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[Research]

Assessment of Two Different Sources of Durable Resistance and Susceptible Cultivar of Wheat to Stripe Rust (*Puccinia striiformis* f. sp. *tritici*)

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ABSTRACT
A study was conducted to assess the durable resistance in a near isogenic line of spring wheat (*Triticum aestivalis* L.), possessing resistance gene Yr-18 to some isolates (race specific resistance) of stripe rust (*Puccinia striiformis* f. sp. *tritici*), namely Thatcher Yr-18 and durable resistance of an cultivar of spring wheat to all isolates of stripe rust (race non- specific resistance), namely Hybrid de Berse'e. In this investigation fresh urediniospores of two isolates namely SRC 99 (race 70E 128) and SRC 89 (race 14E 14), were collected from a susceptible cultivar of spring wheat, Avocet, as inoculums. Then suspension of spore in mineral oil [Soltrol 170 (5 mg/ml)] were sprayed on third and flag leaves of the booth genotypes mentioned above and on the Thatcher cultivar which was susceptible to booth isolates. The Percentage of urediniospore germination, latent period and infection types of all susceptible and resistant genotypes to booth isolates were determined in four replicates at seedling and adult plant stages. Mean percentage of spore germination and the value of latent period were analyzed separately in each replicate, and then compared using analysis of variance and the Student- Newman Keuls test. The results indicated that urediniospoe germination in all genotypes / isolates/ leaf stage combination was high and neither resistance type affected spore germination significantly. In both types of resistance, latent period increased with advancing plant age. In general cultivars possessing resistant gene had longer latent periods. Assessment of the infection type showed that, the durable resistance of Hybrid de Bersée is detected at an earlier stage than the adult-plant resistance of near isogenic line containing the gene Yr18.

Keywords: Stipe rust, *Puccinia stiiformis*, Wheat resistance

INTRODUCTION

Stripe (Yellow) rust of wheat caused by *Puccinia striiformis* f. sp. *tritici* Eriks (Stubs, 1985) is one of the major diseases of wheat (*Triticum aestivum* L.) in various regions in the world (Roelfs *et al*., 1992) such as Northern Europe and cool temperature climate, although its range is extended to warmer and more arid regions throughout the world (Bamdadian, 1972 and Speher, 1966).

The annual yield losses due to wheat yellow rust have been estimated up to 8- 75% (Elahinia, 2000). Wiese (1977) reported that rust infection of wheat has decreased yield in the USA by more than one million tones per year. In Canada stripe rust has been reported in Nova Scotia, Saskatchewan, Alberta, and British Columbia (Salvile, 1983) In Western Canada, under sever infection, yield losses as high as 79% due to stripe rust have been reported (Coner and Kuzyke, 1988).

In Iran, epidemics of cereal rusts occur every 3 or 4 years. (Khazra and Bamdadian, 1974) estimated that overall losses in these years may be as high as 30 to 40%.

These authors also reported that under favorable conditions in Northern Iran, yellow

rust may cause a total loss of yield on susceptible cultivars. In 1993 in some parts of Iran yield losses due to yellow rust was estimated at about 1.5 million tones (Torabi *et al.,* 1995).

Various strategies for control of cereal rusts especially yellow rust have been considered. The most important control strategy is the use of resistant cultivars. The ability of plants to resist rust infection has been known for many years. The first investigation or the inheritance of resistance to *P. striiformis* was made by Biffen (1905 and 1912) who showed that the resistance of Rivet wheat (*Triticum turgidum*) was controlled by a single recessive gene. Non of genetic resistances are widely used, as environmental friendly mean of epidemic control for the three wheat rusts, including stripe rust. Several resistance genes effective at the seedling and/or adult-plant stages exist in wheat germ plasms (McIntosh *et al.*, 1998). Break down of the resistance to cereal rusts has been frequently reported in the world. In ten years the accidental introduction of a single race of *P. striiformis* in Australia, detected eleven new races (Welling and McIntosh, 1990). Recently, detected virulence to wheat stem rust gene Sr31, was reported from Uganda, which is responsible in part, for the stem rust resistance in many of the wheat growing regions in the world (Pretori, *et al.,* 2000).

The effects of resistant gene usage (Yr genes) in Europe, on the evolution of corresponding pathogen virulences is well documented and discussed by Stubbs (1985). Johnson (1981) reported that resistances of some cultivars to stripe rust disease were durable, remaining effective over a considerable period of time whilst in significant commercial usage. Stripe rust durable adult-plant resistance described by Johnson & Law (1973, 1975) and controlled by minor or additive genes is often described as slow rusting and is generally known as being more durable (Welling and McIntosh, 1990; Singh and Rajaram, 1994).

MATERIALS AND METHODS

Plant material

Seeds of a near isogenic line of spring wheat (*Triticum aestivalis* L.) possessing durable resistance gene Yr-18 to some isolates (race specific resistance) of stripe rust (*Puccinia striiformis* f. sp. *tritici*), Thatcher Yr-18, and a cultivar of spring wheat having durable resistance to all isolates of stripe rust (race non-specific resistance) Hybrid de Berseé were kindly supplied by the CYMMIT (Centro International de Mejoramiento de Maize Y Trigo) and The Plant Breeding Institute, Cambridge (PBI), respectively. This investigation was also performed on the Iranian susceptible spring wheat namely Thatcher to both isolates at all growth stages as a control.

Pathogen and inoculums production

Two isolates of *Puccinia striiformis* f. sp. *tritici* Eriks namely SRC 99 (race 70E 128) and SRC-89 (race 14E 14) were kindly supplied from Winnipeg Research Center, Alberta, Canada. These isolates were maintained on seedlings of the cvs Avocet and Lemhi respectively. Urediniospores for experimental use were always used within 2h of their collection and were stored at approximately 4°C over this period.

Production of host plants

All seeds of host plants were surface sterilized in a 1% solution of sodium hypochlorite for 3 min. Then they were rinsed with water and placed on moist paper toweling in closed petri dishes and maintained at room temperature for 2 days whilst germination occurred. In order to conduct the experiment at the third leaf stage 10- 12 seeds, and/or in the adult-plant stage 6-8 seeds of each genotype were sown in 7.5 and 12.5 cm diameter pots containing compost (Metro-Mix 292, Ltd, Terra), respectively and covered with transparent propagator tops (Stewart Plastics Plc.). Pots were maintained in growth chambers, running at 15±1°C with 16h photoperiod and with a relative humidity in the range of 60-70%. The light intensity was approximately 8000 Lux at seedling height for 14 h daily.

Inoculation of plants

Third and flag leaves were inoculated in the second and eigth week, respectively, after sowing, when the third and flag leaves were fully expanded. Suspensions of fresh urediniospores in a light mineral oil (Soltrol 170) at a concentration of 5 mg/ml were sprayed on the leaves. A light coating of oil was enough to ensure good infection.

Table 1. Ranked means of percentage of urediniospore germinated of two isolates of stripe rust (*Puccinia striiformis*) on the third and flag leaves of three genotypes of spring wheat .

Cultivar	TatcherYr-18		H.de Bersée		Thatcher	
Isolale	SRC - 89	SRC 99	SRC - 89	SRC 99	SRC - 89	SRC 99
On third leaves	65.6 ab	62.3 b	63.1 b	64.3 b	68.4 a	67.3 a
On flag leaves	57.8 a	55.83 b	56.5 ab	58.9 a	59.7 a	59.3 a

Value with a same letter(s) in row do not differ significantly at p≤0.05

Inoculated plants were left aside for at least one hour for the oil to evaporate from the leaves. Then the plants received a light spray of water and were placed in a humid chamber (approximately 100% RH) and incubated at 10°C for 24 h in the dark.

Following inoculation, plants were subjected to the growth chamber conditions mentioned above with care being taken to ensure that the humidity gradually dropped to approxi-mately 60% RH that of the chamber.

Sampling and observation

Spore germination assessment was made 24h after inoculation. Leaf segments 2-6cm from the tip, were taken from 4 plants of each replicate and sprayed with a 1:1 mixture of cellulose nitrate dope and cellulose tinner (Humbrol Ltd). After drying, the resulting strips were carefully removed and mounted in lacto phenol trypan blue solution. Spore germination was assessed at a magnification of x100 and spores were considered to have germinated when the length of germ tube exceeded the diameter of the spore. Three samples, each of 100 spores, were observed for each leaf segment. The percentage of germination was then transformed using the arcsin transformation and the mean value for each leaf and then each replicate was calculated. For each leaf the mean number of days between inoculation and the eruption of the first uredinia was noted as the latent period and data was analyzed using the analysis of variance and the Student-Newman-Keuls test.

The assessment of infection type was made 16 days after inoculation on third leaf stage seedlings and 22 days after inoculation on flag leaves. The key used was adapted from that used by Gassner and Straib (1932). where: 0= highly resistant, with or without slight chlorosis and/or necrosis but no pustules; 1= very resistant (R), a few scattered pustules with some chlorosis and/or necrosis; 2= moderately resistant (MR), pustules present and/or necrosis; 3= moderately susceptible (MS), extensive pustule production with some chlorosis; 4= susceptible (S), extensive coalescent pustule production, no or minimal chlorosis.

The mean proportion of plants falling into each category was calculated.

RESULTS

The results indicated that urediniospore germination in all genotypes / isolates/ leaf stage combinations was high and neither resistance type affected spore germination significantly (over 50%). This is in contrast to the findings of Goddard (1994), Johnson and Law (1973 and 1975) and Mares and Cousin (1977) who reported germination levels of 12- 25% and 0-30% respectively. In both types of resistance, latent period increased with advancing plant age. In general resistant cultivars had longer latent periods than the susceptible cultivar Thatcher, especially on flag leaves. The mean percentage germination values (arcsin transformed) and the data relating to latent periods are presented in Table 1- 3 respectively. Values at each growth stage are ranked over all isolate/cultivar combinations.

Infection type data are presented in Table 4. Assessment in the infection type showed that, the resistance of Hybrid de Berseé is

Table 2. Ranked means of days to pustule eruption (Latent period) on the third and flag leaves stages of three genotypes of spring wheat infected with two isolates of *Puccinia striitormis* .

Cultivar	TatcherYr-18		H.de Bersée		Thatcher	
Isolale	SRC - 89	SRC 99	SRC - 89	SRC 99	SRC - 89	SRC 99
On third leaves	13.20 a	13.51 a	13.12 ab	13.30 a	12.03 b	12.40 b
On flag leaves	17.18 a	17.4 a	17.10 a	17.3 a	14.11 b	14.27 b

Value with a same letter(s) in row do not differ significantly at p≤0.05

Table 4. The proportion of plants of three wheat lines in each infection type category, inoculated with two isolates of *Puccinia striiformis*.

Leaf stage	Isolate	Cultivar	INFECTION TYPE *			
			4 (S)	3 (MS)	2 (MR)	1(R)
On third leaves	SRC 99	Thatcher	1	0	0	0
		ThatcherYr -18	0.41	0.59	0	0
		H. de Bersée	0.24	0.68	0.08	0
	SRC 89	Thatcher	1	0	0	0
		Thatcher Yr -18	0.49	0.51	0	0
		H. de Bersée	0.17	0.72	0.11	0
On flag leaves	SRC 99	Thatcher	0.87	0.13	0	0
		Thatcher Yr -18	0	0	0.11	0.89
		H . de Bersée	0	0.02	0.28	0.70
	SRC 89	Thatcher	0.83	0.17	0	0
		Thalcher Yr-18	0	0	0.26	0.74
		H. de Bersée	0	0.03	0.22	0.75

***R=**Resistant**; MR=** Moderately Resistant**; MS=** Moderately Susceptible; **S**= Susceptible

detected at an earlier stage than the adult-plant resistance of near isogenic line containing the gene Yr-18 but both cultivars had lower infection types on flag leaves than on leaf 3. The susceptible cultivar Thatcher had susceptible infection on leaf 3, and a mixture of susceptible and moderated susceptible infection type on flag leaves (Table, 4).

DISCUSSION

Elahinia (1989) investigated urediniospore germination on a number of wheat plants with durable resistance to stripe rust at different growth stages and reported that adult plants of Hybrid de Berseé supported a lower percentage than other cultivars but the range of each growth stage was short, having a maximum variation of approximately 10%, for the flag leaf combination.

Latent period in both types of resistance increased with advancing plant age in this investigation. In general resistant cultivars had longer latent periods than the susceptible cultivar (Table 2). This is similar to findings reported for other cereal rust combinations including barley with *P. hordei* (Parlevliet, 1975) and rye infected with *P. recodita* f. sp. *recondite* (Parlevliet 1977). Isolate SRC 99 in near isogenic line and Hybrid de Berseé does have longer latent periods on third and flag leaf stage plants. Thus there is evidence to associate increased latent periods with both types of adult-plant and durable resistant under investigation.

In this experimental condition cultivar Thatcher was fully susceptible (infection type 4) in the third leaf stage (Table 4). On the flag leaf some chlorosis was evident and a proportion of plants of these cultivars, in

Table 3. Mean number of days to initial observation of chlorotic flecking (Chl. Flc.), Pustule appearance (P.APP) and pustule eruption (P. Er.) (Latent period) on the third And flag leaves of three genotypes of spring wheat infected with two isolates of *Puccinia striiformis.*

Leaf stage	Isolate	Cultivar	Chl. Fl. ± SD	P. APP.	P. Er. ± SD
On third leaves	SRC 99	Thatcher	7.01 ± 0.24	11.8	12.40 ± 28
		ThatcherYr -18	7.61 ± 0.38	12.9	13.51 ± 0.03
		H. de Bersée	7.43 ± 0.16	12.73	13.10 ± 0.18
	SRC 89	Thatcher	7.20 ± 0.43	11.65	12.03 ± 0.7
		Thatcher Yr -18	7.40 ± 0.18	12.45	13.20 ± 0.13
		H. de Bersée	7.51 ± 0.08	12.41	13.30 ± 0.24
On flag leaves	SRC 99	Thatcher Yr -18	8.15 ± 0.42	15.86	17.4 ± 0.50
		H . de Bersée	8.09 ± 0.15	15.32	17.10 ± 0.25
	SRC 89	Thatcher	7.44 ± 0.23	13.52	14.2 ± 0.13
		Thalcher Yr-18	8.02 ± 0.20	15.64	17.18 ± 0.32
		H. de Bersée	8.11 ± 0.26	15.44	17.3 ± 0.08

combination with both isolates, was classified as only moderately susceptible (infection type 3). This may be associated with the general increased latent period which was also reported for this cultivar.

For cv. Tatcher Yr-18 (Isogenic line), 41% of plants infected with isolate SRC 99 and 49% of plants infected with isolate SRC-89 were fully susceptible (infection type 4), but the largest proportion of plants showed a shift from fully susceptible and moderately susceptible (Infection type 3) to moderately resistant (infection type 2) and resistant between the third to flag leaf stage in infection with both isolates. Also the adult-plant stage of cv Hybride de Bersee was similar for the number of plants categorized in each infection type with both isolate and the largest proportion of plants showed a shift from moderately susceptible to resistance similar to near isogenic line (Table 3 and 4).

REFERENCES

Bamdadian, A. (1972) Physiological races of *Puccinia striiformis* in Iran. *Proceeding of the European and Mediterranean Cereal Rust Conference. Prague,* pp. 91- 95.

Biffen, R. H. (1905) Mendel's laws of inheritance and wheat breeding. *Journal of Agricultural Science* **1**, 4- 48.

Biffen, R. H. (1912) Studies in inheritance in disease resistance. II. *Journal of Agricultural Science* **4**, 412- 9.

Coner, R. L. and Kuzyke, A. D. (1988) Effectiveness of different fungicides in controling stripr, leal rust, and black point. *Can. J. Plant pathology* **73**, 927- 936.

Elahinia, S. A. (2000) Assessment of urediniospore germination of *Puccinia striiformis* at various temperature on agar and detached leaves of wheat. *Journal of Agriculture, Science and Technology* **2,** 1-8.

Elahinia, S. A. (1989) Resistance of Wheat to *Puccinia striiformis*. Ph.D. Thesis, University of Salford, Manchester, UK.

Gassner, G. and Streib, W. (1932) Die Bestimmung der Biologischen Rassen des Weizengelbrostes (*Puccinia glumarum* f.sp.*Tritici*) (Schem.) Erikss. *U. Henn. Arb. Biol. Reich Anst. Land-u. Forestw*. **20**, 121-145.

Goddard, M. V. (1974) Induced variation in *Puccinia striiformis* and studies of related to cytological developmental processes. Ph.D. thesis, Cambridge University. UK.

Johnson, R. and Law, C. N. (1973) Cytogentic studies on the resistance of wheat variety Berseé to *Puccinias triiformis .Cereal Rusts Bulletin*, **81,** 38- 43.

Johnson, R. and Law, C. N. (1975) Genetic control of durable resistance to yellow rust (*Puccinia striiformis*) in the wheat cultivar hybrid de Bersée. *Annals Applied Biology* **81**, 385- 391.

Johnson, R. (1981) Durable disease resistance: definition of genetic cotrol and attainment in plant breeding. *Pytolopathology* **71**, 567-568.

Khazra, H. and Bamdadian, A. (1974) The wheat disease situation in Iran. Proceeding of Fourth FAO/Rockfller Foundation Wheat Seminar, Tehran. Iran, pp. 292- 299.

McIntosh, R. A., G. E. Hart, K. M. Devos, M.D. Gale , and W. J. Rogers (1998). Catalogue of gene symbols for wheat. *Proceed. 9th int. Wheat genet. Symp.* Vol. 5: 236 p.

Mares, D. J. and Cousen, S. (1977) The interaction of yellow rust (*Puccinia striformis)* with winter wheat cultivars showing adult plant resistance: macroscopic and microscopy event associated with the resistant reaction. *Physiological Plant Pathology* **10**, 257-274.

Parlevliet, J. E. (1975). Partial resistance of barley to leaf rust, *Puccinia hordei*. 1. Effect of cultivar and development stage on latent period. *Euphytica* **24**, 21- 27.

Parlevliet, J. E. (1977) Variation in partial resistance in a cultivar of rye, *Secale cereale,* to brown rust, *Puccinia recondita* f. sp. *recondite*. *Cereal Rust Bull*. **5**, 13- 16.

Pretori, Z. A., Singh, R. P. Wagoire, W. and Payne, T. S. (2000) Detection of virulence to wheat stem rust resistance gene Sr31 in *puccinia graminis* f. sp. *tritici* in Uganda. *Plant Dis*. **84,** 203.

Roelfs, A. P., Singh, R. P. and Saari, E. E. (1992) *Rust Diseases of Wheat: Concepts and Methods of Diseases Management*. D.F. CIMMYT, Mexico, 81p.

Salvile, D. B. O. (1983) *Puccinia striiformis*. *Fungi*. Canadenses 250.

Singh, R.P., and Rajaram, S. (1994) Genetics of adult plant resistance to stripe rust in ten spring bread wheat. *Euphytica* , **72**, 1- 7.

Spehar, V. (1966) The appearance of yellow rust in Croatia. *Proceeding of the European*

and Mediterranean Cereal Rust Conference, Cambridge, pp. 65- 67.

Stubbs, R.W. (1985) *Stripe Rust. The Cereal Rusts, Diseases, Distribution, Epidemiology, and control* (eds. A. P. Roelf and W.R. Bushnell). Vol. II. PP 61-101. Academic Press. New York

Torabi, M., Mardouchi, W, Nazari, K., Golzar, H. and Kashani, A. S. (1995) Effectiveness of wheat Yellow Rust Resistance Gene in Different Part of Iran. *Cereal Rust and Powdery Mildew Bulletin* **23**, 9- 12.

Wellings, C. R. and R. A. McIntosh. (1990) *Puccinia striformis* f. sp. *tritici* in Australia: pathogen change during the first 10 years. *Plant Pathol.* **39**, 316- 325.

Wiese, M.V. (1977) *Copendium of Wheat Diseases*. The American Phytopathogical Society, St. Paul. 106 p.

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