

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

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

**Stress 1:** *Cochliobolus sativus*  
**Stress 2:** *Pyrenophora tritici-repentis*  
**Stage of plant:** Main shoot and 3 tillers

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

Cultivar	Treatment	Response under combined stress (Type A parameter*)	
		Reduction over control (%)	
		Yield	
Candiotata	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	20.16	↓
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	40.07	↓
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	20.22	↓

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

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

1) ↓ - indicates plant parameter is more affected by stress that leads to high susceptibility (higher the value more 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 fungus *C. sativus* and *P. tritici-repentis* in wheat cultivars in relation to the germination, appressorium formation, germ tube formation, fungal re-isolation, incubation period and disease lesion formed by the pathogen

Effect of sequential inoculations on leaves after 7- and 14-days incubation			
Cultivar	Treatment	Response under combined stress (Type B parameters*)	
		Disease symptoms (%)	
		7 days	14 days
Candiotata	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	66.5	91



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	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	36.5	76.2
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	34	80.2
	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	68.3	72.3
BR8	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	45	75.1
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	24.8	55.9
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	24.2	73.4
	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	46.7	50.2
Max	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	69	86.4
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	42	91
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	44.8	92.1
	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	68.7	84.2
BH1146	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	50.2	78
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	13.8	46.4
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	14.1	72.6
	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	48.7	54
<b>Effect of simultaneous and single inoculations on leaves after 7 days incubation</b>			



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Cultivar	Treatment	Disease symptoms on leaf (%)
Candiota	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	43.42
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (20:80 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	24.96
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (80:20 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	64.72
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	72.27
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	37.69
BR8	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	32.69
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (20:80 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	20.33
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (80:20 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	42.94
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	50.49
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	26.37
Max	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	49.11
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (20:80 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	27.67
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (80:20 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	65.68
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	76.17
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	45.48
BH1146	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	26.73
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (20:80 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	16.03
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (80:20 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	45.33
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	58.27
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	14.74

### Effect of simultaneous and single inoculations on the incubation period and pathogen parameters

Cultivar	Treatment	Effect on incubation period		Conidium germination (%)		Germ tube length (mm)		Appressorium formation (%)	
		C.s.	P.t.r.	C.s.	P.t.r.	C.s.	P.t.r.	C.s.	P.t.r.
Candiota	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum)	25.73	43.85	83	67	244	53	44	31



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	at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)								
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	26.9 0	--	87	--	241	--	45	--
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	--	38.91		83	--	71	--	42
BR8	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	28.7 4	45.14	86	64	238	50	43	30
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	28.7 6	--	83	--	236	--	43	--
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	--	40.77	--	81	--	66	--	43
Max	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	25.8 2	45.09	84	66	241	49	46	29
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	25.8 4	--	85	--	240	--	45	--
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	--	39.00	--	80	--	69	--	40
BH114 6	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	28.0 6	45.99	85	69	240	54	44	33
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	28.8 5	--	86	--	243	--	42	--
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	--	42.20	--	84	--	72	--	43
<b>Percentage of the lesion formed by pathogen on leaves upon simultaneous inoculation</b>									
	<b>Treatment</b>	<b>Recovery of leaf spot (%)</b>							

Cultivar		<i>C. sativus</i>	<i>P. tritici-repentis</i>	<i>C. sativus</i> + <i>P. tritici-repentis</i>	
Candiotata	<i>C. sativus</i> + <i>P. tritici-repentis</i> (50:50 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	82	3	4	
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (20:80 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	75	6	4	
	<i>C. sativus</i> + <i>P. tritici-repentis</i> (80:20 inoculum at 10 <sup>4</sup> conidia/mL) (Simultaneous stress)	86	2	0	
	<i>C. sativus</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	89	0	0	
	<i>P. tritici-repentis</i> (100% inoculum at 10 <sup>4</sup> conidia/mL)	0	84	0	
<b>Re-isolation of the fungal pathogen after 14 days incubation upon sequential inoculation</b>					
Cultivar	Treatment	Fungal isolation at 14 days			
		<i>C. sativus</i>	<i>P. tritici-repentis</i>	<i>C. sativus</i> + <i>P. tritici-repentis</i>	
Candiotata	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) +7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	87	0	0	
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) +7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	0	88	0	
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	12	69	14	
	<i>C. sativus</i> (10 <sup>4</sup> conidia/mL) + 7 days interval + <i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	5	2	2	
<b>Effect of sequential inoculation at different time interval</b>					
Cultivar	Treatment	Disease severity (%)	Fungal re-isolation (%)		
			<i>C. sativus</i>	<i>P. tritici-repentis</i>	<i>C. sativus</i> + <i>P. tritici-repentis</i>
Mixed cultivars	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 0 hr. interval + <i>C. sativus</i> (10 <sup>4</sup> conidia/mL) (Sequential stress)	47	79	4	6
	<i>P. tritici-repentis</i> (10 <sup>4</sup> conidia/mL) + 6 hr. interval + <i>C.</i>	49	42	18	31



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<i>sativus</i> ( $10^4$ conidia/mL) (Sequential stress)				
<i>P. tritici-repentis</i> ( $10^4$ conidia/mL) + 12 hr. interval + <i>C. sativus</i> ( $10^4$ conidia/mL) (Sequential stress)	55	26	32	29
<i>P. tritici-repentis</i> ( $10^4$ conidia/mL) + 24 hr. interval + <i>C. sativus</i> ( $10^4$ conidia/mL) (Sequential stress)	64	24	38	28
<i>P. tritici-repentis</i> ( $10^4$ conidia/mL) + 72 hr. interval + <i>C. sativus</i> ( $10^4$ conidia/mL) (Sequential stress)	72	17	52	25
<i>P. tritici-repentis</i> ( $10^4$ conidia/mL) + 168 hr. interval + <i>C. sativus</i> ( $10^4$ conidia/mL) (Sequential stress)	83	10	73	16

(C.s.- *C. sativus*; P.t.r.- *P. tritici-repentis*)

For raw data– Click here (.xlsx file)

Reference- da Luz WC, Bergstrom GC (1987) Interactions between *Cochliobolus sativus* and *Pyrenophora tritici-repentis* on wheat leaves. *Phytopath.* **77**:1355-1360

**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:** Luz and Bergstrom, 1987, have studied the interaction between the two pathogens *C. sativus* (causal agent of spot blotch) and *P. tritici-repentis* (causal agent of tan spot) on four wheat cultivars Candiota, BR8, Max and BH1146. The combined treatments performed on all the cultivars showed the inhibitory effect of both the pathogens towards each other in comparison with the single inoculation of either pathogen. **Hence the overall observation leads to conclude the antagonistic/competitive nature among both the pathogens.**