



Efficacy Evaluation of Different Foliar Fungicides for the Management of Wheat Strip Rust (*Puccinia striiformis*) in West Shoa Zone, Oromia, Ethiopia

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ABSTRACT: Rust is one of the most widespread and devastating disease of cereal crop all over the world. This study was conducted to evaluate the efficacy of different fungicide against strip rust of wheat (*Puccinia striiformis*) at Toke Kutaye District, West Showa Zone of Oromia region, Ethiopia. The experiment was laid out in Randomized Complete Block Design (RCBD) in three replications and contains five treatments. Disease parameters like incidence, severity, Area under Disease Progress curve (AUDPC), and yield loss (dry biomass, grain yield, and thousands grain weight) were used to evaluate the treatments. The fungicides showed significant differences ($P < 0.05$) in reducing incidence, severity, AUDPC and yield losses compared to the control treatment. There also significant differences between Zantara EC 216 and Rex®Duo fungicide in reducing disease incidence and also between Zantara EC 216 and Tilt 250 EC in reducing the disease severity. Zantara EC 216 fungicide reduced strip rust severity by 94.2% compared to the control treatment. The analysis of variance also revealed significant difference among Zantara EC 216 and Rex®Duo, Tilt 250 EC and Progress fungicides in reducing grain yield loss and thousand grain weights loss. Zantara EC 216 fungicide increased grain yield by 32.2% compared to the control. However, for the most parameters, there was no significant difference among Rex®Duo, Tilt 250 EC and Progress fungicides. Hence, Zantara EC 216 which is newly introduced to Ethiopian country was very effective and can be recommended as alternative fungicide for the management of strip rust of wheat in west showa zone of Ethiopia and areas of similar agro-ecological conditions.

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Wheat is one of the most important cereal crop produced worldwide (Curtis *et al.*, 2002) and thought that it is the first crop ever to be cultivated and playing a major role in human's economic and social development worldwide (Thabet and Najeeb, 2017). It is the major cereal crop which playing a significant role in feeding a hungry world and improving global food security (Ketema and Kassa, 2016). Wheat is produced across a wide range of agro-ecological and crop management regime (Belay and Tanners, 1999). The most suitable area for wheat production falls between 1900-2700 m.a.s.l (Hailu *et al.*, 1991). In 2017, the area under production by wheat worldwide and the yield obtained was 218.54 million hectares and 771.72 million metric tons, respectively, (FAOSTA, 2019). Wheat is the staple food for about 4.5 billion people in the world (Braun *et al.*, 2010). In Ethiopia, wheat ranks fourth in area coverage and importance next to teff (*Eragrostis tef* Zucc.), maize (*Zea mays* L.) and sorghum (*Sorghum bicolor* L.) (CSA, 2015). Ethiopia is the second largest wheat producer next to South Africa in sub Saharan Africa countries (FAO, 2015b) and West and Southwest Shewa zones are among the major wheat producing areas in Oromia region (CSA, 2014). Although the productivity of

wheat has increased in the last few years in Ethiopia, it is still very low as compared to other wheat producing countries. The national average productivity is estimated to be 2.5 tons/ha (Samuel Gebreselassie *et al.*, 2017), which is by far below the world's average of 3.3 tons/ha (FAO, 2007). Productivity of wheat in Sub Saharan Africa is challenged by a number of abiotic and biotic stresses like drought, soil acidity, erosion, poor soil fertility, diseases, insects and weeds (Wuletaw Tadesse *et al.*, 2018) of which rust diseases are the most destructive factors because of their ability to move long distance and form new virulent races causing serious losses (Huerta-Espino *et al.*, 2011). Rusts diseases causes up to 60 and 100% loss of wheat yield by leaf or stripe (yellow) rust and stem rust, respectively, (Park *et al.*, 2007). In spite of great progress made in their control in many countries, it is considered the major diseases of wheat since no other wheat disease could result in greater loss over large area in a given year (Stakman *et al.*, 1962). Wheat stripe rust, caused by *Puccinia striiformis* is one of the most widespread and destructive diseases of the crop worldwide (Chai *et al.*, 2015). The disease was first reported in the early of 1940's in Ethiopia and since then it is becoming more

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devastating and wide spread following the spread of semi-dwarf improved wheat cultivars (Hailu *et al.*, 1991). Stripe rust disease became endemic in Ethiopia since 2010 and caused huge losses to Ethiopian farmers (ICARDA, 2013). The disease favored by minimum temperature, relative humidity and rainfall, while its development reduced with maximum temperature. In severe cases up to 100% yield loss was recorded due to stripe rust in highly susceptible varieties (CIMMYT, 2010). Even though widespread deployment and cultivation of resistant cultivars (Loughman *et al.*, 2005), in Ethiopia, the current commercial wheat cultivars are not withstanding the effect of the pathogen and it is not possible to grow a profitable wheat crop without the application of fungicides (Wanyera *et al.*, 2009). Foliar fungicide spraying has increased due to the breakdown of resistance to rust in wheat in several countries (Murray and Brennan, 2009; Zhensheng Kang, *et al.*, 2010). In Ethiopia, large-scale wheat growers in Arsi and Bale regions have extensively used fungicides to control rusts, spending around 0.5 million US dollars on chemicals annually (CIMMYT, 2005). Generally, rust control by fungicide application is one of the most popular means of maximizing grain yield globally. Fungicides can also play a role in an integrated management of the disease until new cultivars with genetic resistance are available (Loughman *et al.*, 2005). However, until recently farmers in Ethiopia did not use fungicides in wheat production due to lack of awareness about the yield advantage gained by fungicide application, availability and cost of fungicides. Therefore, the objective of this study was to assess the effectivity of different fungicides including the newly introduced product (Zantara EC 216) to control stripe rust of wheat at west showa zone of Oromia region on susceptible variety.

MATERIALS AND METHODS

Study area: The study was conducted at west showa zone of Toke kutaye district under rain fed condition during 2018/19 main cropping seasons of Ethiopia.

The area represents the major wheat growing areas in the zone and hot spot locations for stripe rust. The coordinate of the site is 8° 58' 13.56"N 37° 45' 39.83"E with altitude of 2129 meters above sea level. The minimum and maximum temperature of the district ranges from 10.2-11.7 and 21.8-24.4°C, respectively, with a mean annual rain fall which ranges from 125-218mm. The main rainy season of the site was from June to September when it receives 70% of the annual rainfall.

Treatments and experimental design: Bread wheat *Digalu* variety which is highly susceptible to yellow rust (*Puccinia striiformis f.sp. tritici*) diseases and popular in the area was planted at yellow rust hot spot location of west showa zone, on plot size of 5 m x 5 m. The spacing between the plots and replication was 1m and 1.5m, respectively. The recommended rates of 41 kg/ha Nitrogen and 46 kg/ha P₂O₅ fertilizer were applied during planting. Five treatments, (Tilt 250 EC, Progress, Rex@Duo and Zantara EC 216 fungicides and fungicide unsprayed control) were used as treatments. All the fungicides were applied as per the recommendation rate and schedule of the manufacturer (Table 1). Hand weeding was practiced twice to control weed in the experimental field. All the other agricultural practices were undertaken as recommended.

Disease assessment: Following the appearance of the symptom (stripe rust), fungicide treatment was applied and repeated at 14th day interval. Stripe rust disease incidence and severity percentage was started to be assessed at fourth days of the first fungicide application from 10 randomly selected and pre-tagged tillers of each plots continued at 10 days interval.

Wheat stripe rust incidence was measured as the proportion of the number of leaves showing stripe rust symptom of the total leaves assessed as:

$$\text{Disease incidence} = \frac{\text{Number of diseased leaves}}{\text{Total leaves assessed}} \times 100\%$$

Table 1. Fungicide trade name, common name, content of active ingredients, formulation types, Manufacturer company and application rates.

S/N	Trade name	Common name	Content of ingredients	Formulation type	Manufacturer company	Application rate
1	Tilt 250 EC	Propiconazole	Propiconazole 250	EC	Syngenta Crop protection AG	0.5 lit/ha
2	Zantara EC 216	Bixafen + Tebuconazole	Bixafen 50 g/l + Tebuconazole 166 g/l	EC	Bayer Crop Science AG	1.25 lit/ha
3	Progress 250 EC	Propiconazole	Propiconazole 25g/l	EC	Asiatic Agricultural industrial Pte. Ltd.	0.5 lit/ha
4	Rex@Duo	Epoxiconazole+ Thiophanate-methyl	Epoxiconazole 187 g/l + Thiophanate-methyl 310 g/l	SC	BASF East Africa Limited	0.75 lit/ha
5	Control	-	-	-	-	-

Strip rust severity was scored in percentage using the modified Cobb's Scale (Peterson *et al.*, 1948). From the severity data, AUDPC for each treatment was calculated as described by Campbell and Madden (1990). As follows,

$$\text{AUDPC} = \sum_{i=1}^{n-1} [0.5(x_i + x_{i+1})(t_{i+1} - t_i)]$$

Where,

x_i is the percentage of disease severity index at i^{th} assessment;

t_i is the time of the i^{th} assessment in days from the first assessment date; and

n is the total number of days disease severity was assessed.

Relative yield loss (%): Potential reduction of grain yield loss (in the absence of foliar spray of fungicides) was calculated as yield difference between fungicides sprayed and control treatment expressed in percentage of the sprayed plots (Sharma *et al.*, 2016) as follows:

$$\text{RYL} (\%) = \frac{Y_{fs} - Y_{funs}}{Y_{fs}} \times 100$$

Where, RYL= relative yield loss in percent,

Y_{fs} = yield from the fungicide sprayed plots and Y_{funs} = yield from fungicide unsprayed.

Losses in thousand seed weight: Losses in thousand seed weight was calculated in the same way as FAO (1971).

Fungicide Efficacy: The fungicide efficacy (FE) was calculated using Abbott's formula (Abbott, 1925) as,

$$\text{FE} (\%) = \frac{X - Y}{X} \times 100$$

Where, X – Disease severity in control,

Y – Disease severity in treated plots

RESULT AND DISCUSSION

In the cropping season, of 2018, the occurrence of strip rust disease was slightly severe and the treatments showed differences in reducing the disease on the wheat crop. The fungicides reduced the disease significantly ($P < 0.05$) over unsprayed plot.

Effect of fungicides on strip rust of wheat incidence and severity: The analysis of the result revealed that, the fungicides significantly ($P < 0.05$) reduced the incidence of strip rust disease of wheat as compared to the plot not sprayed with fungicide. Mean incidence of wheat strip rust of 96.69 was recorded from the plot not sprayed with fungicide which was reduced to 50.00, 40.00, 36.67 and 20.00% by Rex@Duo, Tilt 250

EC, Progress and Zantara EC 216 fungicides, respectively, (Table 2). The mean incidence of 100% strip rust was recorded from fungicide unsprayed plot at East Gojam of Ethiopia (Ayalew *et al.*, 2016). However, there was no significant difference among Progress (36.67), Tilt 250 EC (40.00) and Rex@Duo (50.00) and also among Zantara EC 216 (20.00), Progress (36.67) and Tilt 250 EC (40.00) in reducing disease incidence of strip rust of wheat.

Zantara EC 216 and Progress fungicides reduced the strip rust disease by 79.31 and 62.07% compared to the control treatment, respectively. This study was in line with the study conducted by Jonaviciene (2014) who reported that tebuconazole fungicide reduced *Fusarium avenaceum* incidence of wheat by 71.5% as compared to the fungicide unsprayed treatment. The analysis of the variance showed that there was significant ($P < 0.05$) difference among treatments in reducing wheat strip rust severity. Disease severity of strip rust on the control plot was 76.66% which was reduced to 4.44, 10.99, 14.33, 21.11% by Zantara EC 216, Rex@Duo, Progress and Tilt 250 EC fungicides, respectively, (Table 2). However, there was no significance difference in reducing strip rust severity disease among Zantara EC 216, Rex@Duo and Progress fungicides. These fungicides reduced strip rust severity disease by 94.21, 85.66 and 81.31%, respectively, compared to the control treatment. These fungicides showed comparable reduction of strip rust severity. The disease severity recorded from fungicide unsprayed treatment in this study was in line with the study conducted by Ayalew *et al.* (2016) who reported 50-80% wheat strip rust severity when wheat crop not treated by fungicide. Sharma *et al.* (2016) also reported 80% of wheat strip rust disease severity from fungicide unsprayed plot in Uzbekistan. The result obtained from this study was in line with the result obtained by Yared Tesfaye *et al.* (2018) at Bore Guji zone of Oromia Ethiopia, in which Rex@Duo fungicide reduced disease severity of strip rust by 56.68% over the unsprayed treatment. The experiment done on impact of different fungicides and bioagents, and fungicidal spray timing on wheat stripe rust development and grain yield in India revealed, that azoxystrobin 25 SC (Amistar @0.1%) fungicide reduced disease severity of strip rust by 98.67% as compared to unsprayed treatment (Singh *et al.*, 2016).

Table 2. Effect of different fungicides on against strip rust diseases incidence and severity at west showa zone, Ethiopia.

S/N	Treatments	Incidence	Severity
1	Tilt 250 EC	40.00cb	21.11b
2	Zantara EC 216	20.00c	4.44c
3	Rex@Duo	50.00b	10.99bc
4	Progress	36.67cb	14.33bc
5	Control	96.67a	76.66a
	CV	28.67	30.70

LSD 26.29 14.74
 LSD = Least significant difference among treatment means ($p \leq 5\%$), CV= Coefficient of variation, Means with the same letter within the same column are not significantly different from each other.

The analysis result showed significant differences due to treatments in area under disease progress curve (AUDPC) of strip rust disease of wheat crops. The AUDPC of the control plot was 638.9% which was reduced to 45.5, 105.5, 124.4 and 138.9 % by Zantara EC 216, Rex®Duo, Progress and Tilt 250 EC fungicides, respectively (Figure 1). Zantara EC 216 and Rex®Duo fungicides reduced the AUDPC of wheat strip rust by 92.9 and 83.5 % as compared to the

control treatment, respectively. There was no significance difference among fungicides in reducing the AUDPC. Yared Tesfaye *et al.* (2018) also reported non-significant differences due to fungicide treatments on AUDPC between Tilt 250 EC and Rex®Duo fungicides which was in line with this study. Viljanen-Rollinson *et al.* (2002) reported that application azoxystrobin and epoxiconazole on strip rust of wheat reduced the AUDPC of the disease by 65% and 37%, respectively. Fungicides like Amista Xtra 280 SC, Orius 25 EW, Folicur 250 EC, and Silvacur 375 EC also reported to reduced the AUDPC of strip rust of wheat (Wanyera *et al.*, 2014)

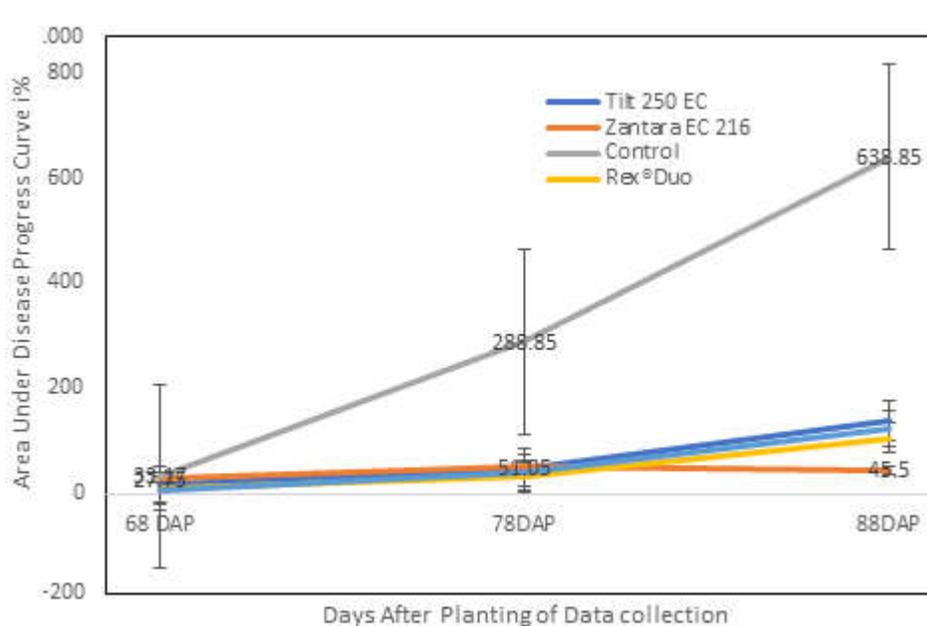


Fig 1. Graph showing the Area under disease progress curve of wheat strip rust treated by different fungicides against control treatment

Effect of fungicides on biomass and grain yield of wheat: The analysis of variance indicated that there was a significant ($p < 0.05$) difference among treatments in affecting wheat biomass yield and grain yield reduction due to strip rust disease. The biomass of the wheat crop from fungicide unsprayed plot was 9222.2 kg/ha (92.22q/ha) which was increased to 11777.8 kg/ha (117.77q/ha), 10814.8 (108.15q/ha), 10148.1 (101.48 q/ha) and 9740.7 (97.41q/ha) when treated by Zantara EC 216, Rex®Duo, Progress and Tilt 250 EC fungicides, respectively, (Table 3). However, there were no significant differences among Rex Dou, Progress, Tilt 250 EC and the control treatments in increasing the biomass of wheat crop. Wubishet Alemu and Tamene Mideksa (2016) also reported non-significant effect on biomass of wheat when treated with fungicides to manage rust disease. There was 2555.5 kg/ha (25.56 q/ha) biomass yield

advantage from Zantara EC 216 fungicide over the fungicide unsprayed treatment. Even though there was no significant difference between Zantara EC 216 and Rex®Duo, Zantara EC 216 provide 963.0 kg/ha (9.63q/ha) biomass yield advantage over Rex®Duo fungicide. Sebei Abdenmour *et al.* (2018) also reported significances differences in biomass of wheat crop infected by strip rust after treated by fungicides when the disease pressure is high compared to fungicide unsprayed control. The result of the analysis revealed that significant ($p < 0.05$) difference among treatments in reducing yield losses due to strip rust of wheat (Table 3). The grain yield obtained from the plots treated by the Zantara EC 216, Rex®Duo and Tilt 250 EC fungicides were 4370.4 kg/ha (43.7 q/ha), 3703.7kg/ha (37.4 q/ha) and 3555.6 (35.56q/ha), respectively, which was reduced to 2962.9 kg/ha (29.6 q/ha) from the fungicide unsprayed plot (Table 3).

Zantara EC 216 and Rex®Duo fungicides provided significant yield advantage over the control treatments. However, there was no significant difference in reducing yield loss among Rex®Duo, Tilt 250 EC and Progress treatments. Even though there was no significant difference among Tilt 250 EC, Progress and the control treatments statistically, Tilt 250 EC and Progress fungicides provided 5.93 and 5.19 q/ha yield advantage over the control treatments. All the fungicides revealed significant yield advantage over the control treatment

The yield obtained from the plot treated by Rex®Duo fungicide (37.4 q/ha) in this study was in line with the yield obtained by the same fungicide in the study conducted by Yared Tesfaye *et al.*(2018) at Yirba site of Bore research center which was 38.8 q/ha. There

was 14.8q/ha grain yield advantage from plots treated by Zantara EC 216 fungicide over the control treatment which was 32.21% yield increment. This result was in agreement with the study conducted by Sharma *et al.* (2016) on reduction of wheat yield losses caused by stripe rust, in which up to 39 % yield increment was obtained by different fungicides compared to unsprayed plot. Singh *et al.* (2016) also reported 44.29 % yield increment of grain yield when treated with fungicide as compared to untreated plot In this study the yield increments due to fungicide application on strip rust infected wheat was slightly lower compared to the previous report using fungicides. This lower yield increment could be due to the low infestation level by the disease during the season.

Table 3. The effect applying fungicide on reducing yield loss on wheat affected by strip rust in 2011/2018 at west show zone

S/N	Treatments	Biomass yield(kg/ha)	Biomass yield Loss (%)	Grain Yield (kg/ha)	Loss (%)	Thousand grain Weight(g)	Loss (%)
1	Zantara EC 216	11777.8a	0.00	4370.4a	0.00	44.03a	0.00
2	Rex®Duo	10814.8ab	8.17	3703.7b	15.25	42.17b	4.22
3	Tilt 250 EC	9740.7ab	17.29	3555.6bc	18.64	41.94b	4.74
4	progress	10148.1ab	13.83	3481.5bc	20.33	40.63b	7.72
5	Control	9222.3b	21.69	2962.9c	32.2	38.00c	13.69
	CV	10.57		9.63		2.33	
	LSD	2057.6		656.58		1.81	

LSD = Least significant difference among treatment means ($p < 5\%$), CV= Coefficient of variation, Means with the same letter within the same column are not significantly different from each other.

Effect of fungicide on thousand grain weight of wheat infected by strip rust disease: There was a significant difference among treatments in reducing thousand grain weight loss of wheat crop infected by strip rusts. Zantara EC 216 fungicide revealed the highest mean (44.03gm) thousand grain weights, whereas the smallest (38.0gm) was recorded from control treatment. However, there was no significant difference among Tilt 250 EC, Rex®Duo and Progress fungicide treatments on thousand grain weights (Table 3).

Wubishet Alemu and Tamene Mideksa (2016) also reported non-significant difference among different fungicides on thousand grain weight of wheat infected by rust diseases. Zantara EC 216 fungicide increased thousand grain weight of wheat infected by strip rust by 9.6 and 7.7% compared to the control and Progress fungicide, respectively. The study conducted by Yared Tesfaye *et al.*(2018) revealed 60gm of thousand grain weight using Rex®Duo and also Tilt 250 EC fungicide to control strip rust of wheat at Guji Zone Southern Ethiopia, which is much larger than the weight obtained in this study by the same fungicides. This less weight could be, during the flowering and seed filling period the rain fall of the season was

minimum and erratic. This could be the possible reason for lower thousand grain weight.

Conclusion: The result of the experiment indicated, that all the fungicides control the strip rust of wheat better than the control treatment. Moreover, the newly introduced fungicide (Zantara EC 216) for the control of strip rust of wheat was by far better than all the fungicides used in the study. Zantara EC 216 fungicide also increased yield of strip rust diseased wheat by 32.2 and 15.25% compared to the control and the next best fungicide (Rex®Duo) fungicide, respectively. Therefore, Zantara EC 216 fungicide can be recommended for the control of strip rust of wheat.

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