Zagazig J. Agric. Res., Vol. 43 No. (4) 2016

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

DETECTION OF RESPONSIBLE RESISTANCE GENES TO STEM RUST (*Puccinia graminis* f.sp. *tritici*) IN SOME EGYPTIAN WHEAT CULTIVARS

Farouk E.Y. El-Banoby[1], O.A. Boulot[2] and B.R. Mohdly[2*]

1. Agric. Bot. Dept., Fac. Agric., Al-Azahr Univ., Cairo, Egypt

2. Pl. Pathol. Res. Inst., ARC, Giza, Egypt

ABSTRACT

Genes for resistance to stem rust (*Puccinia graminis* f. sp. *tritici*) were postulated in eighteen Egyptian wheat cultivars. The reactions of the tested cultivars were compared to the reactions of 20 monogenic lines (Sr's) against 25 known pathogenic isolates of the causal organism. Difference and similarity of the reactions in terms of infection types (I T's) between the monogenic lines and the tested cultivars was used to postulated gene (s) responsible for seedling resistance. Gene postulation showed that no stem rust resistance gene (s) could be detected in the two cultivars; Giza 160 and Sakha 93.while , Misr 1 cv probably has most of the tested genes (18 genes), followed by Gemmeiza 10 and Banisweif 6 (each probably has 16 genes), Sakha 95 (15 genes) and Gemmeiza 7, Gemmeiza 11, Sids 13 and Shandaweal-1 (14 genes probably present in each). Also, eleven and twelve Sr genes were probably present in Misr-2 and Sakha 94, respectively. The other cultivars under study, probably have a few numbers of the tested genes. Some of the postulated genes were common in most of the studied cultivars *i.e.,* Sr30, Sr 17, Sr 9e, Sr 10, Sr 36 and Sr 13, in which other genes were not in common.The most effective stem rust resistance genes which showed very low virulence frequency (%) were Sr's 13, 7a, 9e, 9d and 21. While high occurrence of virulence frequency (%) were found agains Sr's 8b, 6, 10 ,9a, 9g, 9b, 17, 5, 7, 11 and 8b. So, these Sr genes considered to be the least effective genes against the tested isolates of the causal pathogen. The prompt detection of genes conditioning stem rust resistance in wheat cultivars and advanced or promising germplasma complemented or coupled with multilocational evaluation for adult plant resistance (APR) or field resistance, will enable wheat breeders to make well founded decision in relation to planning successful breeding strategy, that aimed to release a new wheat variety with a long- lasting and more durable resistance against wheat stem rust disease.

Key words: Stem rust, resistance genes, infection types, postulated genes, field resistance, adult plant resistance.

INTRODUCTION

Stem rust (*Puccinia graminis* f.sp.*tritici*) has been potentially one of the most destructive diseases on wheat in Egypt, especially in the late sowing. Consistently, major losses in wheat production, can be occurred when the susceptible cultivars have been severely rusted (Abd El-Hak and Kamel, 1973).

As early as the beginning of 1950's, the first two resistant wheat cultivars; Giza 135 and Giza 139, has been released and used in agriculture under the Egyptian field conditions. Since then, stem rust has successfully been controlled in Egypt. After that, many wheat cultivars derived from these two cultivars possessing the same stem rust resistance genes were developed. Most of these derivatives, are characterized by their high levels of resistance to most of the common races of stem rust pathogen and served in agriculture for long period of times (many years). Nevertheless, the probability of introduction

* **Corresponding author: Tel. :** +201119767400
E-mail address: rmahmoud827@gmail.com

and migration of new stem rust races with virulence to Sr genes newly deployed in the widely grown wheat cultivars in Egypt, is of great expectation to occur. Furthermore, in recent years the appearance and detecting of the new virulent race; Ug 99 (TTKSk) in Eastern Africa and Ethiopia, that overcome the genetic resistance in most wheat germplasm in these countries. These introductions have complicated efforts to develop wheat cultivars with durable stem rust resistance and have the ability to overcome and breakdown the effectiveness of most rust resistance genes that are available for deployment (Pretorius *et al*., 2000).Therefore, the new cultivars currently grown in Egypt, have been subjected or threatened by the attack of this aggressive race and its new variants. Early studies have been carried out in Egypt by Kamel, 1971 to determine the number of stem rust resistance genes (Sr's), conditioning resistance in some Egyptian wheat cultivars by crossing them with the susceptible parents. He also identified some seedling resistance genes in very limited local wheat cultivars. Since that time and before, further studies were carried out by Abu El-Naga *et al.* (1990 and 1993), Nazim *et al.* (2001), Mousa *et al.* (2004) and Youssef *et al.* (2012) to postulate the probable genes, responsible for stem rust resistance in the Egyptian wheat cultivars. All of them used infection type data, as the visible response of the gene for gene interaction between the host, the pathogen and the environment (Flor, 1971).

Successful control of stem rust disease, requires throughly understanding of the effective genes conferring resistance to this disease. In better choice within the selected parents to provide an acceptable and high level of protection against stem rust pathogen.

The main objectives of this study were, therefore, to postulate stem rust resistance genes (Sr's) in 17 currently grown wheat cultivars in addition to the control cultivar (Giza 160), under the Egyptian conditions, using 20 monogenic lines each carrying single known gene for stem rust resistance (Sr gene). In addition to evaluate and determine the effectiveness of these genes against the most common isolates of *P. graminis* population, to facilitate an incorporation of additional effective genes into the national breeding programme in the country.

MATERIALS AND METHODS

The present study was carried out under greenhouse conditions in the Wheat Diseases Research Department. Plant Pathology Research Institute, ARC, Giza, Egypt. Eighteen Egyptian wheat cultivars (*Triticum aestivum* L.), with unknown stem rust resistance genes and twenty monogenic lines for resistance to *Puccinia graminis* f.sp. *tritici* (Tables 1 and 2), were used in this study. The tested cultivars were Giza 160, Giza 168, Gemmeiza 7, Gemmeiza 9, Gemmeiza 10, Gemmeiza 11, Sakha 93, Sakha 94, Sakha 95, Sids 1, Sids 12, Sids 13, Misr 1, Misr 2, Beni Sweif 4, Beni.sweif.5, Beni Sweif 6 and Shandaweal 1. All wheat materials or entries (both wheat cultivars and monogenic lines; Sr's), were grown in plastic pots 10 cm in diameter. Each pot contained four genotypes in each corner clockwise.The tested cultivars and 20 monogenic lines (Sr's) were inoculated with 25 pure uredinial isolates from the Egyptain collections of *P. graminis* f.sp. *tritici*. Samples, collected from both Rust Trap Nurseries and farmer fields, during 2009/2010 growing season. The collected samples were then placed in glycine envelops and stored in a desicator in the refrigerator at 3°C. Rust isolates maintained in good viability under these conditions for up to 6 monthes. Inoculation and incubation were performed in moist chambers. Inoculated plants were held at approximately 100% relative humidity for 24 hr. Plants were then returned to the greenhouse bench at 21 ± 4°C, for the duration of the experiments. Rust reaction on the first leaf was recorded, 12 days after inoculation. Rust data were recorded as infection types on each cultivar and monogenic line (Sr), according to the method of Stakman *et al*. (1962). The infection type, expressed on each cultivar and near isogenic line, was classified on a scale. The infection type, 3, 4, was considered as high infection type (HIT) or susceptible reaction. A method similar to that of Loegering (1972), Browder and Eversmeyer (1977), Statler (1984), was used to determine the probable stem rust resistance genes (Sr's) of the Eighteen cultivars, under study.The infection types for each of the 25 isolates, expressed on the tested wheat cultivars with unknown resistance genes, were compared to the infection types of the same

Table 1. List of 18 Egyptian wheat cultivars and their pedigree which were evaluated throughout the present study

No.	Wheat cultivar	Pedigree
1	**Giza-160**	
2	**Giza-168**	MIL/BUC//SeriCM93046-8M-OY-OM-2Y-OB
3	**Gemmeiza-7**	CMH74A.630/5X//Seri82/3AgentCGM.4611-2GM.-3GM.-1GM.-0CM.
4	**Gemmeiza-9**	Ald"s"/Huac "s"//CMH74A.630/5Xcgm4583-5GM-IGM-OGM
5	**Gemmeiza-10**	CMH74A.630/5X/Seri82/3AgentCGM.4611-2GM-3GM-IGM-0CM.
6	**Gemmeiza-11**	BOW"S"/KVZ"S"//7C/SER182/3/GIZA168/SKHA61.
7	**Sakha-93**	Sakha92/TR810328 S8871-IS-25-OS
8	**Sakha-94**	Opea/Rayon/Kaz/CMBW9043180-O10M-010M-010Y-10M-015-0Y.
9	**Sakha-95**	
10	**Sids-1**	HD2172/Pavon"s"//1158.57/Maya74"s"SD46-4sd-2SD-ISD-OSD
11	**Sids-12**	BUC/7C/ALD/5/MAYA74/ON/1160147/3/BB/GLL/4CHAT"S"/6 /MAYA/VUL/CMH74A.630//4*SX.
12	**Sids-13**	AMAZ19=KAUZ"S".
13	**Misr-1**	OASIS/SKAUZ//4*BCN1312*PASTOR
14	**Misr-2**	SKAUZ/BAV92
15	**Beni.sweif-4**	AUSL/5/CANDO/4/BY*2/TAC//1127655/3/TME//ZB/W*2.ICD88-1120-ABL-0TR-IBR-6AP-0AP-OSD.
16	**Beni.sweif-5**	DIPPERZ/BUSHEN3.CDSS92B128-IM-0Y-3B-0Y-0SD.
17	**Beni.sweif-6**	BOOMER-21/BUSCA-3.CDSS95Y01185-8Y-OM-0Y-0B-IY-0B0SD
18	**Shandaweal-1**	SITE/ MO/4/NAC//3*PVN/3/MiRLO

Table 2. Wheat stem rust resistance genes (Sr's), source, genome location and their tester lines (Roelfs *et al*., 1992)

No.	Sr. Gene	Genome location	Original source	Tester
1	**Sr 5**	6 DS	Reliance	Isr 5 –Ra
2	**Sr 6**	2 DS	Red Egyptian	Isr 6 – Ra
3	**Sr 7a**	4 BL	Kenya 117A	Line G Sel
4	**Sr 7b**	4 BL	Marquis	Isr7b –Ra
5	**Sr 8a**	6 AS	Red Egyptian	Isr 8 – Ra
6	**Sr 8b**	6 AS	Barleta Benvenuto	Barleta Banvento
7	**Sr 9a**	2 BL	Red Egyptain	Isrga-Ra
8	**Sr 9b**	2 BL	Kenya 117 A	W2691 Sr gb
9	**Sr 9d**	2 BL	*Triticum.turgidum* (yaroslav emmer)	Isr 9d-Ra
10	**Sr 9e**	2 BL	*T. turgidum* (vernal emmer)	Vernstein
11	**Sr 9g**	2 BL	Lee	Cnssr 9g
12	**Sr 10**	2BL	Egyptian NA 95	W2691 Sr 10
13	**Sr 11**	6 BL	Lee	Isr11-Ra
14	**Sr 13**	6 BL	*T. turgidum* (kaphli emmer)	W2691-sr13
15	**Sr 15**	7AL	Norka	W2691-sr15
16	**Sr 17**	7 BL	*T. turgidum* (yaroslav emner)	CS (Hope 7B)
17	**Sr 21**	2 AL	*T. monococcum*	Einkorn
18	**Sr 30**	5 DL	Webster	Btsr 30 wst
19	**Sr 36**	2 BS	*T. timopheevi*	W2691sr Tt-1
20	**Sr Tmp**	4.B	Triumph 64	Triumph 64

isolates on the twenty monogenic lines, each carrying a single known gene for resistance to stem rust .These comparisons were used to determine whether the tested cultivar was identified as characterized to possess a particular gene or no. The effectiveness of the stem rust resistance genes (Sr genes), was determinded according to their virulence frequency against 41 *P. graminis* f. sp. *tritici* isolates, using the following equation :

$$\text{Gene efficacy (\%)} = \frac{\text{Number of avirulent isolates}}{\text{Total number of the tested isolates}} \times 100$$

RESULTS

To postulate genes conditioning resistance to stem rust *Puccinia graminis* f. sp. *tritici* in 18 Egyptian wheat cultivars, seedling reactions of these cultivars were compared with the reaction of 20 monogenic lines, each possessing designated single stem rust resistance gene (Sr), against 25 pure isolates of the causal pathogen with a wide array of avirulence/virulence combinations. Differences and similarities of the reactions in terms of infection types (IT's) between the monogenic lines (Sr's) and the tested cultivar (Tables 3 and 4) were used to postulate gene (s) for resistance. No or little numbers of avirulent isolates that could not attack the two cultivars; Giza 160 and Sakha 93 ,were detected in the present study .So,it could not accurately hypothesized or postulated any stem rust resistance gene(s) in these cultivars, but they be have gene (s), that were not encountered in the tested Sr lin set.

Meanwhile, some avirulent and virulent isolates were available to the other cultivars understudy (Table 3). Based on these data genes for stem rust resistance in these cultivars could be postulated (Table 4). Comparative analyses between the tested Sr genes and the local wheat cultivars revealed the probability of the presence of different numbers of genes for stem rust resistance in these cultivars. However, some of these genes are common in the majority of the tested cultivars, in which others are not common. The postulated genes conditioning stem rust resistance could be detected in the tested cultivars were sumarized and illustrated in Table 5. Data revealed the following results:

Giza Cultivars

They including Giza 160 and Giza 168. The obtained data relevant to Giza 160 showed that, no avirulent isolates of *P. graminis* f. sp. *tritici* were detected against it, as it was attacked by all the tested isolates, exhibiting high infection type (H) against all of them. This, therefore, means that Giza 160 can not postulated any resistance genes, using the Sr set and pathogens cultures of this study. Whereas, the other cultivar, Giza 168 was more resistant to the pathogen isolates than Giza 160. As, it showed low infection type (L) to most of the tested isolates (19 from 25). Thus this cultivar probably carries 6 Sr genes *i.e.,* 6, 9g, 30, 17, 9d and 8b and may be some additional genes for stem rust resistance.

Gemmeiza Cultivars

Gemmeiza cultivars *i.e.,* Gemmeiza 7, Gemmeiza 9; Gemmeiza 10 and Gemmeiza 11, probably have four common stem rust resitance genes *i.e.,* Sr's 9e, 10, 30 and 36, in addition to other genes that also probably detected in these cultivars (Table 5).

Gemmeiza 7

It probably carries Sr's; 5, 7a, 7b, 8b, 9b, 9d, 9e, 10, 11, 17, 21, 30, 36 and Tmp. This cultivar was resistant to most of the tested isolates as it showed low infection type (L) to 24 cultures from a total of 25 ones, in which these genes were avirulent (Table 4).

Gemmeiza 9

This cultivar probably has 7 Sr genes *i.e.,* 7b, 8a, 9e, 10, 17 , 30 and 36.

Gemmeiza 10

This cultivar probably carries most genes under study (16 genes), out of the tested genes (20 genes). Stem rust resistance genes that probably found in this cultivar are; Sr's, 5,6,7a, 8a, 8b, 9a, 9b, 9d, 9e, 9g, 10,11,21,30,36 and Tmp.

Gemmeiza 11

It probably has most genes found in Gemmeiza 9 as it carries 14 stem rust resistance genes, *i.e.,* Sr's 6, 7b, 8a , 8b , 9a, 9b, 9d, 9e, 9g, 10, 17, 21, 30 and 36.

Table 3. Stem rust reaction of 20 wheat monogenic lines (Sr's), against 25 isolates of *Puccinia graminis* f.sp.*tritici*, under greenhouse conditions

No.	Sr gene	wheat stem rust isolates and their infection types																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	Sr 5	**H	H	H	H	H	H	H	H	H	* L	L	L	H	H	H	H	H	L	L	L	L	H	H	H	H
2	Sr 21	H	H	H	H	H	H	H	H	H	L	L	H	H	H	H	L	L	L	L	L	H	L	L	L	H
3	Sr 9e	H	H	H	H	H	H	H	H	H	L	L	H	H	H	H	H	H	H	H	H	H	H	H	H	L
4	Sr 7b	H	H	H	H	H	H	H	H	H	L	L	H	L	L	L	L	L	H	H	H	H	H	H	L	L
5	Sr 11	H	H	H	H	H	L	H	H	L	L	L	L	L	H	H	H	H	H	H	H	L	L	L	H	H
6	Sr 6	H	H	H	H	H	L	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H
7	Sr 8a	H	H	H	L	L	H	L	H	H	L	L	H	H	H	L	L	H	H	L	L	H	H	L	H	H
8	Sr 9g	H	H	H	L	L	H	L	L	H	L	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H
9	Sr 36	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H	L	H	H
10	Sr 9b	H	L	L	H	H	H	H	L	H	L	L	H	H	H	H	H	H	H	H	L	H	L	L	H	H
11	Sr 30	H	H	H	H	L	H	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H
12	Sr 17	L	H	H	H	H	H	H	H	H	L	L	H	H	L	H	H	H	H	H	H	H	L	L	H	H
13	Sr 9a	H	L	H	L	H	H	H	H	H	H	H	H	H	H	L	H	H	L	L	H	L	L	H	H	
14	Sr 9d	H	H	H	H	H	H	H	L	H	L	H	H	H	H	L	L	H	H	H	L	H	L	L	H	H
15	Sr 10	H	H	L	H	L	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
16	Sr Tmp	H	L	L	H	H	L	H	L	H	L	H	H	L	H	L	L	H	H	H	L	L	L	L	H	H
17	Sr 7a	H	H	H	H	H	H	H	H	H	L	L	H	H	H	H	H	H	H	H	H	L	L	L	H	H
18	Sr 8b	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H	L	H	H	H
19	Sr 13	H	H	L	L	L	H	H	L	L	L	L	L	H	L	L	L	H	L	L	L	L	H	L	H	H
20	Sr 15	H	H	H	L	H	H	H	H	L	L	L	H	H	L	H	L	H	H	H	H	L	H	L	H	H

* L : Low lnfection types (o.o,,1,2, and 3) ** H: High infection type (4) .

Table 4. Seedling reaction of 17 Egyptian wheat cultivars, in addition to the control (Giza 160) against 25 isolates of *Puccinia graminis* f.sp.*tritici*, under greenhouse conditions

No.	Wheat cultivar	Wheat stem rust isolates and their infection types																								
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	Giza-160	*H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
2	Giza-168	**L	H	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	H	L	H	H	L	L	L	H
3	Gemm.-7	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
4	Gemm.-9	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	L	L	L
5	Gemm.-10	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L
6	Gemm.-11	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L
7	Sakha- 93	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
8	Sakha-94	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L
9	Sakha-95	L	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
10	Sids – 1	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	L	L	L
11	Sids – 12	L	L	L	L	L	H	L	L	H	L	L	L	H	L	L	L	L	L	L	L	H	H	L	L	L
12	Sids – 13	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L
13	Misr-1	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H
14	Misr-2	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	L	H	L	L	L	L
15	Beni-Sw-4	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	L	H	L
16	Beni-Sw-5	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	L	L	L	L	H	L	L	L	H
17	Beni-Sw-6	L	L	L	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
18	Shandaweal.1	L	L	L	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

*H: High infection type (4) ** L : Low lnfection types (o.o,,1,2, and 3) .

The relatively high similarity in genes for stem rust resistance which probably found in Gemmeiza cultivars, was in general, attributed to the very close relation in the pedigree of these cultivates.

Sakha Cultivars

They were Saka 93, Sakha 94 and Sakha 95. The obtained data showed that only one isolate of the causal organism *(P. graminis* f.sp.*tritic)i* was avirulent to cultivar Sakha 93. Thus it could not accurately postulated any stem rust resistance genes in this cultivar, using the Sr line set and the causal pathogen cultures that were used in this study (Table 5). Meanwhile, the other two varieties; Sakha 94 and Sakha 95 showed,in general different reactions against the tested isolates, where a wide array of avirulence / virulence combinations was available. Therefore, genes for stem rust resistance in these cultivars could be postulated and /or detected.

Sakha 94

This cultivar exhibited a resistant reaction (low infection type; L) to 23 isolates of *P.graminis* f.sp.*tritici*. Therefore, it probably carries 12 stem rust resistance genes; Sr's 6, 7b, 8a, 8b, 9a, 9d , 9e, 9g, 17, 21, 30 and 36.Also, it may be assumed that this cultivar probably carries additional genes for stem rust resistance, that could not encountered in the tested Sr line set of the current study.

Sakha 95

This new released cultivar showed in general higher level of resistance against the tested isolates of the causal pathogen, more than all Sakha cultivars under study (Table, 4). It showed low infection type against the majority of the tested isolates. (24 isolates from a total of 25 ones), 22 of them are similar to those avirulent against Sakha 94. Thus, this cultivar probably has 15 stem rust resistance genes (Sr's). These genes are, Sr's 5, 6, 7a, 7b, 8a,8b, 9a, 9e, 10,11,15, 17,21, 30 and 36.

Sids cultivars

Sids-1

It probably carries only 6 genes for resistance to stem rust resistance *i.e.,* Sr's 7b, 8a, 9e, 19, 30 and 36.

Sids-12

This cultivar postulated to carry also 6 genes, five of these genes probably found in Sids-1 cv. Only Sr 17 which was found in this cultivar not detected in sids -1. Also, Sr 7b which found in sids-1, not detected in this cultivar (Table 5).

Sides 13

It displayed high level of resistant reaction to most of the tested isolates of *P. graminis* f. sp. *tritici*, than all Sids cultivars under study. Since, it showed low infection type (L) to 24 from 25 of the tested isolates. Therefore, it has all Sr genes that are found in the afore mentioned two Sids cultivars, and probably has some genes not found in these cultivars. However, this cultivar probably carries 14 genes for stem rust resistance *i.e.,* Sr's 6, 7b, 8a, 8b, 9a, 9b, 9d, 9e, 9g, 10, 17, 21, 30 and 36.

Misr Cultivars

They are two new released wheat cultivars *i.e.,* Misr 1and Misr 2.

They have been developed as field resistance cultivars to stem rust, especially after the emergency of race TTKSK (Ug 99) and it's new variants in Africa.

Misr 1

This cultivar showed low infection type (resistant reaction) to the majority of the tested isolates, as 24 out of a total 25 isolates were avirulent and could not attack this cultivar. Only one isolate has the ability to severely infect this cultivar, as it showed high (H) infection type or virulent reaction. Therefore, this cultivar probably carries most of the tested genes (18 Sr's). *i.e.,* Sr's 5, 6,7a, 8a, 8b, 9a, 9b, 9d, 9g, 10,11,13,15,17,12, 30, 36 and Tmp. Only the two genes; 7b and 9e have not postulated or could not detected in this cultivar, based upon the comparison with it's reaction and Sr gene reactions against the causal pathogen cultures used in this study.

Misr 2

It was lesser level against resistant to the tested isolates of *P. graminis* f.sp. *tritic*, than that of. Misr 1. Thus, it seemed that this cultivar postulated to have a relatively lower numbers of Sr genes than those found in Misr 1.it probably carries Sr's; 6, 8b, 9a, 9b, 9e, 9g, 10, 17, 21, 30 and 36 (Table 5).

Table 5. Probable genes for stem rust resistance (Sr's) in 18 Egyptian wheat cultivars

No.	Wheat cultivar	Probable Sr gene (s)
1	**Giza-160**	Non*
2	**Giza – 168**	Sr's 6.9g.30.17.9d.8b.
3	**Gemm-7**	Sr's 5.21,9e,7b,11,36,9b,30,17,9d,10 Tmp,7a,8b
4	**Gemm-9**	Sr's 9e,7b,8a,36,30,17,10.
5	**Gemm-10**	Sr's 5,21,9e,11,6,8a,9g,36,9b,30,9a,9d,10,TMP,7a,8b.
6	**Gemm-11**	Sr' 21.9e.7b,6,8a9d,10,8b,36,9b,30,179g – 9a,.
7	**Sakha-93**	Non
8	**Sakha-94**	Sr's 21.9e,7b,6,8a,9g,36,30,17,9a,9d,8b.
9	**Sakha-95**	Sr's 5.21,9e,7b,11,6,8a,36,30,17,9a,10,7a,8b,15.
10	**Sids -1**	Sr's 9e,7b,8a,36,30,10.
11	**Sids – 12**	Sr's 9e,8a,36,30,17,10.
12	**Sids-13**	Sr's 21,9e,7b,6,8a,9g,36,9b,30,17,9a,9d,10,8b.
13	**Misr-1**	Sr's 5,21,11,6,8a,9g.36,9b,30,17,9a,9d,10,Tmp,7a,8b,13,15.
14	**Misr-2**	Sr's 21,9e,6,9g,36,9b,30,17,9a,10,8b.
15	**Beni-Sw-4**	Sr's 9e,8a,36,30,17,10.
16	**Beni-Sw-5**	Sr's 6,9g,36,9b,30,17,10,8b.
17	**Beni-Sw-6**	Sr's 5,21,9e,7b,11,36,9b,17,9a,9d,10,Tmp,7a,8b,13,15.
18	**Shandaweal.1**	Sr's 5,21,9e,7b,6,36,9b,30,17,9d,10,Tmp,7a,8b.

* Non: Mean that it could not postulate any Sr genes in the concerned variety, using the tested Sr line sets and isolates of the study.

Bani- Sweif Cultivars

This group of cultivars includes three wheat cultivars *i.e.,* Bani- Sweif 4, Bani-Sweif 5 and Bani- Sweif 6. These cultivars probably have four common stem rust resistance genes, *i.e.,* Sr's 9e, 10,17 and 36, in addition to other genes which postulated to be only found in Bani-Sweif 6. Bani- Sweif 6 showed high level of resistance to the majority of the tested isolates than the other two Bani- Sweif cultivars under study. Since, over all the tested isolates, only one isolate proved to be virulent and could attack this cultivar, showing high infection type (H) or susceptible reaction on this cultivar. It is probably carries high numbers of resistance genes to stem rust (16 Sr's),compared with other Bani- Sweif cultivars, Bani- Sweif 4 (only 6 genes) and Bani-Sweif 5 (only 8 genes), in respect cultivars (Table 5).

Shandaweal 1

From the comparison between the reactions infection types (ITs) of cultivar Shandaweal 1 (Tabel 4) against the tested isolates of *P.graminis* f. sp. *tritici* and Sr genes reactions (Table 3), it could be possible to postulate 14 genes for stem rust resistance in this cultivar (Table 5). As indicated in this table, it could be assumed that this cultivar probably carries Sr's, 5, 6, 7a, 7b, 8b, 9b, 9d, 9e, 10, 17, 21, 30, 36 and Tmp.

Regarding the situation of the eighteen wheat cultivars relative to the identified or postulated genes for stem rust resistance (Sr's), the obtained data in Table 6, reveal the presence of 18 out of 20 resistant genes for stem rust in the newly released wheat cultivar, Misr-1, followed by the two cvs, Gemmeiza-10 and Bani-Sweif 6, each

Table 6. Number of postulated genes for stem rust resistance (Sr's) and frequency of distribution (%) in 18 Egyptian wheat cultivars

No.	Wheat cultivare	No. of Sr gene *	Frequency (%)**
1	**Giza-160**	0	-
2	**Giza – 168**	6	30
3	**Gemmeiza-7**	14	70
4	**Gemmeiza-9**	7	35
5	**Gemmeiza-10**	16	80
6	**Gemmeiza-11**	14	70
7	**Sakha-93**	0	-
8	**Sakha-94**	12	60
9	**Sakha-95**	15	75
10	**Sids-1**	6	30
11	**Sids-12**	6	30
12	**Sids-13**	14	70
13	**Misr-1**	18	90
14	**Misr-2**	11	55
15	**Beni-Sweif-4**	6	30
16	**Beni-Sweif-5**	8	40
17	**Beni-Sweif-6**	16	80
18	**Shandaweal-1**	14	70
Total No. of genes		20	-

* : Number of stem rust resistance genes (Sr's) ,postulated in a corresponding cultivar.

$$**:\text{Frequency (\%)} = \frac{\text{No. of Sr genes presence in the cultivar}}{\text{Total No of the tested genes (20)}} \times 100$$

posses 16 Sr genes, (with frequency of 80%). Data in the same Table, also referred to the probability of the presence of 15 Sr genes (75% frequency) in cultivar Sakha 95, and 14 genes in each of the two cultivars Gemmeiza 7, Gemmeiza 11, Side 13 and Shandweal 1. Whereas, no stem rust resistance genes (Sr's) could be postulated or detected in the two wheat cultivars; Giza 160 and Sakha 93, using the Sr line set and the pathogen isolates tested in the current study. Moreover, the other wheat cultivars under study carries low to moderate number of Sr genes (ranged from 6 to 12 genes), with frequency did not exceeded more than 60% (Table 6).

The effectiveness of stem rust resistance genes (Sr's) at seedling stage was estimated as the number of avirulent isolates to the total number of isolates for each monogenic line (Sr), under study (Table 7). The obtained data in this Table indicate that, out of the twenty stem rust monogenic lines tested, five only proved to have the highest degree of efficacy (up to 68%) against the tested isolates. These effective stem rust resistance genes (Sr's) were: Sr 13 (82.93% efficacy), Sr7a (78.10% efficacy), Sr 21 (70.73 efficacy), Sr's9a, and 9d (68.29% efficacy for each).

Meanwhile, a relatively moderate to high frequency of virulence in terms of high infection types (IT's) to the other tested Sr genes was obtained (Table 7). The highest occurrence of virulence frequency (%), was found against Sr's 8b (92.68%), 6 (87.80%), 10 (85.36%), 9e and 9g

Table 7. Virulence frequency (%) of *Puccinia graminis* f.sp. *tritici* isolates,against 20 stem rust resistance genes (Sr's) and gene efficacy (%) at seedling stage under greenhouse conditions, during 2012/2013 growing season

No.	Monogenic Line (Sr's)	No. of isolates		Virulence frequency (%)	Gene efficacy (%)
		Virulent	Avirulent		
1	Sr 5	30	11	73.17	26.82
2	6	36	5	87.80	12.19
3	7a	9	32	21.95	78.10
4	7b	29	12	70.73	29.26
5	8a	25	16	60.97	39.10
6	8b	38	3	92.68	7.31
7	9a	13	28	31.70	68.29
8	9b	31	10	75.60	24.39
9	9d	13	28	31.70	68.29
10	9e	34	7	82.93	17.07
11	9g	34	7	82.93	17.07
12	10	35	6	85.36	14.63
13	11	27	14	65.85	34.14
14	13	7	34	17.07	82.93
15	15	18	23	43.90	56.10
16	17	31	10	75.60	24.39
17	21	12	29	29.26	70.73
18	30	14	27	34.15	65.85
19	36	19	22	46.34	53.66
20	Tmp	20	21	48.78	51.21

Total No. of the tested stem rust isolates = 41 isolates

(each 82.93%), 9b and 17 (each 75.60%), 5 (73.17%), 7b (70.73%), 11 (65.85%) and 8a (60.97%), respectively (Table 7). So, these stem rust resistance, genes have been classified as the highly susceptible monogenic lines. Since, they showed virulent or high susceptible reaction to most of the tested isolates of the causal pathogen, in terms of high infection type (H). In turn, they displayed (%) low levels of gene efficacy (less than 30%). An intermediate levels of gene efficacy (ranged from 51.12% to 65.85%) were displayed by the other stem rust resistance genes under study. *i.e.,* Sr Tmp (51.12%), Sr 36 (53.66%), Sr 15 (56.10%) and Sr 30 (65.85%), respectively (Table 7).

Data in Table 8 also reveal that Sr's 30 and 17 found to be the most common genes (with high frequency of 83-33% for each), as they were detected in 15 out of 18 wheat cultivars under study. Likewise, the three Sr's 9e, 10 and 36 proved to be of a relatively high frequencies also (more the 72%). Since they were identified in 14 and 13 wheat cultivars, respectively. These Sr genes were represented by the frequency of 77.78% (for each of Sr's 9e and 10) 72.22% (for Sr 36). Meanwhile, the lowest frequent genes that were identified in a little or few numbers of the tested cultivars (less than 40% frequency), were Sr's 5 (38.88%), Sr 7a and Tmp (each with only 33.33%), Sr 15 (16.67%) and Sr 13 (11.11%). The other postulated genes were present in moderately frequency rates; ranged from 50% to 66.67% of the tested cultivars (Table 8).

Table 8. Number and frequency (%) of 20 stem rust resistance genes (Sr genes), within 18 Egyptian wheat cultivars

No.	Monogenic lines (Sr's)	No. of cultivars possessing. Sr.gene	* Gene frequency (%)
1	**Sr 5**	7	38.88
2	**Sr 6**	10	55.56
3	**Sr 7a**	6	33.33
4	**Sr 7b**	11	61.11
5	**Sr 8a**	11	61.11
6	**Sr 8b**	12	66.67
7	**Sr 9a**	9	50.00
8	**Sr 9b**	10	55.56
9	**Sr 9d**	10	55.56
10	**Sr 9e**	14	77.78
11	**Sr 9g**	9	50.00
12	**Sr 10**	14	77.78
13	**Sr 11**	7	38.39
14	**Sr 13**	2	11.11
15	**Sr 15**	3	16.67
16	**Sr 17**	15	83.33
17	**Sr 21**	10	55.56
18	**Sr 30**	15	83.33
19	**Sr 36**	13	72.22
20	**Sr Tmp**	6	33.33
	***Total No. of the tested cultivars**	18	-

$$\text{*Gene frequency (\%)} = \frac{\text{No . of cultivars possessing Sr gene}}{\text{Total No. of the tested cultivars (18)}} \times 100$$

DISCUSSION

Host-genetic resistance or deployment of effective resistance genes in wheat cultivars is, still, the best method of controlling stem rust disease, both from economical and ecological perspectives (Ghazvini *et al*., 2012). However this too host resistance has been successfully applied for over 50 years to control stem rust in Egypt and worldwide (Nazim *et al.,* 2001 ; Singh *et al*., 2008). As early as 1950's, the two stem rust resistance cultivars, Giza 135 and Giza 139 were firstly released in Egypt. Thereafter, many wheat cultivars were developed as the derivatives from these two cultivars, possessing the same adult plant resistance (APR) to stem rust, under field conditions. Many of them served in agriculture for a long period of time (many years) showing high levels of field resistance to stem rust without breaking down or even impairing disease resistance. But, evolving or creating of an aggressive race TTKSK (Ug99) in Uganada during 1999, and it's new more aggressive variants in Kenya in 2006 and 2007.

Also due to the widespread of this race to other east African countries then to Middle east and west Asia (Park *et al.,* 2011; Rouse *et al.,* 2012), there has been renewed interest in breeding for stem rust resistance by using different undeployed sources of resistance. A stack of the effective stem rust resistance genes needs to be incorporated into recommended wheat cultivars to produce long-term resistance or durable resistance against the exotic races such as TTKSK and it's variants. It should be noted that TTKSK is virulent on most Sr genes. Since, the majority of stem rust resistance genes previously deployed in wheat varieties have succumbed to the Ug 99 race (Nzuve *et al*., 2013). Among 56 designated and a few undesignated stem rust resistance genes in wheat, only eight designated genes *i.e.,* Sr 13, Sr 14, Sr 22, Sr 28, Sr 33, Sr 35, Sr 42 and Sr 45, confer resistance to this aggressive race (Pretorius *et al.,* 2000 ; Hiebert *et al.,* 2011).

Successful control of wheat stem rust requires a thoroughly understanding of genetic make up of the materials (genotpes) used in a future breeding program. Also, if the effective genes for stem rust resistance could be identified in the currently grown wheat cultivars, it would be of primary importance to make a better choice of the parental genotypes involved in a breeding program for resistance. In addition, it facilitate the incorporation and deployment of some of these desirable genes into modern or new wheat cultivars, in the hope to produce durable resistance against stem rust.

The exact number and type of genes that will produce durable resistance is a subject of much debate by many investigators. As, many previous authors in the literature reported that if any wheat cultivar depend upon only one single gene for stem rust resistance, even though with major and stable effect, it is not likely to lead to durable resistance. Because of the rapidly evolution of a new race (s) within pathogen population that may defeat and overcome this gene, soon after it's incorporation into the concerned cultivar. Due to these limitations of race specific gene (s), the identification and combination of several effective stem rust resistance genes within the same cultivar (gene pyramiding), each conferring resistance against common race spectrum, also to diversify stem rust resistance, is undoubtedly leads to the long-lasting or more durable resistance (Liu and Kolmer , 1997; Sawhney, 1998; Nazim *et al*., 2001 ; Boulot, 2007).In addition, a combination of major and minor resistance genes is likely to offer resistance that would be difficult for pathogen to overcome (Ghazvini *et al.,* 2012). Since with durable resistance, a pathogenic race which overcomes an allele of minor effect does not have a selective advantage, as the host has more resistance alleles. Despite of many documented cases of breakdown of monogenic (race- specific) resistance to wheat rust diseases, especially stem rust, there are some documented cases of long-term effectiveness of specific gene for rust resistance in certain situations. For example, wheat stem rust has been controlled successfully by monogenic resistance in spring wheat cultivars in the Northern plains of the United States for nearly 50 years (McVey *et al.,* 2004). Likewise, Luig in 1983 reported that, although a combinatins of resistance genes may remain effective for a long period, of time one possible exception is the gene Sr 26 for stem rust resistance. Since in world wide survey of virulence genes, it was found that wheat cultivars carrying Sr 26 were resistant to all cultures of stem rust. Nevertheless, the release of wheat cultivars with diverse genotypes for rust resistance, has, undoubtedly, helped in the successful control of stem rust in Australia for a long period of time; several years (Luig, 1983).

Gene postulation as a relatively quick (can be done in short period of time; few days), easy, fairly accurate, but not fool proof method of determining the genetic constitution of the tested germplasma, was used in this study to elucidate the existence of stem rust resistance genes in 18 commercially and widely growing wheat cultivars under the Egyptian conditions. To postulate gene (s) conditioning resistance to stem rust in these cultivars, the seedling reactions in terms of infection types (IT's) of the tested cultivars versus 25 isolates of *P. graminis.* f. sp. *tritici* were compared to the reactions of 20 monogenic lines (Sr's) against the same pathogen isolates. However, none of the isolates used was avirulent or could not attack the wheat cultivar; Giza 160. So, this cultivar probably has gene(s) not represented in the tested Sr line set. Also, only one isolate was avirulent (L:

infection type) on Sakha 93, thus it could not accurately hypothesized all genes in this cultivar. Meanwhile, comparisons between the reactions of different Sr monogenic lines used the other cultivars under study showed that a wide array of isolates with virulent and avirulent reaction to these genotypes were detected or available. Thus, genes for stem rust resistance (Sr's) in these cultivars could be postulated. However, some of these genes were common in most cultivars studied, whereas other genes were not common. Gene postulation at seedling stage lead to the probability of the presence of 18 Sr genes in wheat cv, Misr-1, 16 genes for resistance in each of the two cvs.; Gemmeiza-10 and Bani- Sweif-6, 15 Sr genes and Sakha 95 cvs.; Gemmeiza-7 , Gemmeiza-11 and Shandaweal-1, each postulated to possess 14 Sr genes out of the tested genes in this study. Meanwhile, the rest of the tested wheat cultivars have moderately numbers of stem rust resistance genes (ranged from 6 to 11 genes). Wheat genotypes in this investigation were selected and developed through the national breeding program after the 1950 season and till now on the basis of field resistance in Egypt (Abd El-Hak and Kamel, 1973). The majority of the tested cultivars herein (15 out of 18) mainly, contain the two Sr genes; 17 and 30. Since these two genes were widely present in a 83.33% of the tested cultivars, so that they proved to be the most common or the highly frequent genes in the Egyptian wheat cultivars. Also, the two Sr genes, 9e and 10 were postulated to be present in 14 cultivars, as repeated by 77.78% frequency with each, followed by Sr 36 (72.22% frequency) , Sr 8b (66.67% frequency) and Sr's 7 and 8a (each with 61-11% frequency). Meanwhile the rest of the postulated genes were present in lower rates or little frequencies. The previous gene postulation studies in Egypt are still a subject of controversy by many investigators in relation to some reasons. Possibly due to the masking of some genes for resistance by the effect of another gene(s) that conditioned the same or lower infection type, which led to the inability of detecting or postulating those genes. On the other hand, a gene could be postulated as present, although it was not, because an unknown gene was present in the host to which the pathogen isolate was avirulent and the infection type was the same or lower (McVey, 1992).

In addition, Statler (1984) pointed out that a specific gene cannot be identified or postulated in the tested cultivar, if it is either all virulent or all a virulent on it. Therefore, a wide range of virulence combinations is needed. The previous studies in the elapsed seasons in Egypt suggested that some of stem rust resistance genes were common in the majority of the commercial wheat cultivars and the drop in others (not common). However an early attempt was carried out by Kamel (1971) to identify genes conditioning stem rust resistance (sr's) in some Egyptian wheat cultivars by crossing them with the susceptible parents. Also, the identified some seedling resistance genes in very limited local wheat cultivars. After that more information's and numerious reports were available about genes conditioning stem rust resistance in the Egyptian wheat cultivars (Abd El-Hak *et al*., 1982; Abu El-Naga *et al*., 1990; Imbaby *et al.,* 1997; Nazim *et al*., 2001; Mousa *et al*., 2004; Youssef *et al*., 2012; Hermas *et al*., 2013; Mousa *et al.,* 2013).

This work was also included greenhouse studies to evaluate the effectiveness of a set of 20 Sr genes to serve the national breeding programs for stem rust resistance. From the obtained results in this concern, a considerable low occurrence of virulence frequencies for Sr 13, Sr 7a, Sr 9e and Sr 9d was noticed against the tested isolates of *P. graminis* f.sp. *tricity*. These monogenic lines should be in turn considered to be most effective Sr genes out of the tested genes, as they showed the highest efficacy (ranged from 68.29% to 82.93%) against most of the tested isolates of the causal organism. Mean- while, high occurrence of virulence frequency (ranged from 60.97% to 92.68%) was found against Sr's 8b, 6, 10, 9a, 9g, 9b, 17, 5, 7b, 11 and 8a. So these stem rust resistance genes (Sr's) characterized as the highly susceptible monogenic lines, and they, in the same time, proved to be the least effective genes against the tested isolates. Also, an intermediate levels of gene efficacy (from 51-12% to 65.85%) was in general, conferred by the other Sr genes under study.

The previous reports in Egypt in relation to the efficacy of stem rust resistance genes (Sr's) have been the subject of much debate and speculation by many investigators, due to the reasons behind the activation or the highest efficacy or the inhibition (Lowest efficacy) of certain genes in one year than in the other. As early as 1950's growing seasons, Sr 6 was the most effective stem rust resistance gene during this period. Whereas, during the 1960's years, Sr ll proved to be the most effective gene for stem rust resistance isolates. But during 1970's years, the Sr's 9e, 22, 24, 26 and 27 were displayed the highest efficacy against urediospores populations (Abd El- Hak *et al.,* 1982).

Moreover, Abu EL-Naga and his coworkers, in 1990, confirmed that Sr's 9e, 26 were still the main genes conferring high resistance in the seedling stage in both years of the study (1987/88 and 1988/89). They added that sr's 22, 24, 30, Tt-1, Gt+ and 8, showed variable response being higher effective in one year than the other one.

The same author and others in 1993 indicated that Sr 14, Sr9, Sr 26 , Sr13, Sr9d and Sr 12 proved to be the most effective genes against the tested isolates of the causal organism during 1990/91 growing season.

Also, El-Sherif *et al*. (1996), gave an evidence to the distinction of Sr's ie., 9e, 8a and 26 as the effective genes against stem rust physiologic races prevalent during this growing season.

Recently, the study of Imbaby (2007) demonstrated that four Sr genes proved to have the highest efficacy (more than 80%) *i.e.,* Sr 26, Sr 29, Sr 11 and Sr 34, also 31, Sr 35, Sr9e and Sr 22 have a relatively high efficacy *i.e.,* more than 70% against the tested isolates in the first season of the study (2004/05). Whereas, in the second season of the study; 2005/06, only Sr 24 has efficacy more than 80% and Sr 26 has efficacy more than 70%.

The pounced change in the effectiveness of stem rust resistance genes from one year to another may be attributed to the virulence dynamics and the changes in the genetic structure of stem rust population as well as the change in wheat cultivars in Egypt.

Information about the genetic constitution of the commercial wheat varieties and the effectiveness of stem rust resistance genes coupled with the regular race/ virulence analysis of the pathogen population and multi locational field tests of adult plant resistance will be of great importance to both the breeders and the pathologists which enables them to make a good and well- founded decisions regarding a future breeding program for rust resistance and a successful strategy for disease control or management.

Final proof of the presence of postulated genes may be required additional evidence to corroborate the hypothesis developed by the method of Browder and Eversmeyer (1977), such as genetic analysis and using of molecular marker techniques (Madawi *et al*., 1985).

REFERENCES

Abd El-Hak, T.M. and A.H. Kamel (1973). Induced mutation breeding for disease resistance in wheat and field beans. Proc. Meet Novi Sad, IAFA, Vienna, 69-77.

Abd El-Hak, T.M., N.A. El-Sherif, I.S.A. Shenouda, A.A. Bassiouni, S.E. Keddis and Y.H. El-Dooudi (1982). Studies on wheat stem rust virulence and resistance genes in Egypt and neighboring countries. Egypt. J. Phytopathol., 14: 1-10.

Abu El-Naga, S.A., I.S.A. Shenouda, Y.H. El-Daudi and S. Sherif (1990). Virulences of *Puccinia graminis tritici* and genes conferring resistance in wheat. The Sixth Congr. Phytopathol, Cairo, 99-109.

Abu El-Naga, S.A., M.M. Khalifa, O.A. Abdel-Latif, M.A. Nagib and A.M. Saleh (1993). Effect of stem rust inocula obtained from different wheat genotypes on race identify and virulence trends of *Puccinia gramiis tritici.* In Egypt during 1990/91. J. Agric. Sci., Mansoura Univ., 18 (10): 2960-2968.

Boulot, O.A. (2007). Durable resistance for leaf rust in twelve Egyptian wheat varieties. Egypt. J. Appl. Sci., 22 (7): 40-60.

Browder, L.E. and M.G. Eversmeyer (1977). Pathogenicity associations in *Puccinia recondite tritici*. Phytopathol., 67: 766-771.

El-Sherif, N.A., S.A. Abu El-Naga, H.M. Diab, M.O. Khalifa, W.A. Youssef, A.A. Hamada and M.S. Sharshar (1996). Virulence of *Puccinia graminis* f.sp. *tritic* and genes conferring resistance in wheat during 1994/1995 in Egypt. Egypt. J. Appl. Sci., 11 (3): 79-89.

Flor, H.H. (1971). Current status of gene for gene concept. Ann, Rev. Phytopathol., 9: 275-296.

Ghazvini, H., C. Hiebert, T. Zegeye, S. Liu, M. Diawari, T. Tsilo, J.A. Anderson, M.N. Rouse, Y. Jin and T. Fetch (2012). Inheritance of resistance to U9 99 stem rust in wheat cultivar Norin 40 and genetic mapping of Sr42. Theor. Appl. Genet., 125: 817-824.

Hermas, G.A., I.A.M. Youssef, A.A. Shahin and H.M. Diab (2013). Physiologic specialization in *Puccinia graminis* f. sp. *tritic* and probable genes for resistance in Egyptian wheat varieties during 2009 /2010 growing seasons. Egypt. J. Appl. Sci., 28 (10): 325-344.

Hiebert, C.W., T.G. Fetch, T. Zegeye, J.B. Thomas, D.J. Somers, D.G. Humphreys, B.D. McCuum, S. Cloutier, D. Singh and D.R. Knott (2011). Genetic and mapping of seedling resistance to Ug 99 stem rust in Canadian wheat cultivars Peace and "AC Cadillac". Theor. Appl. Genet., 122: 143-149.

Imbaby, I.A., Y.H. El-Daoudi, M.A. Mostafa, M.M. El-Shamy and A.M.M. Saleh (1997). Probable genes for stem rust resistance in ten new Egyptian wheat verities. Assiut J. Agric. Sci., 28: 107-115.

Imbaby, I.A. (2007). Probable genes for stem rust resistance in some Egyptian wheat cultivars. Egypt J. Phytopathol., 29 (2): 19-27.

Kamel, A.H. (1971). Identification of genes covering resistance to race 11 and M of stem rust on some local valgar wheat cultivars. Ph.D. Thesis, Fac. Agric. Cairo Univ., Egypt.

Liu, J.Q. and J.A. Kolmer (1997). Inheritance of leaf rust resistance in wheat cultivars; Grandin and CDC Teal Plant Diseas., 81: 505 -508.

Loegering, W.Q. (1972). Specificity in plant disease. PP. 29-37 in: R.T. Bingham; R.J. Hoff and G.I. McDonald (eds) Biology of rust resistance in forest trees. Proc. Nato. IUFRO adv. Study Inst., USDA. Misc. Puble, 1221 : 68.

Luig, N.H. (1983). A survey of virulence genes in wheat stem rust, *Puccini graminis* f. sp. *tritic*. Advances in plant breeding, supplement II to Journal of Plant Breeding (Paul Parey: Berlin).

Madawi, R.S., Browder, L.E. and Heyene, E.G. (1985). Use of infection type data to identify genes for low reaction to *Puccinia recondite* in several winter wheat cultivars. Crop science, 25: 9-13.

McVey, D.V. (1992). Genes for nest resistance in international winter wheat nurseries XII through XVII. Crop Sci., 32: 891-895.

McVey, D.V., M. Nazim, K.J. Leanard and D.L. Long (2004). Patterns of virulence diversity in *Puccini triticina* and wheat in Egypt and United States in 1998-2000. Plant Dis., 88: 271-279.

Mousa, M.M., M.A. Najeeb, O.A. Boulot and W.A. Youssef (2004). Probable genes for stem rust resistance in some Egyptian wheat varieties. Egypt. J. Appl. Sci., 19 (8): 151-163.

Mousa, O.M., M.M. Ragab, Sr. Sherif and M. Abou-Zeid (2013). Response of ten Egyptian wheat cultivars to infection by stem rust and postulation of resistance genes. Egypt. J. Phytopathol., 41 (2): 99-111.

Nazim, M.S., M.A. Awad, O.A. Baulot, S.A. Abu El-Naga and I. Abdel- Hamid (2001). Durable resistance to stem rust in some Egyptian wheat cultivars. Minufiya J. Agric. Res., 26 (6): 1485-1499.

Nzuve, F.M., G. Tusiime, S. Bhavani, P.N. Njau and R. Wanyera (2013). Studies of the genetics of inheritance of stem rust reistance in bread wheat. Afr. J. Biothcn., 12 (21): 3153-3159.

Park, R., T. Fetch, D. Hodson, Y. Jin, K. Nazari, M. Prashar and Z. Pretorius (2011). International surveillance of wheat rust

pathogen: Progress and challenges. Euphytica, 179: 109-117.

Pretorius, Z.A., R.P. Singh, W.W. Wagoire and T.S. Payne (2000). Detection of virulence to wheat stem rust resistance gene Sr 31 in *Puccinia graminis* f. sp. *tritici* in Uganda. Plant Dis., 84 : 203.

Roelfs, A.P., R.P. Singh and E.E. Saari (1992). Rust diseases of wheat: concepts and methods of disease management. CIMMYT, Mexico, D.F.

Rouse, M.N., I.C. Nava, Sr. Chao, I.A. Anderson and Y. Jin (2012). Identificaiton of markers linked to race Ug 99 effective stem rust resistance gene Sr 28 in wheat (*Triticum aestivum* L.) theor. Appl. Genet., 125: 877-885.

Sawhney, R.N. (1998). Genetic analysis of wheat rust interactions and strategies to brad for durable resistance. Indian J. Genet., 58 (4): 391-416.

Singh, D., R.F. Park, R.A. Mc Intash and H.S. Baraina (2008): Characteization of stem rust and stripe rust seddling resistance genes in selected wheat cultivars from the united Kingdom. J. Pl. Pathol., 90 (3): 553-562.

Stakman, E.C., D.M. Stewart and W.Q. Loegering (1962). Identification of physiologic races of *Puccinia graminis* var. *tritici* A.R.S. USDA. Agric. Res. Serv. Bull. E., 617- 53.

Statler, G.D. (1984). Probable genes for leaf rust resistance in several hard red spring wheat. Crop Sci., 24: 883-886.

Youssef, I.A.M., G.A. Hermas, D.R. El-Naggaa and N.A. El-Sherif (2012). Virulence of *Puccini gramiis* f.sp. *tritic* and postulated resistance genes for stem rust in thirteen wheat varieties during 2008/2009 growing seasons in Egypt. Egypt. J. Appl. Sci., 27 (11): 326-344.

تحديد الجينات المسئولة عن مقاومة مرض صدأ الساق (بكسينيا جرامينيس تريتيساى) في بعض أصناف القمح المصرية

فاروق الوجيه يوسف البانوبي[١] - أسامة أحمد بعلط[٢] - بدوى رجب حسن مهدلى[٢]

١- قسم النبات الزراعى – كلية الزراعة – جامعة الأزهر – القاهرة – مصر

٢- معهد بحوث أمراض النباتات – مركز البحوث الزراعية – جيزة – مصر

تم تعريف جينات المقاومة لمرض صدأ الساق المتسبب عن بكسينياجرامينيس تحت نوع تريتساي (*Puccinia graminis* f. sp. *tritici*) في ثمانية عشر صنفا من الأقماح المصرية، وذلك بمقارنة رد فعل المقاومة للأصناف المختبرة على ٢٠ سلالة نباتية تحمل جين مفرد للمقاومة (Sr's) ، ضد ٢٥ عزله ممرضة معروفة من الفطر المسبب. وبناءً على الاختلاف والتشابه لرد الفعل المرضى (في صورة طرز الإصابة) بين كل من السلالات النباتية الحاملة لجينات المقاومة المفردة والأصناف المختبرة، فقد تم التحديد الافتراضي أو المحتمل للجينات المسئولة عن المقاومة للمرض في طور البادرة للأصناف المختبرة، اتضح من نتائج التحديد الافتراضي أو المحتمل عدم القدرة على تحديد أى من الجينات المسئولة عن مقاومة صدأ الساق في كل من صنفي القمح جيزة ١٦٠ وسخاً ٩٣ بينما أوضحت النتائج احتمالية احتواء الصنف مصر١ على ثمانية عشر جيناً، يليه في ذلك جميزة ١٠، وبنى سويف ٦ (كل منهما يحتوى على ١٦ جين)، سخا ٩٥ (١٥ جين) ثم جميزة ٧ ، جميزة ١١ ، سدس ١٣ وشندويل ١ (حيث يحتوى كل منهم على ١٤ جين) ، أيضا فإن صنفي القمح مصر ٢ ، سخا ٩٤ احتوى كل منهما على ١١ جين ، ١٢ جين على التوالى، ولكن بقية الأصناف تحت الاختبار فقد ثبت احتواء كل منها على أعداد قليلة من جينات المقاومة (أقل من ٤٠%)، أظهرت النتائج أيضاً أن بعض الجينات المختبرة كانت أكثر شيوعاً وانتشاراً بين أصناف القمح بعد الدراسة وهى ٣٠ ، ١٧، ٩ ، ١٠ ، ٣٦ ثم ١٣، يبدو أن البعض الآخر من تلك الجينات لم يكن شائع التواجد بين تلك الأصناف، ومن ناحية أخرى فقد أثبتت الدراسة أن جينات المقاومة: ١٣ ، ٧، ٩ ، ٩ كانت أكثر الجينات المختبرة كفاءة وفعالة في مقاومة صدأ الساق في طور البادرة، حيث أن عزلات الفطر الممرض كانت أقل ضراوة على تلك الجينات، وعلى العكس من ذلك فقد أظهرت عزلات الفطر المختبرة ضراوة مرتفعه ضد جينات المقاومة: ٨ ، ٦، ١٠ ... إلخ، ولذلك فإن تلك الجينات تعتبر أقل الجينات المختبرة كفاءة ضد عزلات الفطر المسبب للمرض والمستخدمة في هذه الدراسة، إن تحديد وتعريف جينات المقاومة في أصناف القمح المنتجة حديثاً وكذلك في التراكيب الوراثية المبشرة أو الواعدة elite/or promising genotypes متزامناً مع اختبار تقييم مقاومتها في طور البلوغ أو المقاومة الحقلية لها في مواقع مختلفة ومتعددة (multilocaitonal evaluation)، هذه النتائج تمكن مربى نباتات القمح في اتخاذ القرار الصحيح لوضع استراتيجية ناجحة لبرنامج التربية الذى يهدف إلى أنتاج صنف قمح جديد يتمتع بمقاومة طويلة البقاء أو أكثر استدامة لمرض صدأ الساق فى القمح.

المحكمون :

١- أ.د. محمد إبراهيم أبـــو زيـــد أستاذ أمراض النبات – كلية الزراعة – جامعة الزقازيق.

٢- أ.د. محمود محمد محمد عطية أستاذ ورئيس قسم أمراض النبات – كلية الزراعة – جامعة الزقازيق.