Middle East Research Journal of Biological Sciences
ISSN 2789-7710 (Print & ISSN 2958-2091 (Online)
Frequency: Bi-Monthly
DOI: 10.36348/merjbs.2023.v03i01.003

KUWAIT SCHOLARS PUBLISHER
Website: http://www.kspublisher.com/
Email: office@kspublisher.com

Fruit Yield Loss Assessment of Tomato (*Solanum lycopersicum* Mill.) due to Late Blight (*Phytophthora infestans*) Disease in Central Parts of Ethiopia

Asela Kesho[1*], Yitagesu Tadesse[1]
[1]Plant Pathology Department, Ethiopian Institute of Agricultural Research (EIAR), Holetta Agricultural Research Centre (HARC), Addis Ababa, Holetta, Ethiopia

Abstract: Tomato is an important vegetable crop grown around the world. Tomato is the most widely cultivated and lucrative vegetable in Ethiopia in particular and in the world in general. It is well known that disease late blight affects tomato crop production and late blight is one of the most devastating diseases of tomatoes worldwide and causes significant loss in production. The objective of this study is to update fruit yield loss assessment data for tomato late blight disease. In this study, 3 treatments were used in a randomized complete block design (RCBD) with three replications. The combined analysis of variance (ANOVA) results for AUDPC and total fruit yield shows significant differences (P<0.05) among treatments. As compared to the unsprayed (control) plot both fungicides significantly controlled the disease at both early and late stage of the crop. The lowest AUDPC (560) was recorded on fungicide Fahem-Gold 72% WP sprayed treatment followed by Mancozeb (752.5). The control treatment (water sprayed) had the highest AUDPC (1592.5). The highest mean fruit yield (16.5 t ha^{-1}) was obtained from fungicide Fahem-Gold 72% WP followed by the standard fungicide (Mancozeb) which gave (8.98 t ha^{-1}) whereas the control treatment gave 4.67 t ha^{-1}. The highest levels of yield loss 71.7% occurred in the unsprayed plots of variety Gulelema as compared to the best protected plot sprayed with Fahem fungicide. Generally, disease and yield parameters indicate that among the two fungicides spray; Fahem was the most effective followed by Mancozeb sprayed plot as compared to unsprayed plots.

Keywords: Assessment, Late Blight, Phytophthora infestans, Tomato, Fruit Yield Loss.

RESEARCH PAPER

***Corresponding Author:**
Asela Kesho
Plant Pathology Department, Ethiopian Institute of Agricultural Research (EIAR), Holetta Agricultural Research Centre (HARC), Addis Ababa, Holetta, Ethiopia

How to cite this paper:
Asela Kesho & Yitagesu Tadesse (2023). Fruit Yield Loss Assessment of Tomato (*Solanum lycopersicum* Mill.) due to Late Blight (*Phytophthora infestans*) Disease in Central Parts of Ethiopia. *Middle East Res J Biological Sci*, *3*(1): X.

Article History:
| Submit: 03.08.2023 |
| Accepted: 21.08.2023 |
| Published: 23.08.2023 |

INTRODUCTION

Tomato, *Solanum lycopersicum* Mill. (syn. *Lycopersicon esculentum* Mill or *Lycopersicon lycopersicum* Mill) is an important vegetable crop cultivated worldwide, second only to potato (Rubatzky and Yamaguchi, 1997; Mutschler *et al*., 2006). Tomato is the most widely cultivated and profitable vegetable, especially in Ethiopia and generally around the world. It is one of the most important vegetable crops and is widely cultivated in Ethiopia, ranking fifth in annual national vegetable production (CSA, 2022). The importance of the tomato is increasing and, because it is a valuable commodity, it has become a priority in vegetable research also in Ethiopia (Tsedeke, 2007).

It is an important food additive and also a regular source of income for poor rural farmers (Lemma *et al*., 1994). According to CSA (2022), vegetable covers 236,772.95 ha (1.68%) and its share is 866,327.05 t/ha (2.07%) of the total crop production and tomato took 7710.16 (3.3%) ha of land, its share was 33655.84 (3.9 %) tons of production. The 2022 CSA report showed that the national productivity of tomato is 4.37 t/ha.

However, tomato productivity is very low due to several biotic and abiotic factors, the most important of which are diseases (Tesfaye and Habtu, 1985; Mohammed *et al*., 2006). The main tomato disease is caused by fungi; late blight (phytoptera infestans). Yield losses due to the disease are due to premature death of both leaves and diseased fruit. Under the right environmental conditions, tomato disease can cause significant yield loss; can result in even 100% yield loss (Guenthner *et al*., 2001). In Ethiopia, the disease occurs in all major tomato-growing regions, and without chemical protection measures, crop production during the main rainy season is difficult. Some tomato varieties resistant to P. infestans have been released. The resistance of tomato varieties is notoriously unstable. To improve late blight control, growers have increasingly adopted fungicides as the most important control strategy. Global average yield loss in unprotected fields

due to late blight is 70% and up to 100% in early outbreaks. Under favorable weather conditions, the pathogen can destroy tomato and tomato leaves in 10-15 days and the potential yield can be reduced by 50-70% (Tymčenko and Jefronová, 1987). Late blight is now more dangerous than before for tomato cultivation and its control is more difficult. Genetic changes in the pathogen population are a major challenge for effective disease control (Hansen *et al*., 2003).

Resistance/tolerance of tomato varieties to major foliar diseases were evaluated in Melkassa. Tested tomato varieties Floradade, Arizona, CL-5915-206-D4-2-3-0, CL-5915-553-D4-3-0, Heinz 1350 Sel. Mexico B1-444 (Vc294A, Solar set hybrid, Red Ball, Nova At-30) was found to be relatively resistant to major foliar diseases such as late blight (P. infestans), early blight (Alternaria solani) and powdery mildew. (Leveillula taurica) (MARC, 2000). Tomato varieties imported from Asia Vegetable Research and Development Center (AVRDC)/Tanzania (Marglobe 2009, Tengeru 97) and MARC showed a lower late blight severity (3-4 on a scale of 1-9). In both field and validation trials under farmers' conditions, the yield advantage compared to the standard variety Marglobe was 96%, 60% and 50%, respectively (Mohammed, 2002).

Fungicides screened for late blight control in the Central Rift Valley area. Potential fungicides were also secured in farmers' fields around Melkassa, Ziway and Wondo Genet. The three fungicides Metalaxyl-M4% + Mancozeb 64% (Ridomil Gold 68 WP) 350g/100l, Fungomil 250gm/100l, and Mancozeb + Metalaxyl (Mancolaxyl 72%) 250g/100l proved to be more effective in disease control and thus more effectively increased marketable fruit yield 40-66% (MARC, 2000).

In order for farmers and tomato growers to reduce the effects of the disease, some fungicides that are used in the country have been registered. However, over time, these recommended fungicides became less effective at the recommended rate and frequency. This may be due to a change in the global environment; the area of the crop in the crop system and the year-round production of the crop in the country can contribute to the increase of virulent fungicide- resistant races (Schiessendoppler, 2003) in the patho system where the effectiveness of fungicides has decreased. Yield loss caused by the disease is due to premature death of leaves and diseased fruits. In Ethiopia, the disease occurs in all major tomato-growing regions, and without chemical protection, it is difficult to produce crops during the main rainy season. In Ethiopia, research on tomato late blight was very old and rare. Therefore, we are very interested in the estimation of the yield loss of this economically important tomato disease. Therefore, our objective was to investigate the estimation of the yield loss of this economically important tomato disease.

MATERIAL AND METHODS

Description of the Experimental Site

The experiment was conducted under rain-fed conditions at Koka, a subsite of Wondogenet Agricultural Research Center during the main growing season in 2022. The selected location is a major tomato growing area and late blight hotspot in Ethiopia.

Experimental Materials and Procedures

A tomato variety (Gulelema) and its recommended cultivation practices were used. This experiment used the most susceptible to tomato late blight and was recommended by the Melkassa Agricultural Research Center for cultivation in Central Ethiopia and similar agroecologies elsewhere in Ethiopia. The fungicides Mancozeb, previously screened and recommended for late blight control (positive) and unsprayed plot (negative) were used as controls and Fahem-Gold 72% WP is the trade name and Mancozeb 64% Metalaxyl 8.0% is the common name given to this chemical was used as a treatment. The application of fungicides was started immediately after the appearance of disease symptoms on the susceptible variety Gulelema.

Experimental Field Management

Before transplanting, seedlings were grown using the standard cultivation method recommended by MARC (Getachew *et al*., 2014). For the field experiment, seedlings were grown in a bed 1 m wide and 5 m long, with a bed height of 15 cm. The seeds were sown to a depth of 0.5 cm in 30 rows with a row spacing of 15 cm. The grass roof was spread over the bed and removed after the seedlings emerged. The beds were weeded and watered as needed. Seedlings were planted at the appropriate stage 25 days after sowing in the 2022 crop season. The tomato variety Galelema was used for planting on a plot of land 10 m x 10 m = 100 m2 with a total of 330 plants, 10 rows per plot and 33 plants per row with a spacing of 100 cm and a spacing of 30 cm between plants. Contact fungicides Mancozeb 64% (standard control), Fahem-Gold 72% WP (as treatment) and sprayed water (control). Mancozeb 64% and Fahem-Gold 72% were applied at 2.5 Kgha-1 and 3 kg ha -1, respectively, weekly from disease onset using 400 liters of water ha -1.

Data Collected

Severity: The severity of the disease was recorded using the percentage of infected leaf area every seven days from the first symptom appearance using the late blight scoring key (Henfling, 1987).

The area under the disease progression curve (AUDPC) was calculated for each treatment using the formula (Shaner and Finney, 1980).

$AUDPC = \sum[0.5(Xi + 1 + Xi) (ti+1-ti)],$

If Xi is the cumulative disease severity expressed as a ratio at the i^{th} observation, ti is the time (days after planting) at the i^{th} observation and n is the total number of observations. Since the severity of the late blight was expressed as a percentage and time (t) in days, AUDPC values were expressed as a unit percentage in days (Cambell and Madden, 1990).

Total Fruit yield (t ha-1): The sum of the weights of marketable and unmarketable fruits from the net plot area and converted to tons per hectare.

Relative Yield loss (LYL): The percent yield loss was computed using the formula (Robert and James, 1991).

$\%RYL = \frac{YP-YT}{YP} * 100\%$, Where RYL = Relative percent loss

YP = Yield from the maximum protected plot,

YT = Yield from other treated plots.

Marketable fruit yield (t ha-1): The total fruits weight free from diseases and insects harvested from the net plot area was calculated and converted to tons per hectare.

Unmarketable fruit yield (t ha-1): This parameter was determined by weighting fruits as diseased and insect attack harvested from the net plot area.

Data Analysis

The incidence (percentage) and severity of late blight were calculated based on the ratio of diseased and disease- free leaf area. Disease scores were added to the AUDPC (area under the disease progression curve) (Cambell and Madden, 1990). In connection with harvesting, the number of marketable and unmarketable fruits in the plot and the weight of the fruit (kg) were recorded. Two main parameters were considered in the comparison with the standard and control treatments, which help to quantify the effectiveness of the fungicide: the severity of the disease and the marketable and the total fruit yield. Data were subjected to analysis of variance (ANOVA) to determine treatment effects (Gomez and Gomez, 1984). Duncan's multiple range test (DMRT) was used for mean separation at 5% probability. All data analyzes were performed using the statistical analysis system (SAS) Version 9.3 (SAS Institute, 2014).

Result and Discussion

Area under Disease Progress Curve (AUDPC)

The candidate fungicide in the trial significantly controlled the disease in both early and late stages of the crop compared to the unsprayed control (Table 1). The lowest (560%) disease progression measured by AUDPC was recorded in plots sprayed with fungicide Fahem-Gold 72% WP followed by Mancozeb 64% which was 752.5%. The control treatment (sprayed water) had the highest AUDPC (1592.5%). The result agreed with the MARC study (2000), the fungicides Metalaxyl-M4% Mancozeb 64% (Ridomil Gold 68 WP) 350 g/100 lt, Fungomil 250 gm/100 lt and Mancozeb Metalaxyl (Mancolaxyl 72%) at 250 g proved to be more effective in disease control.

Fruit Yield

Mean total fruit number (TFN) and total fruit weight (TFW or yield) differ significantly between treatments. The highest average fruit yield (16.5 ha-1) was obtained from Fahem-Gold 72% WP fungicide, followed by the standard fungicide which gave (8.98 t ha-1), while the control treatment gave (4.67 t ha-1). Fahem-Gold 72% WP had a yield advantage of 45.5% and 71.7% over standard fungicide and control, respectively. The result of the previous study MARC (2000) was consistent, as fungicides proved to be more effective in controlling the disease and thus increased the marketable yield by 40-66%.

Relative Yield Losses

The yield loss caused was calculated each fungicide application relative to the maximum protected plot yield, i.e. Fahem-Gold 72% WP sprayed plot 16.5 t/ha on variety Gulelema (Table 1). The highest yield loss of 71.7% occurred in the unsprayed plots of variety Gulelema compared to the best protected plots sprayed with Fahem-Gold 72% WP fungicide. The second highest percentage yield loss (45.6%) was measured in plots sprayed with Mancozeb 64% compared to plots sprayed with Fahem-Gold 72% WP.

Similarly, Olanya *et al*., (2001) estimated losses due to late blight to average about 30–75% on susceptible varieties, however, in Ethiopia the disease causes 100% yield loss on unimproved local cultivar, and 67.1% on a susceptible variety (Kasa and Hiskias, 1996). Therefore, overall use of resistant varieties would potentially reduce losses due to late blight, reduce the cost of crop protection and reduce the risks of fungicide resistance strain appearance in tomato production. Generally disease and yield parameters indicate that among the two fungicides spray; Fahem-Gold 72% WP was the most effective followed by Mancozeb 64% sprayed plots as compared to unsprayed plots.

Table 1: Fruit yield losses of Tomato variety (Gulelema) due to late blight at Koka, Wondogenet Agricultural research Center subsite in Oromia region in 2022.

Treatments	Severity (%) Last reading	AUDPC	TFN	TFW or Yield (t/ha)	%RYL
Fahem-Gold 72% WP	35b	560.0b	26.62a	16.5a	0
Mancozeb 64%	45b	752.5b	14.29b	8.98b	45.6
Control	90a	1592.5a	12.12b	4.67b	71.7
Mean	56.67	968.33	17.68	10.05	
LSD = 0.05	34.1	251.2	8.26	6.12	
CV %	9.3	14.9	12.21	10.7	

Means in a column followed by the same letters are not significantly different according to LSD at 5% probability level.

Conclussion and Recomendation

Late blight is one of the most destructive tomato diseases worldwide and causes significant production losses. In Ethiopia, research on tomato late blight was very old and few. Therefore, we are very interested in investigating the estimation of yield loss from this economically important tomato disease. Therefore, the objective was to investigate the estimation of fruit production loss from this economically important tomato disease. The trial was conducted during the main cropping season in 2022 at rain-fed Koka, a subsite of the Wondogenet Agricultural Research Center. The trial used a total of 3 treatments with 3 replicates of a randomized complete block (RCBD).

Combined analysis of variance (ANOVA) for AUDPC and total fruit yield shows significant differences ($P<0.05$) between treatments. The highest average yield (16.5 t/ha) was obtained from Fahem-Gold 72% WP fungicide followed by standard fungicide (Mancozeb 64%) which yielded (8.98 t/ha) while the control treatment yielded 4.67 t/ha. The highest yield loss of 71.7% was in the unsprayed plots of variety Gulelema compared to the best protected plots sprayed with Fahem-Gold 72% WP fungicide. Based on the performance of the tested fungicide to control late blight and fruit yield loss, Fahem-Gold 72% WP deserves to be an alternative fungicide to the widely used fungicide Mancozeb 64% for fruit yield loss protection in the country and tomato late blight control. In general, parameters of disease and yield show that between fungicides sprayed; Fahem-Gold 72% WP was the most effective followed by Mancozeb 64% in sprayed plots compared to unsprayed plots.

Author Contribution Statement: Authors have significantly contributed to the development and the writing of this research article.

Funding Statement: This research did not have any fund this article.

Data availability Statement: All data was used for the research described in the article.

Declaration of Interest's Statement: The authors declare that they have no conflict of interests.

Additional Information: All the available information was included in this paper.

References

- Cambell, C. L., & Madden, L.V. (1990). Introduction to plant disease epidemiology. Wiley, New York.532 p.
- CSA (Central Statistical Agency). (2022). Agricultural Sample Survey 2021/2022 (2014 E.C): Report on area and production of major crops, volume-I. Addis Ababa, Ethiopia.
- Getachew, T., Selamawit, K., Yosef, A., Mohammed, Y., & Gashawbeza, A. (2014). Guide to major vegetable crops production and protection. Amharic Version. Addis Ababa, Ethiopia.
- Gomez, K. A., & Gomez, A. A. (1984). Statistical procedures for agricultural research. John wiley & sons. Second Edition.
- Guenthner, J. F., Michael, K. C., & Nolte, P. (2001). The economic impact of potato late blight on USA growers. *Potato Research, 44*(5), 121-125.
- Hansen, J. G., Lassen, P., Koppel, M., Valskyte, A., Turka, I., & Kapsa, J. (2003). Web-blight regional late blight monitoring and variety resistance. *Journal Plant Protection Researches, 43*, 263-273.
- Henfling, J. W. (1987). Late blight of potato (Vol. 4). International Potato Center.
- Kasa, B., & Hiskias, Y. (1996). Tuber yield loss assessment of potato cultivars with different levels of resistance to late blight. In 3. Annual Conference of the Crop Protection Society of Ethiopia, Addis Abeba (Ethiopia), 18-19 May 1995. CPSE.
- Lemma, D., Yayeh, Z., Edward, H., Getachew, T., & Asfaha, G. (1994). Varietal development on vegetables. pp. 89-99. In E. Herath, Lemma D. (eds.). The proceedings of the second national horticultural workshop of Ethiopia, 1-3 December 1992. Addis Ababa, IAR/FAO.
- Melkassa Agricultural Research Center (MARC). (2000). Progress report. Melkassa Agricultural Research Center. Pp. 210-212.
- Mohammed, Y. (2002). Farmers awareness building on integrated pest management (IPM) options on major vegetable pests around Wonji area. Research report, ICIPE/EARO vegetable IPM project. pp.16.
- Mohammed, Y., Lemma, D., Gashawbeza, A., Abera, D., Adam, B., Lidet, S., Giref, S., & Sithanantham, S. (2006). Farmers awareness building on integrated pest management (IPM) options of major vegetable pests in the central rift valley region of Ethiopia. P. 42-56. In: Eshetu Bekele *et al* (eds.). Proceedings of facilitating the implementation and adoption of integrated pest management (IPM) in Ethiopia. Planning workshop, 13-15 October, 2003. Melkassa Agricultural Research Center, EARO.
- Mutschler, M., Zitter, T., & Bornt, C. (2006). Tomato lines for the northeast combining early blight and late blight resistance. Vegetable Program. New York: 14853.
- Olanya, O. M., Adipala, E., Hakiza, J. J., Ojiambo, P., Mujalazi, J. M., & Forbes, G. (2001). Epidemiology and population dynamics of Phytophthora Infestants in Sub-Saharan Africa: Progress and constraints.
- Rubatzky, V. E., & Yamaguchi, M. (1997). World Vegetables; Principles, production and nutritive

values 2nd ed. ISBN-13: 978-1461377566, ISBN-10: 1461377560.

- SAS (Statistical Analysis System). (2014). Statistical Analysis System SAS/STAT user's guide Version 9.3. Carry, North Carolina, SAS Institute Inc. USA.
- Schiessendoppler, E., Molnar, U., Glauninger, J., Olanya, M., & Bekele, K. (2003). Final Report. Characterization of P. infestans populations in sub-Saharan Africa (SSA), as a basis for simulation modelling and integrated disease management. *Vienna.*
- Shaner, G., & Finney, R. E. (1980). New sources of slow leaf rusting resistance in wheat. *Phytopathology, 70*(12), pp.1183-1186.
- Tesfaye, T., & Habtu, A. (1985). A review of vegetable diseases research in Ethiopia. pp. 263-276. In: Tsedeke Abate (eds.). Proceedings of the first Ethiopian crop protection symposium, 4-7 February 1985. Addis Ababa, Ethiopia.
- Tsedeke, A. (2007). Focusing on agricultural research to address development needs: Direction for agricultural research in Ethiopia. Addis Ababa, Ethiopia.
- Tymčenko, V., & Jefronovová, T. (1987). Guide of pests and diseases of vegetable and potato. *Praha, 181.*