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### Abstract

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experiment was conducted in the Ambo Agricultural Research Center on-station and Toke Kutaye district in 2020/22 to evaluate fungicide application frequency and rotation and determine the economic cost of fungicide application for the management of late blight under rain-fed and irrigated conditions of tomato production. Cochoro, the tomato variety that is well adapted to the area, was used in the experiment. Five frequencies and rotations of fungicide application were arranged in an RCBD design with three replications. The result showed that the rotations of fungicide Victory 72 WP, Mancozeb 80% WP, and Ridomil Gold MZ 68 WP spray were found to have the lowest disease incidence (39.57%), percent severity index (25.02%), AUDPC (66.82% days), and highest marketable yield (29.75ton ha<sup>-1</sup>) in all locations as compared to the untreated plots that exhibited the highest percent disease incidence (100%), percent severity index (56.2%), and AUDPC (147.47%). Therefore, from the present study, the application of fungicides in the alternating order of Victory 72 WP to Mancozeb 80% WP to Ridomil Gold MZ 68 WP at a 7-day interval is recommended to reduce the ODWHEOLJKWGDPDJHRQWRPDWRFURSV,QDGGWLRLRQWKHSUHVHQWQGLQJKDVVXJHVWHGWKDWKHSODQWLQJRIWRPDW and reduce the frequency of fungicide sprays in the main rainy season.

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under rainfed condition) for two successive years (2021 and 2021).

The altitude at Dadagelan is 2345 m.a.s.l and its geographical locations at North 8053.02" and East 37046.82", whereas Birbirsa is located at North 8055.04' and East 37044.12" with an altitude of 2112 m.a.s.l.

The areas receive heavy rain from July to August. The annual rainfall ranges from 800-1100 mm and the temperature of the district ranges from 9.44°C to 21.86°C with an average of 15.65°C. The soil of the experimental site is light-red clay loam with a pH value of 6.8 (Source:

Pearson correlation coefficient was analyzed using SAS software while the costs and benefits were analyzed using the standard procedure developed by CIMMYT (1988).

$$\text{Marginal Rate Return(\%)} = \frac{DNI}{DIC} \times 100$$

Where MRR% is the percentage marginal rate of return, DNI is the difference in net income compared with the control [change in net benefits (Net benefits from new technology minus net benefits from control)] and DIC is the difference between input cost compared to control [Change in total variable costs (Total variable cost of new technology minus control)]. To compare alternation fungicide application treatment techniques and frequency fungicide application costs and benefits, the ratio of net benefits (Gross margin) to total variable costs was calculated using the formula below. Treatment that showed the highest ratio was reported as the best [15].

$$\text{Cost Benefit ratio} = \frac{\text{Net Benefit}}{\text{Total Variable Cost}}$$

## Results and Discussion

### Disease intensity and yield components under irrigated conditions

The data revealed that late blight exhibited significant differences (P<0.05) within treatments. The maximum disease incidence was recorded on unsprayed plots (95.00%) and Victory 72 WP 2 times spray (77.67%). The minimum disease incidence recorded on the plots sprayed with Victory 72 WP + Mancozeb 80% WP + Ridomil Gold, Mancozeb 80% WP + Ridomil Gold + Victory 72 WP (39.67, 40.67%), and Mancozeb 80% WP + Ridomil Gold + Victory 72 WP (41.0%) [16].

The maximum percentage severity index recorded on unsprayed plots (56.22%) followed by two-time Victory application (39.05%) while the minimum percent severity index was recorded on the plots treated with Victory 72 WP + Mancozeb 80% WP + Ridomil Gold, Ridomil Gold + Victory 72 WP + Mancozeb 80% WP (25.02, 22.39%), and Mancozeb 80% WP + Ridomil Gold + Victory 72 WP (29.35%). The maximum AUDPC under irrigation was recorded on check (147.47%) followed by plots treated with Victory 72 WP 2 times spray (116.64%).

The minimum AUDPC under irrigation was achieved using alternate application of Victory 72 WP + Mancozeb 80% WP + Ridomil Gold, Mancozeb 80% WP + Ridomil Gold + Victory 72 WP, (73.83, 66.82) control, and Ridomil Gold + Victory 72 WP + Mancozeb 80% WP

(62.21). Maximum marketable yield was obtained through rotation application of Victory 72 WP + Mancozeb 80% WP + Ridomil Gold (29.75 tons ha<sup>-1</sup>) while the least marketable yield was recorded on check (5.33 tons/ha) (Table 2) [17].

### Disease intensity and yield components under rainy seasons

The minimum disease incidence was recorded on plots treated with rotation application of Victory 72 WP + Mancozeb 80% WP + Ridomil Gold, Ridomil Gold + Victory 72 WP + Mancozeb 80% WP (70.00, 70.33%), and Mancozeb 80% WP + Ridomil Gold + Victory 72 WP (70.50%). Maximum disease incidence was recorded on control (100.00%) followed by Victory 72 WP 2 times spray (95.50%). The minimum disease severity index was recorded on plots treated with rotation application of Ridomil Gold + Victory 72 WP + Mancozeb 80% WP, Mancozeb 80% WP + Ridomil Gold + Victory 72 WP (27.07, 27.61%), and Victory 72 WP + Mancozeb 80% WP + Ridomil Gold (27.80%) [18].

Under rainy condition, the minimum AUDPC was recorded in treatments of Ridomil Gold + Victory 72 WP + Mancozeb 80% WP, Mancozeb 80% WP + Ridomil Gold + Victory 72 WP (67.92, 69.96), and Victory 72 WP + Mancozeb 80% WP + Ridomil Gold (73.13), while the maximum AUDPC values were recorded on the control plot (150.35) and Victory 72 WP 2 times spray (129.34). Maximum marketable yield was recorded on the plots treated with alternating application of Victory 72 WP + Mancozeb 80% WP + Ridomil Gold and Ridomil Gold + Victory 72 WP + Mancozeb 80% WP (28.62 a ton ha<sup>-1</sup>). In contrast, the least marketable yield was recorded in untreated plots (4.42 tons/ha) and sole application of Victory 72 WP 2. Maximum unmarketable yield was recorded in treatments obtained from Control (2.50-ton ha<sup>-1</sup>) and Victory 72 WP 2 times (2.44-ton ha<sup>-1</sup>) (untreated or controls), and two times the same fungicide was used in both varieties (Table 3) [19].

The highest percent severity index obtained on the tomato which was produced under rainfed condition than the one produced using irrigation (Figure 1). In both seasons of tomato production, the lowest late blight PSI were recorded in alternations of fungicide treatment (VMR (Victory, Mancozeb, and Redomil), MRV (Mancozeb, Redomil, and Victory), and RVM (Redomil, Victory, and Mancozeb) compared to the sole application of Victory fungicide and the unsprayed plots. The percent severity index of tomato late blight decreased as the number of




S/N	Treatment description	Incidence (%)	PSI (%)	AUDPC	MYD ton/ha	UNMYD ton/ha
1	Victory 72 WP + Mancozeb 80% WP + Ridomil Gold MZ 68 WP	70.00 <sup>f</sup>	27.80 <sup>g</sup>	73.13 <sup>ef</sup>	28.62 <sup>a</sup>	1.56 <sup>d</sup>
2	Mancozeb 80% WP + Ridomil Gold MZ 68 WP + Victory 72 WP	70.50 <sup>f</sup>	27.61 <sup>fg</sup>	69.96 <sup>f</sup>	25.88 <sup>b</sup>	1.70 <sup>cd</sup>
3	Ridomil Gold + Victory 72 WP + Mancozeb 80% WP	70.33 <sup>f</sup>	27.07 <sup>g</sup>	67.92 <sup>f</sup>	23.97 <sup>c</sup>	1.65 <sup>cd</sup>
4	Ridomil Gold MZ68WP + Ridomil Gold MZ68WP Ridomil Gold MZ68WP	78.17 <sup>d</sup>	36.97 <sup>d</sup>	93.47 <sup>d</sup>	23.85 <sup>c</sup>	1.73 <sup>cd</sup>
5	Mancozeb 80% WP + Mancozeb 80% WP + Mancozeb 80% WP	78.67 <sup>d</sup>	44.91 <sup>c</sup>	113.76 <sup>c</sup>	22.91 <sup>cd</sup>	1.83 <sup>bcd</sup>
6	Victory 72 WP (2 times)	95.50 <sup>b</sup>	51.53 <sup>b</sup>	129.34 <sup>b</sup>	21.80 <sup>de</sup>	2.50 <sup>a</sup>
7	Victory 72 WP (3 times)	84.00 <sup>c</sup>	44.50 <sup>c</sup>	112.68 <sup>c</sup>	20.41 <sup>e</sup>	2.04 <sup>b</sup>
8	Victory 72 WP (4 times)	82.33 <sup>c</sup>	44.49 <sup>c</sup>	112.94 <sup>c</sup>	16.92 <sup>f</sup>	1.85 <sup>bcd</sup>
9	Victory 72 WP (5 times)	74.00 <sup>e</sup>	32.26 <sup>e</sup>	81.06 <sup>e</sup>	13.10 <sup>g</sup>	1.93 <sup>bc</sup>
10	Victory 72 WP (6 times)	73.67 <sup>e</sup>	30.97 <sup>ef</sup>	92.89 <sup>d</sup>	10.84 <sup>h</sup>	1.90 <sup>bc</sup>
11	Control check	100.00 <sup>a</sup>	59.72 <sup>a</sup>	150.35 <sup>a</sup>	4.42 <sup>i</sup>	2.44 <sup>a</sup>
CV (%)		1.19	4.35	4.83	4.2	7.16
LSD (0.5)		2.11	3.77	10.73	1.81	0.31

PI=Percent Incidence, PSI=Percent Severity Index, AUDPC=Area Under Disease Progress Curve, MYD=Marketable Yield, UNMYD=Unmarketable Yield

Victory 72 WP application frequency increased (Figure 2) [20].

#### Correlation among tomato late blight and yield parameters

The simple correlation analysis showed that disease parameters, namely disease incidence, percentage severity index, AUDPC, and marketable tomato yield, were significantly ( $P < 0.05$ ) correlated with each other. The correlation analyses indicate that all disease parameters exhibited a strong negative correlation with marketable yield ( $P < 0.05$ ).

This suggests that as disease pressure increases, marketable tomato yield decreases as well, and conversely, as disease pressure decreases, marketable yield increases. This result is consistent with the conclusion reached by Fekede (2011), which stated that yield parameters were negatively correlated with the associated disease parameters (Table 4) [21].

#### Partial budget analysis and marginal rate of return, irrigation

A partial budget and marginal rate of return analysis were undertaken to evaluate the economic feasibility of tomato late blight

management using the alternating fungicide application technique on irrigated tomato production. Results indicate that the alternating fungicide application method especially the systemic (Victory) + contact (Mancozeb) + systemic (Ridomil Gold) technique for tomato late blight management was found to be economically viable and cost-effective. A gross field benefit, net benefit income and marginal rate of return of contact + systemic + contact fungicide application by using alternation was 404773.50, 400143.90, and 7453.571 ETB per hectare, respectively [22,23].

#### Partial budget analysis and marginal rate of return, rainfed

Like fungicide application rotation and frequency under irrigated tomato production, partial budget and marginal rate of return analysis of rainfed tomato production also indicates that the rotation application fungicide method especially the systemic (Victory) + contact (Mancozeb) + systemic (Ridomil Gold) technique for tomato late blight management was found to be economically viable and cost-effective. A gross field benefit, net benefit income and marginal rate of return of contact + systemic + contact fungicide application by using rotation was 389513.85, 384884.25 and 9810.03 ETB per hectare, respectively [24-26].

## Conclusion and Recommendation

Rotation in fungicide application and spray regimes have significant influences on late blight disease incidence, percent severity index, area under disease progress curve, marketable yield, and unmarketable yield