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# Tuber Yield Loss Assessment of Potato (*Solanum tuberosum*) Due to Late Blight (*Phytophthora infestans*) Disease in Central Highland Parts of Ethiopia

**Asela Kesho*, Yitagesu Tadesse**

Department of Plant Pathology, Ethiopian Institute of Agricultural Research (EIAR), Holetta Agricultural Research Center (HARC), Addis Ababa, Ethiopia

## Email address:

aselakesho@gmail.com (Asela Kesho)

*Corresponding author

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**Abstract:** Late blight (*Phytophthora infenstans*) disease is one of the most devastating potato diseases world-widely which causes significant loss in production. It is known to hurt the highest losses from disease attacks. Among potato diseases bacterial wilt and late blight are one of the most economically important. In Ethiopia yield loss study on potato late blight was very old and scanty. This study was designed to update yield loss data for potato late blight disease. In this study, 3 treatments were used with a completely randomized block design (RCBD) with 3 replications including the control. The results of AUDPC and tuber yield shows significant differences ($P<0.05$) among treatments. Compared to the unsprayed plot fungicides significantly controlled the disease at both early and late stages. The lowest (175.0) AUDPC was recorded on fungicide Gachena 525 WG sprayed treatment followed by Mancozeb 80% WP (190.0). The control treatment (water sprayed) had the highest AUDPC (1450.0). The highest (29.3 t/ha) mean tuber yield was obtained from the fungicide Gachena 525 WG followed by the standard fungicide (Mancozeb 80% WP) which gave (27.2 t/ha) whereas the control treatment gave 4.9 t/ha. The fungicide subjected to the test (Gachena 525 WG) deserves to be considered as an alternate fungicide to the widely used fungicide Mancozeb 80% WP in the country. The highest (83.28%) yield loss occurred in the unsprayed plots of the Jalene variety as compared to the best-protected plots sprayed with Gachena 525 WG fungicide. Generally, disease and yield parameters indicate that among the fungicides spray; Gachena 525 WG was the most effective followed by Mancozeb 80% WP sprayed plots as compared to the unsprayed plots.

**Keywords:** Assessment, Late Blight, *Phytophthora infestans*, Potato, Yield Loss

## 1. Introduction

Potato (*Solanum tuberosum* L.) is the most important vegetable crop in terms of quantities produced and consumed world-widely. Potato is the first non-grain food commodity in the world, with its production approaching 325 MT. It is a major non-cereal food crop and is consumed by more than one billion people globally [1]. Some of the inherent qualities of potatoes give them a competitive advantage over the leading food crops. It is capable to produce more protein and carbohydrates per unit area than cereal crops. It is cultivated world-widely over one hundred countries throughout Africa, Asia, Australia, Europe, North America, and South America [2]. In fact, able to produce more protein and carbohydrates per unit area than cereal crops and some leguminous crops like soybeans [3]. Among all the crops grown world-wide, is known to hurt the highest losses from disease attacks. Among those diseases, late blight and bacterial wilt are the most economically important diseases which incurred 100% yield loss [1, 4, 5]. Late blight of potato is caused by *Phytophthora infestans* (Mont. De Bary) and is among the most important diseases, being especially devastating in the major potato-growing tropical highlands of Sub-Saharan Africa. In the mid-1840s, a devastating potato disease swept continental Europe, the British Isles, and Ireland. It is estimated that Ireland's famine as a direct consequence of late blight, lost more than a quarter of its 8 million inhabitants to starvation and emigration, making this one of the most significant crop diseases in history. However, it was not until 1876 that a micro-organism named *Phytophthora* (meaning 'plant destroyer') *infestans* was conclusively demonstrated to be responsible for potato late blight [6]. In the mid-1800, late blight caused widespread crop failures throughout Northern Europe including in Ireland where it was responsible for the Irish famine [7]. Since then, it has spread far and wide and now occurs wherever potatoes are grown. Losses due to *P. infestans* have been estimated to € 12 billion per annum of which the losses in developing countries have been estimated around € 10 billion per annum [8]. Late blight is one of the most dreaded diseases of potatoes worldwide and causes significant loss in production. Indiscriminate use of metalaxyl-based fungicides has led to the development of metalaxyl resistance the world over including in India, which has necessitated the use of additional systemic molecules for the management of this disease [9]. Extreme humidity (above 90% RH) coupled with suitable temperature for the germination of sporangia and further disease development are the principal predisposing factors. Where the mean atmospheric temperature exceeds 25°C, the disease is rare or unknown. Cool moist conditions favor the dispersal or arrival of viable sporangia. Prolonged dry periods or rapid dehydration can quickly kill many sporangia but within the temperature range of 15°C and 20°C and moisture range of 40 to 88% RH, the lifetime of sporangia is extended. The maximum spread of the disease occurs when the conditions are favorable for the germination of sporangia into zoospores [10]. Potato late blight is considered to be the most severe potato disease worldwide. Yield losses due to the disease are attributed to the early death of foliage and diseased tubers. In Ethiopia, the disease occurs throughout the major potato production areas, and is difficult to produce the crop during the main rainy season without chemical protection [11]. In Ethiopia yield loss study on potato late blight was very old and scanty. Due to this reason, we have very eager to study yield loss assessment for this economically important disease. So that this study was designed to assess tuber yield loss for this economically important disease of potato.

# 2. Materials and Methods

### *2.1. Description of the Experimental Site*

The experiment was conducted under rain-fed conditions at Holetta Agricultural Research Center and on farms in Tikur Inchini and Mutulu during the 2020/2021 main cropping season. Holetta Agricultural Research Center is located at $9^o$ 00'N, $38^o$ 30'E at an altitude of 2400 meters above sea level (m.a.s.l.). It is 29 km away from Addis Ababa on the road to Ambo. And characterized by the average annual rainfall of the area ranging from 0.00-304.1mm. The maximum and minimum annual temperatures of Holetta are 23.91°C and 6.75°C, respectively, with an average temperature of 15.33°C. The dominant soil type is clay soil (luvisols). Tikur Inchini is located at $8.84^o$00'N, $39.67^o$30'E at an altitude of 2477 meters above sea level (m.a.s.l.) [12].

### *2.2. Experimental Materials and Procedures*

Potato variety (Jalene) which is the most susceptible to potato late blight was used for this experiment and recommended by Holetta Agricultural Research Center for cultivation in the central highlands and similar agroecologies in other parts of Ethiopia. Fungicides Mancozeb 80% WP, was previously screened and recommended for late blight control (as positive control) and an unsprayed plot (as negative control), were used as control and Gachena 525 WG was used as test treatment. Fungicide application was started as soon as the disease symptom was observed in the susceptible variety.

***Table 1.*** *Description of Jalene variety used for this field experiment.*

| Name of Variety | Accession Code | Year of release | Altitude (m.a.s.l.) | Tuber yield (t ha$^{-1}$) | |
|---|---|---|---|---|---|
| | | | | Research Field | Farmer's Field |
| Jalenie | CIP-37792-5 | 2002 | 1600-2800 | 40.3 | 29.1 |

### *2.3. Treatments and Experimental Design*

In this experiment a total of 3 treatments were used in a randomized complete block design (RCBD) with 3 replications.

### *2.4. Experimental Field Management*

The Jalene variety was used to plant at a plot size of 10 m x 10 m = 100m2, which accommodated a total of 440 plants and 33 plants per row. Medium-sized and well-sprouted potato tubers were planted on prepared ridges of 14 rows per plot at a spacing of 75 cm between rows and 30 cm between plants. The spacing between plots and adjacent replications was 1 m and 2 m, respectively. The application of fungicide started when disease symptoms appeared. The subsequent spray was made at seven days interval for the fungicides (Mancozeb 80% WP and Gachena 525 WG) at rates of 2.5 Kg/ha and 0.4 Kg/ha respectively using 200 lt of water/ha and the control treatment was sprayed with water.

### *2.5. Data Collected*

Severity of disease was recorded by using percent of leaf area infected at seven days interval starting from the onset of the first symptom by using key for scoring severity of late blight under field conditions [13].

Area under Disease Progress Curve (AUDPC): was calculated for each of treatments using the formula [14].

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

Where,

Xi is the cumulative disease severity expressed as a proportion 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 late blight severity was expressed in percent and time (t) in days, AUDPC values were expressed in unit percent-days [15].

Total Tuber Yield (t $ha^{-1}$): The sum of the weights of marketable and unmarketable tubers from the net plot area and converted to tons per hectare.

Relative Yield Loss (RYL): The percent yield loss was calculated using the formula [16].

$$\% RYL = \frac{YP-YT}{YP} * 100\%$$

Where, RYL = Relative percent loss,

YP = Yield from the maximum protected plot,

YT = Yield from other treated plots.

Marketable tuber yield (t $ha^{-1}$): The total tubers weight free from diseases, insect pests, and greater than or equal to 20 g in weight harvested from the net plot area was calculated and converted to tons per hectare.

Unmarketable tuber yield (t $ha^{-1}$): This parameter was determined by weighting tubers as diseased, insect attack and small-sized (< 20 g) harvested from the net plot area.

### *2.6. Data Analysis*

Data were subjected to analysis of variance (ANOVA) to determine the treatment effects [17]. Duncan's Multiple Range Test (DMRT) at 5% probability level was used for mean separation. Data analyses were done using the Statistical Analysis System (SAS) Version 9.3 [18].

## 3. Results and Discussions

### *3.1. Yield and AUDPC*

The combined analysis of variance (ANOVA) results for AUDPC and total tuber yield shows significant differences (P<0.05) among treatments (Table 2). As compared to the control (unsprayed) plot fungicides significantly controlled the disease at both the early and late stages of the crop. The lowest AUDPC (175.0) was recorded on fungicide Gachena 525 WG sprayed treatment followed by Mancozeb 80% WP (190.0). The control treatment (water sprayed) had the highest AUDPC (1450.0). The treatments had significant (p<0.05) differences compared to the control. The mean total tuber number significantly differs among treatments. The highest mean tuber yield (29.3 t/ha) was obtained from the fungicide Gachena 525 WG followed by the standard fungicide (Mancozeb 80% WP) which gave (27.2 t/ha), whereas the control treatment gave 4.9 t/ha. The yield difference between the fungicide treatments compared to the control treatment was statistically significant; but, the yield difference within fungicides was not significant. However, Gachena 525 WG had a 16.72% yield advantage over the control. Thus based on the performance of the fungicide subjected to test on late blight management, Gachena 525 WG deserves to be considered as an alternate fungicide to the widely used (standard) fungicide Mancozeb 80% WP in the country.

### *3.2. Relative Yield Losses*

The yield loss that was incurred for each of the fungicide applications was calculated relative to the yield of maximum protected plots i.e. Gachena 525 WG sprayed plots with 29.3 t/ha for variety Jalene (Table 2).

The highest levels of yield loss 83.28% occurred in the control (unsprayed) plots of variety Jalene as compared to the best-protected plots sprayed with Gachena 525 WG fungicide. Olanya *et al*., [19] estimated losses due to late blight to average about 30–75% on susceptible cultivars. However, in Ethiopia, the disease causes 100% yield loss on un-improved local cultivars and 67.1% on a susceptible cultivars [20]. Hence, the second highest percent yield loss (7.17%) was recorded from plots sprayed with Mancozeb 80% WP as compared to Gachena 525 WG sprayed plots. Therefore, the overall use of resistant cultivars would potentially reduce losses due to late blight, reduce the cost of crop protection and reduce the risks of fungicide resistance strain appearance in potato production. Generally, disease and yield parameters indicate that among the fungicides spray; Gachena 525 WG was the most effective followed by Mancozeb 80% WP sprayed plots as compared to the control (unsprayed) plots.

***Table 2.*** *Tuber yield losses of Potato variety (Jalene) due to late blight at Holetta Agricultural research Center, Tikur Inchini and Mutulu farmers' field in Oromia region in 2020/2021.*

| Treatment | Incidence (%) | Final Severity (%) | AUDPC | Yield t $ha^{-1}$ | % RYL |
|---|---|---|---|---|---|
| Gachena 525 WG | 11.7b | 7.5b | 175.0b | 29.3a | 0 |
| Mancozeb 80% WP | 20.3b | 25.0b | 190.0b | 27.2a | 7.17 |
| Control | 100a | 93.5a | 1450.0a | 4.9b | 83.28 |
| Mean | 44.0 | 45.66 | 605 | 20.46 | |
| LSD = 0.05 | 31.2 | 31.38 | 205.1 | 9.25 | |
| CV % | 10.6 | 9.7 | 15.33 | 11.22 | |

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

## 4. Conclusion and Recommendation

Late blight disease is one of the most devastating diseases of potatoes world-widely and causes significant loss in production. In Ethiopia yield loss study on potato late blight was very old and scanty. Due to this reason, we have very eager to study yield loss assessment for this economically important disease of potatoes. So that the study was to assess tuber yield loss for this economically important disease of potato. The results of AUDPC and total tuber yield show significant differences (P<0.05) among treatments. The highest mean tuber yield (29.3 t/ha) was obtained from fungicide Gachena 525 WG followed by the standard fungicide (Mancozeb 80% WP) which gave (27.2 t/ha) whereas the control treatment gave 4.9 t/ha The fungicide subjected to the test (Gachena 525 WG) deserves to be considered as an alternate fungicide to the widely used fungicide Mancozeb 80% WP in the country. The highest (83.28%) yield loss occurred in the unsprayed plots of the Jalene variety as compared to the best-protected plots sprayed with Gachena 525 WG fungicide. Generally, disease and yield parameters indicate that among the fungicides spray; Gachena 525 WG was the most effective followed by Mancozeb 80% WP sprayed plots as compared to unsprayed control plots.

## Author Contribution Statement

Authors have significantly contributed to the development and the writing of this article.

## Data Availability Statement

All data was used for the research described in the article.

## Declaration of Interest's Statement

Authors declare that they have no conflict of interest.

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