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Evaluation of Fungicide Efficacy against Stripe Rusts (Puccinia Striiformis F.Sp) at Guji Zone Southern Ethiopia

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Abstract

Wheat is one of the most important cereal crops in terms of the area of land covered, volume produced and the number of farmers engaged in its production. However, the production and productivity of wheat is affected by various biotic and abiotic stresses. Among the biotic stresses, Stripe rust caused by Puccinia striiform is f.sp. Was the most destructive disease of wheat (TriticumaestivumL.).Field experiment was conducted to evaluate the efficacy of fungicides against wheat Stripe rust diseases and recommend for used. It was conducted at two wheat stripe rust prone area of Guji zone Bore on-station and Ana sora on-farm in 2016 main cropping season. Four different fungicides including the unsprayed plot were used as a treatment. The experiment was laid out in RCBD with three replicated plots at both locations. The effects of different fungicide application on wheat rust epidemics and yield of susceptible bread wheat (kubsa) varying in reaction to the disease were studied in both major wheat growing districts (Bore and Ana sora) of Guji, Ethiopia. Disease onset was vary from early to late, generally stripe rust was start to observed from tillering to late after ear head emergency at both locations. Fungicide spray treatments significantly reduced at both stripe rust severity to the lowest level possible over the unsprayed check. However, there was statistically significant difference (p = 5%) between the test fungicides and unsprayed check in reducing wheat stripe rust diseases severity. Test fungicides revealed comparable and better level of efficacy on stipe rust diseases severity reduction compared to the unsprayed check. There is significant difference (p = 5%) in plant height, panicle length, total number of tiller, number of fertile tiller, seed per spike, grain yield and thousand kernel weight between fungicide treatments and nil application of fungicide. The disease resulted in relative grain yield losses of up to 72.05% at Boreand72.25%atAna sora on unsprayed plots. Thousand kernel weight reductions of up to 32.3%atBoreand 24.6%atAna sora were recorded. Generally, Rex Duo and Tilt fungicide application gave nearly complete control on the susceptible bread wheat varieties. Tilt250EC had showed maximum economic profitability than Rex Duo and other types with marginal rate of return (MRR) of 6494.4%.

Keywords: *Wheat, Puccinia striform is, Fungicide, Yield loss, Grain yield*

Introduction

Bread wheat (Triticum aestivum L.) is one of the most important cereal crops in terms of area and production in the world. It was grown on more than 216 million ha of land larger than for any other crop and total production of 659 million tons with average productivity of 3160 kg ha-1 grain in 2014/15 cropping season (FAO, 2017). In Ethiopia, wheat covered an area of 1.7 million ha with a total production of 42.1 million quintals with yield average of 26.75 kg ha-1 during Meher season of 2015/16 (CSA, 2017). Though the country ranked second in area of production (1.7miillion ha) next to Morocco (2.9million ha) and third in total production (42.1 million quintals) next to Egypt (92.7 million quintals and Morocco (51.1 million quintals), but stood sixth in yield in Africa next to Zambia, Namibia, Egypt, Mali, and South Africa that takes the rank 1 to 5, respectively (FAO, 2017); indicating that that Ethiopia is increasing the area of farming with low productivity.

Wheat is one of the major cereal crops grown in the Ethiopian highlands, which lie between 6° and 16° N, and 350 and 42° E, and altitudes ranging from 1500 to 3000 m.a.s.l (Hailu, 2003). It accounts for more than 15 percent of the total cereal output. It is the fourth most important crop in area and total production in Ethiopia (CSA, 2017), and its production is increasing more rapidly than other cereal crops in the country (Amsal et al., 1995; CSA, 2017). The average yield of wheat was 26.75 kg ha-1 (CSA, 2017). Low yield of wheat is mainly related to biotic & a biotic factor is responsible for this low yield. Cultivation of unimproved low yield varieties, insufficient and erratic rainfall, poor agronomic practices, disease and insect pests are among the most important constraints to wheat production in Ethiopia. Diseases are one of the major factors reducing crop yield, deteriorate quality of crops and reduce farmers' income. Among biotic stress Stripe rust infestation is the most series and wheat production bottle necks issue in the country.

Wheat rust (stripe rust, caused by Puccinia. Striform is, was highly destructive disease of wheat (Triticum aestivum L.).Wheat stripe rust caused by P.striform is highly destructive disease of wheat. Under favorable conditions, stripe rust cancauseyieldlossesofupto100%in susceptible varieties (Roelfs,1985 a;Leonardand Szabo, 2005). Where as, yield loss of up to 71% was recorded in bread wheat due to stripe rust in Bale highlands (Bekele, 2003; Dereje, 2003). However, in severe cases 100% yield loss was recorded on the highly susceptible varieties due to stripe rust (CIMMYT, 2010).Through the wide spread use of resistant varieties, however, stem and stripe rust are currently largely under control worldwide except in eastern Africa. For reasons that due to either introduction of exotic races or evolvement of new local races and changes in environmental factors (Wubishet and Chemeda , 2016). Trials were conducted during 2016 in different areas of Ethiopia showed that wheat rust has been increasing. The major strategy for the management of wheat rustin Ethiopia would remain focused on the development of resistant varieties and chemical options are the two principal methods of wheat rust management strategies implemented in most wheat producing areas of the world. To come up with this, several fungicides have been evaluated against rusts and are being used in wheat as rusts management options. Hence, to minimize losses due to the uses of fungicide identify effective fungicides, was an important values. Evaluation of new fungicides against wheat rust diseases is important to sustain wheat production and productivity. Thus, the objective of this study was to evaluate the efficacy of selected foliar fungicides for the control of stripe rust in wheat and promote economic and agronomic feasibility of fungicide against wheat rust control in the high land Guji zone southern Oromia

MATERIALS AND METHODS

Description of the Study Area

Field experiments were undertaken at two locations of high land Gujiat Bore Agricultural Research center on station and Ana Sora district on farm during 2016 and 2017 the main cropping season. Bore is located at about 387Km from A.A capital city of the country to South and that of Ana Sora is about 25Km from Bore which is 402Km from A.A to same direction. Both locations represented high land agro-ecologies of Guji Zone having an altitude range of 2200-2780 m.a.s.l. Both locations receive an annual rain fall of 1200-1750mm per annum. The monthly mean minimum and maximum temperatures are 9.3 and 20.9 °C, respectively. The major soil types are Nitosols (red basaltic soils) and Orthic Aerosols (Yazachew and Kasahun, 2011; Wakene et al., 2014). The soil is clayey loam in texture and strongly acidic with pH value of around 5.51. Maize, Barley and wheat are majorly produced cereal crops in the area. Both locations represent major wheat-growing and stripe rust prone areas in the highlands of Guji. They are also characterized by bimodal rainfall, the short rainy season extending from March to July and the main season from July to December.

Description of Materials Employed

For this experiment, four types of fungicide swere used and involving five treatments with nil application. Fungicides (Tilt®250 E.C., Rex®Duo, Natura 250EW, Bayletone 25WP) were applied at manufacturing product ratesha-1indifferent spray schedules. Treated plots received sprays every 14, days in which the first spray was done, at first the appearance of yellow rust symptoms. Susceptible bread wheat variety (Kubsa) was used as seed source. Knapsack sprayer was used for applying the fungicide. During fungicide sprays, plastic sheets were used to separate the plot being sprayed from the adjacent plots. Unsprayed plots at both locations were included.

Experimental design

The experiments were laid out in randomized complete block design (RCBD) with three replications. Wheat was planted at the recommended rate of 150 kg seedha-1 to twenty five rowed plots of 5m x 5m length with 20 cminter-row spacing. The gaps between plots and replications were 1.5m and 2 m wide, respectively. All inputs and agronomic practices were applied as per of its recommendation for wheat production.

Data Collection and Analysis

Data was collected on various parameters including stripe rust severity, AUDPC, rate of disease infestation Severity was assessed and recorded using the modified Cobb's scale (Peterson et al., 1948), by assessing 46 randomly pre-tagged plants and agronomic yield loss, tillers per plan (total and fertile tillers were recorded), plant height (cm), number of grains per spike, thousand kernel weights ,grain yield (kg) were subjected to analysis of variance as suggested by Gomez & Gomezusing SAS software (version 2009). Least Significant Difference (LSD 0.05) was employed to compare treatment means.

Stripe Rust Assessment

Stripe rust severity was estimated as proportion of the leaf and head infection of a plant affected by the disease, was assessed at weekly interval from the time of symptom appearance to physiological maturity of the crop . Severity was recorded using the modified Cobb's scale (Petersonetal.,1948),byassessing23randomly pre-tagged plants.

The average yellow rusts severity from the 23plants of each plot was used for analysis. During disease assessment, the growth stage of the crop was recorded to observe onset and progress of the disease in relation to wheat phenology. Crop growth stage was assessed based on the decimalized key developed by Zadoks etal. (1974).

Stripe rust severity data were obtained based on percentage scores of leaf area with symptoms/signs. Fully formed pustules were considered those with abundant sporulation. Following the appearance of the first symptoms, five infected wheat leaves were sampled from each plot, at weekly interval, up to kernel hard dough stage. Then, these leaves were scanned and compared according to diagrammatic Cobb's scale (Peterson et al. (15)). To determine the Area under Disease Progress Curve (AUDPC), severity percentages obtained in each evaluation were used. The AUDPC values were calculated according to the equation proposed by Campbell & Madden (6) (Equation 1):

$$AACPD = \sum\{[\frac{(Y_i + Y_{i+1})}{2}]x(t_{i+1} - t_i)\}$$

Where: Yi and Yi+1 are the values of two consecutive severity assessments, and ti and ti+1 are the dates of the two assessments. Since the duration of assessment was not the same for each epidemic,

Yield Losses Timation

The relative losses in yield and yield component of each variety were determined as a percentage of that of the protected plots of the respective variety. Losses were calculated separately for each of the treatments with different levels of disease, as:

RL (%) = (Y1-Y2) X100

Y1

Where, RL= relative loss (reduction of the parameters grain yield and TKW),Y=mean of the respective parameter on protected plots(plots with maximum protection)and Y=mean of the respective parameter in unprotected plots(i.e. unsprayed plots or sprayed plots with varying level of disease).

Economic data were collected to compare the economic advantage of each fungicide in different treatments. These included variable input costs and costs for the fungicides and labor during the execution of the experiment. Costs of fungicides were obtained from pesticide companies and local distributing agencies. Based on the data obtained from both locations, economic analysis was computed using partial budget analyses, Marginal Rate of Return (MRR). The following formulas were used to compute partial budget and marginal rate of return (MRR) analysis, respectively.

Net field benefits (NBs) = Gross field benefits (GB)-Total Variable costs (TVC) and

MRR = DNI/DIC

Where: MRR = the marginal rate of return;

DNI = difference in net income compared with control; and

DIC = difference in input cost compared with control.

Result And Discussion

Epidemic Consent and Severity Level

Wheat rust (P.striformis) epidemics, severity and reaction and yield are vary on four fungicide treated and control(unsprayed) bread wheat to the disease were studied in two major wheat growing and wheat rust prone districts (Bore and Ana sora) of Guji, southern Oromia. Disease onset was varying from early at tillering to late ear emergence at both locations. Stripe rust was observed at early tillering growth stage (45-52) of bread wheat at both sites. Under natural epidemics (no spray) at Bore and Ana sora terminal severity levels of stripe rust were observed88 and 81% respectively. Lower levels of stripe rust severity were observed at Ana sora than Bore on unsprayed plots.Stripe rust severity increased at high rates and terminal severity levels up to 4.99, 5.83, 11.67, 19.99 and 61.67% at Bore, and up to 2.66, 4.5, 8.99, 11.66 and 29.16% at Ana sora were recorded on the Rex Duo, Tilt, Natura, Bayle tone sprayed fungicide and Control (unsprayed) respectively.

Table 1. *Combined analysis result of Terminal wheat rusts everity levels on bread wheat with different fungicide spray at Bore and Ana sora, at main season in southern Oromia, Ethiopia*

Treatments	Terminal striperustseverity (%)	
	Bore	**Ana sora**
Rex Duo	4.99[a]	2.66[a]
Tilt 250EC	5.83[a]	4.5[a]
Natura 250EW	11.67[ab]	8.99[a]
Bayletone 25WP	19.99[b]	11.66[a]
Unsprayed	61.67[c]	29.16[b]
LSD (0.05%)	9.36	15
CV (%)	16.19	47.41

Area under Disease Progress Curve

There were significant(P<0.05) differences in AUDPC values among fungicide treatments, both at Bore and Ana sora in both Diseases(Table1).At Bore, the highest standardized AUDPC values (61.67 and 29.16) were observed on unsprayed plots these values were significantly reduced by fungicide sprayed treatments. On fungicide treatment at Bore and Ana sora, AUDPC values of4.99 and 2.66wererecordedonRex Duo treated plots respectively. On Rex Duo and Tilt 250EC fungicide treated, was not showed significant effect on AUDPC at both site. At both sites the fungicide treatments show significantly reduced AUDPC values as compared to control (unsprayed).

Table 2. *Daily increase (%) in wheat stripe rust severity (Puccinia* striiformis*) after treatments with different fungicides in seven-day intervalsat Bore and Ana sora,2016 main crop seasons in Guji southern Oromia, Ethiopia.*

Treatments	Severity (%)	Daily severity increase (%)	Severity (%)	Daily severity increase (%)
	Bore		**Ana sora**	
Rex®Duo	4	0.57	2.5	0.36
Tilt®250 EC	5	0.71	5	0.71
Natura 250EW	9.5	1.36	8	1.14
Bayletone25WP	10	1.43	9.25	1.32
Unsprayed	22	3.14	20.25	2.89

Effect on Grain Yield and Yield Component

Grain yield was significantly (P <0.05) increased by fungicide sprays on bread wheat at both site (Table3). Rex® Duo and Tilt 250EC fungicide treatments were significantly increased grain yield. Nature 250EW and Bayletone25WP fungicide treatment also provided a significant yield increase as compared to unsprayed. Relative yield losses due to stripe rust reached 75.25, 37.7, 34.94 and 11.2% and 71.86, 37.54, 40.69, 15.31% on unsprayed, Nature, Bayle tone and Tilt at Bore and Ana sora respectively.The1000-kernelweight (TKW) of the bread wheat were significantly increased by fungicide treatment both site. The maximum TKW losses of 59.45 and 61.16 % were recorded on unsprayed plots at Bore and Ana sora respectively (Table3).

Table3. *Grainyieldandthousandkernelweightofbreadwheatandthecorrespondingrelativelossesdueto wheat rust under different fungicide spray at Bore and Yirba in 2016mainseasonat southern Oromia, Ethiopia*

	Location

Fungicides(treatments)	Bore				Yirba			
	Grain yield(kg ha)	**Loss (%)**	**TKW(g)**	**Loss (%)**	**Grain yield(kgh1)**	**Loss (%)**	**TKW (g)**	**Loss (%)**
Rex Duo	3484[a]	0.0	60[a]	0.0	3880[a]	0.0	60[a]	0.0
Tilt250EC	3093[b]	11.2	60[a]	0.0	3286[b]	15.31	60[a]	0.0
Natura250W	2169[c]	37.7	53[b]	11.7	2423[c]	37.54	46.6[b]	22.33
BayletonW5	2266[c]	34.94	53[b]	11.7	2301[c]	40.69	46.6[b]	22.6
Unsprayed	967[d]	72.25	24.33[c]	59.45	10.92[d]	71.86	23.3[c]	61.16
LSD(0.05%)	2.24		8.64		2.17		18.63	
CV (%)	7.52		13.88		4.79		21.11	

**Losses calculated relative to yield or thousand-kernel weight of maximum effective fungicide to wheat rust disease control (protected) plots (i.e. Rex Duo sprayed).*

Plant Height

There is significant difference in plant height between fungicide treatments (test fungicides) and nil application (unsprayed plot). However, there is no significant difference among Rex Duo and Tilt 250EC. Also between Natura250EW and BayletonWP25 was not show significant. Even though there was no statistical significant difference among treatments, relatively better plant height was obtained from Rex Duo and other tested fungicide sprayed plots while the lowest from nil application. All test fungicides revealed longer in plant height than the nil (unsprayed check).

Number of Tillers

Effects of fungicides on number of tillers were significant. The result showed highest number of tillers was recorded in treated plots whereas it was the lowest number of tiller was recorded in unsprayed check.

The higher number of tillers recorded at fungicide treated plot might be due to more effectiveness of fungicide treatments on tiller of wheat. Wheat rust that resulted in lower infection thus increase that contributed to more number of tillers.

Grain per Spike

Effect of fungicide treatments on grains per spike was significant. The highest number of grains per spike was recorded in Rex Duo followed by Tilt250EC whereas the lowest was recorded in unsprayed check.

The data revealed that, as the application of fungicides increased grains per spike as compared with unsprayed check in of grains per spike. This result is in accordance with the work of Hailu and Fininsa (2007) reported a relatively better yield for sprayed plots as compared to unsprayed plots under experimental condition.

Thousand Kernel Weight

Effect of combined analysis fungicide treatments on 1000 kernel weight was significant. The maximum1000 grain weight (60g) was recorded in Rex Duo and Tilt250EC followed by Natura250EW and BayletonWP25 (50g) whereas the lowest 1000 grain weight (27g) was obtained from unsprayed check. That might have resulted due to the effectiveness of fungicides to control wheat stripe rust. These results are in agreement with the work Wubishet Alemu & Tamene Mideksa (2016).All fungicides treatments revealed significant difference advantage in thousand kernel weight over unsprayed plot.

Grain Yield

According to the combined analysis of this study, significant variation was observed among the fungicides on grain yield having a range of 1029 kg/ha to 3682 kg/ha with mean value of 2496 kg/ha. The highest grain yield was recorded in Rex Duo (3682kg/ha) followed by Tilt (3189kg/ha). The lowest grain yield was recorded from unsprayed check treatment (1029kg/ha).This result is agree with the result of H Ransom and McMullen (2008)showed that within an environment and across wheat cultivars, fungicides improved yields by 5.5 to 44.0%. Wegulo et al. (2009) showed that up to 42% yield loss was prevented by applying foliar fungicides to winter wheat. In the United Kingdom, experiments conducted from 1978 to 1982 showed that applying fungicides to winter wheat resulted in a yield response of up to 89%, and the value of increased yield from fungicide application to cereals in 1982 was nearly double the fungicide costs (Cook and King, 1984).

These findings are in agreement with the work of Tadesse, K., Amare, A. and Ayalew, B. (2010) who reported that application of fungicide was found to be the best treatment in reducing stem rust infection and producing the higher grain yield compared to unsprayed treatment in wheat crop.

Likely Wubishet Alemu & Tamene Mideksa (2016).All test fungicides revealed better grain yield advantage over unsprayed plot. Different studies from different areas have demonstrated yield increases in wheat due to fungicide application. An economic evaluation of fungicide use in winter wheat in Sweden also showed a mean net return of US$28 ha-1 during the period 1995-2007 and $16 ha-1 during the period 1983-2007 (Wiik and Rosenqvist, 2010).

Table4. *The combined analyzed data of wheat rust fungicide trial at multi locations of Guji highlands.*

Treatments	PH	PL	NT	NFT	GPS	TKW	GY/ha
Rex Duo	70.72^{a}	7.27^{a}	2.72^{a}	2.33^{a}	47.5^{a}	60^{a}	3682^{a}
Tilt250 EC	70.33^{a}	6.88^{a}	2.72^{a}	2.61^{a}	36.7^{b}	60^{a}	3189^{b}
Natura250EW	66.27^{ab}	6.88^{a}	2.55^{a}	2.27^{a}	27.83^{c}	50^{b}	2296^{c}
Bayleton WP25	66.52^{ab}	6.72^{a}	2.67^{a}	2.55^{a}	25.5^{c}	50^{b}	2284^{c}
Control	64.22^{b}	6.05^{b}	1.44b	1.22^{b}	15.2^{d}	27^{c}	1029^{d}
LSD (0.05%)	4.78	0.57	0.43	0.39	3.40	8.64	2.24
CV (%)	5.91	7.10	15.10	14.85	9.32	13.88	7.52

CV=coefficient of variation, LSD= least significant difference, PH= Plant height (cm),NT= Number of tillers, NFT= Number of fertile tiller, GPS =Grain per Spike, TKW=Thousand kernel weight(g), GY/ha=Grain yield per hectare (Kg)

Different studies from different areas have tested yield increases in wheat due to fungicide application. Kelley, (2001) also found that over a period of six years, the fungicide propiconazole (Tilt 250EC) significantly increased winter wheat yield by 77%.

The current study is also clearly shows that in Ethiopia it is not possible to grow susceptible, moderately susceptible even resistant wheat varieties without fungicide application in areas where wheat rust diseases is a major problem . This is due to introduction of exotic races or evolvement of new local races and changes in environmental factors (Wubishet and Chemeda, 2016).

Fungicide efficacy is based on proper application timing to achieve optimum effectiveness of the fungicide as determined by labeled instructions by manufacturer and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparisons among products in field tests and are based (envirnment) on a single application of the labeled rate (Kiersten Wise,2016). All the current commercial wheat cultivars in East Africa 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 (Wanyera et al., 2009). Fungicide tests in Ethiopia showed up to1334.30kgha-1/13.34qt-1ha higher yield advantage in the treated versus the untreated plots (Wubishet Alemu & Tamene Mideksa., 2016). Ordish and Dufour (1969) noted the popularity of spraying fungicides to control crop diseases; returns of up to three times the cost involved often were realized from fungicide application.

Partial Budget Analysis

As farmers attempt to evaluate the economic benefits of shift in practice, partial budget analysis was done to identify the rewarding treatments. Yield from experimental plots was adjusted downward by 10% for management difference for to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment (Getachew and Taye, 2005). Three years average market grain price of wheat (ETB 13.5kg), farm-gate price of Rex Duo, Tilt, Nature and Bayletone fungicides (ETB 1 liter ha-1, 1 liter ha -1, 1liter ha-1 and 1kg ha-1) respectively and labor valued at ETB 40 per person day were used. Labor for wheat field management was 5 person- days per hectare. The result of the partial budget analysis is given in (Table 3). The economic analysis revealed that the highest net benefit of (birr 27217.3 ha-1) was obtained from the application of Rex Duo fungicide, whereas the control treatment (nil application of fungicide) gave the lowest net benefit (birr 5075.67 ha-1).

The economic analysis further revealed that the application of Tilt250ECfungicide used i.e. 1liter ha-1 Tilt250ECconventional provided the highest marginal rate of the return (MRR) of 5077.9% (Table 4) suggesting for each birr invested in wheat production, the producer would collect birr 5.077 after recovering his cost. Since the MRR assumed in this study was 100%, the treatment with application of Tilt250EC fungicide gave an acceptable MRR. Therefore, Tilt fungicide application would be economical to be recommended on wheat to control wheat rust at Guji highlands of Ethiopia

Table 5. *Partial budget analysis of different fungicides to control stripe rust in wheat at Bore and Anna sora district*

Treatments	Average yield(kgha^{-1})	Adjusted yield 15%(kg ha^{-1})	Gross benefit (ETBha^{-1})	TVC(ET Bha^{-1})	NB(ETB ha^{-1})	MC (ETB ha^{-1})	MB(ET B ha^{-1})	MRR(ETB ha^{-1})
Control	1029.5	926.55	8750.75	0	5075.675	0	0	
Bayleton25WP	2283.5	2055.15	19409.75	700	16768.35	700	11692.675	1670.382
Natura250EW	2296	2066.4	19516	730	16834.4	30	66.05	220.1667
Tilt 250EC	3189.5	2870.55	27110.75	862	23537.25	132	6702.85	5077.917
Rex Duo	3682	3313.8	31297	950	27217.3	88	3680.05	4181.875

Conclusion and Recommendations

Although wheat rust (Stripe rust) appears early to late during the crop season, it could develop to severe epidemic levels and could be an important factor limiting bread wheat product joninGuji highland of Ethiopia. Location variations in severity of the disease are may be related to differences in weather conditions. Despite variations among fungicides, the bread wheat was attacked by wheat stripe rust in the absence of fungicide application. There is an urgent need for developing resistant varieties to the existing wheat rust pathos types. The fungicide treatments were effectiveness in reducing wheat stripe rust disease severity and improving crop yield. Partial budget analysis of the study revealed that, applying Rex Duo had the highest net field benefit (27217.3ET B) followed by Tilt (23537.25ETB ha-1 compared to Natura250EW, (16834.4ETB ha-1), Bayletone 25PW (16768.35ETB ha-1) & unsprayed check (5075.675ETB ha-1). However, Tilt250E.C had showed maximum economic profitability than Rex Duo and other fungicides with marginal rate of return (MRR) of 6494.4%.

Therefore, Tilt 250EC at rate of 1itre ha-1 is the best fungicide for the effective control of rust on wheat and there by improve yield of susceptible wheat up to 32.28% under proper management during production season at high lands of Guji Zone, Southern Ethiopia.

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