

Efficacy of Fungicides and Seed Rhizome Treatments for the Control of Ginger Diseases in South Ethiopia

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Abstract- Ginger (*Zingiber officinale* Rosc.) is an economically important spice crop in Ethiopia, where its production has been severely constrained by complex diseases including bacterial wilt (*Ralstonia solanacearum*), Fusarium wilt (*Fusarium oxysporum*), rhizome rot, and *Phyllosticta* leaf spot (*Phyllosticta zingiberi*). To develop an integrated disease management (IDM) strategy, a field experiment was conducted during the 2023 and 2024 cropping seasons at the Areka Agricultural Research Center in South Ethiopia. Twelve treatment combinations involving seed rhizome treatments (copper oxychloride and hot water), fungicide (Matco: metalaxyl 8% + mancozeb 64% WP), and bactericide (Kocide 2000) sprays, and cultural practices were evaluated in a randomized complete block design with three replications. Disease incidence and severity were recorded at 15-day intervals, and yield and yield components were assessed at harvest. Results showed that foliar spraying of Matco alone at 15-day intervals (5 applications) was most effective in reducing *Phyllosticta* leaf spot incidence (52.14%) and severity (31.43%), whereas the combined application of Matco and Kocide significantly reduced bacterial wilt incidence (10%) and severity (60.71%). Matco-treated plots achieved the highest rhizome yield (24.85 t/ha), followed by the combined Matco and Kocide application (21.43 t/ha), both exceeding the national average yield of 16 t/ha. Kocide applied alone was ineffective against *Phyllosticta* leaf spot and did not significantly improve yield. The findings highlight that no single management strategy is sufficient, but integrating seed treatment, fungicide/bactericide sprays, and cultural practices substantially reduces disease pressure and enhances productivity. Adoption of IDM practices is therefore recommended for sustainable ginger production in Ethiopia.

Keywords: Ginger, Bacterial wilt, *Phyllosticta* leaf spot, Fungicide, Integrated disease management, Yield

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INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an important commercial crop grown for its aromatic rhizomes, which are used as both a spice and a medicine (Sharma *et al.*, 2010). Ginger is one of the most important spices, largely for small-scale farmers in Ethiopia. In many production areas of Ethiopia, up to 85% of the farmers and 35% of the total arable land were allotted for ginger production. However, this potential spice crop was wiped out by a sudden outbreak of bacterial wilt epidemics in 2011 and 2012, resulting in estimated yield losses of up to 100% (Habetewold *et al.*, 2015). But Zerhun T *et al.* (2020) reported that fusarium wilt caused by *F. oxysporum* and ginger leaf spot caused by *Phyllosticta zingiberi* are potential ginger production challenges, in addition to *R. solanacearum*. In addition, in 2019, a field experiment conducted at Areka ARC and Tepi ARC, involving plant pathologists from the two ARCs, reported that the systemic fungicide Matico and the bactericide Kocide were effective against *Phyllosticta* leaf spot and bacterial wilt of ginger, respectively. It's reported that Matco Fungicide foliar application five times within a 15-day interval minimized ginger *Phyllosticta* leaf spot disease and rhizome yield loss due to disease (Zerhun Tomas and Alamar Seid, 2023) and that Kocide 2000 bactericide is responsible for

reducing ginger bacterial wilt incidence to the lowest level and comparably increased number of fingers per rhizome as well as rhizome yield (Merga Jibat and Abukiya Getu, 2020). Seed rhizome size of 50 to 75g was found to be optimum for ginger planting because it results in a lower percentage of disease incidence and higher yield, and that of removal/extraction of the mother rhizome during ginger planting resulted in the highest percentage of disease incidence and lower yield (Sharma, 2011). The rhizome rot of ginger was caused by a complex of phythium and *Fusarium* diseases. Seed rhizomes were soaked in 0.3% copper oxychloride for 30 minutes and air-dried before sowing (Lalfakawma *et al.*, 2014), and seed rhizome treatment with hot water at 50 °C for 10 min (Acharya *et al.*, 2016) most effectively reduced rhizome rot of ginger. In a nutshell, the pathogen's seed- and soil-borne nature, along with its disease complexes, makes it difficult to control with a single management strategy. This experiment focused on developing an integrated disease management strategy to manage complex diseases of ginger and increase ginger production and productivity in the South Ethiopia region.

Materials and methods

Description of experimental sites

A field study was carried out during the 2023 and 2024 cropping seasons at Areka Agricultural Research Center Experimental Field in the South Ethiopia Region. Geographically, the site is located at 7°4'24"N, 37°41'30"E, at an elevation of 1830 meters above sea level. The average maximum and minimum temperatures are 26 and 14 degrees Celsius, respectively. The experimental area experiences a bimodal pattern of mean annual precipitation of 1460 mm that runs from March to October and is characterized by large amounts of precipitation during "Belg" (February to June) and comparatively low amounts during "Meher" (July to October) [18]. The soils at Areka are deep, highly weathered, with a pH of 5.2. The daily mean maximum and minimum temperatures in the area are 25 °C and 13 °C, respectively. The main soil type in the area is nitisols.

Treatments, design of experiment, and management procedures

The experiment was conducted on the research farm of the Areka Agricultural Research Center for two consecutive years, 2023 and 2024. Volvo cultivar seed rhizome was used for the study. Planting will be carried out during the dry season. Natural infestation will serve as the primary source of inoculum. The

Table 1. Treatment combination

Treatment Number	Treatment	Treatments Number	Treatment
T1	Rhizome treatment with Copper oxychloride 87% WP for 30 minutes	T7	T2 + T4 + T5
T2	Rhizomes treatment with hot water at 50oC temp for 10 min	T8	T1 + T4
T3	Planting without mother rhizome removal	T9	T1+ T5
T4	Application of Matco five times	T10	T2 + T4
T5	Application of Kocide five times	T11	T2 + T5
T6	T1 + T4 + T5	T12	Control (no treatment applied)

Disease assessment

Disease assessment every fifteen (15) days following the onset of the disease in the field was measured. Incidence of diseases (in Percent) and severity(1-9 scale) of both phylostica leaf spot and ginger bacterial wilt data were collected from 10 randomly selected and pre-tagged ginger plants in each plot, and also yield and yield components data were taken. Disease incidence was measured as the number of infected plants by observing 20 randomly selected plants per plot.

Disease Incidence, DI (%) = $\frac{\text{Number of infected plant}}{\text{Total number of plants}} \times 100$

experiment will consist of 12 treatments, and the experiment will be laid out in a randomized complete block design with three replications. The layout was designed with a total width and length of 35 m x 9 m, for a total of 315 square meters. The net plot size is 2m x 2m = 4 m². Spacing between rows and spacing between plants were (40 cm, 20 cm), respectively. Plots were spaced 2 m apart, and blocks were separated by a 2.0 m safeguard path to prevent drift or cross-contamination. For the fungicides, the rate per hectare and the dilution water volume were used as recommended by the manufacturer. Fungicide application was initiated at the onset of leaf spot disease in ginger, with applications at 15-day intervals for 5 applications. Unsprayed plots were left for each replication as controls to allow maximum disease development. For some treatments, seed rhizomes were treated with copper oxychloride for 30 minutes, followed by hot water at 50 °C for 10 minutes. The recommended rate of fertilizers (DAP 100 kg/ha at planting) and 150 kg/ha urea (60 kg/ha at planting, 50 kg/ha 50 days after planting, and 40 kg/ha 120 days after planting) were used for the study. Cultivation and weeding were carried out simultaneously and equally across the experimental units.

Total number of plants

Disease severity was examined as the percentage of plant parts affected.

Disease severity, DS (%) = $\frac{\text{Area of a plant tissue affected}}{\text{Total area of a plant part assessed}} \times 100$

The total area of a plant part assessed

Data Analysis

The collected data were subjected to Analysis of Variance (ANOVA) using SAS software, and least significant difference (LSD) at the 5% probability level was used for mean separation.

Result and Discussion

The treatments like rhizomes treatment with hot water at 50oC temp for 10 min, rhizomes treatment with hot water at 50oC temp for 10 min with alternative application of Matco and Kocide, rhizomes treatment with hot water at 50oC temp for 10 min with application Matco only, rhizomes treatment with hot water at 50oC temp for 10 min with application Kocide only and planting ginger seed without mother rhizome removal have showed germination percentage per plot less than or equal to 50 %. So it's discarded from the experiment.

Effect of fungicides on the incidence and severity of bacterial wilt and Phylostica leaf spot

The combined analysis of variance indicated that all the fungicides tested in the present investigation significantly reduced phylostica leaf spot disease severity. The lowest incidence and severity of ginger phylostica leaf spot disease, 52.14% and 31.43%, respectively, were achieved with foliar spraying of matco at 15-day intervals starting from the onset of initial symptoms in the field. Next to the matco-treated plot, alternative foliar application of matco and kocide with disease incidence and severity, 58.57% and 35%, respectively, managed phylostica leaf spot disease well, but the highest ginger phylostica leaf spot disease incidence and severity were obtained from plots treated with only kocide

and control (no treatment applied plot) (Figure 3). This indicates that application of Matco alone or, alternatively, with Kocide at 15-day intervals for 5 applications reduced ginger phylostica leaf spot disease compared with the Kocide-treated and no-treatment plots (Figure 3). Similar results were reported by Merga J et al. (2022), who found that applications of the fungicide Matco at the onset of initial symptoms in the field were very effective in reducing ginger phylostica leaf spot disease. Similar findings were reported by Zerhun T et al. (2023), who found that the application of matco can minimize ginger phylostica leaf spot disease and associated rhizome yield loss. In another experiment, Resham B et al. (2021) reported that the highest percentage of ginger disease control was achieved with the foliar application of metalaxyl 8% WP + mancozeb 64% WP, followed by carbendazim 50% WP. Whereas the lowest ginger bacterial wilt disease incidence and severity, 10% and 60.71%, respectively, were obtained with alternative foliar sprays of Matco and Kocide at 15-day intervals for 5 applications (Figure 4). Similar results were reported by Merga J et al. (2020): the application of the kocide at the onset of initial symptoms in the field was effective in reducing ginger bacterial wilt.

Table 2. Effect of fungicide spray on Phylostica leaf spot disease incidence and severity

Trt number	Trt	PDI (%)	PDS (%)	BDI (%)	BDS (%)
1	Treatment with Copper oxychloride 87% WP	89.4a	82.6a	45.75b	30.6b
2	Matco	40.8b	16.5b	89.4a	92.8a
3	Kocide	87.8a	88.7a	44.84b	35.4b
4	T1+ T2+T3	38.4b	15.43b	38.3b	18.6c
5	T1+ T2	39.3b	17.44b	48.1b	28.4b
6	T1+ T3	88.92a	86.41a	36.7b	20.7c
7	Control	95.3a	85.9a	100a	100a
	LSD (5%)	10.8	8.62	13.2	7.5
	CV (%)	18.4	19.6	17.9	16.45

Effect of fungicides on rhizome yield and yield components of ginger

The result showed that a statistically significant ($P>0.05$) difference was observed in the number of fingers per plant, palm length per plant, fresh weight

of rhizome per plant, and fresh weight of rhizome per plot between treatment-applied and untreated (control) plots in the experiment. But no statistically significant difference ($P>0.05$) was observed between the matco-applied plot and the matco-and-kocide-

applied plot at 15-day intervals starting from the onset of disease symptoms, five times. On the other hand, there is a statistically significant difference ($P>0.05$) between the matco and kocide applied plots and the kocide applied plot alone. This result shows that kocide alone is not recommended for managing phylosticta leaf spot and bacterial wilt in ginger. Foliar spraying of Matco (metalaxyl 8% + mancozeb 64% WP) produced the highest yield of 24.85 t/ha, followed by the alternative application of Matco and Kocide at a 15-day interval for 5 applications, yielding 21.43 t/ha. The Matco applied plot has a 3.42 t/ha

yield advantage compared with the alternative application of Matco and Kocide at 15-day intervals for 5 applications. (Table 3). The result also shows that foliar application matco only or alternatively application of matco and kocide, at 15 days interval for five times starting from onset of phylosticta leaf spot of ginger with fresh rhizome yield (24.85t/ha, 21.43t/ha) respectively, has significant role for fresh rhizome yield increment of ginger when compared with national average fresh rhizome yield of 16 t/ha reported in Ethiopian (Endrias and Asfaw, 2011).

Table 3: Effects of fungicide spray on yield and yield components of ginger

Trt number	Trt	NFPP	FWRPP	FWR (ton/ha)
1	Treatment with Copper oxychloride 87% WP	6.31c	112.6c	7.3c
2	Matco	10.4ab	114.6c	8.6c
3	Kocide	5.4c	98.6c	8.4c
4	T1+ T2+T3	16.5a	210.86a	23.85a
5	T1+ T2	8.5b	150.8b	16.6b
6	T1+ T3	9.1b	86.4c	7.5c
7	Control	5c	23.6d	5c
LSD (5%)		7	65.4	5.4
CV (%)		19.6	23.4	20.5

Means in the same column followed by the same letters are not significantly different at 5% level of significance. NFPP = Mean number of fingers per plant; PLPP = Mean palm length per plant (cm); FWRPP = Mean fresh weight of rhizome per plant (gram); FWRPP = Mean fresh weight of rhizome (ton/ha); CV= Coefficients of variation (%) and LSD = Least significant difference at $p < 0.05$ probability level.

Conclusion and Recommendation

The present study demonstrated that integrated management practices are essential in reducing the incidence and severity of major ginger diseases, namely *Phyllosticta* leaf spot and bacterial wilt, and in improving ginger yield. Among the treatments evaluated, foliar application of Matco (metalaxyl 8% + mancozeb 64% WP) at 15-day intervals starting from the onset of initial symptoms was the most effective in reducing *Phyllosticta* leaf spot disease incidence

(52.14%) and severity (31.43%), while the combined application of Matco and Kocide significantly reduced bacterial wilt incidence (10%) and severity (60.71%). Seed rhizome treatments with copper oxychloride and hot water, when integrated with foliar fungicide/bactericide sprays, reduced disease pressure but showed variable effects on germination and yield. The highest rhizome yield (24.85 t/ha) was obtained from Matco alone, followed by the alternative application of Matco and Kocide (21.43 t/ha), both of which surpassed the national average yield of 16 t/ha. Kocide applied alone, however, was ineffective in managing *Phyllosticta* leaf spot and did not significantly improve yield. Overall, the results confirm that no single management practice is sufficient to control the complex disease challenges of ginger. Instead, integrated approaches combining seed treatment and rational fungicide/bactericide use offer the most reliable disease management and

productivity enhancement. Regular foliar applications of Matco, alone or in combination with Kocide, at 15-day intervals (five times per season) are strongly recommended for effective management of *Phyllosticta* leaf spot and bacterial wilt. Kocide should not be used alone for disease management, as it was ineffective in reducing leaf spot severity. Adoption of IDM practices combining seed treatment, timely

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