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LOSSES IN WHEAT GRAIN YIELD DUE TO LEAF RUST, CAUSED BY *Puccinia triticina* Eriks

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ABSTRACT

This work was carried out at Gemmeiza Agriculture Research Station during 2010/11 and 2011/12 growing seasons, to study losses in grain yield of five susceptible wheat cultivars i.e. Gemmeiza 7, Gemmeiza 10, Gemmeiza 11,Sakha 93 and Sakha 94, to leaf rust caused by *Puccinia triticina* Eriks under field conditions. Artificial inoculation was performed using a mixture of urediospores and talcum powder (1/20) ,in addition to treated plots of the same cultivars with fungicide (Sumi-eight 5Ec) served as a protected control .Disease severity was recorded each 10 days and area under disease progress curve(AUDPC) were estimated . The tested cultivars exhibited different disease severity, 5-80%. High values of area under disease progress curve(AUDPC) were detected on Gemmeiza-7 , Sakha-93 (1225 ,925).Whereas the lowest values of yield loss were recorded on cvs. Gemmeiza 11 and Gemmeiza 10 that mean these two cultivars were tolerant to leaf rust infection under field conditions. Correlation and regression coefficions were tested between yield losses and values of AUDPC of the tested cultivars.

Key words : Wheat , leaf rust , yield loss, AUDC.

INTRODUCTION

Leaf rust caused by *Puccinia triticina* Eriks. is a widespread disease on wheat (*Triticum aestivum* L.) in Egypt and worldwide causing significant losses in grain yield Nazim *et al.,* 1983. In Egypt, it occurs annually at booting stage and thereafter large, 1954, but when the disease appears at booting stage. A high level of disease severity may be records on plants and the loss in grain yield reaches the maximum level El Dauodi *et al*., 1984. For this reason, many wheat genotypes have been discarded due to their susceptibility Rao *et al*., 1989. Herrera-Foessel *et al*.,(2006) found that mean yield losses affected by degree of cultivar susceptibility, race-specific, and slow-rusting reactions . Also , yield losses were associated mainly with a reduction in biomass, harvest index, and kernels per square meter. Smith,Lauren M. (2008) stated that leaf rust caused by *Puccinia triticina* caused serious limitation to wheat production between 1% and 40% yield loss, on average and tends to be the worst in years with high yield potential. Strategy of the wheat breeders and pathologists in Egypt aims to increase wheat production through genetic improvement wheat cultivars ,agricultural practice application and protective wheat plants against rust diseases. Among these diseases, wheat leaf rust ,warm temperatures with frequent dew periods at night provided favorable conditions for the rapid increase and spread of leaf rust disease El-Shamy,*et al*., 2011 Therefore, the present study was conducted to show the relationship between leaf rust severity and loss in grain yield and the price of wheat unit (ton) of some new released wheat cultivars.

MATERIALS AND METHODS

The experiment was performed in 2010/11-2011/2012 seasons at Gemmeiza Experimental Research Station, using five susceptible bread wheat cultivars,i.e. Gemmeiza-7, Gemmeiza-10, Gemmeiza-11 , Sakha 93 and Sakha 94.These cultivars were selected to find out the relationship between yield loss and area under disease progress curve (AUDPC). Thirty plots (3x1.2 m =3.6 m^2.) each plot contained 6 rows with 3m. and 20 cm. between rows. The experiment was planted 15 days after the regular sowing date (the first half of December) to expose the plants to suitable environment of rust incidence and development. Randomized Complete Block design with three replicates was used . The experiment was surrounded by a border of highly susceptible wheat genotypes i.e Morroco, *Tiriticum spelta saharences* and Thatcher. The protected plots were treated by the effective fungicide Sumi-eight 5Ec (CE) -1- (2,4 – Dichlaro phenyl) 35 cm /100 litter water. Plants were inspected and rust severity was recorded every 10 days intervals from rust appearance along with the stages of plant growth according to Peterson *et al.,* 1948 . Data on rust incidence were scored as severity of infection. Later on, plots of each treatment were harvested. Yield loss was estimated using simple equation as follows: -

Loss % = 1-yd/yh*100 (Colpauzos *et al.,* .1976)

Where: Yd = yield of diseased plants

Yh = yield of healthy plants

Area under disease progress curve(AUDPC) was assessed for each cultivar according to the equation adopted by Pandy (1989)

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

D = days between two consecutive recording (time intervals)

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

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

Disease assessment:

Adult plant reactions were recorded as rust severity for each cultivar, when rust appeared until the early dough stage (Large, 1954). Rust severity of each cultivar was recorded every ten days after the initial infection occurred using the modified scale (Peterson *et al.,* 1948).

Statistical parameters, least significant differences (L.S.D at 5%)was used to compare yield components according to (Snedecor,1957) correlation coefficient was used to detect the relationship between yield loss and rust severity(AUDPC).

RESULTS AND DISCOUSSION

This investigation aimed to assess loss in grain yield due to leaf rust disease on the newly released susceptible wheat cultivars. Disease severity of five susceptible wheat cultivars against leaf rust infection was determined during 2011-2012 growing seasons under field conditions by studying the relationship between rust severity area under disease progress curve (AUDCP) and yield components, meanwhile transfer to loss in money

Leaf rust occurrence:

All tested cultivars showed different disease severity ranged from 5-80 % with susceptible infection types (Table 1&2). Disease severity was high on cvs. Gemmieza 7 and Sakha 93(80%) while, cv. Sakha 94 was the least one (5%) and the rest cultivars were in between. Kolmer (1997) stated that, the cultivar Katepwa was affected severely by 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 cultivar AC Foremost had high levels of rust severity in Manitoba (Canada).

Table (1): Rust severity and Area Under Disease Progresses Curve of five wheat cultivars during 2010-2011 season.

Cultivar	Date of score/ Rust severity%				AUDPC
	10/3/2011	20/3/2011	30/3/2011	9/4/2011	
Sakha 93	5	10	40	80	925
Sakha 94	0	3	5	10	130
Gemmieza 7	5	20	50	80	1125
Gemmieza 10	0	0	3	5	55
Gemmieza 11	3	5	30	60	665

Data in table (1)and (2)indicate that area under disease progress curve (AUDPC) runs in a parallel line with disease severity, also the results showed that the highest values of AUDPC were observed on cvs. Gemmieza 7, followed by Sakha 93 (1125-925),(1225-825) respectively whereas Gemmieza 10 was the lowest one (55) at 2010/2011 growing season ,while Sakha 94 the lowest at 2011/2012. Regarding to this results, leaf rust developed rapidly on Gemmieza 7and Sakha 93 (fast rusting cultivars) whereas, the disease developed slowly on Gemmieza 11 and Sakha 94 (slow rusting rusting cultivars). Estimating yield loss by a disease is a prerequisite to developing strategies for disease control particularity through breeding objectives for disease resistance (Simmonds, 1988). Resistance of any wheat genotypes to leaf rust can be described as its capacity to reduce the amount of loss in grain yield due to infection. The susceptible varieties with low level of loss in grain yield are considered as tolerant varieties (Chakravarti and Hant, 1959; Wilcoxson *et a*l., 1974; Nazim *et al*, 1983). The effect of leaf rust infection on grain yield of wheat genotypes may be due to the effect on the photosynthetic area of the top three leaves especially flag leaf, which shares with its sheath by about 75 percentages in determining the grain weight, while the ear shares by only 25 percent. Grain shrivels and nutrients produced primarily in the flag leaf are used by the fungus rather than transported to the grain (Subla, Rao *et al*., 1989)and Nazim *et al*.,1983).

Table (2): Rust severity and Area Under Disease Progresses Curve of five wheat cultivars during 2011-2012 season.

Cultivar	Date of score/ Rust severity%				AUDPC
	14/3/2012	24/3/2012	3/4/2012	13/4/2012	
Sakh 93	5	20	30	60	825
Sakh 94	0	3	5	10	130
Gemm. 7	5	20	60	80	1225
Gemm. 10	3	5	5	10	165
Gemm. 11	5	10	20	40	525

Relationship between AUDPC and grain loss:

Statistical analysis of 1000 grain weight and yield per plot reveal highly significant differences between infected and protected treatments in all the tested cultivars in relation to rust severity .

Data in Table (3&4) showed the relationship between AUDPC and yield loss% in both 1000 grain weight and yield per plot during the two seasons. The results reveled that, high values of AUDPC were recorded on cvs. Gemmeiza-7 and cvs. Sakh -93 (1125-925) in 2011 while in 2012 (1225-825) respectively, whereas cvs. Gemmeiza-10 and Sakh 94 exhibits the lowest AUDPC during the two seasons.

Table (3): Area Under Disease Progresses Curve and yield loss in five wheat cultivars during 2010-2011 season.

Cultivar	AUDPC	1000 grain weight(gm.)			Plot weight(kg.)		
		Infected	Protected	Loss%	Infected	Protected	Loss%
Sakh 93	925	44.8	48.2	8	1.8	2.6	31
Sakh 94	130	43.5	46.22	6	2.6	3.1	16
Gemmieza 7	1125	46.8	55.3	16	2.4	3.26	26
Gemmieza 10	55	41.12	43	5	2.3	2.6	11.5
Gemmieza 11	665	52.8	53.7	2	2.4	2.56	6
L.S.D at 5%		1.98	2.25		0.4	0.48	

In the same trend, loss% in 1000 grain weight and yield per plot was less on cvs. Gemmeiza-10 and Sakh 94 . The loss% in 1000 grain weight ranged from (2-16%) in 2011 and (2- 17 %) in 2012 .While it ranged from (6 - 31%) in 2011 season and from(6 - 30%) in 2012 season yield per plot. Based on the values of wheat yield components as well as percentage reduction of these components in both protected and inoculated plants, Gemmeiza-11and Sakh 94 were the most tolerant wheat cultivars to leaf rust infection under field conditions. Andenow, *et al*. (1997) found that different cultivars differed in their responses to leaf rust disease to determine the tolerant cultivars. The percentage losses 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. Bingham *et al*.,(2008) explained the relationship between loss and disease severity as it can differ widely between crops. This has given 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.

Table (4): Rust severity ,Area Under Disease Progresses Curve and yield loss in five wheat cultivars during 2011-2012 season.

Cultivar	AUDPC	1000 grain weight (gm.)			plot weight (kg.)		
		Infected	Protected	Loss%	Infected	Protected	Loss%
Sakha 93	825	41.1	47.62	14	1.7	2.4	30
Sakha 94	130	44.4	48.12	8	2.73	3.2	15
Gemm. 7	1225	45.33	54.6	17	2.3	3.2	29
Gemm.10	165	38.57	42	9	2	2.3	14
Gemm.11	525	52.8	53.77	2	2.46	2.6	6
L.S.D at 5%		2.66	3		0.4	0.48	

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 were correlated strongly with area under disease progress curve, which means that high levels of partial resistance are needed to prevent significant yield damage. El-Shamy *et al*.,(2011) found that a significant correlation between mean disease severity and percentage loss for 1000 kernel and grain yield/plant.

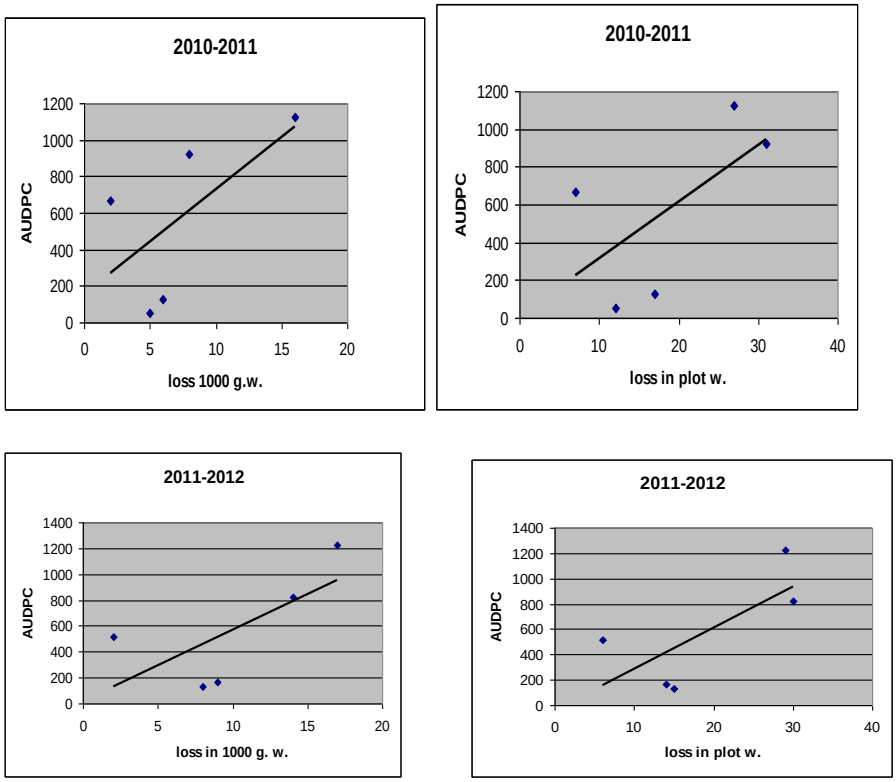

Fig.(1): Graphs showing relationship between AUDPC and loss in grain yield in both two season.

The graph showed that area under disease progress curve (AUDPC) run in a parallel line with yield loss. Also, high correlation value was found between yield loss with different R^2(0.63- 0.99).AUDPC is the result of all factors that influenced disease development such as environments, cultivars and population of the pathogen (Pandy *et al*.,1989).

Table (5): Yield loss per Faddan in both grain yield and price during the two seasons

Cultivar	Season 2011		Season 2012	
	Loss in grain kg.	Loss in price Egyptian pound	Loss in grain kg	Loss in price Egyptian pound
Sakh 93	933	2333	816	2040
Sakh 94	583	1458	546	1365
Gemmieza 7	1003.3	2508	1050	2625
Gemmieza 10	350	875	350	875
Gemmieza 11	186.6	466	163.3	408

***Plot size 3.6 m^2**
***Wheat unit = ardab=150kg.**
***Price of the unit=375 Egyptian pound**
*** Fadden= 4200 m^2**

Results in table (3) indicated that, loss in grain yield in 2011 growing season ranged between 186.6- 1003.3 kg/ Fadden whereas in season 2012 the loss between 163.5-1050 kg/ Faddan. these results showed that Gemmieza 7 was the most affected cultivars with infection by the leaf rust fungus *Puccinia triticina* meanwhile Gemmieza 11 was tolerant to leaf rust under field conditions followed by Gemmieza 10. In the same trend the highest loss in money was observed in Gemmieza 7. In this regards cultivar Gemmieza 7 exhibit 80% rust severity ,the loss will be 933(kg.) and the loss of money will be(2040 Egyptian pounds) meanwhile if the cultivar exhibit low rust severity the los will be less (Gemmieza 11). These results agree with ths economic assessments in the United Kingdom (UK) by Priestley & Bayles (1988) provided estimates of losses in susceptible winter wheats due to stripe rust and leaf rust of £83 million with the value of disease resistance estimated

REFERENCES

Andenow, Y., Hullukal, M., Belay, G. and Tesemma1, T. (1997), Resistance and tolerance to leaf rust in Ethiopian tetraploid wheat land races. Plant Breeding, 116: 533–536.

Bingham *et al*.,(2008) Bengham, L.J.; D.R. Watters; H.J. Foulkes and N.D. Paveley (2008). Crop traits and the tolerance of wheat and barley to foliar diseases. Annals of App. Biology, Vol154: 159-173.

Colpauzos, J.; Roelfs, A.P.; Madson, M.E.; Martin, F.B. and Wilconxson, R.D. (1976). A new model to measure yield losses caused by stem rust in spring wheat. Agric. Exp. Sta. Univ.Minnesota, Tech. Bull. 307 (1-23).

Herrera-Foessel, S. A.; Singh, R. P.; Huerta-Espino, J.; Crossa, J.; Yuen, J. and Djurle, A..(2006).Effect of Leaf Rust on Grain Yield and Yield Traits of Durum Wheats with Race-Specific and Slow-Rusting Resistance to Leaf Rust. Plant Disease, Volume 90, Number 8 : 1065-1072.

El- Daoudi, Y.H.; Nawal, A. Abdel- Hamid and Nabila El-Sherif (1984). "Effect of leaf rust infection on yield and seed quality of two wheat varieties" Agricultural Research Center Vol. 62:33-39.

El-Shamy, M.M.,; Minaas, A. Salam and Abd El-Kader,M.H.(2011). Effect of sowing density of some susceptible bread wheat cultivars on tolerance to leaf rust disease. Zagazig J.Agric.,Res., Vol.38 No. (2).

Large, E.C. (1954): Growth stages in cereals. Illustration of the Feekes scale. PL. parth. , 3:128-129.

Nazim , M. ; A.A El- shehidi ; Y.A. Abdou and Y.H. El-Daoudi (1983): Yield loss caused by leaf rust on four wheat cultivars under epiphytotic levels. 4th Conf. Microbiol., Cairo 1983, PP. 17-27.

Ochoa, J. and J.E. Parlevliet (2007). Effect of partial resistance to brley leaf rust, *Puccinia hordei*, on the yield of three barley cultivars. Euphytica, 153 : 309 -312.

Pandy, H.N.; T.C. Menon and M.V. Rao (1989). A simple formula for calculating area under disease progress curve. Rachis, 8(2) : 38 – 39.

Peterson, R.F.; A.B. Campbell and A.E. Hannah (1948): A diag rammatic scale for estimating rust intensity on leaves and stems of cereals. Can. J. Res., 60: 496-500.

Priestley RH and Bayles RA 1988. The contribution and value of resistant cultivars to disease control in cereals. *In* 'Control of Plant Diseases, Costs and Benefits'. (Eds BC Clifford and E Lester.) pp. 53-65. (Blackwell Scientific Publications: Oxford.)

Kolmer, J.A.(1997).Virulnce in Puccinia recondita f.sp.tritici isolates from Canada to genes for adult plant resistance to wheat leaf rust.Plant Disease 81: 267-271

Rao, K.V.S.; J.P. Snow; G.T. Berggen and K.V. Subba- Rao (1989): "Effect of growth stage and initial inoculum level on leaf rust development and yield loss, caused by *Puccinia recondita* f. sp. *tritici*. Phytopathology 79:3,200-210.

Shaner, G.; H.W. Ohm and R.E. Finnay (1978). Response of susceptibility and slow leaf rusting of wheats to infection by *Puccinia recondita*. Phytopathology, 68: 47 – 475.

Simmonds N.W. (1988). Synthesis the strategy of rust resistance breeding N.W. Simmonds and S. Rajaram (eds), Breeding Strategies for Resistance to the Rusts of wheat, 119 - 136, CIMMYT. Mexico. D.F.

Smith, Lauren M. (2008). Mapping of drought tolerance and leaf rust resistance in wheat. Master of Science,Biology, Genetics, Department of Agronomy, Kansas State University.

Subba Rao, K.V. ; X.B. Yang ; G.T. Berggren and J.P. Snow (1989). A multiple regression model to estimate the contributions of leaves and the effects of leaf rust on yield of winter wheat Phytopathology 79: 1233- 1238.

Snedecor, G.W.(1957). Statistical Methods, 5th eds.Iowa State College Press, Ames, Iowa.

Wilcoxson, R.D.; A.H. Atif and B. Skovmand (1974). Slow-rusting of wheat varieties in the field correlated with stem rust severity on detached leaves in the greenhouse. Pl. Dis. Reptr. 28:1085-1087.

الفقد فى محصول حبوب القمح المتسبب عن الاصابه بمرض صدأ الاوراق,بكسينيا تريتيسينا

محمـــد عبـــد القـــادر حســـن ، عبـــد العزيـــز عبـــد الناصـــر ابـــو علـــى و امل عزت عبد الغنى الشهاوى
معهد بحوث امراض النباتات – مركز البحوث الزراعيه – الجيزة

يهدف هذا البحث الى دراسة الفقد فى محصول الحبوب فى خمسة اصناف من القمح المصرى الحساس للاصابه بصدأ الاوراق وهما جميزه 7, جميزه ,10 جميزه11سخا 93و سخا94 الاوراق تحت الظروف الحقلية بمحطة بحوث الجميزة خلال موسمين زراعين 2010/ 201 و 2012/2011 حيث تمت عدوي النباتات بخليط من جراثيم الصدأ البرتقالي وبودرة الثلج ,عوملت القطع المحميه بالمبيد الفطرى سومى-8 ككنترول .سجلت شدة الاصابة وطراز الاصابه كل عشرة ايام , اظهرت الاصناف المختبره شدة اصابه تراوحت من 5-80% مع طراز الاصابه الحساس, قدرت نسب المساحه الواقعه تحت المنحى المرضى ,وجدت اعلى قيم من المساحه الواقعه تحت المنحنى المرضى فى الاصناف جميزه 7 وسخا 93 (1225-925) كما وجد ارتباط عالى فى الفقد فى المحصول وقيم المساحه الواقعه تحت المنحنى المرضى. كما اوضحت النتائج ان اقل فقد فى المحصول كان على صنفى القمح جميزة 11 وجميزة 10 لذلك تعتبر هذه الاصناف ،اصناف متحمله للاصابه بمرض صدأ الاوراق.

قام بتحكيم البحث

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