Zagazig J. Agric. Res., Vol. 38 No. (2) 2011 339-352

EFFECT OF SOWING DENSITY ON TOLERANCE OF SOME SUSCEPTIBLE BREAD WHEAT CULTIVARS TO LEAF RUST DISEASE

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ABSTRACT

Wheat leaf rust caused by *Puccinia triticina* Erikson is one of the most important diseases of wheat worldwide. Field experiment was carried out at Gemmeiza Research Station. Four wheat cvs. Sakha-93, Gemmeiza-7, Gemmeiza -10, and Gemmeiza -11 were sown at two different densities (100 and 50 seed/ m^2). Artificial inoculation was performed using spore suspension at flag leaf opening (growth stage - GS 53) as well as a mixture of uridia and talcum powder. The cultivars response to leaf rust showed the susceptible infection type and its disease severity was usually high. The tested four cultivars exhibited high disease severity, 70-80% on the flag and second leaves. High values of area under disease progress curve (AUDPC) were detected for Gemmeiza-10 , Sakha-93, Gemmeiza-7 then Gemmeiza-11 (1405 ,1350, 1190 and 1165,respectively). High correlation value was found between disease severities and values of AUDPC of the tested cultivars (r =0.99166). The effect of the disease on grain weight and grain yield/plant was studied to detect whether some form of incomplete resistance or tolerance was involved in the tested cultivars. In general, percentage losses in grain yield was low with the lower sowing density (50 seed/m^2) than the high sowing density (100 seed/m^2). Percentage losses varied from 4.17 to 18.41% and from 5.39 to 21.20% for 1000 grain weight in 2009 and 2010 growing seasons, respectively .Percentage losses in grain yield / plant ranged from 14.78 to 21.70% in 2009 and from 13.01 to 26.53 % in 2010 growing seasons. Correlation analysis revealed a significant linear relationship (r = 0.56 & 0.55 $P < 0.05$) between mean disease severity and mean percentage loss for 1000 kernel weight and grain yield/ plant.

Keywords: Wheat, leaf rust, sowing density, tolerance, AUDC.

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INTRODUCTION

Strategy of the wheat breeders and pathologists in Egypt aims to increase wheat production through genetically improvement wheat cultivars, agricultural practice application and protective wheat plants against pests and diseases. Among these diseases, wheat leaf rust caused by *P. triticina*, is considered a widespread disease in wheat growing fields .Warm temperatures with frequent dew periods at night provided favorable conditions for the rapid increase and spread of leaf rust disease. Resistance to plant diseases might be brought by various mechanisms and be present in differing degrees. Tolerance is considered one of these mechanisms, which plants endure severe disease without severe losses in yield or quality (Caldwel *et al.*, 1958). It is well known that some cultivars suffer less damage than others at the same level of infection, this phenomenon is called tolerance (Wilcoxon *et al.*, 1974; Zadoks and Schein, 1979; Roberts *et al.*, 1984; and Lal Ahmed *et al.*, 2004). Tolerance is an alternative way to fight diseases, while resistance aims to reduce the pathogen growth within the plant. Tolerance only restricts the (harmful) consequences caused by the pathogen and reduces the damage. This harmful is normally assessed as reduction of yield compared with a protective check. Several research workers studied the positive correlation between grain yield reduction and AUDPC. Among them Smith (2008) stated that leaf rust (*Puccinia triticina*) caused serious limitation to wheat production between 1% and 20% yield loss on average and tends to be the worst in years with high yield potential. Herrera- Foessel *et al.* (2006) found that mean yield losses affected by degree of cultivar susceptibility, race-specific, and slow-rusting genotypes. Also, yield losses was associated mainly with a reduction in biomass, harvest index, and kernels per square meter. The goal of this work is characterize the tolerance affected by four Egyptian bread wheat cultivars showing high disease severity to leaf rust using different sowing density.

MATERIALS AND METHODS

This experiment was performed in 2009 and 2010 growing seasons at Gemmeiza experimental research station, Gharbia governorate, using four susceptible bread wheat cultivars, Sakha-93, Gemmeiza-7, Gemmeiza-10 and the newly cultivar Gemmeiza-11.These cultivars were selected to determine the level of tolerance to leaf rust disease. Forty- eight

plots (3.5x1.2 m =4.2 m^2.) each consists of six rows with 3.5 m length and 20 cm apart were sown in hills (single plants) at two densities, in 5 and 10 cm apart resulting in plant densities ranging from 50 to 100 seed /m^2. Randomized Complete Block design with three replicates was used. The experiment was surrounded by a border of highly susceptible wheat cultivars like Morroco, and Thatcher to ensure statement of leaf rust.

Inoculations were performed on the border adult plants, before flag leaf emergence. The border wheat plants were sprayed with water suspension of *P. triticina* spores, then uniformly dusted with a mixture of spore talc powder at the rate of 1: 20(v / v) using baby cyclone . Another non inoculated set of plots acted as check which completely protected by fungicides every 15 day intervals. Two fungicides were used in the first spray, Sumi-8 (Diniconazole) at 0.35 ml/l, while Tilt (Propiconazole) at 0.25ml/l was used in the second one. Disease severity was estimated visually from heading to maturity, four times from the onset of leaf rust appearance at 15 days intervals according to the scale 0-100 adopted by Peterson *et. al.*, (1948). Area under disease progress curve (AUDPC) was assessed for each cultivars according to the equation adopted by Pandy (1989)

$$AUDPC = D\,[\,1/2\,(Y_1 + Y_k) + (Y_2 + Y_3 + \text{- - - - -} + Y_{k-1})],$$

where

D = days between two consecutive recording (time intervals)

$Y_1 + Y_k$ = Sum of the first and last scores.

$Y_2 + Y_3 + \text{- - - - -} + Y_{k-1}$ = Sum of all in between disease scores.

At early dough stage, 20 plants in each plot were labeled of the main tillers for disease severity assessment. At maturity stage, the labeled plants were separately threshed and its grains were counted and weighted. Observed loss in 1000 kernel weight and grain yield/ plant were determined and compared with the protected plants following the equation adopted by Calpouzos *et al.* (1976).

$$\text{Loss \%} = 1 - \frac{Y_d}{Y_h} \times 100$$

Where:

Y_d = yield for diseased plants

Y_h = yield for healthy plants

Statistical parameters, least significant differences (L.S.D) was used to compare between yield components according to Snedecor (1957); correlation coefficient were used to detect the relationship between yield loss and rust severity

RESULTS AND DISCUSSION

Wheat Leaf rust caused by *Puccinia triticina* is considered one of the main biotic stresses which affects wheat plants and consequently the grain yield which is inversely proportional to the degree of rust infection. Tolerance of four susceptible wheat cultivars (6-rowed) against leaf rust infection was determined during 2009-2010 growing seasons under field conditions by studying the relationship between severity of infection, area under disease progress curve (AUDCP) and yield components.

Leaf Rust Epidemic

All the tested cultivars showed high disease severity ranged from 70-80 % with susceptible infection type (S) on the flag and second leaves (Figs.1 and 2) in both densities (100 and 50 seed /m^2). Disease severity was not affected by the difference in density of plants/ unit area. Kolmer (1997) in Manitoba stated that, the cultivar Katepwa was severely affected by the rust, with infection levels between 50-90 %. Cultivars AC Barrie, CDC Teal, and Roblin had moderate levels of infection, ranged between 10-40 %. The CPS and AC cultivars had high levels of infection ranged between 50-90 %.

Area under disease progress curve (AUDPC) run in a parallel line with disease severity (Fig.3). No differences were detected between the four different cultivars. The highest value of AUDPC was recorded on plants of Gemmeiza-10 (1405) followed by Sakha-93 (1350) ,Gemmeiza-7 (1195) then Gemmeiza-11 which showed the lowest value (1165). High correlation value was found between disease severities and values of AUDPC of the tested cultivars (r =0.99166). AUDPC is the result of all factors that influenced disease development such as environments, cultivars and population of the pathogen (Pandy *et al.*,1989). The obtained results also revealed that Gemmeiza-11 is considered the best comparing with the other tested cultivars .

Fig.1. Photogram illustrates severe leaf rust disease symptoms on tested wheat cultivars

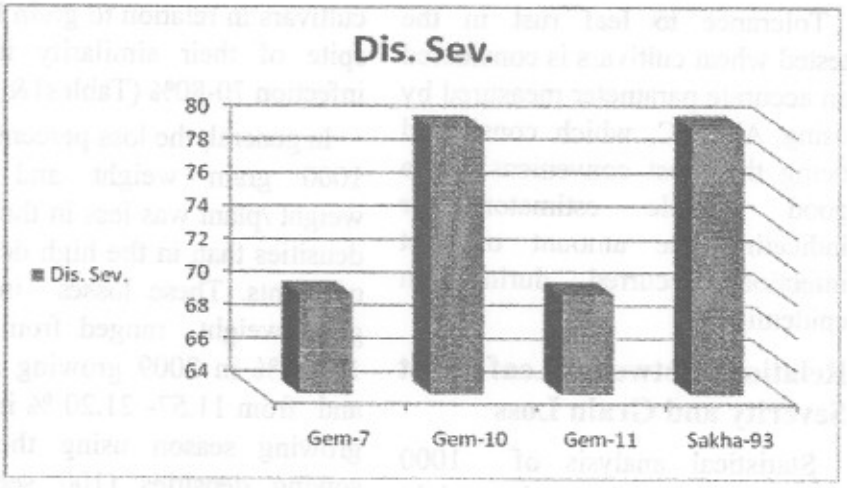

Fig. 2. The percentage of leaf rust severity on four bread wheat cultivars

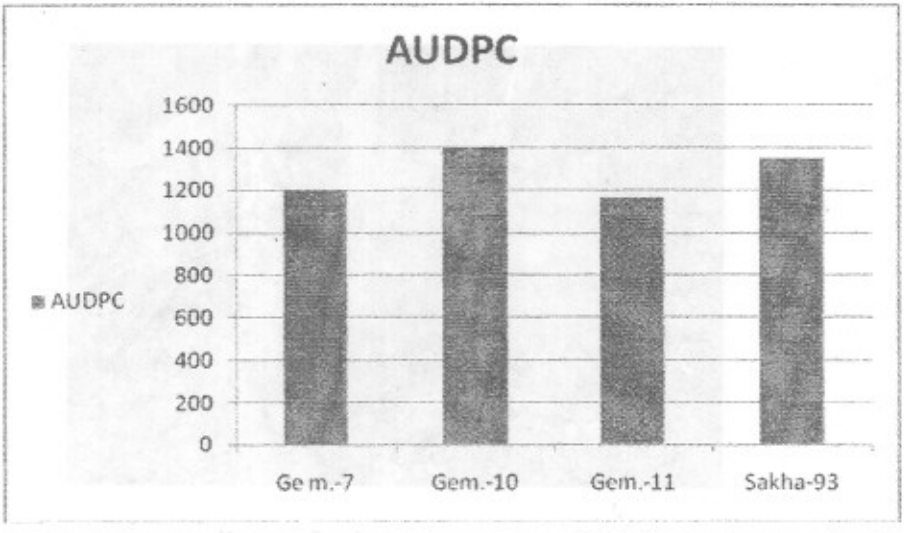

Fig. 3. Different values of area under disease progress curve (AUDPC) of four bread wheat cultivars affected by leaf rust.. (r = 0.99166)

Tolerance to leaf rust in the tested wheat cultivars is considered an accurate parameter measured by using AUDPC, which considered being the most convenient and a good reliable estimator for indicating the amount of rust infection occurred during an epidemic

Relation Between Leaf Rust Severity and Grain Loss

Statistical analysis of 1000 grain weight and grain weight /plant revealed highly significant differences between the two densities of sowing and the tested cultivars in relation to grain loss in spite of their similarity in rust infection 70-80% (Tables1& 2).

In general, the loss percentage in 1000 grain weight and grain weight /plant was less in the lower densities than in the high densities of plants. These losses in 1000 grain weight ranged from 9.51-18.41 % in 2009 growing season and from 11.57- 21.20 % in 2010 growing season using the high sowing densities (100 seed/m^2). While it ranged from 4.17- 11.13% in 2009 season and from 5.39 - 18.24% in 2010 season in

Table 1. Effect of leaf rust (*Puccinia triticina*) infection on percentage yield reduction in four bread wheat cultivars (2009 growing season)

Cultivar	Treatment	Seed rating (100 /m^2)				Seed rating (50 /m^2)			
		1000 grain weight	Loss %	Grain weight/ plant	Loss %	1000 grain weight	Loss %	Grain weight/ plant	Loss %
Gemmeiza-7	**Protected**	37.472		10.382		48.656		27.498.	
	infected	31.557	15.785	8.462	18.493	43.238	11.135	23.159	15.779
Gemmeiza-10	**Protected**	46.149		13.437		45.047		28.837	
	infected	37.647	18.417	10.521	21.701	40.258	10.631	23.826	17.376
Gemmeiza-11	**Protected**	55.590		11.676		54.328		29.213.	
	infected	50.303	9.510	9.756	16.443	52.059	4.176	24.746	15.291
Sakha-93	**Protected**	44.736		10.409		47.776		26.129	
	infected	38.387	14.192	8.387	19.425	41.895	9.815	22.265	14.788
L.S.D. at 0.05		0.77		0.0.78		0.94		1.09	

Table 2. Effect of leaf rust *(Puccinia triticina)* infection on percentage yield reduction in four bread wheat cultivars (2010 growing season)

Cultivar	Treatment	Seed rating (100 /m^2)				Seed rating (50 /m^2)			
		1000 grain weight	Loss %	Grain weight/ plant	Loss %	1000 grain weight	Loss %	Grain weight/ plant	Loss %
Gemmeiza-7	**Protected**	43.721		12.803		48.328		22.681	
	infected	36.397	16.751	9.557	25.353	40.119	17.138	18.548	18.222
Gemmeiza-10	**Protected**	36.190		16.904		45.656		22.983	
	infected	28.515	21.207	12.418	26.538	37.238	18.240	18.704	18.618
Gemmeiza-11	**Protected**	51.841		15.482		54.257		26.074	
	infected	45.841	11.573	11.620	24.945	51.332	5.391	22.681	13.012
Sakha-93	**Protected**	42.472		11.819		46.089		23.821	
	infected	37.468	11.781	9.297	21.338	39.477	14.346	20.593	13.551
L.S.D. at 0.05		0.90		0.42		1.70		0.97	

the lower densities (50 seed/m^2). Gemmeiza-10 followed by Gemmeiza-7 and Sakha-93 showed the highest values of percentage loss under the two densities of sowing. However, Gemmeiza –11 recorded the lowest % of loss in 1000 grain weight.

The same trend was found in-relation with the loss in grain weight /plant. The loss percentage in grain yield/plant ranged from 16.44-21.70 % in 2009 and from 21.33 - 26.53 % in 2010 using the high sowing densities (100 seed/m^2).While it ranged from 15.29 - 17.37% in 2009 season and from 13.01 - 18.61% in 2010 season in the lower densities (50 seed/m^2). Finckh *et al.* (1999) found that yield per plant decreased logarithmically with increasing density. The values of loss percentage in yield components were higher in 2010 season than that in 2009 gowing season. Such differences might be due to the combined effect of high epidemic of leaf rust and the degrees of temperature in the filling stages of wheat in Mars, April and May, 2010.

Positive correlation coefficients were found between percentage disease severity of the tested cultivars and percentage loss in 1000 grain weight and grain yield/plant (Table 3).

The effect of leaf rust infection on reducing grain yield of wheat cultivars might be due to affecting the photosynthetic area of the top three leaves especially flag leaf, which shares with its sheath by about 75 percentage in determining the grain weight, while ear shares by only 25 percent (Seck *et al.*,1988 and Subba Rao *et al.*,1989). Some results of their research warks are run in a parallel line with the obtained results .

In this respect, Andenow *et al.* (1997) found that different cultivars differed in their responses to leaf rust disease to determine the tolerant cultivars. The losses percentage varied between cultivars in kernel weight and grain yield. Also, they found that regression analysis revealed a significant linear relationship ($r = 0.66$, $P < 0.05$) between mean percentage loss and mean disease severity for kernel weight but not for grain yield.

Bengham *et al.* (2008) explained the relationship between loss and disease severity as it can differ widely between crops.

Table 3. Correlation coefficient between disease severity of four susceptible bread wheat cultivars and their yield components affected by severe infection with leaf rust

cultivar	Disease severity	2008/09				2009/10			
		100 seed/m		50 seed/m		100 seed/m		50 seed/m	
		1000 G.W.	G.Y./ plant	1000 G.W.	G.Y./ plant	1000 G.W.	G.Y./ plant	1000 G.W.	G.Y./ plant
Gemmeiza-7	70-S								
Gemmeiza-10	80-S	0.5643	0.8193	0.4601	0.2818	0.2931	-0.3119	0.4982	0.0905
Gemmeiza-11	70-S								
Sakha-93	80-S								

G.W. =Grain weight
G.Y. = Grain yield

It has give rise to the concept of disease tolerance. They added that genetic improvement to minimize yield loss under disease epidemic is an attractive goal, as it exerts little or no selection pressure on pathogen population.

Fida Hussain (2005) examined fifteen wheat varieties (slow rusting and fast rusting) for response of slow rusting to leaf rust epidemic in replicated trials (normal and late planting) for two years under artificially created leaf rust epidemics with and without fungicide protection. She stated that average loss in grain yields of the wheat cultivars ranged from 1.81 to 46.31 % that was significantly correlated with the grain weight loss ranged from 0.54 to 58.23 %. Average loss in grain number per spike ranged from 1.06 to 20.39 % and slight reduction was observed in spikes/m2 and plant height under rusted conditions

The obtained results suggests a different genetic makeup of the tolerance presented by the used cultivars. Parker *et al.*(2004) suggested that further attention should be paid to genotype variability related to reserve pool constitution as well as green canopy size during grain filling on the tolerance of wheat genotypes to leaf diseases. Generally, the studies of disease tolerance to cereal rusts can play an active role in mapping the areas of commercial varieties in different locations of Egypt according to the hot spots to avoid / reduce the yield losses. Therefore, estimating the degree of tolerance to this disease is important in wheat susceptible cultivars.

Based on the values of wheat yield components as well as percentage reduction of these components in both protected and inoculated plants, it might be considered that Gemmeiza-11 is the most tolerant wheat cultivar to leaf rust infection followed by Gemmeiza-7. This trend is in a harmony with previous finding obtained by Shaner *et al.* (1978) against leaf rust disease of wheat. Ochoa and Parlevliet (2007) reported that yield loss was correlated strongly with area under disease progress curve, which means that high levels of partial resistance are needed to prevent significant yield damage.

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تأثير الكثافة النباتية على تحمل بعض أصناف قمح الخبز القابلة للإصابة بمرض صدأ الأوراق

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يعتبر مرض صدأ الأوراق الذي يسببه الفطر بكسينيا تريتيسينا من أهم أمراض القمح إنتشارا على مستوى العالم . أجريت تجربة حقلية بمحطة بحوث الجميزة إشتملت على أربعة أصناف من قمح الخبز (سخا ٩٣ ، جميزة ٧ ، جميزة ١٠ ، جميزة ١١) . تم زراعتها على مستويان من الكثافة النباتية (٥٠ ، ١٠٠ ، بذرة / م ٢) . أجريت العدوى الصناعية عند تكشف ورقة العلم (مرحلة النمو ٥٣). أظهرت أصناف القمح المختبرة درجة عالية من شدة الاصابة بالمرض والتى تراوحت بين ٧٠– ٨٠% على ورقة العلم والأوراق التالية لها.

سجلت الأصناف جميزة ١٠ ،سخا ٩٣ ، جميزة ٧ وأخيرا جميزة ١١ أعلى قيم للمساحة تحت منحنى تقدم المرض مسجلة قيما مقدارها ١٤٠٥ ، ١٣٥٠ ، ١١٩٠ ،١١٦٥ ، على الترتيب . تم دراسة تأثير المرض على وزن الألف حبة ومحصول الحبوب / نبات وذلك لتقدير سبب المقاومة الصنفية (المقاومة الجزئية أوالتحمل). وبصفة عامة أوضحت الدراسة إنخفاض الفقد في محصول الحبوب عند تطبيق الكثافة الزراعية المنخفضة (٥٠ بذرة / م٢) عن الكثافة المرتفعة (١٠٠ بذرة/م٢) . إختلفت نسبة الفقد وتراوحت بين ١٤,١٧–١٨,٤١ %ومن ٥,٣٩–٢١,٢٠% لوزن الألف حبة في موسمى ٢٠٠٩–٢٠١٠ على الترتيب وتغيرت في محصول الحبوب بين ١٤,٧٨–٢١,٧٠ % في موسم ٢٠٠٩ في حين تراوحت مابين ١٣,٠١– ٢٦,٥٣% في موسم ٢٠١٠ . أظهر تحليل الإرتباط معنوية في العلاقة الخطية بين متوسط شدة المرض ومتوسط نسبة النقص في وزن الألف حبة ومحصول الحبوب للنبات (الإرتباط يساوى ٠,٥٦ و ٠,٥٥عند مستوى أقل من ٠,٠٥%).