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Yield and Shoot Biomass Losses under Different Fungicides applications for the Control of Leaf Rust disease (Uromayesis eragrostidis) of Tef at East and North Shoa Zones of Ethiopia

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Tef; Fungicides; Yield loss; Shoot biomass; Tef leaf rust

1. Abstract

Tef leaf rust disease caused by Uromyces eragrostis is widely distributed tef disease in Ethiopia. Currently, quantification of yield and straw losses due to tef leaf rust under the application of different fungicides are very crucial to tackle and minimize yield and straw losses caused by this pathogen. Therefore, the activity aimed to quantify tef yield and shoot biomass (straw) losses under the application of different fungicides. The experiment was conducted at Minjar sub-station and Debre Zeit on station from 2018/19 to 2019/20 main cropping seasons. Fungicides like Rex Duo, Tilt, Nativo and Natura 250 EW were applied and unsprayed plots exist for comparison. The popular varieties Quncho was used in the yield and shoot biomass losses assessment. Quncho is susceptible to tef leaf rust and enabled the assessment of the effects of tef leaf rust disease on tef grain yield and shoot biomass losses during the cropping season. The application of different fungicides created significantly different levels of terminal tef leaf rust severity on tef variety Quncho. In general, the analysis of variance revealed that there was no significant difference among Rex Duo and Tilt fungicides but the highest grain yield and shoot biomass were obtained through the application of Rex Duo during both cropping years at each location. Yield and shoot biomass losses in tef from natural infections with Uromyces eragrostidis ranged from 16-25% and 13-21% in two experimental locations over two years, respectively. Fungicides reduced successive tef leaf rust severity on plant parts. Fungicide control of tef leaf rust was economical in the array of situations. Fungicide Rex Duo was more effective at reducing disease pressure and increasing tef yield and shoot biomass tha Tilt, Natura or Nativo fungicides used during the study.

2. Introduction

Tef [Eragrostis tef (Zucc.) Trotter] is an indigenous staple cereal crop of Ethiopia. There is no doubt that tef is a very ancient crop in Ethiopia, where domestication took place before the birth of Christ. Tef is an important cereal crop in Ethiopia. In 2018/19, it was estimated that tef made up to 24.17% of all the cultivated areain Ethiopia, covering about 3.1 million hectares and grown by 7 million farmers (CSA 2018/19). Tef is grown in almost all regions of the country for home consumption since it is a preferred grain, and for the local market, since it fetches the highest grain price compared with other cereals and is used as a cash crop by farmers.Although the crop is dominantly cultivated as sole crop, it is also grown as an intercrop or mixed crop, relay crop, or in rotation withseveral types of crops. The crop is grown both in belg (short rainy)and Meher (long rainy) seasons.

Tef leaf rust disease of tef caused by Uromyces eragrostis is the widely distributed tef disease (Ashenafi et. al, .2018). According to Tadesse, Leaf rust of tef can be managed by various means. Among which, early planting, the use of the genetic tolerance or resistant cultivars are the most effective, environmentally friendly,and sound methods. But most of the tef genotypes were suscepti- ble to tef rust disease [1]. Under such a scenario, fungicide inter- ference is crucial.

In Ethiopia, several fungicides were registered and recommendedfor the management of rust diseases of wheat and this has been reviewed by [15, 3] and a more recent review in this regard was

by [3]. Though tilt fungicides were recommended for the control of tef leaf rust on tef based on the recommendation done for other crops like wheat, no attempt was made to integrate varieties and different rates of fungicides applications in tef that is valuable for the integrated management of tef leaf rust.

Currently, quantification of yield and straw losses due to tef leaf rust under the application of different fungicides are very crucial to tackle and diminish yield and straw losses caused by this pathogen. Therefore, the activity aimed to quantify tef yield and shoot biomass (straw) losses under the application of different fungicides.

3. Materials and Methods

Debre Zeit is 1931m above sea level. The climate here is mild, and generally warm and temperate. In winter, there is much less rainfall in Debre Zeit than in summer. The average annual temperature in Debre Zeit is 17.7 °C | 63.8 °F. In a year, the rainfall is 867 mm.

The experiment was conducted at two locations (Minjar sub-station and Debre Zeit on the station) for two years (2018/19 and 2019/20) during main cropping seasons. Tef cultivar Quncho that was relatively vigor and show susceptible reaction to tef leaf rust was utilized. The trial was planted in 2.5m plot length and 1.2m width at each site. The recommended seed rate of 15kg/ha was used during planting. There was no artificial inoculation of Quncho variety to have high disease pressure and rather the trial was planted at hot spot areas for tef leaf rust disease. [2] The yield and shoot biomass losses study was done under four different fungicides having different active ingredients. Each fungicide was applied at a recommended rate of company basis for the control of other cereal diseases like wheat rusts and others. Fungicides Nativo SC 300 (trifloxystrobin 100gm/lt + tebuconazol 200 gm/lt), Natura 250EW (Ebuconazole), Rex Duo (Epoxiconazole + Thiophanatemethy), Tilt 250 EC* (Propiconazole) were used to quantify yield under each fungicide. The unsprayed plots were also used for comparison purpose.

All plots received one-time fungicide spraying during the heading of tef crop. The check is left untreated for comparison. The experimental design used was a randomized complete block design with a factorial arrangement with three replications.

4. Disease Assessments

Disease scoring was done using the modified Cobb's scale [13] and the reaction as recommended for other cereal by [5] but without having a resistant type response [3]. Three times disease scoring was done at ten days interval during the cropping season. The first scoring was done before the application of each fungicide and the rest two scoring were done after spraying of fungicides [4].

Yield loss was calculated according to Colpauzos

Loss % = 1-yd/yh*100

Where: Yd = yield of diseased plants

Yh = yield of healthy plants

Data on terminal Tef Leaf Rust Severity (TRS), lodging index, shoot biomass and grain yield were subjected to analysis of variance using GLM procedure of the System Analysis Software [10]. Least Significant Difference (LSD 0.05) was employed to compare treatment means. Data on tef leaf rust, shoot biomass, lodging index and yield were correlated using the Proc-Corr procedures of [10].

5. Results and Discussion

Yield, shoot biomass Lodging index, and Terminal rust severity. The application of different fungicides created significantly different levels of terminal tef leaf rust severity on tef variety Quncho which is susceptible to tef leaf rust that enabled to the assessment of the effects of tef leaf rust disease on tef grain yield, shoot biomass and lodging index during the cropping season(Table 1).

Table 1: The Effect of different fungicides application on tef yield and shoot biomass losses

Treatment	Trs	Yield t/ha)	Loss (%)	SBM t/ha	Loss (%)
Rex duo	10.8^{c}	3.0^{a}	25.5	15.2^{a}	20.7
Tilt	17.5^{b}	2.7^{ab}	19	13.5^{a}	10.5
Natura	15.0^{b}	2.6^{ab}	15.7	13.4^{a}	12.8
Nativo	17.1^{b}	2.7^{ab}	16.6	12.9^{a}	6.5
Untreated	35.4^{a}	2.2^{b}	0	12.1^{a}	0
LSD	4.1	0.7		3.9	

In general, the analysis of variance revealed that there was significant difference between Rex Duo and Tilt 250EC fungicides in terms terminal rust severity and statistically no significance difference between them in grain yield [6]. But the highest yield gain was obtained through the application of Rex Duo during the cropping season.

Terminal tef rust severity: Mean terminal tef leaf rust severity on untreated unsprayed plots recorded the highest value of 41.7% (Figure 1). Terminal tef leaf rust severity on treated plots by different fungicides varied between 10 and 17.5%. Tef leaf rust disease level was reduced significantly through the application of different fungicides (Nativo with mean value of 17.5%, Tilt with mean value of 16.7%, Natura 250EW with mean value of 15% and Rex Duo with mean value of 10%) , suggesting a significant reduction in tef leaf rust disease level as the result of fungicides sprayed (Table 2a).

The Rex Duo fungicide application was thus considered the most effective as it led to the lowest terminal stem rust severity (a mean value of 10%) (Figure 2a). This finding was similar with the finding of [11] which reported that application of fungicides effectively reduced disease severity. [7] also reported that the Tilt protected remained almost free from stem rust of wheat which is similar to these findings. Mean of grain yield of tef, shoot biomass and lodging index over locations [8].

Table 2a: Correlation analysis of Terminal leaf rust severity, Lodging, yield and Shoot biomass at Minjar sub-station

parameters	Trs	LI	GY	SHB
Trs	1			
LI	0.45**	1		
GY	-0.60***	-0.42**	1	
SHB	-0.25	-0.01	0.57***	1

Trs= Terminal rust severity, LI= Lodging Index; GY= Grain Yield;
SHB= Shoot Biomass;
**= Significant at 5%
***= Highly Significant at 1%

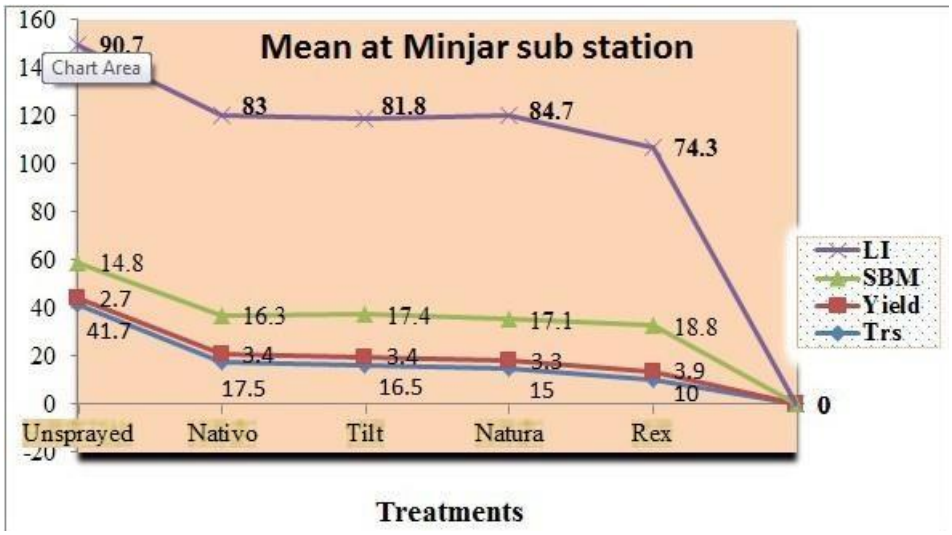

Figure 1: Infilence of fungicides comparison on unsprayed plots on yield, final tef leaf rust severity(Frs), Shoot Biomass(SBM) and Lodging Index (LI) at Minjar sub-staion in 2018/19-2019/20 G.C

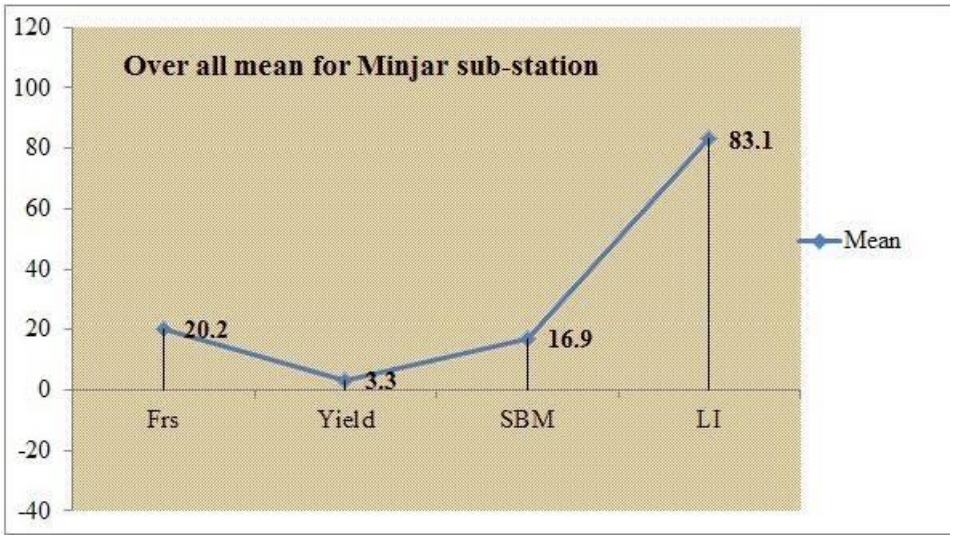

Figure 2a: The overall mean value of yield, Final Rust Severity (Frs), Shoot Biomass (SBM) and Lodging index (LI) at Minjar sub-station in 2018/19-2019/20 G.C

Estimating yield loss by disease is a precondition to develop strategies for disease control particularly through breeding objectives for disease resistance or tolerance [9].

During the cropping season, the combined result over location for two years of the yield on untreated plots accounted for about 2.2tha-1 on the variety Quncho [12]. The yield varied from fungicide to fungicides. In all the cases the treated plots give higher tef yield than the untreated plots (Figure 1)

The maximum tef yield of 3.9tha-1 was obtained from treated plots through the application of Rex Duo and followed by Tilt having the mean value of 3.4tha-1 of Quncho tef varieties; whilst grain yields of 3.3tha-1 was obtained from fungicide treated plot by Natura250EW (Figure 1). Results suggest that the effect of fungicides in improving the yield performance of susceptible tef varieties.

a. Shoot Biomass

The lowest shoot biomass was recorded on untreated plots having the mean value of 14.8tha-1 and this showed that the pathogen is obligate and it procure all the nutrients from the host [14]. The highest shoot biomass was recorded on the treated plot by Rex Duo having the mean value of 18.8tha-1 which is significantly different from other evaluated fungicides for the control of tef leaf rust (Figure 1).

b. Lodging Index

The highest lodging index mean value was recorded on the unsprayed plot having the mean value of 90.7% at Minjar (Figure 1). At Debre Zeit; the highest mean value of 95.2% of lodging index was recorded (Figure 2b). Lodging index was reduced through the application of fungicides in general but the lowest mean value was recorded through the application of Rex Duo fungicide as compared to other fungicides 74.3 and 69.5% at Minjar sub-station and Debre Zeit on station, respectively. This may supplement the most challenging task in the tef improvement program by minimizing the lodging problem of tef. So, application of fungicides showed a positive contribution in minimizing lodging problems by keeping the health of the crop (Figure 3).

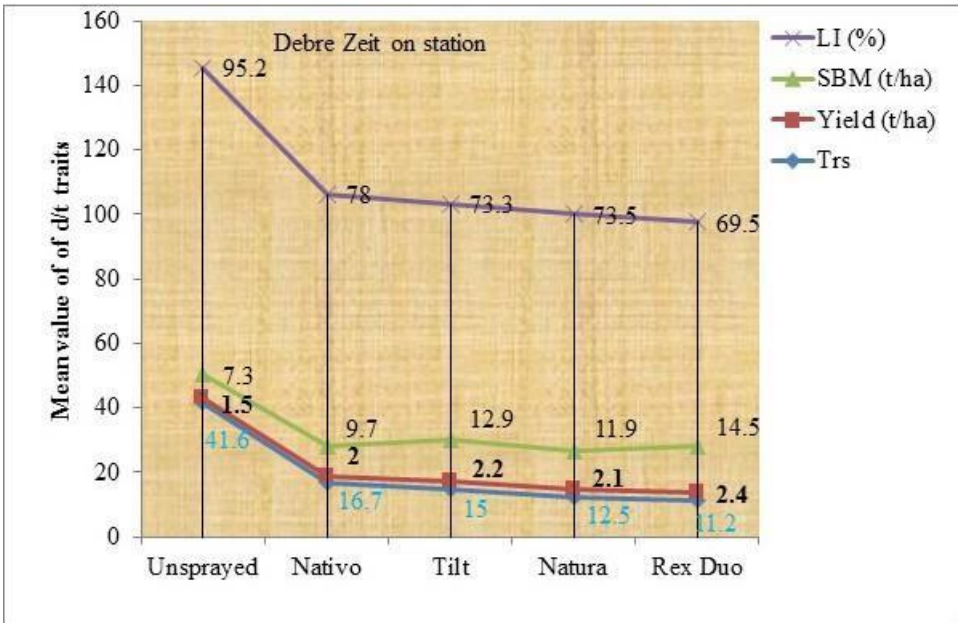

Figure 2b: Infilence of fungicides comparison on unsprayed plots on yield, Final Tef Leaf Rust Severity (Frs), Shoot Biomass (SBM) and Lodging Index (LI) at Debre Zeit On Station in 2018/19-2019/20 G.C

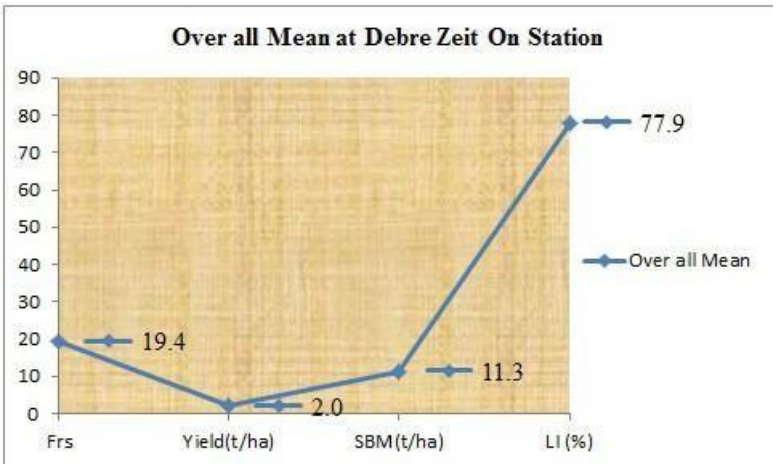

Figure 3: The overall mean value of yield, Final Rust Severity (Frs), Shoot Biomass(SBM) and Lodging Index (LI) at Debre Zeit on-station in 2018/19-2019/20 G.C

c. Correlation Between Terminal Tef Leaf Rust Severity, Yield, Lodging and Shoot Biomass

Correlation analysis among terminal tef leaf rust severity revealed the negative impact of tef leaf rust on grain yield and SHB. On the other hand, lodging index was positively influenced by tef leaf rust disease [15].

Grain yield was negatively correlated with terminal tef leaf rust severity and the correlation was highly significant while the correlation between terminal leaf rust severity and SHB was negative but

non-significant at Minjar sub station. At Debre Zeit on station; the correlation analysis among terminal leaf rust severity and shoot biomass showed highly significant negative correlation (r=0.51**) (Table 2b). This implies that as the disease pressure increase or severe; the shoot biomass decreased due to the effect of this obligate pathogen and vice versa [16].

Ashenafi G and Alemayehu Ch (2019) also reported that durum wheat yield was correlated strongly with the terminal wheat stem rust disease.

Table 2b: Correlation analysis of Terminal leaf rust severity, Lodging, yield and Shoot biomass at Debre Zeit on- station

	Trs	LI	GYkg/ha	SBMkg/ha
Frs	1			
LI	0.81***	1		
GY	0.68***	-0.69***	1	
SBM	0.51**	-0.70***	0.83***	1

Trs= Terminal rust severity, LI= Lodging Index; GY= Grain Yield;
SHB= Shoot Biomass;
**= Significant at 5%
***= Highly Significant at 1%

6. Conclusion and Recommendation

Tef leaf rust disease resulted in significant reduction in yield and shoot biomass and also disease parameters of tef during the main cropping season of 2019 and 2020 when left untreated. It can also increase the lodging index of the test crop through procuring nutrients from the crop and making the crop weak and weak. However, application of fungicides significantly reduced terminal tef leaf rust severity, area under disease progress curve, average coefficient of infection and there by significantly improved tef grain yield and shoot biomass. The current study also revealed highly negative correlation of terminal tef leaf rust severity with grain yield and weak negative correlation with shoot biomass. For lodging index, which showed a highly significantly (r=0.45**) positive correlation with terminal tef leaf rust severity during the cropping years.

Current results not only demonstrated the negative impact of tef leaf rust on grain yield and shoot biomass of tef, but also the role of fungicides application which reduce tef leaf rust severity and hence it was possible to improve grain yield, lodging index and shoot biomass of the produce.

Yield and shoot biomass losses in tef from natural infections with *Uromyces eragrostidis* ranged from 16-25% and 13-21% in two experimental locations over two years, respectively. Fungicides reduced successive tef leaf rust severity on plant parts. Fungicide control of tef leaf rust was economical in the array of situations. Fungicide Rex Duo *was more effective at reducing* disease pressure and increasing tef yield and shoot biomass than Tilt, Natura or Nativo.

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