ISSN: 2338-1345 – Vol. 9 (1) 45-57 Journal online http://journal.bakrie.ac.id/index.php/APJSAFE

Asia Pacific Journal of Sustainable Agriculture Food and Energy (APJSAFE)

Seasonal incidence of foliar diseases of Cowpea and their eco-friendly management through a shifting of planting time

Sanchari Roy and Amitava Basu *

Department of Plant Pathology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal, India

**Corresponding author's E-mail address: basuamitava1961@gmail.com*

Abstract— A thorough study was conducted on foliar diseases of cowpea under widely cultivated cowpea producing areas of Nadia & Hooghly district of West Bengal. The areas were Mondouri, BaraJaguli Instructional farm, Muragacha, Rajberia, Chakdaha, Madanpur, Basantapur, Kalyani Incheck farm, Kalyani "C" block farm under Nadia district and Mogra under Hooghly district. The fixed plot survey was conducted during Pre-kharif, Kharif & Rabi season. Seven fungal pathogens were isolated during survey period and these are- *Alternaria alternata, Colletotrichum capsici, Corynespora cassicola, Fusarium ciceri, Rhizoctonia solani, Sclerotium rolfsii, Curvularia lunata*. Among these pathogens, *Alternaria alternata*, *Colletotrichum capsici*, and *Corynespora cassicola* were found to be most important pathogens during Pre-Kharif, Kharif & Rabi season respectively. Shifting of planting time was carried out for avoiding the plant pathogen at a particular growth stage of the crop. Five cultivars (Kashikanchan, Triguna, Manikanchan, KSP-170 &Arka garima) were selected for the experimental trial for three different seasons against the main dominating pathogens. For Pre-Kharif planting of cowpea, the 1st week of March, for Kharif planting time, 1st week of June were established as most profitable. During Rabi season for planting of three varieties *viz.*Kashikanchan, Manikanchan& KSP-170, 4th week of November and for Triguna & Arka Garima, 2nd week of November were found to be economically most profitable due to least incidence of diseases and maximum yield.

Keywords— **cowpea, disease survey, seasonal incidence and cultural management**

INTRODUCTION

Cowpea (Vigna unguiculata L. Walp) a dicotyledonous plant belonging to the family fabaceae, genus Vigna (Cronquist, 1988) is of major importance to the livelihood of millions of people in the tropics (Quin, 1997). Cowpea is one of the important Kharif legumes grown in India. It is a warm season crop, well adapted to many areas of the humid tropics and subtropical zones. Cowpea is tolerant to heat and dry conditions, but is intolerant to frost (Davis et al., 2000) and it also has the useful ability to fix atmospheric nitrogen through its root nodules. In India, cowpea is grown on about 0.5 million ha with an average productivity of 600 to 750 kg grains/ha (Ahlawat and Shivakumar, 2005). It is grown throughout India for its long, green vegetable pods, seeds, and foliage for fodder (Mandalet al, 2009). Now-a-days foliar disease of cowpea have become a major constraint for vegetable growers of West Bengal. Sometime the disease(s) cause huge crop loss. During last few years, the weather has undergone a significant change world over. This had a direct bearing on cowpea disease outbreak and consequently the crop losses. In India, the weather had a pronounced effect on development of new virulence of different foliar fungal pathogens. Hence, a suitable disease incidence warning system is very much essential for the vegetable growers of West Bengal in order to reduce the crop losses during period of severe outbreaks. On the other hand, adjustment of planting time is not only an eco-friendly but also a non-chemical approach for plant disease management (Tu, J. C., 1993). So far as the pathogen(s) are concerned for a particular disease for a particular season such as Pre-Kharif, Kharif & Rabi season, this eco-friendly management strategies should be adopted, where growers are usually habituated to apply agrochemicals and pesticides injudiciously. Keeping these views in mind, the present investigation were undertaken with the following objectives:

i) Survey on seasonal incidence of foliar fungal diseases of Cowpea to alert the farmers in advance about the severe outbreak and possible crop losses.

ii) Adjustment of time of planting to avoid the disease menace due to important foliar pathogens in different cropping seasons.

MATERIALS AND METHODS

The field experiments were carried out at 'Agricultural Instructional Farm', BCKV, Jaguli, Nadia, West Bengal.

The farmis located very close to tropic of Cancer at approximately 22o56'N latitude and 88o32' E longitude. The altitude of the site is about 12 meter above the mean sea level. In this region, seasons are broadly classified into: (i) Pre-Kharif (March to May), (ii) Kharif (June to August) and (iii) Rabi (November to February). Neither the summer is too hot nor is the winter too cold. The climate of the experimental site is subtropical humid. The soil is sandy-loam in texture with neutral pH-6.0. The Fixed plot survey was carried out to record the real time seasonal incidence of different leaf spot diseases of cowpea on 10 different cowpea growing areas of Nadia & Hooghly district during 2014-15 cropping seasons. The areas were Mondouri 22.9358° N, 88.5100° E, Jaguli Instructional farm, 22.9460° N, 88.5366° E Muragacha22.6965° N, 88.4189° E, Rajberia22.9187° N, 88.5505° E, Chakdaha 23.0765° N, 88.5293° E, Madanpur 23.0089° N, 88.4912° E, Basantapur, Kalyani Incheck farm 22° 58' 30.3024" N 88° 26' 4.2324" E, Kalyani "C" block farm and Mogra23.03967,88.12284E. Final yield data was recorded after last harvesting of the pod. Yield loss was calculated by the following formula-

$$\text{Yield loss (\%)} = \frac{\text{Attainable yield} - \text{Actual yield}}{\text{Attainable yield}} \times 100$$

A. Isolation of the pathogen:

Diseased leaves having numerous spots collected from the field were cut into 0.5x0.5 cm pieces containing only 1 spots and initially rinsed with sterile distilled water. Then, they were surface sterilized with 0.1% mercuric chloride (Hgcl2) solution for 45 seconds followed by 5-6 times serial washing with sterilized distilled water. Surface sterilized diseased parts were then placed at the centre of a Petri plate containing 20 ml of sterilized water agar medium supplemented with antibiotic chloramphenicol @ 50mg/litre. Plates were incubated at 28±1oC temperature for48-72 hrs. The mycelial growth that radiated from the diseased tissue was picked up and inoculated on to the fresh PDA slant. Inoculated PDA slants were then incubated at 28±1oC temperature for 7 days.

B. Identification of the pathogen:

After isolation of fungal pathogen in purified form, it was grown on culture medium, kept for 8-10 days for sporulation. The slides were prepared from cultures or infected parts for morphometric studies of fungal spores, spore bearing and other structures like pycnidia, sclerotia, acervulus etc. Sections of affected of were also made for getting clear idea about the structures of fungal fruit bodies like pycnidia or acervulus and types of conidia and conidiophores they possessed. Microphotograph of all fungal structures was taken with help of Leica binocular microscope and or Karl Zeiss Phase Contrast Microscope (under 10x, 20x, 40x & 100x) and by using Canon Power Shot A640 camera. Dimensions (length &breadth) of conidia, conidiophore, pycnidia, acervuli, sclerotia and hyphae of fungi were measured using Axio Vision (Rel. 4.8) software. Based on the morphometric characteristic, fungi were attempted to identify to the genus and or species level. The severity of disease is the proportion of area or amount of plant tissue that is diseased. Disease severity is usually expressed as the percentage or proportion of plant area or unit destroyed by the causal pathogen. For the measurement of the disease severity, disease assessment scales were used to express relative proportion of affected tissue at a particular point of time. In case of foliar disease of cowpea, disease scoring was done as per Datar & Mayee (1986).The disease severity was recorded at 7, 14, 21 and 28 days after onset of the disease in all tested cultivars for consecutive three years.

C. Disease severity scale followed:

% area infected	Scales
0	0
1% or less	1
1-10%	3
11-25%	5
26-50%	7
>51%	9

Disease severity was calculated following the formula (Mc. Kinney, 1923)

D. **Area under disease progress curve (AUDPC):** The pattern of an epidemic in terms of the number of lesions or the amount of disease tissue is given by a curve that shows the progress of the disease over time in a cropped area is called area under disease progress curve. It was calculated by following the formula (Shanner and Finey, 1977)

$$AUDPC = \sum_{i=1}^{n} [(x_{i+1} + x_i)/2] (t_2 - t_1)$$ Where,

x_{i+1} = disease severity at time t_{i+1}

x_i= disease severity at time t_i

n = number of observation

E. **Lesion Area:** It is an important parameter for describing the magnitude of the disease. Length and breadth of the lesions were measured and lesion area was calculated as per formula given Birhman and Singh, 1995.

$$\text{Lesion Area} = \pi ab/4$$

Where, a = length of the lesion, b = breadth of the lesion
Lesion area was measured during disease progress period. In each replicated plot, randomly 10 plants were selected where, lesion area was measured.

F. Environmental data was collected from Meteorological Department of Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal

G. Statistical Analysis:

The data collected were subjected to statistical analysis by Fischer's method of analysis of variance. Significance of variance among the data were calculated out by calculating the

"F" value and comparing it with tabulated values of "F" at 5 per cent level of probability. The percentage values were transformed by angular transformation. Further the treatments were compared among themselves by calculating critical difference (CD) as follows:

CD = S. Ed x t0.05 or t0.01 for error degree of freedom

Where, S. Ed is the standard error of difference of mean which was calculated by using the following formula: S. Ed± = √((2 x Error mean square)/(No. of replications)) and t0.05 is the table values of student's 't' obtained at 5 per cent probability level. The significance and non-significance of treatments at 5 per cent and 1 per cent probability level were calculated out by multiplying the S. Ed with appropriate tabulated value for error degrees of freedom.

RESULTS AND DISCUSSIONS

Under West Bengal condition, there is no information still available regarding seasonal incidence of different leaf spot diseases. Hence, a detail survey was carried out for corresponding two years cropping season in major cowpea growing areas of Nadia & Hooghly district of West Bengal. The areas are Mondouri, Jaguli Instructional farm, Muragacha, Rajberia, Chakdaha, Madanpur, Basantapur, Kalyani Incheck farm, Kalyani "C" block farm under Nadia district and Mogra under Hooghly district. In these locations Pre-kharif survey was conducted during March & April, Kharif survey was conducted during July & August and survey during Rabi season was conducted during November-December. The detail survey is presented by the table-1 given below. The results reveal that, during Pre-Kharif season, incidence of four pathogens were observed. Maximum damage caused by Alternaria leaf spot (46.3%) followed by Cercospora sp (35.6%), Curvularia sp (22.8%) &Fusarium sp (6.53%). During Kharif season, incidence of total seven pathogens were recorded. Percent incidence level was maximum in case of Colletotrichum sp leaf spot (56.8%) followed by Rhizoctonia solani (28.2%), Cercospora sp (26.8%), Curvularia sp (15.6%), Fusarium sp (12.3%), Sclerotium rolfsii (5.6%) and Choanephora sp (4.8%). During Rabi season, incidence of total three pathogens were recorded. Maximum damage was caused by Corynespora leaf spot (31.5%) followed by Alternaria sp (24.3%) and Curvularia sp (13.2%).From the record it was observed that, Alternaria leaf spot is proved to be as one of the main biotic stresses during Pre-Kharif season. The disease severity and crop losses were maximum due to Alternaria leaf spot. During Kharif season main obstacle of cowpea cultivation was the Colletotrichum leaf spot disease. It recorded highest disease severity as well as maximum crop losses. In Rabi season, Corynespora leaf spot was one of the main problems of cowpea cultivation. The Corynespora leaf spot gave maximum threats to the cowpea growers during Rabi season in West Bengal.

During Pre-Kharif season it is already observed that Alternaria alternata is most dominating pathogen of cowpea. Keeping these views in minds, the present trial was conducted to avoid Alternaria alternata. In general four planting time i.e. 1st, 2nd, 3rd& 4th week of March was selected for each & every cultivar when the appearance of Alternaria alternata actually takes place. Total five cultivars were selected for this trial and these are Kashikanchan, Triguna, Manikanchan, KSP-170 and Arka Garima.

Results from the **Table-2** reveal that all the cultivars not only exhibited least disease severity (28.67-50.10%), AUDPC (290.26-501.62) and lesion area (2.53-5.21 cm^2) but also gave the highest yield (1.65-2.46 q/ha) due to planting during 1st week of March. But for the rest planting times, the disease severity, AUDPC & lesion area due to Alternaria infection increased as well as the yield also was decreased. From the result it is finally observed that if these above mentioned five cultivars are chosen by the cowpea growers to grow during Pre-Kharif season they should follow the planting time of all these varieties during 1st week of March as compared to the other planting times (2nd, 3rd& 4th week of March). During this planting time the pathogen could not damage the crop significantly and as well as gave a better yield to the cowpea growers. The prevalent environmental condition during progress of Alternaria leaf spot infection were temp.(16.03^{0}C to 39.69^{0}C),Relative humidity(30.43% to 96.00%) and cumulative rainfall(28.07mm,54.68mm &91.35mm during 2017, 2018 & 2019 respectively).

Similar work had been done by Tu, J. C. (1993) where he observed that, the disease severity and pod discoloration caused by *Alternaria alternata* (Fr.) Keissler in bean (*Phaseolus vulgaris* L.). He noted that, delaying planting date reduced disease incidence and severity. Disease incidence and severity were negatively related to planting date and increased over time during the growing season. This result contradict the belief that early planting reduces this disease (Tu *et al*. 1988). Bean crops planted early risk more injuries and diseases (e.g., from cold, insects, damping off and root rots), which may predispose them to *Alternaria*, than do late-planted crops. Also, because of higher temperatures as the season progressed, late-planted beans caught up in growth with those planted early. Under West Bengal condition, farmers are confused about the suitable time of planting of cowpea during Pre-Kharif season. Present research findings clarify that planting during 1st week of March, the cowpea plant can escape the *Alternaria* leaf spot disease and can give competitive yield also. Hence, for Pre-Kharif planting of cowpea the 1st week of March would be the ideal time for planting.

Results from the **Table-3** reveal that all the cultivars when sown during 1st week of June not only exhibited least disease severity (25.73-61.23%), AUDPC (245.07-598.50) and lesion area (2.34-5.98 cm^2) but also gave the highest yield (1.23-2.78 q/ha). But for the rest planting times, the disease severity, AUDPC & lesion area increased as well as the yield also was decreased. From the results, it is noted critically that, if these above mentioned five cultivars are selected by the cowpea growers for planting at Kharif season they should follow the planting time of all these varieties during 1st week of June as compared to the other

planting times (2nd, 3rd& 4th week of June). During 1st week of planting, the pathogen could not cause damage the crop significantly and as well as gave a consistent yield to the cowpea growers. Because, the older plants have shown their resistance than younger plants. The prevalent environmental condition during progress of Colletotrichum infection were temp.(24.04^{0}C to 37.61^{0}C),Relative humidity(57.43% to 98.86%) and cumulative rainfall(200.59 mm,146.44 mm & 214.06 mm during 2017,2018 & 2019 respectively). Therefore, for Kharif planting of cowpea the 1st week of June should be the ideal time for planting. Yaycock *et al*, 1988 reported that change of sowing dates have reduced effects on diseases caused by anthracnose (*C. lindemuthianum*) and brown blotch (*C. capsici*) of cowpeas. Roberts *et al*. 2001, Agrios *et al*. 2005 also reported that change in planting time was responsible for enhancing resistance and avoiding predisposition of *C. capsici*. So these works by the previous research worker have clearly justified our present research findings.

When the adjust of planting time was tested against the cowpea leaf spot causing pathogen *Corynespora cassicola*, a significant result was obtained during Rabi season **Table-4**. Though the tested cultivars were same but against the different time of planting the different responses were detected. In case of Kashi Kanchan, Mani Kanchan & KSP-170 the planting during 4th week of November exhibited least disease severity (30.23-50.24%), AUDPC (293.93-492.80) and lesion area (2.94-4.98 cm^2) and gave the highest yield (1.52-2.40 q/ha). But for the rest planting times, the disease severity, AUDPC & lesion area were increased as well as the yield also was decreased. In case of Triguna & Arka Garima variety, planting during 2nd week of November not only reduced the disease severity (22.64-42.50%), AUDPC (215.28-423.04) and lesion area (1.23-4.28 cm^2) but also increased the yield (1.74-2.58 q/ha). But for the rest planting times, the disease severity, AUDPC & lesion area were increased as well as the yield also was decreased. From the results, it can be stated finally that if these above mentioned five cultivars are taken by the cowpea growers to plant during Rabi season they should adopt the planting time of all the three varieties *viz* Kashi kanchan, Mani kanchan & KSP-170 during 4thweek of November but in case of Triguna & Arka Garima it was 2ndweek of November because the pathogen could not damage the crop significantly as well as gave a consistent yield to the cowpea growers. The environmental condition prevailed during progress of Corynespora infection were temp.(8.06^{0}C to 31.61^{0}C),Relative humidity(38.44% to 98.86%) and cumulative rainfall(0.00 mm,1.2 mm & 13.90 mm during 2017,2018 & 2019 respectively).

For successful disease development, the virulent pathogen, susceptible variety and favorable environment are essential factors along with particular growth stage of the crop. From the above results it may be concluded that probably the susceptible growth stages of the cultivars did not coincide with the virulent phase of the pathogen and favorable environmental factors. That's why these cultivars not only exhibited their tolerance towards pathogen but also projected higher yield in different planting times. Older plants have shown their resistance than younger plants. Improved cultivars and alteration of crop planting dates have been reported by many researchers as eco friendly strategies for reducing severe outbreak of pest and pathogen (Asante *et al*, 2001). Hence, it may be stated finally that the change of planting time is an effective nonchemical approach to avoid the crop losses.

CONCLUSIONS

During survey it was noticed that, cowpea plants are infected by various fungal pathogens throughout the year. During Pre-Kharif season *Alternaria alternata* (46.3%) was found to be most dominating pathogen. Other pathogen(s) found during this season was *Fusarium ciceri, Cercospora sp, Curvularia lunata*. During Kharif season, *Colletotrichum capsici* (56.8%) is found as a most important pathogen. Other pathogens found in this season are *Rhizoctonia solani, Fusarium ciceri* and trace amount of *Sclerotium rolfsii* & *Choanephora sp*. During Rabi season, it was recorded that *Corynespora cassicola* (27.5%) is the most dominating pathogen. Other than this, *Alternaria alternata*, *Curvularia lunata* and *Fusarium cicieri* are also recorded during survey.

Shifting of planting time for avoiding the virulent plant pathogen at a particular growth stage of the crop is an eco-friendly approach for plant disease management. It does not require any chemical application for managing the plant disease. Five cultivars (Kashi kanchan, Triguna, Manikanchan, KSP-170 &Arka garima) are selected for the experimental trial for three different seasons against the serious pathogens. For Pre-Kharif planting of cowpea, the 1st week of March is established as ideal time for planting as compared to the other planting times (2nd, 3rd&4th week of March) to avoid *Alternaria* leaf spot disease. During Kharif, planting time of all these cultivars during 1st week of June is established as most profitable as compared to the other planting times (2nd, 3rd& 4th week of June) to avoid *Colletotrichum* leaf spot. During Rabi, three cultivars *viz.* Kashikanchan, Mani kanchan & KSP-170 during 4th week of November and in case of Triguna & Arka Garima during 2nd week of November is profitable as compared to the other planting times (2nd, 3rd& 4th week of November) because the pathogen *Corynespora cassicola* could not cause any significant damage the crop as well as gave a good yield.

REFERENCES

Agrios GN. 2005 Path Press– Plant Pathology. 5th ed. Academic, San Diego. pp. 922.

Ahlawat, I.P.S. and Shivakumar, B. G. 2005. Kharif pulses. In Textbook of Field Crops Production. Dr. R. Prasad (Ed.) Indian Council of Agricultural Research, New Delhi, India.

Asante, S.K., minimum insecticide application Tamo, M. and Jackal, L.E.N. 2001. Integrated management of cowpea insect pests using elite cultivars, date of planting and. Afr. Crop Sci. J. 9(4): 655-665.

Birhman, R. K. and Singh, B. P. 1995. Path co-efficient analysis and genetic parameters of the components of field resistance of potatoes to late blight. Ann Appl. Biol. 127: 353-362.

Cronquist, A. 1988. The evaluation and classification of flowering plants 2nd edition. The New York botanical garden, New York, ISBN, 0-89327-332-5. P 555.

Datar, V. V. and Mayee, C. D. 1986. Chemical Management of early blight of Tomato. Journal of Maharashtra Agricultural Universities. 10: 278-280.

Davis, D.W., Oelke, E. A., Oplinger, E. S., Doll, J. D., Hanson, C.V. and Putman, D. H. 2000. Alternative field crops manual. http://www.hort.purdue.edu/new crop/afcm/cowpea.html.

Mandal, M.K., Pati, R., Mukhopadhyay, D. and Majumdar K. 2009. Maximising Yield of Cowpea through Soil Test-Based Nutrient Application in Terai Alluvial Soils. Better Crops – India. Pp. 28-30

Mc. Kinney, H. H. 1923. Influence of soil temperature and moisture on infection of wheat seedling by *Helminthosporium sativum*. J. Agric. Res. 26: 195-218.

Quin, F.M. 1997. Importance of Cowpea in advances in cowpea research. B.B. Singh, K.E. Dashiell, D.R. Mohan Raj and L.E.N. Jackai (Eds.), pg. X-Xii. Printed by colcorcraft, Hong Kong, p 375.

Roberts, P. D., Pernezny, K. and Kucharek, T. A. 2001. Anthracnose Caused by Colletotrichum sp. on Pepper. Journal of University of Florida/ Institute of Food and Agricultural Sciences. (online) Available http:// edis.ifas.ufl.edu/PP104 (25 December 2007).

Shaner, G., and Finney, R. 1977. The effect of nitrogen fertilization on the expression of slow mild-mildewing in knox wheat. Phytopathology. 67: 1051-1056.

Tu, J. C. 1993. Effects of planting date, irrigation and rain on infection, disease severity and pod discoloration caused by *Alternaria alternata* (Fr.) Keissler in bean (*Phaseolus vulgaris* L.). Can. J. Plant Sci. 73**:** 315-321.

Tu, J. C., Mcllonnell, M. and Dirks, V. A. 1988. Factors affecting seed quality of navy bean in the field in south western Ontario. Seed Sci. Technol. 16**:**371-381.

Yaycock, J. Y., Lombin, G., Onazi, O. C. and Owonubi, J. J. 1988. Crop science and production in warm climates. Macmillan Intermediate Agriculture Series, pp: 307.

Table 1: Survey on seasonal incidence of foliar diseases of Cowpea in different Cowpea growing areas of Nadia & Hooghly district

Sl. no	Location	Pre - kharif			Kharif			Rabi		
		Time of visit	Maximum damage (PDI) by pathogen	Yield loss (%)	Time of visit	Maximum damage (PDI) by pathogen	Yield loss (%)	Time of visit	Maximum damage (PDI) by pathogen	Yield loss (%)
1	Mondouri	March	*Alternaria* (23.8%) *Cercospora sp*(16.5%)	26.5 16.0	July	*Colletotrichum* sp(28.63%) *Sclerotium rolfsii* (5.8%)	38.2 -	November	*Alternaria sp*(10.3%)	8.0
2	Jaguli instructional farm	March	*Alternaria* sp(34.5%) *Curvularia* sp(18.6%) *Cercospora* sp(20.6%)	34.8 11.5 21.2	July	*Rhizoctonia solani* (10.25%) *Colletotrichum sp* (24.6%)	17.2 33.5	November	*Corynespora sp*(24.5%) *Alternaria* sp(11.4%) *Curvularia sp*(13.2%)	15.3 10.8 -
3	Muragacha	March	*Alternaria sp*(24.8%) *Cercospora sp* (20.3%)	24.0 19.3	July	*Colletotrichum* sp(36.7%) *Curvularia* sp(12.7%)	40.2 10.0	November	*Alternaria* sp(10.3%)	10.0
4	Rajberia	March	*Alternaria* sp(32.7%)	29.7	July	*Colletotrichum* sp(38.2%) *Curvularia* sp(15.6%) *Cercospora* sp(26.8%)	43.5 11.2 23.6	November	*Alternaria* sp(13.8%)	12.3
5	Chakdah	April	*Alternaria sp*(28.3%)	23.5	August	*Colletotrichum* sp(46.3%)	51.3	December	*Corynespora* sp(12.5%)	19.8
6	Madanpur	April	*Alternaria* sp(28.8%) *Fusarium sp* (6.53%)	25.2 -	August	*Colletotrichum sp*(42.5%) *Rhizoctonia solani* (20.5%) *Fusrium ciceri* (9.23%)	48.6 23.2 -	December	*Corynespora* sp(25.6%) *Alternaria* sp(11.2%) *Curvularia sp*(9.38%)	27.5 9.3 -
7	Basantapur	April	*Alternaria* sp(32.5%)	30.2	August	*Rhizoctonia solani* (28.2%)	28.5	December	*Corynespora* sp(31.5%)	33.5
8	KalyaniIncheck Farm	April	*Alternaria* sp(25.3%)	27.6	August	*Colletotrichum* sp(38.5%)	36.0	December	*Corynespora sp*(21.4%)	27.8
9	Kalyani 'C' Block Farm	April	*Alternaria* sp(28.6%) *Curvularia sp* (22.8%) *Cercospora* sp(35.6%)	28.1 15.6 36.7	August	*Colletotrichum* sp(41.6%) *Fusarium ciceri* (12.3%) *Choanephora* sp(trace)	45.3 - -	December	*Alternaria sp*(24.3%)	23.9
10	Mogra, Hooghly	April	*Alternaria* sp(46.3%)	45.3	August	*Colletotrichum sp* (56.8%)	60.2	December	*Alternaria sp*(15.3%)	16.5

Table 2. Influence of date of planting on *Alternaria alternata* infection during Pre-Kharif seasons

Cultivar with Maturity period (days)	Date of Planting	2017-2018				2018-2019			
		Max severity due to *Alternaria* sp (%)	AUDPC (%)	Lesion Area (cm^2)	Yield (q/ha)	Max severity due to *Alternaria* sp (%)	AUDPC (%)	Lesion Area (cm^2)	Yield (q/ha)
Kashikanchan (90)	1st week of March	43.45	488.11	5.21	1.85	50.10	501.62	5.12	1.65
	2nd week of March	62.84	585.65	5.67	1.30	60.47	606.02	5.73	1.18
	3rd week of March	53.48	627.93	5.54	1.10	65.12	632.76	5.82	1.03
	4th week of March	48.46	557.94	5.43	1.40	57.12	580.61	5.37	1.45
Triguna (90)	1st week of March	45.32	449.54	3.92	2.00	46.23	462.10	3.95	2.15
	2nd week of March	55.65	556.46	4.24	1.25	57.76	563.01	4.38	1.20
	3rd week of March	52.83	552.93	4.18	1.10	55.33	560.14	4.25	1.13
	4th week of March	49.83	507.43	4.01	1.35	50.12	502.21	4.10	1.40
Manikanchan (90)	1st week of March	42.46	422.66	3.74	2.20	41.27	409.74	3.68	2.30
	2nd week of March	55.65	532.21	4.23	1.30	51.35	497.52	4.15	1.42
	3rd week of March	51.56	506.76	4.12	1.32	52.13	514.25	4.26	1.27
	4th week of March	45.65	443.21	3.98	1.80	46.21	475.21	3.95	1.75
KSP- 170 (90)	1st week of March	40.63	399.35	3.46	2.28	38.67	377.26	3.27	2.25
	2nd week of March	47.32	461.68	3.76	1.33	48.52	473.06	3.82	1.38
	3rd week of March	45.23	445.13	3.52	1.79	43.28	427.63	3.45	1.82
	4th week of March	39.40	385.64	2.89	2.13	39.63	392.07	2.92	2.18
Arka Garima (90)	1st week of March	31.39	304.99	2.64	2.40	28.67	290.26	2.53	2.46
	2nd week of March	35.62	345.41	2.87	2.16	35.56	337.48	2.83	2.18
	3rd week of March	34.26	329.21	2.70	2.20	31.45	323.24	2.58	2.38
	4th week of March	31.28	315.10	2.61	2.30	30.14	300.16	2.35	2.32
SEm (±)	-	5.03	19.7	0.8	3.15	4.6	18.3	0.5	1.2
CD at 5%	-	14.1	57.2	2.52	9.54	13.5	55.5	1.6	3.8

Table 3. Influence of date of planting on *Colletotrichum capsici* infection during Kharif season

Cultivar with Maturity period (days)	Date of Planting	2017-2018				2018-2019			
		Max severity due to *Colletotrichum sp(%)*	AUDPC (%)	Lesion Area (cm^2)	Yield (q/ha)	Max severity due to *Colletotrichum sp (%)*	AUDPC (%)	Lesion Area (cm^2)	Yield (q/ha)
Kashikanchan (90)	1st week of June	60.42	591.95	5.96	1.28	61.23	598.50	5.98	1.23
	2nd week of June	72.48	718.06	6.32	1.03	70.12	708.64	6.21	1.08
	3rd week of June	73.48	743.12	6.40	0.98	72.82	738.04	6.37	1.02
	4th week of June	66.64	681.83	6.10	1.12	63.87	644.31	6.02	1.17
Triguna (90)	1st week of June	52.80	514.43	5.16	1.36	61.23	524.79	5.10	1.33
	2nd week of June	65.84	644.00	6.08	1.16	70.12	613.30	5.76	1.22
	3rd week of June	67.57	669.79	6.17	1.10	72.82	670.35	6.12	1.14
	4th week of June	60.38	612.46	5.88	1.24	63.87	570.30	5.42	1.28
Manikanchan (90)	1st week of June	45.26	433.33	4.32	1.36	43.67	429.17	4.25	1.39
	2nd week of June	56.78	546.80	5.87	1.31	57.63	565.21	5.93	1.28
	3rd week of June	58.46	569.59	5.92	1.26	60.18	591.08	6.01	1.23
	4th week of June	45.65	462.21	4.40	1.33	49.85	489.37	4.92	1.32
KSP- 170 (90)	1st week of June	36.25	347.65	3.54	2.25	38.12	363.02	3.68	2.20
	2nd week of June	44.29	435.43	4.21	1.46	48.57	467.56	4.64	1.38
	3rd week of June	49.23	485.20	4.76	1.34	52.78	514.08	5.23	1.28
	4th week of June	40.40	400.64	3.89	1.85	41.43	409.78	3.95	1.79
Arka Garima (90)	1st week of June	25.73	245.07	2.34	2.78	26.32	249.90	2.38	2.72
	2nd week of June	30.26	290.71	2.72	2.57	31.43	306.53	2.80	2.52
	3rd week of June	32.26	315.21	2.93	2.49	35.34	344.75	3.44	2.35
	4th week of June	31.28	315.10	2.85	2.53	30.12	292.91	2.79	2.60
SEm (±)	-	3.85	17.3	0.6	2.5	3.1	18.2	0.5	2.8
CD at 5%	-	10.2	50.1	1.85	7.6	9.2	52.0	1.6	8.5

Table 4.Influence of time of planting on *Corynespora cassicola* infection during Rabi seasons

Cultivar with Maturity period (days)	Date of Planting	2017-2018				2018-2019			
		Max severity due to *Corynespora sp* (%)	AUDPC (%)	Lesion Area (cm^2)	Yield (q/ha)	Max severity due to *Corynespora sp (%)*	AUDPC (%)	Lesion Area (cm^2)	Yield (q/ha)
Kashikanchan (90)	1st week of November	51.24	514.50	5.30	1.47	49.50	433.23	5.12	1.51
	2nd week of November	52.86	521.01	5.34	1.43	51.26	417.72	5.32	1.48
	3rd week of November	55.48	549.22	5.56	1.36	52.17	454.54	5.35	1.45
	4th week of November	50.24	492.80	4.86	1.52	48.52	411.04	4.98	1.57
Triguna (90)	1st week of November	43.50	432.67	4.33	1.68	42.34	363.44	4.25	1.73
	2nd week of November	42.50	423.04	4.28	1.74	41.58	360.85	4.13	1.75
	3rd week of November	46.75	457.87	4.56	1.66	45.82	391.51	4.47	1.63
	4th week of November	45.13	445.30	4.45	1.62	43.25	378.07	4.32	1.67
Manikanchan (90)	1st week of November	38.66	380.62	3.65	1.85	37.28	360.85	3.45	1.87
	2nd week of November	38.65	379.50	3.62	1.83	38.23	363.44	3.64	1.85
	3rd week of November	41.64	406.35	4.11	1.73	40.15	391.51	4.02	1.78
	4th week of November	37.03	360.325	3.42	1.87	36.23	378.07	3.32	1.92
KSP- 170 (90)	1st week of November	32.76	321.72	3.10	2.35	31.28	307.93	3.09	2.32
	2nd week of November	31.39	307.30	3.23	2.28	30.28	297.92	3.00	2.32
	3rd week of November	32.32	314.33	3.11	2.27	31.54	304.22	3.12	2.34
	4th week of November	30.45	300.16	2.94	2.33	30.23	293.93	2.97	2.40
ArkaGarima (90)	1st week of November	25.62	244.09	1.82	2.50	26.47	250.11	1.91	2.46
	2nd week of November	24.42	231.94	1.67	2.52	22.64	215.28	1.23	2.58
	3rd week of November	25.58	250.95	1.85	2.49	26.28	255.43	1.88	2.45
	4th week of November	26.52	256.79	1.93	2.46	25.34	251.33	1.78	2.48
SEm (±)	-	3.1	17.8	0.7	2.5	3.6	16.8	0.9	3.2
CD at 5%	-	9.5	54.3	2.4	7.8	10.5	49.2	3.0	9.3

Table-5: Weather parameters recorded during Pre-Kharif season on three successive years

Year	Month	Weather Variables							
		Max T (°C)	Min T (°C)	Average temperature during prevailing season	Max RH (%)	Min RH (%)	Average RH during prevailing season	Rainfall (mm)	Cumulative rainfall (mm)
2017	March	29.01	16.03	39.69-16.03 °C	94.71	51.86	95.43-39.29%	0	28.07 mm
		31.61	17.33		90.29	52.71		0	
		34.33	18.07		86.86	39.29		0	
		34.69	21.31		94.40	49.80		12.25	
	April	36.50	23.16		95.43	45.29		0	
		36.06	23.44		93.57	52.14		0	
		37.61	23.51		86.57	41.14		0	
		38.59	25.54		85.89	44.44		0	
	May	32.44	22.59		88.00	62.86		6.5	
		33.04	25.93		87.86	52.00		2.65	
		39.69	27.27		89.86	41.14		0	
		34.88	26.34		89.40	73.0		6.67	
2018	March	31.03	16.19	37.45-15.10 °C	96.00	49.00	96.00-40.57%	5.5	54.68 mm
		33.24	15.10		86.14	40.57		0	
		33.76	18.46		75.71	46.71		0	
		33.98	20.63		91.90	55.30		10.2	
	April	34.31	22.40		95.57	63.43		3.8	
		34.74	22.01		92.71	58.43		14.5	
		35.44	22.84		86.71	59.71		0	
		32.86	19.97		91.33	72.78		13.78	
	May	35.34	21.57		90.57	68.14		0	
		35.0	20.76		92.43	62.29		0	
		35.17	21.39		90.86	65.14		6.9	
		37.45	27.33		85.00	65.20		0	
2019	March	32.01	13.64	39.27-13.64 °C	91.57	30.43	95.30-30.43%	0	91.35 mm
		34.74	19.53		93.86	42.14		0	
		35.37	20.46		94.43	39.00		0	
		36.25	21.56		90.20	41.40		0	
	April	37.89	23.33		85.29	39.00		0	
		39.27	24.56		91.57	38.43		0	
		35.74	21.54		91.29	55.57		25.4	
		34.78	24.20		92.56	59.89		20.8	
	May	35.56	27.24		90.29	65.43		0	
		35.10	24.86		91.43	67.43		7.53	
		34.61	23.66		94.29	72.86		16.6	
		32.91	23.02		95.30	85.30		21.02	

Table-6: Weather parameters recorded during Kharif season for three successive years

Year	Month	Weather Variables							
		Max T (°C)	Min T (°C)	Average temperature during prevailing season	Max RH (%)	Min RH (%)	Average RH during prevailing season	Rainfall (mm)	Cumulative rainfall (mm)
2017	June	34.83	23.91	34.83-23.81°C	91.71	70.29	98.86 – 70.29%	41.0	200.59 mm
		33.61	25.43		95.43	82.71		11.15	
		34.60	25.36		93.86	78.86		5.07	
		32.46	25.86		95.11	85.67		16.36	
	July	33.21	25.71		95.43	80.00		26.25	
		33.57	25.63		94.00	77.57		7.68	
		33.29	25.57		93.71	79.14		5.48	
		31.01	24.73		96.90	88.20		17.59	
	August	32.20	25.07		94.71	78.80		4.20	
		31.61	24.76		96.29	81.23		16.40	
		30.20	23.81		98.86	84.13		28.87	
		32.34	24.42		97.10	73.50		20.54	
2018	June	32.71	25.67	36.01 – 24.04°C	94.71	72.29	98.44 – 66.86%	4.50	146.44 mm
		36.01	27.51		92.57	66.86		0.00	
		34.76	25.04		94.71	80.43		17.16	
		33.04	25.84		98.44	81.44		15.44	
	July	31.22	25.68		98.40	91.50		8.74	
		33.92	26.60		95.70	78.70		13.1	
		32.37	26.63		97.71	88.00		10.06	
		32.39	26.08		96.30	79.90		8.43	
	August	32.97	26.17		97.86	78.71		15.14	
		33.64	26.21		96.43	82.14		20.05	
		32.86	24.04		98.00	76.86		29.97	
		33.10	25.64		95.60	76.40		3.85	
2019	June	37.61	27.10	37.61 – 21.74 °C	86.71	57.43	98.67 – 57.43%	0.00	214.06 mm
		36.01	24.07		88.29	67.14		14.70	
		33.53	24.33		90.86	72.43		5.73	
		30.26	24.48		98.67	88.44		20.36	
	July	33.61	24.51		96.14	82.57		19.37	
		32.94	24.53		98.14	92.00		44.48	
		32.49	24.81		98.14	83.29		15.42	
		31.8	21.74		95.70	89.60		15.43	
	August	32.04	24.73		95.71	79.57		53.57	
		34.59	25.87		91.86	75.86		4.40	
		33.59	25.81		94.00	77.86		15.90	
		33.24	25.20		96.30	80.60		4.70	

Table-7: Weather parameters recorded during Rabi season for three successive years

Year	Month	Weather Variables							
		Max T (°C)	Min T (°C)	Average temperature during prevailing season	Max RH (%)	Min RH (%)	Average RH during prevailing season	Rainfall (mm)	Cumulative rainfall (mm)
2017	Nov	30.40	18.00	30.40 – 9.20 °C	97.14	64.14	98.00 – 46.29%	0	0.00 mm
		28.77	15.49		91.71	50.14		0	
		29.01	14.26		95.14	46.29		0	
		28.33	15.92		96.00	55.44		0	
	Dec	27.26	14.34		95.71	56.43		0	
		26.26	13.10		97.86	52.00		0	
		26.27	11.97		97.57	59.71		0	
		22.75	11.78		97.70	60.70		0	
	Jan	23.27	10.66		95.57	57.86		0	
		23.19	9.20		98.00	60.57		0	
		23.30	10.49		93.71	70.00		0	
		24.37	10.18		94.50	58.60		0	
2018	Nov	30.63	18.67	31.61 – 8.99 °C	98.00	59.57	98.86 – 38.44%	0	1.2 mm
		31.61	18.36		96.57	46.86		0	
		28.77	13.86		96.57	43.71		0	
		27.87	11.87		97.22	38.44		0	
	Dec	27.06	13.19		98.86	56.86		0	
		25.04	11.86		98.43	61.86		0	
		25.81	11.46		97.14	57.14		0	
		22.92	9.01		97.90	54.70		0	
	Jan	25.40	15.13		97.71	68.00		1.2	
		24.30	9.06		98.14	56.57		0	
		24.73	8.99		97.57	55.57		0	
		25.91	10.80		93.80	48.60		0	
2019	Nov	31.13	19.56	31.13 – 8.06 °C	98.14	60.14	98.86 – 47.40%	0	13.90 mm
		30.73	16.60		98.29	48.57		0	
		30.46	16.76		98.86	53.14		0	
		29.61	15.10		97.67	58.00		0	
	Dec	29.37	17.67		98.14	60.71		0	
		27.67	15.43		97.71	63.29		0	
		24.06	11.19		94.71	55.43		12.9	
		23.82	10.22		93.00	47.40		0	
	Jan	25.41	9.53		98.43	53.86		0	
		25.60	10.56		97.43	50.29		0	
		25.71	12.03		98.29	61.43		1	
		23.97	8.06		97.40	51.40		0	

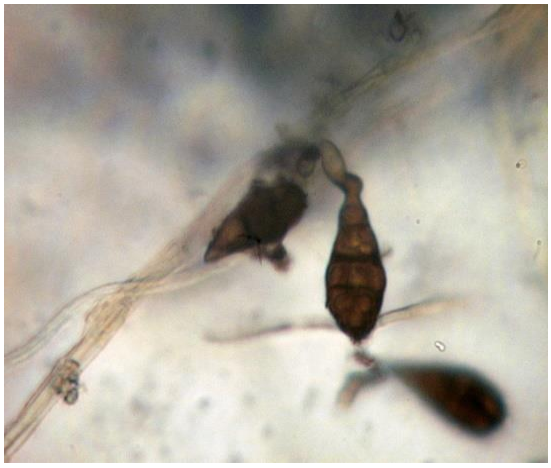

Plate 1: *Alternaria* leaf spot symptom on leaf and spores of *Alternaria*

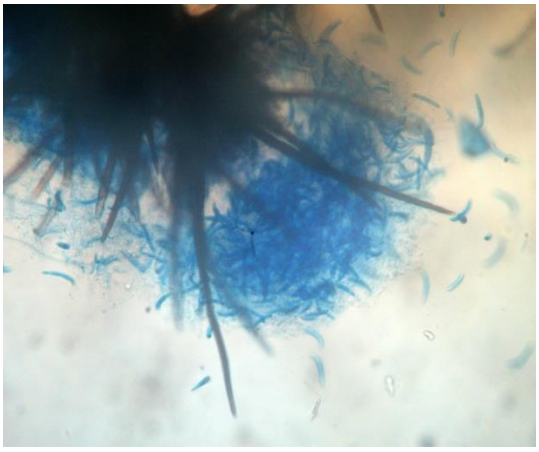

Plate 2: *Colletotrichum* leaf spot disease and acervuli & spores of *Colletotrichum capsici*

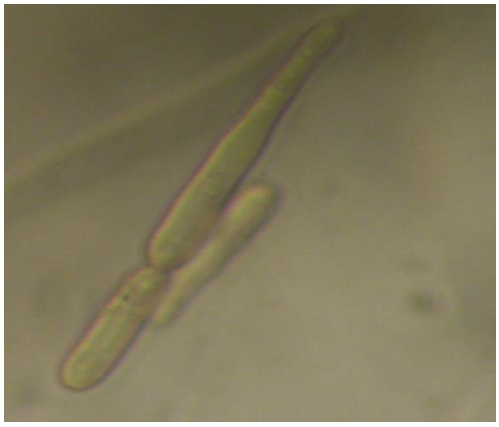

Plate 3: *Corynespora* leaf spot disease and spores of *Corynespora cassicola*