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INHERITANCE OF STRIPE RUST RESISTANCE IN THE WHEAT CULTIVAR TRITICUM SPELTA ALBUM (YR_5)

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ABSTRACT

Stripe rust of wheat as considered one of the most important diseases in the vast majority of the world area grown to wheat.

In Egypt the first record of epiplytotic due to such disease was that of 1967 which attacked the local wheat var. Giza 144. On the other hand the last epiplytotic was that of 1995 which affected most of the cultivated vars. and inducing high losses.

The present work aimed to increase the levels of stripe rust resistance by the incorporation of Y_{r5} (*Triticum spilta* album) via crossing with our susceptible cultivars viz. Sakha 8, Sids 4,- 5,-6 at Sakha Agric.Res.Stn.

The obtain of results F_1 plants exhibited high levels of resistance when infected by race E at both seedling and adult stages. This result indicated that resistance is dominant over susceptibility.

The F_2 segregation's (3 resistant : 1 susceptible) indicated that resistance in the tested material is governed by two gene pairs .The third result indicated that the phenotype was not affected by the factor (y_{r5}).This result reflected the significance of exploiting this factor in the breeding program.

The increasing values of heritability in broad sense in F_1 and F_2 in most crosses confirmed the importance of the additive dominant action consequently, it will be easy to performs the selection at easily generations. But ,it is better to make selection at late generations because of it's importance and befitial for breeding programs.

INTRODUCTION

Stripe rust caused by *Puccinia striiformis tritici* is the most important disease of wheat in many regions of the world and is present essentially every where wheat is grown and favorable conditions are prevailed. Its importance from area to area depends on climate and also on predominant cultivars.

In Egypt, the first stripe rust epidemic was recorded on wheat var.Giza 144 in northern governorats in general and Manzala district in particular (Abd El-Hak and Kamel,1972).The last epidemic was that of 1995 in which stripe rust attacked most of the commercial wheat vars. causing severe infection and high losses in Giza 163, sakha 8, and Sids 4,5 and 6 wheat cultivars (EL-Daoudi et.al 1996).

Disease resistance is controlled by major and minor genes or both together, however complementary effect between major genes may enhance the response of variety to disease resistance genes at different loci or their products may interact to give higher levels of resistance (Simons et.al 1978).On of the most widely effective resistance gene to yellow rust of wheat described so far is $y_{r\ 5}$ which occurs in *T. spelta* album and is located on chromosome 2 BL(Macer,1966).

The objective of the present study was directed to investigate the role of such gene when incorporated in certain commercial wheat vars. from the perspective of disease and genetic parameters.

MATERIALS AND METHODS

Four wheat cultivars i.e Sakha8,Sids 4,Sids 5 and Sids 6 exhibited wide range of variability in their susceptibility to stripe rust, while the monogenic line i.e $y_{r\ 5}$ exhibited high resistance to stripe rust..(Macer.1966).These parents were sown at Sakha Agric .Res. Stn. In 1999/2000 growing season in six rows each. All possible crosses among the four cultivars and $Y_{r\ 5}$ were performed to produce the hybrid seeds of the four crosses, the resulted F'_1s are represented as follow :-

Yr_5/ Sakha 8,Yr_5 / Sids 4,Yr_5 / Sids 5 and Yr_5 / Sids 6 during 2000/2001 growing season, part of the four F'_1 hybrid seeds was sown to produce the F_2 seeds, the rest were left for the final experiment in the next season during growing season 2001/2002 a comparative experiment was conducted in a randomized complete block design with three replicates. Each replicate contained two rows for each parent and F'_1 as well as 10 rows for each F_2.This performance was carried out to create uniformal environmental conditions. The rows were 3m long, 30 cm apart and seeds were sown 10 cm apart within rows, there for, each row contained 30 plants. A mixture of highly susceptible wheat cultivars were sown around the experiments as a spreader to disseminate the stripe rust uredinispores of the *pathogen (Puccinia striifoims f-sp-tritici)*.All regular cultural practices were applied during the growing seasons.

Pathogencity test :-

A) at Seedling Stage.

Eight pots for each of the parents and F'_1 as well as 20 pots of each of the F_2 were sown. Each pot contained 10 seeds, Seedling (7-8 days-old) of the parents, F'_1 and F_2 were uniformaly inoculated with the urediniospores of *Puccinia striiforms*, which was used for inoculating all of the tested materials at seedling stage in the greenhouse using the technique described by (Johnson et al 1972).Infection type data against the pathogen have been recorded after approximately 15 days of inoculation according to the scale described by (Mc Neal et al 1971) .The infection type i.e. 0, 1, and 2 were considered resistant however ,3,4, and 5 moderate types, were considered resistant or (intermediate sporulation),6 and 7 moderate susceptible and 8 and 9 high susceptible.

B) at Adult Stage :-

The adult tests in field were accomplished through the inoculation of the spreader plants which were moistened and dusted with spore mixture using the most prevalent stripe rust isolates in the area, the amount was1: 20(urediniospores to talcum powder) (w.w).All materials were inoculated at booting stage according to the method adapted by (Tervet and Cassell 1951).Data of stripe rust severity were recorded on adult plants according to

(Peterson et al 1948). For study, the inheritance of resistance, the F_2 plants were grouped into 10 categories depending on the percentages of the disease severity and infection type under field conditions, the disease severity 0, 10R, 10 MR,20 MR were considered as the resistant phenotypes ,while 10 MS 10S, 20 S,30 S,40 S,50 S, and 70S were considered as the susceptible phenotype. Statistical and genetic analysis, frequency distribution value, were computed for parents,F_1 and F_2 populations for infection type in all the crosses at seedling testes.

Likewise at the adult stage under the field conditions, frequency distribution values for stripe rust severity were also computed. In respect to mode of inheritance goodness of fit of the expected ratio of the phenotype classes concerning the stripe rust, infection types were determined by X^2 Analysis (steel and torrie, 1960). Degrees of dominance were calculated according to the methods suggested by (Peter and Frey, 1966). In these methods, the degrees of dominance symbolized as h_1 and h_2 for F'_1 and F_2 were respectively calculated by the formula

$h_1=(\bar{x}F_1-\bar{x}Mp)/D$

$h_2=2(\bar{x}F_2-\bar{x}Mp)/D$

$D=(\bar{x}hp-\bar{x}Mp)$

$\bar{x}F_1, \bar{x}F_2$ and $\bar{x}$ hp are the means of F'_1, F_2 and higher parent, respectively, while $\bar{x}Mp$ is the mid-parents value.

In addition, the F'_1 and F_2 means were compared with mid-parents values using "t" test to determine whether h_1 and h_2 values were significantly different from zero.

Heritability in its broad-sense was estimated according to Lush(1949) as follows:-

$$h^2_{bs} = \frac{VG}{VP} \quad X100$$

Where

h^2_{bs} = broad-sense heritability

VG = genotypic variance of F_2 individual

VP = phenotypic variance of F_2 individual

VE = environmental variance estimated from variation with the non-segregating populations,i.e parents, and F'_1 plants.

RESULTS

The infection type, frequency distribution and the disease Severity classes of the parents, F'_1 and F_2 populations of each of the four crosses which were ,inoculated with the race No.133 E24 of *Puccinia striiformis* at seedling stage and inoculated with mixture from the most prevalent stripe rust isolates in the area i.e o E o,133 E124 and 180 E 116 at adult stage.

Data presented in table (1) showed that, the parent Yr_5 showed low infection type i.e 4.

Table (1): the infection type frequency distribution of parents, F_1 and F_2 population of crosses at seedling stage againts stripe rust caused *Puccinia striiformis* racE 133 E 124. Carried out at Sakha during 2000/2001.

Cross No.	Cross Name		Number of tested plants	Infection type									
				0	1	2	3	4	5	6	7	8	9
1	Yr5 x sakha 8	P1	70					70					
		P2	60										60
		F1	58		27		31						
		F2	220	37	45	15	39	13	5	21	38		7
2	Yr5 x sids 4	P1	70					70					
		P2	75			28	36						75
		F1	64			28	36						
		F2	211	5	38	35	41	29	10	15	10	28	
3	Yr5 x sids 5	P1	70					70					
		P2	60										60
		F1	57				27	30					
		F2	193	5	28	43	39	7	28	13	14	16	
4	Yr5 x sids 6	P1	70					70					
		P2	65									68	
		F1	63			23	40						
		F2	173	16	8	51	18		15	42	11		4

Moreover the parents Sakha 8,Sids 4,Sids 5 and Sids 6 showed highly infection type (9,9,9 and 8 respectively).On the other hand, the infection type of F'_1 plants in all crosses showed low infection type from 1 to 3,these results revealed that, resistance is dominant over susceptibility in all crosses. In addition , the F_2 frequency distribution showed a wide range of infection types, however the frequency distribution of 4 crosses ranged from 0 to 9.the number of resistant and susceptible plants were 154 :66,158 :53,150:43 and 116:57.All these data phenotypic ratio fit the 3 : 1,theoretical expected ratios indicating the functioning of one dominant gene pairs as clarified in table (2).

Table (2): phenotypic classes expected ratios and X^2 of F_2 plants in 4 wheat crosses inoculated with race 133E124 of *Puccinia striiformis* at seedling stage under greenhouse conditions performed at Sakha during 2000/2001.

Cross number	Cross name	Race : 133 E 124			X^2
		Phenotypes		Expected ratio	
		R	S		
1	Yr 5 X Sakha 8	154	66	3:1	2.94
2	Yr 5 X Sids 4	158	53	3:1	0.2
3	Yr 5 X Sids 5	150	43	3:1	0.77
4	Yr 5 X Sids 6	116	57	3:1	5.81

As regard to, the adult plants tests conducted for inheritance of wheat resistance to stripe rust caused by a collection of different races of *Puccinia striiformis* under ield conditions, the frequency distribution of disease severity for the F'_1 , F2 and their 5 respective parents of the 4 crosses are presented in Table(3).

Table (3): Frequency distribution of stripe rust severity for parents F_1 and F_2 populations in 4 wheat Crosses artificially inoculated at adult stage under field condition .at Sakha Res.Stn. during 2000/2001.

Cross No.	Cross Name		Number of tested plants	Rust Severity class											
				0	10 R	10M R	20M R	10M S	20M S	10 S	20 S	30 S	40 S	50 S	60 S	80S
1	Yr5 x sakha 8	P1	90		90											
		P2	60												20	40
		F1	65		30	35										
		F2	219	20	18	70	52	18	20		10	9	2			5
2	Yr5 x sids 4	P1	50	20	30											
		P2	58												20	38
		F1	49		20	29										
		F2	246	16	30	60	63	10	20		20	10	10	7		
3	Yr5 x sids 5	P1	90	30	60											
		P2	64												24	40
		F1	55		15	40										
		F2	185	20	56	50	8	10	11		20				10	
4	Yr5 x sids 6	P1	90		90											
		P2	85												20	65
		F1	70		50	20										
		F2	238	36	45	53	40	26				15	11		9	

Data in table (3) indicated that, monogenic line Yr_5 showed low disease severity (10R),on the other hand, the other parents i.e Sakha 8,Sids 4,Sids 5 and Sids 6 exhibited the highest disease severity (60 S-80 S).Also, data in the table showed that, the F'_1 plants exhibited the lowest disease severity which was raneged from (10R to 10 MR) in all crosses indicate dominance of resistance over susceptibility.Concerning, F_2 plants the disease severity, frequency distribution of the 4 crosses the results indicated that they exhibited wide range of infection types i.e.(0-80S). As regard to, the behavior of all crosses at adult plants, data in table (4) indicated that, the number of resistant to susceptible plants were (160: 59),(169: 77),(134: 51)and (177: 61) respectively. These observed ratios fitted the theoretical expected ratio 3:1.these results indicated,the presence of dominant gene for resistance.

Table (4) : Stripe rust severity phenotypic classes , expected ratios and x^2 of 4 wheat crosses inoculated with stripe rust race mixure the adult stage under field condition Sakha 2000/2001.

Cross number	Cross name	Phenotypes		Expected ratio	x^2
		R	S		
1	Yr 5 X Sakha 8	160	59	3:1	0.44
2	Yr 5 X Sids 4	169	77	3:1	5.21
3	Yr 5 X Sids 5	134	51	3:1	0.65
4	Yr 5 X Sids 6	177	61	3:1	0.14

The means and variance of coefficient of infection for the parents, F'_1 and F_2 respectively, and heritability in broad sense are given in table (5), means of infection types for $y_{r\ 5}$.Sakha 8, Sids 4,Sids 5 and Sids 6 were 1.34,73.34,73.10,72-5, and 75.29 respectively, F'_1 mean values were very close to the resistant parent (3.08,3.18,3.46 and2.57) respectively and very

far from their of the mid-parent estimates (36,35,88,35.58 and 36.98) respectively, these data indicate the presence of partial dominance since h_1 values for the four crosses were 0.94, 0.95, 0.93 and 0.97, respectively.

Over dominance for resistance in the four crosses were also manifested in the F_2 since h_2 values were 1.61, 1.48, 1.57 and 1.55 respectively, (table 5).in which heritability values in broad sense for the infection types, characters are given .

Table (5): Average performance of parents, F_1 and F_2 generations, degree of dominance and heritability for the infection type in the four studied crosses.

Cross No.	C ross name	P1	P2	F1	F2	MP	Dominance		Broad sense
							F1	F2	
1	Yr5 x sakha 8								
	X	1.34	73.34	3.08	8.07	36	0.94**	1.61**	46.45
	S^2	0.89	88.89	1.01	56.51				
2	Yr5 x Sids 4								
	X	1.34	73.10	3.18	10.27	35.88	0.95**	1.48**	75.65
	S^2	0.89	90.37	0.96	126.28				
3	Yr5 x Sids 5								
	x	1.34	72.5	3.46	8.84	35.58	0.93**	1.57**	87.61
	S^2	0.89	93.75	0.80	189.04				
4	Yr5 x Sids 6								
	x	1.34	75.29	2.57	9.52	36.98	0.97**	1.55**	83.32
	S^2	0.89	71.98	0.81	198.25				

** significant at the 1% level of probability.

Heritability estimates in narrow sense were moderate (46.45) for the cross (yr_5 /Sakha 8) while estimates exhibited high values i.e. 75,65,87.61 and 83.32 for crosses yr_5 / Sids 4, yr_5 / Sids 5, and yr_5 / Sids 6 respectively. These findings indicate that selecting resistant plants in early generation would be an effective tool in searching for stripe rust resistance from the perspective of genetic estimates.

DISCUSSION

The combined F'_1 and F_2 results demonstrated that Yr_{-5} were valuable sources of stripe rust resistance in crosses with susceptible vars. belonging to *T. aestivum*. The present study further corroborates our previous findings ({Gerechter- Amitai and Grama 1974) who indicated that this resistance was controlled by one dominant gene . One of the most widely effective resistance gene to yellow rust of wheat described so far was Yr_5 which occurs in *T. spelta* album and was located on chromosome 2BL (Macer, 1966).

Macer (1975) reported that *T. spelta* var. album exhibited one dominant gene (Yr_5) . Kema (1988) confirmed that *T.spelta* var. album included a single dominant gene for stripe rust resistant to European races. Luthra *et al.* (1989) reported that *T. spelta* var. album has three dominant genes and another recessive one for resistance to Indian recess.

Also when tested with north America races of *P.striiformis* .(Chen and Line 1987, 1988), Lupton and Macer (1962) and McIntosh (1983) reported that, *T. Spelta* var album and other monogenics exhibited have a single gene for resistance to races (cereal disease lab.4) CDL-21, on the other hand analysis of population means and variances suggested that , the predominant portion of the total variance could be attributed to the dominance effect and that resistance to stripe .rust is a simple inherited character. Moreover, selecting resistant plants in the early generation would be effective since the heritability estimates in broad sense, could be exploited in this respect.

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وراثة مقاومة الصدأ الأصفر فى قمح الخبز باستخدام العامل الوراثي(Yr_5)

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***قسم بحوث القمح ، معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية**

يعتبر الصدأ الأصفر من أهم الأمراض التي تصيب محصول القمح فى كثير من دول العالم و يساعد على انتشاره الظروف المناخية وقابلية الأصناف للإصابة.

وسجلت أول خسارة فى مصر عام ١٩٦٧ على الصنف جيزة ١٤٤وأخر خسارة كانت عام ١٩٩٥على معظم الأصناف التجارية السائدة فى هذه الفترة حيث سببت لها خسارة كبيرة.والدراسة فى مجملها تهدف لرفع درجة المقاومة فى أربعة أصناف قمح مصرية هى(سخا٨،سدس٦،٤،٥)وذلك بإدخال العامل الوراثي Yr_5 الموجود بالصنف *triticum spelta* album .

وقد أظهرت النتائج أن نباتات الجيل الأول أظهرت درجة مقاومة عالية ضد المرض فى طوري البادرة والبلوغ وهذا يؤكد سيادة صفة المقاومة على القابلية للإصابة .كما أظهرت نسبة الانعزلات فى الجيل الثانى (٣مقاومة:١قابل للإصابة) أن صفة المقاومة فيها زوج واحد من العوامل الوراثية وذلك عندما تمت العدوى بالسلالة 133E124 السائدة هذا الموسم .

ولم يتأثر الشكل الظاهري لنباتات الجيل الثانى بإدخال العامل الوراثى Yr_5 بالتهجين مع الأصناف المحلية وانعكاسات هذه النتيجة تتضح فى إمكانية استخدام هذا العامل الوراثي فى برامج التربية بلا خوف من تغير الشكل الظاهري للأصناف

وتبين الدراسة أيضا أن معامل التوريث بمفهومة الواسع لصفة المقاومة كانت قيمته (متوسطة الى مرتفعة) (٤٦,٤٥-٨٧,٦١)وان درجة السيادة فى الجيل الأول والثاني كانت عالية المعنوية فى غالبية التهجينات، وهذا يوضح أهمية تأثير الفعل المضيف والسيادى فى توريث هذه الصفة ويتيح إجراء عملية الانتخاب فى الأجيال المبكرة إلا أنة يفضل الانتخاب فى الأجيال المتأخرة مما يجعله اكثر فاعلية واعظم فائدة لعملية التربية للمقاومة.