A SURVEY REPORT
ON
STATUS OF BIOTIC STRESSES OF CROPS IN CHHATTISGARH

Sridhar J
R K Murali Baskaran
P N Sivalingam
S K Jain
Mallikarjuna J
P Kaushal
P K Ghosh

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Rendering solution to biotic stresses

ICAR-National Institute of Biotic Stress Management
Baronda, Raipur - 493 225, Chhattisgarh, India
Tel. No. : +91-771-2277333
E-mail : director.nibsm@icar.gov.in
Website : https://nibsm.icar.gov.in/

Citation
Sridhar, J., R. K. Murali Baskaran, P. N. Sivalingam, S. K. Jain, Mallikarjuna, J., P. Kaushal and P. K. Ghosh. 2022. A Survey Report on Status of Biotic Stresses of Crops in Chhattisgarh. ICAR - National Institute of Biotic Stress Management, Raipur - 493225, Chhattisgarh, India, pp. 1-26.

Published by
Director and Vice-chancellor
ICAR - NIBSM, Raipur - 493 225
Chhattisgarh, India

Authors
Sridhar J.
R. K. Murali Baskaran
P. N. Sivalingam
S. K. Jain
Mallikarjuna J.
P. Kaushal
P. K. Ghosh

Technical bulletin number
ICAR-NIBSM/B&B-4/2022-4

Printed by:
A-1 Art
Raipur - 492 004
Chhattisgarh, India
Phone: +91 9009940219

भाकृअनुप - राष्ट्रीय जैविक स्ट्रैस प्रबंधन संस्थान
बरौंडा, रायपुर – 493225, छत्तीसगढ़, भारत
ICAR-NATIONAL INSTITUTE OF BIOTIC STRESS MANAGEMENT
Indian Council of Agricultural Research
(DARE, Ministry of Agriculture and Farmers' Welfare)
Baronda, Raipur - 493225, Chhattisgarh, India

Dr. P K Ghosh, FNASc, FNAAS, FISA, FISPP, FWAST
Founder Director and Vice Chancellor

FOREWORD

Indian agriculture is the backbone of the country ensuring food and nutritional security and feeding 1.3 billion population in the country. Second green revolution is expected from Eastern parts of India including Chhattisgarh to feed the enormously growing population in India. Chhattisgarh is one such state comes under the Eastern Plateau and Hill Region of the 15 agro-climatic regions of India. The state has three different ecological zones; northern hill zone, central plain zone and southern Bastar plateau and is popularly known as "rice bowl" of the country as rice is the principle crop of the state with about 70% of the net sown area in *kharif* (June-September). Other important crops grown namely, maize, redgram, blackgram, green gram, horse gram, soybean, sesame and vegetables and fruit crops in *kharif* season and wheat, chickpea, pea, lathyrus, mustard, linseed, vegetables and fruits are grown in *rabi* season. Last 10 years, the area under rice and pulses cultivation has not changed much, however, the area under vegetable cultivation in this region has increased by four times which has created a favourable microclimate and availability of the host plants for the perpetuation and multiplication of the many insect pests, pathogens, nematodes etc. Recently, many pests and pathogens have emerged in the Chhattisgarh and causing serious economic damage to the crops.

To devise and deploy management practices effectively, we need to have present status on pest incidence, damage, distribution etc. The survey report on "Status of Biotic Stresses of Crops in Chhattisgarh" presented in this document is pertinent and timely. I am confident that this report will act as a base document for plant protection agencies, researchers, policy makers and other stake holders for devising suitable management strategies to reduce the losses caused by biotic stresses emerged in the recent times in Chhattisgarh. I congratulate all the authors for the timely publication of this report.

(P. K. Ghosh)

Named in top 2% Agricultural Scientist at global level as world ranking analysis made by scientists of Stanford University, USA
Mobile: +91 9453042870, Phone (O) : +91-771-2225352 / 2225333 Ext.: 201
Email: director.nibsm@icar.gov.in, Website : https://nibsm.icar.gov.in

PREFACE

Chhattisgarh is well known as rice bowl of India. During last one decade, the crop diversity has increased tremendously and the year-round cultivation of agricultural crops have also been increased which has changed the biotic stress scenario in the state. However, the present status of pest scenario across the state has not been documented systematically. Our preliminary field surveys, interactions with extension functionaries and farmers felt for urgent need of base document on pest and disease status of different crops in the state. To accomplish this, several intensive and extensive surveys were conducted across the state during 2016-2022 by scientific team of ICAR-NIBSM, Raipur. This report is developed based on the real time field visits, interaction with KVK and state Government officials and farmers. This publication covers information on pest and disease status of different agricultural and horticultural crops including new pests emerged, prioritised pest and diseases to be managed based on economic damage caused by them etc. This compiled report will be highly useful for the various stakeholders involved in the biotic stress management of crops in the state. We also find this report will be useful for researchers and students to take up research on these emerging issues.

Sridhar J
R K Murali Baskaran
P N Sivalingam
S K Jain
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P K Ghosh

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I. Introduction

Chhattisgarh state comes under the Eastern Plateau and Hill Region of the 15 agro-climatic regions of India. It has three different ecological zones; northern hill zone, central plain zone and southern Bastar plateau zone. Chhattisgarh is popularly known as "rice bowl" of the country as rice occupied about 70% of the net sown area in *kharif*. The important crops cultivated during *kharif* are maize, redgram, blackgram, greengram, horsegram, soybean, sesame and vegetables and fruit crops and during *rabi* are wheat, chickpea, pea, *lathyrus*, mustard, linseed, vegetables and fruits. During last 10 years, the area under rice and pulses cultivation has not changed, however, the area under vegetable cultivation in this region has increased by four times. During 2018-19, the vegetable crops were cultivated in 0.4 mha with a production level of 6.8 million tonnes and pulses in around 0.8 mha with a production of 0.55 million tonnes. This kind of intensive and overlapping cultivation of crops throughout the year has not only aided for change in the spectrum of pest and pathogen but also their perpetuation particularly of viruses and their vectors. Due to intensive cultivation of crops in Chhattisgarh and adjacent areas, the incidence of pests and diseases have crossed the economic threshold limits, sometime encountered an epidemic. For example, tomato cultivation was badly affected by leaf curl disease along with spotted wilt and early blight disease during 2017. Very few reports are available to report on status of biotic stresses of crop plants in Chhattisgarh. Additionally many pests and diseases have also emerged in a serious proportion in this region. Therefore, the systematic survey of different region of Chhattisgarh, collection of information on the present status of pests, diseases, nematodes etc occurring on economically important crops and new biotic stresses in crops was urgently needed to enrich the database and also to overcome the economic losses.

A series of extensive field surveys were conducted during 2016-2022 in various districts of Chhattisgarh covering all three zones. During the survey in the farmers' fields, symptomatology, pests and disease incidence were recorded. Besides, interactions with farmers and officials of Krishi Vigyan Kendra were also held on the cropping pattern, awareness of the pests and diseases and their management measures etc.

The present status of the biotic stresses recorded on major crops (cereals, pulses, vegetables, oil seeds, fruit crops etc.) grown during *kharif* and *rabi* seasons in different districts of Chhattisgarh during 2016-2022 is reported in this compilation.

II. Incidence of Biotic Stresses in Crops

(A) Cereals:

1. Rice

Rice is the most important staple food crop of Chhattisgarh. The yellow stem borer (*Scirpophaga incertulas*), leaf folder (*Cnaphalocrocis medinalis*), brown plant hopper (*Nilaparvata lugens*) and rice

hispa (*Dicladispa armigera*) were recorded in rice growing areas of Chhattisgarh. Among them, yellow stem borer was the major borer and its damage ranged from 15 to 40% during *kharif* and summer. Rise in temperature was favourable for rapid multiplication of yellow stem borer. Brown planthopper damage was comparatively high in farmers' fields (20-50%) as they follow direct sowing of rice. Stray incidence of rice hispa (5%) was recorded during late vegetative stage of rice (Fig 1).

White ear symptom | Brown planthopper | Rice hispa

Fig 1. Incidence of insect pests of rice

Among diseases, widespread occurrence of false smut (*Ustilaginoidea virens*) disease was observed in most of the farmers' fields in different villages of Raipur district especially on late maturing variety like Swarna in 2016. The disease incidence (percentage of false smut-infected tillers) varied from 4.5% to 42.2% whereas number of infected grains per panicle varied from 1 to 25 in Swarna variety. Average number of smut balls per kilo gram harvested grains varied from 47 to 53. In the experimental farm of NIBSM, false smut was also observed in severe form on varieties PKV KISAN and HMT where number of infected grains reached around 40 per panicle with disease incidence of 30.3%. Similarly, brown spot was also observed with varying intensity in direct seeded and upland rice. The severity varied between 5 to 50% in different varieties. In Adsena, Baronda, Matiya villages of Raipur district, sheath blight was observed with up to 20% severity. Sheath rot was observed in moderate intensity. Leaf and neck blast was observed in low severity at NIBSM farm. Other diseases of rice observed were kernel smut, black kernel and leaf smut with low incidence.

In *kharif* 2017, surveys were undertaken in Dhamtari, Kanker, Kondagaon, Bastar, Balod and Rajnandgaon districts of Chhattisgarh. Transplanted rice was mostly affected by leaf blast (*Pyricularia oryzae*) and sheath blight (*Rhizoctonia solani*) whereas severe occurrence of bacterial blight (BB) in rice hybrid (MC13) was observed in farmers' fields in Kanker district. In direct seeded rice mainly brown spot (*Bipolaris oryae*) disease was observed with moderate intensity and up to 50-70% severity in NIBSM experimental farm (Fig 2). In 2018, brown spot was observed with low to medium severity late in the season and sheath blight appeared with moderate intensity in the farmers' fields in Raipur district. False smut incidence was low due to fewer rains during anthesis stage of the crop.

Bacterial blight of rice | False smut of rice | Sheath blight disease

Fig 2. Symptoms of various diseases in rice

In the *kharif 2019* season, Raipur, Baloda Bazar-Bhatapara, Bilaspur, Janjgir-Champa, Korba, Raigarh, Jashpur and Mahasamund districts were covered to assess the disease incidence and severity when flowering and grain filling stage of the rice crop was the predominant stage in these districts. Bacterial blight (*Xanthomons oryzae* pv. *oryzae*) disease was invariably found in most of the districts with low to moderate incidence. In Balodabazar and Bilaspur districts, bacterial blight severity up to 30-40% was observed. Sheath blight (*Rhizoctonia solani*) was another disease which was common everywhere with low to moderate severity which was found to be up to 50% severity in few fields, however, in most places it was managed by fungicidal sprays. Leaf blast (*Pyricularia oryzae*) generally was not observed in these districts but neck blast with moderate severity was observed in 1-2 fields in Raigarh district. False smut of rice with low severity was observed in most of the villages covered in these districts. Crop lodging was also observed in rice due to unseasonal intense rains. At NIBSM, false smut was observed with moderate to high incidence in few fields. Leaf and neck blast incidence was low. During *kharif* 2020 season, high severity of bacterial blight (BB) of paddy was observed in Budgahan and Farhada villages of Raipur district where hybrid varieties were planted. Low to moderate severity of BB was also observed in other cultivars including Swarna towards the maturity of the crop in villages and at NIBSM farm. False smut with low to moderate incidence was observed in Swarna variety whereas early varieties like Mahamaya, MTU 1010 were escaped from infection.

2. Wheat

Wheat is grown during *rabi* season and it is being grown in central and northern parts of Chhattisgarh. The stem borer and termite were found as major insect pests. However, during 2017-18, heavy incidence of sugarcane pyrilla [*Pyrilla perpusilla* (Walker, 1851)] (Hemiptera: Lophopidae) was recorded on wheat and oat and the level of incidence was 30-70 nymphs and 10-15 adults/tiller. Due to climate change, the pyrilla which was specific on sugarcane earlier might have expanded its habitats and hosts and occupied Poaceae crops. The incidence of pink stem borer (*Sesamia inference*) was noticed in Sarguja, Korba, Raigarh, Raipur Ambikapur, Mainpat, Korba, Pathalgaon, Arang and Baloda Bazar of Chhattisgarh. The Pink stem borer infestation on wheat ranged from 5-10% at various places surveyed (Fig 3).

Pink stem borer larvae | White ears of PSB infestation | Brown plant hopper infestation | Sugarcane pyrilla infestation in wheat

Fig 3. Damage caused by insect pests of wheat

Among diseases, during *rabi* 2015-16 season, brown rust of wheat (*Puccinia triticina*) was observed with low to moderate severity at the dough stage of timely sown wheat crop in the farmers fields in Raipur district as well as at the ICAR-NIBSM Baronda experimental farm. However, in the very late-sown crop (January sown) in Adsena village, brown rust was observed with high severity at anthesis stage under irrigated condition on cultivar GW 273. Brown rust was not observed during 2016 to 2019 in surveys, however, it was again observed during *rabi* 2019-20 season with severity up to 40% owing to favourable weather and frequent rains. Black rust caused by *Puccinia graminis* f.sp. *tritici* made a rare occurrence in Chhattisgarh with low severity near to crop maturity in 2020.

Pathotype prevalence of *Puccinia triticina* in Chhattisgarh

Brown rust samples from 2015-16 crop season were analysed at the ICAR-IIWBR Regional Station, Flowerdale, Shimla (H.P.) for the identification of pathotypes prevalent in this region. Analysis revealed that the pathotype 121R60-1 (77-9) virulent on *Lr1, Lr3, Lr10, Lr11, Lr12, Lr13, Lr14a, Lr14b, Lr14ab, Lr15, Lr16, Lr17a, Lr17b, Lr18, Lr20, Lr21, Lr22a, Lr22b, Lr23, Lr26 ,Lr27+31, Lr30, Lr33, Lr34, Lr35, Lr36, Lr37, Lr38, Lr44, Lr46, Lr48, Lr49* was the most predominant whereas pathotypes 21R55 (104-2) and 121R63-1 (77-5) were also identified.

Analysis of brown rust samples in 2019-20, again showed the predominance of the pathotype 77-9 (121R60-1) in Chhattisgarh, two other pathotypes 77-1 (109R63) and 104-2 (21R55) were also identified in one sample each.

In the *rabi* 2017-18 season, in general wheat crops was free from diseases in the survey conducted in Raipur, Baloda Bazar, Bilaspur, Korba, Surguja, Raigarh and Mahasamund districts. Low incidence of foot rot disease (*Sclerotium rolfsii*) was observed in a few fields in Raigarh and Mahasamund districts whereas loose smut was observed in one field only in Mahasamund district. Glume blotch was observed with low severity in Baloda Bazar.

3. Maize and other millets

Maize is mainly affected by borer and aphids. Termite incidence has been noticed in the central part of Chhattisgarh. The tobacco caterpillar which has been reported to emerge in maize crop was recorded in Kanker only with 5% damage. Two stem borers, (*Chilo partellus*) and pink stem borer (*Sesamia inferens*) were recorded on maize crop with the infestation of 25-35% while *C. partellus* was alone recorded in other districts with the damage of 5-20%. Shoot fly (*Atherigona soccata*) and aphids (*Rhopalosipum maidis*) were recorded in maize growing areas of Kanker with damage intensity of 10-15% while these two pests were absent in other maize growing areas (Fig 4).

Fig 4. Pink stem borer and aphid feeding on plants

3.1. FAW infestation level in Maize

Fall armyworm (FAW), *Spodoptera frugiperda* is an invasive pest, recently invaded India and first reported in Karnataka state on maize during 2018 which had spread to all southern states of India in a short span of time. This notorious pest has entered into Bastar region for the first time in Chhattisgarh. The damage caused by fall armyworm was 30-50% in Bastar plateau region (Bastar, Kondagaon, Kanker) of Chhattisgarh while it was 20-25% in Chhattisgarh plains and absent in Jashpur, indicating that fall armyworm has been spreading from south to plains and northern parts of Chhattisgarh. As high as 40-50% per cent infestation this pest was observed in IGKV research farm. Recently during *kharif* 2022, a severe infestation of 60-80% was observed in 60 days old maize fields in Jarauda of Raipur district (Fig 5a). On an average, 60-65% percent leaves per plant were damaged by FAW. Stunted growth was observed in FAW infested maize plants as compared to healthy plants (Fig 5b). The incidence of FAW in Kondagaon in *kharif* and *rabi* seasons was 73.7% and 71% respectively. However, maximum incidence of fall armyworm was observed during seedling stage during both seasons. While in Surajpur and Sarguja, an infestation of 30-35 and 65-70 per cent respectively in knee high stage and tassel stage were observed. The pest intensity was comparatively high in maize growing areas of Bastar plateau of Chhattisgarh as the pests like fall armyworm and shoot fly might have moved from southern states of India *viz.* Andhra Pradesh.

a. Larvae of FAW feeding on maize plants

b. Tall uninfested plant and controlled growth in infested plant

Fig 5. FAW larvae feeding on maize plants

Small millets including finger millet, mostly were affected with blast disease and termite. In *kharif* 2017 season, neck and finger blast was observed in finger millet in moderate to high severity. High incidence of sheath blight was also observed in finger millet and foxtail millet. In pearl millet, rust disease was observed up to 80% severity. In 2018, foot rot (*Sclerotium rolfsii)* occurred with moderate to high intensity in finger millet, however, neck blast (*Pyricularia grisea*) of finger millet appeared late in the first week of October with moderate to high severity (Fig 6). In 2019, high incidence of finger millet neck and finger blast was observed in the NIBSM fields. Foot rot, sheath blight and Helminthospoium leaf spots in finger millet were observed with low to moderate severity in few lines. In 2020, moderate incidence of finger millet leaf, neck and finger blast was observed in the NIBSM fields.

Foot rot of finger millet

Neck blast of finger millet

Fig 6. Diseases of minor millets

(B) Pulses

1. Pigeonpea

Pigeonpea is mostly cultivated in the central and southern region of Chhattisgarh. The economically important insect pests of this crop are pod borer and spotted pod borer which are mostly found in the central region of Chhattisgarh. Among the pod borer complex, only three pod borers including spotted pod borer (*Maruca vitrata*), American pod borer (*Helicoverpa armigera*) and pod fly (*Melanogromyza obtuse*) were recorded to cause damage to internal contents of the pod (Fig 7). The maximum pod damage by spotted pod borer (40-50%) was recorded, followed by pod fly (20-30% shriveled seeds) and American pod borer (10.-20%). Pulse aphids which are very common in crops belonging to Fabaeceae were also recorded to the tune of 10%.

American pod borer | Spotted pod borer | Pod fly

Fig 7. Insect pests recorded on pigeonpea in Chhattisgarh

Among diseases, wilt, Phytophthora stem blight and sterility mosaic were observed. In *kharif* 2016, phytophthora stem blight was observed with 5 to 30% severity in different lines at NIBSM farm, collar rot was also observed in pigeonpea with about 5% incidence. During *kharif* 2018 and 2019, a high incidence of wilt, moderate incidence of Phytophthora stem blight and low incidence of Alternaria blight were observed in pigeonpea fields.

2. Mungbean and Urdbean

These two crops are found to grow throughout the Chhattisgarh and were found affected with hoppers, whitefly and pod borers. The diseases such as yellow mosaic, leaf crinkle, leaf spot, powdery mildew and veinal necrosis were recorded. In mungbean, cercospora leaf spot was observed in moderate intensity in Raipur district. Among these biotic stresses yellow mosaic, pod borer and sucking pests were found to be important (Fig 8).

Urd bean leaf crinkle

Yellow mosaic disease of mungbean

Fig 8. Diseases of mungbean and urdbean

3. Cowpea

This crop is mostly grown for vegetable purpose. Two pests including spotted pod borer [*Maruca vitrata*) and leaf hopper (*Empoasca kerri*) which were recorded during surveys (2019-2020) on cowpea at Kanker, Durg and Baloda Bazar causing damage to the tune of 20-50% to pods and 10-40% through sucking sap, respectively. Other pests including pulse aphid (10-40%), pod borer (20-50%) and whitefly (5-40 adults/plant) which are occurring regularly on cowpea were also recorded (Fig 9).

Aphid infestation

Spotted pod borer adult

Whitefly

Fig 9. List of insect pests recorded on cowpea

Yellow mosaic was recorded as important particularly in the northern hill zone areas whereas anthracnose disease was observed with low to moderate severity in Mahasamund and Raipur districts.

4. Horsegram

This crop mostly grown in southern parts of Chhattisgarh. Yellow mosaic disease was found to be important. Mild symptoms with very low incidence of the disease was observed.

5. Chickpea and lentil

In all three regions of Chhattisgarh, wilt, collar rot and borers were noticed during survey and interaction with farmers. In *rabi* 2016-17 season, chickpea was found affected with collar rot in few fields with 5-10% severity in some places. In *rabi* 2017-18, chickpea was found affected with collar rot and wilt complex with <5% diseases severity whereas in lentil crop, this disease complex was observed with 5-10% severity in Raipur and Baloda bazaar districts. In *rabi* 2018-19, wilt and collar/root rot in chickpea and lentil were observed with the incidence ranged from 5 to 30% in the farmers fields in Raipur district. In the NIBSM fields, wilt severity ranged from 0 to 35.71% and that of root rot 0 to 25.0% was observed in chickpea. Wilt and collar/root rot were observed with the incidence ranged from 5 to 10% in 2019-20 at NIBSM farm. Chickpea rust was also observed at pod filling stage with low severity. Among the insect pests, gram pod borer was observed as most serious pest causing 20-40% yield loss in Raipur district (Fig 10).

Chickpea wilt | Gram pod borer

Fig 10. Incidence of biotic stresses in chickpea

6. Lathyrus

It is one of the important pulse crop grown during *rabi* season in Chhattisgarh. Fruit borer and thrips were recorded as important in the central region. A very high incidence of two thrips species namely, *Scirtothrips dorsalis* and *Thrips florum* were recorded on lathyrus in the research farm of NIBSM, Raipur during 2017-19. Lathyrus was free from diseases in any of these crop seasons in different districts.

(C) Oilseeds

1. Soybean, Sesame, Mustard, Linseed

Soybean is mostly grown in the central region particularly in Rajnandgaon district. The important biotic stresses recorded were, yellow mosaic, defoliator, girdle weevil and pod borer. Soybean yellow mosaic disease has been recorded in Baronda of Raipur district with an incidence of 20-50%.

Spingid caterpillar was noticed in sesame. Mustard is grown in *rabi* season in which severe infestation of aphid and white rust were recorded as important biotic stresses in this region. Pod fly, wilt and collar rot were recorded in linseed as important biotic stresses in the central region.

(D) Vegetable crops

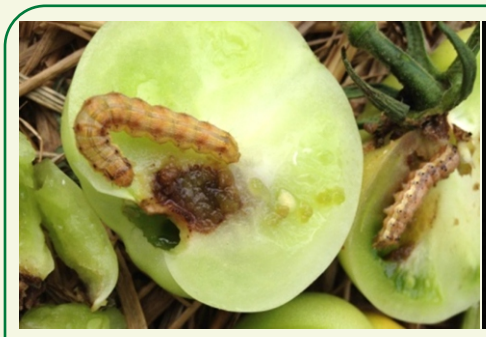
1. Solanaceous crops

Tomato, chilli and brinjal are the important solanaceous vegetable crops grown throughout the state. In *kharif* 2017, chilli, tomato crops were found to invariably affected with leaf curl and wilt diseases all over the state. During February 2018 crop season, tomato and chilli crops were found infected with the early blight and leaf curl disease with 20-30% disease severity (Fig 11). Leaf minor was noticed in northern region, fruit borer, veinal necrosis and blight disease were noticed in the central and northern parts of Chhattisgarh. In chilli, leaf curl disease and thrips mostly noticed in the central and southern parts, leaf curl disease and fruit borer mostly noticed in northern parts of Chhattisgarh. In 2019 die-back and leaf curl were the major diseases in Mahasamund and Jashpur districts.

Tomato leaf curl disease | Chilli leaf curl disease

Fig 11. Incidence and damage symptoms of leaf curl disease

In tomato, fruit borer (*Helicoverpa armigera*), tobacco caterpillar (*Spodoptera litura*) and whitefly (*Bemisia tabaci*) were found to occur regularly on tomato while serpentine leafminer (*Lyriomyza trifolii)* was found to be emerging from tomato in Dhamtari and Bastar districts of Chhattisgarh during 2019-2020 (Fig 12). The fruit borer damage on tomato was 30-40% in Dhamtari while it was only 20% in Bastar. Mealybug (*Phenococcus solenopsis*) and Pinworm (*Tuta absoluta*) have been reported to invade India. The damage caused by the remaining pests including tobacco caterpillar (10% leaf damage), whitefly (10-15 adults/plant), serpentine leafminer (10-15 leaf damage), pin worm (10-15% fruit damage) and mealybug (5-10% damage) are found to be in the same status both in Dhamtari and Bastar. However, invasive pests including mealybug and pinworm were not recorded in Bastar district which indicates that the spread of these two pests have been progressing from north parts to southern parts of Chhattisgarh.



Fruit borer damage

Pinworm damage

Serpentine leafminer damage

Fruit borer damage

Rat tail symptom

Sclerotium rolfsii infection on potato crop

Fig 12. List of insect pests and diseases recorded in solanaceous crops

Occurrence of thrips (*Thrips tabaci*) and yellow mite (*Polyphagotarsonemus latus*) was noticed together on chilli during 2019-20 to cause curling and cupping of leaves with elongation of petiole of leaves (rat tail) in almost all chilli growing areas of Chhattisgarh including Durg, Baloda Bazar, Koriya and Mahasamum districts. Their damage was 30-40% in all areas surveyed while it was 10-20% in Koriya. The fruit borer (*Helicoverpa armigera)* was not common in all places surveyed, however 30% fruit damage was recorded in Durg and Baloda Bazar.

In brinjal, shoot and fruit borer was noticed in all the three regions. Wilt disease noticed in more places in southern and northern region, blight disease mostly noticed in northern region. Infection of collar rot (*Sclerotium rolfsii*) and Alternaria leaf spot was observed in few brinjal fields. *Sclerotium rolfsii* infection was also found in potato crop with upto 30% infection in few fields.

During 2019-20, shoot and fruit borer (*Leucinodes arbonalis*) Jassids (*Amrasca devanstans*), epilachna beetle (*Henosepilachna vigintioctopunctata*) whitefly (*Bemisia tabaci*), aphids (*Phenococcus solenopsis*) in Durg, Baloda Bazar, Bilaspur, Korba, Koriya, Surajpur, Narayanpur, Janjgir Champa, Raigarh and Jashpur were recorded (Fig 13). The shoot and fruit borer which was recorded as major pest on brinjal (10-40% fruit damage) in Durg and Baloda Bazar was not significant in causing damage to fruits (5-20%) in Bilaspur, Korba, Koriya, Surajpur, Narayanpur, Raigarh and Jashpur. The epilachna beetle which causes comb like skeletonization on brinjal leaves could be medium in terms of causing damage (5-20%) and is wide spread in all brinjal growing areas. The sucking pests including jassid, whitefly and mealybug attacks are low to medium (10-30%) in Durg, Baloda Bazar and Janjgir Champa while they were very low in population and damage wise on brinjal in districts like Bilaspur, Korba, Koriya, Surajpur, Narayanpur, situating at northern hilly region of Chhattisgarh. The *Solenopsis* mealybug invaded India and occupied brinjal *via* cotton was recorded in brinjal growing areas of Durg, Baloda Baszar and Bilaspur while its

incidence was not noticed in brinjal growing areas of Northern hill region. In general, the major fruit borer and sucking pests incidences could not be noticed in districts of Northern hills of Chhattisgarh as the farmers mostly cultivate the local varieties/land races of brinjal which are naturally resistant to major pests.

Shoot and fruit borer | Hadda beetle | Mealybug

Fig 13. Insect pests of brinjal

2.Okra

In this crop, hoppers, borer, yellow vein mosaic, leaf curl, powdery mildew were found in all three regions. Powdery mildew and Cercospora leaf spot with moderate to high severity were found in Raigarh and Raipur districts in 2019 (Fig 14).

During the period of survey, five insect pests including fruit borer (*Helicoverpa armigera*), shoot and fruit borer (*Earias vittella)*, jassids (*Amrasca devanstans*), whitefly (*Bemisia tabaci*) and aphids (*Aphis gossypii*) were recorded as regular and major insect pest in Kanker, Durg, Baloda Bazar, Kondagaon, Janjgir Champa of Chhattisgarh. The fruit borer damage ranged from 20-30% in Kanker and Durg while it was 5-15% in Baloda Bazar, Kondagoan and Janjgir Champa. Wide spread occurrence of shoot and fruit borer was noticed in all districts which ranged from 20-40% had considered as major pest. The hopper burn symptoms produced by the jassid was up to 25% in Baloda Bazar and Kondagoan whereas in Kanker, Durg and Janjgir Champa, it was only 10%. The density of whitefly was high (30-40 adults/plant) in Baloda Bazar, Kondagoan and Durg while it was 15 adults/plant in Kanker and Janjgir Champa. Aphid infestation was not common in all districts which was noticed in Kanker with the damage of 10-15%. There are disparities on the incidences of sucking pests in okra might be due to the cultivation of local varieties or land races of okra which are suspected to be tolerant/resistant to sucking pests.

Okra yellow vein disease | Okra leaf curl disease

Fig 14. Viral diseases recorded in okra

3. Cucurbitaceous vegetables

Bitter gourd, bottle gourd, ridge gourd, pumpkin and cucumber are mostly grown in all three regions. Bitter gourd, bottle gourd and ridge gourd found to be infected with leaf crinkle, mosaic, powdery mildew, fruit fly and whitefly. Pumpkin infected with powdery mildew, mosaic and fruit fly. Cucumber mostly found infected with mosaic and leaf minor (Fig 15).

Two insect pests which were recorded on cucurbit crops during surveys 2019-2020 including fruit fly (*Bactrocera cucurbitae*) and red pumpkin beetle (*Aulacophora foveicollis*) have been reported to emerge in bitter gourd and bottle gourd from other cucurbitaceous crops. The fruit fly caused significant damage to the fruits of bitter and bottle gourd (30-60% fruit damage) while 5 to 10 red pumpkin beetles were recorded per plant. Other pests including serpentine leafminer (5-10%), aphids (5-15%), epilachna beetle (15-30%) and leaf eating caterpillar (*Diaphania indica*) (10-15%) were recorded occurring regularly in cucurbits growing areas of Chhattisgarh (Balod, Durg, Baloda Bazar).

Pumpkin beetle | Cucurbit caterpillar | Hadda beetle damage

Fig 15. Pests observed on cucurbits

4. Gardenpea

Powdery mildew was the major disease with moderate to high severity, however, the incidence was up to 20% in Raipur, Mahasamund, Raigarh and Jashpur districts. Aphids and leaf minor were the other important biotic stresses.

5. Cruciferous vegetables

Among the cruciferous vegetables, cabbage, cauliflower and knol khol are mostly grown in this region. Only few pests attacking crucifer crops was noticed during surveys 2019-2020 which includes tobacco cutworm (*Spodoptera litura*) and aphids (*Aphis gossypii*). Among them, tobacco cutworm is a defoliator and caused 20-30% leaf damage while the damage by aphids was only 5-10%. Diamond back moth and jassids were also noticed.

(E) Fruits and other crops

1. Papaya: Papaya grown in most parts of the state. Mealybug, mosaic, ringspot and leaf curl disease are noticed. Mosaic disease was found in severe form in this region (Fig 16).

2. Mango: It is mostly grown in northern part of Chhattisgarh, malformation and hopper incidence are found the major biotic stresses.

3. Guava: Wilt and mealybug are the major biotic stresses.

4. Cashew: It is mostly grown in southern part and some parts of central region of Chhattisgarh. Stem borer/ bark caterpillar are found to be the major biotic stresses.

5. Sugarcane: Inter node borer and red rot are found the major biotic stresses.

Papaya ringspot disease

Fig 16. Symptoms of papaya ringspot disease

III. Incidence and distribution of whitefly (*Bemisia tabaci*) in Chhattisgarh

1. Incidence

Whitefly, *Bemisia tabaci* is one of the polyphagous pests infesting variety of agricultural and horticultural crop plants and is a vectors of >100 plant viruses belonging to Begomivruses. The virus transmission efficiencies of various genetic groups of *B tabaci* have been reported to be different. Therefore, it is essential to determine the incidence and distribution of *B. tabaci* and their transmission efficiencies with respect to begomoviruses in various crops across Chhattisgarh.

Extensive surveys were conducted during 2019-21 to monitor whitefly, *B. tabaci* populations in 22 districts of Chhattisgarh state. *B. tabaci* populations were recorded on three leaves per plant (bottom, middle, top). Leaf was carefully turned over by holding the petiole from single main stem and whitefly adult present was counted on randomly selected 10 plants in a field in a zigzag manner for recording incidence of *B. tabaci*. Whitefly incidence was observed in all the surveyed locations in open field conditions, which differed significantly among host plants as well as across the various geographical locations. During survey, whiteflies were recorded on 16 different host plants namely brinjal, bhendi, tomato, chilli, lab lab bean, cowpea, cotton, cucumber, dolichos bean, urd bean, mungbean, ricebean, bottle gourd, amaranthus, ridge gourd and bitter gourd.

Among the eight host plants, highest incidence was recorded on brinjal, followed by cotton, bhendi, tomato etc. Among the pulses and vegetables, brinjal was the most predominant vegetable crop grown in Chhattisgarh. The whitefly population ranged from 5.6 to 55.4 per plant across the 22 districts. Highest

incidence of *B. tabaci* on brinjal was recorded in Dhamtari, Durg and Raipur districts (55.4/plant). However, whitefly incidence on brinjal in northern districts (Jashpur, Sarguja, Surajpur) and southern plateau (Bastar, Narayanpur, Kondagaon) was very low (only 2-8/plant). Large scale cotton crop was observed in Berla of Bemetara district where significant whitefly population was recorded (34/plant) whereas no leaf curl symptoms were observed. Significant higher populations of *B. tabaci* (18/plant) was recorded on bhendi in Kumhari of Durg district followed by Bohardi of Balod district (12/plant). Whitefly transmitted begomoviruses incidence (MYMIV, ToLCKV, etc) was very high (50-60%) in Durg, Bemetara and Raipur districts as compared to other locations/districts. Moderate populations of *B. tabaci* was recorded on mungbean, urdbean, cucumber, cowpea, tomato and chilli (8-12/plant). However, a very low population was recorded on bitter gourd, lab lab bean, rice bean, amaranthus, ridge gourd across the districts (2-4/plant) (Fig 17 & 18). Overall, the whitefly populations were more predominant in central region i.e. Durg, Raipur, Bemetara as compared to northern and plateau regions of the state.

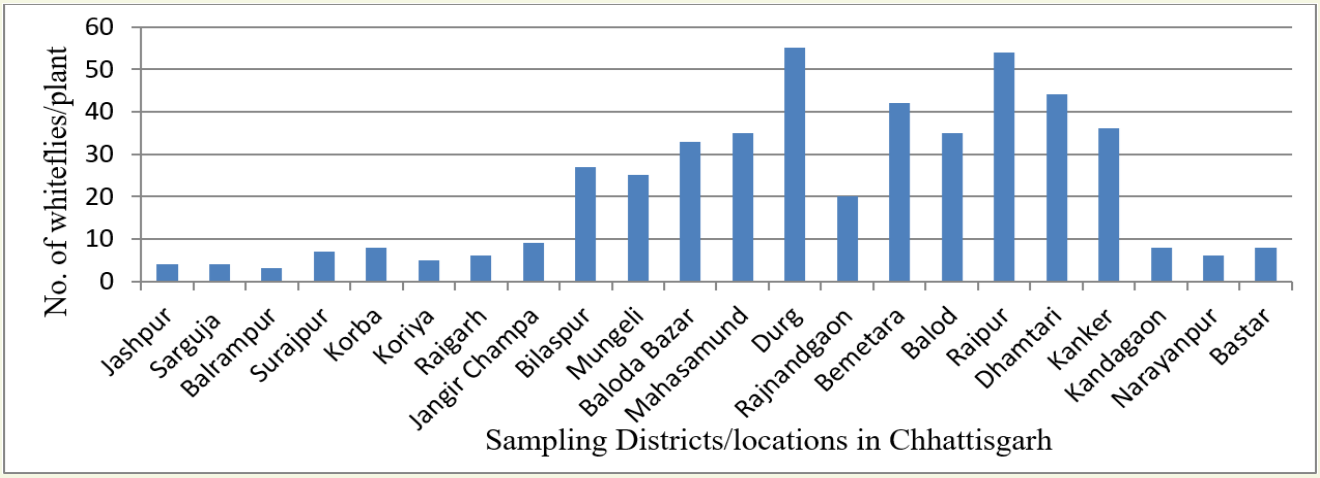


Fig 17. Incidence of *B tabaci* populations in various districts of Chhattisgarh (across crops)

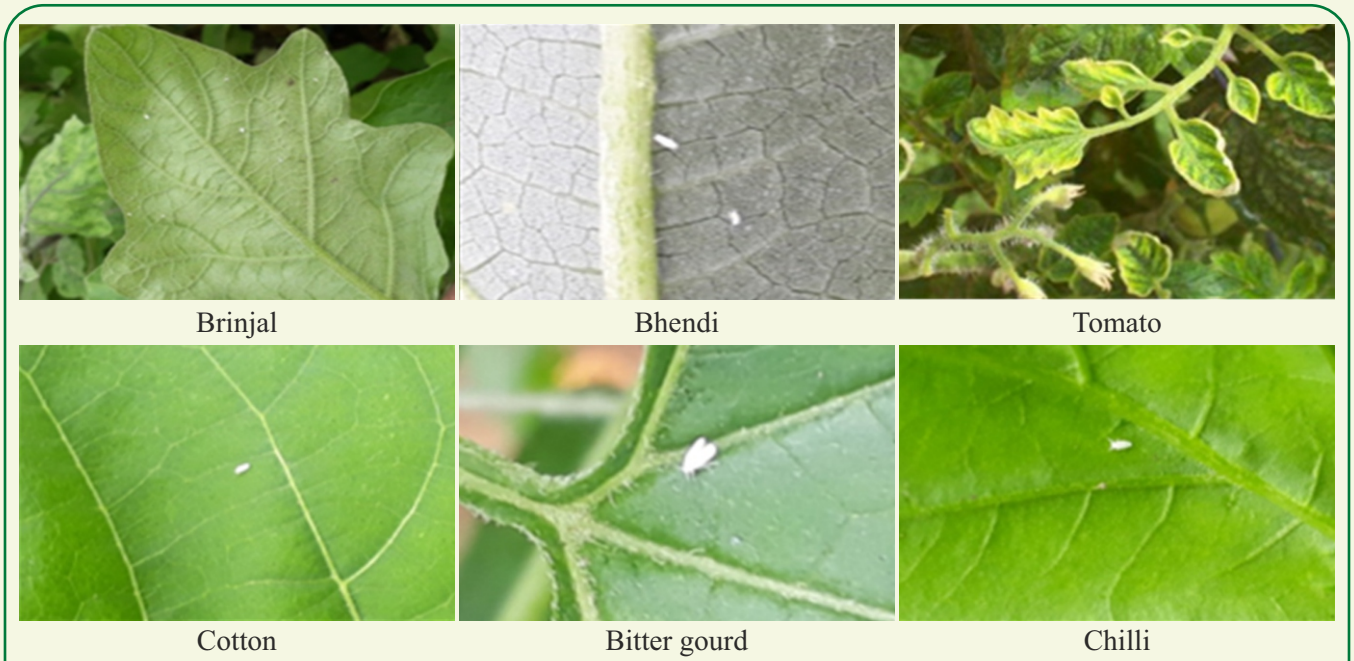


Fig 18. *B. tabaci* feeding on different host plants

2. Population dynamics

The dynamics of *B. tabaci* was studied on 14 different crops during two consecutive *kharif* seasons i.e. 2017 and 2019 and summer 2018. The number of whitefly adults per plant (from three leaves, one each from upper, middle and lower section of the plant was monitored in each field during morning hours). The genetic group of *B. tabaci* has been identified as Asia II-7. Very low populations of whitefly (4.2 whiteflies/plant) were recorded on bitter gourd, ridge gourd, mung bean, urd bean and cowpea during *kharif* season (Fig 19). However, the whitefly population on urd bean and cowpea was four times higher during summer crop as compared to *kharif.* Significantly high populations of *B. tabaci* were recorded on brinjal in three seasons as compared to other hosts. Moderate populations were recorded on tomato, bhendi, rice bean and bottle gourd. Very interesting, very high incidence of *B. tabaci* was recorded in summer crop as compared to *kharif* which has been to due favourable temperatures in microclimate in the absence of rains.

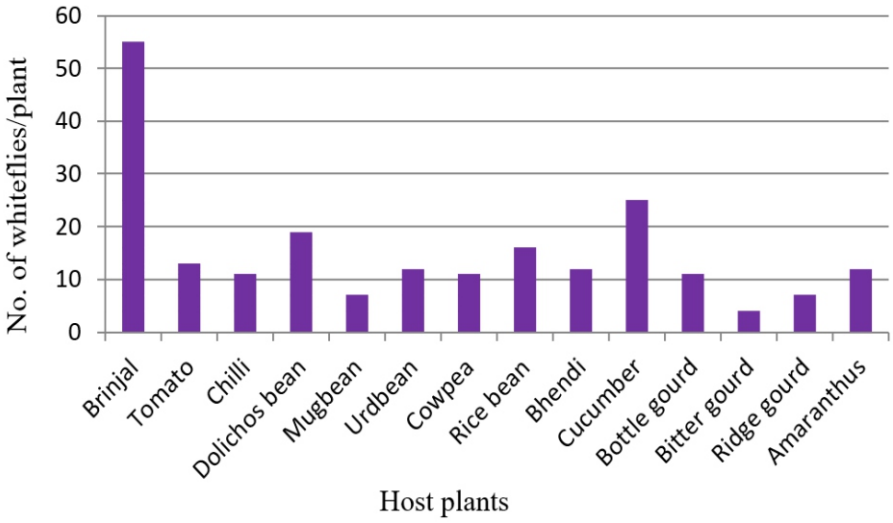


Fig 19. Incidence of *B. tabaci* in various host plants in central region of Chhattisgarh (Raipur)

3. Distribution of genetic groups

A total of 7 distinct genetic groups namely MEAM-1, Asia 1, Asia II-1, Asia II-5, Asia II-6, Asia II-7 and Asia III were identified and recorded in Chhattisgarh state including two new genetic groups, Asia II-6 and Asia III for the first time. Another genetic group Asia III was recorded only in Kanker. Within Chhattisgarh, Asia 1 is distributed in southern plateau while Asia II-7 and MEAM-1 are widely distributed in central region. However, Asia II-1 is distributed in northern region of Chhattisgarh (Fig 20).

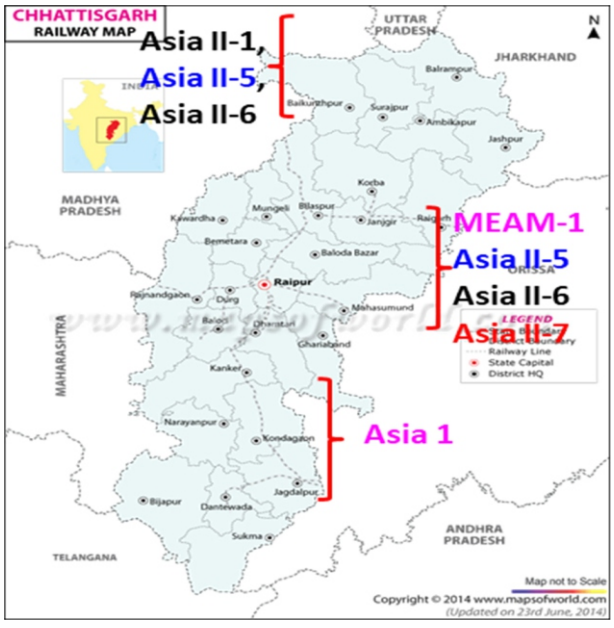


Fig 20. Map depicting distribution of genetic groups of *B. tabaci* in Chhattisgarh

Reasons for whitefly and whitefly transmitted begomoviruses outbreak in Chhattisgarh

The presence of population of whitefly vector (*B. tabaci*) of begomoviral diseases counted during survey in the central region of Chhattisgarh suggest most of the places recorded high population (>10 per plant) whose density is very much sufficient for horizontal transmission of begomoviruses efficiently. Cultivation of brinjal, chilli, tomato and cowpea throughout the year facilitates survival of whitefly vector as well as persistence of begomoviruses infecting solanaceous and leguminacous crops in this region. Besides, whitefly was also observed in several weed species and home garden crops which may be considered as one of the sources for virus and vector survival as there would be a carryover effect between seasons. Field experiments conducted in central plain zone suggest that a very high incidence of *B. tabaci* occurred in summer crop as compared to *kharif* crop which possibly due to favourable temperatures in microclimate. *B. tabaci* followed type II pattern, wherein the insect population increased initially and decreased afterwards and remained very low for a few weeks but recovered again towards the end of crop season and then slowly disappeared completely during *kharif* season. In type-III pattern, most crops in which the whitefly population remained on the crop throughout the season, population size increased gradually till it peaked towards the midseason and declined afterwards during summer season. In another study, it found that the genetic groups of *B. tabaci* have been identified as Asia II-7 and MEAM1 in the central region. The efficient virus transmission by MEAM-1, Asia II-7 therefore suggest possibility of the high incidence and emergence of begomoviral diseases in these ecological zones particularly on vegetable crops could be due to (i) four times increase in the area of vegetable cultivation one decade (ii) availability alternative crop species (weeds) round the year facilitating survival of vector and virus and (iii) year round cultivation of tomato, chilli, cowpea and to some extend cucurbitaceous vegetables which serves as reservoir.

IV. Incidence and distribution of thrips spp.

Surveys were conduct in year 2021 at three major vegetable growing district of Chhattisgarh namely Durg, Bemetara and Raipur on tomato, brinjal and chilli crops for studying the distribution of thrips sp. in vegetable crops in Chhattisgarh. A total of seven species of thrips belong to four genera *viz. Scirtothrips dorsali, Thrips hawaiensis, Thrips palmi, Thrips flourm, Thrips parvispinus, Haplothrips ganglbaueri, Franklinella schultzei.* were recorded on chilli, brinjal and tomato in Chhattisgarh of which *H. ganglbaueri* and *T. parvispinus* were reported for the first time from Chhattisgarh state (Fig 21). These thrips species are economically very important in transmission of tospoviruses in vegetable crops not only in India but also across the world. The most abundant thrips species reported in this study was *Thrip dorsalis* with 54% of total specimens followed by *T. palmi* 23.2%.

The population of thrips per plant were recorded on vegetable and pulse crop in different district of Chhattisgarh. Highest mean population was recorded on chilli (4.81) followed by soybean (4.4), whereas the lowest thrips population were recorded on tomato (1.43) followed by brinjal (2.7) (Fig 22).

Fig. 21. Map depicting sampling sites, sample size and distribution of thrips species in Chhattisgarh

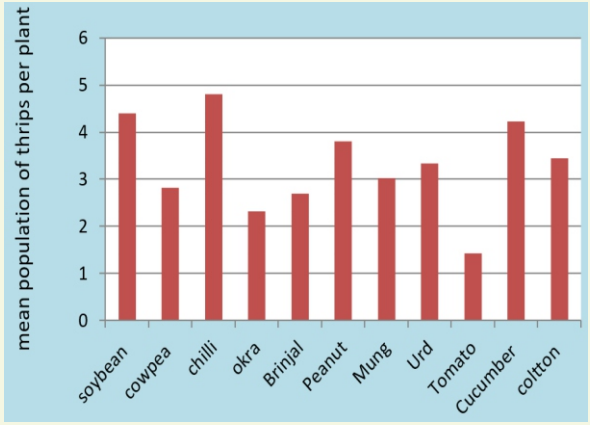


Fig 22. Mean population of thrips on different host plants during *rabi* season 2022

V. Occurrence of plant parasitic nematodes

Surveys were carried out for identification and population estimation of economically important plant parasitic nematodes infecting different crops in different districts of Chhattisgarh. A composite sample comprising rhizospheric soil of 200 cc along with 5g root were collected randomly based on at least 5 cores from a field (one acre). Nematodes were extracted from soil and root samples by Cobb sieving and decanting method.

Rice: Rice fields surveyed during *kharif,* 2016 at nursery stage in Raipur and Durg districts were found heavily infested with root-knot nematode, *Meloidogyne graminicola* (Fig 23). In the village Chataud (Arang block, Raipur district) root-knot nematode population was found to be very high at the rate of 1248 nematodes per 200 cc of soil+5 g of root. In Bilaspur district, the paddy fields at Dhuma and Lormi blocks were found infested with root-knot nematode. During *kharif* 2018 in Dhamtari district rice root-knot nematode was found with very low infestation i.e., 25-100 nematodes per 200 cc of soil+5 g of root. It may be because of farmers practising direct seeded rice in this district.

Fig 23. Rice root knot nematode

Pulse and oilseed crops: The major crops surveyed were fieldbean, pigeonpea and soybean during *kharif* 2016. The major nematodes present in the samples were *Meloidogyne incognita* and *Helicotylenchus* spp. During *kharif* 2017, the major crops surveyed were blackgram, pigeonpea, soybean, cowpea and clusterbean. The major nematodes identified were *Meloidogyne incognita* and *Helicotylenchus* spp.

Vegetables: The river basin area of Durg district where vegetable cultivation is on large scale was found heavily infested with *M. incognita* followed by Bemetera, Raipur, Bilaspur and Kabirdham districts during *kharif* 2016. During *kharif* 2017, Kawardha, Balodabazar, Bastar, Kondagaon, Kanker and Dhamatari districts were surveyed.

Solanaceous crops: During *kharif* 2016, soil and root samples collected from tomato crop from Bemetera, Kabirdham and Bilaspur districts were found heavily infested with *M. incognita* with a population range of 278-589 per 200 cc of soil +5 g roots followed by *Helicotylenchus* spp with population range of 106-156 per 200 cc of soil +5 g roots. During *kharif* 2017, the soil and root samples were collected from above mentioned districts and the population range of *M. incognita* was 226-364 per 200 cc of soil +5 g roots followed by *Helicotylenchus* spp with population range of 56-146 per 200 cc of soil +5 g roots.

In brinjal during kharif 2016, heavy infestation of *M. incognita* with a population range of 236-579 per 200 cc of soil +5 g roots followed by *Helicotylenchus* spp. with population range of 158-264 per 200 cc of soil +5 g roots in Durg, Bemetera, Kabirdham and Bilaspur districts. In *kharif* 2017, heavy infestation of *M. incognita* was found in Balodabazar, Janjgir Champa and Kanker districts with a population range of 246-347 per 200 cc of soil +5 g roots.

Okra: During kharif 2016, Soil and root samples collected from okra crop from Raipur, Durg, Bemetera, Kabirdham and Bilaspur districts were found heavily infested with *M. incognita* with a population range of 255-459 per 200 cc of soil +5 g roots followed by *Helicotylenchus* spp with population range of 69-154 per 200 cc of soil +5 g roots. During kharif 2017, soil and root samples from Okra from Bastar, Kanker and Balodabazar districts were found infested with *M. incognita* and *Helicotylenchus* spp with a population range of 268-324 per 200 cc of soil +5 g roots.

Cucurbits: In bittergourd, heavy infestation of *M. incognita* (population range of 114-249 per 200 cc of soil +5 g roots) and *Helicotylenchus* spp (population range of 57-187 per 200 cc of soil +5 g roots) in Durg and Bilaspur districts. Similarly in bottlegourd, both the nematode species were found to infest heavily with a population range of 159-216 per 200 cc of soil +5 g roots and 105-106 per 200 cc of soil +5 g roots, respectively in Bilaspur districts (Fig 24)

Fig 24. Heavy infestation of root knot nematode in bottle guard

Heavy infestation of *M. incognita* and *Helicotylenchus* spp on other crops like field bean and Coccinia were also observed in Raipur and Durg districts.

VI. Forest trees

Teakwood (*Tectona grandis* L.; Family: Lamiaceae) is largely used for poles, beams, trusses, columns, roofs, doors, window frames, flooring, planking, panelling, and staircases, and other constructional work and best timbers for furniture and cabinet-making, wagon and railway carriages. It occupies 6.05% area of the total forest area (6.32 lakhs ha) in Chhattisgarh. Two insect pests including skeletonizer (*Eutectona machaeralis*) and leaf webber (*Hyblaea puera*) are reported to cause significant damage to foliages of teakwood regularly during rainy season. These two pests were recorded on teakwood in Balod, Korba, Sarguja, Rajnandgaon and Raipur districts of Chhattisgarh during 2019-2020. The damage to foliages caused by skeletonizer ranged from 5% (winter) to 50% (rainy season) while they were 5% (winter) to 30%

(rainy season) for leaf webber. High moisture coupled with low sunshine hours are favourable climatic variables to support the rapid multiplication of these pests to cause significant damage to foliages of the teakwood, besides impacting on the girth of the trunk (Fig 25).

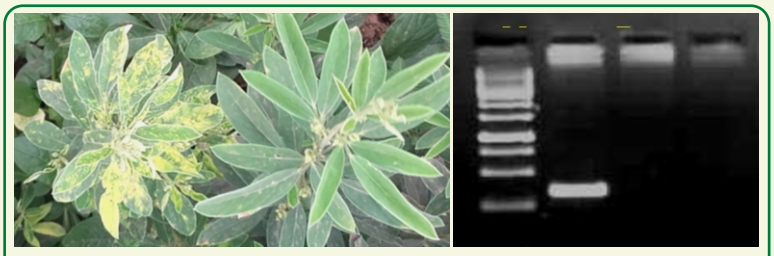
Skeletonizer damage Leaf webber damage

Fig 25. Larvae feeding on teak leaves

VII. New diseases recorded in Chhattisgarh

1. Pigeon pea yellow mosaic disease

Pigeonpea yellow mosaic disease (PYMD) was appeared in the experimental farm of NIBSM and farmers' field of Chhattisgarh. Symptoms of PYMD were characterized as yellow mosaic, mottling, shortening of leaves and stunting. Disease incidence recorded in Chhattisgarh varies from 1.5 to 6.1% and whitefly vector population was recorded as 1.8 to 3.2 per plant. Causal agent associated with PYMD identified as begomovirus by PCR (Fig 26). This is the first report of the occurrence yellow mosaic disease in pigeon pea in the central India particularly in Chhattisgarh.



a) Pigeonpea yellow mosaic disease (b) PCR confirmation

Fig 26. Infection of yellow mosaic disease in pigeonpea

2. Witches broom disease of karonda (*Carissa carandas*)

In 2017, a few karonda plants (less than 5%) at the experimental farm of NIBSM showed witches' broom symptoms characterized with smaller leaf size, shortened intermodal length, proliferation of more leaves and shoots, bushy appearance (Fig 27). Further investigations confirmed that it was witches broom reported for the first time in Chhattisgarh.

Fig 27. Symptoms of witchesbroom on karonda

3. Witches broom disease of *Ziziphus*

Ziziphus rotundifolia plants growing in the experimental farm of ICAR-NIBSM, Raipur and farmers' fields in various parts of Chhattisgarh showed symptoms of rosetting, proliferation of axillary shoots and witches' broom-like appearance (Fig 28). Among 22 districts surveyed in Chhattisgarh, the witches' broom disease was noticed in the five districts. The disease incidence was recorded to vary between 4.0 to 66%. Positive PCR amplification with universal primers specific to phytoplasma with total DNA extracted was obtained only with symptomatic leaves.

Fig 28. Witches broom symptoms and detection of phytoplasma by PCR

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Supplementary material 1. Incidence of various biotic stresses in crops in Chhattisgarh

Village/Block/ Farmer name	Latitude /longitude	Name of the crop	Viral Disease	Incidence (%)
Khorsi/Arang/Raipur Kuman Sahu	N21°25'58" E82°2'49"	Tomato	Leaf curl	20
		Chilli	Leaf curl	38
Hardikala/Bilaspur/ Mr. Sarju Prasad Khausik	N21°59'23" E82°10'7"	Tomato	-	-
Kuthur/Nawagarh/ Janjgir-Champa/ Mrs Rani Bai	N21°54'34" E82°31'3"	Chilli	Leaf curl	8
Baradwar/Sakti/ Janjgir-Champa	N22°05'5" E82°48'8"	Tomato	Leaf curl	30
Pandripani/Raigarh/Raigarh/ Mr. Prahlad Patel	N22°57'0" E83°12'7"	Mungbean	Leaf crinkle	15
			Yellow mosaic	70
		Mungbean	Leaf crinkle	10
			Yellow mosaic	62
		Tomato	Leaf Curl	10
Karrabhauna/Basna/ Mahasamund/Mr. Daya Das	N21°21'23" E82°53'32"	Mungbean	Yellow mosaic	30
			Leaf crinkle	5
		Urd bean	Yellow mosaic	10
Memra/Pithora/ Mahasamund/ Mr. Lakhan lal	N21°15'46" E82°35'25"	Mungbean	Yellow mosaic	10
Samhar/Bagbahra/ Mahasamund/Mr. Tushar Chauhan	N21°04'18" E82°21'02"	Tomato	Leaf curl	38
Simga/Raipur	N21°36'53"/ E81°42'14"	Brinjal	Mosaic	20
Sendri/ Bilaspur - Marwahi Bypass Road/Bilaspur Bishnu Kevar	N22°10.870'/ E82°07.906'	Bhendi	Yellow vein mosaic	72
		Sponge gourd	Leaf crinkle	10
		Cow pea	Yellow mosaic	40
Kanjipani/ Bilaspur - Katghora Road, Chaitma/Pali/ Korba Mr. Tirumohan Singh	N22°26'16"/ E82°25'25"	Cow pea (long)	Yellow mosaic	80
		Cow pea (short)	Yellow mosaic	10
		Cow pea	Yellow mosaic	70
Piperland/Pali/Korba Mr. Ramlal	N22°56'13"/ E82°25'33"	Tomato	Leaf curl	80
		Cucumber	Mosaic	5
Ducksola/Chirimi/Koriya Mr. Vidyar Singh	N23°9'6"/ E82°23'2"	Tomato	Leaf curl	90
		Chilli	Leaf curl	60
Umzarh/ Baikunthpur/Koriya Mr. Lakhan Ram	N23°18'16"/ E82°28'411"	Tomato	Leaf curl	64

Mahora/Dabripara/Baikunthpur/ Koriya Mr.Thankur Prasad	N23°18'4"/ E82°37'29"	Tomato	Leaf curl	70
Ranai/ Tenduwa/ Baikunthpur/ Koriya Mr. Balmukund	N23°16'17"/ E82°42'45"	Urd bean	Yellow mosaic	30
Bhaiyathan Rd/ Pachira/ Surajpur/ Surajpur Mr. Theerth Ram	N23°11'921"/ E82°54'269"	Mung bean	Yellow mosaic	
		Tomato	Leaf curl	30
		Mungbean	Yellow mosaic	28
Dharima/Ambikapur Mr. Jagdish Singh	N23°8'22"/ E83°8'55"	Black gram	Yellow mosaic	90
Katangtharai/ Pathalgaon-Lailunga Rd, Charkhapara/ Jashpur Mr. Jevithra	N22°32'0"/ E83°26'6"	Tomato	Leaf curl	4
Chachia/Korba / Korba Mr. Unnikrishnan	N22°20'50"/ E83°0'50"	Urd bean	Yellow mosaic	35
		Tomato	Leaf curl	23
		Cowpea	Yellow mosaic	4
		Bottle gourd	Leaf crinkle	-
		Chilli	Leaf curl	17

Supplementary material 2. Feedback of farmers/KVK staff on incidence of biotic stresses in Chhattisgarh

Village/Block/ District	Latitude /longitude	Name of the crop	Pest/ Disease	Incidence (%)	Remarks
Bhusrenga/ Dhamtari	N20°50'16" E81°40'33"	Rice	Bacterial leaf blight	10-20	Farmer rated BLB as major disease, followed by BPH and sheath blight. Rice-rice/Lathyrus cropping system. Cassia weed found crinkle on road side, Xanthiam showed yellowish with crinkle symptoms. Severe incidence of BPH.
Mahud Machandur/ Charma/ Kanker	N20°31'25" E81°22'1"	Rice	Brown plant hopper	>90	Farmers rated BPH, sheath blight and false smut as an important biotic stress in rice. Rice-Coriander-Urd/ Lathyrus / mung bean cropping system followed but they were affected with yellow mosaic disease. Earlier they found neck blast and now the false smut is emerging. Wild mung bean also collected from this place.

Dokla/ Dongari/ Dhamtari/	N20°31'58" E81°20'4"	Brinjal	Shoot and fruit borer	35	Farmers are continuously growing vegetables like tomato, brinjal, chilli, bitter gourd, cow pea, vegetable type and cabbage. Whitefly was found less 1-3 per plant as the field was regularly sprayed with imidacloprid. No knowledge on viral diseases.
		Chilli	Leaf curl	48	
		Bitter gourd	Leaf crinkle	82	
		Cow pea	-		
Telguda/Charama/ Kanker	N20°31'13" E81°21'56"	Rice	Blast	80	Severe incidence of blast disease in rice. No vegetables were found nearby areas. Rice-pulse-fallow system followed.
Makri Singrai/Kanker/ Kanker	N20°19'35" E81°27'31"	Bhendi	Cercospora leaf spot	30	*C. scarabaeoides* found affected with yellow mosaic disease.
		Pigeon pea	-	-	
Nayapara/ Singanpur/ Narharpur/ Kanker	N20°1'37" E81°35'5"	Rice-Transplaning	Blast	>75	DSR rice found more incidence of brown spot, and less of blast, sheath blight, BPH. This area is cultivated mainly rice followed by Kulthi, Mungbean, Urd bean, then fallow. But these pulses affected with yellow mosaic disease Blast and false smut are the recently emerged diseases.
		Rice-DSR	Blast	<26	
		Maize	Maydis blight	<10	
		Finger millet	Leaf blast	10-15	
		Urd bean	Yellow mosaic	12	
Taragaon/ Bastar/	N19°18'50" E81°50'46"	Rice-DSR	Brown spot	51	
		Rice-Trans	Blast	28	
Chitrakot/ Tiratha/ Jagdalpur/ Bastar	N19°12'18" E81°41'56"	Cow pea	-	-	
Badanji/Lohandiguda/ Jagdalpur/ Bastar	N19°9'33" E81°47'8"	Urd bean	Yellow mosaic	14	YM disease
Pralee/Chhapar-bhanpuri/ Jagdalpur/ Bastar	N19°9'3" E81°50'33"	Rice	Blast	21	

Badechakwa/ Jagdalpur/ Bastar	N19°9'44" E81°49'44"	Maize	-		
		Psoro millet	-		
		Ragi	Blast	<5	
		Khatta Bhaji	-		
		Brinjal	Root knot	-	
		Tomato	Leaf curl	18	
		Turmeric	-		
		Ginger	-		
Shampur/Lanjoda / Kondagaon	N19°44'0" E81°44'35"	Rice	Brown spot	25	DSR, no awareness on viral disease and vector. No diseases observed in pulses. As per farmer view the yellow mosaic was appeared in last year and this year due to late rainfall the green flush was not available.
		Urd bean	-	-	
		Mung bean	-	-	
		Cow pea	-	-	
Bedma/ Keshkal / Kondagaon	N19°59'9" E81°36'16"	Brinjal	Shoot and fruit borer	38	Aware of viral disease and not transmission by vectors. The problem in brinjal cultivation during *kharif* is water stagnation.
		Dolichos bean	Yellow mosaic	47	
Malaldobri/ Bardevri/ Kanker	N20°18'44" E81°24'47"	Rice	Stem borer	14	
		Mung bean	Powdery mildew	10	
			Yellow mosaic	40	
		Red gram	-	-	
		Brinjal	Shoot and fruit borer	10	
		Bhendi	Powdery mildew	70	
Malaldobri/ Bardevri/ Kanker/	N20°18'44" E81°24'47"	Rice	Sheath blight	29	Mungbean grown as bund crop and affected with yellow mosaic (>40 %), not aware of viral disease and vector. Chickpea borer comes in winter.
			Blast	>35	
			Brown spot	<5	
		Chickpea	Borer	>50	

Markatlola, Kanker, Chhattisgarh	N20°18'5" E81°20'34"	Rice	BLB	>90	Severe outbreak of BLB in MC13 hybrid of Danish company. Farmers not aware of BLB.
		Rice	BPH		Severe out break BPH due to excess N fertilizer application, closed spacing and water stagnation
Dabena/ Narharpur/ Kanker/	N20°18'31" E81°19'42"	Rice	-	>90	
Chhindgaon/ Durg/	N20°28'19" E81°5'25"	Rice	Brown spot	- -	Unaware of viral disease
		Dhania	-	-	
		Chilli	Leaf curl	-	
		Bhendi	Yellow vein mosaic	- 13	
Daundi Lohara/ Rajnandgaon	N20°47'57" E81°3'9"	Pumpkin	Yellow mosaic		
		Tomato	Leaf curl		

Supplementary material 3. Important biotic stresses of different crops in Chhattisgarh

Crop	Diseases	Insect pests	Emerging
Rice	Brown spot (DSR), blast, sheath blight (Transplanted)	Brown plant hopper	False smut
Wheat	Rust	Pink stem borer	
Ragi	Blast		
Chickpea/ Pigeonpea	Wilt	Borer	Yellow mosaic (in pigeon pea)
Mungbean/ Urdbean/ Horse gram	Powdery mildew, yellow mosaic		
Dolichos bean	Yellow mosaic		
Tomato	Blight, Leaf curl, wilt spotted wilt		Early leaf blight
Chilli	Leaf curl	Thrips	
Brinjal	Fruit and shoot borer		Root knot nematode
Cucurbitaceous	Mosaic and mosaic & leaf crinkle		
Cucumber	Mosaic and mosaic & leaf crinkle		
Bhendi	Yellow vein mosaic, Leaf curl	Jassids	
Papaya	Leaf curl, ringspot	Mealybug	

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Baronda, Raipur-493 225, Chhattisgarh