Stress Combination and their Interaction in Plants (SCIP) Database

Website link: http://www.nipgr.res.in/scipdb.php

Effect on wheat cultivars (*Triticum aestivum* L.)

A. The net impact of individual and combined stress on the plant

Stress 1: *Puccinia striiformis*
Stress 2: *Pseudocercosporella herpotrichoides*

The table shows the impact of individual and combined stress on grain yield

Cultivar	Treatment	Response under combined stress (Type A parameters*)			
		Reduction over control (%)			
		Grain yield/year			Yield
		1989	1990	1991	Averaged 3 years
Faro	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	50 ↓	46.08 ↓	45.01 ↓	47.05 ↓
	P. striiformis (0.7-l mg spores/pot)	27.09 ↓	20.37 ↓	29.26 ↓	25.58 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	43.34 ↓	37.30 ↓	36.33 ↓	39.11 ↓
Hyak	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	14.52 ↓	6.67 ↓	13.79 ↓	11.80 ↓
	P. striiformis (0.7-l mg spores/pot)	6.53 ↓	-2.80 ↑	-8.27 ↑	-1.24 ↑
	P. herpotrichoides (2.5x10^4 conidia/mL)	11.13 ↓	8.07 ↓	0 ↑	6.52 ↓
Jacmar	*P. striiformis* (0.7-l mg spores /pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	53.77 ↓	47.14 ↓	51.56 ↓	50.93 ↓
	P. striiformis (0.7-l mg spores/pot)	47.40 ↓	26.42 ↓	26.13 ↓	33.85 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	26.65 ↓	16.42 ↓	22.64 ↓	22.36 ↓
Tres	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	36.06 ↓	25.81 ↓	30.43 ↓	30.96 ↓
	P. striiformis (0.7-l mg spores/pot)	0.99 ↓	-5.45 ↑	-2.89 ↑	-2.25 ↑
	P. herpotrichoides (2.5x10^4 conidia/mL)	39.05 ↓	24.36 ↓	18.84 ↓	27.74 ↓
Tyee	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	48.16 ↓	34.05 ↓	51.59 ↓	44.95 ↓
	P. striiformis (0.7-l mg spores/pot)	35.45 ↓	-0.71 ↑	23.24 ↓	20.18 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	37.65 ↓	13.97 ↓	31.21 ↓	28.13 ↓
FH	*P. striiformis* (0.7-l mg spores/pot) +	-13.15 ↑	-11.78 ↑	5.37 ↓	25.39 ↓

	P. herpotrichoides (2.5x10^4 conidia/mL) (Sequential stress)				
	P. striiformis (0.7-l mg spores /pot)	-4.41 ↑	-14.59 ↑	-3.51 ↑	6.26 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	-5.32 ↑	-20.75 ↑	2.78 ↓	17.55 ↓
JH	*P. striiformis* (0.7-l mg spores /pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	-15.13 ↑	-12.99 ↑	5.70 ↓	26.33 ↓
	P. striiformis (0.7-l mg spores /pot)	-8.43 ↑	6.98 ↓	6.52 ↓	18.04 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	6.30 ↓	-0.19 ↑	11.05 ↓	19.52 ↓
FR	*P. striiformis* (0.7-l mg spores /pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	-1.46 ↑	2.43 ↓	-2.76 ↑	39.01 ↓
	P. striiformis (0.7-l mg spores /pot)	-3.13 ↑	1.93 ↓	-8.69 ↑	9.28 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	12.83 ↓	2.23 ↓	-3.37 ↑	35.91 ↓
FY	*P. striiformis* (0.7-l mg spores /pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	4.83 ↓	-12.44 ↑	-5.30 ↑	43.73 ↓
	P. striiformis (0.7-l mg spores/pot)	4.47 ↓	-1.85 ↑	-17.81 ↑	19.53 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	-4.29 ↑	0.41 ↓	-15.71 ↑	29.44 ↓
JR	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	-2.77 ↑	-4.83 ↑	-14.37 ↑	36.53 ↓
	P. striiformis (0.7-l mg spores/pot)	-29.34 ↑	-7.09 ↑	0.27 ↓	6.73 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	-15.67 ↑	9.96 ↓	4.91 ↓	25 ↓
JY	*P. striiformis* (0.7-l mg spores /pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	-11.68 ↑	1.31 ↓	-18.87 ↑	42.98 ↓
	P. striiformis (0.7-l mg spores /pot)	-28.41 ↑	-2.44 ↑	-3.19 ↑	19.40 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	5.55 ↓	-3.29 ↑	12.68 ↓	28.35 ↓
FHRY	*P. striiformis* (0.7-l mg spores /pot) + *P. herpotrichoides* (2.5x10^4 conidia/mL) (Sequential stress)	-7.60 ↑	-1.61 ↑	-3.94 ↑	31.25 ↓
	P. striiformis (0.7-l mg spores /pot)	-9.88 ↑	3.03 ↓	6.26 ↓	11.01 ↓
	P. herpotrichoides (2.5x10^4 conidia/mL)	-16.99 ↑	-3.41 ↑	8.28 ↓	22.92 ↓

Note: *Values presented in the table were calculated using the formula described below.*

$$\text{Reduction over control (\%)} = \frac{(\text{Value}_{\text{Control}} - \text{Value}_{\text{Stress}})}{\text{Value}_{\text{Control}}} \times 100$$

1) ‘⬇’- indicates plant parameter is more affected by stress that leads to high susceptibility (higher the value more the damage).
2) ‘⬆’- indicates plant parameters less/not affected by stress leading to improved resistance (higher the value lesser the damage)

‘*’- *For more information on parameters classification, please refer to ‘methodology’ tab*

B. The interaction between the fungal pathogens under combined stress at plant interface

The table shows the interaction between the fungus *P. striiformis* and *P. herpotrichoides* in wheat cultivars in relation to yellow rust and eye spot severity for three consecutive years

Observation of yellow rust severity for three years in the presence and absence of eye spot				
Cultivar	**Treatment**	**Response under combined stress (Type B parameters*)**		
		Yellow rust severity/year (%)		
		1989	**1990**	**1991**
Faro	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	52.33	52.38	44.13
	P. striiformis (0.7-l mg spores/pot)	65	71.5	54.5
Hyak	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0	0	0.13
	P. striiformis (0.7-l mg spores /pot)	0	0.03	0
Jacmar	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	70	63.75	46.5
	P. striiformis (0.7-l mg spores/pot)	78	68.13	36.13
Tres	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.03	3.53	2.88
	P. striiformis (0.7-l mg spores /pot)	0	3.4	3.05
Tyee	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	62.67	26.63	40
	P. striiformis (0.7-l mg spores /pot)	69	29.63	48.5
FH	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.30	0.43	0.77
	P. striiformis (0.7-l mg spores /pot)	0.18	0.43	0.66
JH	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.24	0.34	0.60
	P. striiformis (0.7-l mg spores/pot)	0.23	0.42	1.1
FR	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.25	0.43	0.52
	P. striiformis (0.7-l mg spores/pot)	0.42	0.45	0.53
FY	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.59	0.38	0.71
	P. striiformis (0.7-l mg spores/pot)	0.56	0.64	0.55
JR	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.30	0.54	0.43
	P. striiformis (0.7-l mg spores/pot)	0.20	0.52	0.81
JY	*P. herpotrichoides* (2.5x10^4 conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.49	0.38	0.74

	P. striiformis (0.7-l mg spores/pot)	0.42	0.60	0.53
FHRY	*P. herpotrichoides* ($2.5x10^4$ conidia/mL) + *P. striiformis* (0.7-l mg spores/pot) (Sequential stress)	0.19	0.49	0.44
	P. striiformis (0.7-l mg spores /pot)	0.18	0.39	0.40

Observation of eye spot severity for three years in the presence and absence of yellow rust

Cultivar	Treatment	Eye spot severity/year (%)		
		1989	1990	1991
Faro	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	70.57	64.2	64.46
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	75.16	50.49	54.57
Hyak	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	43.52	37.28	45.13
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	40.13	29.63	50.53
Jacmar	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	79.22	67.32	73.64
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	83.85	52.37	79.77
Tres	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	77.49	70.38	78.5
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	78.49	56.11	75.4
Tyee	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	70.72	62.74	63.44
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	77.63	53.26	65.26
FH	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	0.97	0.96	1.20
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	0.97	0.76	1.15
JH	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	1.027	0.84	1.02
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	0.80	0.84	0.78
FR	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	0.97	0.97	1.03
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	1.01	0.954	0.93
FY	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	1.06	1.08	1.06
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	0.97	0.94	1.1
JR	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	0.96	0.86	0.94
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	0.91	1.07	0.79
JY	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	0.94	1.02	1.11
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	0.97	1.09	0.96
FHRY	*P. striiformis* (0.7-l mg spores/pot) + *P. herpotrichoides* ($2.5x10^4$ conidia/mL) (Sequential stress)	0.95	0.89	1.08
	P. herpotrichoides ($2.5x10^4$ conidia/mL)	0.81	1.07	0.81

For raw data – Click here (.xlsx file)

Reference– Mundt CC, Brophy LS, Schmitt MS (1995) Disease severity and yield of pure-line wheat cultivars and mixtures in the presence of eyespot, yellow rust, and their combination. Plant Pathol. **44:**173-182

Note: *Values are presented as it is from the source article without subjecting to the calculation.*

'*'- *For more information on parameters classification, please refer to 'methodology' tab*

The inference from the study: Mundt *et al.*, 1995 studied the yield loss and disease severity caused by *P. striiformis* (causal agent of yellow rust), *P. herpotrichoides* (causal agent of eyespot), and their combination in the field for three consecutive years using artificial inoculation in winter wheat cultivar Faro (F), Hyak (H), Jacmar (J), Tres (R), Tyee (Y); six two-component cultivar mixture FH (Faro+Hyak), JH (Jacmar+Hyak), FR (Faro+Tres), FY (Faro+Tyee), JR (Jacmar+Tres), JY (Jacmar+Tyee) and one four-way mixture FHRY (Faro+Hyak+Tres+Tyee). The following table shows the reaction of pure wheat cultivar and mixtures to *P. herpotrichoides* and *P. striiformis* could be related to the yield reduction data caused by both the pathogen.

Cultivar/Mixture	***P. herpotrichoides***	***P. striiformis***	
		CDL 27	**CLD 29**
Faro (F)	S	R	S
Hyak	R	R	R
Jacmar (J)	M	R	S
Tres (R)	S	R	R
Tyee (Y)	S	S	R
F/H	S/R	RR	SR
F/R	S/S	RR	SR
J/H	M/R	RR	SR
J/R	M/S	RR	SR
J/Y	M/S	RS	SR
F/H/R/Y	S/R/S/S	RRRS	SRRR

(S-Susceptible; R-Resistant; M-Moderately susceptible)

The data shows that the combined treatment caused no yield reduction in two-component mixture cultivars with few variations in cultivars FR and FY, however the slight yield reduction observed for the eye spot. And showed a stable effect on the four-way mixture showed less on yield reduction in combined treatment as well as a single treatment. The combined treatments caused a significant yield reduction in comparison with the single pathogen inoculation in all the pure line cultivar except the stand Hyak which was resistant to both the pathogen. Averaged yield data for three years indicated the increased yield of mixtures plants relative to the pure cultivars in the presence of *P. striiformis*, *P. herpotrichoides,* and combination of both pathogens. **The overall study concludes the yield stability of the mixture wheat cultivars relative to the pure cultivars in the presence of *P. striiformis*, *P. herpotrichoides,* and combination of both the pathogens, with the distinct stability in four-way cultivars mixture.**