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Efficacy of Greenzeb 80% WP Fungicide on Potato Late Blight (*Phytophthora infestans*) in Bonke, Chencha and Kamba, Southern Nation Nationality People Regional States, Ethiopia

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Original Research Article

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Abstract

The verification research was carried out at Bonke, Chencha, and Kamba in SNNPRs in 2021 to assess the performance of the fungicide Greenzeb 80% WP in comparison to another promising standard fungicide, Sabozeb 80% WP, for the treatment of potato late blight for registration reasons. The trials consisted of three treatments and were organized in a randomized full block design with three replications. Analysis of variance showed substantial ($P < 0.001$) differences in late blight severity, area under disease progress curve (AUDPC), and tuber yield between treatments and sites. The results revealed that plots sprayed with Greenzeb 80% WP at the three sites had the lowest mean severity (34.98%) and AUDPC (576.46%-days), as well as the highest marketable tuber output (16,622 kg ha-1). Plots sprayed with Sabozeb 80% WP at all three

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locations, however, revealed statistical similarities. In summary, evidence from the current verification studies revealed that Greenzeb 80% WP considerably decreased late blight epidemics, resulting in higher potato tuber yields across all sites when compared to unsprayed controls. Greenzeb 80% WP is therefore recommended for registration in order to manage potato late blight, as it has been shown to be quite effective.

Keywords: AUDPC; fungicides; late blight; marketable tuber yield; severities.

1. Introduction

Potato (*Solanum tubersum* L.) is a profitable and food-secure crop in Ethiopia's highlands (Tesfaye, 2010; CSA, 2018). The crop can produce higher-quality products per unit area while having a shorter cycle of life than main grain and pulse crops grown in the country's highlands. Despite its relevance and potential in the country, production is limited by a variety of biotic and abiotic variables (Semira, 2016; Adane et al., 2010). As a result, the average potato productivity (14.01 t ha-1) (CSA, 2018) is much lower than the global average yield of 23.04 t ha-1 (FAOSTAT, 2018). Late blight (Phytophthora infestans) is one of the most important production constraints and is responsible for low productivity per unit area in potato production systems worldwide, particularly in countries with moderate temperatures, high rainfall, and relative humidity (de Barry, 1876; Hijmans et al., 2000; Agrios, 2005; Yoshida et al., 2013). The disease affects both the foliage and tubers of potatoes in the field, even when stored for tuber reservations, which can slow or disrupt sprout development (Schumann and D'Arcy, 2000; Agrios, 2005). Yield losses from late blight can range from minimal to complete failure, depending on the severity of the infection. Potato yield losses of 65 to 100% have been reported in highly severe potato cultivars in Ethiopia (Kassa and Hiskias, 1996; Mekonen *et al.*, 2011; Tsedaley, 2014). During favorable environmental conditions yield loss due to late blight can be speedy and unstoppable if preventative measures are not used (Agrios, 2005).

Several management options for late blight had been reported, including fungicide measures as a foliar application (Kassa et al., 2002; Agrios, 2005) and integrated disease management, which included cultural plus fungicide spray, host resistance plus fungicide spray, or a combination of cultural, host resistance, and fungicide spray (Kirk et al., 2005; Mekonen et al., 2011; Getachew et al., 2018). The majority of potato growers in the region and country employ sensitive types to late blight, which causes significant yield loss, particularly in areas where the climate favors disease growth. Thus, there is a need for alternative and effective fungicides, such as the introduction of a new fungicide or different formulations of existing fungicides containing the same active ingredient, which pesticide firms may continue to introduce. As a result, the efficiency of novel fungicides on potato late blight should be studied and verified on a regular basis before they are introduced into production systems. For this reason, Arba Minch Agricultural Research Center has been designated by the Ministry of Agriculture through Southern Agricultural Research Institute to test the efficacy of the new fungicide, Greenzeb 80% WP, against potato late blight during the 2021 cropping season. The goal of the verification experiment was to compare the efficacy of the fungicide Greenzeb 80% WP (Mancozeb 80%) to another promising standard fungicide, Sabozeb 80% WP (Mancozeb 800 g/kg), for the treatment of potato late blight for registration reasons.

2. Materials and Methods

2.1 Description of the Study Site

The verification trial took place during the 2021 primary cropping seasons in Bonke, Chencha, and Kamba. The area is chosen based on the importance and frequency of late blight throughout the growing season. Throughout the production year, potato production has taken place in both short and extended rainy seasons. The sites are located at elevations of 2527m (Chano), 3003m (Chencha), and 2465m (Kamba) masl. Bonke, Chencha, and Kamba have a bimodal rainfall pattern, with the short rainy season from March to May and the main rainy season from July to November. Thus, the areas receive an average annual rainfall and temperature during the growth season of 1201 mm and 15.3 °C, 1170 mm and 15.50 °C, and 991 mm and 16.8 °C for Bonke, Chencha and Kamaba, respectively.

2.2 Treatments, Experimental Design and Field Management

Fungicides used included Greenzeb 80% WP at 2 kg/ha with 400 L water (candidate fungicide), Sabozeb 80% WP at 2 kg/ha with 200 L water (standard check), and unsprayed check. A susceptible local cultivar was utilized to test the fungicides. The layout's total width and length were 35 x 33 m, with unit plots of 10 x 10 m. The trials were set up in a randomized complete block design with three replicates. On July 1, 2021, the onion seedlings were transplanted at 10-cm intervals along the rows. Medium-sized sprout tubers (35 - 55 mm in diameter) were manually planted in rows on the experimental dates in both cropping seasons specified by Mohammad et al. (2013). The distance between plots and replications was 1 and 1.5 meters, respectively. Nutrient management was carried out with 236 kg ha-1 NPS, 144 kg ha-1 N fertilizer, and 125 kg ha-1 Muriate of Potash (MoP). At the time of planting, the full rate of NPS and MoP, as well as half of the N fertilizer, were applied. The other half of the nitrogen fertilizer has been applied during the blossoming period. Weeding, cultivation, and ridging procedures were followed as recommended for potatoes. For both fungicides, the manufacturer's recommended fungicide rate per hectare and amount of water for fungicide mixing were followed. Spraying was done with a manual knapsack sprayer adjusted to give 500-700 L of water per hectare. During the growing period, each spot was sprayed three times. The fungicide was applied on each plot every 7 days. Unsprayed plots were left as controls in each replication to allow for maximum disease development. The first fungicide spray was started 41-days after transplanting when the first symptom of late blight was appeared on the leaves within the plot.

2.3 Disease and Yield Parameter Assessment

Starting 41 days after planting (DAP), the frequency and severity of late blight were monitored every week. Twelve randomly chosen pre-tagged potato plants from the center rows of each plot were used for disease assessments. The cultivar was examined six times in total until it reached physiological maturity. The ratio of diseased plants to all plants evaluated within the plot was used to compute disease incidence (%).Heinfnings (1978) proposed a 1–9 rating system for disease severity, with 1 denoting no obvious late blight symptoms. 2 = A maximum of ten injuries per plant, including up to 5% of the leaf area, are indicative of late blight. 3 = Although plants appear healthy, damage can be readily seen and covered up to 15%; each plant has no more than 20 afflicted leaves. 4 = About 25% of the leaf area is damaged, and late blight is clearly visible on the plants. 5 = Although the plants appear green, the infection affects them all., lower leaves are necrotic, and about 50% of the leaf area is destroyed, 6 = Plants look green with brown spots, and about 75% of the leaf area is affected and leaves in the middle of the plant are destroyed, 7 = Only upper leaves are green and most of leaves are affected and many stems have external injuries (90% of aboveground part of the plant is affected), 8 = Plants look brown, few upper leaves are green and most of the stems are hardly affected or dead (97.50% of aboveground part of the plant is affected), and 9 = Leaves and stems are destroyed (100% of aboveground part of the plant is affected). Then, the severity scores were transformed into percentage severity index (PSI) for the analysis following the formula suggested by Wheeler (1969) hereafter.

$$\mathrm{PSI} = \frac{\text{Sum of numerical ratings}}{\text{No. of plants scored x maximum score on scale}} \mathrm{X}\ 100$$

The area under disease progress curve (AUDPC), the development of disease on a whole plant or part of the plant, was calculated from PSI values assessed at different days for each plot using the formula suggested by Campbell and Madden (1990) hereafter.

$$\mathrm{AUDPC} = \sum_{i=1}^{n-1} 0.5\ (X_i + X_{i+1})\ (t_{i-1} - t_i)$$

Where Xi = percentage of disease severity index (PSI) of disease at ith assessment; ti = time of the ith assessment in days from the first assessment date; and n = total number of disease assessments. AUDPC value was expressed in %-days because severity (x) is expressed in percent and time (t) in days.

Throughout the growing season, data on eye observations of tomato leaf phytotoxicity were evaluated. Additionally, by avoiding boundary effects, data on tuber yield (marketable, unmarketable, and overall yield) were gathered from each plot's middle rows. The weight of all tubers gathered from each plot was used to calculate the total tuber yield, which was then expressed in kg ha-1. Marketable bulbs (tubers weighing less than

80 g or having a diameter of less than 20 mm and free of any damage) were weighed from each plot and converted to kg ha-1 in order to calculate the marketable tuber yield.

2.4 Data Analysis

To ascertain the treatment effects, analysis of variance was applied to data on illness scores and yield-related factors. The Fishers protected least significant difference (LSD) test was used to differentiate the treatment averages at a 5% probability level (Gomez and Gomez, 1984). The SAS software version 9.2's general linear model approach was used to analyze the data (SAS, 2009).

3. Results and Discussion

3.1 Efficacy of Greenzeb 80% WP on Potato Late Blight Development

At the final assessment dates in Bonke, Chencha, and Kamba during the 2021 cropping season, late blight severity and AUDPC demonstrated a substantial ($p < 0.001$) difference between fungicide-sprayed and unsprayed plots. However, during the 2021 cropping seasons, no discernible variations in disease incidence were found in the three locations at the final assessment dates. The experiment's unsprayed plots had the highest illness severity, according to analysis of variance. Conversely, at the final evaluation dates in the three locations, the Greenzeb 80% WP and Sabozeb 80% WP sprayed plots showed the least amount of disease severity. In contrast, the experiment's unsprayed plots in all three locations had the highest AUDPC values. In contrast, plots sprayed with Greenzeb 80% WP had the lowest AUDPC as compared to unsprayed plots in all three sites. Nonetheless, during the growing season in the three locations, the outcomes from plots sprayed with Greenzeb 80% WP and plots sprayed with Sabozeb 80% WP were statistically comparable (Table 1). According to Mekonen et al. (2001), the only way to lower late blight pressure was to use contact fungicides often. Greenzeb 80% WP can effectively minimize the size of late blight pressure by applying foliar sprays three times at seven-day intervals, according to these verification trials. Better active component compositions aimed at potato late blight may be the likely cause of Greenzeb 80% WP's efficacy. The total late blight epidemic development was highest at Chencha, followed by Bonke and Kamba, according to across comparisons. According to Bekelea and Gebre-Medhin (2000), Singh and Pundhir (2012), Gaire et al. (2014), and Semira (2016), these could be explained by the comparatively high temperature and prolonged potato leaf moisture from frequent rain or dews throughout the infection phase. After spraying onion leaves at all fungicide application rates, no phytotoxic symptoms, such as yellowing and burning, were seen.

Table 1. Effect of Greenzeb 80% WP on late blight, incidence (%), severity (%) and area under disease progress curve (%-days) at Bonke, Chencha and Kamba during the 2021 main cropping season

Treatment	Bonke			Chencha			Kamba		
	PDI_f (%)	PSI_f (%)	AUDPC (%-day)	PDI_f (%)	PSI_f (%)	AUDPC (%-day)	PDI_f (%)	PSI_f (%)	AUDPC (%-day)
Greenzeb 80% WP	100	33.95b	534.61b	100	38.67b	682.14b	100	32.33b	521.64b
Sabozeb 80% WP	100	33.95b	603.25b	100	39.07b	766.87b	100	32.33b	607.16b
Unsprayed check	100	65.41a	1149.17a	100	76.19a	1492.03a	100	57.83a	1048.57a
Mean	100	44.44	762.34	100	51.31	980.35	100	40.83	725.79
P-value	> 0.05 (ns)	<0.0001	<0.001	>0.05 (ns)	<0.001	<0.0001	>0.05 (ns)	< 0.0001	<0.0001
LSD (5%)	0.00	11.73	365.51	0.00	10.07	247.40	0.00	24.75	218.40
CV (%)	0.00	15.67	19.27	0.00	19.34	33.35	0.00	35.91	30.85

Means in the same column followed by the same letters are not significantly different at 5% level of significance. PDI_f = Percent disease incidence at final assessment date; PSI_f = Percent severity index at final assessment date; AUDPC = Area under disease progress curve in %-day; CV = Coefficients of variation (%); and LSD = Least significant difference at p < 0.05 probability level

3.2 Tuber Yield Parameters

Tuber yield and yield attributes (marketable, unmarketable, and total tuber yields) were significantly ($p < 0.0001$) impacted by the application of Greenzeb 80% WP and Sabozeb 80% WP in all locations at Bonke, Chencha, and Kamba, according to analysis of variance (Table 2). Plots sprayed with Greenzeb 80% WP had the highest mean marketable and total tuber yields and the lowest unmarketable tuber yield; these results were not statistically different from plots treated with Sabozeb 80% WP across the locations (Table 2). The high pressure of late blight and the cultivar's susceptibility during the epidemic periods may be the cause of Chencha's lowest mean marketable and total tuber yields and highest unmarketable tuber yield when compared to Bonke; the medium effects of environmental factors were also taken into consideration. According to the results, the fungicide Greenzeb 80% WP significantly increased tuber yields. This could be explained by its positive effects on parameters that contribute to tuber yield, such as the number of healthy leaves and the total leaf area index, while having negative effects on various metabolic activities of the pathogen (late blight), such as a breakdown of the host membrane and biochemical processes, and suppressing high disease pressure. As stated by Shiferaw *et al.* (2001), Kassa *et al.* (2002) and Ayda (2015), the application of effective fungicide protects the potato late blight epidemic development and increased yield and yield components.

Table 2. Effects of Greenzeb 80% WP application on mean marketable, unmarketable and total tuber yield of potato at Bonke, Chencha and Kamba during the 2021 main cropping season

Treatment	Bonke			Chencha			Kamba		
	MTY (kg/ha)	UMTY (kg/ha)	TTY (kg/ha)	MTY (kg/ha)	UMTY (kg/ha)	TTY (kg/ha)	MTY (kg/ha)	UMTY (kg/ha)	TTY (kg/ha)
Greenzeb 80% WP	18336.89a	3438.22b	21775.11a	14918.23a	3407.63b	18325.87a	16610.88a	3794.271b	20405.15a
Sabozeb 80% WP	18118.59a	3622.21b	21740.80a	13059.38a	3939.19b	16998.57a	14541.12a	4386.135b	18927.26a
Unsprayed	6479.95b	9567.23a	16047.18b	5348.94b	14864.50a	20213.44a	5955.84b	12894.18a	18850.02a
Mean	14311.81	5542.55	19854.37	11108.85	7403.77	18512.63	12369.28	7024.862	19394.14
P-value	<0.0001	<0.0001	<0.0001	< 0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
LSD (5%)	3857.69	543.51	923.67	5958.34	4447.03	7335.67	4298.09	562.44	6087.14
CV (%)	21.71	10.44	10.67	27.79	18.29	8.67	16.09	13.33	18.51

Means in the same column followed by the same letters are not significantly different at 5% level of significance. MTY = Marketable tuber yield in kg/ha; UMTY = Unmarketable tuber yield in kg/ha; TTY = Total tuber yield in kg/ha; CV = Coefficients of variation (%); and LSD = Least significant difference at $p < 0.05$ probability level

4. Conclusion

In comparison to unsprayed control plots at Bonke, Chencha, and Kamba, data from the current verification trials showed that Greenzeb 80% WP (Mancozeb 80%) at a rate of 2 kg/ha mixed with 400 liters of water significantly reduced late blight epidemics and, as a result, increased potato tuber yield. However, in terms of late blight epidemic development and potato tuber output, statistically comparable outcomes were found between the candidate (Greenzeb 80% WP) and standard check (Sabozeb 80% WP). None of the tested fungicides had any foliar harmful effects during the growing season. Overall, the findings demonstrated that Greenzeb 80% WP effectively controlled potato late blight at a rate of 2 kg/ha with 400 liters of water. Greenzeb 80% WP is therefore advised for registration in order to control potato late blight since it was proved to be very effective.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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Competing Interests

Authors have declared that no competing interests exist.

References

Adane, H., Miranda, P., Meuwissen, M., Agajie, T., Willemien, J., Lommen, J., Alfons, O. L., Admasu, T., & Struik, P. C. (2010). Analysis of seed potato systems in Ethiopia. *American Journal of Potato Research, 87*, 537–552. https://doi.org/10.1007/s12230-010-9164-1

Agrios, G. N. (2005). *Plant pathology* (5th ed.). Academic Press–Elsevier. https://www.elsevier.com/books/plant-pathology/agrios/978-0-12-044565-3

Ayda, T. (2015). *Effect of fungicides and resistant genotypes on severity of potato late blight [Phytophthora infestans (Mont.) de Bary] and yield and yield components at Haramaya, Eastern Ethiopia* (Master's thesis). Haramaya University, Haramaya, Ethiopia.

Bekele, K., & Gebre-Medhin, W. (2000). Effect of planting date on late blight severity and tuber yields of different potato varieties. *Pest Management Journal of Ethiopia, 4*, 51–63. https://doi.org/10.20372/pmjoe.v4i1%20&%202.318

Campbell, C. L., & Madden, L. V. (1990). Temporal analysis of epidemics I. Description and comparison of disease progress curves. In *Introduction to plant disease epidemiology* (ISBN 0471832367).

FAOSTAT (Food and Agriculture Organization of the United Nations). (2018). *Agricultural data: Production and indices data crop primary*. http://www.fao.org/faostat/en/#data/QC/visualize

Gaire, S. P., Shrestha, S. M., & Sharma, A. B. P. (2014). Effect of planting dates and fungicides on potato late blight (*Phytophthora infestans* (Mont.) de Bary) development and tuber yield in Chitwan, Nepal. *International Journal of Research, 1*(5), 148–160. https://www.researchgate.net/publication/263300300_Effect_Of_Planting_Dates_and_Fungicides_on_Potato_Late_Blight_Phytophthora_Infestans_Mont_De_Bary_Development_and_Tuber_Yield_In_Chitwan_Nepal

Getachew, G., Temam, H., Mashilla, D., & Birhanu, B. (2018). Integrated management of tomato late blight [*Phytophthora infestans* (Mont.) de Bary] through host plant resistance and reduced frequency of fungicide in Arba Minch areas, southern Ethiopia. *Journal of Biology, Agriculture and Healthcare, 8*(9), 94–109.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). John Wiley & Sons. https://www.wiley.com/en-us/Statistical+Procedures+for+Agricultural+Research%2C+2nd+Edition-p-9780471870920

Heinfnings, J. W. (1987). *Late blight of potato (Phytophthora infestans)* (Technical Information Bulletin No. 4). Lima, Peru.

Hijmans, R. J., Forbes, G. A., & Walker, T. S. (2000). Estimating the global severity of potato late blight with GIS-linked disease forecast models. *Plant Pathology, 49*, 697–705. https://doi.org/10.1046/J.1365-3059.2000.00511.X

Kassa, B., & Hiskias, Y. (1996). Tuber yield loss assessments of potato cultivars with different levels of resistance to late blight (pp. 149–152). In E. Bekele, A. Abdulahi, & A. Yemane (Eds.), *Proceedings of the 3rd Annual Conference* (18–19 May 1996). Crop Protection Society of Ethiopia, Addis Ababa, Ethiopia.

Kassa, B., Olanya, M., Tesfaye, A., Lemaga, B., & Woldegiorgis, G. (2002). Economic implications of late blight management in tropical highlands of Ethiopia (p. 161). In C. Lizarraga (Ed.), *Late blight: Managing the global threat*. Proceedings of the Global Initiative on Late Blight Conference, Hamburg, Germany.

Kirk, W. W., Abu-El Samen, F. M., Muhinyuza, J. B., Hammerschmidt, R., Douches, D. S., Thill, C. A., Groza, H., & Thompson, A. L. (2005). Evaluation of potato late blight management utilizing host plant resistance and reduced rates and frequencies of fungicide applications. *Crop Protection, 24*, 961–970. https://doi.org/10.1016/j.cropro.2004.12.016

Mekonen, S., Alemu, T., Kassa, B., & Forbes, G. (2011). Evaluation of contact fungicide spray regimes for control of late blight (*Phytophthora infestans*) in southern Ethiopia using potato cultivars with different levels of host resistance. *Tropical Plant Pathology, 36*, 021–027. https://doi.org/10.1590/S1982-56762011000100003

Mohammad, A., Mohammad, N., Safarzadeh, V., Peyman, S., & Ali, S. (2013). Effect of plant density date and depth of cultivation on yield and yield components of potato planting in the Chabahar. *International Journal of Agronomy and Plant Production, 4*(8), 1890–1897.

Schumann, G. L., & D'Arcy, C. J. (2000). *Late blight of potato and tomato*. American Phytopathological Society. https://doi.org/10.1094/PHI-I-2000-0724-01

Semira, N. (2016). Review on major potato disease and their management in Ethiopia. *International Journal of Horticulture and Floriculture, 4*(5), 239–246. https://www.internationalscholarsjournals.org/journal/ijhf/volume/volume-4-issue-5-2016

Singh, V. K., & Pundhir, V. S. (2012). Effect of date of planting on potato late blight development and tuber yield. *Pantanagar Journal of Research, 10*(1), 31–35.

Tesfaye, A., Weldegiorgis, G., Kaguongo, W., Lemaga, B., & Nigussie, D. (2013). Adoption and impact of potato production technologies in Oromia and Amhara regions (pp. 256–278). In G. Weldegiorgis, S. Schulz, & B. Berihun (Eds.), *Seed potato tuber production and dissemination, experiences and challenges and prospects*. Proceedings of the National Workshop on Seed Potato Production and Dissemination, 12–14 March 2012, Bahir Dar, Ethiopia.

Tsedaley, B. (2014). Late blight of potato (*Phytophthora infestans*): Biology, economic importance and its management approaches. *Journal of Biology, Agriculture and Healthcare, 25*, 215–226. https://www.iiste.org/Journals/index.php/JBAH/article/view/17394

Wheeler, B. J. (1969). *An introduction to plant diseases*. John Wiley & Sons.

Yoshida, K., Schuenemann, V. J., Cano, L. M., Pais, M., Mishra, B., & Sharma, R. (2013). The rise and fall of the *Phytophthora infestans* lineage that triggered the Irish potato famine. *eLife, 2*, e00731. https://doi.org/10.7554/eLife.00731

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