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GENETIC PREDICTION OF LEAF RUST RESISTANCE THROUGH CROSSING BETWEEN TWO Lr's AND FIVE EGYPTIAN WHEAT VARIETIES.

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ABSTRACT

Leaf rust caused by *Puccinia triticina* Eriks.is a common and widespread disease of wheat in Egypt and worldwide. Durable genetic resistance to leaf rust in wheat has been difficult to achieve, since the virulence of leaf rust pathogen to specific leaf rust resistance genes form high variability in wheat cultivars aiming to make a genetic prediction of leaf rust resistance, six crosses i.e. Lr25/Gemmeiza 7 , Lr25/Giza163 , Lr25/sids1; Lr35/Gemmeiza7 , Lr35/sakha 61 and Lr35/Sakha93 were carried out. These Egyptian Wheat varieties showed high infection type at both seedling and adult while Lr25 showed resistance and Lr35 was susceptible at seedling stage , but at adult plant stage they showed low rust severity under greenhouse and field conditions subsequently . The segregation in the F_2 plant populations at both seedling and adult plants stage tending to the side of partial resistance and dominance with digenic pairs. Lr25 or Lr35 have low rust severity because of the rarity of leaf rust isolates with virulence to Lr25 or Lr35. Wheat cultivars with the combination of Lr25 or Lr35 displayed high levels of partial leaf rust resistance. From this stand point, these cultivars don't contain Lr25 or Lr35. The dominant nature of some of the slow rusting resistance genes in crosses are of a great interest in breeding for rust durable resistance. This type of resistance will be easier in segregating generations as smaller population sizes would be required than when used lesser effects.

INTRODUCTION

Leaf rust of wheat (*Triticum aestivum* L.) caused by *Puccini triticina* Eriks={ *Puccinia recondeta* Roberge ex. Desmaz, f. sp. tritici Eriks & Henn.} is found nearly wherever wheat is grown, and is the most regular occuring of the three rusts found on wheat, Samborski (1985). The wheat leaf rust fungus is adapted to a range of diffirent climates, and the disease can be found in diverse wheat growth areas throughout the world, Roelfs and Singh (1992). Wheat cultivars that are susceptible to leaf rust regularly suffer yield reduction by 5-15% or greater, depending on the stage of crop development when the initial rust infections occur, Samborski (1985). Although damage caused by leaf rust is usually not sever, Samborski (1985) considered that on a worldwide bases the disease probably caused more damage in wheat than stem rust or stripe rust .In Egypt, the susceptibility of the grown wheat cultivars, caused 23% reduction in grain yield of some varieties, Nazim *et al* (1983). Resistance gene expression is dependent on the genetics of host parasite interaction, temperature conditions, plant development stage and interaction between resistance genes with other resistance genes in the wheat genomes, Kolmer (1996). Resistance may be effective throughout the life of the plant or only at the adult plant stage . Breeding programes usually select for adult plant resistance in the field, Eversmeyer and Kramer (2000). Whilst most confer seedling resistance (i.e resistance that's usually effective

at all growth stages), some confer resistance that's effective at adult plant growth stages only (adult plant resistance , APR). Leaf rust resistance in wheat cultivars is often conferred by one or more seedling genes. These genes have in many cases proven non-durable, being overcome by the development of matching virulence in the leaf rust pathogen , *Piccinia triticina*. Although APR are considered to be potenial more durable, Singh and Rajram (1992), the development of virulence rendered some of them ineffective, Park and McIntosh (1994), Huerta-Espino and Singh (1996). Resistance based on epideminology characteristics such as slow rusting or reducing latent period length has generally been assumed to be race non-specific and thus to be durable, Kolmer and Liu (2001). Studying resistance to leaf rust in wheat has been depending on genetic isolation and charactarization of single genes that condition infection type in seedling tests and the severity of rust infection in field tests, Dyck *et al* (1966). The main target of this study was to identify seedling and adult plant resistance genes and to determine the genetic level of resistance of wheat leaf rust.

MATERIALS AND METHODS

The present work was carried out during three successive growing seasons of 2008/2009 to 2010/2011, at Tag El-Ezz Agricultural Research Station, Dakahliea Governorate and also at greenhouse condition in Wheat Disease Research Division, Plant Pathology Research Institute at Giza,Egypt. The crossess between leaf rust monogenic lines and Egyptian commercial wheat varieties aiming to identify seedling and adult plant resistance genes and determing level of resistance to wheat leaf rust. The monogenic line (Lr,s) i.e. Lr25 was crossed with Gemmeiza 7, Giza163 and Sids 1. However Lr35 was crossed with Gemmeiza 7 , Sakha61 and Sakha93, their parent were selected and results were recorded in six crosses. Any doubt of the hybrid seeds or F_1 plants were discarded and the others were separately harvested. The parents of leaf rust resistance genes (Lr 's) and commercial varieties (cv) were sown during 2008/2009 growing season in 1.5m long and 30cm apart. Each row was sown to 15 seed with a distance 10 cm. The experimental unite included 4 rows of each parent (Lr 's x cv). The parents were selected according to their low and high rust severity on the basis of their reaction to leaf rust in the field during the elapsed growing seasons. In 2009/2010 growing season, part of the six (Lr 's x cv) crosses of hybrid seeds was sown to produce F_1 plants and the other part was left for final experiment in the next growing season. In 2010/2011 growing season, evaluation of parents, F_1's and F_2's plant populations under greenhouse and field conditions was carried out as follows :

Under greenhouse conditions. For seedling test in the greenhouse of Wheat Disease Research Division, one pot for each of parents or F_1's and either of 13 pots of each of F_2 crossess were sown. Each pot contained 20 seed. Eight days old seedlings of these were uniformly inoculated with urediniospores of (*P. triticina* Eriks) using pathotype TKTT of the pathogen. For inoculation all tested materials under greenhouse conditions at seedling stage, using the gently rubbing technique was done as described by Stakman

et al (1962). The seedlings were evaluated for infection type(IT) 21 days after sowing on pots under greenhouse tests. Infection type was classified according to the 0-4 scale used by Long and Kolmer (1989) : O= Immunity, no hypersensitive fleks or uredinia, O;= faint hypersensitive flecks; ;=distinct hypersensitive flecks; 1= small uredinia surrounded by distinct necrosis ; 2= small uredinia surroundeb by distinct chlorosis ; 3= intermediate size uredinia lacking chlorosis and 4= large size uredinia lacking chlorosis. Designation (+) and (-) indicate uredinia that were larger and smaller than normal, respectively. Infection type from 0 to 2+ were considered low and infection type 3 and 4 were considered high, Kolmer and Oelke (2006).

Field test : Under field conditions, six plots, each included sixteen rows, one row for each of parent and F_1's as well as thirteen row for F_2 plant populations. The row was 2m long, spaced 30 cm apart and seeds were 10 cm apart within row. Each row was planted with 20 seed. The adjacent plots were separated by 1m wide belt. All plots were surrounded by a spreader area of one meter in width, planted with a mixtures of the two highly susceptible wheat cultivars to the leaf rust pathogen i.e. *Triticum spelta* Saharensis and *Morocco*. For the field inoculation, the spreader plants were moistened and dusted with spore-powder mixtures of the most prevalent leaf rust pathotypes in the area, i.e. TTTT, TKTT and PKTT (one volume of fresh uredinia mixture : 20 volume of talcum powder). Dusting was carried out in the early evening at (sunset) before dew formation and when air was still in .

The inocultion of all plants was carried out at late tellering and early booting stages according to the method suggested by Tervet and Cassel (1951). Data of leaf rust severity were reported on the adult plant stage of the tested plants according to the modified Cobb scale, Peterson *et al* (1948). All regular cultural practices specific for wheat crop were applied during the growing season. Data were reported according to the technical recommedations as rust severity for each plant.

Plant were divided into classes according to the level of rust severity, i.e.(0-10% , 11-20% , 21-30% , 31-40%) and(41-50% , 51-60% , 61-70% , 71-80% , 81-90%). Plant grouped in the first four classes were considered as having low rust severity. While other five classes (more than 40%) were considered as having high rust severity according to Khanna *et al* (2005), Singh *et al* (1998), Negm (2004), Shahin (2005), Youssef *et al* (2007) and Youssef (2011).

Statistical and genetic analysis : Frequency distribution values were computed for parental, F_1 and F_2 plant populations for leaf rust infection type and rust severity percentge under greenhouse and field conditions. With respect to mode of inheritance, goodness of fit of the observed to the expected ratios of phenotypic classes concerning leaf rust infection type and rust disease severity were determined by X^2 anlysis according to Steel and Torrie (1960). However, the minimum number of effective genes controlling slow-rusting resistance in each cross was estimated by the formula of Wright (1968). Degree of dominance were calculated according to the method suggested by Romera and Frey (1973). In addition, the F_1 and F_2 means were compared with mid-parents value using (t) test to determine whether h1

and h2 values were significantly different from zero. Heritability in its broad-sense was estimated according to the method mentioned by Lush (1949).

RESULTS

Response of the parents, Lr_{25} and Lr_{35} displayed (resistance) low infection type response (0; and 1) sequently, against leaf rust pathotype TKTT at seedling stage under greenhouse conditions, while at adult plant stage under field condition, the low rust severity were 10 and 20% sequently, against leaf rust pathotypes mixtures, i.e.TTTT, TKTT, PKTT Tables (1and2).

Table (1) Infection type frequency distributions for parents, F1 and F2 plant populations. Phenotypic classes. Expected ratio, X^2 and probable values of F_2 populations of 6 (Lr's x cv) crosses as affected by inoculation with race TKTT of leaf rust (*P. triticina* Eriks.) at seedling stage under greenhouse conditions in 2010/2011 growing season.

No.	Cross name Low x High		No. of tested plants	Infection type of race TKTT						Observed ratio		Expected ratio	X^2	Probable values
				0 ;1	0; 0.1	1 1	2 2	3 3	4 4	Resistant	Susceptible			
1	Lr2 5 x	P_1	20		4	16								
	Gemmeiza7	P_2	20					1	19					
		F_1	20			4	16							
		F_2	209	5	14	39	55	60	36	113	96	9:7	0.4114	0.750-0.500
2	Lr2 5 x	P_1	20		4	16								
	Giza163	P_2	20					1	19					
		F_1	20			17	3							
		F_2	217	11	68	58	39	27	14	176	41	13:3	0.0048	0.950-0.900
3	Lr2 5 x	P_1	20		4	16								
	Sids 1	P_2	20					2	18					
		F_1	20			18	2							
		F_2	217	21	43	69	45	28	11	178	39	13:3	0.0873	0.900-0.750
4	Lr35 x	P_1	20		2	18								
	Gemmeiza7	P_2	20					3	17					
		F_1	20		18	2								
		F_2	215	17	69	68	43	15	3	197	18	15:1	1.6004	0.250-0.100
5	Lr35 x	P_1	20		2	18								
	Sakha61	P_2	20					2	18					
		F_1	20		4	16								
		F_2	203	23	42	54	41	31	12	160	43	13:3	0.789	0.500–0.250
6	Lr35 x	P_1	20		2	18								
	Sakha93	P_2	20					3	17					
		F_1	20		16	4								
		F_2	213	8	12	30	65	72	26	115	98	9:7	0.458	0.500–0.250

Race TKTT was averulant on Lr 9 and Lr 25 and virulant on Lr 1, Lr 2a, Lr 2c, Lr 3; Lr 16, Lr 24; Lr 3k,Lr11,Lr17,Lr30;Lr10,Lr18,Lr21,Lr26.

n the other hand Egyptian commercial wheat varieties (parents) were : Gemmeiza 7 , Giza 163 , Sids1 , Sakha 61 and Sakha 93 displayed susceptible high infection type (3 or 4) at seedling stage and high rust severity 60-80% at adult plant stage.

Response of F_1's plant of (resistance X susceptible) low x high infection type (Lr's x cv) crosses. At seedling stage under greenhouse conditions. The F_1's plant displayed (resistance) low infection type (0; to 2) similar to one parent (Table 1) with all tested crosses . On the other hand, response of F_1 plants ranged from 10-20% low rust severity with one parent, (Table 2).

For the evaluation of F_2 plant population at seedling and adult plant stages under greenhouse and field conditions and identification of the leaf rust resistance gene Lr25 and Lr35, three crosses derived from leaf rust resistance gene Lr25 and three commercial wheat cultivars i.e. Gemmeiza 7, Giza 163 and Sids1. Also, Lr35 and Gemmeiza 7, Sakha 61 and Sakha 93 under study, Tables 1 and 2 .

At seedling stage under greenhouse conditions : Data obtained in Table (1) showed that the crosses Lr25/Gemmeiza7, Lr25/Giza163 , Lr25/sids1 ; Lr35/Gemmeiza7 , Lr35/Sakha61 , Lr35/Sakha93 segregated to 113L : 96H , 176L : 41H , 178L : 39H; 197L : 18H , 160L : 43H and 115L : 98H, respectively. These observed ratios fitted the theoritical expected ratios i.e.9:7 , 13:3 , 13:13 ; 15:1 , 13:3 and 9:7 with probable values 0.750-0.500 , 0.950-0.900 , 0.900-0.750 ; 0.250-0.100 , 0.500-0.250 and 0.500-0.250, respectively.

At adult plant stage under field conditions : The obtained data in Table (2) showed that the six crosses exhibited segregation, i.e. 124L : 87H , 117L : 97H , 163L : 45H ; 175L : 44H , 174L : 41H and 200L : 18H, respectively. These observed ratios fitted with the theoritical expected ratios i.e. 9:7 , 9:7 , 13:3 ; 13:3 , 13:3 and 15:1 with p. values i.e. 0.500-0.250 , 0.750-0.500, 0.250-0.100 ; 0.750-0.500 , 0.950-0.900 , 0.250-0.100, respectively. Which leads to the assumption that these vrieties lacked leaf rust resistance gene Lr25 and Lr35.

Quantitative analysis : The genetic behaviour of infection type and wheat leaf rust resistance was studied quantitatively. The two parents, F_1 and F_2 plant populations for each of the six crosses were tested at seedling and adult plant stages. Population means and variance of the parents, F_1's and F_2's were used to estimate the degrees 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 of cross, Tables (3 and 4) .

Table (2): Leaf rust severity (%) frequency distributions of the two parents, F1 and F2 plant populations. Phenotypic classes, expected ratios, X^2 and probable values of F2 plant populations of 6 (Lr's x cv) crosses as affected by inoculation with race mixtures leaf rust (*P. triticina*) at adult plant stage under field conditions in 2010/2011 growing season.

No.	Cross name		No. of tested plants	Disease severity classes %								Observed ratio		Expected ratio		X^2	Probable values
				0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	Low	High	Low	High		
A	Low x High*			Low				High									
1	Lr25 x	P_1	20	18	2												
	Gemmeiza7	P_2	20							2	18						
		F_1	20	3	17												
		F_2	211	9	21	45	49	41	22	15	9	124	87	9	7	0.542	0.500-0.250
2	Lr25 x	P_1	20	18	2												
	Giza163	P_2	20							1	19						
		F_1	20	4	16												
		F_2	214	6	28	42	41	34	29	20	14	117	97	9	7	0.2162	0.750-0.500
3	Lr25 x	P_1	20	18	2												
	Sids 1	P_2	20							3	17						
		F_1	20	2	18												
		F_2	208	18	79	43	23	16	15	11	3	163	45	13	3	1.136	0.250-0.100
4	Lr35 x	P_1	20		17	3											
	Gemmeiza7	P_2	20							2	18						
		F_1	20	1	19												
		F_2	219	14	80	56	25	19	17	8		175	44	13	3	0.2518	0.750-0.500
5	Lr35 x	P_1	20		17	3											
	Sakha61	P_2	20						17	3							
		F_1	20	2	18												
		F_2	215	15	60	68	31	22	11	8		174	41	13	3	0.01243	0.950-0.900
6	Lr35 x	P_1	20		17	3											
	Sakha93	P_2	20					3	17								
		F_1	20	1	19												
		F_2	218	53	58	57	32	10	5	3		200	18	15	1	1.4987	0.250-0.100

***Low disease severity x High disease severity.**

Under greenhouse conditions at seedling stage :

Data presented in Table (3) showed that the mean of infection type of parents (%), Lr25, Lr35 ; Gemmeiza 7 , Giza 163 , Sids1 ; Sakha61 and Sakha93 were : 0.82,0.91 ; 3.95, 3.95, 3.9, 3.91 and 3.85, respectively. The F_1 and F_2 mean values were lower than their mid-parent values, revealing the presence of resistance (low infection type) . The estimated values of h_1 and h_2 also indicated the significant negative values of h_1 and h_2 (low infection type), also, suggested the manifestation of resistance dominance on susceptibilty (Table 3).

Table (3): Means of P1, P2, F1, F2, MP, degree of dominance of F1 and F2 as well as heritability and number of genes for leaf rust infection type of 6 (Lr's x cv) crosses at seedling stage inoculated with pathotype TKTT (*P. triticina*) under greenhouse conditions in 2010/2011 growing season.

No.	Cross name	Mean of infection type					Degree of dominance		Heritability	No. of genes
		P1	P2	F1	F2	MP	h1	h2		
	Low x high P1 x P2									
1	Lr 25 x Gemmeiza 7	0.82	3.95	1.8	2.27	2.385	-0.373	-0.146	92.12	0.967
2	Lr 25 x Giza 163	0.82	3.95	1.15	1.289	2.385	-0.789	-1.4006	93.125	0.90745
3	Lr25 x Sids 1	0.82	3.9	1.1	1.343	2.36	-0.818	-1.3207	92.164	0.9664
4	Lr 35 x Gemmeiza 7	0.91	3.95	0.19	1.014	2.43	-1.4735	-1.863	93.158	1.3294
5	Lr35 x Sakha 61	0.91	3.91	0.82	1.386	2.405	-3.202	-4.117	93.38	0.831
6	Lr35 x Sakha 93	0.91	3.85	0.28	2.259	2.38	-1.428	-0.164	91.26	0.9609

MP= Mid-Parents
Lr's= leaf rust resistance genes
C.V.=Commercial varaiety

At adult plant stage under field conditions :

Data obtained in Table (4) clarified that the mean rust severity (%) for the parents i.e. Lr25, Lr35 ; Gemmeiza7 , Giz163, Sids1 ; Sakha61 and Sakh93 were 6.0 , 6.5 ; 74.0 , 74.5 , 73.5 , 74.0 and 74.0, respectively. The F_1's and F_2's mean rust severity showed values lower than their values calculated for their respective mid-parents, revealing the presence of partial leaf rust resistance dominance (slow-rusting) for low rust severity confirming the obtained data from F_1's and F_2's plant populations, Table (4) . Expression of gene action measured as the degree of dominance h_1 and h_2 had negative values in all six crosses at seedling and at adult plant stages, which suggested the manifestation of partial dominance for leaf rust resistance and supported the F_1 data. The heritability values for all cross under greenhouse and field conditions are considered to be high, Tables (3 and 4).

Number of genes : The minimum number of effective genes controlling the resistance was digenic pairs dominance for all crosses under greenhouse and field conditions, Tables (3 and 4).

Table (4): Means of P1, P2, F1, F2, MP, degree of dominance of F1 and F2 as well as heritability and number of genes for leaf rust severity % of 6 (Lr's x cv) crosses inoculated with race mixtures of *P. triticina* under field conditions in 2010/2011 growing season.

No.	Cross name	Mean of rust severity %					Degree of dominance		Heritability	No. of genes
		P1	P2	F1	F2	MP	h1	h2		
	Low x High P1 x P2									
1	Lr 25 x Gemmeiza 7	6.0	74.0	13.5	37.46	40.0	-0.779	-0.149	96.42	2.1089
2	Lr25 x Giza 163	6.0	74.5	13.0	26.73	40.25	-0.795	-0.789	95.73	2.696
3	Lr25 x Sids 1	6.0	73.5	14.0	27.11	39.75	-0.762	-0.748	96.53	1.987
4	Lr 35 x Gemmeiza 7	16.5	74.0	14.5	21.10	45.25	-1.069	-1.679	95.18	2.314
5	Lr 35 x Sakha 61	16.5	74.0	14.5	27.32	45.25	-1.069	-1.246	95.82	2.000
6	Lr 35 x Sakha 93	16.5	74.0	14.5	21.10	45.25	-1.069	-1.679	95.20	2.301

MP= Mid-Parents
Lr's= leaf rust resistance genes
C.V.=Commercial varaiety

DISCUSSION

The seedling and adult plant leaf rust resistance genes studies were conducted on resistance of wheat leaf rust (Puccinia triticina) in six crosses of (Lr's x cv) i.e. Lr25 or Lr35 and local wheat cvs i.e. Gem-7,Giza163and Sids1;and Gem-7, Sakha61 andSakha93. The obtained results gave evidance to the lack of each group from Lr25 or Lr35,in respect. At least against the prevalent patholytypes in the area, i.e. the F_2 plant population showed partial resistance dominant over susceptibility at both seedlin and adult stsges with complementary, suppressor or additive gene action. Kerber and Dyck (1990) mentioned that Lr35 was transferred by backcrossing on amphiaploid of triticum speltoides x T. monococcum to the wheat cultivar Marquis. Resistance expressed by Lr35 first becomes noticeable at the second- leaf stage and is fully expressed after the sixth-leaf stage .

Twenty-five Lr genes from Lr1-Lr34 were isolated directly from hexaploid wheats, Long and Kolmer (1989) and Roelfs and Singh (1992). The other genes were derived from lower ploidy relatives of hexaploid wheat within the tribe Triticeae in the poaceae. Negm (2004) showed the presence of Lr35 in wheat cultivar Sakha92 while it was absent in cv Sakh 8 , Sakha69 and Sids 1. Similar results were recotded by Singh et al (1999) , Long and Kolmer (1989) and Singh (1991) who pointed to that resistance genes Lr3ka, 9 , 21, 25, 29, 30, 32, 33 and 35 displayed low or intermediat infection types (IT's) with 14 *P. triticina* races. Absence of Lr gene is indicated in cultivar whenever a high infection type is observed with any of the races used in the

tests. Genes Lr12, Lr22a, Lr22b and Lr35 are known to be effective only in adult plant, McIntosh *et al* (1995). Similar results were suggested by Singh *et al* (1995) and Kolmer (2002). The susceptibility of leaf seedlings of the near-isogenic lines (NIL) possessing Lr37 probably resulted from the warmer conditions (15-25 'C). As with the Lr37, the expression of Lr13 is known to be temperature sensitive, Hawthorn (1984) and Pretoruis *et al* (1984). Park and McIntosh (1994) reported that at certain temperatures both genes are ineffective at seedling growth stages, acting as classical APR genes in becoming effective at post-seedling growth stage, and at contrasting temperatures they condition seedling resistance in being effective at all growth stages. In both instances, the level of resistance conferred by the genes does increase with the plant age and in this sense, they could be regarded as adult plant resistance. Several cultivars were heterogeneous for leaf rust response, and therfore could be purified and evaluted in the respective areas of adptation against the prevalent pathotypes.

Gentic diversity for leaf rust resistance can be enhanced by incorporating various known Lr genes that were absent , provided they confer resistance to pathotypes of *P. recondita* prevalent in praticular area. Another breeding approach could be crossing cultivars with adult plant resistance and selecting progenies that displayed low leaf rust severity under disease pressure. Such a breeding methodology increases the possibility of accumulating combinations particullarly effective additive genes. Resistance based on the combintion of such genes appears to be long lasting and possibly durable, Knott and Yadav (1993) and Singh and Rajarm (1992). Comparisons between stripe rust protected and non protected treatments showed that stripe rust infection caused grain yield losses of 31 to 52% in Yr18 carrying jupatico 73R and 74 to 94% Yr18 lacking Jupatico 73S, Ma and Singh (1996). This show that slow rusting resistance based on Yr 18 protected grain yield in the range of 36 to 58% depending on the year and sowing date. Alvarez-Zamazano(1995). Also, observed structural change in the Lr34 line leading to invagination or contruction of cell wall, which may delay the completion of infection process. These observations indicate a different mechanism for Lr34 based on slow-rusting than hypersensitivity, which is associated with race-specific genes, beacuase pathogen isolates can vary for aggressiveness, Lahman and Shaner (1996).

One of the slow-rusting genes present in Mexican wheat cultivar Pavon 76, which has moderate leveles of durable adult-plant resistance to leaf rust, was recently designated as Lr46, Singh *et al* (1998). Gene Lr46 also affects all components at slow-rusting resistance to leaf rust, Martinez *et al* (2001). In Mexico, leaf rust severity on most cultivars can be related to the number of slow-rusting genes they carry. Cultivars with Lr34 and three or four additional genes show a stable response in environment tested so far, with final leaf rust ratings lower than 5% even under heavy rust pressure. Results of Sayer *et al* (1998) show tht 7.7. to 10.4% loss in grain yield of cultivars such combintions of 2 or 3 genes with Lr34 were similar to 6.6 to 10.2% loss in cultivars that carry hypersensitive types of resistance under high leaf rust pressure. Park and McIntosh (1994) mentioned that the relationships

between frequencies of resistance genes in the host and corresponding virulence in the pathogen (the "boom and bust" cycle) were established in Australian for wheat stem rust, Luig and Watson (1970) and Zwer *et al* (1992). Zhang et al (2008) pointed out that when effective gene Lr23 interacted with the APR gene Lr34 and provided higher levels of APR than when these genes acted alone. Ineffective against corresponding virulent races , Lr23 failed to interact with Lr34. Thus, there wasn't residual effect of gene Lr23. A simple example of interaction where Lr34 enhances the effect of Lr13 and the other plant race-specific leaf rust resistance gene, Ezzahiri and Roelfs (1989), German and Kolmer (1992) and Kolmer (1992). Slow rusting to leaf rusting is charactarized by slow disease progress in the field despite a compatible or high or sesceptible infection. Cultivars carrying slow rusting resistance show high infection type in the seedling growth stage, Johnson (1988). For stripe rust , which progress in plants also in a systemic manner , it's often not possible to identify fully compatible in adult plant growth stages, Johnson (1988). Slow rusting can be readly identified within the improved germplasm, Singh and Rajaram (1991). The existence in slow rusting in most cultivars is often a chance inheritance from their ancestors. Slow rusting can be charactarized in greenhouse exiperiments by evaluating latent period, infection frequency (number of uredinia per unite area or receptivity) size of uredinia of infection, inoculum production etc. under quatitative inoculation, Singh et al (1991).

Inheritnce of slow rusting resistance in five wheat varieties, their F_1's and F_2's at seedling and adult plant stages under greenhouse and field conditions was quntitatively and qualitatively analysed. Mean of infection type of the F_1's plants in the six crosses at seedling and adult plant population was lower than that calculated for their respective mid-parents. Also, the estimated values of degrees of dominance (h_1 and h_2) were significant and negative in all tested crosses under greenhouse or field conditions. These obtained results supported the manifestation of partial dominance for mean of rust severity and confirmed the above conclusion. These results are in agreement with what was previously obtained by Millas and Line (1986), Line and Chen (1989), Shehab El Dien *et al* (1991 and 1996), Boulot (1997) and Youssef *et al* (2007).

The heritability in its broad-sense estimated from parents. F_1's and F_2's plant populations for slow rust resistance (partial leaf rust resistance), is considered to be high in magnitude, since values seemed to be ranging from 91.26 to 93.38% for mean of infection type at seedling stage , aslo values ranged from 95.18% to 96.42% for mean of rust severity at adult plant stage under field condition. However, high heritability values are indicative for high rates of seccess in recovering the desired genes in successive generations. Added, these high estimtes values demonstrated that the selection of this trait in early segregating generations sould be possible. While delaying it would be more effective , these results are in harmony with those of Kuhn *et al* (1980), Lee and Shamer (1985), Bjarko and Line (1988), Abdel Latif et al (1995), Shehab El Dien *et al* (1996) and Boulot (1997).

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التنبؤ بوراثة مقاومة صدأ الأوراق من خلال التهجين بين سلالتين مـــن Lr's فى خمسة أصناف من القمح المصرى

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يعتبر مرض صدأ الأوراق المتسبب بالفطر *Puccinia triticina* Eriks الأكثر إنتشارا علـــى محصول القمح فى مصر و معظم دول العالم . وقد تبين أنه من الصعب إنجاز أو الوصـــول إلـــى وراثـــة المقاومة المستديمة لصدأ الأوراق فى القمح، حيث أن عدوانية المسبب المرضى لصدأ الأوراق ترجع لجينات المقاومة المتخصصة لصدأ الأوراق تشكل مدى واسعا من الإختلافات و التغيرات العالية فى أصناف القمح.
وللتنبؤ بوراثة مقاومة صدأ الأوراق فى القمح تم إستخدام سلالتين أحادية الجين وخمسة أصناف تجارية من القمح المصرى وتم الحصول على ستة هجن وهى :
Lr25X Gemmeiza7 , Lr25X Giza163 , Lr25X Sids1 ; Lr35X Gemmeiza7 , Lr35X Sakha61 , Lr35X Sakha93 . وقد تلاحظ أن الأصناف التجارية المـــستخدمة فـــى هـــذا البحث تعطى نوع إصابة عالى فى البادرة و شدة إصابة عالية فى طور النبات البالغ. بينما السلالة الأحاديـــة الجين Lr25 تعطى مقاومة و السلالة Lr35 قابل للإصابة فى طور البادرة لكن فى طـــور النبـــات البـــالغ أظهرت شدة إصابة منخفضة وذلك فى إختبارات الصوبة و الحقل على التوالى. وتبين النتائج أن الإنعزالات فى عشيرة النباتات فى الجيل الثانى فى البادرة و النبات البالغ تميل تجاه إنتاج سيادة المقاومة الجزئيـــة مـــع زوج من الجينات.ويلاحظ أن السلالات الأحادية Lr25 or Lr35 كانت منخفضة فى شدة الإصابة وذلـــك بسبب ندرة عزلات صدأ الأوراق العدوانية للسلالة Lr25 or Lr35. وبإتحاد أصناف القمح التجارية مـــع Lr25 or Lr35 أعطت مستويات عالية من مقاومة صدأ الأوراق الجزئية. من تلك النتائج يتبين أن هـــذه الأصناف لا تحتوى على Lr25 or Lr35. وأن طبيعة السيادة فى بعض جينات المقاومة للصدأ البطـــىء فى الهجن تعتبر مهمة جدا فى التربية من أجل المقاومة الدائمة للصدأ حيث أن هذا النوع من المقاومة يصبح من السهل الحصول عليه فى الأجيال الإنعزالية والتى تتطلب أن تكون العشائر صغيرة الحجم المطلوب عـــن أن تكون التأثيرت منخفضة فى العشائر كبيرة الحجم.

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