt started at about 62 days after sowing and increased significantly with the age of the crop. Temperature was found to be negatively correlated with the incidence. Relative humidity and maximum temperature were found to be non-significant in disease development. Rainfall during October was found to be conducive for the spread of this disease. The incidence of disease is less in early (mid-April) sown crop. In low-lying areas wilt incidence was also found to be more.

Management

Host resistance : K-12 yellow – a selection from K-12 (black) was found to be largely resistant against wilt. Considerable work on screening of germplasm against wilt has been made. But as the crop is highly cross-pollinated in nature, whatever promising germplasm were found to possess resistance became ultimately susceptible. A number of wild *Crotalaria* species and wasteredfound that *C. brevidence*, *C. mucronata*, *C. verucosa* and *C. striata* are highly resistant against wilt under natural conditions. This character may be transfered to the cultivated species but so far attempts on interspecific cross between different *Crotalaria* spp. has remained unsuccessful. ***Seed treatment :*** Seed treatment with Carbendazim @ 2g/kg and spraying of Carbendazim @ 2g/l was found to reduce the disease considerably. Soil application of neem cake along with seed treatment and application of $ZnSO_4$ has been recommended. ***Cultural practices:*** Sunnhemp can be successfully grown between April to August in North Indian conditions. But it was observed that delay in sowing increased this disease. In April sowing, the crop almost escape the disease. Intercropping with sesame and sorghum and application of zinc reduced the incidence of Wilt.

Anthracnose of sunnhemp

Distribution and Economics: In India severe incidence (60-80%) of the disease in seedling stage at Pusa, Bihar have been reported.

Symptoms

The cotyledon of seedlings are attacked first and subsequently infection spreads to the stem and growing point. The disease makes an appearance in the form of soft discoloured areas on the cotyledon. Later, brownish spots are formed on all parts of host except underground parts. The affected seedling droops from the point below cotyledon. The affected cotyledons themselves drop from the petiole. The infection spreads downward and acervuli are formed with copious spores on the infected areas within two days. The young seedling when infected generally dies. When older plants are infected the disease is restricted on leaf and stem and the heavily infected leaves fall off. The spots on older leaves appear on one side of the leaf but gradually enlarge and extend to the opposite side. These spots are grayish brown to dark brown, roundish or irregular. Several spots coalesce and cover the entire leaf. Alongwith the growth of seedlings the plant becomes tolerant to the disease.

Epidemiology

The disease is caused by *Colletotrichum curvatum* Briant and Martyn. Initially the mycelium is local-

ized in the tissues of a lesion either on leaf or stem of a young seedling. In severe cases, however, it not only penetrates in the cortical tissues but also invades the vascular bundles. The acervulli are formed in the epidermis of the diseased area on which numerous single celled hyaline condia are formed which spread the disease. The cloudy weather accompanied by continuous rain favour the rapid spread of disease in the thickly populated crop. The infection is found to be severe in the seedling stage. Rain splashing helps the spores to spread in adjacent plants.

Management

Resistance: Amongst the cultivated varieties, K-12 yellow was found to be largely resistant to the disease. Recently released varieties SH-4, SUN 053, SUIN 037 and JRJ 610 are tolerant to wilt under natural conditions. ***Chemical treatment:*** Seed borne infection can be checked by disinfecting the seed with suitable fungicides -Thiram or Carbendazim 2g/kg are highly effective in reducing this disease at seedling stage. Spraying with same fungicide at 15 days interval also reduces the disease incidence. Sowing time: As the disease is favoured by high rainfall and high humidity, early sowing in dry season i.e. mid-April to mid-May helps to escape this disease.

Leaf blight (Macrophomina phaseolina)

The blight started from the margin of the leaf and proceeds inwards. Under moist and warm conditions with intermittent rains, the whole leaf may be blighted. But with the fall in temperature along with receding rains severity was restricted. Often black pinhead like fungal structure is noticed on blighted site. In the early morning, the blighted leaves look greyish and water soaked, which ultimately become brownish with broad yellow margin. Subsequently, the infected leaf becomes weak and droops down from the plant, which gives a sickly appearance of the whole field. This disease is caused by *Macrophomina phaseolina* (Tassi) Goid. Generally it is a soil borne disease but the seed borne nature of the pathogen was also known.

Management

Seed treatment with Thiram or Carbendazim 2g/kg followed by spraying with Carbendazim 50 WP @0.2% at 15 days interval reduces the disease incidence. As the disease is favoured by high rainfall and high humidity, early sowing in dry season i.e. mid-April to mid-May helps to escape this disease.

Choanephora twig blight (Choanephora cucurbitarum)

Distribution and Economics: The disease has been reported from the wild species like *C. spectabilis, C. sericea* and *C. retusa*. About 20 % incidence of this disease was recorded in the month of August.

Symptoms

This disease is characterized by the rotting of terminals. Brown discolouration occurred just below the infection point. Affected portions decay, break and droop. White mycelial growth along with black coloured sexual bodies of the fungus is seen on the affected parts from the tip towards petioles. A characteristic whitish brown discolouration in leaves precedes the disease development. Infected leaves loose their chlorophyll and droop from the stem. The pathogen affects the epidermal and outer cortical layers, and cells in these regions get disintegrated. High rainfall and humidity favours the disease incidence.

Management

Foliar spraying with Carbendazim 50 WP @0.2% at 15 days interval reduces the disease incidence. As the disease is favoured by high rainfall and high humidity, early sowing in dry season i.e. mid-April to mid-May helps to escape this disease.

Sunnhemp mosaic

Symptoms: The first visible symptom appeared within 10 to 12 days after inoculation when mottling was seen on the youngest leaves. As the disease progressed, patches of light and dark green areas became more prominent. Diseased leaves were smaller than the normal. In severe cases of infection, growth of the lamina generally became abnormal. Frequently dark green raised areas on the upper surface were seen with corresponding depression on the lower surface. The infected plant remained shorter in height and therefore, fibre and seed yields weregreatly reduced.

Causal agent : The disease is caused by virus. The structure of the virus was determined under electron microscope The virus consists of spherical particles measuring 26-40 µm.

Transmission and host range: The disease was reported to be transmitted mechanically and the hosts of the disease are *C. mucronata, Cyamopsis tetragonoloba*, *Pisum sativum, Nicotiana tabacum, Datura strumonium* and *Lycopersicon esculenta*. Optimum dose of nitrogen and increased dose of phosphorus increased the spread of the virus within the plant but the reverse was true in case of potassium. The concentration of the virus was found to be more in optimum nitrogen application whereas, potash application was found to reduce the concentration of the virus.

Epidemiology

Epidemiological studies on the virus have not been studied so far. But at Sunnhemp Research Station, Pratapgarh, U.P. it was observed that the severity of the virus increases with the onset of monsoon. As the virus is reported to be sap transmitted and having wide host range, the disease may be initiated from the other wild or weed host(s). The same observation was also noticed in the farmers' field in and around Pratapgarh. Higher dose of nitrogen increases while potassium application reduces the disease

Management

Sowing time: Time of sowing is very important to escape the disease. Drastic reduction of this disease was noticed in the early sown (mid- April) crop than the monsoon crop. Host resistance: No resistant varieties are reported so far, but recently released varieties such as SH-4, SUIN 053, SUIN 037 are tolerant to sunnhemp mosaic under field condition.

Southern Sunnhemp Mosaic

The incidence of the disease is more in monsoon months when temperature ranges between 22-41^{0}C and relative humidity 80%.

Symptoms

Initial symptom of the disease appeared within 9-20 days depending on weather conditions. It is characterized by faint discoloured patches appearing first on young leaves. Distinct mosaic with puckering and blistering of leaves developed. Subsequently thin elongated enations running more or less parallel to each other developed on the under surface of the leaves. The characteristics mosaic mottle and varying degree of leaf distortion occurred in advanced stage of the disease. Plants became dwarf with reduced leaves and bear scanty flush of flower resulting in poor pod setting and seed yield.

Host range and Transmission : The host range of southern sunnhemp mosaic virus was confined mainly to the families, Leguminosae and Solanaceae. Systemic mosaic mottling appeared at about 10-20 days after inoculation in *C. retusa, C. mucronata, C. laburnifolia, C. usaramoensis, C. spectabilis, C. lanceolata, Pisum sativum, Vigna sinensis, V. unguiculata, V. cylindricum, V sesquipedalis, Phaseolus vulguris, P latanus, Cassia tora, Cajanus cajan, Solanum nigrum, Datura inoxia and Nicandra physaloides*. Local lesion develops on *Nicotiana tabacum, N glutinosa, N. sylvestris, D. strumonium, D. aegyptiana, and Gompherena globosa*. The virus was readily transmitted by leaf rubbing without the help of any abbrasive or by pinpricking. It was also transmitted by wedge or patch grafting of diseased tissues to healthy sunnhemp plants. However, the virus is not transmitted through seed and soil.

Virus particles and physical properties: The electron monograph revealed that the particles are rod shaped with 300 µm x 18 µm. Basis on cross-inoculation and serological studies, it is found to be a strain of tobacco mosaic virus. The virus particle is highly stable with TIP-950C, DEP 10-7 and aging *in vitro* for 6 years. The virus can withstand complete desiccation.

Management

Clean cultivation reduces the disease pressure as the virus has wide host range. Drastic reduction of this disease was noticed in the early sown (mid-April) crop than the monsoon crop.

Sunnhemp phyllody

Sporadic incidence of this disease is reported from different parts of the country. It is characterized by yellowing of apical leaf, followed by big bud formation at the terminal raceme, conversion of floral meristem to the vegetative state, leading to buds becoming phylloid and forming dwarf shoot. At Sunnhemp Research Station, Pratapgarh, Uttar Pradesh, a similar type of disease called Witches'

Broom, assumed to have been caused by Phytoplasma like organism because of its remission after application of Tetracycline @ 500 ppm. He observed the disease after 30–60 days of sowing and transmitted mechanically. Recently sunnhemp phyllody is invariably (2-4%) occurring in seed crop at Sunnhemp Research Station, Pratapgarh causing considerable loss in seed yield (Sarkar, 2010).

Management

Continuous field monitoring of seed crop is essential to identify the first infection. The infected plant should be uprooted and burnt to reduce the further spread. The vector of sunnhemp phyllody (*Bemisia tabaci*) can be managed effectively by Imidaclorprid 17.8 SL @0.3% and Thiamethoxam 25 WG @0.25%

Sunnhemp leaf curl

Sunnhemp leaf curl (Raj *et al*, 2003) caused by begomovirus (Khan, *et al*, 2002) is an important limitation for cultivation of the crop particularly in monsoon crop. The natural incidence of the disease at different districts of eastern Uttar Pradesh is about 75% whereas severity is about 90%. Fibre yield loss is about 90% was recorded at Sunnhemp Research Station, Uttar Pradesh (Sarkar *et al*, 2015).

Symptoms

The symptoms started appearing approximately after 15 days of germination of seed as light faint mosaic mottling and leaf curling. At the initial stage little difference in symptoms are noticed in crops grown from different source. But with time the symptoms intensified with severe mosaic, yellowing mottling and leaf curling (upwards and downwards) with reduction in leaf size and plant height (Kumar *et al,* 2010). Monsoon sown crop is severely affected.

Management

There is no direct control measure. However, controlling of vector (*BEMISIA TABACI*) with spraying of Imidaclorprid 17.8 SL @0.3% or Thiamethoxam 25 WG @0.25% can reduce the spread of the disease. Sowing in Mid-April escape the disease.

D. Diseases of Ramie (Boehmeria nivea)

Ramie (*Boehmeria nivea*), a perennial bast fibre crop produces strongest and finest fabrics fibre and can be blended with any other natural fibres. It is grown in tropical, sub-tropical and temperate regions and the main countries where it is grown are China, Brazil and the Philippines. In India, ramie cultivation is concentrated in North Eastern parts of the country. The major diseases (Fig. 4) are Leaf spot (*Cercospora boehremia*), Damping off (*Rhizoctonia solani*), Eye rot (*Myrothecium roridum*), *Anthracnose* (*Colletotrichum gloeosporioides*), Cane rot (*Rhizoctonia bataticola*) and Stem rot (*Sclerotium rolfsi*) (Anon, 2013-14) (Fig. 4).

Cercospora leaf spot (Cercospora boehremia)

It is a common and widespread disease in all the ramie growing areas of Assam. Affected plants are not killed outright. When the spotting is very severe and if the plant is very young the growth is retarded. The disease appears as circular to angular spot on the upper surface of the leaf. Sometimes the spots which are 1-8 mm in diameter and dark brown to nearly black in colour are limited by the leaf veins. The centre of older spots, however, turns paler and becomes greyish brown. Adjacent spots may coalesce. The disease has been observed throughout the year but the severe infection occurs from the later part of September to early January. The development of this disease is favoured by moist and cool weather. Infection is usually more severe on the lower leaves. In severe infection more than 60% of leaves are affected and 30-60% of the leaf area destroyed by spotting. Leaves severely spotted turn yellow and fall prematurely. The morphology of the fungus, which grew well on a number of culture media but failed to produce spores. The disease can be controlled by spraying with copper fungicides.

Damping off (Rhizoctonia solani)

Damping off of ramie is caused by Rhizoctonia solani. The fungus attacks foot of the stem or crown of the roots under certain condition rendering the tissues at the region weak resulting seedlings collapse. In seed beds (when ramie is raised through seed for breeding purpose) the seedlings may be attacked by damping off in humid and moist conditions. Affected seedlings are pale green and show a girdle of brown decaying cortex leading to collapsing of seedling. Moisture content of soil and

humidity are important factors for seedling disease. Sterilization of soil of seed bed by using formaldehyde (1:50) is the best remedy. Treating planting stalks with captain is also effective in controlling *Rhizoctonia* disease in ramie.

Eye rot (Myrothecium roridum)

The disease attacks leaves as well as stems. Infection of leaves results in both qualitative and quantitative loss of fibre. The first symptom appears as irregular, small, round tan coloured spots about 1 mm in diameter on the upper surface of the lamina. As the disease advances the spots become circular and elongated to irregular, 1-16 mm in diameter and brown to dark brown in colour. In case of severity, the incidence of disease is reported to be 7-10%. The disease is controlled by spraying Copper oxycloride @ 4-5g/l.

Cane rot (Rhizoctonia bataticola)

The symptom of cane rot disease appears as necrotic lesions on the leaves which gradually cover the entire leaf blade. The leaves then crinkle, rot, adhere to the canes and ultimately shed off. Root system become weak and turns brown. The disease is prevalent during rainy season on mature clumps. Brown shunken circular or elongated lesions are common on the stalks of ramie specially in the basal regions. They increase in size and several such lesions coalesce and girdle the stalk. When the lesions streaks along the length of the stalk it shrivels resulting in complete drying. A number of stalks may be infected in a single clump. The organism causing the symptoms exists as a brown mycelium on the affected region of the stalk and forming black sclerotia.

Anthracnose (Colletotrichum gloeosporioides)

In China anthracnose is regarded as one of the most widespread and devastating diseases of ramie. In China Ramie yield was reduced by 20% - 55% under field condition. Lesions were initially small, scattered, round, and gray with brown margin on leaves. As the disease progressed, irregular spots developed and expanded until the leaves withered. Initial lesions on stems were fusiform and expanded, causing the stem to break. Finally, the fibers ruptured. The pathogen was identified as *Colletotrichum gloeosporioides.* Conidia were single celled, colorless, straight, oval, obtuse at both ends, and 11 to 18 × 3 to 6 μm with an average of 14.89 × 4.32 μm. Conidiophores were dense and 11 to 22 × 4 to 5 μm with an average of 15.82 × 4.43 μm. Setae were few, dark brown, one to two septa, and 62 to 71 × 4 to 5 μm with an average of 65.13 × 4.46 μm.

Stem rot of ramie

A new disease of ramie, named Stem rot, was observed and reported for the first time in the Philippines. The disease is caused by a fungus, *Sclerotium rolfsii.* Symptoms of the disease were wilting and water soaking of the basal portion of the plant. Severely infected plant turned brown, defoliated and ultimately died. Profuse white mycelia of the fungus covered the infected stem. The fungus has a wide host range. Of the six inoculation methods evaluated, inoculation at the base of the stem, inoculation of the injured stem 5 cm and 10 cm above soil surface showed the symptoms of the disease. Management of ramie diseases: Very little information is available on management of ramie diseases. Application of Propiconazole @0.1% or Difenoconazole @0.1% are very effective against Cercospora leaf spot and Anthracnose disease. Eye spot of ramie can be controlled by spraying Copper-oxycloride @ 4-5g/l. Damping off of ramie can be controlled by sterilizing the soil of nursery seed bed by formaldehyde (1:50) followed by treating planting stalks with captan (Anon, 2012-13).

Integrated Disease Management of jute and allied fibres

As such very little information is available for management of allied fibre diseases which hinders the development of integrated management practices. However, sufficient information of management of jute diseases are available, based on which following strategies may be considered for integrated management of jute diseases.

1. Selection of species / varieties: All the available jute varieties are not equally affected by the various diseases in different areas. This depends upon the type of pathogens present in the locality. Pathogen of different locations of the same disease is also not equally virulent on all the jute varieties. For example in case of *C. olitorius* JRO 632 is expected to be less affected by stem rot around Barrackpore, Coochbehar and Katihar areas than JRO 524, whereas JRO 524 is less affected in Singur areas of West Bengal. Anthracnose is a

major disease for *C. capsularis* but in *C. olitorius* the disease is practically negligible in fibre crop. So, in the traditional capsularis belt olitorius varieties may be grown wherever possible.

2. Clean cultivation: Most of the jute pathogens are seed borne, soil borne as well as air borne. The pathogens once introduced in the soil can remain there for a long time in the debris, stubbles of the last year's crops and weeds as such serve as primary source of inoculum. So these should be collected and burnt and land should be prepared cleanly. Deep ploughing and exposure of the soil to sun for a longer period reduces soft rot infection.

3. Adjustment of soil pH: Acid soil is preferred for most of the diseases. If the soil is acidic, lime @ 2 - 4 tons/ha should be applied depending upon the soil pH. A neutral soil having pH between 6.5 to 7.5 is preferable. Indiscriminate use of fertilizers specially the nitrogenous fertilizers makes the soil acidic. Care should be taken for lime application so that the application is done at least a month before sowing otherwise the seedlings may be damaged.

4. Use of clean and healthy seed: Most of the jute pathogens are seed borne, soil borne and also air borne. Infected seeds serve as the primary source of inoculum. Therefore, clean and healthy seeds should be used. Seeds should be treated with recommended fungicides. Carbendazim 50 WP @ 2 g / kg seed or Mancozeb @ 5 g / kg seed are effective in checking the seed borne infection.

5. Adjustment in sowing time: By adjustment in the sowing time some of the diseases can be avoided. It has been observed that jute sown after second week of April suffers less from stem rot and root rot. But sowing time again depends on the preceding and the succeeding crops in the cropping sequences. So these factors also are to be considered and the adjustments should be made accordingly.

6. Fertilizer application: Excess nitrogen makes the plants more susceptible to diseases whereas potash confers some degree of resistance. There is a general tendency to add more nitrogenous fertilizers for quick vegetative growth of the crop. This initially provides some quick growth but invites more disease at the later stage. Therefore, judicious use of balanced fertilizers as recommended depending upon the soil condition is essential for a good healthy crop.

7. Spacing: If the population is too thick disease attack is more. Close spacing is very much conducive to stem rot infection. So recommended spacing should be followed. In line sown crop 30 cm row to row and 5-6 cm plant to plant spacing gives good result. Spacing can be maintained at the time of thinning.

8. Weeding: Jute pathogens especially *M. phaseolina* and *S. rolfsii* have a very wide host range, which includes a good number of weeds also. The pathogens from these weeds serve as source of inoculum for the jute crop. To avoid this timely weeding should be done.

9. Drainage: Jute, especially the olitorius jute dose not prefers water logging. Though some of the varieties can withstand inundated condition, they develop numerous adventitious roots at the basal region from where either no fibre is obtained or even if obtained the quality is very low.

10. Crop rotation: A good number of pathogens are common to Jute as well as some other crops in Jute based cropping system. For example *M. phaseolina* the most serious pathogen of Jute attacks Brinjal, Cowpeas, Pea, Ground nut, Black gram. Another pathogen *R. solani* attacks besides Jute, Sesamum, Potato, Beet and Ground nut. *S. rolfsii* attacks Sesame and Brinjal other than Jute. Root knot nematode (*Meloidogyne incognita*) of Jute cause same disease in brinjal also. *R. solanacearum*, the Hooghly wilt pathogen of jute is also a major pathogen of potato and other solanaceaous vegetables like brinjal, tomato etc. Therefore, selection of crops in the rotation plays a very important role in disease management. It has been observed that inclusion of paddy always reduces the disease in jute. Use of solanaceaous vegetables like potato, brinjal, tomato years after years increases wilt in olitorius jute. So crop rotation should be carefully followed. Some important rotation are: Jute-paddy–paddy, Jute-paddy-wheat, Jute-paddy-winter vegetables (other than solanaceaous ones), Jute-paddy-potato (or other solanaceaous vegetables if these are the major crops of the area but these should be replaced by paddy or wheat after two years).

11. Application of chemicals : In spite of above

measures, if symptoms are observed in the field and if there is an increasing tendency, recommended fungicides should be applied. Carbendazim 50WP@ 2 g/l water or Copper-oxychloride 50WP @ 5-7/l water or Mancozeb @ 5 g/l water provides good control. In case of stem rot if the infection is very high alternate sprays of Copper-oxychloride - Carbendazim - Copper-oxychloride (total three sprays) gives good control. In case of seedling blight and damping off symptom at the very early stage of the crop one spray of Copper-oxychloride or Carbendazim gives good protection. In case of soft rot, spraying of copper-oxychloride should be directed towards the ground level. In case of jute mosaic, spraying of Imidacloprid or Thiamethoxam could prevent the spread of the disease.

12. Biological control: Seed treatment with T. viride and soil drenching twice at 15 and 30 DAS with the same antagonist effectively controlled root rot disease of jute in multi-locational testing. Besides *T. viride* some other species of *Trichoderma, Aspergillus niger* and also different PGPRs have been proved to be effective in controlling *Macrophomina* diseases in Jute.

Future strategies
Development of forecast model

Weather based model for forecasting of important disease outbreak and their impact on crop yield and fibre quality in each agro-climatic condition in niche areas.

Biological control: Identification of efficient local strains of antagonistic microbes for disease control, mass scale production of bio-agents for productivity enhancement and quality improvement in jute and allied fibres. Works on endophytes in jute & allied fibres to give a new dimension to biological control by providing inbuilt resistance.

IPM: Development of a cost-effective, eco-friendly and socially compatible protocol in IPM for productivity enhancement and quality improvement in fibre crops.

Disease free seed production: Development of technology for production of healthy seeds of jute and allied fibres to get quality seeds free from seed borne pathogens.

Impact of climate change on biotic stress in jute and allied fibres: Dynamics of pest status, biological and behavioral activity with respect to diseases of jute and allied fibre crops under changing climatic conditions

Molecular diagnosis of disease and variability: Quick and correct diagnosis of specific pathogen to the level of races, strains and variants of different pathogens will facilitate to develop correct measure to combat epidemic.

Development of expert system for disease management advisory: An interactive expert system supported by matching visuals and data for adopting short and long term measures based on the crop protection technology will be developed.

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