



## Effect on chickpea cultivars (*Cicer arietinum* cv. CPS1, UC27, PV61)

### 1. The net impact of individual and combined stress on plant growth

Crop: Chickpea (*Cicer arietinum* cv. CPS1, UC27, PV61)  
 Stress 1: *Pratylenchus thornei*  
 Stress 2: *Fusarium oxysporum*  
 Stage of plant: At sowing

The table shows the impact of nematode and fungus alone and in combination on fresh root weight and dry shoot weight of chickpea plants.

	Treatment	Plant response to stress (reduction over control %) Type A parameters*	
		Fresh root weight	Dry shoot weight
CPS1	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil)	73.0 ↓	70.5 ↓
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)	84.1 ↓	70.5 ↓
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)	89.2 ↓	76.8 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil)	31.7 ↓	22.3 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) (simultaneous stress)	82.2 ↓	75.0 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) (simultaneous stress)	87.3 ↓	74.5 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) (simultaneous stress)	92.6 ↓	83.6 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) 10 days later (sequential stress)	94.9 ↓	59.4 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) 10 days later (sequential stress)	95.3 ↓	57.7 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) 10 days later (sequential stress)	94.5 ↓	69.7 ↓
	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	39.3 ↓	13.6 ↓

	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	30.8 ↓	9.6 ↓
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	37.1 ↓	13.0 ↓
UC27	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil)	13.1 ↓	20.3 ↓
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)	15.4 ↓	-19.1 ↑
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)	11.1 ↓	-27.4 ↑
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil)	28.6 ↓	2.9 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) (simultaneous stress)	27.3 ↓	5.6 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) (simultaneous stress)	18.4 ↓	2.5 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) (simultaneous stress)	29.4 ↓	22.2 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) 10 days later (sequential stress)	33.5 ↓	0.2 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) 10 days later (sequential stress)	17.1 ↓	7.1 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) 10 days later (sequential stress)	23.8 ↓	-0.7 ↑
	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	5.4 ↓	-5.3 ↑
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	14.7 ↓	-6.9 ↑
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	17.6 ↓	-5.2 ↑

PV61	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil)	77.7 ↓	73.1 ↓
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)	88.0 ↓	76.3 ↓
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)	95.6 ↓	88.8 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil)	31.6 ↓	35.2 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) (simultaneous stress)	83.6 ↓	80.8 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)(simultaneous stress)	80.6 ↓	68.1 ↓
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)(simultaneous stress)	90.5 ↓	81.5 ↓

**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 parameters affected by stress that lead 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.

## 2. The interaction between nematode and fungal pathogen under combined stress at plant interface

The table shows the effect of the fungal pathogen on nematode reproduction factor and effect of nematode on fungus induced root necrotic severity and disease intensity index under combined stress treatment

	Treatment	Response to combined stress** Type B parameters*		
		Root necrotic severity	Disease intensity index	Reproduction factor
CPS1	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil)	7.08	0.89	N/A
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)	6.8	0.93	N/A
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)	7.05	0.98	N/A
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil)	4.2	0	2.53
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) (simultaneous stress)	7.6	0.88	3.57
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)(simultaneous stress)	7.25	0.91	3.37
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)(simultaneous stress)	7.38	0.94	2.88
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) 10 days later (sequential stress)	6.22	0.64	N/A
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) 10 days later (sequential stress)	6.11	0.74	N/A
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) 10 days later (sequential stress)	6.33	0.84	N/A
	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	6.33	0.15	77.6
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	6.56	0.15	66.3
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	6.5	0.21	64.1
UC27	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil)	2.55	0	N/A
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)	2.15	0	N/A

	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)	2.25	0	N/A
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil)	3.23	0	4.3
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) (simultaneous stress)	2.63	0	5.03
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)(simultaneous stress)	2.88	0	5.31
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)(simultaneous stress)	2.6	0	4.41
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) 10 days later (sequential stress)	4.33	N/A	N/A
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) 10 days later (sequential stress)	3.94	N/A	N/A
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) 10 days later (sequential stress)	2.78	N/A	N/A
	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	3.33	N/A	36.6
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	3.39	N/A	51.4
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil) + <i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) 10 days later (sequential stress)	3.28	N/A	32.8
PV61	<i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil)	4.95	0.87	N/A
	<i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)	5.9	0.93	N/A
	<i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)	4.35	1	N/A
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil)	2.6	0	2.07
	<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (1000 chlamydo spores/g soil) (simultaneous stress)	4.95	0.91	3.47

<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (2000 chlamydo spores/g soil)(simultaneous stress)	5.5	0.88	4.15
<i>Pratylenchus thornei</i> (10 nematodes/cm <sup>3</sup> soil) + <i>Fusarium oxysporum</i> (5000 chlamydo spores/g soil)(simultaneous stress)	5.2	0.98	5.44

For raw data – Click here (.xlsx file)

Reference - Castillo P, Mora-Rodríguez MP, Navas-Cortés JA, Jiménez-Díaz RM (1998) Interactions of *Pratylenchus thornei* and *Fusarium oxysporum* f. sp. *ciceris* on chickpea. *Phytopathology* 88:828-836.

**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.

**Inference From the study:** Castillo P (1998) studied the interaction of *Pratylenchus thornei* with *Fusarium oxysporum* in chickpea cultivar CPS1, UC27, and PV61. Pathogens were inoculated singly, sequentially, and simultaneously. Plants were then analyzed for their fresh root weight and dry shoot weight. Fresh shoot weight showed an additive reduction under simultaneous and sequential inoculation. This reduction was high in cultivar CPS1 and PV61 compared to UC27. With higher inoculum levels of pathogens, this reduction increased. The reproduction factor of the nematode was less under simultaneous inoculation but under sequential inoculation, this factor was high. Root necrotic activity and disease index was higher under simultaneous stress compared to sequential inoculation of pathogens in all cultivars. **Thus, this pathogen combination act synergistically to reduce plant growth and forms a complex disease phenotype.**