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Pathogenic divergence in *Puccinia striiformis* f.sp. *tritici* populations, The causal agent of yellow rust disease of wheat in Iraq

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Introduction

Yellow (stripe) rust of wheat incited by *Puccinia striiformis* f. sp. *tritici* (Pst), is currently considered to be the most important biotic constraint to sustainable wheat production in Iraq. Yield losses of 10-70% in Iraq are common, if susceptible cultivars are grown. This is due to the ability of *Pst* to evolve rapidly into new races and to migrate long distances by air-borne dispersal. Many outbreak of yellow rust were observed in all wheat growing areas in Iraq especially in the irrigated fields in the last decades. The most sever epidemics were recorded in 1998 and 2010 which has caused significant decline in the national grain production. This was due to development of new virulence against *Yr9* and *Yr27* genes respectively which were predominant in most of wheat cultivars as a single major gene. Breakdown of *Yr9* and *Yr27* resistance gene resulted in widespread epidemics in these areas which have been stimulated with the recent climatic condition changes.

Material and Methods

Biological trap nurseries of yellow rust were planted in different locations representing the main wheat growing areas in Iraq. Two sites were selected in the north, Sulaimani and Nineveh and two sites in the middle, Diyala and Babylon. The plants were exposed to the natural population inoculum of the pathogen in the fields. Disease scoring was conducted by recording disease severity and infection types on each genotype at different stages of wheat development. Yellow rust samples collected from the commercial wheat fields from different locations were sent to the Global Rust Center for race analyses.

Results and Discussions

Virulence analysis of *P. striiformis* f. sp. tritici population, revealed virulence detection against the known resistant gene *Yr2, Yr6, Yr7, Yr9, Yr18, YrA, Yr20, Yr21, Yr27, Yr28, Yr29* and *Yr31* at adult plant stage in Sulaimania, while virulence against the known resistant genes *Yr2, Yr6, Yr7, Yr9, Yr SD, YrSP, YrA, Yr21, Yr27, Yr28 and Yr31,* were detected in the natural populations of *P. striiformis* f.sp. *tritici* at adult plant stage tn Nineveh (Table1). Virulence's were also detected against the known resistant gene *Yr5, Yr6, Yr7, Yr9, Yr20, Yr21, Yr27, Yr28* and *Yr31* in Babylon and against *Yr2, Yr5, Yr6, Yr7, Yr9, Yr18, YrA, Yr20, Yr25, Yr28, Yr29* and *Yr31* in Diyala.

Fig1.Yellow rust infection on YR Biological trap nursery at adult plant stage.

Table 1. Disease Severity and infection types of Yellow rust on biological trap nurseries under natural epidemic of *P. striiformis* at the main wheat growing area's in Iraq in 2013.

Cultivar/ Genotype	Yr genes	Disease Severity and Infection Type			
		Sulaimani	Nineveh	Babylon	Diyala
Triticale	-	15MR	15MR	5R	TR
Morocco	-	100S	100S	55S	80S
Yr 1/6* Avocet S	Yr1	10MR	10MR	0	0
Yr 1/6* AVS	NIL 1	7.5MR	7.5MR	0	TR
Chinese 166(W;Yr1)	(W, Yr1)	5R	5R	7.5R	2.5R
Chinese 166	Yr1	15MR	15MR	10R	5R
Kalyansona(S)	Yr2	20MR	20MR	10R	15R
Heines VII (W; Yr2+?)	(W; Yr2+?)	10MR	10MR	TR	5R
Vilmorin23(W;Yr3a,4a+other)	(W;Yr3a,4a+other)	10MR	10MR	TR	2.5R
Hybrid 46(WYr4)	(W, Yr4)	10R	10R	2.5R	2.5R
Yr5/6* Avocet S	Yr5	12.5R	12.5R	30S	7.5R
Triticum spelta (Inter, Yr5)	Yr5	12.5R	12.5R	25S	10MS
Yr 6/6*Avocet S	Yr6	35MR	35MR	30S	30S
Heine's Kolben(S; Yr6+1)	(S; Yr6+1)	5MR	5MR	TR	TR
Heine's Peko(S; Yr6+?)	(S; Yr6+?)	5R	5R	40S	TR
Fielder	Yr6, Yr20	80S	80S	45S	30MS
Yr7/6*Avocet S	Yr7	70S	70S	50S	50S
Lee(S; Yr7)	(S; Yr7)	50S	50S	0	50S
Reichersberg 42(W; Yr7+?)	(W; Yr7+?)	60MS	60MS	TR	TR
Thatcher	Yr7	50MS	50MS	TR	5R
Yr8/6*Avocet S	Yr8	15R	15R	7.5R	5R
Compair(S; Yr8)	(S; Yr8)	10R	10R	7.5R	10R
Yr9/6*Avocet S	Yr9	90S	90S	40S	10R
Fed.4/Kavkaz(Yr9)	Yr9	70MS	70MS	20MS	TR
Clement (W; Yr9+Yr2+?)	(W; Yr9+Yr2+?)	50MS	50MS	TR	5R
Federation	-	60MS	60MS	30MSS	7.5R
Yr10/6*Avocet S	Yr10	10R	10R	TR	5R
Moro(W; Yr10)	(W; Yr10)	100S	100S	2.5R	TR
Yr15/6*Avocet S	Yr15	10R	10R	2.5R	10R
YR17/6*Avocet S	Yr17	15MR	50MS	5R	TR
Strubes Dickopf(W;2-more?)	(W; 2-more?)	100S	100MSS	55S	80MS
Suwon 92×Omar(W)	(W)	10MR	10R	0	0
Nord Desprez (W;YrND)	(W;YrND)	7.5MR	10R	0	TR
Yr32/6*Avocet S	Yr32	5R	R20	7.5R	2.5R
Carstens V (W,Yr32)	(W, Yr32)	15MR	10MR	10R	5R
Yr SP/6* Avocet S	Yr SP	20MR	60MS	10R	15R
Morocco	-	10MR	100S	TR	5R
Spalding Proiific(W;YrSP)	(W;YrSP)	5MR	60MSS	TR	10R
Avocet 'R'	YrA	20R	70S	5R	10R
Inia 66	YrA	5R	20MS	TR	5R
Avocet 'S'	-	0	90S	7.5R	10R
Tres/6*AVS	-	TR	10MR	TR	TR
Yr18/3*Avocet S	Yr18	5MR	40MS	5R	TR
Jupateco'R' (S)	Yr18+	5MR	30MS	5R	10R
Jupateco'S'	-	0	50MS	5R	10R
Anza	YrA, Yr18	60S	10MR	TR	20MR
Cook (S)	APR	0	15MR	5R	5R
Lemhi	Yr21	45MSS	90S	50S	80S
TP 981	-	0	40MS	5R	TR
TP1295	Yr25	30MS	20MR	7.5R	40MR
YR27/6*Avocet S	Yr27	10MS	70S	TR	30MR
Ciano 79	Yr27	20S	70S	5R	TR
ATTILA CM85836-50Y-0M-0Y-3M-0Y	Yr27+?	20S	20MR	7.5R	TR
OPATA 85	Yr27+Yr18	0	50MS	5R	TR
Avocet-YRA*3/3/ALTAR 84/AE.SQ//OPATA	Yr28	80S	60MS	20MS	5R
Lal Bahadur/ Pavon 1B L	Yr 29	10MR	20MR	5R	10R
AVOCET-YRA*3/PASTOR	Yr 31	5RMR	60MS	5R	40MR
PASTOR	Yr 31+ APR	40S	20MR	40MSS	15R

The a virulence/Virulence patter of *P. striiformis* in Sulaimani is *Yr1, Yr3, Yr4, Yr5, Yr8, Yr10, Yr15, Yr17,Yr25, Yr32, YrSP and YrND/ Yr2, Yr6, Yr7, Yr9, Yr18, Yr20, Yr21,Yr27, Yr28,Yr29, Yr31*, and *YrA*; *Yr1, Yr3, Yr4, Yr5, Yr8,Yr15, Yr25, Yr29, and YrND/Yr2, Yr6, Yr7, Yr9, Yr10, Yr17, Yr18, Yr20, Yr21, Yr27, Yr28, Yr31, Yr32, YrA, and YrSP* in Nineveh; *Yr1, Yr2, Yr3, Yr4, Yr8, Yr10, Yr15, Yr17, Yr18, Yr25, Yr29, Yr32, YrA, YrSP,* and *YrND /Yr5, Yr6, Yr7, Yr9, Yr20, Yr21, Yr27, Yr28, and Yr31* in Babylon and *Yr1, Yr2,Yr3, Yr4, Yr8, Yr9, Yr10, Yr15, Yr17, Yr18, Yr21, Yr25, Yr27, Yr28, Yr29, Yr31, Yr32, YrA,YrSP, and YrND/Yr5, Yr6, Yr7, and Yr20* in Diyala. Out of 21 Yr samples sent to GRRC for race analysis in 2013, 4 samples were only recovered while 17 samples were failed to be recovered (Table 2). Two pathotypes were prevalent in *P. striiformis* f. sp. *tritici* population, the first one has virulence against *Yr2, Yr6, Yr7, Yr8, Yr9, Yr27* and *AvS* which was prevalent in Nineveh and Erbil, while the second one has virulence against *Yr2, Yr6, Yr7, Yr8, Yr9, Yr25, Yr27* and AvS at seedling stage and was predominant in Sulaimani and Erbil. Both pathotypes were aggressive based on Milus *et. al.* measures.

Table 2. GRRC race analysis for Iraqi isolates of *P. striiformis* f.sp. *tritici,* in 2013.

Location	No. of Samples		Pathotype code	No. of isolate	Aggressiveness
	Failed	Recover			
Erbil	2	1	-,(2),-,-,-, 6, 7, 8, 9,-,-,-,-, 25,-,-,-, AvS,-	1	+
Suliamani	4	1	-,(2),-,-,-,6, 7,8, 9,-,-,-,-, 25, 27,-,-,AvS,-	1	+
Nineveh	9	2	-,(2),-,-,-, 6, 7, 8, 9,-,-,-,-, 25,-,-,-, AvS,-	1	+
Babylon	6	0	-,(2),-,-,-, 6,7, 8,9,-,-,-,-, 25,27,-,-, AvS,-	1 0	+
Total	21	4		4	