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RESEARCH ARTICLE

Evaluation of quake TM 112.5 EC fungicide against stripe and stem rust diseases on bread wheat (*Triticum aestivum* L.) in Arsi Zone, Ethiopia

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Wheat (*Triticum aestivum* L.) is one of the most important cereal and food security crops in Ethiopia. The crop is widely grown by subsistent farmers under rain-fed conditions and over one-third of cereal farm households are dependent on wheat farming. The mean wheat yield in the country is estimated to be 2.67 t ha^{-1} which is well below the world mean yield (3 tons/ha) and research station (6-7 tons/ha) mean yield. This is due to losses caused by biotic and abiotic constraints. Among the biotic stresses, wheat rust especially, stripe and stem rust diseases caused by *Puccinia striiformis* f.sp. tritici and *Puccinia graminis* f.sp. tritici, respectively are the most bottlenecks for wheat production. A field experiment was conducted to evaluate the efficacy of fungicides against stripe and stem rust diseases and recommend them to farmers in Ethiopia. It was conducted at three stripe rust and stem rust hot spot locations respectively, for stripe rust we selected (Kulumsa, Boru-chilalow, Meraro) and Stem rust (Kulumsa, Asasa on Farm and Asasa on station) from the 2019-2021 main cropping season. Two standard check fungicides including an untreated check (Nil) were used as a treatment. The experiment was laid out in non-replicated plots at three locations for stripe and stem rust respectively. In this case, locations were considered as replicas. Fungicide spray treatments significantly reduced both stripe and stem rust disease severity to the lowest level likely over the nil application. However, there was no statistically significant difference ($p \leq 5\%$) between the test and check fungicides in reducing both stripe and stem rust disease severity. Experimental fungicide s revealed comparable and better levels of efficacy on both stripe and stem rust disease severity reduction compared to the standard check. There is a highly significant difference ($p \leq 5\%$) in biomass yield, grain yield and thousand kernel weight between fungicide treatments and nil application of fungicide. The highest grain yield was obtained from Quake TM 112.5 EC sprayed plots while the lowest was from nil application. Newly tested fungicides revealed better grain yield advantage than the standard check fungicides. All fungicide treatments also obtain a significant yield advantage over untreated plots. The newly evaluated fungicides are found to be very effective in controlling both stripe rust and stem rust diseases of wheat and it is recommended 1 liter/ha for controlling stripe and stem rust disease.

Keywords: Bread wheat, Disease severity, Fungicide, *Puccinia striiformis* f.sp. tritici, *Puccinia graminis* f.sp. tritici, Stem rust, Stripe rust.

Introduction

Wheat (*Triticum aestivum*,) is one of the most important food security crops in Ethiopia. It is cultivated on a total area of 2.1 million (1.7 million ha rain fed and 0.4 million ha irrigated) hectares annually with a total production of 6.7 million tons of grain at an average productivity of 3.0 and 4.0 t/ha under rain-fed and irrigated conditions, respectively during 2021/22 (CSA, 2022). In terms of area, wheat ranks fourth after teff, maize and sorghum (CSA, 2017). The crop is widely grown by subsistent farmers under rain-fed conditions and over one-third of cereal farm households are dependent on wheat farming (Negassa, A., et al., 2013). The mean wheat yield in the country is estimated to be 2.67 t ha^{-1} (CSA, 2017), which is well below the world mean of 3.0 t ha^{-1} (Hawkesford, MJ., et al., 2013) and very low as compared to that of the research station 6-7 tons/ha (MoARD, 2016). This is due to losses caused by biotic and a biotic constraint. Among the biotic constraints wheat rusts are the major limiting factors for wheat production in Ethiopia (Teklay Abebe, TA., et al., 2012).

Both stripe rust and stem rust of wheat caused by *Puccinia striiformis* f.sp. tritici and *Puccinia graminis* f.sp. tritici, respectively are the most important diseases on bread wheat. Yield loss up to 71% was recorded in Bread wheat due to stripe rust in Ethiopia (Bekele, E. 1985). According to (CIMMYT, 2010) research reported in severe cases stripe rust can cause yield losses of up to 100% on susceptible cultivars if infection occurs very early in the crop development stage and the disease continues to develop during the growing season. According to Mozgovoy, AR., 1987, epidemics of stripe rust occurred in 1977, 1980-83 and 1986, resulting in yield losses of 30-40%. In another report, grain yield losses of up to 96% were inflicted on susceptible common wheat cultivars. Epidemics in 1998-1990 have resulted in 58% of yield loss).

Stem rust is also the most important wheat disease in Arsi zones. From the recent year, most of popular bread wheat varieties grown in Arsi and Bale zones are susceptible to virulent stem rust race. According to David, research reported in 2013 main cropping season a new stem rust race was detected on popular bread wheat variety called Digalu and caused 100% yield loss in the primary risk areas. The susceptibility of Digalu is due to the breakdown SrTmp gene. Therefore, the past two decades, frequent epidemics of stripe and Stem rust have been a major challenge to wheat production in the country. Resistance sources to rusts are the most preferred diseases management options in wheat. Therefore, use of genetically resistant cultivars has been the major strategy to control major diseases of wheat in breeding program. In Ethiopia, since the inception of wheat breeding in 1950s several improved wheat cultivars have been released for farmers. However, they were withdrawn from production due to their susceptibility to stripe and stem rusts of wheat. This is mainly due to the evolution of a new virulent race of pathogen. Breeding efforts are too long to accomplish and could not cope up with the pace at which the pathogen is evolving for new races. This necessitated the need for protecting high yielding but rust susceptible varieties grown by the farmers to maintain their productivity up until replaced by new resistant ones. As a short-term solution the use of economically feasible and environmentally friendly fungicides has become necessary. The objective of this trial was to evaluate the efficacy of the QuakeTM 112.5 EC foliar fungicide for the control of stripe and stem rust of wheat.

Materials and Methods

The most popular and highly susceptible bread wheat cultivar Kubsa (HAR 1685) was used as a test cultivar. Kubsa is a susceptible cultivar to both stripe and stem rust of wheat in Ethiopia. The cultivar Kubsa was planted at a hot spot location for both diseases; for stripe rust, we selected Kulumsa, Boru-chilalow, Meraro and Stem rust Kulumsa, Asasa on Farm and Asasa on station a standard plot size of 5 m x 5 m with 20 cm inter-row spacing and the location was considered as a replica. Fertilizers were applied as per the recommendation for the respective test locations and a seed rate of 150 kg/ha were also used as per recommendation. In order to control weeds, Pallas 45 OD was applied at a rate of 0.5lt/ha. QuakeTM 112.5 EC, the experimental fungicide, was applied at a rate of 1 liter per hectare for both diseases and two recommended standard fungicides Rex-Duo (stripe rust) and Nativo SC 300 (stem rust) were applied at the recommended rate of 0.5 and 0.75 liter per hectare respectively and an untreated or nil was included for comparison. The fungicide was applied at 5% severity level for both diseases (stripe and stem rust). The test and the standard fungicide were applied using a knapsack sprayer with 200 water liter per hectare. The severity of the disease was recorded on whole plots using the modified Cobb's scale before and after fungicide application. Crop Biomass: Grain yield and thousand kernel

weight from each plot was recorded as these are the most important traits that are affected by stripe and stem rust infection. All information about the products (fungicide) was listed in (Table 1).

Table 1. Common name, trade name, formulation and manufacturers of fungicide evaluated against Stripe and Stem rust in wheat 2019.

Tr	Common Name	Trade Name	Formulation	Manufacturers	Rate and Recommend Pathogen
1	Fenpicoxamid + Pyraclostrobin	Quake ^{TM} 112.5	EC	CORTEVA	1 lt/ha
2	Epoxiconazole+ Thiophanate-methyl	Rex-Duo	EC	BASF	0.5lt/ha
3	Tebuconazole +Trifloxystrobin	Nativo SC 300	SC	BAYER	0.75 lt/ha
4	Nil	-	-	-	-

Data Analysis

Analysis of Variance (ANOVA) was done by using SAS version 9.00, Inst. 2002 and means comparisons for the significantly different variables were made among treatments using the Least Significant Differences (LSD) test at 0.05 levels of significance.

Results and Discussion

Epidemiology of the disease

All the current commercial wheat cultivars in Ethiopia are susceptible to the new wheat rust races and it is not possible to grow a profitable crop of wheat without the application of fungicides. Therefore, during the 2019 up to 2021 main cropping season stripe and stem rust of wheat occurred at epidemic level in Arsi zones of Ethiopia. In all testing sites, a good level and distribution of stripe and stem rust infection was observed. Therefore, this good epidemic creates an opportunity to evaluate the experimental fungicide s on both diseases (stripe and stem rust) at all testing locations. The test and check spray fungicides significantly reduce both stripe and stem rust disease severity as compared to the untreated check or nil application. However, there was no statistically significant difference between the test and check fungicides and among the experimental fungicide s in reducing both stripe and stem rust disease severity (Table 1 and Table 2). The standard check fungicides Rex-Duo and Nativo SC 300 was registered in Ethiopia at rate of 0.5 l/ha and 0.75 l/ha for the control of stripe and stem rust respectively. However, there was no statistically significant difference between the test (QuakeTM 112.5 EC) and check fungicides; relatively Rex Duo and Nativo SC 300 (standard check fungicide) reduced both stripe and stem rust disease severity to the lowest level. The untreated check (Nil) shows higher stripe and stem rust severities in all hot spot testing sites.

Grain yield, biomass yield, hectoliter weight and thousand kernel weights

The experiment result revealed that there exists no distinguished difference among the check fungicides and the experimental fungicide concerning biomass yield, grain yield and thousand kernel weights (Table 2 and Table 3). Across all experimental sites, the hectoliter weight remained indistinguishable among the experimental fungicides, standard benchmark fungicide and the untreated check (Nil), irrespective of being sprayed for both diseases. Although the statistical variances in biomass yield, grain yield and thousand kernel weight between the experimental fungicides (QuakeTM 112.5 EC) and the standard check fungicide (Nativo SC 300 and Rex Duo) were non-existent, marginally higher figures were obtained from QuakeTM 112.5 EC sprayed treatments, although insufficient to delineate the chemical's effects. Biomass yield, grain yield and thousand kernel weight significantly different between fungicide treatments (experimental and standard check fungicides) and the nil application (untreated check). Notably, the maximum thousand-grain weight (43.8 g) was recorded in Quake TM 112.5 EC, followed by Nativo SC 300 (43.6 g) for stem rust sprayed, while Rex-dou results (35.4 g) were noted for stripe rust spraying, with the lowest thousand-grain weight (13.7 g) obtained from the unsprayed check (Table 2 and Table 3). Such outcomes could be attributed to the fungicides' efficacy in combating wheat

stripe rust, this research result finding similar to with Wubishet A., et al., 2016 report. All fungicide treatments demonstrated substantial advantages in thousand kernel weight over unsprayed plots.

Despite the lack of statistically significant disparity among treatments, relatively superior grain yield was obtained from QuakeTM 112.5 EC sprayed plots compared to the untreated check (nil) application. Experimental fungicide displayed a notable grain yield advantage over the standard check Rex Duo and Nativo SC 300. Additionally, both test and check fungicides exhibited significant yield advantages over unsprayed plots in both diseases. For stripe rust, the experimental fungicide QuakeTM 112.5 EC and standard check fungicide Rex Duo showed 3391.0 kg/ha (21.67 q/ha) and 3298.3 kg/ha (20.74q/ha) yield advantages over the untreated check (Nil), respectively. In comparison, for stem rust, the experimental fungicide (QuakeTM 112.5 EC) and standard check fungicides (Nativo SC 300) yielded 2768.3 kg/ha (15.11 q/ha) and 2690 kg/ha (14.3 q/ha) respectively, representing a yield advantage over the untreated check (Nil) (Table 2 and Table 3).

Numerous previous studies across different regions have confirmed yield increments in wheat attributed to fungicide application for instant, study by Wegulo, SN., et al. 2009 revealed that up to 42% yield loss was prevented by applying foliar fungicides to winter wheat. Similarly, Kelley (2001) found that over a six-year period, the fungicide propiconazole significantly boosted winter wheat yield by 77%. Furthermore, Vamshidhar Puppala, VP., et al. 1998 reported significant yield increases from fungicide application to control the disease complex of leaf rust, tan spot and *Septoria tritici* blotch in wheat. In general, the current study also clearly shows that in Ethiopia it is not possible to grow susceptible to moderately susceptible wheat varieties without fungicide application in areas where wheat rust diseases are a major problem especially, in Arsi and Bale zones.

Table 2. Evaluation of fungicides efficacy against stripe rustdiseases severity, yield and yield components of bread wheat in Arsi zones during 2019/2020 main cropping season.

Treatments		**Rate**	**Stripe rust**	**Biomass**	**Grain Yield**	**TKW**	**HLW**
Common Name	**Trade Name**	**(l/ha)**	**Severity (%)**	**(t/ha)**	**(kg/ha)**	**(g)**	
Fenpicoxamid + Pyraclostrobin	Quake ^{TM} 112.5 EC	1	9.59^{b}	6.4^{a}	3391.0^{a}	36.7^{a}	65.7^{a}
Epoxiconazole+ Thiophanate-methyl	Rex-Dou	0.5	14.3^{b}	5.5^{a}	3298.3^{a}	35.4^{a}	64.1^{a}
	Untreated check (Nil)	-	59.1^{a}	2.9^{b}	1224.0^{b}	13.7^{b}	51.8^{a}
Mean			27.7	4.9	2637.8	28.6	60.5
CV%			50.9	14.1	38.0	42.1	43.5
LSD (0.05)			28.2	1.39	2002.5	24.1	52.6

TKW = Thousand Kernel Weight, HLW = Hectoliter Weight, LSD = Least Significant Difference among treatment means ($p \leq 5\%$), CV= Coefficient of Variation, means with the same letter within a column are not significantly different

Table 3. Evaluation of fungicides efficacy against stem rust diseases severity, yield and yield components of bread wheat in Arsi zones during 2020/2021 main cropping season.

Treatments		**Rate**	**Stem Rust**	**Biomass**	**Grain Yield**	**TKW**	**HLW**
Common Name	**Trade Name**	**(l/ha)**	**Severity (%)**	**(t/ha)**	**(kg/ha)**	**(g)**	
Tebuconazole +Trifloxystrobin	Nativo SC 300	0.75	11.7^{b}	6.3^{a}	2690^{a}	43.8^{a}	77.7^{a}
Fenpicoxamid + Pyraclostrobin	Quake ^{TM} 112.5 EC	1	10.1^{b}	6.6^{a}	2768.3^{a}	43.8^{a}	79.0^{a}
	Untreated check (Nil)	-	50.5^{a}	4.1^{b}	1257^{b}	24.7^{b}	48.1^{a}
Mean			24.1	5.7	2238.4	37.4	68.28
CV%			23.9	14.7	13.8	12.1	33.93
LSD (0.05)			11.4	1.67	617.3	9.03	46.28

TKW = Thousand Kernel Weight, HLW = Hectoliter Weight, LSD = Least Significant Difference among treatment means ($p \leq 5\%$), CV= Coefficient of Variation, means with the same letter within a column are not significantly different.

Conclusion and Recommendations

QuakeTM 112.5 EC statistically did not differ from the standard check fungicide (Rex Duo & Nativo SC 300) in controlling both wheat stripe and stem rust diseases and provided better biomass yield, grain yield, thousand kernel weight and hectoliter weight than Rex Duo and Nativo SC 300 sprayed treatments. Moreover, these fungicides reduced both stripe and stem rust diseases severity to the lowest level possible and revealed grain yield advantage better than the standard check and nil fungicide application (local check). After all assessment and evaluation result, the newly verified fungicides are found to be very effective in controlling both stripe rust and stem rust diseases of wheat. Therefore, QuakeTM 112.5 EC with a dose rate of 1 liter/ ha should be recommended for the control of wheat rust diseases (stripe rust and stem rust).

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Conflict of Interest

The authors declare no conflict of interest.

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