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Losses Assessment in some Egyptian Wheat Cultivars caused by Stripe Rust Pathogen (*Puccinia striiformis)*

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Seven Egyptian wheat (*Triticum aestivum* L.) cultivars were evaluated at Kafr El-Hamam Agricultural Research Station, Sharkyia Governorate, Egypt, to stripe rust disease during 2013/2014 and 2014/2015 growing seasons under artificial inoculation. The evaluation included epidemiological parameters, *i.e.* final rust severity (%), area under disease progress curve (AUDPC), relative area under disease progress curve (r-AUDPC) and rate of disease increase (r-value) as well as yield components, *i.e.* estimated and actual percentage loss of 1000 kernel weight and grain yield/feddan. All tested cultivars Gemmeiza-7, Gemmeiza-9, Gemmeiza-10, Gemmeiza-11, Sids-1, Sids-12 and Sids-13 showed significant differences in disease parameters and yield components. Fast disease development was observed with Sids-12, Gemmeiza-11 and Gemmeiza-7 cultivars. Furthermore, they gave the highest values of estimated and actual percentage loss of 1000 kernel weight and grain yield/feddan compared to the other tested cultivars. On the other hand, stripe rust development was slow with Gemmeiza-10 and Gemmeiza-9 cultivars. They gave the lowest values of estimated and actual percentage loss of the 1000 kernel weight and the grain yield/feddan. Accordingly, there were strong positive relations between epidemiological parameters and yield components during the two seasons. The relation between FRS (%) and estimated loss (%) of 1000 kernel weight and grain yield/feddan was more stable than AUDPC, rAUDPC and r-value. Therefore, it can be concluded that the loss (%) of yield/feddan can be predicted from FRS (%). Moreover, the obtained results gave evidence to the importance of chemical control application in all cultivars against stripe rust disease particularly with Sids-12, Gemmeiza-11 and Gemmeiza-7. It seems that these results are reasonable for the explanation of economic threshold obtained from fungicide applications against stripe rust disease in wheat fields in Egypt.

Keywords: AUDPC, *Puccinia striiformis,* wheat and yield losses.

Wheat is the largest crop being cultivated in 27 countries overall the world. About 90% of the world's wheat production is attributed to bread wheat while the other 10% to durum wheat (Stubbs, 1985). It is used mainly for human consumption and is sole source of energy for nearly 35% of the world population. Wheat production in Egypt did not adequate to the urgent need of people, thus more than 50% of consumption are annually imported.

Limiting factors in wheat production are associated with several biotic and abiotic stresses. Rust diseases in the former category, are the most significant wheat diseases, which have continued to ravage this crop since ancient times. Stripe rust, also known as yellow rust, caused by *Puccinia striiformis* f.sp. *tritici*, is one of the most damaging rust diseases of wheat in many areas around the world (Chen, 2005 and Fu *et al*., 2008). The obligate parasitic fungus has devastated cereal production worldwide due to rapid semi systemic infection of affected plants resulting in defoliation and shriveled kernels. Hassebrauk (1965), Stubbs (1985), Line (2002), and Li and Zeng (2002) were among the research workers who reported the occurrence, damage caused by the stripe rust and its distribution around the world. By now, stripe rust of wheat has been reported in more than 27 countries of the globe. In Egypt, wheat stripe rust was epidemic in 1967, 1995, 1997 and 2015 attacking bread wheat cultivars, *i.e.* Giza-144 and Giza-150; Gemmieza-1, Giza-163; Sakha-69, Sids-1, Sids-12, Sids-13, Gemmeiza-7 and Gemmeiza-11, respectively (Abd El-Hak *et al*., 1972, El-Daoudi *et al*., 1996 and Abu El-Naga *et al*., 1997). There is a strong relationship between the values of area under disease progress curve (AUDPC) and resistance characteristics of seedlings and adult stages (Putnik-Deliã, 2008). Also, Maqsood *et al*. (2009) showed that variations among the cultivars for (AUDPC) were greater than the components of non-hypersensitive resistance in greenhouse experiments. Ahmad *et al*. (2010) reported that the varieties/lines which displayed 1-50, 55-100 and 100-200 AUDPC exhibited 3.43%, 6.74% and 11.70% yield losses, respectively. However, the varieties/lines which showed medium range of AUDPC, *i.e.* 500-1000 suffered from 21.50% losses, whereas the maximum area under leaf rust disease, *i.e.*1000-1500 and 1500-2000 caused 33 and 38% losses, respectively in different wheat varieties/lines.

The rust fungus infects the glumes at flowering stage, which results in an accumulation of spores in the florets and on the surface of the developing grain (Grant *et al*., 2005). Finally, yield loss caused by stripe rust depends on several factors, including the degree of cultivar susceptibility, infection time, rate of disease development, and duration of disease (Chen 2005). This crop and disease factors are influenced by environmental factors, among which temperature and moisture are the most important in determining disease severity and yield loss (Chen 2007 and Gladders *et al*., 2007). Because temperature and moisture conditions vary significantly from year to year in most wheat producing regions, they are the major limiting factors for the development of stripe rust epidemics and therefore have been used to develop descriptive and forecasting models for the disease.

Accordingly, this disease is able to attack most of the Egyptian commercial wheat cultivars causing severe infection and consequently high losses particularly at the Northern Governorates. Through the present study, an attempt has also been made to assess the effect of stripe rust towards yield loss in the commercially grown wheat cultivars in Egypt. Accordingly, the study was carried out to ascertain wheat yield losses due to stripe rust in the field under disease stress conditions and also to evaluate the economic impact of this disease thereby predicting the losses, in case of epidemics.

Materials and Methods

Pathological part:

1. Experimental site:

The present work was carried out at Kafr El-Hamam Agricultural Research Station, (ElEU: 71ft, N: 30*36.901 and E:031*30.871), Sharkiya Governorate, Egypt, in two successive growing seasons 2013/2014 and 2014/2015.

2. Wheat cultivars:

Seven wheat cultivars Gemmeiza-7, Gemmeiza-9, Gemmeiza-10, Gemmeiza-11, Sids-1, Sids-12 and Sids-13 obtained kindly from wheat Research Department, Field Crops Research Institute, ARC, Giza, Egypt were used as protected and infected cultivars.

3. Fungicide treatment:

Sumi-8 fungicide was used at the rate of 35cm/100L for three times to protect the plots. The first application was conducted soon after disease onset and 15 days thereafter.

4. Filed experiment:

A split plot design with three replicates was followed to carry out this experiment. The main plots included the tested cultivars. While, sub-plots were represented by the infected or protected treatments. The experimental unit consisted of 15 rows with 7m. long. Plot size measured 7×6 =42 m^2(1/100 feddan). The experiment was surrounded with one m^2 border of the rust susceptible cultivars such as *Triticum spelta saharenses* (T.S.S) and Morocco to serve as a spreader. At booting stage, spreader received an artificial inoculation of the pathogen in addition to the natural infection following the procedure adopted by Tervet and Cassel (1951). The inocula (urediniospores mixture) were obtained from stripe rust greenhouse in Wheat Diseases Research Department, Plant Pathology Research Institute, ARC and mixed with talcum powder at the rate of 1:20 (w:w). The difference between day and night temperature during that period and nearly all over the season was 10^{o}C on the average. The experiment received the agricultural practices recommended for the wheat crop.

4.1. Disease assessment:

Disease severity (%) was recorded weakly for eight times, during the two successive growing seasons and was expressed as percentage coverage of leaves with rust pustules according to the method adopted by Peterson *et al*., (1948). Rust reaction was expressed in five infection types *i.e.* Immune (0), resistant (R), moderately resistant (MR), moderately susceptible (MS) and susceptible (S) (Stakman *et al.*, 1962). The obtained data served in the determination of the final rust severity (FRS %), as outlined by Das *et al*. (1993), area under disease progress curve (AUDPC) according to Pandey *et al*. (1989) and rate of disease increase (r-value) according to Van der Plank (1963). Relative area under disease progress curve (rAUDPC) was estimated according to Milus and Line (1986).

4.2. Yield components:

Yield components expressed as 1000 kernel weight and grain yield/feddan were determined.

4.3. Estimated loss (%):

Estimated total loss (%) for each cultivar was recorded according to the equation of Calpouzos *et al.* (1976).

$$\text{Loss (\%)} = (1 - Y_d / Y_h) \times 100$$

Whereas: Y_d= Yield of infected or diseased plot and Y_h= Yield of protected plot.

4.4. Actual loss (%):

Correlation of regression and coefficient were estimated to determine the effect of stripe rust infection on yield discarding the other factors than disease stress which called actual percentage loss.

5. Statistical analysis:

Data were statistically analyzed by the variance and least significant difference (L.S.D) at 5% levels, according to the method described by McClave and Benson (1991). Correlation and regression coefficient "SPSS Regression Modeling" was used to determine the following relationships:

a. Relationship between FRS (%), AUDPC, rAUDPC, r-value and estimated loss (%) of 1000 kernel weight and yield/feddan during the two growing seasons.
b. Relationship between FRS (%) and each of 1000 kernel weight and yield/feddan of the infected wheat cultivars during both seasons.
c. Relationship between estimated loss (%) in 1000 kernel weight and estimated loss (%) in yield/feddan during both seasons.

Results and Discussion

Disease severity of stripe rust on seven Egyptian wheat cultivars was recorded as the percentage of final rust severity (%) and used to calculate the (AUDPC) and r-value during 2013/14 and 2014/15 growing seasons. Data in Table (1) show that the final rust severity ranged from 20 to 70 % and from 20 to 90 % of the tested wheat cultivars during 2013/14 and 2014/15 growing seasons, respectively. The highest final rust severity in the two seasons was recorded with Sids-12 (70S, 90S), Gemmeiza-11 (60S, 90S) and Gemmeiza-7 (50S, 70S). While, the rest of the tested cultivars exhibited final rust severity ranged from 20 to 40 % and 20 to 60 % during the two seasons, respectively.

Table 1. Final rust severity (%), AUDPC, rAUDPC and r-value for 7 Egyptian wheat cultivars during 2013/14 and 2014/15 growing seasons

Cultivar	Season/Epidemiological parameters							
	2013/2014				2014/2015			
	FRS (%)	AUDPC	rAUDPC	r-value	FRS (%)	AUDPC	rAUDPC	r-value
Gem.-7	50S	1522.5	81.3	0.098	70S	2152.5	75.5	0.126
Gem.-9	30S	631.4	33.7	0.095	40S	900.2	31.6	0.110
Gem.-10	20S	462.0	24.7	0.060	20S	456.4	16.0	0.077
Gem.-11	60S	1697.5	90.6	0.112	90S	2572.5	90.2	0.171
Sids-1	40S	1137.5	60.7	0.085	60S	1697.5	59.5	0.112
Sids-12	70S	1872.5	100.0	0.126	90S	2852.5	100.0	0.171
Sids-13	40S	924.0	49.3	0.092	50S	1270.5	44.5	0.116
$LSD_{0.05}$	-	15.07	6.56	0.006	-	17.11	7.94	0.002

Stripe rust was recorded on all tested cultivars at two weeks after artificial inoculation during the two growing successive seasons. Percentage of disease severity was differed among the cultivars. Sids-12, Gemmeiza-11 and Gemmeiza-7 were the fast cultivars for the disease development followed by Sids-1 and Sids-13. On the other hand, stripe rust development was slow with Gemmeiza-10 and Gemmeiza-9 cultivars during 2013/14 and 2014/15 growing seasons (Fig. 1).

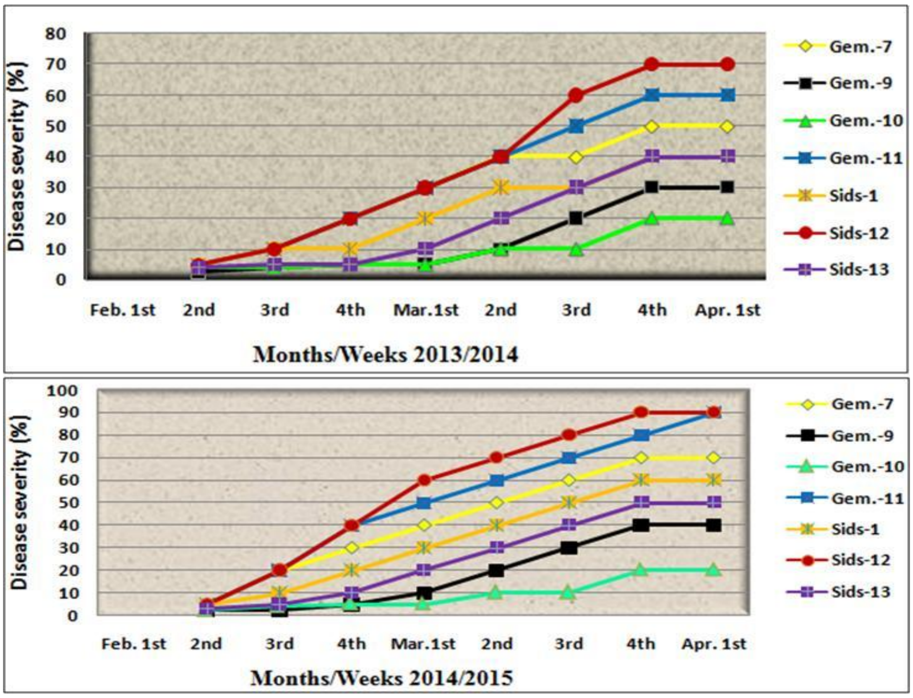

Fig.1. Maximum percentage of disease severity for commercial wheat cultivars during 2013/14 and 2014/15 growing seasons.

Also, data in Table (1) indicate that AUDPC values run in a parallel line with final rust severity. A value of AUDPC for each cultivar was recorded between brackets for the two seasons starting by 2013/14 followed by 2014/15. The highest values of AUDPC were observed on Sids-12 (1872.5, 2852.5), Gemmeiza-11 (1697.5, 2572.5) and Gemmeiza-7 (1522.5, 2152.5) followed by Sids-1 (1137.5, 1697.5) and Sids-13 (924.0, 1270.5). But, Gemmeiza-10 and Gemmeiza-9, exhibited low values of AUDPC, *i.e.* (462.0, 456.4) and (631.4, 900.2). The obtained results showed that rAUDPC and r-value were run in a parallel line with the values of AUDPC. It could be concluded from the obtained results that all of the tested wheat cultivars showed high susceptibility degree to stripe rust under the stress of epidemic circumstances prevalent in Egypt during the two growing seasons. This finding led to explain that Gemmeiza-10 and Gemmeiza-9 may be exhibited partial resistance or tolerance against the disease. But under the prevalent circumstances of the elapsed season the situation was completely different. This conclusion may be true with

Gemmeiza-10 which exhibited the lowest values of FRS (%), AUDPC, rAUDPC and r-value. This could be attributed to the change in weathering conditions, virulence of stripe rust races and large acreage grown to highly susceptibility cultivars. All these factors were not in turn of Gemmeiza-9, so it was dramatically affected during the second season. Consequently, it is better to establish a net of information relevant to stripe rust epiphytotics between the concerned countries. Similar results were reported by Boshoff *et al*. (2002); Li *et al.* (2004); Singh *et al.* (2005); Bolat and Altay (2007); Safar 2015 and Ali *et al*. (2016).

Grain yield and yield losses:

Differences between mean values of infected and protected plots showed significance regarding the 1000 kernel weight and yield/feddan as shown in Tables (2 and 3). This would be due to the differences in the level of stripe rust severity. In 2013/14 growing season, the estimated and actual percentage loss of the 1000 kernel weight ranged from 7.7 to 29.1% and 7.2 to 27.2%, respectively. Sids-12, Gemmeiza-11 and Gemmeiza-7 cultivars gave the highest values of estimated and actual percentage loss of 1000 kernel weight (29.1 and 27.2 %), (25.3 and 23.7 %) and (16.3 and 15.3 %), respectively compared to the other tested cultivars. On the other hand, the estimated and actual percentage loss of the grain yield/feddan ranged from 18.9 to 55.4 % and from 18.3 to 53.7 %, respectively. Sids-12, Gemmeiza-11 and Gemmeiza-7 cultivars gave the highest values of estimated and actual percentage loss of the grain yield/feddan, *i.e.* 55.4 and 53.7 %, 53.4 and 51.8 % and 42.8 and 41.5 %, respectively. Accordingly, the cultivars Gemmeiza-10 and Gemmeiza-9 gave the lowest values of the estimated and actual percentage loss of the 1000 kernel weight and the grain yield/feddan as shown in Table (2).

Table 2. Loss of thousand kernel weight and grain yield/feddan (ardab) for seven Egyptian wheat cultivars infected with stripe rust during 2013/14 growing season

Cultivar	1000 kernel weight (g)					Grain yield (ardab/feddan)				
	I*	P**	Mean	Estimated loss (%)	Actual loss (%)	I	P	Mean	Estimated loss (%)	Actual loss (%)
Gem.-7	41.5	49.6	45.6	16.3	15.3	10.7	18.7	14.7	42.8	41.5
Gem.-9	51.4	56.3	53.9	8.7	8.1	15.1	19.9	17.5	24.1	23.4
Gem.-10	52.6	57.0	54.8	7.7	7.2	15.4	19.0	17.2	18.9	18.3
Gem.-11	44.3	59.3	51.8	25.3	23.7	10.4	22.3	16.4	53.4	51.8
Sids-1	46.7	54.3	50.5	14.0	13.1	11.5	17.7	14.6	35.0	34.0
Sids-12	42.2	59.5	50.9	29.1	27.2	9.5	21.3	15.4	55.4	53.7
Sids-13	50.5	57.1	53.8	11.6	10.8	13.7	19.8	16.8	30.8	29.9
Mean	47.0	56.2	-	-	-	12.3	19.8	-	-	-
$LSD_{0.05}$:										
Cultivars			2.09					2.35		
Treatments			1.09					0.61		
C×T			2.88					1.61		

* I = (Infected) and P** = (Protected).

In 2014/15 growing season, data presented in Table (3) show that estimated and actual percentage loss of the 1000 kernel weight ranged from 7.9 to 32.1% and from 7.4 to 30.0 %, respectively. The grain yield/feddan ranged from 23.9 to 58.3 % and from 23.0 to 56.3 % of the estimated and actual percentage loss, respectively. Accordingly, Sids-12, Gemmeiza-11 and Gemmeiza-7 cultivars gave the highest values of estimated and actual percentage loss of the two previous parameters followed by Sids-1 and Sids-13.

Table 3. Loss of thousand kernel weight and grain yield/feddan (ardab) for seven Egyptian wheat cultivars infected with stripe rust during 2014/15 growing season

Cultivar	1000 kernel weight (g)					Grain yield (ardab/feddan)				
	I*	P**	Mean	Estimated loss (%)	Actual loss	I	P	Mean	Estimated loss (%)	Actual loss
Gem.-7	39.7	49.6	44.7	19.9	18.6	9.5	17.8	13.7	46.6	44.9
Gem.-9	51.8	57.1	54.5	9.3	8.7	14.7	20.1	17.4	26.8	25.8
Gem.-10	52.2	56.7	54.5	7.9	7.4	12.4	16.3	14.4	23.9	23.0
Gem.-11	41.8	58.5	50.2	28.5	26.7	8.6	20.0	14.3	57.0	55.0
Sids-1	41.3	49.7	45.5	16.9	15.8	10.0	16.5	13.3	39.4	38.0
Sids-12	40.7	59.9	50.3	32.1	30.0	8.5	20.4	14.5	58.3	56.3
Sids-13	48.0	56.3	52.2	14.7	13.8	11.3	17.5	14.4	35.4	34.2
Mean	45.1	55.4	-	-	-	10.7	18.4	-	-	-
$LSD_{0.05}$:										
Cultivars			2.22					1.84		
Treatments			1.02					0.65		
C×T			2.71					1.73		

* I = (Infected) and P**= (Protected).

Irrespective of high susceptibility of the tested cultivars, the lowest level of percentage loss was recorded with Gemmeiza-10. This may be attributed to the process of reselection in such cultivars. On the other hand, the significant difference between infected and protected plots in yield and 1000 kernel weight gave evidence to the justification of fungicide applications during critical times, *i.e.* times of epiphytotics especially when we know that the mean average percentage loss within the tested wheat cultivars in the two seasons was estimated by 18.9 to 58.3 % yield/feddan. Similar results were reported by El- Daoudi *et al*. (1996); Chen *et al.* (2002); Wang *et al*. (2004); Livinder and Singh (2005); Chicaiza *et al*. (2006); Omara (2009); Sharma-Poudyal and Chen (2011) and Safar (2015)**.** Going back to El-Daoudi *et al*. (1996) who pointed out that average percentage loss in grain yield of four Egyptian cultivars including Sakha-69, which was infected by stripe rust, was estimated by 20.5% at Delta region. Abu El-Naga *et al*. (1999) indicated that Sids-7 and Sids-9 were dramatically affected by stripe rust infection since they exhibited the highest percentage loss in wheat grains and in yield components. Menshawy and Najeeb (2004) indicated that all susceptible tested local cultivars are correlated by high percentage reduction in yield and 1000 kernel weight. Afzal *et al*.

(2007) reported that the stripe rust can cause 100% yield loss when infection occurs very early and the disease continues to develop during the growing season.

Relationships between FRS (%), AUDPC, rAUDPC, r-value and estimated loss (%) of 1000 kernel weight and grain yield/feddan were determined through regression analysis test, during 2013/14 and 2014/15 growing seasons (Table 4). In season 2013/14, there were strong positive relations between the four parameters under study and each of estimated loss (%) of 1000-kernel weight and grain yield/feddan, where estimates of R^2 were 0.936 and 0.970; 0.897 and 0.982; 0.897 and 0.982 and 0.754 and 0.769 for FRS (%), AUDPC, rAUDPC, r-value, respectively. In the second season, the results were parallel to those obtained during the first season (Table 4). Accordingly, it can be concluded that the relation between FRS (%) and each of estimated loss (%) of 1000 kernel weight and grain yield/feddan was more stable than AUDPC, rAUDPC, r-value, during the two growing seasons of the study (Ali *et al*., 2016).

Table. 4. Relationship between FRS (%), AUDPC, rAUDPC, r-value and estimated loss (%) of 1000 kernel weight (g) and grain yield/feddan (ardab) during 2013/14 and 2014/15 growing seasons

Epidemiological parameter	Coefficient of determination (R^2)			
	2013/2014		2014/2015	
	1000 kernel weight	Estimated loss (%) of yield (ardab/feddan)	1000 kernel weight	Estimated loss (%) of yield (ardab/feddan)
FRS (%)	0.936	0.970	0.935	0.965
AUDPC	0.897	0.982	0.953	0.979
rAUDPC	0.897	0.982	0.953	0.979
r-value	0.754	0.769	0.914	0.893

The relation between FRS (%) and each of 1000 kernel weight and grain yield/feddan of the infected wheat cultivars under study indicated that there were negative relations between them, where estimates of R^2 were 0.767 and 0.867 in season 2013/14; 0.757 and 0.711 in season 2014/15, respectively, (Fig. 2). Therefore, the loss (%) of yield/feddan could be predicted from FRS (%). These results are in agreement with those reported by Ali *et al*. (2016) who showed that the loss (%) of yield/feddan could be predicted from FRS (%). Accordingly, the losses can be calculated from only infected cultivars. Ochoa and Parlevliet (2007), previously reported that yield loss (%) was strongly correlated with AUDPC. Also, there was a positive relation between estimated loss (%) in 1000 kernel weight and estimated loss (%) in yield/feddan, where R^2 = 0.947 in 2013/14 and 0.981 in 2014/15 seasons (Fig. 3). Similar results were reported by Afzal *et al*. (2007) who showed that the correlation coefficient (-0.67805) depicted highly significant effect of stripe rust in lowering wheat yield.

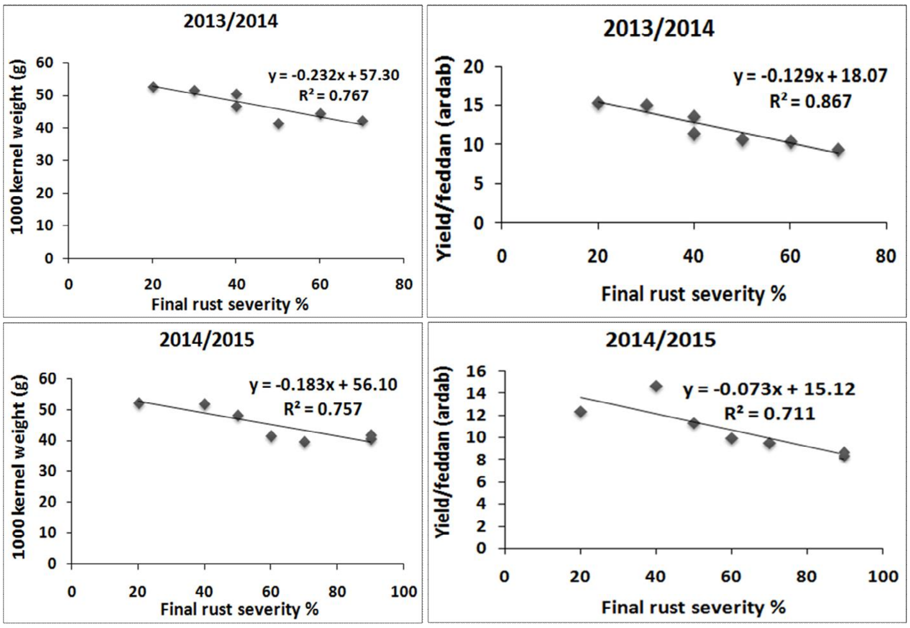

Fig. 2. Relationship between FRS (%) and each of 1000 kernel weight and grain yield/feddan of seven Egyptian wheat cultivars infected with stripe rust during 2013/14 and 2014/15 growing seasons.

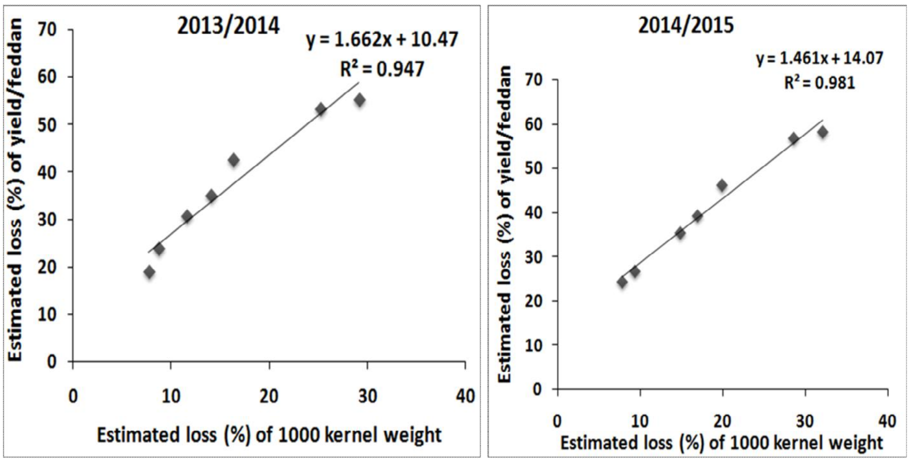

Fig. 3. Relationship between estimated loss (%) of 1000 kernel weight and estimated loss (%) of grain yield/feddan of seven Egyptian wheat cultivars due to stripe rust infection, during 2013/14 and 2014/15 growing seasons.

Conclusion

It could be concluded that the highest losses were recorded with the highly susceptible cultivars, *i.e.* Sids-12, Gemmeiza-11, Gemmeiza-7, Sids-1 and Sids-13 in respect. Therefore, these results seem to be logic and reasonable for the explanation of economic threshold obtained from fungicide applications against stripe rust disease in wheat fields. Moreover, it could be concluded that rates of net return equal one or nearly one reflecting the productivity of cultivating wheat under protected conditions. Also, this study must be correlated with the climate changes, strew prices, workers' salaries or wages and soil analysis. Therefore, these items would be taken into considerations in further studies.

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تقدير الخسائر الناتجة عن مرض الصدأ المخطط في بعض أصناف القمح المصرية المتسبب عن الاصابة بالفطر *Puccinia striiformis*

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الهدف من هذا البحث هو تقييم سبعة أصناف من الأقماح المصرية التجارية في محطة البحوث الزراعية بكفر الحمام بمحافظة الشرقية – مصر ضد مرض الصدأ المخطط في المواسم الزراعية 2014/2013 و 2015/2014 تحت ظروف العدوي الصناعية. وقد اشتمل التقييم علي النسبة المئوية للشدة النهائية للمرض والمساحة الواقعة تحت منحني الأصابة المرضي والمساحة النسبية الواقعة تحت منحي الأصابة المرضي ومعدل تزايد المرض وتأثير ذلك علي الخسارة في وزن الألف حبة ووزن محصول الفدان. وأظهرت كل الأصناف التجارية المختبرة (جميزة 7، جميزة 9 ، جميزة 10، جميزة 11، سدس 1، سدس 12 ، سدس 13) أختلافات معنوية في مقاييس المرض المستخدمة سابقا وكذلك الخسارة في مكونات المحصول. حيث لوحظ تطور سريع للمرض مع الأصناف سدس 12 ، جميزة 11 ، جميزة 7 والتي سجلت أعلي قيم في الخسارة المتوقعة واالخسارة الفعلية لكل من وزن الألف حبة ووزن محصول الفدان مقارنة بباقي الأصناف تحت الدراسة. وعلي الجانب الاخر لوحظ تطور بطئ للمرض مع الأصناف جميزة 9 ، جميزة 10 حيث سجلت أقل قيم في الخسارة المتوقعة والخسارة الفعلية لكل من وزن الالف حبة ووزن محصول الفدان . وجد أيضا علاقة موجبة بين مقايس المرض الوبائية ومكونات المحصول حيث ترتب علي ذلك علاقة أكثر ثباتاً بين النسبة المئوية للشدة النهائية للمرض والخسارة المتوقعة لكل من وزن الألف حبة ووزن محصول الفدان من المساحة الواقعة تحت منحني الأصابة المرضي والمساحة النسبية الواقعة تحت منحي الأصابة المرضي ومعدل تزايد المرض . وبالتالي يمكن التنبؤ بنسبة الخسارة في المحصول من خلال النسبة المئوية للشدة النهائية للمرض. ويستنتج أيضا أهمية تطبيق المكافحه الكيماوية لهذه الأصناف لمقاومة مرض الصدأ المخطط خاصة مع أصناف القمح سدس 12 ، جميزة 11 ، جميزة 7 التي يتم زراعتهم بمساحات شاسعة عند المزارعين. وبالتالي فان هذة النتائج تبدو منطقية لتبريرالأهمية الأقتصادية المتحصل عليها من حيث تطبيق المبيدات الفطرية ضد مرض الصدأ المخطط في حالة ظهورة بصورة وبائية في حقول القمح في مصر.