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Efficacy and Economics of Fungicides and their Application Schedule for Early Blight (*Alternaria solani*) Management and Yield of Tomato at South Tigray, Ethiopia

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Abstract

Early blight, caused by Alternaria solani, is the most pressing problem of tomato Production and productivity in Tigray region. However, only limited attempts have been made to tackle this problem in the study area. Therefore, this study was conducted to (1) investigate the efficacy and spray frequencies of fungicides (2) determine yield loss incurred due to early blight and (3) assess cost benefit of the fungicides. Three fungicides (ridomil gold, Agrolaxyl and Mancozeb) each with three spray frequencies (every 7, 14 and 21 days) were evaluated using moderately susceptible variety, Melkashola in a Randomized Complete Block Design (RCBD) with three replications. Significant differences were observed among the treatments in-terms of disease incidence (DI), disease severity (DS), and AUDPC and disease progress rate (DPR) and; yield and yield components. Mancozeb among the fungicides and weekly spray among the spray frequencies were found the most effective in controlling the disease and improving the yield of tomato. Application of Mancozeb every week minimizes the disease by (47.75%) and consequently improves the yield by (112.48%). Weekly application of Mancozeb was found the most effective in controlling the disease with minimum values of DS (10.45%), AUDPC (266.0%-days), and DPR (0.09) and; higher marketable yield of (355.68 q/ha) and most economical with maximum marginal rate of return (MRR) (2,671.3%). Bi-weekly spray of Mancozeb also gave next higher MRR (1,724.3%). Maximum yield loss (52.94%) as compared to the most protected plot was incurred on untreated plots. Therefore, from the findings it can be conclude that application of mancozeb at weekly interval can be considered as the best management strategy to reduce disease epidemics and improve tomato yield.

Keywords: Alternaria solani; AUDPC; Disease incidence; Disease severity; Fungicide

Introduction

Tomato is the second most important vegetable crop next to potato worldwide with almost 4.5 million hectares of cultivated land [1-5] and with a yield potential of up to 42.1 tons/ha [6]. The total production of tomato in Ethiopia has shown a marked increase [7], since it became the most profitable crop providing a higher income to small scale farmers compared to other vegetable crops. According to Maheswari et al. [8] productivity of 9 tons/ha under farmers' practice and about 24 and 40 tons/ha under demonstration and research plots, respectively was realized. However, the national average yield of tomato in the country is very low which is around 7 tons/ha [9] and less than 50% of the current world average yield of about 27 tons/ha. Tomato is a key food and cash crop for many low income farmers in the tropics [10]. Tomato fruit is rich in vitamins A and C and contains an antioxidant, lycopene [11]. Despite of its importance, in the world as well as in Ethiopia the production and productivity of the crop is very low which mostly attributes to disease.

Among the major diseases of tomato, early blight caused by Alternaria solani is the worst damaging one [1,3] and cause reduction in quantity and quality of the crop. It is an economically important disease throughout the Southeastern United States and much of the world wherever tomato crops are grown under hot and humid conditions [12]. According to Batista et al. and Markham et al. [13,14] early blight epidemics are particularly severe in tropical countries during warm and wet seasons. Nevertheless, the disease is becoming more severe in all regions partly due to warmer temperatures experienced worldwide [15]. During severe cases early blight can lead to complete defoliation and is most damaging on tomato [16] in regions with heavy rainfall, high humidity and fairly high temperature (24-29°C). Alternaria solani (Ellis and Martin) is a soil inhabiting air-born pathogen responsible for leaf blight, collar and fruit rot of tomato disseminated by fungal spores [17]. The pathogen causes infection on leaves, stem, petiole, twig and fruits as well as leads to the defoliation, drying of twigs and premature fruit drop which ultimately reduce the yield [18].

Like in other parts of the world in Ethiopia early blight which is caused by *A. solani* is the most destructive disease of tomato next to late blight [19]. Even though, the yield loss was not quantified, early blight is the bottle neck of tomato production in many tomatoes growing areas of Tigray region. It significantly reduces the production and market value of the crop.

Currently, sanitation, long crop rotation to reduce the spore concentration on decaying plant material and routine application of

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fungicides are the most common early blight management options in tomato production [20]. Management of early blight in tomato through fungicides such as ridomil gold, sulphur, copper oxychloride, carbendzim and mancozeb has been also reported [21,22]. In the tropics, management of early blight relies mostly on the intensive use of fungicides [13]. Apart from the application of fungicides, emphasis should be given to their time of application and/or frequency. In this regard Lemma et al. [23] have studied different fungicide application schedules such as weekly basis spray, SC-IPM, and TOM CAST and reported that TOM-CAST schedule reduced the number of spray application to 6 compared with 10 at weekly interval and the AUDPC of early blight was lowest with TOM-CAST schedule while highest with no fungicide. According to the same author weekly fungicide applications delayed early blight development by 8 days compared with non sprayed and SC-IPM treatments. AUDPC and EB severity at the end of the season were lower in the weekly and TOM-CAST treatments. Under Ethiopian condition there are also different fungicides recommended for the management of early blight. However, fungicide efficacy and their appropriate spray frequency are not properly studied in the study area. Therefore, the aim of this study was to (1) evaluate the efficacy of registered fungicides and their spray frequency on disease epidemics; (2) determine the yield loss incurred due to early blight of tomato and (3) determine cost effectiveness of the fungicides against early blight of tomato.

Materials and Methods

Description of the study area

Field experiment on management of early blight using fungicides was conducted during 2010 cropping season with supplement irrigation at alamata, south Tigray which is located 12° 15' N latitude and 39° 35' E longitude. It lies at an altitude of 1600 m.a.s.l. The mean annual rainfall is 663 mm.

Experimental design and treatments

Planting material was obtained from Melkassa agricultural research center and seedlings of improved tomato variety (Melkashola) were raised on a standard seed bed size of 1 m × 5 m. Apparently healthy seedlings were then transplanted into the experimental field with a plot size of 4.8 m × 3.3 m. Spacing between plants and rows were maintained as 30 cm and 80 cm, respectively. Each plot and block was separated by a buffer zone of 1.5 m and 2 m, respectively to prevent fungicide drift or cross contamination [24]. The experiment was consisted a total of six rows and four harvestable middle rows. The treatments (spray frequencies of each fungicide) were arranged in a Randomized Complete Block Design (RCBD) with three replications.

Three fungicides, ridomil gold, agrolaxyl and mancozeb were evaluated against tomato early blight at different frequencies with the rates of 2.5, 3 and 2 kg/ha, respectively. Spray frequencies were scheduled as every 7, 14, 21 days for all fungicides and unsprayed plot was included as a control. Spray was started soon after the initial appearance of symptoms. A total of four, three and two times application was practiced for every week, two week and three week spray frequencies of each fungicide, respectively.

Disease assessment

Disease incidence and severity were recorded every week starting from the first appearance of disease symptoms (i.e. at flowering and early fruiting stage) and a total of six assessments were conducted during the crop season. Incidence of early blight was assessed by counting the number of infected plants on the middle four rows and expressed as percentage of total plants assessed as:

$$\mathrm{DI}(\%) = \frac{\text{Number of diseased plants}}{\text{Total number of plants inspected}} \times 100$$

Five plants were selected randomly from each replication per treatment, and then five leaves of each plant were used to determine the disease severity [2]. Severity of early blight was then recorded on the basis of 1-6 rating scales by modifying the scales adopted by [25] where 1=trace to 20% leaf infection, 2=21-41% infection, 3=41-60% infection, 4=61-80% infection, 5=81-99% infection and 6=100% leaf infection or the entire plant defoliation. The per cent severity index was then calculated as:

$$\mathrm{PSI} = \sum \frac{\text{Individual numerical ratings} \times 100}{\text{Total number of leaves assessed} \times 6}$$

Where 6 is the highest numerical rating on the scale

Assessment of yield and yield components

Fruits were considered ready for picking when 50% of fruits turned yellow or red. Harvested fruits were categorized as clean marketable fruits (smooth, glossy surface and firm skin) or unmarketable if they had symptoms of damage by insects, disease infection or other physiological disorder. Fruits from each plot were sorted in to infected and healthy groups.

Data analysis

Data on early blight incidence and severity from each assessment; yield and yield components, PSI, AUDPC and disease progress rate were subjected to analysis of variance using Statistical Analysis System (SAS) version 9 Software [26]. Fisher's protected Least Significant Difference (LSD) values were used to separate differences among treatment means ($P<0.05$). AUDPC values were calculated from per cent severity index for each plot according to [27] and subjected to analysis of variance.

$$\mathrm{AUDPC} = \sum_{i=1}^{n} \left[0.5\left(x_{i+1} + x_i\right)\left[t_{i+1} - t_i\right]\right]$$

Where, x_i is the cumulative disease severity expressed as a proportion at the i^{th} observation, t_i is the time (days after planting) at the i^{th} observation and n is total number of observations.

Logistic, ln [(Y/1-Y)], [28] and Gompertz, -ln [-ln(Y)] [29] models were compared for estimation of disease progression parameters from each treatment. The transformed data of disease severity were regressed over time (days after planting) to determine the model. The goodness of fit of the models was tested based on the magnitude of the coefficient of determination (R^2). The appropriate model was then used to determine the apparent rate of disease increase (r) and the intercept of the curve.

Yield loss estimation

The relative losses in yield of each treatment were determined as percentage of that of the protected plots of the experiment according to [30] as:

$$\mathrm{RL}(\%) = \frac{\left(\mathrm{YP} - \mathrm{YT}\right)}{\mathrm{YP}} \times 100$$

Where, RL: Relative Loss (reduction of the yield parameter), YP: Mean Yield of the Protected Plots (plots with maximum protection - from mancozeb sprayed at weekly interval) and YT: Mean Yield in

Unprotected Plots (i.e. unsprayed plots or sprayed plots with varying level of disease).

Cost and benefit analysis

Price of tomato fruits (Birr/kg) was assessed from the local market and total price of the commodity obtained was computed on hectare basis. Input costs like fungicides and labor costs/ha were recorded. The price of fungicides was calculated based on their frequencies used on plot basis and converted in to hectare. The price of ridomil gold, agrolaxyl and mancozeb was 500, 160 and 115 Birr/kg, respectively. The total amount of these fungicides used for the experiment was computed and their price was converted into hectare basis. Cost of labor for spraying these fungicides from the first spray up to the final was 30 Birr per man-day and this was converted on hectare basis.

Before doing the economic analysis (partial budget) statistical analysis was done on the collected data to compare the average yields between treatments. Since there was difference between treatment means, the obtained economic data were subjected to analysis using the partial budget analysis method [31] Marginal rate of return was calculated as:

$$MRR(\%)=\frac{DNI}{DIC}\times 100$$

Where, MRR is marginal rate of returns, DNI, difference in net income compared with control, DIC, difference in input cost compared to control.

Results

Disease incidence and severity

Disease data before spray of fungicides indicated uniform spread of the disease in all experimental plots. However, in all the treatments there was an increase in disease incidence starting from the second assessment (104th DAP) to the last assessment (132th DAP). The rate of increase in the per cent disease index was slow in case of fungicide treated plots as compared to unsprayed plot. In the subsequent sprays, all the fungicide treated plots had recorded significantly less disease index over the control. Treatments were significantly different ($P<0.05$) on the per cent final disease incidence of early blight. All the treatments significantly reduced the final per cent disease incidence of tomato early blight recorded on the 132th DAP as compared to the unsprayed control. However, the highest disease incidence reduction was observed on the most frequently sprayed fungicides (Table 1). The lowest disease incidence was obtained from mancozeb and ridomil gold each sprayed every 7 days and mancozeb sprayed every 14 days interval, respectively. The highest disease incidence, however, was recorded from unsprayed plot and agrolaxyl sprayed every 14 and 21 days; and ridomil gold sprayed every 21 days, respectively (Table 1). Frequently applied fungicides by far reduced disease severity as compared to the less frequently sprayed fungicides and unsprayed plots. All the fungicides reduced the severity significantly over unsprayed control. Four times applications at weekly interval of the fungicides mancozeb followed by ridomil gold at the same application interval significantly reduced early blight disease severity compared to other fungicide treatments and untreated plots (Table 1). The minimum disease severity was recorded on plots treated with mancozeb, ridomil gold and agrolaxyl sprayed at weekly interval, respectively followed by every two week application of same fungicides. On the contrary, the highest disease severity was recorded on unsprayed plot and the low frequently applied fungicides (i.e. at every 21 days interval). The overall fungicide treatments reduced the severity of early blight being 5.55 to 47.75% as compared to the unsprayed control.

Area under disease progress curve (AUDPC)

Early blight symptom appeared to start in both sprayed and unsprayed plots at about the same time, but subsequent disease progress was rapid in the non-sprayed plots and on the less frequently applied fungicides as indicated by their higher mean AUDPC values (Table 1). The AUDPC value of early blight on tomato exhibited highly significant difference ($P<0.05$) among the treatments. Minimum AUDPC was recorded on plots treated with different fungicides having different spray frequencies as compared to the untreated plot. Likewise, every week spray reduces the AUDPC values significantly as compared to all other spray interval as well unsprayed control. The lowest AUDPC values were obtained from mancozeb and ridomil gold treated plots at every 7 days interval and; mancozeb sprayed every 14 days interval, respectively. However, the maximum AUDPC value was recorded on the untreated control (Table 1).

Generally, when compared the three fungicides among each other and their spray frequencies mancozeb was found very effective than the other in reducing the AUDPC and; weekly and two week spray frequencies of all the fungicides were also best in minimizing the AUDPC value of the disease.

Fungicides	Spray frequency(Days)	DI (%)	DS (%)	Reduction of DS compared to control (%)	AUDPC (%-days)	Disease progress rate (r)
Ridomil Gold	7	37.07^{g}	14.45^{f}	27.75	357.00^{f}	0.11
	14	50.93^{e}	16.45^{d}	17.75	431.67^{d}	0.12
	21	68.38^{c}	18.45^{b}	7.75	472.89^{c}	0.13
Agrolaxyl	7	54.09^{e}	14.89^{fe}	25.55	394.33^{e}	0.11
	14	71.70^{c}	17.55^{c}	12.25	475.22^{c}	0.12
	21	80.55^{b}	18.89^{b}	5.55	514.11^{b}	0.12
Mancozeb	7	29.58^{h}	10.45^{g}	47.75	266.0^{g}	0.09
	14	41.37^{f}	15.33^{e}	23.35	381.89^{fe}	0.12
	21	61.04^{d}	17.11^{dc}	14.45	439.44^{d}	0.12
Unsprayed	-	89.24^{a}	20.00^{a}	-	567.00^{a}	0.28
Mean	-	58.40	16.36	-	429.96	
CV (%)	-	3.99	3.08	-	3.38	
LSD (5%)	-	4.01	0.86	-	24.93	

Table 1: Effect of different fungicide and their frequency on disease incidence (DI), disease severity, AUDPC and disease progress rate of early blight of tomato under field condition at south Tigray, Ethiopia. CV: Coefficient of Variation; LSD: Least Significant Difference; DI: Disease Incidence; ns: Not Significant; DS: Disease Severity, Means in a column followed by the same letter(s) are not significantly different.

Disease progress rate (r)

Based on Gompertz model, the regression equation used to describe the rate of early blight progress was significant for all treatments as compared to the control (Table 1). On unsprayed plots early blight was increased at a rate of 0.28 units per day. However, all the fungicides sprayed at weekly interval was reduced the progress rate significantly. Disease progress rate on mancozeb treated plots at weekly interval was retarded by about 0.19 units per day which was more than half as compared to unsprayed control. Similarly, the disease progress rate was reduced by about 0.17 units per day on plots treated with ridomil gold and agrolaxyl sprayed at weekly interval (Table 1).

Generally, variation in early blight disease progress rate due to different fungicide application at different intervals was clearly observed. Early blight was progressed more rapidly on unsprayed plots and on the less frequently sprayed plots than those plots sprayed most frequently.

Fruit yield

There was a significant increase in fruit yields in the fungicide treated plots in contrast to untreated plots. Highly significant difference ($P<0.05$) was observed among treatments in-terms of harvested marketable fruit yields expressed per hectare basis. The efficacy of fungicides was reflected on the produced fruit yield. In this regard, plots sprayed with fungicides produced the highest fruit yield, being 355.68, 305.12, 291.24, 260.35 and 195.44 q/ha obtained from mancozeb, ridomil gold and agrolaxyl sprayed every week and; mancozeb sprayed every two and three week interval, respectively. However, the lowest yield was recorded from unsprayed plot (Table 2). Yield advantage which ranged from 6.79 to 112.48% was observed among treatments as compared to the non-sprayed plots. The maximum yield increase (112.48%) was recorded from every 7 days mancozeb sprayed plots followed by ridomil gold sprayed at the same interval. While least yield increase (6.79%) was observed on plots sprayed with agrolaxyl at every 21 days (Table 2).

Yield loss estimation

The variation in fruit yield losses was observed among the different frequencies of the fungicides in comparison to the most protected plot (Table 2). In unsprayed plots, fruit yield losses were notably higher than the protected plots. Fruit yield losses were significantly reduced by all fungicides at each spray frequencies as compared to the unsprayed control of the variety Melkashola. Maximum relative fruit yield loss (52.94%) as compared to the most protected plot (mancozeb treated plots at weekly interval) was recorded on unsprayed plots and relatively minimum fruit yield losses was recorded on ridomil gold and agrolaxyl treated plots each sprayed every 7 days interval and; mancozeb sprayed every 14 days interval, respectively.

Cost benefit

Partial budget analysis indicated that every week and every two week spray interval of the fungicide ridomil gold had the highest total variable costs (Table 3). The highest gross field benefits were obtained in every week spray of mancozeb, ridomil gold and agrolaxyl, respectively. The net benefit obtained from sales of the produce from each spray frequencies ranged from 6233.55 to 12,460.20 US dollar. The highest net benefit in comparison with unsprayed plot and other treatments was obtained from weekly treated plots with the fungicide mancozeb. Ridomil gold and agrolaxyl each sprayed at weekly interval were ranked second and third. However, the least net benefit was obtained from plots treated with agrolaxyl at tri-weekly interval (Table 3).

Marginal analysis indicated that the highest marginal rate of return in comparison with unsprayed plots was obtained where mancozeb at weekly interval was used. Next highest marginal rate of return was attained from application of mancozeb and agrolaxyl at bi-weekly and weekly interval, respectively. However, the least marginal rate of return was recorded from plots treated with ridomil gold and agrolaxyl each at tri-weekly interval, respectively (Table 3).

Discussion

In this study symptom of early blight was appeared at early fruiting stage and this showed tomato plants are more susceptible at fruiting stage of the plant than early at the vegetative stage. This observation is in line with [18,32] who states that plants are more susceptible to infection by the disease during fruiting stage. Infected leaves were begun to defoliate starting two weeks after the appearance of symptom on those plots severely attacked. Jones [33] also reported that infected leaves eventually wither, die, and fall from the plant. In this study more defoliated leaves were observed on the unprotected plots than those plots treated with different fungicides having different frequency levels. Maximum fruit rot also observed on unprotected plots than the protected ones. This resulted in fruit yield losses up to 52.94% on untreated plots as compared to the most effective fungicide (mancozeb)

Fungicides	Spray frequency (days)	Marketable fruit yield (q/ha)	Unmarketable fruit yield (q/ha)	Yield advantage over the control (%)	Yield loss (%)
Ridomil gold	7	305.12^{b}	22.70^{i}	82.28	14.22
	14	234.50^{e}	43.27^{f}	40.09	34.07
	21	182.10^{h}	65.80^{c}	8.79	48.80
Agrolaxyl	7	291.24^{c}	31.71^{h}	73.98	18.12
	14	220.47^{f}	53.02^{e}	31.71	38.01
	21	178.77^{h}	71.35^{b}	6.79	49.74
Mancozeb	7	355.68^{a}	16.59^{j}	112.48	-
	14	260.35^{d}	35.58^{g}	55.53	26.80
	21	195.44^{g}	61.49^{d}	16.76	45.05
Unsprayed check	-	167.39^{i}	81.18^{a}	-	52.94
Mean		239.11	48.27	-	
CV (%)	-	2.01	4.64	-	
LSD (5%)	-	8.26	3.84		

Table 2: Effect of fungicides and their spray frequency on yield and yield components of tomato. CV: coefficient of variation, LSD: least significant difference, Means in a column followed by the same letter(s) are not significantly different.

Fungicides	Spray frequency(days)	Gross field benefit	Total variable Cost(TVC)	Net benefit ($ ha^{-1})	MRR (%)
Ridomil Gold	7	10897.14	485.51	10411.63	913.12
	14	8375	364.13	8010.87	558.22
	21	6503.57	242.75	6260.82	116.4
Agrolaxyl	7	10401.43	302.18	10099.25	1363.8
	14	7873.93	226.63	7647.30	736.47
	21	6384.64	151.09	6233.55	169.00
Mancozeb	7	12702.86	242.65	12460.20	2671.3
	14	9298.21	181.99	9116.23	1724.3
	21	6980	121.33	6858.67	725.70
Control		5978.21	-	5978.21	-

Table 3: Partial budget analysis for three fungicides and spray frequencies for the control of tomato early blight at south Tigrat, Ethiopia. MRR: marginal rate of return.

of the tested fungicides sprayed at weekly interval. This is because plants on the less protected plots fail to set fruits due to defoliation and drop their fruits due to fruit rot. This finding is in confirmation with Gwary and Nahunnaro [34] as he reported yield losses of 30-50% of the harvest due to fall of infected fruits. This observation was also agreed with Deahl et al. [35] who reported that yield reduction is observed when plants losses their leaves; because the plants fail to set fruits.

The overall yield losses of tomato due to early blight in this study were relatively lower compared to previous reports. Significant yield reduction (35 to 78%) in USA, Australia, Israel, UK and India has been reported by Deahl [35]. Yield losses up to 79% due to early blight damage were also reported from Canada, India, USA, and Nigeria [36-38]. This yield loss variation is likely to be occurred because various interrelated factors are attributed. These factors might be environmental condition, under which the experiment is conducted, the season when the study is carried out, the genotypes used and disease epidemics under the area.

The tested fungicides control early blight effectively and increase yield and yield components as compared to the control. Four times application of mancozeb at weekly interval minimizes the severity of early blight by (47.75%) and increases fruit yield by (112.48%) as compared to unprotected control. This is agreed with the findings of Mantecon [39] who reported that among the tested commercial fungicides mancozeb followed by Kavach were found to be very effective in controlling early blight with more than 50% disease control compared to the untreated control. Mantecon [39] also reported the most effective control of *A. solani* was achieved by copper oxychlorode (64.7%) followed by mancozeb (61.7%). According to Prior et al. [40] three spray of mancozeb reduces the disease intensity significantly compared to other chemicals and botanicals and gave the highest economic benefit. FAOSTAT [41] also reported that the highest usable yields of tomato with greater financial benefits obtained in chlorothalonil or mancozeb at 7 and 10 days interval was primarily due to suppression of Alternaria and other fruit rot.

The highest per cent disease incidence reduction (66.85%) was observed on plots treated four times with mancozeb sprayed at weekly interval. Three times application of mancozeb at two weeks interval was also resulted in 53.64% disease incidence reduction. This result is in line with Niederhauser [42] who noticed that best control of leaf blight disease of tomato caused by *A. solani* was achieved by three foliar sprays of mancozeb at 15 day interval. The incidence of blight was significantly lower in the said treatment [43,44]. However, Praveen Kumar Chourasiya et al. [45] reported that among the four fungicides sprayed 4 times at 15 days interval after the first appearance of tomato early blight and thereafter at 10 days interval for control of *A. solani* mancozeb gave effective control of the disease. SAS Institute Inc., [46] also reported that among the non-systemic and systemic fungicides in controlling early blight of tomato mancozeb treatment gave the highest cost-benefit ratio of 1:11.4 in addition to reducing the disease incidence.

In addition to the appearances of more aggressive isolates, and isolates that are no longer inhibited by chemical protectants, the burden on the environment due to application of fungicide is high. Subsequently, plant pathogens are responsible for large amounts of chemical fungicides applied annually exacerbating control strategies [47,48]. Besides environmental problems unplanned and wide use of fungicides affects the health of users and consumers. To cope with these problems and due to the increase of public concern about adverse effects of agrochemicals on food safety and environment, there is need to stimulate the search for control strategies that are more durable and preferably based on natural products. So that, biological control agents which include effective microorganisms and microbial products, and organic fertilizers, have been attracting attention as alternatives to chemical agents [49]. Zhang et al. [49-51] reported that based on the whole plant tests, foliar spray with *Paenibacillus macerans*-GC subgroup A, *Serra-tia plymuthica*, *Bacillus coagulans*, *Serratia marcescens*-GC subgroup A, *Bacillus pumilis* -GC subgroup B and *Pantoea agglomerans* bacterial isolates reduced the disease severity of early blight significantly when compared with control. Such bio agents as *T. harzianum, T. viride, B. subtilis, P. fluorescens and S. cerivisae* have also been reported in reducing early and late blight of tomato significantly [6]. However, under Ethiopian condition, management of early blight through biological agents and botanicals has not been reported. So as to minimize the problems related to application of fungicides, biological control and botanicals should be considered in the future perspectives under Ethiopian condition as it has been practiced in other parts of the world.

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