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INHERITANCE OF STRIPE RUST RESISTANCE IN FIVE EGYPTIAN BREAD WHEAT CULTIVARS CROSSED TO FOUR Yr's

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ABSTRACT

The inheritance of resistance in 5 Egyptian bread wheat cultivars (*Triticum aestivum*, L.) crossed to 4 Yr's was studied. These parents, F_1's and F_2's were tested under greenhouse conditions at seedling stage against pathotype (race) 230E18 of *Puccinia striiformis* Westend. All of the tested parents and F_1's exhibited a susceptible phenotype. All crosses, F_2's plant populations were segregated into digenic pairs. The dominance was in the side of susceptibility while resistance genes were recessive. On the other hand, under field conditions, at adult plant stage against more virulent race mixtures of that pathogen, the tested (cv.) parents, Oxly (Yr 6 +APR), Yr18, Giza 168, Sakha 61 and Sids1 showed low rust severity, while Yr 2, Yr 9 ; Sakha 8 and Sakha 69 showed high rust severity. The F_1's showed that all of the crosses exhibited low rust severity except for four crosses i.e. Yr 18 X Sakha 69 , Yr 2 X Sakha 69 , Yr 9 X Sakha 8 and Yr 9 X Sakha 69 which possessed high rust severity. Seven crossess out of the F_2 plant populations were segregated fitting the expected ratios 7(R) : 9(S) , 1(R) :15(S) , 3(R) :13(S) and 9(R) : 7(S). While the rest of crosses (Yr 18 X Giza 168 and Yr 2 X Sakha 61) showed no segregation and was directed to the side of dominance of resistance. The cultivar Giza 168 may have Yr 18 and also Sakha 61 have Yr 2 in adult plant stage under field conditions. These findings confirmed that this gene is effective under the Egyptian environmental conditions except for Yr 2 which showed high rust severity. From these results, it could be concluded that the selection for slow rusting materials in the early generations was possible, but delaying it to late ones is more effective, due to the important role of dominance effect in the expression of this trait.

INTRODUCTION

Yellow rust of cereals caused by *Puccinia striiformis* Westend f.sp. tritici Erikson and Hennen is potentially a damaging disease in all cool temperature climates (Roelfs *et al*., 1992), although its range is now extending to warmer and more arid regions such as Yogoslavia and Iran (Elahinia, 1998). Yellow rust is considered more sensitive to environmental conditions than other cereal rusts (Zadoks, 1968). Urediniospore germination is dependent on genetic constitution and environmental conditions (Osman-Ghani and Manners, 1983). In Egypt, it was a sporadic disease because its occurrence was noticable every 8-10 years during the past three - four decads with the exception of what happened during the 1990's throughout the Middle East areas, (Abu El Naga *et al*., 1997 and 1998). The critical times of such disease in Egypt has been truly recognized epidemically from 1967/68 on wheat cv. Giza 144 at Manzala district , Dakahlia Governorate during

1994/95, 1996/97 , 1997/98 and 1999/2000 on cvs Sakha 69, Giza 163, Gemmeiza-1 and most of the commercial cvs. especially the long spiked ones at the northern Governorates in particular, (Abu El Naga *et al*., 1998 , 1999a and 1999b) and (Youssef *et al*., 2003).

The deployment of disease resistant varieties is the most effective approach to reduce fungicide usage and minimize crop losses. Breeding program is mainly based on three kinds of resistance. One of these, refered to overall resistance, operates in all growth stages of the plant and is effective under a wide range of environmental conditions. The other two kinds of resistance are often detected in the field at the adult plant stage and are therefore called " field resistance " . One being conferred by genes sensitive to environmental conditions which prevail in summer and coincide with the adult plant stage , the other could be detected by genes which come to expression only in the adult plant stage. Transitions and intermediate situation between the latter two kinds of resistance may be existed (Pope, 1968); (Sharp and Fuchs, 1982); (Qayome and Line, 1985); (Millus and Line, 1986) and (Mallard *et al*., 2005). Therefore the main target of the present study was to identify adult plant resistance genes in commercial cultivars and to determine the number of genes in the cross.

MATERIALS AND METHODS

The present work was carried out at Sakha Agricultural Research Station, Kafr El-Shiekh, during the period (2008 – 2011).

Five Egyptian commercial wheat cultivars i.e. Sakha 8, Sakha 69, Giza 168, Sakha 61 and Sids1 exhibited different levels of susceptibility or resistance, they were crossed to number of monogenic lines (Yr's) i.e. Oxly (Yr 6+APR), Jupatico (Yr18), Kalynsona (Yr 2) and Fed. 4 / Kavkaz (Yr 9) which showed resistance with Yr 6 and Yr18 showed susceptibility with Yr 2 and Yr 9. So they were chosen as parental materials in the present investigation. The monogenic lines (Yr's) were used as male parents, while Egyptian commercial wheat cultivars were used as female parents. The crosses among (Yr's) and Egyptian wheat cultivars i.e. (Yr 6 X Sakha 8) , (Yr18 X Sakha 69) , (Yr18 X Giza 168) , (Yr 2 X Sakha 69) , (Yr 2 X Sakaha 61) , (Yr 9 X Sakha 8) , (Yr 9 X Sakah 69) , (Yr 9 X Giza 168) and (Yr 9 X Sids 1), were carried out during the first season.

The parental seeds were sown during 2008/2009 growing season in plots with 1.5 m long and 30 cm apart. Each row was sown to 15 seed with a distance of 10 cm each. The experimental unite included 4 rows of each parent. The parents were selected on the basis of their reaction to yellow rust in the field during the elapsed growing seasons. In 2009/2010 growing season, part of 9 (Yr's X local varieties) crosses of hybrid seed were sown to produce F_1 plants and the other part was left for the final experiment in the next growing season. In 2010/2011 growing season, evaluation of parents, F_1 and F_2 plant populations against single race i.e. 230E18 of yellow rust pathogen caused by *Puccinia striiformis* under greenhouse conditions was done as follows:

A- For seedling test (in the greenhouse) at Sakha Agricultural Research Station. Three replicates, each one pot for each of parents and F_1's as well as 13 pots of each of F_2 plant populations were sown. These materials were tested at controlled conditions in the greenhouse with daylight rhythm of 16/8 hours. Light intensity was approaxmatly 7500 Lux and temperature of 5-10 C was adjusted for day/night in the permanent cabenits. The plants were ready to be inoculated at 8 days of sowing. The plants were inoculated following the method of (Stubbs, 1988), in which , plants were dusted with mixture of spores and Talcum Powder at the rate 1:20 (w:w) or tightly rubbing method. Inoculated plants were kept in an incubator apparatus for 24 hours at 90% relative humidity and 10 C and transferred to the growth chamber for 14 days. Infection types were recorded 15 days after inoculation using a 0-9 scale adopted by (Mc Neal *et al*., 1971). Scores of 0-6 were normally considered as having low infection type (resistant) and 7-9 as having high infection type (susceptible), (Mc Neal *et al*., 1971) as used in the seedling studies, where 0:immune, 1 to 3 were classified as resistant, 4 to 6 were intermediate and 7 to 9 were susceptible.

B- Adult plant test (under field conditions): Thirteen plot, each plot included 16 rows, one row for each parent and F_1 as well as 13 row for F_2 plant populations, the row measured 2 m long, spaced 30 cm apart and seeds measured 10 cm apart within row. Each row was sown with 20 seed. The adjacent plots were separated by a 1m wide belt. All plots were surrounded by a spreader area of one meter in width, planted to a mixture of the three highly susceptible cultivars to yellow rust pathogen i.e. Triticum Spelta Saharensis, Morocco and Little Club. For the field inoculation, the spreader plants were moistend and dusted with spore – Talcum Powder mixture of the most prevalent yellow rust races in the area (one volume of fresh urediospores mixture : 20 volume of Talcum Powder). Dusting was carried out in the early evening at (sunset) before dew formation and when air still in, following the methods of (Tervet and Cassel, 1951).

All regular cultural practicies assigned for wheat crop were applied during the growing season. Data were recorded according to the technical recommendations as rust severity for each cultivar.

C- Genetical Study : To study the inheritance of stripe rust resistance, the F_2 plant populations were divided into 12 categories depending upon their percentage of rust severity under field conditions. These classes were 0 , 0;, 10R, 10MR, 20MR ; 10MS, 20MS, 10S, 20S, 30S, 40S, and 50S. Plants of the first five classes were pooled together and considered as low rust severity (resistant phenotype). However, plants in the other classes were considered as high rust severity (susceptible phenotype). Frequency distribution values were recorded for parents, F_1 and F_2 plant populations in terms of infection type in all of the crosses at seedling as well as adult plant stage. Qualitative and quantitative analyses regarding the mode of inheritance, goodness of fit to expected ratio of the phenotype classes relevant to the stripe rust severity and infection type which were determined using X^2 analysis (Steel and Torrie, 1960). The minimum number of effective genes controlling slow-rusting resistance in each cross was estimated by the formula of (Wright, 1968).

Degree of dominance was calculated according to the method suggested by (Romero and Frey, 1973). Heritability in its broad-sense was estimated according to (Lush, 1949).

RESULTS

Stripe rust infection type developed uniformly throughout the experiments and parental varieties exhibited consistent disease reactions between (Yr's x Local variety) against race 230E18 at seedling stage under greenhouse conditions in 2010/2011 growing season.

Data obtained in Table (1) showed that this group was represented by nine crosses (susceptible x susceptible) i.e. Oxly (Yr_6 + APR) x Sakha 8, Yr_{18} X Sakha 69 , Yr_{18} X Giza 168, Yr_2 X Sakha 69 , Yr_2 X Sakha 61, Yr_9 X Sakha 8, Yr_9 X Sakha 69, Yr_9 X Giza 168 and Yr_9 X Sids1. The F_1 plant infection type tend to the side of susceptibility similar to their parents. Meanwhile, F_2 plant populations infection type indicated that the nine tested crosses were segregated to the side of susceptibility dominance. However, the number of F_2 resistant plants : susceptible ones (observed ratios) of these crosses were : 42:165 , 17:185 , 98:110 , 34:173 , 18:185 , 18:192 , 17:185 , 97:115 and 45:158.

The observed ratios fitted the theoritical expected ratios i.e 3:13 , 1:15 , 7:9 , 3:13 , 1:15 , 1:15 , 1:15 , 7:9 and 3:13 with P. values i.e. 0.500-0.750 , 0.100-0.250 , 0.250-0.500, 0.250-0.500 , 0.100-0.250 , 0.100-0.250 , 0.100-0.250 , 0.500-0.750 and 0.100-0.250, which suggests insedence of digenic pairs controlling independent recessive genes conditioning resistance to race 230E18 Table (1).

Data presented in Table (2) showed that the nine crosses could be divided into six categories i.e. MR X S , MR X R , MS X S , MS X R , S X S and S X R sequently. The first category was represented by two crosses i.e. (Yr_6 + APR) X Sakha 8 and Yr_{18} X Sakha 69, the second group included one cross Yr_{18} X Giza 168, the third group consists of one cross Yr_2 X Sakha 69 , the fourth group also included one cross Yr_2 X Sakha 61, the fifth group included two crosses Yr_9 X Sakha 8 and Yr_9 X Sakha 69 and the sixth group was represented by two crosses i.e Yr_9 X Giza 168 and Yr_9 X Sids1.

The F_1 tested plants showed the same trend with two parents or with one parent. Five crosses out of nine exhibited resistance in terms of (slow-rusting) i.e. (Yr_6 +APR) X Sakha 8 , Yr_{18} X Giza 168 , Yr_2 X Sakha 61 , Yr_9 X Giza 168 and Yr_9 X Sids1. Regarding, the F_2 plant populations, two out of nine crosses i.e. Yr_{18} X Giza 168 and Yr_2 X Sakha 61 were resistant and no segregation for susceptibility could be detected. These results proved that, these two cultivars i.e. Giza 168 and Sakha 61 likely carry the yellow rust resistance gene i.e. Yr_{18} and Yr_2, sequently. The rest of crosses i.e. (Yr_6 + APR) X Sakha 8, Yr_{18} X Sakha 69 , Yr_2 X Sakha 69 , Yr_9 X Sakha 8 , Yr_9 X Sakha 69 , Yr_9 X Giza 168 and Yr_9 X Sids1 were segregated in ratios ranging between resistant and susceptible infection type (slow rusting – fast rusting) , which fitted the expected ratios of 7:9 , 7:9 , 3:13 , 1:15 , 3:13 , 7:9 and 9:7 , indicating that these cultivars when crossing with Yr's gene don't have this gene inside cultivar. However, the cultivars Giza168 and Sids1 crossed to Yr_9

indicated the presence of complementary gene action governing the dominance of resistnce over susceptibility, this would indicate that cvs. Giza168 and Sids-1 may have different minor genes that cause slow-rusting.

Table (1): Stripe rust infection type and disease severity of 9 crosses between 4 stripe rust monogenic lines and 5 Egyptian commercial wheat varieties against race 230E18 of *P.striiformis* at seedling stage and the ratios of segregation of F_2's under greenhouse conditions in 2011/2012 growing season.

No.	Cross name		Infection type of race 230E18											Observed ratio		Expected ratio	X^2	Probable values
			0	0;	1	2	3	4	5	6	7	8	9	L	H	L : H		
1	Oxly (yr_6+APR)	P_1									2	18						
	Sakha 8	P_2										3	17					
		F_1									17	3						
		F_2						5	12	25	50	70	45	42	165	3:13	0.324	0.500-0.750
2	Jupatico (yr_{18})	P_1										3	17					
	Sakha 69	P_2										17	3					
		F_1									2	18						
		F_2							5	12	40	80	65	17	185	1:15	1.638	0.100-0.250
3	Jupatico (yr_{18})	P_1										3	17					
	Giza168	P_2									1	19						
		F_1									19	1						
		F_2					8	10	40	40	50	40	20	98	110	7:9	0.956	0.250-0.500
4	kalyanson (yr_2)	P_1										2	18					
	Sakha 69	P_2										17	3					
		F_1									2	18						
		F_2						4	12	18	29	75	69	34	173	3:13	0.729	0.250-0.500
5	kalyanson (yr_2)	P_1										2	18					
	Sakha 61	P_2									3	17						
		F_1									18	2						
		F_2							6	12	70	100	15	18	185	1:15	2.238	0.100-0.250
6	Fed.4/kavkaz (yr_9)	P_1										1	19					
	Sakha 8	P_2										3	17					
		F_1									18	2						
		F_2							3	15	50	105	37	18	192	1:15	2.04	0.100-0.250
7	Fed.4/kavkaz (yr_9)	P_1										1	19					
	Sakha 69	P_2										17	3					
		F_1									3	17						
		F_2							4	13	60	80	45	17	185	1:15	1.638	0.100-0.250
8	Fed.4/kavkaz (yr_9)	P_1										1	19					
	Giza 168	P_2									1	19						
		F_1									19	1						
		F_2						7	40	50	50	60	5	97	115	7:9	0.3461	0.500-0.750
9	Fed.4/kavkaz (yr_9)	P_1										1	19					
	Sids 1	P_2									2	18						
		F_1									17	3						
		F_2						10	12	23	60	68	30	45	158	3:13	1.534	0.100-0.250

Table (2): Stripe rust infection type and severity of 9 crosses between 4 stripe rust monogenic lines and five Egyptian commercial wheat varieties against race mixtures of *P.striiformis* and their segregation at adult plant stage under field conditions in 2011/2012 growing season.

No.	Cross name		Mean of rust severity %													Observed ratio		Expected ratio	X^2	Probable values
			0	0;	10 R	10 MR	20 MR	10 MS	10 S	20 S	30 S	40 S	50 S	60 S	70 S	L	H	L : H		
1	Oxly (Yr_6+APR)	P_1				1	19													
	Sakha 8	P_2						1	19											
		F_1				2	18													
		F_2		10	13	25	50	60	30	10	6	2				98	108	7:9	1.262	0.250-0.500
2	Jupatico (Yr_{18})	P_1			2	18														
	Sakha 69	P_2										1	19							
		F_1						19	1											
		F_2		5	15	30	40	45	40	30	10	5				90	130	7:9	0.720	0.250-0.500
3	Jupatico (Yr_{18})	P_1			2	18														
	Giza168	P_2				1	19													
		F_1		2	18															
		F_2		14	30	50	110									204	0	1:0	0.0	0.99
4	kalyanson (Yr_2)	P_1						19	1											
	Sakha 69	P_2										1	19							
		F_1						17	3											
		F_2			4	20	20	35	75	54						44	164	3:13	0.788	0.250-0.500
5	kalyanson (Yr_2)	P_1						19	1											
	Sakha 61	P_2			1	19														
		F_1			2	18														
		F_2		9	23	80	97									209	0	1:0	0.0	0.99
6	Fed.4/kavkaz (Yr_9)	P_1							2	18										
	Sakha 8	P_2						1	19											
		F_1							17	3										
		F_2			2	3	12	25	92	60	10					17	187	1:15	1.511	0.100-0.250
7	Fed.4/kavkaz (Yr_9)	P_1							2	18										
	Sakha 69	P_2										1	19							
		F_1							17	3										
		F_2			5	13	17	18	30	70	40	19				35	177	3:13	0.696	0.250-0.500
8	Fed.4/kavkaz (Yr_9)	P_1							2	18										
	Giza 168	P_2				1	19													
		F_1				3	19													
		F_2		11	16	30	55	52	20	10	8	6				112	96	9:7	0.487	0.250-500
9	Fed.4/kavkaz (Yr_9)	P_1							2	18										
	Sids 1	P_2			18	2														
		F_1				3	17													
		F_2		12	15	30	60	50	25	10	8	5				117	98	9:7	0.287	0.500-0.750

Quantitative analysis :

To study genetic behaviour of infection type and wheat partial stripe rust resistance quantitatively, the two parents, F_1 and F_2 plant populations for each of the nine crosses were tested at both seedling and adult stages under both greenhouse and field conditions. Population means of the parents, F_1's and F_2's were used to estimate the degree of dominance for F_1 (h_1) and F_2 (h_2), the heritability in its broad-sense and the number of functioning genes for each cross {Tables (3) and (4)}.

At seedling stage under greenhouse conditions :

The obtained data in Table (3) demonstrated that means of infection types to (Yr's x cvs.) i.e. (Yr_6 + APR) , Yr_{18} , Yr_2 , Yr_9 ; Sakha 8 , Sakha 69 , Giza 168 , Sakha 61 , and Sids1, were determined as 7.9 , 8.85 , 8.9 , 8.95 ; 8.85 , 8.15 , 7.95 , 7.85 and 7.9, sequently . The F_1 and F_2 mean values in nine crosses showed values lower than their mid-parent values, indicating the presence of resistance (low infection type) . Expression of gene actions measured as the degree of dominance (h_1 and h_2) has been shown in Table (3). The estimated values of (h_1 and h_2) aslo showed the segnificant negative values of h_1 and h_2 (low infection type less than mid-parent) also , suggested the manifestation of resistance for stripe rust resistance.

Table (3): Means of P_1, P_2, F1, F_2 and X MP, degree of dominance of F_1 (h_1) and F_2 (h_2) as well as broad-sense heritability for infection type of 9 wheat crosses inoculated with race 230E18 of *P.striiformis F. sp. tritici* at seedling stage under greenhouse conditions in 2011/2012 growing season.

No.	Cross name	Mean of infection type					Degree of dominance		Heritability	No. of genes
		P_1	P_2	F_1	F_2	XMP	h_1	h_2		
A-	S X S									
1	Oxly (yr_6+APR) x Sakha 8	7.9	8.85	7.15	7.463	8.37	-2.578	-3.84	92.64	0.0786
2	Jupatico (yr_{18}) x Sakha 69	8.85	8.15	7.9	7.93	8.5	-1.71	-3.25	88.20	0.06918
B-										
3	Jupatico (yr_{18}) x Giza 168	8.85	7.95	7.05	6.509	8.4	-3.0	-8.40	96.83	0.044
C-										
4	kalyanson (yr_2) x Sakha 69	8.9	8.15	7.9	7.76	8.52	-1.66	-4.037	93.58	0.0466
D-										
5	kalyanson (yr_2) x Sakha 61	8.9	7.85	7.1	7.52	8.37	-2.428	-3.249	85.2	0.2286
E-										
6	Fed.4/kavkaz (yr_9) x Sakha 8	8.95	8.85	7.1	7.75	8.9	-36.0	-45.92	88.48	0.0018
7	Fed.4/kavkaz (yr_9) x Sakha 69	8.95	8.15	7.85	7.73	8.55	-1.75	-4.065	88.62	1.105
F-										
8	Fed.4/kavkaz (yr_9) x Giza168	8.95	7.95	7.05	7.58	8.45	-2.8	-7.33	96.87	0.084
9	Fed.4/kavkaz (yr_9) x Sids 1	8.95	7.9	7.15	7.251	8.42	-3.0	-5.529	94.66	0.090

At adult plant stage, under field conditions :

Data in Table (4) indicated that mean of disease severity (%) for (Yr's x cvs.) i.e. (Yr_6 + APR) , Yr_{18} , Yr_2 , Yr_9 ; Sakha 8 , Sakha 69 , Giza 168 , Sakha 61 and Sids1 were recorded as 7.8 , 3.8 , 8.1 , 19.1 ; 9.9 , 49.5 , 7.8 , 3.9 , 2.2, sequently. The F_1 values were : 7.6 , 8.1 , 1.8 , 8.3 , 3.8 , 11.5 , 11.5

, 7.4 and 7.4. Also, F_2 values were : 8.57 , 10.59 , 5.58 , 11.33 , 5.46 , 13.39 , 18.87 , 9.077 and 8.93, respectively.

Expression of gene action measured as the degree of dominance (h_1 and h_2) are shown in the same Table (4). The estimated values of h_1 and h_2 exhibited negative values in the nine crosses suggesting the manifestation of partial dominance (slow- rusting) for stripe rust resistance and supported the F_1's results. The heritability values of all of the tested crosses at seedling stage and adult plant stage are measured at high values {Tables (3) and (4)}. Number of genes : the minimum number of effective genes controlling the resistance was digenic recessive for each of the nine crosses at the seedling stage {Table (3)}. While in the adult plant stage , there was a difference between each of the two parents that was controlled by digenic recessive, dominance or no segregation for susceptibility , the calculated number of genes was recorded in {Tables (3 and 4)}.

Table (4): Means of P_1, P_2, F_1, F_2 and X MP, degree of dominance of $F_1(h_1)$ and F_2 (h_2) as well as broad-sense heritability for rust severity % of 9 wheat crosses inoculated with race mixtures of *P.striiformis* at adult plant stage under field conditions in 2011/2012 growing season.

No.	Cross name	Mean of rust severity					Degree of dominance		Heritability	No. of genes
		P_1	P_2	F_1	F_2	XMP	h_1	h_2		
A-	R-MR X S									
1	Oxly (yr_6+APR) x Sakha 8	7.8	9.9	7.6	8.57	8.85	-1.19	-0.533	97.79	0.0148
2	Jupatico (yr_{18}) x Sakha 69	3.8	49.5	8.1	10.59	26.65	-0.811	-1.405	83.317	4.02
B-	MR x R									
3	Jupatico (yr_{18}) x Giza 168	3.8	7.8	1.8	5.58	5.8	-1.99	-0.22	93.67	0.269
C-	Ms x S									
4	kalyanson (yr_2) x Sakha 69	8.1	49.5	8.3	11.33	28.8	-0.99	-1.68	93.92	7.28
D-	Ms x R									
5	kalyanson (yr_2) x Sakha 61	8.1	3.9	3.8	5.46	6.0	-1.047	-0.51	96.14	0.3646
E-	S x S									
6	Fed.4/kavkaz (yr_9) x Sakha 8	19	9.9	11.5	13.39	14.45	-0.648	-0.465	81.435	0.388
7	Fed.4/kavkaz (yr_9) x Sakha 69	19	49.0	11.5	18.87	34.0	-1.5	-2.016	92.3	1.103
F-	S x R									
8	Fed.4/kavkaz (yr_9) x Giza 168	19	7.8	7.4	9.077	13.4	-1.071	-1.543	93.73	0.258
9	Fed.4/kavkaz (yr_9) x Sids 1	19	2.2	7.4	8.93	10.6	-0.38	-0.397	93.62	0.648

DISCUSSION

Yellow or (stripe) rust caused by *Puccinia Striiformis* is cosidered to be an important disease of wheat worldwide. This is mainly due to the ablility of the pathogen to mutate , rapidly multiply, and to use their air-borne dispersal mechanism from one field to another and even long distance. Stripe rust , which progresses in plants also, in a systemic manner , is often not possible to identify fully compatible stripes in adult growth stages. Johnson (1988) presented examples of adult resistance genes that are race- specific in nature. It is difficult to distinguish such resistance from the resistance conferred by genes of race- non- specific nature based on the adult plant infection type. At least some reduction in infection type is most often associated with low disease severity. However , it was observed that in case of potentially durable slow rusting resistance, the first uredinia to appear are moderate susceptible to susceptible. Subsequent growth of the fungal mycelium causes some chlorosis or necrosis ; therefore , the final infection type not uredinia , is usually rated as moderately resistant to moderately susceptible (MR-MS). While , slow- rusting to leaf rust is charactarized by slow disease progress in the field despite a compatible either high or susceptible , infection type. Cultivars carrying slow- rusting resistance show high infection in the seedling growth stage.

The obtained results indicated the presence of nine crosses (susceptible x susceptible) i.e. (Yr_6 + APR) x Sakha 8 , Yr_{18} X Sakha 69 , Yr_{18} X Giza 168 , Yr_2 X Sakha 69 , Yr_2 X Sakha 61 , Yr_9 X Sakha 8 , Yr_9 X Sakha 69 , Yr_9 X Giza 168 and Yr_9 X Sids1. These crosses showed segregation patterns confirming the expected ratios resistant : susceptible i.e. 3:13 , 1:15 , 7:9 , 3:13 , 1:15 , 1:15 , 1:15 , 7:9 and 3 :13 respectively, which suggested the presence of digenic control and dominance of susceptibility over resistance.

The F_2 plant populations showed segregation for all of the tested crosses indicating that their cultivars don't have any of the tested Yr's in seedling stage at least against race 230E18 of *Puccinia striiformis*. These results were supported by the findings of (Anpilogova, 1983) who poiented out that the resistance was controlled by recessive genes in some cases and dominant in others. (Qayom and Line, 1985) confirmed that resistance in wheat seedlings are controlled by recessive or dominant genes at both low or high temperature. (Millus and Line 1986) indicated that seedling resistance to stripe rust was partially recessive whereas, (Kema *et al* ., 1986) indicated that all of the tested wheat cvs that proved their resistance in adult although they were susceptible in seedling against race 360E137A. (Dulto and Demir, 1983) confirmed that genes controlling resistant in adult stage against stripe rust are not the same in seedling stage. (Chen and Line, 1995) suggested to make crosses in the breeding program between cvs having seedling resistance with those proved to have (HTAP) as female. (Yadav, 1997) found that the crosses between Hindi 62 (susceptible to stripe rust) and Kanchan (resistant), the resulted cross exhibited moderate resistance to stripe rust . (Wagoir *et al*., 1999) pointed out that additivity, dominance and epistasis play a significant role in the genetic control of wheat stripe rust and (Wang *et al*., 1997) found that 7 out of 9 cultivars showed susceptipility in seedling and resistance in adult plant stage started as temperature increased.

The obtained results revealed that all the F_2 plant populations of two from nine crosses i.e. Yr_{18} X Giza 168 and Yr_2 X Sakha 61 exhibited low rust severity showing no segregation and indicating that the cultivars Giza 168 carries gene Yr_{18} and Sakha 61 carries gene Yr_2. However, the rest of crosses i.e. (Yr_6+APR) X Sakha 8 , Yr_{18} X Sakha 69 , Yr_2 X Sakha 69 , Yr_9 X Sakha 8 , Yr_9 X Sakha 69 , Yr_9 X Giza 168 and Yr_9 X Sids1 were segregated as low:high rust severity with expected ratios i.e. 7:9 , 7:9 , 3:13 , 1:15 , 3:13

, 9:7 and 9:7, reveals that these cultivars don't have tested Yr gene in cultivar. From this result which indicated that Giza 168 carries gene Yr_{18} and Sakha 61 carries gene Yr_2, these findings showed that these genes were effective under the Egyptian environmental conditions. Therefore, it must be transferred to the Egyptian genetic materials as a yellow (stripe) rust resistance source in breeding programs taking into consideration that Yr_2 is susceptible under Egyptian conditions. These results disagreed with those of (Park and Wellings 1992) who indicated that stripe rust races were avirulent to Yr_2 in Austuralia. On the other hand, (Singh 1992 b) and (McIntosh 1992) found that Lr_{34} of leaf rust is closely linked with Yr_{18}, which confers slow rusting to srtipe rust throughout the increase of latent period and decreasing infection length and frequancy.The use of cv. Jupatico 73R (which is better than Jupatico 73S) played a significant role in such regard , (Ma and Singh 1996) indicated that the presence of Yr_{18} within the entries protected the grain yield by (31% to 52%). (Alvarez- Zamarano 1995) explained the role of Yr_{18} in decreasing susceptibility (slow rusting) throughout electromicroscope studies, since the presence of Yr_{18} leads to the accumulation of (cell wall apposition) causes a thickening of the cell wall of the mesophyll, that caused the progress of the haustorial mother cell and this would delay or blocking the fungal establishment. (Singh 1992 b) and (McIntosh 1992) indicated that the moderate level of durable adult plant resistance of the CIMMYT dirived US wheat cultivar Anza is controlled by gene Yr_{18}, which is also present in winter wheats such as Bezostaja. As mentioned earlier, this gene is completely linked with the Lr_{34} gene. The level of resistance it confers is usually not adequate when present alone. However, combination of Yr_{18} and Lr_{34} additional slow rusting genes (the Yr_{18} complex) results in adequate resistance levels were reported in most environments (Singh and Rajaram 1994) and (Youssef and Hamada 2007).

As a conclusion, the genetical quantitative analysis for F_1 and F_2 plant population mean values in both seedlings and adults of the tested crosses were lower than those of the respective values of the mid-parents. Likewise, the estimated values of dominance were significant and negative in either of the tested crosses . These results gave us the ground to expect the insidance of partial resistance within the tested crosses. These results were supported with the finding of (Shehab El-Dien *et al*., 1991a , 1991 b) and (Shehab El-Dien and Abdel Latif 1996), (Negm 2004) and (Shahin 2005). The high heritability values gave evidance to the high rate of success in recovering of the desired genes in further generations. The high estimates demonstrated that selection for that character (partial resistance) in early segregations could be possible. But it would be more difficult in case of delaying the selections particularly, after the occurance of (HTAP) resistance. These view point run in the same line with those of (Kuhn et al., 1980), (Millus and Line 1986) and (Najeeb *et al*., 2004). The obtained results indicated that no segregation could be detected in the F_2 plant populations in the crosses i.e.(Giza 168 x Yr 18) and (Sakha 61 x Yr 2). This result gave us the ground to suppose the incidence of each of the two Yr's in the respective cv. On the other hand, the obtained results confirmed the presence of complementary genes controlling stripe rust resistace within Sids-1 and Giza 168 due to the occurance of the segregation ratio (9:7) when crossed to (Yr 9). It must be recommended to carry out more studies using more cvs and Yr's in the national breeding programme.

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وراثة المقاومة للصدأ المخطط فى خمسة أصناف قمح خبز مصرية مهجنة فى أربعة سلالات من (Yr's)

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تم دراسة وراثة المقاومة فى خمسة أصناف قمح خبز مصرية(*Triticum aestivium* L.) مهجنة مع أربعة من السلالات الأحادية الجين (Yr's). وقد أختبرت نباتات الآباء والجيل الأول والجيل الثانى تحت ظروف الصوبة فى مرحلة البادرة ضد السلالة 230E18 من فطر *Puccinia striiformis*. وقد امتلك كل من الآباء والجيل الأول شكلا مظهريا قابلا للإصابة , فى حين أن عشيرة الجيل الثانى فى كل الهجن تنعزل مظهريا إلى زوج من الجينات حيث كانت هناك سيادة للقابلية للإصابة فى حين كانت جينات المقاومة متنحية فى البادرة تحت ظروف الصوبة . لكن تحت ظروف الحقل وفى طور النبات البالغ ضد مخلوط من سلالات المسبب المرضى كانت الآباء المختبرة من السلالات أحادية الجينات ومن الأصناف التجارية المصرية قد نجم عنها شدة صدأ منخفضة (مقاوم جزئيا) وأخرى تعطى شدة صدأ عالية (قابل للإصابة) . وقد أعطت كل هجن الجيل الأول شدة صدأ منخفضة (مقاوم) باستثناء أربعة هجن وهى : Yr18 x Sakha 69 , Yr2 x Sakha 69 , Yr9 x Sakha 8 and Yr9 x Sakha 69 والتى أظهرت شدة صدأ عالية (قابل للإصابة) . أما عشيرة الجيل الثانى فقد أظهرت إنعزالا فى سبعة هجن تتفق مع النسب المتوقعة 7 مقاوم :9 قابل للإصابة ، 1 مقاوم : 15 قابل للإصابة ، 3 مقاوم : 13 قابل للإصابة و 9 مقاوم : 7 قابل للإصابة. بينما باقى الهجن لا يوجد بها إنعزال , مع سيادة المقاومة. فى الصنف جيزة 168 يتحكم فى المقاومة جينات مكملة وكذا الصنف سخا 61 لوجود النسب الإنعزالية 7:9 و 9:7 كما أن حالة عدم الإنعزال تؤكد وجود الجين Yr18 و الجين Yr2 فى الصنفين على الترتيب . هذا التواجد يؤكد أن هذه الجينات تكون مؤثرة تحت ظروف البيئة المصرية ويرجع السبب فى ظاهرة إبطاء الأصداء لوجود بعض الجينات المكملة المسئولة عنها وينعكس ذلك على عدم وجود فرق معنوى بين محصول المصاب والسليم فى نفس الصنف . من هذه النتائج يمكن أن نستنتج إمكانية الإنتخاب من أجل ظاهرة إبطاء الصدأ فى الأجيال المبكرة , لكن التأجيل للأجيال المتأخرة يكون أكثر تأثيرا حيث يرجع ذلك إلى الدور الهام من تأثير السيادة فى التعبير عن هذه الصفة .وكذا إرتفاع درجة الحرارة التى تتناسب طرديا مع تكشف المرض.

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