Evaluation of the growth parameters with respect to Bio-control agents with chemical fungicides against *Cercospora* leaf spot of Okra (*Abelmoschus esculentus* L.) Moench

ABSTRACT

Okra (*Abelmoschus esculentus* L.) is one of the fore most vegetable crop grown during *kharif* as well as summer seasons. *Cercospora* leaf spot incited by *Cercospora* spp. is one of the emerging disease in all regions wherever okra is grown. *C. abelmoschi* causes sooty black, angular spots and cause severe defoliation common during humid seasons. 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* leaf spot of okra. Studies revealed that minimum disease intensity , Maximum plant height , maximum no. of branches per plant and Maximum no. of fruits was observed in *T4 - Mancozeb (1%) + Trichoderma(2%) + Pseudomonas(2%)* and is hereby considered as the best treatment.

Keywords: Mancozeb , Trichoderma , Pseudomonas, Bacillus.

1. INTRODUCTION

Okra *(Abelmoschus esculentus* L.) Moench is one of the most widely known species ofthe family Malvaceae and an economically important vegetable crop grown in tropical climateof temperature range between 25^0 to 35^0c. The name "Okra" derives from one of Niger-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 . Some studies are being developed targeting okra extract as remedy to manage diabetes. Its ripe seeds are roasted, ground and used as a substitute for coffee 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 linoleic acid up to 47.4% and polyunsaturated fatty acid essential for human nutrition. **(Singh *et al.,* 2014).**

Okra contains Potassium, Sodium, Magnesium and Calcium as principal elements in pods, which contains 17% seeds. Presence of Iron, Zinc, Manganese and Nickel also has been reported (**Moyin-Jesu, 2007).** Fresh pods are low in calories (20/100 g), practically no fat, richin fiber, and with several valuable nutrients. Okra seed is mainly composed of oligomeric catechins (2.5 mg g^{-1} of seeds), while the mesocarp is mainly composed of hydroxycinnamic (0.2 mg g^{-1}) and quercetin derivatives (0.3 mg g^{-1}). Pods are rich in phenolic compounds with important biological properties like quartering derivatives, catechin oligomers and hydroxycinnamic derivatives (**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 **.**

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* is one of the most economically important in all regions wherever bhendi is grown. In India, twospecies of *Cercospora* produce leaf spots on bhendi. *C. malayensis* causes brown, irregular spots and *C. abelmoschi* causes sooty black, angular spots. Both the leaf spots cause severe defoliation and are common during humid seasons. Now a days, this disease incited by *C. abelmoschi* becomes more severe in southern transition zone of Karnataka. Initially the diseasesymptoms observed on the lower surface of the leaves as in distinct spots in the form of olivaceous specks. Later on, light brown to grey mouldy growth of the fungus covered the entire lower surface. The infected leaves ultimately dry and defoliate. The disease progress upward from lower leaves and infects stem and fruits and produces similar symptoms. **(Naik *et al.,* 2017).**

Cercospora produce a perylene quinone toxin called cercosporin which is non- selective, affecting bacteria and fungi unless these produce protective antioxidants such as carotenoids. Morphology of the pathogen of genus *Cercospora* was

first described by Frensious (1863), Etymologically the generic name means a fungus has obclavate (tail shaped)spores. Sporulation occurs at temperature range 8-24 °C, where mature spores sporulate after 14to 24 hours.

For the management of *Cercospora* leaf spot of okra from many years, many have beenrelied on chemicals and this resulted in many undesirable problems. Now a day's tremendous use of chemicals in agriculture has resulted in growing concern of both public health and environment hazards thus, emphasis is now on judicious use of bio-agents, botanicals and organics for management of the plant diseases which is less costly, nontoxic and doesn't affect public health and environment. Fungicides are also effective in managing this disease as such their use in the management strategy can not be ruled out but their indiscriminate use should be avoided. There is need to incorporate alternative control components that are effective in field.Considering the above-mentioned facts, a study was conducted, entitled, , **"Evaluation of the growth parameters with respect to Bio-control agents with chemical fungicides against Cercospora leaf spot of Okra (Abelmoschus esculentus L.) Moench"** with the following objectives :-

1. To evaluate the effect of bioagents on *Cercospora* disease intensity in okra.

2. MATERIAL AND METHODS

The experiment was conducted at the research plot of the Department of Plant Pathology and Central Research Field, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj during the *Kharif* season 2022. The selected site was uniform, cultivable with typical sandy loam soil having good drainage.

Table 1. the treatment details.

S. No	Treatments	Treatment Details
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.		Mancozeb (1%) + *Pseudomonas*

	T5	*fluorescens* (2%) + Bacillus subtilis(2%)
7.	T6	Mancozeb (1%) + *Bacillus subtilis*(2%) + *Trichoderma harzianum* (2%)
8.	T7	Mancozeb (1%)

Table 2: Effect of treatments on Plant height of *Cercospora* leaf spot of okra at30, 60 and 90 DAS

Tr.no	Treatment	Plant height (cm)		
		30 DAS	**60 DAS**	**90 DAS**
T0	**Control**	10.41^{h}	30.26^{e}	69.81^{g}
T1	**Mancozeb (1%) +*Trichoderma harzianum* (4%)**	15.58^{d}	35.04^{c}	75.46^{d}
T2	**Mancozeb (1%) + *Pseudomonas fluorescens* (4%)**	17.24^{c}	35.57^{c}	76.38^{d}
T3	**Mancozeb (1%) + *Bacillus subtilis(4%)***	12.75^{f}	34.22^{c}	72.89^{e}
T4	**Mancozeb (1%) + *Trichoderma harzianum* (2%) + *Pseudomonas fluorescens* (2%)**	20.89^{a}	38.70^{a}	78.85^{a}
T5	**Mancozeb (1%) + *Pseudomonas fluorescens* (2%) + *Bacillus subtilis(2%)***	18.96^{b}	37.04^{b}	78.04^{b}
T6	**Mancozeb (1%) + Bacillus subtilis(2%) + *Trichoderma harzianum* (2%)**	14.16^{e}	34.93^{c}	74.72^{c}
T7	**Mancozeb (1%)**	11.58^{g}	32.22^{d}	71.92^{f}

C.D (5%)	0.86	1.46	0.79

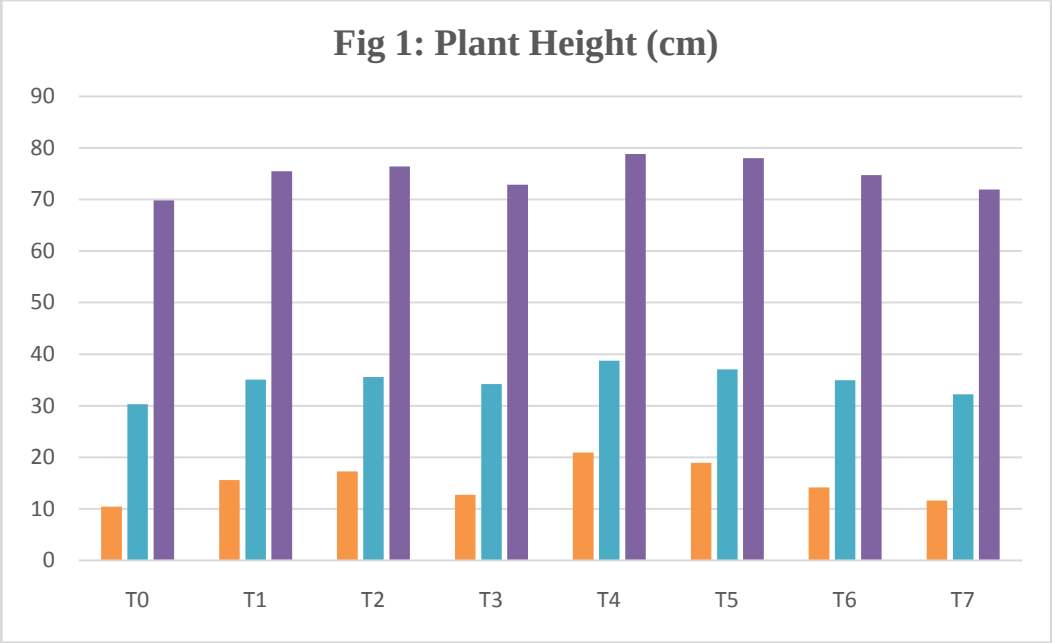

Table 3: Effect of treatments on No. of Branches of *Cercospora* leaf spot of okra at30, 60 and 90 DAS

Tr.no	Treatment	No. of Branches		
		30 DAS	**60 DAS**	**90 DAS**
T0	**Control**	1.067^{h}	4.333^{g}	6.63^{f}
T1	**Mancozeb (1%) +*Trichoderma harzianum* (4%)**	2.000^{d}	5.333^{cd}	7.63^{d}
T2	**Mancozeb (1%) + *Pseudomonas fluorescens* (4%)**	2.200^{c}	5.533b^{c}	7.96^{c}
T3	**Mancozeb (1%) + *Bacillus subtilis(4%)***	1.533^{f}	4.867^{e}	7.13^{e}
T4	**Mancozeb (1%) + *Trichoderma harzianum* (2%) + *Pseudomonas fluorescens* (2%)**	2.600^{a}	6.333^{a}	8.63^{a}
T5	**Mancozeb (1%) + *Pseudomonas fluorescens* (2%) + *Bacillus subtilis(2%)***	2.400^{b}	5.733^{b}	8.30^{b}

T6	**Mancozeb (1%) + Bacillus subtilis(2%) + *Trichoderma harzianum* (2%)**	1.733[e]	5.133[d]	7.26[e]
T7	**Mancozeb (1%)**	1.333[g]	4.600[f]	7.03[e]
C.D (5%)		0.86	0.118	0.27

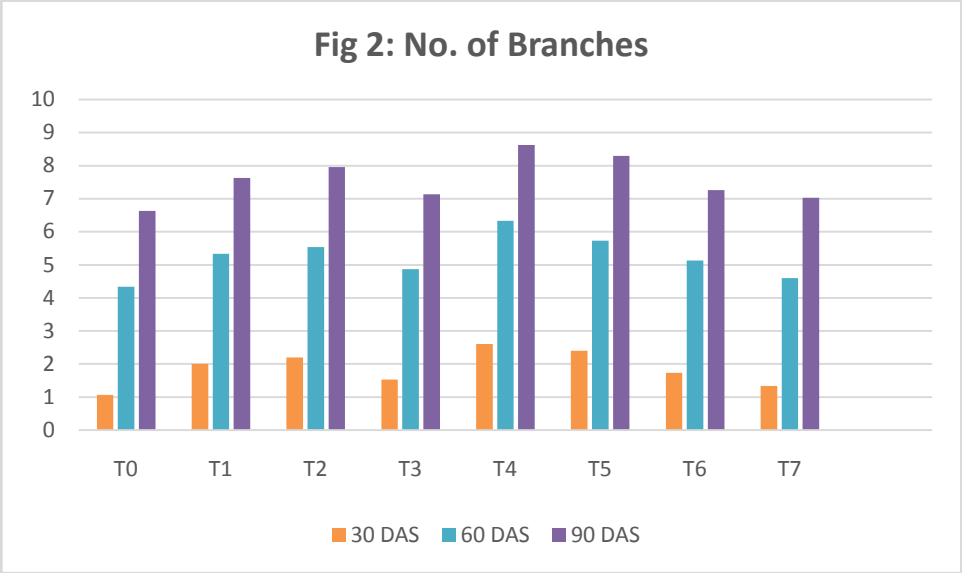

Table 4: Effect of treatments on No. of Fruits of *Cercospora* leaf spot of okra at60,75 and 90 DAS

Tr.no	Treatment	No. of fruits		
		60DAS	**75 DAS**	**90 DAS**
T0	**Control**	1.600[h]	4.267[h]	7.00[f]
T1	**Mancozeb (1%) +*Trichoderma harzianum* (4%)**	2.800[d]	5.533[d]	8.63[d]
T2	**Mancozeb (1%) + *Pseudomonas fluorescens* (4%)**	3.000[c]	5.800[c]	8.96[b]
T3	**Mancozeb (1%) + *Bacillus subtilis(4%)***	2.267[f]	5.067[f]	8.10[c]
T4	**Mancozeb (1%) + *Trichoderma harzianum* (2%) + *Pseudomonas fluorescens* (2%)**	3.600[a]	6.267[a]	9.23[a]
T5	**Mancozeb (1%) + *Pseudomonas fluorescens* (2%) + *Bacillus***	3.267[b]	6.000[b]	9.00[b]

	subtilis(2%)			
T6	**Mancozeb (1%) + Bacillus subtilis(2%) + *Trichoderma harzianum* (2%)**	2.600^{e}	5.267^{e}	8.16^{d}
T7	**Mancozeb (1%)**	1.867^{g}	4.800^{g}	7.90^{e}
C.D (5%)		0.86	0.181	0.19

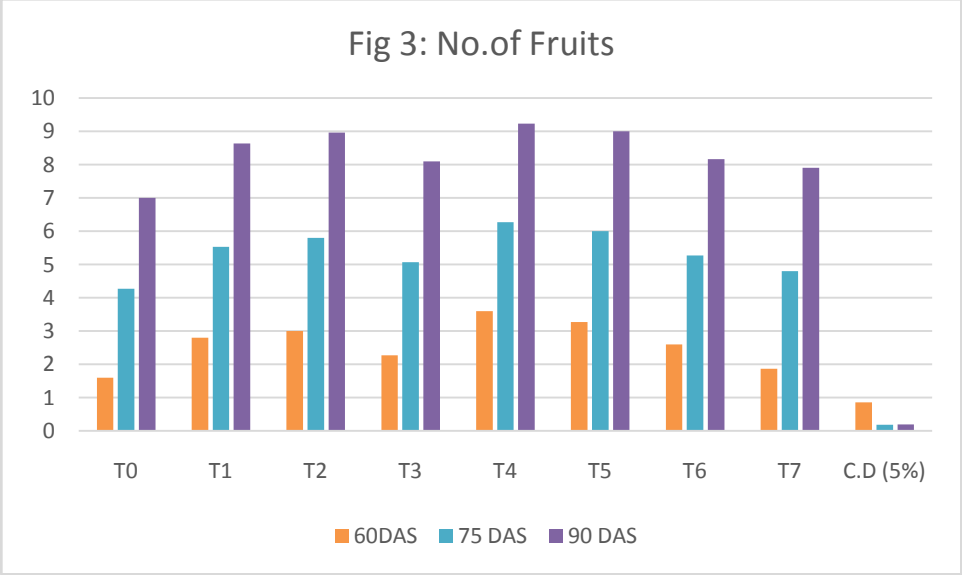

Fig 4: Overview of Spraying

Fig 5: Overview of Disease Infested Leaves

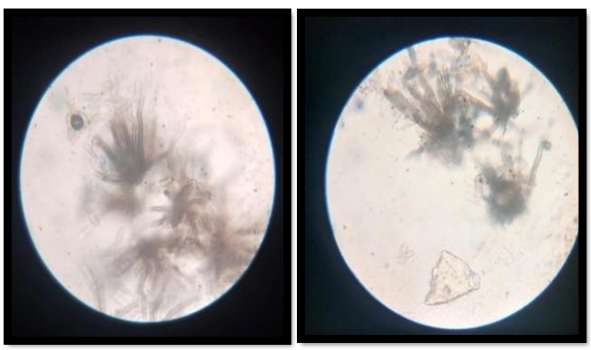

Fig 6: OVERVIEW OF MICROSCOPIC VIEW OF *Cercospora sp.*

RESULTS :-

Effect of bioagents and chemical fungicide on plant height (cm) of okra at 30, 60 and 90 DAS

4.1 Plant height (cm):

4.1.1 Plant height (cm) at 30 DAS

The data presented in table 1 and depicted in figure 1 reveals that maximum plant height (cm) of okra at 30 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (20.89 cm) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (18.96 cm) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (17.24 cm) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (15.58) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(14.16), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (12.75) as compared to T_7 - Mancozeb (1%) (11.58cm) and T_0 – untreated control- (10.41cm). All the treatments were significant over untreated control.

4.1.2 Plant height (cm) at 60 DAS

The data presented in table 1 and depicted in figure 1 reveals that maximum plant height (cm) of okra at 60 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (38.70 cm) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (37.04 cm) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (35.57 cm) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (35.04 cm) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma((2%)* 34.93 cm), T_3

Mancozeb (1%) + *Bacillus subtilis(4%)* (34.22 cm) as compared to T_7 - Mancozeb (1%) (32.22 cm) and T_0 – untreated control- (30.26 cm). All the treatments were significant over untreated control , Among the treatments (T_3 and T_4) , (T_4 and T_2) , (T_2 and T_7) were statistically non significant to each other .

4.1.3 Plant height (cm) at 90 DAS

The data presented in table 1 and depicted in figure 1 reveals that maximum plant height (cm) of okra at 90 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (78.85 cm) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (78.04 cm) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (76.38 cm) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (75.46 cm) , T_6 Mancozeb (1%) + *Bacillus subtilis(4%)* + *Trichoderma(4%)*(74.72 cm), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (72.89 cm) as compared to T_7 - Mancozeb (1%) (71.92 cm) and T_0 – untreated control- (69.81 cm). All the treatments were significant over untreated control , Among the treatments (T_3 and T_2) were statistically non significant to each other

Effect of bioagents and chemical fungicide on No. of Branches of okra at 30, 60 and 90 DAS

4.2 No. of Branches:

4.2.1 No. of Branches at 30 DAS

The data presented in table 2 and depicted in figure 2 reveals that maximum plant height (cm) of okra at 30 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (2.60) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (2.40) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (2.20) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (2.0) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(1.73), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (1.53) as compared to T_7 - Mancozeb (1%) (1.33) and T_0 – untreated control- (1.06). All the treatments were significant over untreated control.

4.2.2 No. of Branches at 60 DAS

The data presented in table 2 and depicted in figure 2 reveals that maximum plant height (cm) of okra at 60 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (6.33) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (5.73) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (5.53) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (5.33) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(5.13), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (4.86) as compared to T_7 - Mancozeb (1%) (4.60) and T_0 – untreated control- (4.33). All the treatments were significant over untreated control , Among the treatments (T_6 and T_3) (T_3 and T_2) (T_2 and T_7) were statistically non significant to each other

4.2.3 No. of Branches at 90 DAS

The data presented in table 2 and depicted in figure 2 reveals that maximum plant height (cm) of okra at 90 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (8.63) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (8.30) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (7.96) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (7.63) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(7.26), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (7.13) as compared to T_7 - Mancozeb (1%) (7.03) and T_0 – untreated control- (6.63). All the treatments were significant over untreated control , Among the treatments (T_7 and T_4) (T_4 and T_8) were statistically non significant to each other

4.2.4 No. of Fruits at 60 DAS

The data presented in table 3 and depicted in figure 3 reveals that maximum plant height (cm) of okra at 60 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (3.60) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (3.26) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (3.00) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (2.80) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(2.60), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (2.26) as compared to T_7 - Mancozeb (1%) (1.86) and T_0 – untreated control- (1.60). All the treatments were significant over untreated control.

4.2.5 No. of Fruits at 75 DAS

The data presented in table 3 and depicted in figure 3 reveals that maximum plant height (cm) of okra at 75 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (6.26) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (6.00) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)*

(5.80) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (5.53) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(5.26), T_3 Mancozeb (1%) +

Bacillus subtilis(4%) (5.06) as compared to T_7 - Mancozeb (1%) (4.80) and T_0 – untreated control- (4.26). All the treatments were significant over untreated control.

4.2.6 No. of Fruits at 90 DAS

The data presented in table 3 and depicted in figure 3 reveals that maximum plant height (cm) of okra at 90 DAS was recorded in T_4 - Mancozeb (1%) + *Trichoderma(2%)* + *Pseudomonas(2%)* (9.23) followed by T_5 - Mancozeb (1%) + *Pseudomonas(2%)* + *Bacillus subtilis(2%)* (9.00) and T_2 - Mancozeb (1%) + *Pseudomonas(4%)* (8.96) followed by T_1 Mancozeb (1%) + *Trichoderma(4%)* (8.63) , T_6 Mancozeb (1%) + *Bacillus subtilis(2%)* + *Trichoderma(2%)*(8.16), T_3 Mancozeb (1%) + *Bacillus subtilis(4%)* (8.10) as compared to T_7 - Mancozeb (1%) (7.90) and T_0 – untreated control- (7.00). All the treatments were significant over untreated control. Among the treatments (T_3 and T_6) (T_2 and T_7) were statistically non significant to each other

DISCUSIION :-

In the present study, the **Plant height of okra** at 60,75 and 90 DAS was significantly increased by the use of Mancozeb (1%) + *Trichoderma(4%)* + *Pseudomonas(4%)*.

The No. of **Branches of okra** at 60,75 and 90 DAS was significantly increased by the use of Mancozeb (1%) + *Trichoderma(4%)* + *Pseudomonas(4%)*.

The **No. of Fruits of okra** at 60,75 and 90 DAS was significantly increased by the use of Mancozeb (1%) + *Trichoderma(4%)* + *Pseudomonas(4%)*.

Maximum **Plant height , No. of Branches , no. of fruits** was observed in Mancozeb (1%) + *Trichoderma(4%)* + *Pseudomonas(4%)* the probable reason for such finding may be because of the inhibitory effect of bio-agents due to hyper parasitism/mycoparasitism, competition for space and nutritional source and antagonistic chemical produced by them **.** *Trichoderma sp. , Pseudomonas* has been reported to produce antibiotic compounds (Trichodermin), extracellular enzymes (chitinase, cellulose) unsaturated monobasic acids (Dermadine) and peptides

CONCLUSION:-

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 **GROWTH PARAMETERS** at 60,75 and 90 DAS which 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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DEFINITIONS, ACRONYMS, ABBREVIATIONS

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

Term: Definition for the term