Oromia Agricultural Research Institute Review Workshop on Completed Research Activities

Proceedings of Review Workshop on Completed Research Activities of Crop Research Directorate held at Adami Tulu Agricultural Research Center, Adami Tulu, Ethiopia 17-21 November 2015

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Oromia Agricultural Research Institute

Validation of Fungicide Application for Management of Late Blight *(Phytophthora infestans* (Mont.) de Bary*)* Under Rain Fed Potato Production System of Western Oromia

Teshome Bogale*, FeyeraTakele, Abraham Negera, TilahunWondimu, Bikila Akasa, Negash Teshome and Lalise Ararsa

Bako Agricultural Research Center, P.O.box.03,West Shoa, Ethiopia

***Corresponding author: E-mail: Teshe_2008@yahoo.com**

Abstract

The study was conducted at Bako Agricultural Research Center, Shambu sub-site to determine effectiveness and economically most feasible fungicide application schemes for late blight management in Irish potat. The experiment was laid down in randomized complete block design (RCBD) in $2^2 \times 3$ factorial arrangements with three replications. Two potato varieties currently under production but differing in their reaction to late blight (Jalane - moderately resistant and Menagesha-moderately susceptible), two fungicides (Matco which is systemic fungicide and Mancozeb which is contact fungicide) and three fungicide application schemes 7, 14 and 21-days intervals were used for the treatments combination. Potato late blight progress was significantly affected by fungicide and its application schemes. Application of Matco and Macozeb sol and their combination highly controlled disease progress on Managesha variety than Jalane under the same condition. Maximum severity index and Area under Disease Progress Curve were recorded from untreated plot (control). Application of Matco and Mancozeb sole and their combination within 7days, 14days and 21days intervals checked potato late blight (Phytophthora infestans) under economic injury level. Significantly highest yield (47308 kg/ha) was obtained from variety Managesha treated with Matco applied at seven day intervals followed by variety Menagasha (46074 kg/ha) treated with Matco and Mancozeb at seven days interval. Whereas the lowest yield (12592 kg/ha) and (21234 kg/ha) was obtained from untreated Jalane variety and untreated Managesha variety, respectively. Economic analyses indicated that combination of Matco with Mancozeb application in 21days intervals for three times was recommended for Managesha variety and Matco alone under the same condition was recommended for Jalane variety as Potato late blight management options.

Key words: late blight, fungicide validation and management

Introduction

Late blight, caused by *Phytophthora infestans* (Mont. de Bary) is the most distructive disease of potato (*Solanum tuberosum* L.) worldwide. Economic impacts of this disease and the costs associated with its management are often substantial (Johnson *et al.*, 1997). Such information is necessary in developing and implementing economical disease management strategies (James, 1980). However, often reliable and quantitative estimates of plant disease losses and cost incurred to manage the plant disease are often scarcely available.

Unchecked, *P. infestans* can rapidly defoliate plants in the field and can infect potato tubers when spores are washed into the soil (Lambert and Currier, 1997). Potato late blight control strategies changed following the discovery of Mefenoxam/ Metalaxyl-resistant populations of *P. infestans* (Fry

and Goodwin, 1997). The cost of protecting potato crops in developed world against late blight was estimated to be $155 million annually (Sender, 2000). However, this information was not documented in western Ethiopia where both host and pathogen are economically important.

Now days, late blight of potato is most likely severe at western Ethiopian highlands due to several factors. The probable reasons are the raise of aggressive races of *P. infestans* due to mating type spores (Miller *et.al.*, 1997), insensitivity of the pathogens to the known systemic fungicide Ridomil (Metalaxyl), inappropriate dosage and application frequencies of fungicides, higher rainfall, and late planting of susceptible cultivars. Thus, economically sound application schemes and effective fungicide group should be identified for sustainable potato production in western Ethiopia under rain feed conditions. To this effect, this study was initiated to determine effective and economically feasible fungicide application schemes for Irish potato productions in the face of late blight under rain feed conditions.

Materials and Methods

Field experiment was conducted at Shambu during rainy season of 2013 and 2014. Two potato varieties currently under production but differing in their reaction to late blight (Jalane- moderately resistant and Menagesha-moderately susceptible) were planted on plot size 3.5m × 3m. During the onset of the target disease, late blight, each of the test fungicides (sole systemic fungicide Matco and mixture of systemic and contact fungicides, Matco and Mancozeb, respectively in 50:50 ratio) were sprayed on the experimental plots in three intervals: every 7, 14 and 21days. Spray continued at specified interval until the crop attained its physiological maturity.

The experiment was laid down in randomized complete block design (RCBD) with a factorial arrangement in three replications. There were a total of 14 treatments comprising two potato varieties, two fungicides and four fungicide application schemes/intervals (including unsprayed checks) or numerically $2^1 \times 2^1 \times 3^1 + 2$ unsprayed checks. Disease severity was assessed at an interval of 7-9 days from nine randomly pre-tagged plants in the central rows of each plot. Disease severity was then converted to severity index and area under disease progress curve (AUDPC-% day) using the following formula.

$$AUDPC = \sum_{i=1}^{n-1} [(0.5)(Xi + 1 + Xi)(ti + 1 - ti)]$$ (Shaner and Finney, 1977)

Where, X is disease severity at i^{th} observation, n is the total number of days disease is assessed and t is time at the i^{th} observation (in days numbered sequentially beginning with the initial assessment).

$$\text{Severity index} = \frac{Snr}{Npr \times Msc} \times 100$$ (Wheeler, 1969)

Where, Snr = the sum of numerical ratings, Npr = the number of plant rated, Msc = the maximum score of the scale

All agronomic and epidemiological data were subjected to ANOVA after appropriate data transformation for fitness of ANOVA assumption using SAS 9.1.3 model. Mean of significantly varied treatment were separated at $P \leq 0.05$ using Least Significance Difference. Effective fungicide application scheme was determined by analyzing disease severity index and AUDPC. Economic decision was based on partial budget analysis based on cost of input (labor, fungicide) and price of output (total revenue) which was calculated at farm gate price. Marginal rate of return (MRR) or dominance analysis applied for decision of point of economically feasible fungicide application schemes for potato production.

Results and Discussion

Potato late blight severity

The first symptom of potato late blight was observed on the 79th date after sowing (DAS). Severity of late blight was assessed seven times at weekly interval starting from the onset of the disease to physiological maturity of the plant. Generally, potato late blight severity was higher in 2014 as compared to 2013 cropping season. Late blight percentage severity index was significantly affected by variety, fungicide and fungicide application frequencies. Variety Jalane was highly infected by the disease than Menagesha in both years. During both cropping seasons, the highest PSI values were recorded on Jalane. Application of Mancozeb + Matico reduced PSI by more than 69 and 32% as compared to the un-sprayed plots in 2013 and 2014, respectively. In both years, PSI was lower on plots which were sprayed by the fungicides at weekly interval and higher on the un-sprayed plots (Table 1).

On the final date of disease assessment (127 days after sowing), the interaction between variety by fungicide and fungicide by its application frequency could not result in significantly varying percentage severity index (PSI) among the experimental plots in both 2013 and 2014 cropping seasons. However, variety × frequency of application/spray interval significantly affected PSI in both years. Lower (22.84%) PSI was recorded on Menagesha variety that received fungicide every seven days, which was at par with Jalane sprayed at seven days interval, and Menagesha variety sprayed every 14 and 21days interval in 2013. In 2014, the lowest (30.25%) PSI was recorded on Menagesha variety sprayed every 7 days followed by Jalane which was sprayed at similar interval and Menagesha sprayed every 14 days (Table 2).

Area under disease progress curve (AUDPC)

AUDPC values significantly varied between varieties in 2014 and fungicides and application frequencies in both years. AUDPC value was higher (2350.64 %-day) in Jalane than Menagesha variety. In addition, non-sprayed plot showed significantly higher AUDPC value than the sprayed plots in both cropping seasons. However, AUDPC values on fungicides sprayed plots were at par with each other in both years. Application interval of seven day significantly reduced AUDPC value than other frequencies in both years (Table 1). Similar to PSI, AUDPC significantly differed in variety by frequency interaction. During both cropping seasons, the highest AUDPC values were recorded on unsprayed plots of Jalene while the lowest were on weekly sprayed plots of the same variety (Table 2).

Marketable tuber yield

Analysis of variance revealed that marketable tuber yield significantly differed between varieties, fungicides and application frequencies. Menagesha variety resulted in higher marketable tuber yield than Jalane. There was significant difference in marketable tuber yield between fungicides sprayed and unsprayed plots. However, there was no significant difference in marketable yield harvested from the two fungicide sprayed plots (Table 1).

Variety × fungicide and fungicide × application frequency were not significantly different in marketable tuber yield in both years. However, interaction of variety with application frequency showed significant difference on marketable tuber yield. The highest marketable tuber yield was observed on plots sown to Menagesha and sprayed every seven days followed by the same variety sprayed every 14 days in both years. However, marketable tuber yield was lower on non-sprayed plots of both varieties in both years. Application of fungicides every seven days increased marketable tuber yield by more than 66 and 57% on Jalane and Menagesha varieties, respectively in 2013 over non-

sprayed check. For both varieties, marketable tuber yield showed non-significance between seven and 14 days application intervals.
Marketable tuber yield was increased by more than 65 and 53% for Jalane and Menagesha varieties sprayed every 14 days than non-sprayed treatment, respectively, in 2013 and application of fungicide every 14 days increased marketable tuber yield by more than 65 and 42% over untreated check of Jalane and Menagesha, respectively in 2014 (Table 2).

Cost-benefit analysis in apotato late blight management

Dominance analysis was carried out for the treatments before partial budget analyses were performed. Marginal rates of return (MRR) were performed for significant treatments under dominant analysis for comparison of the treatment cost/benefit of the treatments (Table 4). For variety Jalane, the highest (2391%) MRR was obtained from plots sprayed with Matico every 21 days, which implied that for every one ETB invested on potato late blight management costs, there was about ETB 23.91 additional return incurred as compared to the control plot. However, the marginal rate of return was lower on the control plots than any other treatment combinations. The highest (2766.80%) marginal rate of return was obtained from plots sprayed with the mixture of Mancozeb and Matico every 21 days on Managesha variety (Table 3).

Conclusion and Recommendation

The result of the study indicated the possibility of potato production by application of fungicides during rainy season when late blight disease is the major constraint of potato production. Application of fungicide and its application scheme increased marketable yield by reducing disease severity.

Tolerant potato varieties like Managesha with sole Matco and Mancozeb combination at seven days of application intervals has shown the best result in maximizing potato yields by reducing late blight infection. However, partial budget analysis showed that producers could be more benefited by producing tolerant variety (Menagesha) with three times application of combination of Matco and Mancozeb at 21days interval. For the susceptible variety (Jalane) however, three times application of Matco at 21days interval has indicated another option to increase potato yield by reducing late blight severity. Thus, three times application of the combination of Matco with Mancozeb at 21days intervals can be recommended for Managesha variety and Matco alone under the same condition could also be recommended for Jalane variety as potato late blight management options.

Table 1: Effect of variety, fungicide and its application frequency on late blight severity index, AUDPC and Marketable yield in 2013 and 2014 main cropping season

Treatment	2013			2014		
	Severity index	AUDPC	Marketable yield (kg/ha)	Severity index	AUDPC	Marketable yield
Varity						
Jalane	41.80 a	1901.82 a	33650.79 a	78.25 a	2350.64 a	29079 b
Menagesh	33.39 a	1610.82 a	37319.22 a	59.55 b	1721.75 b	39605 a
Fungicide						
Mancozeb + Matico	28.33 b	1306.93 b	39176.95 a	67.49 b	1824.59 b	36049.38 a
Matico	28.88 b	1115.23 b	38271.61 a	59.95 b	1568.07 b	38156.38 a
Non	91.56 a	5027.78 a	16049.38 b	100.00 a	4103.40 a	17777.78 b
CV	20.68	19.84	16.94	28.37	32.68	23.54
Application Frequency						
7	23.66 c	869.34 c	41728.40 a	44.56 c	1017.03 d	40592.60 a
14	30.25 b	1326.13 b	36049.38 b	68.72 b	1761.78 c	38000.00 ab
21	31.89 b	1437.76 b	38395. 06 b	77.78 b	2310.19 b	32716.05 b
0	91.56 a	5027.79 a	16049.38 c	100.00 a	4103.40 a	17777.78 c
CV	18.72	15.43	15.93	21.12	21.48	22.09

Means followed by the same or no letter within a column are not significantly different from each other at 0.05 probability level, DMRT test.

Table 2: Two-way interaction of variety, fungicide and its application frequency effects on final severity index, AUDPC and marketable yield at Bako in 2013 and 2014 main cropping season

Treatments	2013			2014		
	Severity Index	AUDPC	Marketable yield	Severity Index	AUDPC	Marketable yield
Variety*Fungicide						
Variety	Fungicide					
Jalane	Mancozeb	31.41	1417.70	36707.82	75.31	2106.52	30584.36
	Matico	33.88	1270.23	37530.86	73.94	1957.20	33152.27
	Non	96.71	5248.97	12839.50	100.00	4319.34	12345.68
Menagesha	Mancozeb	25.24	1196.16	41646.09	59.67	1542.66	41514.40
	Matico	23.87	960.22	39012.35	45.95	1178.94	43160.50
	Non	86.42	4806.58	19252.26	100.00	3887.45	23209.88
Variety*Frequency						
Variety	Freq. (day)					
Jalane	7	24.49 d	868.31 e	38518.52 bc	59.05 c	1284.36	32740.74
	14	36.63 c	1553.50 c	37530.87 bc	77.57 bc	2121.30	35308.64
	21	36.83 c	1610.08 c	35308.64 c	87.24 ab	2689.92	27555.56
	None	96.71 a	5248.97 a	12839.50 d	100.00 a	4319.34	12345.68
Menagesha	7	22.84 d	870.37 e	44938.28 a	30.25 d	749.69	48444.45
	14	23.87 d	1098.77 d	41481.49 ab	59.88 c	1402.26	40691.36
	21	26.96 d	1265.43 d	34567.90 c	68.31 c	1930.45	37876.55
	None	86.42 b	4806.58 b	19259.26 d	100.00 a	3887.45	23209.88
Fungicide* Frequency						
Fungicide	Freq. (day)					
Mancozeb+matico	7	22.84	912.55	42222.22	44.24	1023.25	38962.96
	14	30.04	1443.42	34567.90	73.25	1927.57	36444.45
	21	32.10	1564.84	40740.74	84.98	2522.94	32740.74
Matico	7	24.49	826.13	41234.57	45.06	1010.80	42222.23
	14	30.45	1208.85	37530.87	64.20	1595.99	39555.56
	21	31.69	1310.70	36049.38	70.58	2097.43	32691.36
Non	Non	91.57	5027.78	16049.38	100.00	4103.40	17777.78
CV (%)		13.90	10.60	13.50	11.91	11.68	14.27

Means followed by the same or no letter within a column are not significantly different from each other at 0.05 probability level, DMRT test.

Table: 3. Cost benefit analysis of Potato production as influenced by Late blight management options under rain fed condition at Shambu in 2013 and 2014

Fungicide	Frequency	Yield (kg/ha)	Gross return Birr/ha	Variable cost Birr/ha)	Net benefit Birr/ha)	MRR (%)
Jalane						
Matco	7days(8x)	36148	90370.0	5260.00	85110.00	1019.58
Matco	14days(4x)	37629	94072.5	2630.00	91442.50	2279.94
Matco	21days(3x)	32246	80615.0	1972.50	78642.50	2391.00
Matco+Mancozeb	7days(8x)	35111	87777.5	5030.00	82747.50	1019.23
Matco+Mancozeb	14days(4x)	35209	88022.5	2515.00	85507.50	2148.21
Matco+Mancozeb	21days(3x)	30617	76542.5	1886.25	74656.25	2289.00
Non sprayed		12592	31480.0	0	31480.00	
Menagesha						
Matco	7days(8x)	47308	118270.0	5260.00	113010.00	1139.26
Matco	14days(4x)	39456	98640.0	2630.00	96010.00	1632.13
Matco	21days(3x)	36493	91232.5	1972.50	89260.00	1833.97
Matco+Mancozeb	7days(8x)	46074	115185.0	5030.00	110155.00	1134.59
Matco+Mancozeb	14days(4x)	35802	89505.0	2515.00	86990.00	1348.11
Matco+Mancozeb	21days(3x)	42864	107160.0	1886.25	105273.75	2766.80
Non sprayed		21234	53085.0	0	53085.00	

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