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Effect of Fungicide and Varieties on Management of Potato Late Blight (*Phytophthora infestans*) on Bale Highlands, South Eastern Ethiopia

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Abstract

Late blight caused by Phytophthora infestans (Mont.) de Bary, is one of the most significant constraints to potato production in Bale highlands. Therefore, this study was conducted to assess the integrated effects of fungicide (Mancozeb 80 wp) and varieties (Kellecho, Hunde and Ararsa) on late blight of potato. The experiment was laid out in Randomized Complete Block Design in factorial arrangement with three replications at Sinana, Goba and Disho. All variety, fungicide and variety by fungicide interaction showed highly significant ($P \leq 0.01$) differences for all the characters, except for number of tuber per hill. The highest total tuber yield (26.8 t ha^{-1}) and the lowest disease severity (48.8%) were recorded from one of the improved varieties, Ararsa, which was sprayed with the fungicide at weekly interval. The highest disease severity and subsequent lowest total tuber yield was recorded on local cultivar Kellecho and four times application of Mancozeb at weekly interval was found to be effective for control of the disease on local cultivar kellocho. However, for Ararsa and Hundie weekly two times of chemical application was effective for management of late blight on the highlands of Bale.

Key Words:-late blight; Varieties; fungicide application

Introduction

Potato has been highly recommended by the Food and Agriculture Organization (FAO) as a food security crop and it is the third most important food crop in the world after rice and wheat in terms of human consumption (FAO, 2014). It is grown by over 1.4 million households in Ethiopia. It also created a direct employment opportunity to at least 1.4 million household growers excluding those involved at wholesaler, retailer, transportation and processing areas. However, the national average tuber yield (11.8 t.ha^{-1}) is very low compared to the world's average of 19 t.ha^{-1} (CSA, 2014). This is because of several factors among which shortage of good quality seeds of improved varieties, low input use, unfavorable weather and soil physico-chemical properties and prevalence of various pests (Bekele and Hailu, 2003; Gildemacher *et al*., 2009 and Hirpa *et al*., 2010).

Late blight caused by *Phytophthora infestans* is one of the most important diseases of potato worldwide. It is the main production constraint of the crop in the highlands of Bale. Losses due to this disease were estimated to be 65-70% and complete crop failures are frequently reported (Bekele and Yaynu, 1996). To manage late blight, farmers have increasingly adopted fungicide application as a main control strategy. The combined uses of fungicide and resistant varieties have evolved as one of the most important options in the management of late blight of potato (Abreham *et al*., 2009). Integrating fungicide applications with varieties by choosing the best fungicide-cultivar combinations improves the durability/sustainability of the released potato varieties in the potato production system.

This is particularly important in developing countries such as Ethiopia, where potato breeding programmes depend entirely on CIP materials. The variety development, which involves evaluation, selection, release and registration procedures pass through several stages. Hence, integration of fungicides with cultivars should be commonly practiced for sustaining the production of potatoes in the region. Accordingly, this study was conducted to determine the combined effects of varieties (Hunde, Ararsa and Kellecho) and fungicide (Mancozeb 80% wp) for management of late blight of potato.

Materials and Methods

A local potato variety, Kellecho and two improved varieties, Hunde and Ararsa were planted in plots with size of 4.5m × 3m at Sinana on-station, Goba and Dinsho during 'Gena' cropping seasons of 2012, 2013 and 2014. The experiment was arranged in randomized complete block design (RCBD) in a factorial arrangement with 3 replications. During the onset of late blight, Mancozeb 80% WP, was applied on each variety at recommended rate in three different spray schedules viz., every 7, 14 and 21 days. Spray was continued at specified interval until the crop attained its physiological maturity. Unsprayed plots of each variety were included for comparison. Recommended row and plant spacing (0.75 and 0.3 m, respectively), fertilizer rate (200 kg/ha DAP and 75 kg/ha urea) and agronomic practices were applied. Tuber yield was harvested from the middle four rows of each plot and converted to tone per hectare. Disease severity was assessed on weekly bases starting from the onset of the late blight until the crop attained its physiological maturity as percentage of leaf area affected by late blight.

Data on tuber yield and disease severity were subjected to analysis of variance using GenStat 15th edition computer software. Means that are significantly different were compared using Duncan's Multiple Range Test (DMRT) of probability at 5% probability of significance.

Results and Discussion

Analysis of variance

Analysis of variance indicated significant ($P \leq 0.05$) and ($P \leq 0.001$) differences among varieties, chemical, and variety × chemical interactions for most of the traits except number of tuber per hill (Table 1). This may allow us to select combination of varieties with higher yield, late blight tolerant and less chemical application to produce potato effectively. This is in line with Habtamu *et al.*, (2012) who indicated significance difference for combination of different varieties for different chemical application frequencies.

Mean performances of varieties

Late blight was recorded in all locations, Sinana on station, Goba and Dinsho with different levels of severity during the growing season. The highest late blight severity (97%) was recorded from the unsprayed plot of susceptible variety, Kellecho while the lowest (48.8%) was on weekly fungicide sprayed plots of one of the improved varieties, Ararsa. On unsprayed plots of improved varieties, Ararsa and Hunde, the record of disease severity was 75 and 77.7%, respectively. Among fungicide sprayed plots, the highest late blight severity (97%) was recorded on local variety, Kelecho, which was sprayed with the fungicide at 21 days interval (Table 2). Generally, application of mancozeb reduced the progress of the disease. This is in line with previous reports by Bekele and Hailu (2003) who suggested application of fungicides play a vital role in the management of late blight. Similar results were reported by Shiferaw *et al* (2009) that indicated moderately resistant cultivar, Gudanie, had a clear AUDPC response to additional fungicide sprays, although apparently for about three sprays.

The highest total tuber yield (26.8 t ha^{-1}) was harvested from an improved variety, Ararsa, on which late blight was controlled by spraying Mancozeb 80% WP at 7days interval where as the lowest (14.3 th^{-1}) was from unsprayed plots of the local variety, Kelecho. Among fungicide sprayed plots, the lowest total tuber yield (14.3 t ha^{-1}) was recorded from variety Kelecho, which was sprayed with the fungicide every 21days.

Moreover, marketable and unmarketable tuber yield also varied between the interaction of variety and chemical application frequencies. The highest unmarketable tuber yield (4.2 t ha^{-1}) was harvested from unsprayed plots of the local variety and the lowest (0.7t ha^{-1}) was from Ararsa which was sprayed with fungicide at weekly interval. This implies that unchecked, late blight can greatly reduce ield level and quality resulting in more of unmarketable tubers. But in the present study number of uber per hill was recorded to be statistically the same for varieties as well as chemical application schedules. Unlike unmarketable yield, the highest marketable tuber yield was recorded from the released variety, Ararsa which was sprayed with fungicide every 7 days, while the lowest was recorded from unsprayed plots of the local cultivar, Kellecho (14.3 t ha^{-1}).

Both released varieties with different chemical application frequencies reordered statistically the same total tuber yield across the location and year. However, improved varieties namely Ararsa and Hunde as well as local cultivar, Kellecho with different chemical application recorded significantly different total tube yield. This may be due to the ability of improved varieties viz. Ararsa and Hunde to resist or tolerate late blight of potato. This is in agreement with Shiferaw *et al* (2011) and Abreham (2009) who indicated potato varieties greatly differ in their reaction to late blight infection. More over local cultivar Kellecho with chemical application frequencies of weekly, 14 and 21 days resulted in the highest unmarketable tuber yield (4.2 t ha^{-1}).

Conclusion and recommendation

The highest total tuber yield (26.8t ha^{-1}) and the lowest disease severity (48.8%) were recorded from improved varieites on which late blight was controlled by spraying Mancozeb every 7 days. The lowest total tuber yield (14.3t ha^{-1}) and the highest disease severity were recorded from the local cultivar, Kelecho. The released verities, Ararsa and Hunde, yielded statistically the same level of total tuber when sprayed with fungicides at intervals of 7, 14 and 21 days. However, for local cultivar Kellecho, total tubers yield significantly varried among weekly, 14 and 21 days of fungicide application schemes. In this cultivar, four times weekly fungicide application gave 41% yield advantage over unsprayed and 11% over 14 and 21 days interval of fungicides application schemes. This indicates that weekly application of mancozeb 80% WP on local cultivar Kellecho can save about 41% of total tuber yield on the highlands of Bale while on Ararsa and Hundie weekly fungicide application increased total tuber yield by 13% than unsprayed treatment. However, fungicide application at intervals of weekly, 14 and 21 days did not result in significantly differing levels of yield for improved varieties. This may due to resistance/tolerance of both varieties to late blight infection. Similar results were reported by Bekele and Hailu (2003) who found out those different varieties with different levels of resistnace to late blight have different reactions towards fungicide application frequencies.

In conclusion the present study revealed combination of resistant varieties with different fungicide application schedules can be commonly practiced for sustainable production of potato in Bale highlands. Selection of tolerant varieties can also reduce frequency of chemical application. Hence, four times application of mancozeb 80% at weekly intervals and two times on varieties Ararsa and Hunde was recommended in high land of Bale. In addition, in te future potato improvement in this region should focus on the development of imprvied varieties with better relative resistnace to late blight.

Table 1. Analysis of variance on the effects of variety and fungicide combinations on late blight management and yield on three potato varieties

Source	df	DS	NTPH	MTY	TTY
Replication	2	482.6*	2.5ns	4.18	47.7*
Variety	2	2770.6**	409.71ns	96.4**	237.4**
Chemical	3	93.0**	8.65ns	96.4**	7.5*
Variety * Chemical	6	88.2**	41.64ns	5.3*	23.8*
Error	94	405	15.6	3.1	108.1

ns-Statistically not significant *Significant at P< 0.05 and **significant at P<0.01.df= degree of freedom, DS= disease severity NTPH= number of tuber per hill, MTY=marketable tuber yield, TTY= total tuber yield

Table 2. Effect of varieties and fungicide combinations on late blight management on number of tuber per hill, unmarketable tuber yield, marketable tuber yield and total tuber yield

TRT	NTPH	unMTY(t/ha)	MTY(t/ha)	TTY(t/ha)	DS(%)
Ararsa-control	16.36 ^{a}	1.3^{de}	17.8a-c	19.1^{b}	75 ^{cd}
Kelecho x 21	14.37^{a}	3.2^{ab}	15.3de	18.5 ^{c}	85^{bc}
Hunde x 7	16.14^{a}	2.0 ^{cd}	24.4ab	26.43^{a}	50 ^{f}
Kelecho - control	14.90^{a}	4.2 ^{a}	11.1e	14.3 ^{c}	97 ^{a}
Ararsa x 21	14.55^{a}	0.8 ^{e}	25.3a	25.1^{a}	80.5^{bc}
Ararsa x 7	14.59 ^{a}	0.7 ^{e}	26.1a	26.8^{a}	48.8^{f}
Kelecho x 14	16.52 ^{a}	3.9 ^{a}	15.6de	19.5 ^{b}	82.7 ^{bc}
Ararsa x 14	15.46^{a}	0.8 ^{e}	25.7a	26.5 ^{a}	70 ^{e}
Kelecho x 7	14.34 ^{a}	3.1 ^{ab}	17.6c-e	20.6 ^{ab}	49 ^{f}
Hunde x 14	17.57 ^{a}	2.5 ^{bc}	22.5a-d	25.1 ^{a}	75^{cd}
Hunde – control	18.99^{a}	2.6^{bc}	20.4b-d	23.4^{ab}	77.7 ^{c}
Hunde – 21	16.35^{a}	1.7 $^{c-e}$	24.2ab	25.9 ^{a}	75^{cd}
Range	14.37-18.9	0.7-3.9	11.1-26.1	14.3-26.8	48.8-97
Mean	15.8	2.19	20.6	22.6	71.1
CV%	34.5	24.7	26	13.0	5.1
Level of significance	ns	**	**	*	**

ns=Statistically not significant, *=Significant at P< 0.05 and **=significant at P<0.001.df= degree of freedom. NTPH= number of tuber per hill, MTY=marketable tuber yield, TTY= total tuber yield, DS=disease severity

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