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Evaluation of fungicides, garlic clove extract, *T. viride* and their combinations on maydis leaf blight disease and yield and yield attributing traits of maize (*Zea mays* L.)

Hem Chandra Chaudhary, Sunil Zacharia, Abhilasha A Lal and Sobita Simon

Abstract
A study was conducted during the *Kharif* seasons of 2021 and 2022 at the Central Research Farm of the Department of Plant Pathology, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj. The purpose of the study was to observe the effects of fungicides; garlic clove extract, *T. viride*, and their combinations on maydis leaf blight disease under natural epiphytic conditions. Eleven treatment combinations, including a control, were prepared and evaluated under field conditions. The percent disease incidence and the effects of the treatments on yield and yield attributing traits, B: C ratio were measured. The minimum percent disease incidence (29.34%.) was observed in seed treatment with a combination of carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed followed by two foliar sprays of propiconazole 25% EC @ 0.1% concentration at 15 days intervals after initiation of symptoms. The next best treatment was seed treatment with *Trichoderma viride* @ 5 g/kg of seed followed by two foliar sprays of propiconazole 25 % EC @ 0.1% concentration at 15 days intervals after initiation of symptoms (30.95%.) The maximum percent disease incidence was observed in seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed, with 67.91% over control. The application of different seed treatments and foliar sprays on maize plants was evaluated for their impact on various yield parameters and B: C ratio. The highest values for grain yield (4.94 t/ha), plant height (187.75 cm), cob length (26.76 cm), cob diameter (18.89 cm), cob weight (112.04 g), shelling percentage (78.28), and 1000 grain weight (256.08 g) were observed in the treatment where seeds were treated with a combination of carbendazim 12% + mancozeb 63% WP @ 3 g/kg of seed, followed by two foliar sprays of propiconazole 25% EC @ 0.1% concentration at 15 days intervals after initiation of symptoms. The second highest values were obtained when seeds were treated with *Trichoderma viride* @ 5 g/kg of seed, followed by the same two foliar sprays of propiconazole at 15 days intervals after initiation of symptoms. On the other hand, the lowest values for grain yield (2.29 t/ha), plant height (171.92 cm), cob length (20.18 cm), cob diameter (15.27 cm), cob weight (61.69 g), shelling percentage (65.04), and 1000 grain weight (144.84 g) were observed in the treatment where seeds were treated with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed. However, the treatment, seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed, followed by two foliar sprays of propiconazole 25 % EC @ 0.1% concentration a 15 days intervals after initiation of symptoms resulted in the highest benefit-cost ratio.

Keywords: *T. viride*, propiconazole, carbendazim, mancozeb, garlic clove extract, seed treatment, maydis leaf blight, *B. maydis*, percent disease incidence, B: C ratio

1. Introduction
The Mexican native maize (*Zea mays* L.), also known as corn, is a highly adaptable crop that has been called a "miracle crop." It can thrive in a variety of agro-climatic conditions and is the third most important crop in India, after rice and wheat. According to preliminary data from 2020-2021, it is grown on 9.89 million hectares, which accounts for 81% of the land used for crops in India. Research conducted over the last few years by the All India Coordinated Maize Improvement Project has identified 16 major diseases out of the 61 diseases that adversely affect this crop (Payak and Sharma, 1980) [19]. These include maydis leaf blight, *Tursicum* leaf blight, banded leaf and sheath blight, brown spot, *Curvularia* leaf spot, Zonate leaf spot, *Polisora* rust, common rust, sorghum downy mildew, Rajasthan downy mildew, and brown stripe downy mildew. One of the major diseases affecting the crop is maydis leaf blight (MLB), which is caused by a fungus called *Bipolaris maydis* (Nisikado & Miyake)

Shoemaker. This foliar disease affects almost all of India's maize-growing regions and is most prevalent in warm, humid climates. Maydis leaf blight caused by *H. maydis* was first discovered by Drechsler (1925) [6], in the United States, but it was first identified in India by Munjal and Kapoor (1960) [18], in the Malda district of West Bengal. The disease also broke out in Rajasthan and Ludhiana reported it as well, as documented by Sharma *et al*. (1978) [20].

MLB disease is a significant issue in maize-growing regions of India, encompassing states such as Uttar Pradesh, Bihar, Uttarakhand, Punjab, Haryana, Jammu & Kashmir, Himachal Pradesh, Sikkim, Meghalaya, Rajasthan, Delhi, Madhya Pradesh, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu. Depending on weather conditions, MLB caused by *Bipolaris maydis* can reduce maize yields by 9.7% to 11.7%, as reported by Bera and Giri (1979) [3], Harlapur *et al*. (2000) [7], Sharma *et al*. (2003) [21], Kumar and Saxena (2007) [11]. However, this disease has also been linked to yield losses of up to 70%, as noted by Wang *et al.* (2001) [23] and Ali *et al*. (2012) [1].

The severity of maydis leaf blight disease can be influenced by agronomic practices that encourage high humidity and moderate temperatures. It may not be possible to effectively treat this disease with a single method. Therefore, it is essential to develop management plans that combine fungicides, bio-agents, and botanicals as effective constituents. In light of this, the present research investigates the effects of fungicides, aqueous plant extracts, bio-agents, and their combinations on maydis leaf blight disease.

2. Material and Methods

2.1. Effect of fungicides, garlic clove extract, *Trichoderma viride* and their combination on MLB disease *in situ*

The experiment was conducted at CRF Farm, Department of Plant Pathology, SHUATS, Prayagraj, during the *Kharif* season of 2021 and 2022 to evaluate the effectiveness of eleven fungicide treatments, including a control group, on maydis leaf blight. The treatments were as follows: T_1 (seed treatment with *Trichoderma viride* @ 5g/kg of seed); T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3g/kg of seed); T_3 (T_1 + two foliar sprays of garlic clove extract @ 10% conc.); T_4 (T_1+ two foliar sprays of propiconazole 25 % EC @ 0.1% conc.); T_5 (T_1 + two foliar sprays of mancozeb 75% WP @ 0.2% conc.); T_6 (T_1 + two foliar sprays of propiconazole 13.9% EC + difenoconazole 13.9 % EC @ 0.1% conc.); T_7 (T_2 + two foliar sprays of garlic clove extract @ 10% conc.); T_8 (T_2 + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.); T_9 (T_2 + two foliar sprays of mancozeb 75% WP @ 0.2% conc.); T_{10} (T_2 + two foliar sprays of propiconazole 13.9% EC + difenoconazole 13.9 % EC @ 0.1% conc.). The study also assessed the treatments' impact on grain yield and yield attributing traits and economics too. The crops were fertilized with a mixture of NPK in the ratio of 120:60:40 kg/ha. The full amount of phosphorus (P) and potassium (K) and half of the nitrogen (N) were applied during the final land preparation. The remaining amount of nitrogen was split into two doses, with one being applied 40 days after sowing and the other at 60 days after sowing. Intended plant population was kept constant. Three to four chloropyriphos 4 G granules were manually applied to each plant's whorl at 45 DAS to control armyworm and fall armyworm. Two manual weeding's were performed, the first at the knee-high stage and the second before tasseling. First spraying was given after initiation of symptoms and second after 15 days of first spray.

2.2. Per cent disease index (PDI)

Ten plants were randomly selected from each replicated plot and the severity of the disease was recorded using a disease rating scale ranging from 1 to 9 (refer to Table 1), which was developed by Balint-Kurti *et al.* (2006) [2], Mitiku *et al.* (2014) [17], and Chung *et al.* (2010) [5]. The percentage of disease incidence was calculated using the formula proposed by Wheeler (1969) [24].

$$\text{Disease incidence (\%)} = \frac{\text{Sum of numerical ratings}}{\text{No. of leaves observed X Maximum grade}} \text{ X 100}$$

2.3. Shelling Per cent

Shelling per cent was recorded from average of 10 randomly selected ear from each plot and calculated by using formula provided by Tandzi and Mutengwa (2020) [22].

$$\text{Shelling percent} = \frac{\text{Grain weight}}{\text{Fresh ear weight}} \text{ X 100}$$

2.4. Grain yield (t/ha)

Total grain yield is harvested from each replicated plot (2 m x 2.4 m) was determined and adjusted to 15 % moisture content (MC) and calculated using the formula provided by Horrocks and Zuber (1970) [8].

$$\text{Grain yield (t/ha)} = \frac{\{\text{Fresh ear weights (kg/plot) X 10 X (100-MC) X shelling per cent}\}}{\text{(100-adjsted MC) X Plot area}} \text{X 100}$$

Table 1: Standard disease rating scale for maydis leaf blight disease assessment (Balint-Kurti *et al*. (2006) [2], Mitiku *et al*. (2014) [17], and Chung *et al*. (2010) [5]

Rating scale	Degree of infection (Per cent diseased leaf area)	Per cent disease index
1	The plants showed little to no infection, with the infection rate being less than or equal to 10%.	≤11.11
2	There were only a small number of lesions present on the two lower leaves, with the infection rate ranging from 10.1% to 20%. The overall infection level could be described as slight.	22.22
3	A moderate number of lesions were observed on four lower leaves, indicating a light infection level with the rate ranging from 20.1% to 30%.	33.33
4	A moderate number of lesions were observed on the lower leaves, with a few lesions scattered on middle leaves below the cob, indicating a light infection level with the rate ranging from 30.1% to 40%.	44.44
5	The infection level could be classified as moderate, with an abundant number of lesions scattered on the lower leaves and a moderate number of lesions scattered on middle leaves below the cob. The infection rate ranged from 40.1% to 50%.	55.55

6	The plants were heavily infected, with an abundant number of lesions scattered on the lower leaves, a moderate infection level observed on the middle leaves, and a few lesions on two leaves above the cob. The infection rate ranged from 50.1% to 60%.	66.66
7	The plants showed a heavy infection level, with an abundant number of lesions scattered on both the lower and middle leaves. The infection rate ranged from 60.1% to 70%.	77.77
8	The plants were severely affected by the disease, showing a very heavy infection level. Lesions were observed in abundance and were scattered on both the lower and middle leaves, with the infection spreading up to the flag leaves. The infection rate ranged from 70.1% to 80%.	88.88
9	The plants were severely affected by the disease, showing a very heavy infection level. Lesions were observed in abundance and were scattered on almost all the leaves. As a result, the plants prematurely dried and died, with an infection rate exceeding 80%.	99.99

3. Results and Discussion

3.1. Effect of fungicides, garlic clove extract, *T. viride* and their combination on PDI and grain yield of maize *in situ* during *Kharif* 2021 and 2022

Ten treatment combinations of fungicides, garlic clove extract and *T. viride* were prepared, viz., T_0 (control), T_1 (ST with *T. viride* @ 5g/kg of seed), T_2 (ST with carbendazim 12% WP + mancozeb 63% WP @ 3g/kg of seed), T_3 (T_1 + two foliar sprays of garlic clove extract @ 10% conc.), T_4 (T_1 + two foliar sprays of propiconazole 25% EC @ 0.1% conc.), T_5 (T_1 + two foliar sprays of mancozeb 75% WP @ 0.2% conc.), T_6 (T_1+ two foliar sprays of propiconazole 13.9% + difenoconazole 13.9% EC @ 0.1% conc.), T_7 (T_2 + two foliar sprays of garlic clove extract @ 10% conc.), T_8 (T_2 + two foliar sprays of propiconazole 25% EC @ 0.1% conc.), T_9 (T_2 + two sprays of mancozeb 75% WP @ 0.2% conc.), T_{10} (T_2 + two foliar sprays of propiconazole 13.9 % EC + difenoconazole 13.9% EC @ 0.1% conc.), and evaluated against maydis leaf blight for assessment of percent disease incidence and effect on grain yield of maize during *Kharif* 2021 and 2022 (table 4.15 and fig. 4.18). Maydis leaf blight was significantly managed by all treatment combinations, including seed treatments and foliar sprays, in *Kharif* 2021 and 2022.

3.2. Percent disease incidence

The data regarding effect of fungicides, garlic extract, *T. viride* and their combination on percent disease incidence are presented in table 1 and discuss hereunder.

During *Kharif* 2021, minimum per cent disease incidence was recorded in T_8 (Seed treatment with mancozeb 63% WP + carbendazim 12% WP @ 3 g/ kg of seed + two foliar sprays of propiconazole 25% EC @ 0.1% conc.) with 29.83% followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 31.06% and maximum was observed in T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 69.40 % over control 78.38%. All the treatments were found significant over control. However treatment T_1, T_2 and T_7 were found significant from each other.

During *Kharif* 2022, minimum per cent disease incidence was recorded in T_8 (seed treatment with mancozeb 63% WP + carbendazim 12% WP @ 3 g/ kg of seed + two foliar sprays of propiconazole 25% EC @ 0.1% conc.) with 28.84% followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 30.84% and maximum was observed in T_2 (seed treatment with carbendazim 12% + mancozeb 63% WP @ 3 g/kg of seed) with 66.41% over control 79.62%. All the treatments were found significant over control. However treatment T_1, T_2, T_3, T_4, T_7 and T_8 are significant from each other.

In pooled analysis, minimum per cent disease incidence was recorded in T_8 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/ kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 29.34 % followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 30.95% and the maximum was observed in T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 67.91 over control 79%. All the treatment was found significant over control. However treatment T_1, T_2, T_3, T_4, T_5, T_7, T_8 and T_9 are significant from each other. The per cent disease incidence increase over control was found maximum in T_8 (carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 62.86% followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 60.82% and minimum was observed in T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 14.03%. Similar finding was reported Bharti *et al.* (2020) [4], who reported that seed treatment with SAAF @ 3 g/ kg of seed followed by foliar application of propiconazole @ 0.1% conc. was effective against MLB disease which was significantly reduced disease incidence in all the spray i.e. first spray with 28.67%, second spray with 31.0 % and third spray with 34.75% over control.

3.3. Grain yield (t/ha)

The data regarding effect of fungicides, garlic extract, *T. viride* and their combination on yield (t/ha) are presented in table 1 and discuss hereunder.

During *Kharif* 2021, maximum grain yield was recorded in T_8 (Seed treatment with carbendazim 12% + mancozeb 63% @ 3 g/ kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 5.12 t/ha followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25% EC @ 0.1% conc.) with 4.16 t/ha and minimum was observed in T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 2.11 t/ha over control (1.76 t/ha). All the treatments were found significant over control. However, T_1, T_2, T_4, T_6, T_8, T_9 and T_{10} are significant from each other. The treatments T_5 and T_9 are non- significant from each other. Also the treatments T_3 and T_7 are also non- significant from each other by DMRT at 5% level of significance.

During *Kharif* 2022, maximum grain yield was recorded in T_8 (seed treatment with carbendazim 12% + mancozeb 63% @ 3 g/ kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 4.76 t/ha followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 4.60 t/ha and

minimum was observed in T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 2.46 t/ha over control 1.97 t/ ha.. All the treatments were found significant over control. However, T_4, T_5, T_6, T_8, T_9 and T_{10} are significant from each other. The treatments T_3 and T_7 are non- significant from each other. Also the treatments T_1 and T_2 are non- significant from each other by DMRT at 5% level of significance.

In pooled analysis, maximum grain yield was recorded in T_8 (seed treatment with carbendazim 12% WP + mancozeb 63% @ 3 g/ kg of seed + two foliar sprays of propiconazole 25 EC @ 0.1% conc.) with 4.94 t/ha followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with 4.71 t/ha and the minimum was observed in T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 2.29 t/ha over control 1.86 t/ha. All the treatments were found significant over control. However, T_1, T_2, T_3, T_4, T_6, T_7, T_8 and T_{10} are significant from each other. The treatments T_5 and T_9 area non- significant from each other by DMRT at 5% level of significance. To control the southern corn leaf blight, it has been demonstrated by Kumar (2010) [12] and he showed that the most effective combination for preventing maydis leaf blight and increasing maize yield was the integration of early sowing, seed treatment with SAAF (carbendazim + mancozeb), and foliar spray with Tilt 25 EC (propiconazole) which was also found in the present studies. The present findings were further corroborated by Hulagappa *et al*. (2013) [9] and he was observed that two foliar applications of propiconazole 25 % EC @ 0.1%, tebuconazole 25% EC @ 0.1%, and difenconazole 25 % EC @ 0.1% at 30 to 50 DAS were successful in preventing maydis leaf blight and increased grain and fodder yield.

Table 2: Effect of fungicides, garlic clove extract, *T. viride* and their combination on per cent disease incidence and grain yield of maize during *Kharif* 2021 and 2022

Treatments		Percent Disease Incidence (%)			Percent disese control over check	Grain yield (t/ha)			Percent increase in yield
No.	Treatment Details	2021	2022	Pooled		2021	2022	Pooled	
T_1	Seed treatment with *Trichoderma viride* @ 5 g/kg of seed	61.31	63.29	62.31	21.13	2.41	2.48^{b}	2.45	24.08
T_2	Seed treatment with carbendazim 12% WP + mancozeb 63% WP@ 3 g/kg of seed	69.40	66.41	67.91	14.03	2.11	2.46^{b}	2.29	18.78
T_3	T_1+ two foliar sprays of garlic clove extract @ 10% conc.	42.83^{a}	44.18	43.51	44.92	4.16^{ab}	3.79^{a}	3.97	53.15
T_4	T_1 + two foliar sprays of propiconazole 25 % EC@ 0.1% conc.	31.06^{c}	30.84	30.95	60.82	4.83	4.60	4.71	60.51
T_5	T_1+ two foliar sprays of mancozeb75 % WP@ 0.2% conc.	41.68^{a}	39.65^{ab}	40.67	48.52	4.20^{a}	4.02	4.11^{a}	54.74
T_6	T_1 + two foliar sprays of propiconazole 13.9% EC + difenoconazole 13.9 % EC @ 0.1% conc.	37.97^{b}	38.58^{bc}	38.28^{a}	51.54	4.47	4.30	4.38	57.53
T_7	T_2+two foliar sprays of garlic clove extract @10% conc.	45.65	46.17	45.91	41.88	4.06^{b}	3.70^{a}	3.88	52.06
T_8	T_2 + two foliar sprays of propiconazole 25% EC@ 0.1% conc.	29.83^{c}	28.84	29.34	62.86	5.12	4.76	4.94	62.35
T_9	T_2+ two foliar sprays of mancozeb 75%WP @ 0.2% conc.	42.79^{a}	40.47^{a}	41.63	47.30	4.34	3.91	4.12^{a}	54.85
T_{10}	T_2 + two foliar sprays of propiconazole 13.9% EC + difenoconazole 13.9 % EC @ 0.1% conc.	38.28^{b}	37.25^{c}	37.76^{a}	52.58	4.67	4.42	4.56	59.21
T_0	Control (untreated)	78.38	79.62	79.00		1.76	1.97	1.86	
Mean		47.20	46.84	47.02		3.67	3.83	3.75	
CD (5%)		2.06	1.51	0.96		0.10	0.12	0.08	
S. Em (±)		0.70	0.51	0.33		0.04	0.04	0.03	

Note: Similar alphabets in table 2 indicate no significant difference from each other by DMRT at 5% level of significance.

3.4. Effect of fungicides, garlic clove extract, *T. viride* and their combination on various yield parameter of maize *in-vivo* during *Kharif* 2021 and 2022

The data regarding effect of fungicides, garlic extract, *T. viride* and their combination on yield attributes presented in table 3a and 3b and discuss hereunder.

During *Kharif* 2021, maximum plant height (187.52 cm), cob length (26.85), cob diameter (18.33 cm) , cob weight (115.21 g), shelling percent (77.54) and 1000 grain weight (257.92 g) was observed in T_8 (seed treatment with carbendazim 12% + mancozeb 63% @ 3 g/ kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) The lowest plant height (170.87 cm), cob length (22.27), cob diameter (15.63 cm), cob weight (62.56 g), and 1000 grain weight (143.18 g) was observed in T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) and the lowest shelling percent was observed in T_1 (seed treatment with *Trichoderma viride* @ 5 g/kg of seed) with 68.67. All the treatments were found significant over control. Similar alphabets indicate no significant different from each other (table 3a and 3b). During *Kharif* 2022, maximum grain yield (4.76 t/ha), plant height (187.99 cm), cob length (26.67), cob diameter (19.27 cm) , cob weight (108.87 g), shelling percent (79.01) and 1000 grain weight (254.24 g) was observed in T_8 (seed treatment with mancozeb 63% + carbendazim 12% @ 3 g/ kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) The lowest cob length (18.10), cob diameter (14.90 cm) , cob weight (61.45 g), shelling percent (59.76%)

and 1000 grain weight (146.39 g) was observed in T_2 (seed treatment with carbendazim 12% EC + mancozeb 63% WP @ 3 g/kg of seed) and the lowest plant height was observed in T_1 (seed treatment with *Trichoderma viride* @ 5 g/kg of seed) with 171.83. All the treatments were found significant over control. Similar alphabets indicate no significant different from each other (table 3a and 3b). In pooled analysis, maximum grain yield (4.49 t/ha), plant height (187.75 cm), cob length (26.76), cob diameter (18.89 cm) , cob weight (112.04 g), shelling percent (78.28) and 1000 grain weight (256.08 g) was observed in T_8 (seed treatment with mancozeb 63% + carbendazim 12% @ 3 g/ kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) followed by T_4 (seed treatment with *T. viride* @ 5 g/kg of seed + two foliar sprays of propiconazole 25% EC @ 0.1% conc.) The minimum plant height (171.92 cm), cob length (20.18), cob diameter (15.27 cm) , cob weight (61.99 g), shelling percent (65.04%) and 1000 grain weight (144.84 g) was observed in T_2 (seed treatment with carbendazim 12% WP+ mancozeb 63% WP @ 3 g/kg of seed) presented in table 3a and 3b. All the treatments are found significant over control. Similar alphabets indicate no significant different from each other (table 3a and 3b). To control the southern corn leaf blight, it has been demonstrated by Mehra (2011)) [15], Hulagappa *et al.* (2013)) [9], Wang *et al.* (2015) [23], Kumar *et al.* (2009b) [13], Malik *et al.* (2018) [14],, and Bharti *et al.* (2020) [4], that seed treatment of combi- fungicides followed by foliar application of propiconazole 25% EC @ 0.1% conc.

Table 3a: Effect of fungicides, garlic clove extract, *T. viride* and their combination on plant height, cob length and cob diameter of maize during *Kharif* 2021 and *Kharif* 2022

Treatments		Plant height (cm)			Cob length (cm)			Cob diameter (cm)		
No.	**Treatment Details**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_1	Seed treatment with *Trichoderma viride* @ 5 g/kg of seed	172.39	171.83^{e}	172.61^{f}	22.36^{g}	18.90^{f}	20.63^{g}	15.73	15.07^{f}	15.53^{d}
T_2	Seed treatment with carbendazim 12% WP+ mancozeb 63% WP @ 3 g/kg of seed	170.87	172.97^{e}	171.92^{f}	22.27^{g}	18.10^{f}	20.18^{g}	15.63	14.90^{f}	15.27^{d}
T_3	T_1+ two foliar sprays of garlic clove extract @ 10% conc.	183.72^{d}	183.90^{d}	183.81^{e}	23.62^{f}	23.33^{de}	23.48^{ef}	15.86	16.17^{de}	16.01^{c}
T_4	T_1+ two foliar sprays of Propiconazole 25% EC @ 0.1% conc.	186.91^{ab}	187.40^{ab}	187.16^{ab}	26.29^{ab}	25.83^{ab}	26.06^{ab}	18.17	18.90^{ab}	18.45
T_5	T_1+ two foliar sprays of Mancozeb 75% WP @ 0.2% conc.	184.60^{cd}	185.83^{bcd}	185.22^{cde}	24.27^{e}	24.20^{cd}	24.24^{de}	17.04^{b}	16.83^{d}	16.88^{b}
T_6	T_1+ two foliar spray of Propiconazole 13.9% EC+ Difenoconazole 13.9 % EC @ 0.1% conc.	185.81^{bc}	185.37^{cd}	185.59^{cd}	25.21^{cd}	24.93^{bc}	25.07^{cd}	17.29^{a}	18.07^{c}	17.79^{a}
T_7	T_2 + two foliar sprays of garlic clove extract @ 10% conc.	184.16^{d}	184.80^{cd}	184.48^{de}	23.65^{ef}	22.33^{e}	22.99^{f}	16.00	15.60^{ef}	15.81^{c}
T_8	T_2+ two foliar sprays of Propiconazole 25 % EC @ 0.1% conc.	187.52^{a}	187.99^{a}	187.75^{a}	26.85^{a}	26.67^{a}	26.76^{a}	18.33	19.27^{a}	18.89
T_9	T_2+ two foliar sprays of Mancozeb 75% WP @ 0.2% conc.	185.75^{bc}	186.03^{abc}	185.89^{cd}	25.01^{d}	23.87^{cd}	24.44^{ab}	17.11^{b}	16.30^{de}	16.69^{b}
T_{10}	T_2+ two foliar sprays of propiconazole 13.9% EC + difenoconazole 13.9 % EC @ 0.1% conc.	186.31^{ab}	186.20^{abc}	186.25^{bc}	25.71^{bc}	24.67^{abc}	25.19^{bc}	17.37^{a}	18.37^{bc}	17.83^{a}
T_0	Control (Untreated)	166.92	168.23	167.58	21.93^{g}	18.37^{f}	20.15^{g}	15.37	13.47	14.53
Mean		181.36	181.87	181.66	24.29	22.84	23.56	16.72	16.63	16.70
CD (5%)		1.50	2.02	1.41	0.64	1.51	0.89	0.94	0.81	0.26
S.E. m (±)		0.66	0.51	0.47	0.22	0.51	0.30	0.03	0.27	0.09

Table 3b: Effect of fungicides, garlic clove extract, *T. viride* and their combination cob weight, shelling per cent and grain weight of maize during *Kharif* 2021 and 2022

Treatments		Cob weight (g)			Shelling percent(%)			1000 grain weight (g)		
No.	**Treatment Details**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**	**2021**	**2022**	**Pooled**
T_1	Seed treatment with *Trichoderma viride* @ 5 g/kg of seed	65.36	63.86	64.61^{d}	68.67^{c}	65.74^{bc}	67.20^{cd}	144.57^{d}	151.90^{d}	148.27^{d}
T_2	Seed treatment with carbendazim 12% WP+ mancozeb 63% WP @ 3 g/kg of seed	62.56	61.45	61.99^{e}	70.19^{bc}	59.76	65.04^{e}	143.18^{d}	146.39^{d}	144.84^{d}
T_3	T_1+ two foliar sprays of garlic clove extract @ 10% conc.	108.31^{bc}	107.51^{bc}	107.91^{c}	62.71	68.25^{b}	65.48^{de}	233.97^{bc}	230.37^{bc}	232.17^{bc}
T_4	T_1+ two foliar sprays of Propiconazole 25% EC @ 0.1% conc.	113.05^{a}	110.59^{a}	111.82^{a}	73.86^{a}	75.97^{a}	74.91^{a}	257.39^{a}	253.42^{a}	255.41^{a}
T_5	T_1+ two foliar sprays of Mancozeb 75% WP @ 0.2% conc.	109.87^{b}	108.71^{ab}	109.29^{b}	65.91^{d}	68.00^{bc}	66.96^{cd}	254.85^{ab}	251.57^{ab}	253.22^{ab}
T_6	T_1+ two foliar spray of Propiconazole 13.9% EC+ Difenoconazole 13.9 % EC @ 0.1% conc.	106.78^{c}	108.80^{ab}	107.79^{c}	70.30^{bc}	74.37^{a}	72.33^{b}	256.26^{a}	252.54^{a}	254.40^{a}
T_7	T_2 + two foliar sprays of garlic clove extract @ 10% conc.	110.35^{b}	108.47^{b}	109.41^{b}	60.54^{f}	65.36^{c}	62.94	231.41^{c}	227.74^{c}	229.58^{c}
T_8	T_2+ two foliar sprays of Propiconazole 25 % EC @ 0.1% conc.	115.21^{a}	108.87^{ab}	112.04^{a}	77.54	79.01	78.28	257.92^{a}	254.24^{a}	256.08^{a}
T_9	T_2+ two foliar sprays of Mancozeb 75% WP @ 0.2% conc.	108.41^{bc}	105.87^{c}	107.14^{c}	65.59^{d}	71.39	68.33^{c}	254.98^{ab}	251.30^{ab}	253.14^{ab}
T_{10}	T_2+ two foliar sprays of propiconazole 13.9% EC + difenoconazole 13.9 % EC @ 0.1% conc.	109.34^{b}	109.36^{ab}	109.36^{b}	71.88^{ab}	75.90^{a}	73.90^{ab}	256.21^{a}	252.84^{a}	254.53^{a}
T_0	Control (Untreated)	71.23^{d}	57.70	64.47^{d}	59.83^{f}	43.77	51.80	139.89^{d}	141.56^{d}	140.73^{d}
Mean		98.23	95.56	96.89	67.91	67.96	67.93	220.96	219.44	220.23
CD (5%)		2.30	2.12	1.37	2.09	2.87	1.85	21.48	21.82	21.62
S.E. m (±)		0.78	0.72	0.46	0.71	0.94	0.63	7.29	7.39	7.33

Note: Similar alphabets indicate no significant difference from each other by DMRT at 5% level of significance.

3.5. Effect of fungicides, garlic clove extract, *T. viride* and their combination on economics and B: C ratio during *Kharif* 2021 and 2022.

The data regarding effect of fungicides, garlic extract, *T. viride* and their combination on economic and B: C ratio presented in table 4 and discuss hereunder

During *Kharif* 2021, the highest gross return was observed in treatment T_8 (Seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) + two foliar sprays of propiconazole 25% EC @ 0.1% conc.) with ₹ 95744.00, followed by T_4 (seed treatment with *T. viride*+ two foliar sprays of propiconazole 25% EC @ 0.1% conc.) with ₹ 90321.00 and T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP) @ 3 g/kg of seed) recorded the lowest gross return with ₹ 39457.00. T_8 (Seed treatment with carbendazim 12% WP + mancozeb 63 % WP @ 3 g/kg of seed) + two foliar spray of propiconazole 25 % EC @ 0.1% conc.) had maximum net return with ₹ 56161.00, followed by T_4 (seed treatment with *T. viride* + two spray of propiconazole 25 % EC @ 0.1% conc.) with ₹ 50738.00 over control. T_2 (seed treatment with carbendazim 12% WP + mancozeb 63 % WP) @ 3 g/kg of seed) recorded the lowest net return with ₹ 634.00. T_8 had the highest benefit-cost ratio, 2.42, followed by T_4 with 2.28. The lowest benefit cost ratio was found in treatment T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 1.02 over control (0.90). During *Kharif* 2022, the highest gross return was observed in treatment T_8 (Seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed + two foliar sprays of propiconazole 25% EC @ 0.1% conc.) with ₹ 90440.00, followed by T_4 (seed treatment with *T. viride*+ two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with ₹ 87400.00. T_2 (seed treatment with carbendazim 12% WP+ mancozeb 63% WP) @ 3 g/kg of seed) recorded the lowest gross return with ₹ 46740.00. T_8 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed + two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) had maximum net return with ₹ 50311.00, followed by T_4 (seed treatment with *T. viride*+ two foliar sprays of propiconazole 25 % EC @ 0.1% conc.) with ₹ 47271.00 over control (₹-3636.00). T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP) @ 3 g/kg of seed) recorded the lowest net return with ₹ 7371.00. T_8 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed ++ two foliar spray of propiconazole 25 % EC @ 0.1% conc.) had the highest benefit-cost ratio, 2.25, followed by (seed treatment with *T. viride* + two foliar spray of propiconazole 25 EC @ 0.1% conc.) with 2.18. The lowest benefit cost ratio was found in treatment T_2 (seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed) with 1.19 over control (1.01) (table 4).

Table 4: Effect of different fungicides, Garlic clove extract, *T. viride* and their combination on economics and B: C ratio during *Kharif* 2021and 2022

Treatment		*Kharif 2021*				*Kharif 2022*			
No.	**Treatment details**	**Gross cost (Rs)**	**Gross return (Rs)**	**Net return (Rs)**	**B:C ratio**	**Gross cost (Rs)**	**Gross return (Rs)**	**Net return (Rs)**	**B:C ratio**
T_1	Seed treatment with *Trichoderma viride* @ 5 g/kg of seed	38823	45067	6244.00	1.16	39369	47120	7751.00	1.20
T_2	Seed treatment with carbendazim 12% WP + mancozeb 63% WP @ 3 g/kg of seed	38823	39457	634.00	1.02	39369	46740	7371.00	1.19
T_3	T_1+ two foliar sprays of garlic clove extract @ 10% conc.	42823	77792	34969.00	1.82	43369	72010	28641.00	1.66
T_4	T_1+ two foliar sprays of propiconazole 25 % EC @ 0.1% conc.	39583	90321	50738.00	2.28	40129	87400	47271.00	2.18
T_5	T_1+ two foliar sprays of mancozeb 75% WP @ 0.2% conc.	40295	78540	38245.00	1.95	40841	76380	35539.00	1.87
T_6	T_1+ two foliar spray of propiconazole 13.9% EC + difenoconazole 13.9 % EC @ 0.1% conc.	39943	83589	43646.00	2.09	40489	81700	41211.00	2.02
T_7	T_2 + two foliar spray of garlic clove extract @ 10% conc.	42823	75922	33099.00	1.77	43369	70300	26931.00	1.62
T_8	T_2+ two foliar sprays of propiconazole 25 % EC @ 0.1% conc.	39583	95744	56161.00	2.42	40129	90440	50311.00	2.25
T_9	T_2+ two foliar sprays of mancozeb 75% WP @ 0.2% conc.	40295	81158	40863.00	2.01	40841	74290	33449.00	1.82
T_{10}	T_2+ two foliar sprays of propiconazole 13.9% EC+ difenoconazole 13.9 % EC @ 0.1% conc.	39943	87329	47386.00	2.19	40489	83980	43491.00	2.07
T_0	Control (untreated)	36548.00	32912.00	-3636.00	0.90	37094.00	37430.00	336.00	1.01

BCR=Gross return/Gross cost

Conclusion

To conclude the present studies, under different treatment combinations prepared using fungicides, garlic clove extract and *Trichoderma viride* for evaluation of fungicides, garlic clove extract, *T. viride* and their combinations on maydis leaf blight disease and yield and yield attributing traits of maize (*Zea mays* L.). minimum disease incidence and maximum yield (t/ha) was recorded in treatment seed treatment with carbendazim 12% WP + mancozeb 63% WP followed by two foliar sprays of propiconazole 25 % EC @ 0.1% concentration. Therefore, it can be suggested that for management of MLB disease, treatment combination of seed treatment with carbendazim 12% WP + mancozeb 63% WP followed by two foliar sprays of propiconazole 25% EC @ 0.1% conc. can be awarding.

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