Efficacy of bio-control agents with chemical fungicides against *Cercospora*leaf spot of Okra (*Abelmoschus esculentus* L.) Moench

ABSTRACT

Okra(*Abelmoschusesculentus*L.)isoneoftheforemostvegetablecropgrownduring*k harif* as well as summer seasons. *Cercospora* leaf spot incited by *Cercospora*spp. isoneoftheemergingdisease in all regions wherever okra is grown. *C.abelmoschi*causessootyblack,angular spots and cause severe defoliation common during humidseasons. An experiment was conducted to evaluate the efficacy of bioagents and chemicals *viz., T0–Untreated control,T1 Mancozeb (1%) + Trichoderma(4%) , T2 - Mancozeb (1%) + Pseudomonas(4%) , T3 Mancozeb (1%) + Bacillus subtilis(4%), T4 - Mancozeb (1%) + Trichoderma(2%) + Pseudomonas(2%) ,T5- Mancozeb (1%) + Pseudomonas(2%) + Bacillus subtilis(2%), T6 Mancozeb (1%) + Bacillus subtilis(2%) + Trichoderma(2%), T7-Mancozeb (1%)* against*Cercospora*leafspotofokra.Studiesrevealedthatminimumdiseaseintensity, Maximum plant height , maximum no. of branches per plant and Maximum no. of fruits wasobserved in *T4 - Mancozeb (1%) + Trichoderma(2%) + Pseudomonas(2%)* and is hereby considered as the best treatment.

Keywords: Mancozeb , Trichoderma , Pseudomonas, Bacillus.

1. INTRODUCTION

Okra(*Abelmoschusesculentus*L.)Moenchisoneofthemostwidelyknownspeciesofthefamily Malvaceaeandaneconomicallyimportantvegetablecropgrownintropicalclimateoftemperaturerangebetween25^{0}to35^{0}c.Thename“Okra”derivesfromoneofNiger-Congogroup of languages. “Okra” originated in Ethiopia and was then propagated in North Africa,In India okra is grown in sub tropical areas and it is commonly known as Bhendi .Somestudiesarebeingdevelopedtargetingokraextractas remedy to manage diabetes. Its ripe seeds are roasted, ground and used as a substitute forcoffee in some countries.Mature pods and stems containing crude fibre are used in the paperindustry. Okra seeds are a potential source of oil, which consists of linoleicacid up to 47.4%andpolyunsaturatedfattyacid essential forhumannutrition.**(Singhe*tal.*, 2014).**

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Okra contains Potassium, Sodium, Magnesium and Calcium as principal elements inpods, which contains 17% seeds. Presence of Iron, Zinc, Manganese and Nickel also has been reported(**Moyin-Jesu,2007).**Freshpodsarelowincalories(20/100g),practicallynofat,richin fiber, and with several valuable nutrients. Okra seed is mainly composed of oligomericcatechins(2.5mg g^{-1} ofseeds),whilethemesocarpismainlycomposedof hydroxycinnamic (0.2 mg g^{-1}) and quercetin derivatives (0.3 mg g^{-1}). Pods are rich in phenolic compounds withimportantbiologicalpropertieslikequarteringderivatives,catechinoligomersandhydroxycinnamicderivatives (**Arapitsas, 2008**).

Okra plant also contains many medicinal properties with it. But before using, it is very necessary to seek advice from a professional. The mucilage can be used as plasma replacement, helpful in washing away toxic substances from the body and have strongly demulcent action **(Gemede et al., 2015).** In the treatment of syphilis infusion of root is used. In Nepal the juice of root is used in the boils, wound and cuts. It is used in the medication of catarrhal infections, dysuria and gonorrhoea. Other than this fibre present in okra has property of controlling blood sugar level in blood. Okra has nutrient that insure proper functioning of intestine. It is also effective in ulcer and joint healthiness. Due to its alkaline nature, it also gourds the mucous membrane in the digestive system. Useful in curing of pulmonary inflammation, bowel irritation and sore throat **(Kumar et al., 2013).** Its fruit can be also be used for the control of goitre due to high iodine content in it **.**

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Diseases play a vital role in yield losses of the crop. Among them, fungi are one of the most important and prevalent pathogens which attack the crops from seedling to harvesting stage. Some of the fungal diseases that attack are *Cercospora* leaf spot *(Cercospora abelmoschi),* damping-off (*Pythium sp. and Rhizoctonia sp.),* powdery mildew *(Oidium sp.),* southern blight *(Sclerotium rolfsii),* verticillium wilt (*Verticillium albo-atrum)* and *alternaria leaf spot***(Raid and Palmateer, 2006).**

Among the fungal diseases *Cercospora* leaf spot of bhendi incited by *Cercospora*isoneofthemosteconomicallyimportantinallregionswhereverbhendiisgrown.InIndia,twospecies of *Cercospora*produce leaf spots on bhendi. *C. malayensis* causes brown, irregularspots and *C. abelmoschi* causes sooty black, angular spots. Both the leaf spots cause severedefoliation and are common during humid seasons. Now a days, this disease incited by *C.abelmoschi*becomesmoresevereinsoutherntransitionzoneofKarnataka.Initiallythediseasesymptomsobservedonthelower surface of the leaves as indistinct spots in the form ofolivaceousspecks.Lateron,lightbrowntogreymouldygrowthofthefunguscoveredtheentirelower surface. The infected leaves ultimately dry and defoliate. The disease progress upwardfrom lower leaves and infects stem and fruits and produces similar symptoms. **(Naik *et al.,*2017).**

*Cercospora*produceaperylenequinonetoxincalledcercosporinwhichisnon-selective, affecting bacteria and fungi unless these produce protective antioxidants such ascarotenoids.Morphologyofthepathogenofgenus*Cercospora*wasfirstdescribedbyFrensious(1863),Etymologicallythegenericnamemeansafungushasobclavate(tailshaped)spores.Sporulationoccursattemperaturerange8-24°C,wherematurespores sporulateafter14to 24 hours.

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Forthemanagementof*Cercospora*leafspotofokrafrommanyyears,manyhavebeenrelied on chemicals and this resulted in many undesirable problems. Now a day's tremendoususe of chemicals in agriculture has resulted in growing concern of both public health andenvironment hazards thus, emphasis is now on judicious use of bio-agents, botanicals andorganicsformanagementoftheplantdiseaseswhichislesscostly,nontoxicanddoesn'taffectpublic health and

environment. Fungicides are also effective in managing this disease as suchtheir use inthemanagementstrategycannotberuledoutbuttheirindiscriminateuseshouldbeavoided.Thereisneedtoincorporatealternativecontrolcomponentsthatareeffectiveinfield.Considering theabove-mentionedfacts,a studywasconducted,entitled,"**"Efficacy of bio control agents with chemical fungicides against *Cercospora* leaf spot of Okra (*Abelmoschus esculentus* L.) Moench"**with thefollowing objectives :-

1. Toevaluate theeffectof~~bioagents~~bio-agentson*Cercospora* diseaseintensityin okra.

2. MATERIAL AND METHODS

Theexperimentwasconductedattheresearchplotofthe~~D~~ddepartmentofPlantPathologyandCentralResearchField, SamHigginbottomUniversityofAgricultureTechnology ~~A~~and Sciences, Prayagraj during the *Kharif* season 2022. The selected site wasuniform,cultivablewith typicalsandyloamsoilhaving gooddrainage.

Table 1.~~t~~The treatment details.

S.No	Treatments	TreatmentDetails
1.	T0	Control
2.	T1	Mancozeb (1%) +*Trichoderma harzianum* (4%)
3.	T2	Mancozeb (1%) + *Pseudomonas fluorescens* (4%)
4.	T3	Mancozeb (1%) + *Bacillus subtilis* (4%)
5.	T4	Mancozeb (1%) + *Trichoderma harzianum* (2%) + *Pseudomonas fluorescens* (2%)
6.	T5	Mancozeb (1%) + *Pseudomonas fluorescens* (2%) + Bacillus subtilis (2%)
7.	T6	Mancozeb (1%) + *Bacillus subtilis* (2%) + *Trichoderma harzianum* (2%)
8.	T7	Mancozeb (1%)

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Diseaseseverityscaleof*Cercospora*leafspot

Disease intensity was recorded as grades in five randomly selected plants in each plotatdifferenttimethatisbeforespraying,15daysafterthefirstsprayand15daysafterthesecondsprayas per thescaleof**Farrag (2011)**whichisgiven below.

Table 2. Disease intensity and description.

Diseaserating/ grade	Description
0	Nodisease
1	Noticeablespottingwithsomedefoliation(<25%)
3	Spottingheavywithsignificantdefoliation(< 50%)
5	Veryheavyleafspottingwith severedefoliation(<75%)
7	Numerousspotsonfewremainingleavesandveryheavydefoliation(<90%)
9	Veryfewremainingleavescoveredwithspotsandnearlycompletedefoliation(<95%)

~~3.5~~Diseaseintensity(%)

PercentageofDiseaseintensitywillberecordedat60,75 and 90 days afterincidenceof *Cercospora* leaf spot. Percentage of Disease intensity will be calculated in accordance withfollowingformula.Thediseasewillbevisuallyassessedinalltheplotsatweeklyintervalfromfirstappearanceofdiseaseforeach treatment. Foreachplotthenumberofinfectedokraplantswill be counted and expressed as a percentage of the total number of okra plants in that plot.The mean percentage disease incidence for each treatment will be obtained from the threereplications.Thedatawillbefurtherstatisticallyanalyzed.

Disease intensity (%) formula was given by **Wheeler (1969).** It is calculated by usingthefollowing formula:

$$\textbf{Diseaseintensity(\%)} = \frac{\textbf{Sumofalldiseaseratings}}{\textbf{Total no.of ratings X Maximum disease groups}} X100$$

Statisticalanalysis

The data obtained from the field experiment were statistically analyzed by followingthestandardprocedures(**PanseandSukhatme,1989**).Thepercentagevalueswereconvertedtoarcsinevalues wherever required.

Analysisofvariance:

Theanalysisofvariancewasworkedouttotestthesignificanceof Fandt-tests.Itwascarriedoutwas followedaccording to procedure of RBD analysis for each character. The total variance anddegree of freedom were partitioned into three components *viz.,* replications, treatments anderror.Analysisofvariancewasdoneunderthefixedeffectmodelgivenbelow:Letussupposethat there are 'k' treatments applied to 'r' number of replications. These can be represented bythesymbols as follows:

AnalysisofVariancewasdoneunderthefixedeffectmodelgivenbelow

Letussupposethatthereare'k'treatmentsappliedto'r'numberofreplications.Thesecanberepresented bythesymbolsas follows

Table 3. **AnalysisofVariance**

SourceofVariation	d.f.	S.S.	M.S.S.	F(cal)	F(tab)at5%	Result
Dueto Replication	r-1	R.S.S.	M.S.S.R =RSS r-1	M.S.S.R M.E.S.S	F (r-1)	S/NS
DuetoTreatments	t-1	T.S.S.	T.S.S t-1 = M.T.S.R	M.T.S.S M.E.S.S	F(r-1)(t-1)	N/NS
Dueto error	(r-1) (t-1)	E.S.S	S.S.E. (r-1)(t-1)	-	f(t-1),(r-1),(t-1)	-
Total	(rt-1)	T.S.S.	-	-	-	-

Fig 1. Overview of Spraying

Fig 2. Overview of Disease Infested Leaves

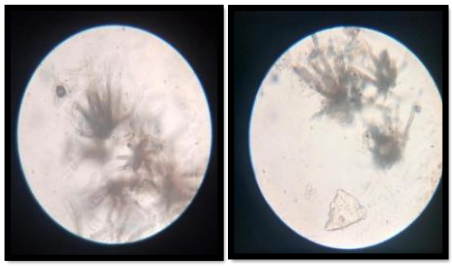

Fig 3. OVERVIEW OF MICROSCOPIC VIEW OF *Cercospora sp.*

Table 4. Effect of treatments on Disease Intensity of *Cercospora* leaf spot of okra at60,75 and 90DAS

Tr.no	Treatment	DISEASE INTENSITY		
		60DAS	75 DAS	90DAS
T0	Control	29.183[a]	36.290[a]	41.18[a]
T1	Mancozeb (1%) +*Trichoderma harzianum* (4%)	21.033[d]	27.403[e]	34.44[c]
T2	Mancozeb (1%) + *Pseudomonas fluorescens* (4%)	18.810[e]	25.920[f]	32.33[d]
T3	Mancozeb (1%) + *Bacillus subtilis(4%)*	23.553[c]	30.810[c]	36.47[b]
T4	Mancozeb (1%) + *Trichoderma harzianum* (2%) + *Pseudomonas fluorescens* (2%)	14.367[g]	21.920[h]	26.66[f]
T5	Mancozeb (1%) + *Pseudomonas fluorescens* (2%) + *Bacillus subtilis(2%)*	15.703[f]	23.847[g]	29.33[e]
T6	Mancozeb (1%) + Bacillus subtilis(2%) + *Trichoderma harzianum* (2%)	23.847[c]	28.887[d]	34.51[c]
T7	Mancozeb (1%)	27.183[b]	33.480[b]	37.33[b]
C.D (5%)		1.009	1.044	1.867

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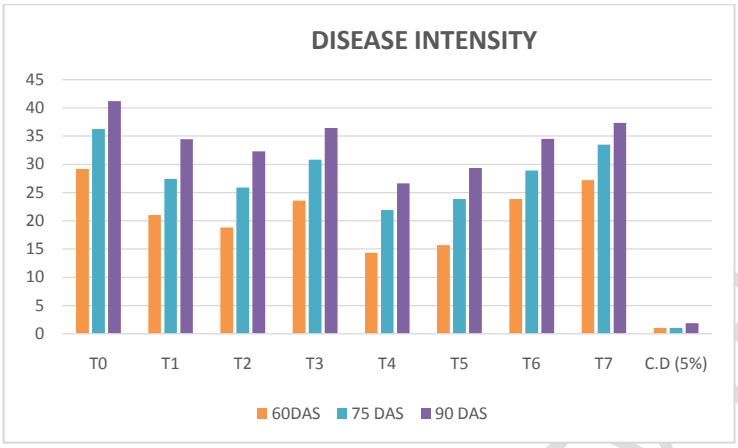

Fig 4.DISEASE INTENSITY

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4.1 Disease Intensity:

4.1.1 Disease Intensity at 60 DAS

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The data presented in table 4 and depicted in figure 4 reveals that maximum Disease intensity ofokraat60DASwasrecordedinT4- Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (14.36)followedby T5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (15.70) and T2 - Mancozeb (1%) + *Pseudomonas(4%)* (18.81) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)*(21.03) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(23.553), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (23.847)ascomparedtoT7-Mancozeb (1%) (27.18)andT0–untreatedcontrol-(29.18).Allthetreatmentsweresignificantover untreated control. Among the treatments (T_7 and T_4) were statistically non-significant to each other

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4.1.2 Disease Intensity at 75 DAS

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The data presented in table 4 and depicted in figure 4 reveals that maximum Disease Intensity ofokraat75DASwasrecordedinT4- Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (21.92)followedby T5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (23.84) and T2 - Mancozeb (1%) + *Pseudomonas(4%)* (25.92) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)*(27.40) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(28.88), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (30.81)ascomparedtoT7-Mancozeb (1%) (33.48)andT0–untreatedcontrol-(36.29).Allthetreatmentsweresignificantover untreated control.

4.1.3 Disease Intensity at 90 DAS

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The data presented in table 4 and depicted in figure 4 reveals that maximum Disease Intensity ofokraat90 DASwasrecordedinT4- Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (26.66)followedby T5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (29.33) and T2 - Mancozeb (1%) + *Pseudomonas(4%)* (32.33) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)*(34.44) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* +

Trichoderma(2%)(34.51), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (36.47)ascomparedtoT_7-Mancozeb (1%) (37.33)andT_0–untreatedcontrol-(41.18).Allthetreatmentsweresignificantover untreated control. Among the treatments (T_8 and T_4), (T_7 and T_2) were statistically non significant to each other

From this present study entitled **"Efficacy of bio control agents with chemical fungicides against *Cercospora* leaf spot of Okra *(Abelmoschus esculentus* L.) Moench"**based on the observations it can be concluded that the efficacy of combining readily available and ecologically safe bioagents with synthetic safe mancozeb fungicide for the management of *Cercospora* leaf spot of okra .

From the critical analysis of the present findings, it can be concluded that after the application of all the treatments with three replications, T4- Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* is the best treatment as it showed The **Disease Intensity of okra**at 60,75 and 90 DASwhich was significantly increased by the use of Mancozeb (1%) + *Trichoderma(4%)* + *Pseudomonas(4%)*under Prayagraj Agro climatic conditions . Based on analysis T4- Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* is recommended to control the *cercospora*leaf spot disease in Okra. The present findings were limited to one crop season *kharif* under the climatic conditions of Prayagraj , U.P. , therefore substantiate the present result more trails are required for further recommendations .

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Reference

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.

Term: Definition for the term