

IMPACT OF DIFFERENT LEVELS OF STEM AND STRIPE RUST SEVERITIES ON TWO GRAIN YIELD COMPONENTS OF WHEAT

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ABSTRACT: Improvement of wheat (*Triticum aestivum* L.) is a major goal of plant breeders and pathologists to ensure food security and self sufficiency. Relationship between different levels of stem and stripe rust severities on the two grain yield components (1000-kernel weight and plot yield) were studied during 2013/2014 and 2014/2015 seasons at Gemmeiza Agricultural Research Station. Different epiphytotic levels of stem and stripe rust were created using spreader artificial inoculation and spraying the fungicide (Sumi-eight). To create different rust severities three, two and one spray were used with 7 days intervals. Whereas protected control treatment was obtained by spraying the fungicide four times. Correlation coefficient (R^2) analysis depicted that positive correlation was found between different rust severity levels and yield loss. In 2013/2014 growing season, which stem rust started early, disease severity (%) reached its relatively high percentage (80%) with the highest loss (%) in both 1000 kernel weight (36.3%) and plot weight (37.82%). The effect of stripe rust infection on yield components was lower than those of stem rust. On the other hand, the lowest loss was observed with 10% of stem and yellow rust which sprayed three times. During 2014/2015 stripe rust infection caused the highest loss (%) in yield components, under the highest level 80% of severity.

Key words: Wheat stem rust; stripe rust; yield losses.

INTRODUCTION

Wheat is the staple food and the main source of calories intake in most developing countries, and considered to be an important source to maintain food security in those countries. Rust diseases are still the most dangerous biotic stress that threatens wheat production in many growing areas of the world; this is mainly due to the appearance of new aggressive races of the pathogen (Singh *et al.*, 2005). Stem rust (*Puccinia graminis* f. sp. *tritici*) and stripe rust (*P. striiformis* f. sp. *tritici*) of wheat causing severe damage in grain yield of wheat locally and globally.

Stem rust affects the entire wheat crop, especially during the early growth stages. The infection led to the blocking of the vascular system, hence stunting and lodging of weak stalks, eventually caused yield

losses of even 100% due to shriveled grains and damaged tillers (Boukhatem *et al.*, 2002 and Kokhmetova *et al.*, 2011). In Egypt, yield losses due to the stem rust ranged from 1.96% to 8.21% in some Egyptian wheat cultivars (Ashmawy *et al.*, 2013). Stripe rust causes also severe losses in grain yield which may reach more than 70% in the susceptible wheat cultivars depending on environmental conditions, level of resistance, stage of crop development at the infection process and the dominant physiologic races (Nazim *et al.*, 1983). However, in most cases, susceptible cultivars were discarded and replaced with new resistant one (Rattu *et al.*, 2007). As various control options are available for combating wheat rusts using resistant varieties as the most effective and safety methods was alleyways used. The salient objective of the present study was to assess

the effect of different epiphytotic levels of stem and stripe rust on two grain yield components (1000-kernel weight and plot yield). Also, to determine the relationship between different severity levels of stem and stripe rusts and those two yield components.

MATERIALS AND METHODS

To determine the relationship between different stem, stripe rust severities and grain yield components, two susceptible wheat cultivars were used (Misri-1 for stem rust and Morocco for stripe rust). These experiments were conducted at Gemmeiza Agricultural Research Station during the two successive growing seasons (2013/2014 and 2014/2015) in a randomized complete block design with four replicates. The plot size was 3m x 3.5m = 10.5 m² and each plot included 6 rows with 3m long and 30cm apart. Spreader area planted with a mixture of highly susceptible wheat cultivars to stem and stripe rust to create rust uredio spores as source of inoculum.

Different levels of stem and stripe rust severity were created by spraying a systemic fungicide (Sumi-eight) at different dates with 7 days intervals. Protected control plots were treated four times to inhibit rust development, while untreated control ones were used to estimate rust severities.

Rust severity (%) was estimated according to modified Cobbs scale (Peterson *et al.*, 1948).

Determination of yield components:-

At harvest, the two grain yield components, *i.e.* 1000-kernels weight (gm) and plot weight (kg) were estimated. Yield loss was estimated using the following equation adopted by Calpauzos *et al.* (1976):

$$\text{Loss (\%)} = 1 - y_d / y_h \times 100$$

Where:

y_d = yield of diseased plants,

y_h = yield of healthy plant.

Statistical analysis: Data of disease severity (%) and the two grain yield components were subjected to analysis of variance (ANOVA) to determine treatment effects as well as by using MS-Excel programme for regression and correlation analysis.

RESULTS AND DISCUSSION

Data obtained (Table 1&2) from the two successive seasons showed that, fungicide spray intervals created different levels of stem and stripe rust severity (%) that enable us to assess their effects on two yield components under study, *i.e.* 1000-kernels weight and plot yield weight. Also complete control was achieved by the fungicide application four times at 7-day intervals.

Stem rust:

Data presented in tables (1 and 2) show the relationship between different stem rust severity levels and yield loss (%) during two successive seasons, 2013/2014 and 2014/2015. Positive correlation between the date of stem rust appearance and disease severity, whereas stem rust started at (25/3/2014) and disease severity reached (80%).

In 2013/2014 growing season, approximately full protection has been obtained with the four fungicide treatments, whereas one spray only exhibit disease severity by (40%). However untreated control plants showed the highest level of disease severity (80%). The results showed also that losses in grain yield due to various severities (%) varied from (4.71%-36.3%) in 1000-kernel weight. Whereas, loss in plot yield weight ranged from (5.21%-37.82%) depending on disease severity. Maximum yield reduction in 1000-kernel weight was observed with untreated control plants (80% disease severity). Meanwhile, the lowest loss (%) was obtained with 10% disease

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severity. Intermediate losses in the two yield components under study were recorded with the intermediate disease severities levels. Positive relation between different stem rust levels(%) and yield loss(%) in both 1000-kernel weight and plot yield weight ($R^2 = 0.989$ and 0.911). The recently study under the Egyptian conditions was carried out by Ashmmawy *et al.* (2013) reported that yield losses due to stem rust infection reached 6.17% in 1000-kernel weight and 8.21% in plot yield weight on the susceptible cultivar Misri 1. In this respect, Shorima, Kakaba, ETBW13A2, and ETBW5496 cultivars had better yield and lower stem rust severity (%) under moderate stem rust infection Tolessa *et al.* (2015).

In 2014/2015, yield loss in each of 1000-kernel weight and plot weight were in general lower than those in the previous growing season (Table 2). Therefore, disease severity reached only (60%) at the end of growing season due to the late appearance of stem rust infection (7/4/2015),i.e. 12 days later than the first season. The relatively high loss in 1000-kernel weight during this season (29.65%) and plot weight (30.48%), followed by the loss under disease severity (40%) which showed (21.09%) yield loss with 1000-kernel weight and (22.76%) with plot weight. On the other hand, the lowest reduction in grain yield was observed with (10%) disease severity.

Table (1): Levels of stem rust severity % and losses % in the two yield components on the susceptible wheat cultivar Misri-1 during 2013/2014 season.

disease appearance	No. of spray	Disease severity (%)	1000 kernel weight (gm)			Plot yield weight (kg)		
			Protected control	Infected	Loss (%)	Protected control	Infected	Loss (%)
25/3/2014	Four	0	40.11	-	-	2.30	-	-
	Three	10		38.22	4.71		2.18	5.21
	Two	20		35.61	11.21		2.04	11.30
	One	40		31.68	21.01		1.65	28.26
	Non	80		25.55	36.3		1.43	37.82
	LSD		N.S	0.756		N.S	0.404	

Table (2): Levels of stem rust severity % and losses % in the two yield components on the susceptible wheat cultivar Misri-1 during 2014/2015 season.

disease appearance	No. of spray	Disease severity (%)	1000 kernel weight (gm)			Plot yield weight (kg)		
			Protected control	Infected	Loss (%)	Protected control	Infected	Loss (%)
7/4/2015	four	0	41.82	-	-	2.46	-	-
	three	10		40.6	2.91		2.37	3.65
	Two	20		39.21	6.24		2.3	6.5
	One	40		33.85	21.09		1.9	22.76
	non	60		29.42	29.65		1.71	30.48
	LSD		N.S	1.183		N.S	0.940	

The effect of rust on grain yield may be due to the energy expenditure in plant defense mechanisms rather than for growth and grain information (Smedegaard *et al.* 1985).

Stripe rust:

Early stripe rust infection was recorded during the two growing seasons under study, which led to high loss (%) in the two grain yield components more than stem rust with the same levels of disease severity.

In 2013/2014 growing season, stripe rust appeared at late time (5/3/2014) showed lower yield loss in the two components compared with the next season. Loss % in grain yield was in parallel line with stripe rust severity, which ranged from (2.71%-32.8%) with 1000-kernels weight and (6.61%-35.54%) with plot weight (Table 3). Depending upon the fungicide treatments, different levels of stripe rust severity (%) were recorded on the susceptible wheat cv. Morocco ranged from (10%- 80%). The lowest stripe rust severity (0%) was obtained with four fungicide treatments, while the untreated control treatment reached the

maximum level of stripe rust severity (80%). El-Daoudi *et al.*,(1996) reported that, the average grain yield loss (%) in Egypt duo to wheat stripe rust at Delta region during 1995 ranged from 14% to 26% in this region, while the national loss was about 10%. El-Shamy *et al.* (2011) found that a significant positive correlation between mean disease severity % and loss % in each 1000-kernel and grain yield/plant. Salman *et al.*, (2006) reported that yield losses increased proportionately with the increase in severity of the disease.

During 2014/2015 growing season stripe rust appeared early compared with the previous season which exhibit the highest loss in grain yield in both 1000-kernel weight and plot yield weight. The highest loss in 1000-kernels was recorded with 80% disease severity (45.89%), meanwhile the lowest value was observed with 10% disease severity (3.86) (Table 4). Grant *et al.* (2005) reported that, in Australia stripe rust can reduced yield by up to 50 percent and leaf rust by greater than 20 percent in susceptible varieties.

Table (3): Levels of stripe rust severity % and losses % in the two yield components on the susceptible wheat cultivar Morocco during 2013/2014.

disease appearance	No. of spray	Disease Severity (%)	1000 kernel weight (gm)			Plot yield weight (kg)		
			Protected control	Infected	Loss %	Protected control	Infected	Loss %
5/3/2014	four	0	41.23	-	-	2.11	-	-
	three	10		40.11	2.71		1.98	6.61
	Two	20		37	10.25		1.85	12.32
	One	40		33.68	18.31		1.6	24.11
	non	80		28.02	32.8		1.36	35.54
	LSD		N.S	0.946		N.S	0.525	

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Table (4): Levels of stripe rust severity % and losses % in the two yield components on the susceptible wheat cultivar Morocco during 2014/2015 season.

Disease appearance	No. of spray	Disease Severity (%)	1000 kernel weight (gm)			Plot yield weight (kg)		
			Protected control	Infected	Loss %	Protected control	Infected	Loss %
28/2/2015	Four	0	42.16	-	-	2.31	-	-
	Three	10		40.53	3.86		1.99	13.85
	Two	20		36.12	14.32		1.91	17.31
	One	50		29.88	29.12		1.45	37.22
	Non	80		22.81	45.89		1.11	51.94
	LSD		N.S	0.863		N.S	0.491	

Different disease levels of disease severities were observed with different fungicide treatments. Protected control which free from rust infection, showed the highest values of yield components by spraying fungicide four times. Dereje and Chemedda (2007) reported that different spray intervals were significantly differed in disease severity among the tested cultivars. Syed *et al.* (2007) found that, wheat variety Morocco was the most susceptible among the tested varieties to stripe rust which causes the maximum yield loss (39.79%).

Association between stem and stripe rust severities with the two yield components during 2013/2014 and 2014/2015 seasons:

In this study, association between different levels of stem and stripe rust severities with loss in 1000- kernel weight and loss in plot yield weight determined through regression analysis during 2013/14 and 2014/15 growing seasons (Table 5 and Figs. 1 and 2). A strong and positive correlation (R^2) was found between disease severity (%) and yield loss (%), which ranged from 0.853 to 0.989.

The correlation coefficient data revealed that, the two yield components correlated with rust severity%. The highest values ($R^2=0.989$) were recorded between stem rust severity and 1000 kernel weight during 2013/2014 season, which stem rust started early.

Table (5): Correlation coefficient (R^2) between rust severity and yield components during 2013/14 and 2014/15 seasons.

Disease	2013/2014		2014/2015	
	1000-kernel weight	plot weight	1000-kernel weight	plot weight
Stem	0.989	0.911	0.982	0.971
Stripe	0.986	0.961	0.853	0.956

The lowest values of correlation coefficient ($R^2= 0.853$) were obtained with strip rust severity and 1000 kernel weight during 2014/2015. Also, regression analysis revealed a significant linear relationship between yield loss% and disease severity%. Shaner *et al.* (1978) reported that overall cultivars had the maximum disease severity had lower mean grain yield and vice versa. Ochoa and Parlevliet (2007) found that yield loss was correlated strongly with rust severity%.

The effect of rust on grain yield may be due to the energy expenditure in plant defense mechanisms rather than for growth and grain information (Smedegaard, and Tolstrup, 1985). Also, Safar (2015) reported that, positive correlation was observed between yield percentage, 1000- kernel weight losses and final rust severity%. Moreover, correlation coefficient between infection rate and yield loss was higher than final rust severity% and 1000- kernel weight losses.

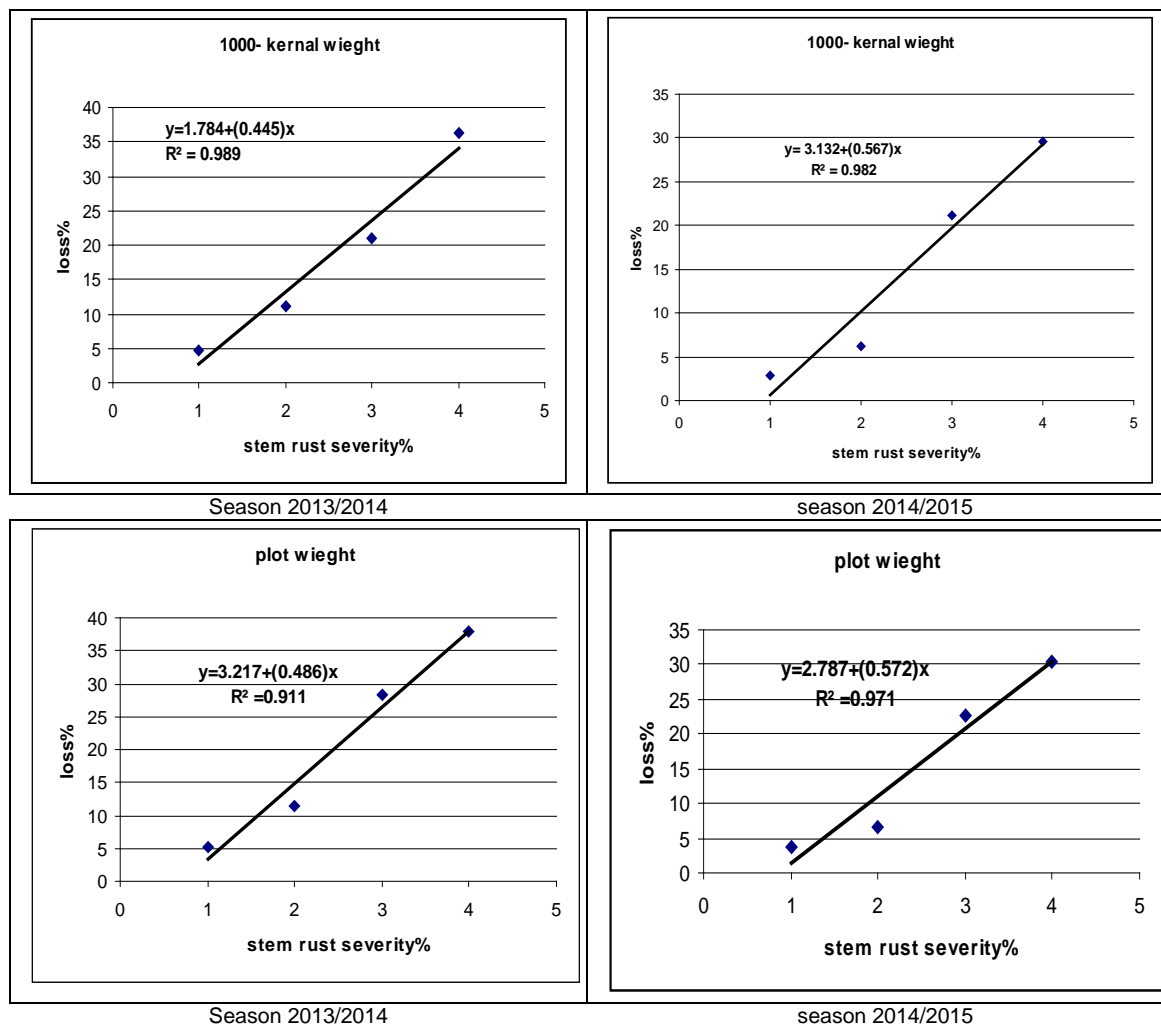


Fig. (1): Relationship between stem severity% and loss% in 1000-kernel weight and plot yield weight during 2013/2014 and 2014/2015.

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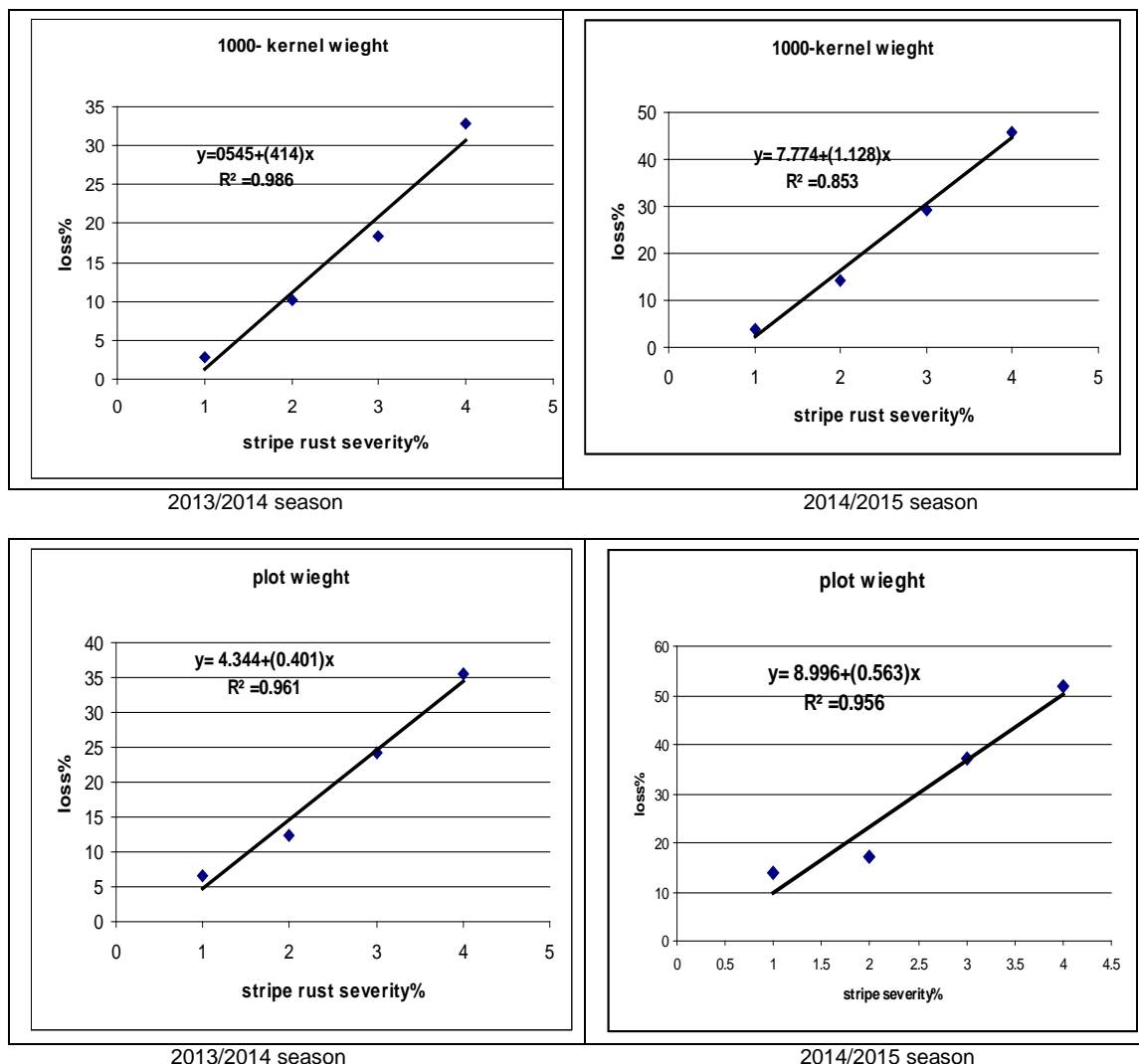


Fig. (2): Relationship between stripe severity% and loss% in 1000-kernel weight and plot yield weight during 2013/2014 and 2014/2015.

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تأثير مستويات مختلفه من الاصابه بصدأ الساق والصدأ الاصفر على محصول الحبوب فى القمح

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الملخص العربى

زيادة القمح هو الهدف الرئيسى لمربى النباتات و علماء امراض النبات لضمان الأمن الغذائي والاكتفاء الذاتى من محصول القمح. لذلك درست العلاقة بين مستويات مختلفة من صدأ الساق والصدأ الاصفر على مكونات المحصول (وزن ١٠٠٠ حبة ووزن الحوض) خلال موسمى ٢٠١٣/٢٠١٤ و ٢٠١٤/٢٠١٥ بمحطة البحوث الزراعية بالجيزة . ولقد تم الحصول مستويات مختلفة من الاصابة بصدأ الساق و الصدأ الاصفر بالعدوى الصناعية للدائر حول التجربة والرش بالمبيد الفطرى (سومي ايت-). للحصول على مستويات مختلفة من الاصابة بالصدأ تم الرش مرة واحدة ، مرتين ثم ثلاثة مرات بين كل مرة والثانية ٧ أيام ، بينما تم رش معاملة الكنترول للحصول نباتات خالية من الاصابة أربع مرات. وقد لوحظ ارتباط إيجابي بين شدة الاصابة والخسارة فى المحصول. فى موسم ٢٠١٣/٢٠١٤ ظهر صدأ الساق مبكرا ، وصلت شدة الاصابة لاعلى مستوى (٨٠٪) مصحوبة باعلى خسارة فى محصول وزن الالف حبة ووزن محصول الحوض المنزرع (٣٦.٣٪ و ٣٧.٨٢٪) على التوالي. وعلى الجانب الاخر سجلت اقل خسارة فى المحصول مع شدة الاصابة ١٠% وذلك بالرش ثلاث مرات. خلال موسم ٢٠١٤/٢٠١٥ ولقد سبب الصدأ الاصفر اعلى خسارة فى المحصول حيث وصلت شدة الاصابة الى ٨٠٪.

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