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Yield Loss Assessment of Potato Late Blight Disease in Central Highland Parts of Ethiopia

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Abstract: Late blight of potato is the most economical disease which can result into crop failures if it is not properly managed early**.** So that, our objective was to update yield loss assessment on late blight disease of potato. The experiment was arranged in a randomized complete block design (RCBD) with three replications with a total of 5 treatments. All fungicides significantly controlled the disease at both early and late stage of the crop in comparison to the unsprayed plot. The minimum 151.7 AUDPC was recorded on the tretement was sprayed by fungicide supper plus. The lowest next three treatements were spayed by Mancozeb, Zorphic, and Redomil, were resulted 320.8, 350, 408 AUDPC respectively. The control treatment (water sprayed) had the highest AUDPC (1131.7). The highest mean tuber yield (34.4t/ha) was obtained from fungicide Zorphic followed by the standard fungicide (Redomil) which gave (30 t ha^{-1}) whereas the control treatment gave 5.7 t ha -1. The highest yield loss (72.9%) occurred in the unsprayed plots of cultivar Jalenie compared with Zorphic fungicide sprayed plots. Generally all disease and yield parameter indicate that among the four fungicides spray; Zorphic was the most effective followed by Redomil Gold, Supper plus and Mancozeb sprayed plots. Thus based on the performance of fungicides for the management of late blight, potato yield and yield components, Supper plus and zorphic deserve to be considered as an alternate fungicide to the widely used fungicide Mancozeb and Redomil, respectivelly in the country.

Keywords: P. Infestans, Potato, Yield Loss

1. Introduction

Potato is number one of non-grain food commodity, with production reaching 325 million tons in the world and consumed by more than one billion people globally [1]. Potato is cultivated worldwide in over one hundred countries throughout Africa, Asia, Australia, Europe, North and South America [2]. It is able to produce more protein and carbohydrates per unit area than cereals and some leguminous crops like soybeans [3]. It is known to suffer the greatest losses from disease attack by late blight and bacterial wilt diseases which incurred 100% yield loss [4, 1, 5]. Late blight of potato is among its most important diseases, being especially devastating in the major potato growing areas of Sub-Saharan African. It is estimated that Ireland, 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 human 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 mid1800, late blight caused widespread crop failures swept continental Europe, the British Isles and Ireland where it was responsible for the Irish famine [7]. After 1840 it has spread far and wide and now occurs wherever potato is grown. Yield loss due to *P. infestans* was estimated around € 12 billion per annum [8]. Late blight is one of the most dreaded diseases of potato worldwide and cause significant loss in production; indiscriminate use of metalaxyl based fungicides led to the development of metalaxyl resistance world over including India, which has necessitated the use of additional systemic molecules for the management of this disease [9]. Excessive humidity (above 90% RH) integrated with suitable temperature for germination of sporangia and further disease development are the principal pre-disposing factors. Favorable condition for late blight disease occurrence: Cool moist condition favor

dispersal or arrival of viable sporangia; Extended 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 life time of sporangia is extended; Maximum spread of the disease occurs when the conditions are favorable for germination of sporangia into zoospores [10]. Potato late blight is considered to be the most serious potato disease worldwide with yield losses of both premature death of foliage and diseased tubers. In Ethiopia, the disease occurs throughout the major potato production areas and it is unthinkable to produce the crop during the main rainy season without chemical protection measures applied at the right with recommended rate [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 our objective was to study yield loss assessment for this economically important disease.

2. Materials and Methods

2.1. Description of the Experimental Site

Our experiment was conducted under rain fed condition at Holetta Agricultural Research Center and on farm in Tikur enchini during the 2020 & 2021 main cropping season when the environment is very conducive for disease existence. Holetta Agricultural Research Center is located at 9o00'N, 38o30'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 with mean annual rainfall of 89.3and mean maximum and mean minimum temperature of 22.13 and 6.54°C, respectively. Tikure enchini is located at 8.84°00'N, 39.67°30'E at an altitude of 2477 meters above sea level (m.a.s.l.) according to HARC [12] unpublished data.

2.2. Experimental Materials and Procedures

Potato variety (Jalenie) which is the most susciptable for potato late blight was used for this experiment. Four fungicides with one control: two new fungicides, Supper plus and Zorphic, the other two fungicides Mancozeb, and Ridomil Gold MZ 68 WG which have been evaluated before were included during this research. Fungicides applications began when the disease riches with 5% disease severity on the susceptible variety.

Table 1. *Potato variety was used for the field experiment during 2020 & 2021 cropping season.*

Name of	Accession	Year of	Altitude	Yield t/ha at Research	Yield t/ha at Farmer's field
Variety	Code	Release	(m.a.s.l.)	Field	Field
Jalenie	CIP-37792-5	2002	1600-2800	40.3	29.1

2.3. Treatments and Experimental Design

The experimental treatments were arranged with randomized complete block design, organizing a total of 5 experimental treatments comprising the untreated plots as controls with three locations as replication.

2.4. Experimental Field Management

Our plot size was 10x10 m=100m^2, which accommodated 33 plants per row and thus 440 plants per plot. Medium-sized and well-sprouted potato tubers were planted on 14 rows per plot at spacing of 75 cm between rows and 30 cm between plants. The spacing between plots was 2 m. Fungicides application started when disease symptoms riches with 5% disease severity on the susceptible potato variety (Jalenie). Spray interval were made at 7 and 14 days interval for the contact (Mancozeb& Supper plus) and systemic (Ridomil Gold MZ 68 WG and Zorphic) fungicides respectively; and the control treatment was sprayed with water.

2.5. Data Collected

Severity of disease was recorded based on percent leaf area infected at seven days interval starting from the onset of the first symptom by using this scholar formula which is mentioned below [13].

Area under disease progress curve (AUDPC) was calculated using the formula developed by those scholars [14].

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

Where Xi is the cumulative disease severity expressed as a proportion at the ith observation, ti is the time (days after planting) at the ith 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 (LYL): The percent yield loss was computed 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 and converted to tons per hectare.

Unmarketable tuber yield (t ha^{-1}): 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 SAS softawer version 9.3 [17] and

analysis of variance (ANOVA) was done by Generalized linear model to determine the treatment effects [18]. Duncan's Multiple Range Test (DMRT) at 5% probability level was used for mean separation.

3. Result and Discussion

ANOVA revealed that the AUDPC and total tuber yields of treatements were significantly different ($p<0.05$). All fungicides significantly controlled the disease at both early and late stage of the crop as compared to the unsprayed control plot. The supper plus sprayed treatement were resulted 151.7 the lowest AUDPC. Next to this, 320.8, 350, and 408 AUDPC were recoreded from Mancozeb, Zorphic, and Redomil spayed treatements respectively. The control treatment (water sprayed) had the highest AUDPC (1131.7). The treatments had significant ($p<0.05$) differences when compared to the control. Mean total tuber number significantly differ among treatments. The highest mean tuber yield (34.4t/ha) was obtained from fungicide Zorphic followed by the standard fungicide (Redomil) which gave (30 t/ ha) whereas the control treatment gave 5.7 t/ ha. The yield difference of the fungicide treatments compared to the control treatment were statistically significant. The yield difference within systemic fungicides and contact fungicide was not significant; but, there was highly significant different between systemic and contact fungicides. However, Supper plus had 28.5 % yield advantage over the control.

Relative Yield Losses

The yield loss that was incurred for each of the fungicide application were calculated relative to the yield of maximum protected plots i.e. Zorphic sprayed plots with 34.4t/ha for variety Jalenie (Table 2).

On the Zorphic fungicide untreated plots of Jaliene 72.9% yield loss was recorded. 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 unimproved local cultivar, and 67.1% on a susceptible cultivar [20]. Hence, the second highest percent yield loss (43.89%) was recorded from plots sprayed with Mancozeb as compared to Supper plus and Redomil sprayed plots. Therefore, overall use of resistant cultivars would potentially reduce losses due to late blight, and reduce the cost of crop protection and reduce the risks of fungicide resistance strain appearance in potato production. Generally all disease and yield parameter indicate that among the four fungicides spray; Zorphic was the most effective followed by Redomil Gold, Supper plus and Mancozeb sprayed plots as compared to unsprayed plots.

Table 2. *Yield losses of Potato variety (Jalenie) due to late blight during 2020& 2021 cropping season.*

Treatment	Final Disease Severity	AUDPC	UNMTW (t/ha)	MTN	MTW (t/ha)	TTN	TTW (t/ha)	%RYL
Zorphic	5b	350b	6a	212,593a	27.7a	342222a	34.4a	0
Redomil	6.7b	408b	4.3a	176,296b	25.2a	304815a	30a	12.79
Supper Plus	6.7b	151.7b	5.3a	200,349a	20a	344444a	25.3a	26.45
Mancozeb	16.7b	320.8b	4.3a	155,823b	15b	243333b	19.3b	43.89
Control	98a	1131.7a	3.7a	109,155c	5.7c	211111b	9.3c	72.96
Mean	40.5	535	4	171604.9	13.6	301605	112.7	
CV	14.9	27.4	24.7	7.3	17.9	12.4	23.6	
LSD	12.8	536	2.6	28,398	3.4	122	60.2	

4. Conclusion and Recommendation

Late blight is one of the most dreaded diseases of potato worldwide and cause 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. So our objective was to study yield loss assessment for this economically important disease. The highest mean tuber yield (34.4t/ha) was obtained from fungicide Zorphic followed by the standard fungicide (Redomil) which gave (30 t ha^{-1}) whereas the control treatment gave 5.7 t ha -1. Based on the performance of the fungicide subjected to test on the late blight management and total tuber yield, Supper plus and zorphic deserve to be considered as an alternate fungicide to the widely used fungicide Mancozeb and Redomil, respectively in the country. Greatest yield loss 72.9%occurred in the unsprayed plots of cultivar Jalenie as compared to the best protected plots sprayed with Zorphic fungicide. Generally all disease and yield parameter indicate that among the four fungicides spray; Zorphic was the most effective followed by Redomil Gold, Supper plus and Mancozeb sprayed plots as compared to unsprayed plots.

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