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Original scientific paper

Efficacy of fungicides in control of turmeric leaf spot caused by *Colletotrichum capsici* at Tepi, Southwestern Ethiopia

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SUMMARY

Turmeric leaf spot, caused by the pathogen *Colletotrichum capsici*, is the greatest damaging disease that limits the production and productivity of turmeric, and reduces qualitative and quantitative rhizome yields in Southwestern Ethiopia. A field trial was conducted to evaluate the efficacy of different fungicides against a disease epidemic of turmeric leaf spot in Southwestern Ethiopia. The field experiment was performed at Tepi Agricultural Research Center during the 2019 and 2020 main cropping seasons using four fungicides: Ethiozeb 80% WP (mancozeb), Prozole 255 EC (propiconazole), Mancolaxyl 72% WP (mancozeb + metalaxyl) and Ridomil Gold MZ 68 WG (metalaxyl-M), which were applied either as seed rhizome treatments plus foliar spray, or as foliar spray alone for control of leaf spot infection. The field experiment was laid out in a randomized complete block design with nine treatments and three replications. The results of the experiment indicated that both rhizome treatment + foliar spray, and foliar fungicide spray treatments significantly affected the turmeric leaf spot epidemics. The effect of the foliar spray Prozole 255 EC (propiconazole) was significantly higher than the other treatments in reducing disease severity (27.0) and maximizing rhizome fresh yield (34.1 ton/ha). The maximum cost benefit ratio (1:2.65) was achieved by the foliar spray fungicide Prozole 255 EC (propiconazole). Amongst different fungicides considered, the foliar spray Prozole 255 EC (propiconazole) reduced leaf spot disease incidence up to 47.1% over the control on the last day of disease evaluation. The whole outcome of this experiment showed that foliar Prozole 255 EC (propiconazole) fungicide sprays were effective in alleviating the epidemic of turmeric leaf spot and boosting turmeric production and productivity.

Keywords: *Colletotrichum capsici*, turmeric, fungicides, yield, Ethiopia

INTRODUCTION

Turmeric (*Curcuma longa* L.) is an important annual, monocotyledonous rhizomatous crop (Singh et al. 2013). Turmeric cultivation is rapidly increasing at national and international level in response to demands for medicinal and culinary herbs. Rhizome is the chief source of reserves of essential secondary metabolites, including alkaloids, glycosides, coumarins, flavonoids, steroids, corticosteroids, essential oils, etc. (Amalraj et

al., 2016). Turmeric is the most cultivated spice crop in the agricultural southwestern part of Ethiopia both on a small and large scale. It is a versatile and important cash crop and its prime product is the harvested dried rhizome. Turmeric has a broad range of uses from providing a carroty coloring powder for textile industry to diet and herbal medicine industry, and is cherished for its aroma, taste and oleoresin content (Purseglove et al., 1981).

Turmeric is widely recognized as a source of elements in Ethiopian cuisine (Girma et al., 2008a). Also, turmeric is one of the most significant marketable crops in Ethiopia. Its cultivation in the country is increasing and potentially becoming a cash crop with decent economic return, particularly for resource deprived farmers of Ethiopia. It has similarly remained a commercial commodity of big private farms and in giant investment plans at state level, which shows the promising future of the crop in Ethiopia. The crop offers an opportunity for diversification of the current coffee Arabica-based cropping scheme in Southwestern Ethiopia. Ethiopia exports turmeric primarily in dried form, and as oleoresin or essential oil extracts (Maseresha, 2010). According to Herms (2015), turmeric accounts for around 8% (USD 2.1 million) of the total spice exports of Ethiopia.

Despite all these benefits for small scale farmers and economic development of the country, turmeric crops are currently at extreme risk from leaf spot in rainy seasons in Southwestern Ethiopia where the main commercial production is undertaken by small-scale farmers and large private investors. Assessments made in major production areas of Southwestern Ethiopia indicate that the crop is vulnerable to this disease (Merga & Wakjira, 2019). *Colletotrichum capsici,* which causes turmeric leaf spot, is one of the nastiest pathogens which triggers quantitative and qualitative impact all over the turmeric-producing area of Southwestern Ethiopia. The highest losses have been found in heavily diseased plants (more than 50 %), i.e. about 24 and 63 % in mother and finger rhizomes, respectively (Mishra & Pandey, 2015).

Disease symptoms of turmeric leaf spot include brown, necrotic and sunken lesions of ashy center surrounded by yellow halo or sometime numerous black dots like a structure called 'acervuli', formed in a concentric manner on leaves during September and October (Ramakrishnan, 1954). The prevailing atmospheric conditions of monsoon rains, high humidity of 80-90% and optimum temperature induce great losses in rhizome yields of up to 62.5% (Mishra & Pandey, 2015). The disease is recognized to cause extensive injury by reducing rhizome size and mass up to 53 % (Mishra & Pandey, 2015). Even though the disease is extremely devastating and widespread throughout Southwestern Ethiopia, there is no information or study on turmeric leaf spot disease management in Southwestern Ethiopia. This study was therefore conducted with the following objectives:

- to evaluate the effects of fungicide treatments and foliar sprays on turmeric leaf spot disease epidemics, and
- to evaluate the effects of fungicide sprays and seed treatments on turmeric rhizome yield and its components.

MATERIALS AND METHODS

Description of study area

The experiment was conducted at the Tepi Agricultural Research Center during the 2019 and 2020 main cropping seasons (under rain-fed conditions). It is positioned at 7°10' N latitude and 35°25' E longitude at the altitude of 1200 meters above sea level and the region is categorized as hot moist with mean annual rainfall of 1559 mm, and the highest and lowest mean temperatures of 30.23°C and 16.09°C, respectively (Girma et al., 2008b). The soil type of the trial site is categorized as Nito soils, which is characterized by loamy texture and pH ranging from 5.6 to 6.0 (Abayneh & Ashenafi, 2005).

Experimental design and trial management

The Dame variety of turmeric was used in the experiment. The trial was set up in a randomized block design with nine treatments and three replications and plots of 3 × 4 m (length × width) with spacing of 0.5 m and 1 m between plots and blocks, respectively, 0.3 m between rows and 0.15 m between plants. Four fungicides: Ethiozeb 80% WP (mancozeb) 3 kg ha^{-1}, Prozole 255 EC (propiconazole) 2.5 l ha^{-1}, Mancolaxyl 72% WP (mancozeb + metalaxyl) 3 kg ha^{-1}, and Ridomil Gold MZ 68 WG (metalaxyl-M) 2.5 kg ha^{-1} were applied as seed rhizome treatment before planting and foliar spray 75, 90 and 105 days after planting, using a Knapsack sprayer. Other usual agronomic practices were also implemented to cultivate the crop apart from fungicide treatments. Rhizome germination (%) was calculated as the total number of germinated rhizomes in each plot and their means were converted into percentages as the total number of seed rhizomes planted.

Disease severity was assessed every fifteen (15) days, starting from the appearance of lesions on plant leaves, i.e. 75 days after planting, and was recorded three times. Leaf spot severity was assessed on 10 (ten) randomly pre-tagged turmeric plants in each replication for disease recording. The severity of the disease was scored by implementing a 0-6 scoring scale (Mishra and Pandey., 2015), where 0=no disease (healthy plants), 1=1-10% leaf area infected, 2=11-20% leaf area infected, 3=21-30% leaf area infected, 4=31-40% leaf area infected, 5=41-50% leaf area infected, 6= more than 50% leaf area infected by the disease.

The percent disease intensity (PDI) was measured according to a formula recommended by Mishra and Pandey (2015), given beneath:

$$PDI = \frac{\text{(Sum of rating of infected leaves in plant)}}{\text{Total no.of leaves observed} \times \text{maximum disease score}} \times 100$$

The percent efficiency of disease control (PEDC) was calculated by using the following formula:

$$PEDC = \frac{\text{(PDI in control-PDI in treatment)}}{\text{PDI in control}} \times 100$$

Cost-benefit analysis

The gross return obtained from each treatment was calculated using the adjusted rhizome yield (15%) obtained per hectare and the average local market price of turmeric during the production period. Net return was calculated by subtracting the total variable cost (TVC) from gross return. To identify the best treatment regarding net benefits, MRR (%) was computed according to the CIMMYT (1988) procedure, using the formula:

$$MRR\ (\%) = \frac{DNI}{DIC} \times 100$$

Where: MRR is marginal rate of return, DNI is difference in net income compared with untreated control, DIC is difference in input cost compared with untreated control.

At the end, the cost benefit ratio was identified per treatment per hectare based on the current marketing rates of turmeric in the resident market.

Data analysis

Analysis of variance (ANOVA) was performed for disease intensity and yield to determine the effect of treatments. Least significant difference (LSD at 5% probability level) was used for mean separation. All data analyses were done using the Statistical Analysis System (SAS) Version 9.3 (SAS Institute, 2003).

RESULTS AND DISCUSSION

Trial data from the 2019 and 2020 experimental years are shown in Tables 1 and 2. All treatments displayed significantly higher effects in comparison with control on rhizome germination, disease intensity and yield. Rhizome germination ranged from 80.53 to 92.13%. The highest germination was obtained by Ridomil Gold Mz 63.5 WP rhizome treatment + foliar spray, followed by Prozole 255 EC (propiconazole) rhizome treatment + foliar spray of (88.43%) and Prozole 255 EC (propiconazole) foliar spray (87.8%). All tested fungicides significantly reduced disease severity in comparison with control plants. Among the fungicides, minimum percent disease intensity was documented after the application of Prozole 255 EC (propiconazole), both foliar spray (27.0) and rhizome treatment + foliar spray (29.2), and there was no significant difference between these two treatments. The following efficient treatments were Ethiozeb 80% WP (mancozeb) foliar spray (31.6) and rhizome treatment + foliar spray (32.7). Mancolaxyl 72% WP (mancozeb + metalaxyl) and Ridomil Gold MZ 68 WG (metalaxyl-M) were less effective in managing the leaf spot disease of turmeric. The results are consistent with recommendations by Rao et al. (2012) and Jagtap et al. (2013). Maximum rhizome yield was achieved with the Prozole 255 EC (propiconazole) foliar spray (34.1 t ha^{-1}). Prozole 255 EC (propiconazole) rhizome treatment + foliar spray, Ethiozeb 80% WP (mancozeb) foliar spray, and Ethiozeb 80% WP (mancozeb) rhizome treatment + foliar spray recorded yields of 33.1 t ha^{-1}, 31.6 t ha^{-1} and 30.5 t ha^{-1}, respectively. Rhizome treatments and foliar sprays of Mancolaxyl 72% WP (mancozeb + metalaxyl) and Ridomil Gold MZ 68 WG (metalaxyl-M) were found less effective in increasing fresh rhizome yield. The present results regarding the supremacy of Prozole 255 EC (propiconazole) in managing leaf spot disease and increasing rhizome yield are in agreement with findings reported by Mishra and Pandey (2015). Similarly, Jagtap et al. (2013) and Musheer et al. (2019) studied the foliar efficacy of fungicides, biocontrol agents and botanical extracts against *Colletotrichum* species to enhance turmeric growth and yield traits. Yadav et al. (2017) also achieved the best results with foliar sprays of propiconazole and neem leaves extracts in minimizing the severity of disease caused

by the same pathogen *C. capsici*. Another previous study (Musheer et al., 2019) determined the best results of propiconazole, *Trichoderma viride* and neem cake foliar sprays in decreasing the turmeric leaf spots disease incited by *C. gloeosporioides* and in enhancing plant height, rhizome girth, fresh rhizome weight, dry rhizome weight, photopigments of leaves and curcumin content of rhizome.

Table 1. Effects of fungicides on germination and leaf spot disease severity assessed on the final date (combined analysis of 2019 and 2020).

Treatment	Treatment description	Germination (%)	Leaf spot disease (105 DAP)	
			PDI*	PEDC*
T1	Ethiozeb 80% WP (mancozeb) rhizome treatment + foliar spray	87.33	32.7^{d}	35.9
T2	Prozole 255 EC (propiconazole) rhizome treatment + foliar spray	88.43	29.2^{ef}	42.7
T3	Mancolaxyl 72% WP (mancozeb + metalaxyl) rhizome treatment + foliar spray	86.43	33.7^{cd}	33.9
T4	Ridomil Gold MZ 68 WG (metalaxyl-M) rhizome treatment + foliar spray	92.13	37.3^{b}	26.9
T5	Ethiozeb 80% WP (mancozeb) foliar spray	84.53	31.6^{de}	38
T6	Prozole 255 EC (propiconazole) foliar spray	87.8	27.0^{f}	47.1
T7	Mancolaxyl 72% WP (mancozeb + metalaxyl) foliar spray	86.1	36.9^{bc}	27.6
T8	Ridomil Gold MZ 68 WG (metalaxyl-M) foliar spray	87	39.6^{b}	22.4
T9	Control	80.53	51.0^{a}	–
	CV (%)		5.32	
	LSD (5%)		3.27	

*PDI=percent disease intensity; PEDC=percent efficacy of disease control, DAP=days after planting. Means followed by the same letter(s) within a column and between adjacent columns are not significantly different at 5% level of significance.

Table 2. Effects of fungicides on yield (t ha^{-1}), yield increase over control, and cost benefit ratio (combined analysis of 2019 and 2020 data).

Treatment	Treatment description	Yield (t ha^{-1})	Yield increase over control (%)	C:B*
T1	Ethiozeb 80% WP (mancozeb) rhizome treatment + foliar spray	30.5^{bc}	13.4	1:2.45
T2	Prozole 255 EC (propiconazole) rhizome treatment + foliar spray	33.1^{ab}	23	1:2.51
T3	Mancolaxyl 72% WP (mancozeb + metalaxyl) rhizome treatment + foliar spray	29.5^{cd}	9.7	1:2.14
T4	Ridomil Gold MZ 68 WG (metalaxyl-M) rhizome treatment + foliar spray	29.9^{bcd}	11.2	1:2.22
T5	Ethiozeb 80% WP (mancozeb) foliar spray	31.6^{abc}	17.5	1:2.32
T6	Prozole 255 EC (propiconazole) foliar spray	34.1^{a}	26.8	1:2.65
T7	Mancolaxyl 72% WP (mancozeb + metalaxyl) foliar spray	30.6^{abc}	13.8	1:2.21
T8	Ridomil Gold MZ 68 WG (metalaxyl-M) foliar spray	31.3^{abc}	16.4	1:2.28
T9	Control	26.9^{d}	–	1:2.09
	CV (%)	6.61		
	LSD (5%)	3.5		

*C:B=Cost benefit ratio; means followed by the same letter(s) within a column and between adjacent columns are not significantly different at 5% level of significance

The economic gains and cost benefit ratio regarding treatments showed that all treatments highly decreased disease incidence and increased rhizome yield, which resulted in higher gross and extra income with good cost benefit ratio over control. The best treatment in economic terms with the highest cost benefit ratio was the foliar spray Prozole 255 EC (propiconazole) (1:2.65), followed by Prozole 255 EC (propiconazole) seed treatment + foliar spray (1:2.51), while the untreated control showed the lowest cost benefit ratio (1:2:09). The findings on the cost of fungicides for the control of leaf spot on turmeric are in agreement with the results reported by Rao et al. (2012). It is recommended that rhizome treatment + foliar spray, and foliar spray alone of Prozole 255 EC (propiconazole) be considered as effective in managing leaf spot severity and increasing turmeric yield.

CONCLUSION

Turmeric leaf spot caused by *Colletotrichum capsici* is one of the greatest challenges in turmeric production in Southwestern Ethiopia. Leaf spot epidemics are reduced by application of fungicides. However, real management of this disease requires that an integrated disease management method be applied. Chemical control is the most significant measure and *Colletotrichum capsici* could be managed by fungicide treatments (contact or systemic products) that weaken or destroy the pathogen during the crop cycle.

In conclusion, Prozole 255 EC (propiconazole) foliar spray extremely reduced the parameters of turmeric leaf spot and it is therefore recommended for the management of leaf spot disease of turmeric. Prozole 255 EC (propiconazole) rhizome treatment + foliar spray also plays a significant role in managing turmeric leaf spot. Foliar spray and seed rhizome treatment with fungicides was found to reduce significantly disease incidence and increase turmeric productivity through reducing disease effects. It is therefore auspicious to grow turmeric using foliar sprays of fungicides in addition to seed rhizome treatment to manage turmeric leaf spot disease in Southwestern Ethiopia. Further research needs to be undertaken to test fungicides spray combinations with other cultural practices and host resistance to provide other improvements in turmeric leaf spot management in the same and other turmeric growing regions of the country.

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Efikasnost fungicida u suzbijanju pegavosti lista kurkume izazvane gljivicom *Colletotrichum capsici* u Tepi, jugozapadna Etiopija

REZIME

Pegavost lista kurkume, koju izaziva patogena gljivica *Colletotrichum capsici*, je bolest koja nanosi najozbiljnije štete proizvodnji kurkume, umanjujući kvalitativno i kvantitativno prinos rizoma u jugozapadnoj Etiopiji. Izveden je poljski ogleda kako bi se procenila efikasnost različitih fungicida tokom epidemije pegavosti lista kurkume u sugozapadnoj Etiopiji. Poljski ogled je izveden u Tepi Agricultural Research Center tokom vegetacija 2019. i 2020. godine koristeći četiri fungicida: Ethiozeb 80% WP (mankozeb), Prozole 255 EC (propikonazol), Mancolaxyl 72% WP (mankozeb + metalaksil) i Ridomil Gold MZ 68 WG (metalaksil-M), koji su primenjeni kao tretman rizoma zajedno sa folijarnom primenom spreja ili samo kao folijarni sprej radi suzbijanja bolesti pegavost lista. Eksperiment je postavljen kao potpuno slučajni blok sistem sa devet tretmana i tri ponavljanja. Rezultati eksperimenta pokazuju da su i tretmani rizoma praćeni folijarnom primenom spreja, kao i samo folijarni tretman imali značajan efekat na epidemiju pegavosti lista kurkume. Efekat folijarnog spreja Prozole 255 EC (propikonazol) bio je značajno veći u smanjenju procenta bolesti (27.0) i postizanju maksimalnog prinosa rizoma. Maksimalan odnost troškova i koristi (1:2.65) postigao je tretman folijarnim sprejom Prozole 255 EC (propikonazol). Među procenjivanim fungicidima, folijarni sprej tretman Prozole 255 EC (propikonazol) je smanjio intenzitet bolesti pegavosti lista do 47.1% u odnosu na kontrolu poslednjeg dana ocenjivanja bolesti. Rezultati eksperimenta su pokazali da je folijarna primena fungicida delotvorna u smanjivanju epidemije pegavosti lista i u povećanju proizvodnje i produktivnosti kurkume.

Ključne reči: *Colletotrichum capsici*, kurkuma, fungicidi, prinos, Etiopija