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GENETICAL AND PATHOLOGICAL STUDIES ON CERTAIN EGYPTIAN WHEAT GENOTYPES AS AFFECTED BY BOTH LEAF AND STRIPE RUST

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ABESTACT

The present study was conducted to determine the inheritance and yield reduction resulted from both stripe and leaf rust as well as correlation analysis between rusts and yield traits in 2001/2002 and 2002/2003 seasons at Sakha Agric. Res. Stn.. Using five wheat cultivars, two susceptible for stripe and leaf rusts i.e. Giza 163 and Giza 165, one resistant for two rusts i.e. Gemmeiza 9 and two resistant for stripe rust and susceptible for leaf rust i.e. Sakha 61 and Sids 1. Genotypes were crossed in all possible combinations, excluding reciprocals in the first season i.e. 2001/2002. In the second season i.e. 2002/2003 the parents and F_1's were evaluated in two experiments, one was protected with fungicide and the other was severely infected with the rusts. The obtained results suggest that stripe rust was more serious than leaf rust on bread wheat. All susceptible genotypes for stripe rust associated with high reduction (%) in grain yield and kernel weight. On the other hand, many genotypes proved to be susceptible for leaf rust, while only one genotype possessed high values for yield reduction (%). Correlation analysis showed negative and high significant association between stripe rust reaction and both grain yield and kernel weight, while negative and insignificant association was recorded between leaf rust and yield traits. Broad sense heritability values were high for rust traits and grain yield. Meanwhile, heritability in narrow sense was high for rust traits and low for grain yield. Early generation selection for rust traits would be effective for improving these characters.

Estimates of the genetic components, indicated that primary part of the genetic variability for rust traits was correlated with additive gene action, however, it was associated with non additive genes regarding yield characters. As for average degree of dominance $(H_1/D)^{1/2}$, less than one for rust traits while, it was more than one for grain yield. The F values indicated an excess of dominant alleles compared with recessive ones for stripe rust and grain yield, while the reverse was recorded for leaf rust.

INTRODUCTION

Wheat is a stable food for more than one – third of the world's population. Bread wheat (*Triticum aestivum* L.) is subjected to the attack of many diseases especially rusts, which are the most destructive diseases and responsible for the colossal damage to wheat crop. Stripe rust of wheat caused by *Puccinia striiformis* f.sp. *tritici* and leaf rust caused by *Puccinia reccondita* f.sp. *tritici* are the most dangerous diseases of bread wheat in Egypt. Wheat stripe rust is considered to be the principal contemporary problematic disease of wheat in Egypt, wherein, it causes an average loss in grain yield ranged from 14% to 20.50 % in the Delta region (El-Daoudi *et al.*

1996). In Azerbijan, Seidov *et al.* (2001) reported that yellow rust caused major damage and crop losses, yield loss varied from 25 to 50 % depending on the location and the variety. Meanwhile, in a screening trial, most lines scored more than 40% severity; their reaction was almost invariably susceptible for leaf rust but a reasonable amount of grain yield was obtained and the seeds were less shriveled, relevant to disease severity (Tesemma *et al* 1993). Estimating the loss caused by diseases is also a prerequisite to developing strategies for disease control and to formulating sound resistance for breeding objectives (Simmonds 1988). Information about association of rusts and yield traits can help in increasing the selection efficiency.

Due to the dynamic nature of the pathogen, the rusts are most economically and effectively controlled via the use of resistance cultivars. Thus, breeding for resistance is more advantageous than using fungicides or any other disease control method. Recently, there is much interest in the type of resistance that is expressed under natural field conditions as opposed to seedling resistance (Broers *et al.* 1996 and Yadav *et al.* 1998). Field resistance is usually long lasting and quantitatively inherited (Yadav *et al.* 1998). However, for sustainable wheat production, emphasis is given to develop cultivars with durable resistance to diseases and tolerant to environmental stress (Charan and Bahadur 1997).

The inheritance of resistance is controlled by few genes; oligogenic (Millus and Line 1986, Ezzahiri and Roelfs 1989, Chen and Line 1995 and Shehab El-Din *et al* 1996) or polygenes (Walkins *et al* 1995, Mahgoub 2001, Aglan 2003 and Hammad, 2003).

For developing high yielding wheat cultivars with resistance to rusts, information on the nature and magnitude of genetic variation of these traits are essential. Such information will help wheat breeders in their identification to good parents and selection procedure. This investigation was undertaken to determine the effect of both stripe and leaf rust diseases on kernel weight and grain yield in wheat and thereby to detect whether some forms of incomplete resistance or tolerance may occur in some Egyptian wheat genotypes. In addition, to study the mode of inheritance and correlation analysis for rust and yield traits.

MATERIALS AND METHODS

Five parents diallel crosses in Egyptian spring wheat cultivars, excluding reciprocals, were used in this study. The experiments were carried out through the two wheat-growing seasons 2001/2002 and 2002/2003 at Sakha Agriculture Research Station, Agriculture Research Center. The five parent genotypes differentiated in their resistance to both stripe and leaf rust (Table 1).

Table1: Name, pedigree and rust reaction to stripe and leaf rusts for the five parental bread wheat cultivars.

Parent #	Name	Pedigree	YR*	LR
1	Sids 1	HD 2172 / Pavon "S" // 1158.57/ Maya 74 "S" Sd 46-4Sd-2Sd-1Sd-0Sd	R**	S
2	Gemmeiza 9	Ald "S" / Huac // Cmh 74A. 630 / Sx CGM 4583-5GM-1GM-0GM	R	R
3	Sakha 61	Inia / RL 4220 // 7c / Yr "S" CM15430 -2S-5S-0S-0S	R	S
4	Giza 165	Cno / Mfd //Man "S" CM43339-C-1Y-1M-2Y-1M-2Y-0B	S	S
5	Giza 163	T. aestivun / Bon // Cno / 7c CM33009 -F-15M-4Y-2M-1M-1M-1Y-0M	S	S

***YR and LR= yellow (stripe) and leaf rust, respectively.**
****R= Resistant and S= Susceptible.**

Through out the growing season; 2001/2002, the five parents were sown and crossed in all possible combinations (excluding reciprocals) to produce the hybrid seeds. The plant materials, comprising 15 genotypes (5-parents +10 F_1's) were evaluated in a randomized complete block design with three replicates during 2002/2003 wheat growing season. Two adjacent experiments were carried out, one was protected with fungicide and the other was inoculated with both stripe and leaf rust. Each genotype was grown in a single row with 2m long and 30cm apart in each experiment. The experiments were surrounded with highly susceptible wheat cultivars to both stripe and leaf rust as spreader. The artificial inoculation was not carried out for stripe rust, because Sakha is considered a hot spot for this disease. Meanwhile, the artificial inoculation for leaf rust was carried out, using a mixture of fresh urediniospores for the most prevalent pathotypes of leaf rust, since uredospores were mixed with talcum powder at a rate of 1 :25 (w/w) and dusted at booting stages, using the methods of Tervet and Cassel (1951). The recommended package of all cultural practices was precisely followed. The rust free experiment (protected) was accomplished by spraying the systemic fungicide Sumi-8 EC "(E)-1-2,4-Dichlorophenyl)-4,4-dimethly1-2-(1,2,4-triazol-1-yl)-1-penten-3-01" (diniconazole) at the rate of 0.35 ml / L water in addition to 0.5 ml of Tryton B as a adhesive agent at booting stage and repeated 3 times at 15 days interval to serve as infection free (control).

Data were recorded on five randomly selected plants per row, in each of the three replicates, in each experiment. The studied characters were; 100-kernel weight (gm) and grain yield per plant (gm). Also, the rust reaction for both stripe and leaf rust was record and estimated as diseases severity (%) and infection type according to Peterson *et al.*(1948). Rust reaction was expressed thereafter in terms of Average Coefficient of Infection (ACI) to be easy for statistical analyses, following the methods adjusted by Shehab El-Din and Abdel-Latif (1996) from the methods adopter by (c.f.) Saari and Wilcoxson (1974). ACI data of both rusts were transformed using square root scale. Data obtained were statistically analyzed on plot mean basis. Analysis of variance and genetic analysis were conducted only for the protected experiment for yield character, while it were carried out only in the unprotected experiment for rust characters. Evaluating the reduction of wheat grain yield and 100-kernel weight relevant to both stripe and leaf rust infection was calculated as:

- Reduction (%) = (protected - unprotected) / protected

Mean yield reduction (%) differences between fungicides of the protected and unprotected plots for each genotype were tested for significance using paired t-test. The diallel cross analysis adopted by Hayman (1954) was applied. Estimates of genetic variation components were calculated and nature of gene action for the studied characters was determined. In addition, heritability values were also estimated.

RESULTS AND DISCUSSION

At Sakha location, stripe and leaf rusts were the predominant diseases. However, during the growing seasons, there was a good level of disease development and sufficient control with fungicide protection was achieved, in the protected experiment.

The analysis of variance revealed significant differences in all studied characters among the genotypes (Table 2). These results indicating that the parents were diversion and could be transmitted to the offspring's.

Table 2: Analysis of variance for grain yield and 100-kernel weight (protected experiment) and rust reaction (ACI) for both rusts infected at Sakha Station during 2001/2002 .

Source of variation	df	Yield characters		Reaction in terms of ACI	
		Grain yield	100-kernel	Stripe rust	Leaf rust
Replicates	2	135.40**	0.021	0.009	0.028
Genotypes	14	181.83**	0.34**	29.675**	25.99**
Error	28	21.69	0.053	.043	0.14

** Significant at 0.01, probability level.

Table 3 showed the mean performance of both rust reaction for unprotected experiment and intragenotypic mean percentage losses of the studied genotypes. Mean disease reaction ranged from 0.1 to 8.46 for stripe rust and from 0.90 to 9.04 for leaf rust (Table 3). Considering magnitude of diseases reaction, the overall mean reduction (%) was generally lower for

100- kernel weight (i.e. 8.06%) comparing with that recorded with yield (i.e. 12.06). The reduction (%) ranged from 0.99 to 54.55 % for grain yield and, ranged from 0 to 29.22 % for 100-kernel weight. Significant mean differences between fungicide protected and unprotected plots were found for only four genotypes for grain yield and 100- kernel weight. These genotypes possessed significant mean differences, out of them three were susceptible to stripe rust and only one was susceptible to leaf rust. All susceptible genotypes for stripe rust (the genotypes with high values of ACI) possessed highest values for reduction (%) in grain yield and in 100- kernel weight (Table 3). Meanwhile many genotypes were susceptible for leaf rust, while only one genotype i.e. Sids 1 / Sakha 61 possessed high values for reduction (%) in grain yield and 100-kernel weight. These results suggested that the stripe rust is more destructive disease than leaf rust.

Table 3: Mean strip and leaf rusts reaction for unprotected experiment and intragenotypic mean percentage reduction of the studied genotypes.

	Disease reaction		reduction (%)	
Genotypes	YR	LR	Grain yield	100 Kernel wt.
Sids 1	0.10e	9.04a	1.64c	6.05c
Gemmeiza 9	0.10e	0.90h	1.12c	1.21cd
Sakha 61	0.10e	8.66ab	3.08c	1.53cd
Giza 165	8.16a	3.84c	54.37a**	29.10a*
Giza 163	8.46a	2.85f	26.30b**	17.94b**
Sids 1/Gimmeiza 9	0.10e	2.10g	3.27c	2.31cd
Sids 1/ Sakha 61	0.10e	8.85a	26.44b*	25.08ab*
Sids 1/ Giza 165	1.28c	5.28c	0.83c	7.40c
Sids 1/ Giza 163	0.55d	4.00de	2.76c	4.51d
Gimmeiza 9/ Sakha61	0.10e	4.60de	1.87c	0.26cd
Gimmeiza 9/ Giza 165	1.61c	2.10g	4.43c	0.88cd
Gimmeiza 9/ Giza 163	1.28c	1.23h	2.51c	1.33cd
Sakha 61/ Giza 165	0.71d	8.16b	2.14c	2.84cd
Sakha 61/ Giza 163	0.71d	8.06b	0.98c	0.00cd
Giza 165/ Giza 163	7.52b	3.40ef	47.37a**	17.94b*
Mean	2.06	4.87	10.97	7.35

Asterisk indicate significant intragenotypic differences; *, ** Significant at 0.05 and 0.01, probability levels respectively.
Mean values followed by the same latter in a column are not significantly differences according Duncan, (0.05) test.

In so far as the genotypes varied in disease reaction for leaf rust, dissimilar levels of intergenotypic reduction percentage would be expected. In this case, it appears that tolerance is involved as its variation could not be explained by differences in disease reaction and reduction percentage did not appear to be function of disease reaction for leaf rust. These results are in agreement with those recorded by Andenow *et al.* (1997).

The mean values of studied wheat genotypes when protected with fungicide were significantly different for grain yield and 100- kernel weight (Table 4). The parent (Sids 1) possessed the highest value for grain yield, while Gemmeiza 9 had the highest value for 100- kernel weight. However, the highest values for crosses were recorded with the cross Sids 1 / Giza 165 for grain yield and 100- kernel weight (Table4).

Table 4: Mean performance of studied wheat genotypes when fungicide protected (FP) and un protected (NFP).

	Grain Yield/plant (gm)		100- Kernel weight (gm)	
Genotype	NFP	FP	NFP	FP
Sids 1	53.3*	52.4*	4.5	4.8
Gemmeiza 9	42.3*	42.8	5.0*	5.1
Sakha 61	33.3*	34.3	4.6*	4.7
Giza 165	17.5	38.4	3.4	4.8
Giza 163	25.3	34.8	4.2	5.1
Hydrides				
Sids 1/Gimmeiza 9	43.3*	44.7	5.6*	5.7*
Sids 1/ Sakha 61	35.8*	48.8*	4.0	5.4*
Sids 1/ Giza 165	61.5*	62.0*	5.4*	5.8*
Sids 1/ Giza 163	45.5*	47.0	5.7*	5.5*
Gimmeiza 9/ Sakha61	41.2*	42.0	5.4*	5.4*
Gimmeiza 9/ Giza 165	41.0*	42.8	5.5*	5.5*
Gimmeiza 9/ Giza 163	43.1*	42.2	5.4*	5.5*
Sakha 61/ Giza 165	45.5*	44.7	5.0*	5.1
Sakha 61/ Giza 163	57.5*	58.1*	5.2*	5.2
Giza 165/ Giza 163	22.5	42.9	3.9	4.9
Mean	40.59	45.24	4.86	5.24
New LSD	13.04	12.84	0.63	0.66

Correlation Analysis:

Correlation analysis of the date from the parents and F_1 hybrids showed negative and highly significant associations between stripe rust reaction in term of (ACI) and both grain yield / plant and 100-kernel weight (Table5). However, relationships between leaf rust reaction and both grain yield / plant and 100-kernel weight was negative and insignificant. These results confirmed the previous studies, which indicated the stripe rust disease is more destructive for yield than leaf rust. Higher kernel weight exhibited highly significant association with grain yield / plant in the set of genotypes. These results are in agreement with the those recorded by Aglan (2003) and Hammad (2003).

Association found in a set of parents and their F_1 might reflect specific gene combinations, characterizing only those particular genotypes. For breeding purposes, it is more relevant to study the correlation between traits in segregating populations, involving contrasting parents (Mou and Kronstad 1994).

Table 5: Correlation coefficients between studied characters of five parents and their F_1 in wheat.

	Grain yield	Yellow rust	Leaf rust
100-kernel weight	0.72**	-0.73**	-0.23
Grain yield		-0.73**	-0.29
Yellow rust			-0.34

** Significant at 0.01, probability level.

Genetic Analysis:

Results in Table 6 revealed that t^2 values were not significant for all studied characters except for 100-kernel weight. Accordingly, the major assumption postulated for diallel analysis appeared to be valid except for 100-kernel weight.

Table 6: Values of t^2, regression coefficient of covariance (Wr) on variance (Vr) and t-values for b= 0 and b = 1 for studied characters in wheat.

Characters	T^2	Regression coefficient	T value for b=0	T value for b=1
100-Kernel weight	3.61**	0.02	0.09	4.37**
Grain yield /plant	0.52	0.31	0.86	1.92
Stripe rust	0.97	1.03	3.80**	-0.90
Leaf rust	0.25	0.04	11.05**	0.65

b=0 and b=1 indicate difference of regression coefficient value from 0 and 1 (unit), respectively.
** Significant at 0.01, probability level.

The regression coefficients and their significance for the studied characters are given in Table 6.The coefficients are expected to be significantly different from zero but not from the unity if all assumptions are correct. The yield character, which is insignificantly differed from zero, showed a partial failure of the assumption.

Table 7: Estimated genetic and environmental components of variance for studied characters in F_1 diallel crosses (Hayman 1954).

Parameters	Mean Squares of :			
	Yield characters		Rust reaction in terms of ACI	
	100-Kernel weigh	Grain yield	Stripe rust	Leaf rust
D	-	45.44±25.05	20.23**±0.51	12.9**±0.35
F	-	37.74±62.58	7.87**±1.28	-1.63±0.86
H1	-	200.81**±67.70	11.47**±1.98	6.28**±0.93
H2	-	175.67**±61.36	10.63**±1.25	3.84**±0.85
H2	-	120.07**±4143	10.13**±0.85	0.18±0.57
E	-	9.75±10.22	0.01±0.21	0.04±0.14

***, ** Significant at 0.05 and 0.01, probability levels, respectively.**

The estimates of genetic and environmental components of variation as well as their proportions for the studied characters are given in Table 7 and 8. The additive component (D) was significant for rust characters but not for grain yield / plant. The dominance component (H_1) and (H_2) were found to be significant for all studied character. Comparison between magnitude of additive and dominance values revealed that additive gene effects were more important than dominance for rust characters. Similar results were reported by Yadav *et al.* (1998) , Mahgoub (2001) Aglan (2003) and Hammad (2003). The sign of (F) indicates the relative frequencies of dominant and recessive alleles in the parents. The (F) values were positive for grain yield /plant and stripe rust resistance, indicating an excess of dominant alleles. In contrast (F) values were negative for the leaf rust indicating an excess of recessive alleles compared with dominant one.

The estimates of (h^2) values which refer to the dominance effects over all heterozygous loci, were found to be significant and positive for grain yield and stripe rust. This result indicating the prevalence of positive genes controlling these characters and suggesting that dominance was unidirectional.

The average degree of dominance $(H_1/D)^{1/2}$ was less than one for rusts traits (Table 8), indicating an average partial dominance, meanwhile , it was > one for grain yield indicating over dominance . The proportion values of both positive and negative genes are equally distributed among the parental genotypes when $H_2/4\ H_1$ is 0.25. The estimated values of $H_2\ /\ 4H_1$ were lower than 0.25, indicating that positive and negative genes were not equally distributed among the parents.

Number of effective factors, (k), that controlling the character and exhibit dominance to certain degree, showed that at least one effective factor for the three studied traits, could be detected.

Table 8: Estimates of genetic ratios and heritability for rust reaction in F_1 diallel crosses.

	Characters			
Parameters	100-Kernel weight	Grain yield	Stripe rust	Leaf rust
$(H_1/D)^{1/2}$	-	2.099	0.753	0.696
$H_2/4H_1$	-	0.219	0.232	0.153
KD/KR	-	1.492	1.695	0.834
h^2/H_2 (K)	-	0.684	0.953	0.047
r	-	-0.399	0.997	0.463
$h_{(n)}$	-	0.23	0.712	0.895
$h_{(b)}$	-	0.86	0.998	0.995

The correlation coefficient (r) between the parental values (yr) and the parental order of dominance (wr + vr) for these attributes are given in Table 8. A high positive correlation coefficients indicate that most dominant alleles act in one direction while most recessive alleles act in the opposite direction as shown in rust traits. Meanwhile the negative coefficient indicates that the dominant alleles have lower variance array and covariance than high recessive parents as shown in grain yield.

Broad sense heritability estimates were high for three studied traits. Meanwhile, narrow sense heritability estimates were high for rust traits while, it was low for grain yield / plant. This indicates again that additive gene action was primarily important to the inheritance of rust resistance traits. The large additive effects suggest that selection could be effective for these traits. These findings are in agreement with those reported by Ali *et al.*(1994), Yadav *et al.*(1998) Ageez and Boulot (1999) Zhang *et al.*(2001) Aglan (2003) and Hamad (2003).

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دراسات وراثية ومرضية في بعض طرز القمح المصري المتأثرة بكل من مرض الصدأ المخطط وصدأ الأوراق

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*** البرنامج القومي لبحوث القمح - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية**

****قسم بحوث أمراض القمح معهد بحوث أمراض النباتات- مركز البحوث الزراعية**

يهدف البحث الحالي إلى دراسة وراثة صفة المقاومة لمرض الصدأ المخطط (الأصفر) وصدأ الأوراق (البرتقالي) و بعض الصفات المحصولية وتقدير النقص الناتج عن الإصابة وكذلك الارتباط بين المرض ومحصول الحبوب ووزن الـ ١٠٠ حبة في محصول القمح المصري. وقد استخدمت خمسة أصناف من القمح، صنفان حساسان لكلا المرضين (جيزة ١٦٣ و جيزة ١٦٥) وصنف مقاوم لكلا المرضين (جميزة ٩) وصنفان مقاومان لمرض الصدأ الأصفر وحساسين لمرض الصدأ البرتقالي (سخا ٦١ وسدس ١). وقد تم إجراء التهجينات الممكنة بدون التهجين العكسي في موسم ٢٠٠١/٢٠٠٢م بمحطة بحوث سخا الزراعية، و في موسم ٢٠٠٢/٢٠٠٣زرعت الآباء وهجن الجيل الأول في تجربتين حقليتين كنباتات فردية في ثلاثة مكررات، وتم عمل حماية لها بالمبيد الفطري في إحداها والأخرى تركت بدون حماية. أوضحت النتائج أن مرض الصدأ الأصفر كان الأكثر خطورة عن صدأ الأوراق. كانت كل التراكيب الوراثية المصابة بالصدأ الأصفر لها قيم عالية ومعنوية لنسبة النقص في المحصول ووزن الحبوب ، في حين وجد أن كثيراً من التراكيب الوراثية مصابة بصدأ الأوراق ولكن كان أحدهما فقط له نسبة نقص معنوية. كما وجد ارتباط موجب وعالي المعنوية بين مرض الصدأ الأصفر والمحصول ووزن الـ ١٠٠ حبة، بينما كان هناك ارتباط سالب وغير معنوي بالنسبة للارتباط بين صدأ الأوراق والمحصول ووزن الـ ١٠٠ حبة. مما يؤكد النتائج السابقة بخطورة الصدأ الأصفر عن البرتقالي.

أوضح تحليل المكونات الوراثية أن الجزء الأساسي للاختلافات الوراثية ناتج عن الفعل الجيني المضيف بالنسبة لصفة المقاومة للمرض بينما كان الجزء غير المضيف هو الأساس للصفات المحصولية وكان متوسط درجة السيادة أقل من الواحد لصفة المقاومة مما يدل على وجود سيادة جزئية بينما كان أكبر من الواحد للصفة المحصولية. كانت قيمه F موجبة ومعنوية لصفة المقاومة للصدأ الأصفر ومحصول الحبوب مما يدل على زيادة جينات السيادة بالمقارنة مع الجينات المتنحية في حين كانت النتائج عكس ذلك بالنسبة لصدأ الأوراق ارتفعت قيم درجة التوريث بمعناها الواسع للصفات تحت الدراسة بينما كانت قيم درجة التوريث بالمعنى الضيق مرتفعة لصفتي المقاومة بينما كانت منخفضة لصفة محصول الحبوب، مما يشير إلى أن الانتخاب في الأجيال الانعزالية المبكرة قد يكون مؤثراً في الحصول على تراكيب وراثية تحمل صفة المقاومة لمرض الصدأ المخطط أو صدأ الأوراق أو كليهما.