International Journal of Biomedical Science and Engineering
2022; 10(4): 86-90
http://www.sciencepublishinggroup.com/j/ijbse
doi: 10.11648/j.ijbse.20221004.11
ISSN: 2376-7227 (Print); ISSN: 2376-7235 (Online)

Verification of CONA Fungicide Against Stem Rust (*Puccinia graminis* f. sp. *tritici*) on Durum Wheat (*Triticum turgidum*) in East Shoa and West Arsi, Ethiopia

Gizachew Hirpa Regasa, Ashenafi Gemechu Degete

Ethiopian Institute of Agricultural Research, Debre Zeit Agricultural Research Center, Debre Zeit, Ethiopia

Email address:
gizachewhirpa@gmail.com (Gizachew Hirpa Regasa)

To cite this article:
Gizachew Hirpa Regasa, Ashenafi Gemechu Degete. Verification of CONA Fungicide Against Stem Rust (*Puccinia graminis* f. sp. *tritici*) on Durum Wheat (*Triticum turgidum*) in East Shoa and West Arsi, Ethiopia. *International Journal of Biomedical Science and Engineering*. Vol. 10, No. 4, 2022, pp. 86-90. doi: 10.11648/j.ijbse.20221004.11

Received: August 2, 2022; **Accepted**: September 15, 2022; **Published**: December 27, 2022

Abstract: Wheat is one of Ethiopia's foremost important cereal crops in terms of area coverage and volume produced. However, the production and productivity of wheat is constrained by various biotic and a biotic stress. Among biotic stresses, wheat stem rust disease caused by *Puccinia graminis* f. sp. *tritici* is the most catastrophic disease. Field experiments were conducted to verify and evaluate the efficacy of new fungicide against wheat stem rust at Debrezeit and Negelle Arsi locations in 2021/2022 main cropping season. For comparison, treatments included one candidate fungicide (Cona), Rex Duo as a standard check, and Unsprayed (control) applied towards the durum wheat variety Alemtena. The experiment was designed with a randomized complete block design and three replications. Terminal rust severity levels of up to 20MS, 15MS, and 60S at Debrezeit and 15MS, 20MS and 50S at Arsi Negelle were recorded on the tested fungicide CONA, Rex Duo and unsprayed or control treatments, respectively. Fungicide-sprayed treatments was significantly reduced the severity of stem rust to the lowest level possible when compared to nil (unsprayed) application. However, there was no statistically significant difference ($P<0.05$) in reducing the severity of stem rust disease between the test and standard check fungicides. When compared to the standard check, the test fungicides demonstrated comparable and better efficacy in reducing the severity of stem rust. The difference in biomass yield, grain yield, and thousand kernel weight between fungicide treatments and no fungicide application were highly significant ($P<0.05$). The highest grain yield was obtained from CONA sprayed plots at Negelle Arsi, while the lowest yield was obtained from nil application. At both locations, fungicide treatments outperformed untreated plots in terms of disease severity, yield and yield components. The newly verified fungicide has been found to be very effective in controlling wheat stem rust, and is recommended for registration to control wheat stem rust.

Keywords: Wheat, Disease Severity, Fungicide, *Puccinia graminis* f. sp. *Tritici*, Stem Rust

1. Introduction

Wheat (Triticum spp.) is one of the most important and major cereal crops in the world in terms of production and nutritional value that provides a major source of daily protein [20]. Worldwide, it is the leading source of cereal proteins and essential to ensure global food security [13, 2]. However, wheat stem rust causes by *Puccinia graminis* f. sp. *tritici* is a serious catastrophic threat to wheat production all over the world. Stem rust is the most potentially destructive wheat crops historically and becoming the most feared disease in wheat growing countries all over the world seriously threatening the production [9]. It is extremely aggressive, if sufficient inoculum from a severely infected wheat crop surrounding field arrives, it can severely devastate and destroy an otherwise healthy-looking crop three weeks prior to harvest. [14, 8].

It is estimated that yearly losses to wheat rust pathogens range between US$4.30 and 5.00 billion globally, in particular, stem rust estimated that under severe epidemics, losses would average 6.20 million metric tonnes per year or more worldwide [8, 2]. In Ethiopia,

yield losses of 70.70%, 60.50% and 60.00% were reported in Arsi, Bale and West Shoa zones of Oromia region, respectively [4]. The highland of Ethiopia is regarded as a hot spot for the development of stem rust diversity, and its intensity varies from year to year and from location to location depending on the type of variety grown and climatic conditions [14].

When wheat stems are severely infected, nutrient flow to the developing heads is interrupted, resulting in shriveled grain and in addition, stems weakened by rust infection are prone to lodging, causing high yield loss [6]. This loss can increase to a total loss depending on the growth stage of the host when infection starts [7]. Unfortunately, the stem rust pathogen has never sleep they mutate and evolve, new aggressive strains have emerged, spread intercontinentally, and caused severe epidemics in humid and warmer regions across the world. This has put stem rust as a disease that poses a first rank threat to the world food security. Now a day, the preferred strategy for control of stem rust is developing wheat cultivars with adequate levels of stem rust resistance. Several efforts were made towards resistant cultivars development in our country and several wheat cultivars with various levels of rust resistance were released for production. Nevertheless, most of the released wheat varieties succumb to stem rust soon after their release due to either introduction of exotic races or evolvement of new local races and changes in environmental factors [18].

However, wheat breeding programs are not sufficiently advanced to cope up with the recently emerged and destructive *Puccinia graminis* f. sp. *tritici* strains. Under this situation, foliar fungicide applications have become an important component of stem rust management practices and in the absence of the option to grow resistant varieties, the use of fungicides becomes necessary or mandatory. A way to limit disease development and reduce disease severity is the timely application of fungicide, specifically a fungicide containing a triazole group is one of the most effective to control wheat rusts. To cope up the above stated scenario, several fungicides have been verified, evaluated, registered against rusts and is being used in wheat as sole or integrated rusts management options [19]. Hence, to maximize more number of fungicide options in the market and to identify effective fungicides, frequent verification and evaluation of newly introduced fungicides against wheat stem rust is very important to sustain wheat production and productivity. Therefore, the objective of current study was to verify efficacy of CONA fungicide for the management of wheat stem rust and recommend for registration.

2. Materials and Methods

The experiments were conducted at DZARC Pathology quarantine site and on farm at Negelle Arsi. The experiment was designed in randomized complete block design (RCBD) with three replications. Three chemical treatments and one durum wheat varieties was used. Those are, Cona, Rex Duo (as standard check) and untreated (without fungicide treated) with durum wheat Alemtena variety which is susceptible to stem rust were used. Durum wheat seed was hand drilled at the recommended rate of 150kg/ha by 10m x 10m length with 20 cm inter-row spacing. The space between plots and replications was 1m and 1.5m wide, respectively. The recommended rates of 41 kg/ha Nitrogen and 46 kg/ha P2O5 fertilizer was applied during planting. All inputs and agronomic practices were applied as per of its recommendation.

Test fungicides, CONA (Difenoconazole 150g/l+ propiconazole 150g/l) obtained from CHEMTEX PLC pesticide companies were sprayed with the rate of their recommendation per hectare (500ml/ha). Recently registered and widely used fungicide Rex Duo (Epoxiconazole 187 g/l + Thiophanate-methyl 310 g/l SC) was included as standard check along with nil application (local check) for comparison. Test (candidate) and check fungicides were applied manually using Knapsack sprayer. Treated plots were sprayed every 14 days in which the first spray was applied at first appearance or onset of stem rust occurrence. During fungicide sprays, plastic sheets was used to separate the plot being sprayed from the adjacent plots.

Data were collected on various parameters including stem rust severity, AUDPC and infection rate. Disease severity was assessed and recorded using the modified Cobb's scale [10]. Yield and yield related data like plant height (cm), number of grains per spike, thousand kernel weights, grain yield (kg) was recorded.

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, in other word, yield increase over the change of yield increase to untreated plots [12] as follows;

$$\text{Relative yield Loss (\%)} = \frac{(YP-YuS)}{\text{YP}} \text{x } 100$$

Where L = relative percent yield loss, YP = yield from the maximum protected plot (fungicide sprayed plots) and YuS = yield from fungicide unsprayed plots.

Fungicide Efficacy: The fungicide efficacy (FE) was calculated as stated below,

$$\text{Fungicide Efficacy (\%)} = \frac{(X-Y)}{\text{X}} \text{x } 100$$

Where, X – Disease severity in control, Y – Disease severity in treated plots.

3. Statistical Analysis

Analysis of Variance (ANOVA) were done by using SAS GLM Procedure (version 9.3) and means comparisons for the significantly different variables was made among treatments using Least Significant Differences (LSD) test at 0.05 level of significance.

4. Results and Discussion

4.1. Disease Epidemics and Severity Level

Stem rust (*Puccinia graminis* f. sp. *tritici*) disease was developed on variety Alemtena across the two locations during 2021/2022 cropping season resulting in severe infection to create a significant difference among the treatments at tested locations. The test fungicides were significantly ($P<0.05$) effective against stem rust in reducing the disease severity and increasing the yield as compared with the unsprayed check at both locations. This work is in line with the findings of Tamene and Zerihun [15] indicated that fungicide treatments significantly reduced stem rust severity over the nil application. The tested fungicide resulted in significantly less mean disease severity as compared with the unsprayed check. Terminal rust severity levels of up to 20MS, 15MS, and 60S at Debrezeit and 15MS, 20MS and 50S at Negelle Arsi were recorded on the tested fungicide CONA, Rex Duo and unsprayed or control treatments, respectively. The test fungicide CONA recorded 20 and 18.33% mean disease severity at Negelle Arsi and Debrezeit locations, respectively while untreated plots recorded 50% mean severity at both locations.

Foster et al. [3] reported that the rate of disease epidemics was significantly reduced when the management of rusts was supplemented with fungicide applications. Statistically, no significant difference was observed between the fungicide treatments in controlling stem rust disease severity (Table 2). Based on the visual field observation and analyzed data showed that the test fungicide (CONA) had comparable effect in reducing stem rust disease compared to standard check fungicide Rex Duo. Test fungicide and the check fungicide reduced stem rust mean disease severity by 33.33% and 30% as compared to the unsprayed plots, respectively at Negelle Arsi locations. The fungicide efficacy percentage for the candidate fungicide (CONA) over nil applications were 60 and 63.34% at Negelle Arsi and Debrezeit, respectively. Results revealed that, the new candidate fungicide showed a comparable level of efficacy on stem rust disease reduction compared to the Rex Duo fungicide.

The study revealed that, significant variation was observed among the fungicides on grain yield on both locations having a range of 1145.70 kg/ha to 3824.20 kg/ha. The highest mean grain yield was recorded in CONA (3052.20 kg/ha) followed by Rex Duo (2973.2 kg/ha) at Negelle Arsi but were significantly at par with each other. The lowest grain yield was recorded from unsprayed check treatment (1145.70 kg/ha).

However, at Debrezeit location, the highest grain yield was recorded from Rex Duo 3824.20 kg/ha followed by CONA 3525.20 kg/ha which was statically not different and the lowest grain yield was from the nil application 1755.10 kg/ha. It was stated that, the highest mean grain yield of 30.52 q/ha was recorded from the treatment sprayed of CONA (Table 2) with 19.07 q/ha mean increase in yield i.e., 62.46% over check (nil application) at Negelle Arsi location and 17.70 q/ha (50.21) yield advantage over control check at Debrezeit location. The current work was agreed with the result of Ransom and McMullen [11] showed that within an environment and across wheat cultivars, fungicides improved yields by 5.5 to 44.0%. Fungicides are easily available effective alternatives on susceptible cultivars, grown on succumbing the resistant varieties to new races and provide a practical, rapid-response solution to manage stem rust. However, fungicide application has become more and more common in developing countries where wheat is a major source of national food security.

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 Rates
1	CONA	Difenoconazole + propiconazole	Difenoconazole 150g/l + propiconazole 150g/l	EC	Ningbo Megagro Chemical Co., Ltd, China	0.5L/ha
2	Rex Duo	Epoxiconazole+ Thiophanate-methyl	Epoxiconazole 187 g/l + Thiophanate-methyl 310 g/l	SC	BASF East Africa Limited Company	0.5L/ha
3	Control	-	-	-	-	-

Table 2. *Mean of stem rust severity, yield, and yield components of durum wheat in East Shoa and West Arsi during 2021/2022 main cropping season.*

Location	Negelle Arsi					Debrezeit			
Trade Name	Common Name	Severity (%)	Grain yield (kg/ha)	TKW (g)	Biomass (t/ha)	Severity (%)	Grain yield (kg/ha)	TKW (g)	Biomass (t/ha)
CONA	Difenoconazole + propiconazole	20.00^{b}	3052.30^{a}	47.067^{a}	6.15^{a}	18.33^{b}	3525.20^{a}	42.60^{a}	12.37^{a}
Rex Duo	Epoxiconazole + Thiophanate-methyl	16.67^{b}	2973.20^{a}	46.633^{a}	5.67^{a}	13.33^{b}	3824.20^{a}	44.40^{a}	13.56^{a}
Untreated	Nil	50.00^{a}	1145.70^{b}	32.500^{b}	1.81^{b}	50.00^{a}	1755.10^{b}	23.37^{b}	9.11^{b}
Mean		28.89	2390.40	42.07	4.54	27.22	3034.84	36.79	11.68
CV		27.06	11.25	11.41	12.42	9.68	15.49	10.53	7.22
LSD (0.05%)		17.72	609.86	10.883	1.28	5.97	1065.90	8.78	1.91

TKW = Thousand Kernel Weight, TKW = Thousand Kernel Weight, A. I = Active Ingredients, 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

4.2. Grain Yield and Yield Components

The ANOVA table revealed that no significant difference observed between test fungicide and check fungicide in grain yield, thousand kernel weight and yield biomass at both locations (Table 2). Highly significant

differences ($P < 0.05$) were observed between fungicide treatments and untreated plots for all yield and related parameters (Table 2). The test fungicide and check fungicide recorded 1906.6 kg/ha (19.07 q/ha) and 1827.5 kg/ha (18.26 q/ha) yield advantage over unsprayed plots, respectively at Negelle Arsi location (Table 2). This is in line with Basandrai et al. [1] reported that the fungicide treatments resulted in an increase of 6.72-14.58 qt/ha in mean grain yields over the unsprayed check. Wegulo et al. [17] showed that up to 42% yield loss was prevented by applying foliar fungicides to winter wheat. Similar work was conducted by Foster et al. [3] reported that significant variation in yield parameters was observed among the fungicide applications under different environments. The highest mean thousand kernel weight were recorded from plots sprayed CONA and check (Rex Duo) fungicides compared to unsprayed plot. In the same fashion, the highest mean biomass yield was recorded from the candidate and standard check fungicide compared.

The current study conclusively demonstrates that, where wheat stem rust disease is a serious issue, it is impossible to grow susceptible, moderately susceptible, or even resistant wheat variety without the use of fungicides. Changes in environmental variables, the introduction of exotic races, or the evolution of new local races are too responsible for this [18, 15]. Generally, it is impossible to grow a productive wheat harvest in East Africa without the use of fungicides since all of the current commercial wheat cultivars are vulnerable to the new wheat rust races [16].

The manufacturer's labeling instructions and the total level of disease present in the field at the time of application determine the proper application timing to achieve the fungicide's maximum effectiveness. Direct comparisons of products in field testing were used to identify differences in fungicide product efficacy, which are based (environmentally) on a single application of the indicated rate [5].

5. Conclusions and Recommendation

The candidate fungicide CONA had significantly reduced the severity of wheat stem rust compared to the untreated plots. When compared to the standard check fungicide (Rex Duo), the newly introduced fungicide had comparable efficacy in controlling stem rust severity. Plots sprayed with CONA and Rex Duo had the highest mean grain yield and yield-related traits when compared to unsprayed plots. Furthermore, CONA fungicide had significantly reduced the severity of stem rust. The CONA fungicide also provided higher grain yield and yield-related parameters when compared to the unsprayed control but were comparable to the check fungicide. As a result of the strong positive benefits demonstrated by the test fungicide in reducing stem rust disease severity to the lowest level, CONA fungicide could be registered as an alternative for the management of wheat stem rust.

References

[1] Basandrai, A. K., Mehta, A., Rathee, V. K., Basandrai, D., and Sharma, B. K., 2020. Efficacy of fungicides in managing yellow rust of wheat. Journal of Cereal Research, 12 (2), pp. 103-108.

[2] Figueroa M, Hammond-kosack K, Solomon S (2018). Review of wheat diseases a field perspective. Molecular Plant Pathology., vol. 19, no. 6, pp. 1523_1536, doi: 10.1111/m: pp. 12618.

[3] Foster, A. J., Lollato, R., Vandeveer, M. and De Wolf, E. D., 2017. Value of fungicide application in wheat production in Southwest Kansas. Kansas Agricultural Experiment Station Research Reports, 3 (5), p. 3.

[4] Hei, N., Shimelis, A., and Laing, M. 2017. Appraisal of farmers' wheat production constraints and breeding priorities in rust prone agro-ecologies of Ethiopia. African journal of agricultural research. 12. 944-952. 10.5897/AJAR2016.11518.

[5] Kiersten, W. 2016. Fungicide Efficacy for Control of Wheat Diseases. Purdue Extension Education Store. Purdue University. Available at www.edustore.purdue.edu.

[6] Knott, R. 1989. The inheritance of rust resistance. VI. The transfer of stem rust resistance from Agropyron elongatum to common wheat. Can. J. Plant Sci. 41: 109-123.

[7] Leonard, J., and Szabo, J. 2005. Stem Rust of Small Grains and Grasses caused by Puccinia graminis f. sp. tritici. doi: 10.1111/j.1364-3703.2004.00273. x.

[8] Olivera Firpo, P. D., Newcomb, M., Flath, K., Sommerfeldt-Impe, N., Szabo, L. J., Carter, M., Luster, D. G., & Jin, Y. 2017. Characterization of Puccinia graminis f. sp. tritici isolates derived froman unusual wheat stem rust outbreak in Germany in 2013. Plant Pathology, 66, 1258–1266. https://doi.org/10.1111/ppa.12674.

[9] Pardey, P., Beddow, J., Kriticos, D., Hurley, T., Park, R., Duveiller, E., Sutherst, R., Burdon, J., and Hodson, D. 2013. Right-sizing stem-rust research. Science, 340, 147–148. DOI 10.1126/science.122970.

[10] Peterson, R., Campbell, A., and Hannah, A. 1948. A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Canadaian Journal Research 26: 496-500.

[11] Ransom, J. K. and McMullen, M. P. 2008. Yield and disease control on hard winter wheat cultivars with foliar fungicides. Agronomy Journal, Vol. 100, No. 4, (October 2008) pp. 1130-1137, ISSN 0002-1962.

[12] Sharma, RC; Kumarse, N; Amir, A; Zafar, Z; Anwar, UJ. 2016. Reduction of winter wheat yield losses caused by stripe rust through fungicide management. J Phytopathol. 164: 671–677.

[13] Shiferaw B, Smale M, Braun J, Duveiller E, Reynolds M, Muricho G. 2013. Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. Food Security, 5 (3): pp. 291-317.

[14] Singh, R., Hodson, D., Jin, Y., Huerta-Espino, J., Kinyua, M., Wanyera, R., Njau, P., Ward, R. 2006. Current status, likely migration, and strategies to mitigate the threat to wheat production from race Ug99 (TTKS) of stem rust pathogen. CAB Review: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 1: pp. 1- 13.

[15] Tamene Mideksa and Zerihun Eshetu. 2021. Verification of Comet Plus 475 G/L EC Fungicide Against Wheat Stripe Rust (Puccinia striiformis f. sp. tritici) Disease on Bread Wheat in Bale, Southeastern Ethiopia. Advances in Applied Physiology. Vol. 6, No. 2, 2021, pp. 30-32. doi: 10.11648/j.aap.20210602.11.

[16] Wanyera, R., Macharia, J., Kilonzo, S., and Kamundia, J. 2009. Foliar fungicides to control wheat stem rust, race TTKS (Ug99), in Kenya, Plant Disease. 93, pp. 929-932.

[17] Wegulo, S. N., Breathnach, J. A. and Baenziger, P. S. 2009. Effect of growth stage on the relationship between tan spot and spot blotch severity and yield in winter wheat. Crop Protection, Vol. 28, No. 8, (May 2009), pp. 696-702, ISSN 0261-2194.

[18] Wubishet Alemu and Chemeda Fininsa. 2016. Effects of Environment on Wheat Varieties' Yellow Rust Resistance, Yield and Yield Related Traits in South-Eastern Ethiopia. Science publishing group. Plant. 4 (3): 14-22.

[19] Wubishet, A; Tamene, M 2016. Verification and Evaluation of Fungicides Efficacy against Wheat Rust Diseases on Bread Wheat (Triticum aestivum L.) in the Highlands of Bale, Southeastern Ethiopia. Inter J. Res. Stud. Agric. Sci. 2 (9): 35-40.

[20] Yazdani, M. 2022. Inducing novel resistance gene in wheat towards stem rust to improve food security. Introductory paper at the Faculty of Landscape Architecture, Horticulture and Crop Production Science, 2022: 1. https://pub.epsilon.slu.se.