

Germination of *Peronospora farinosa* f. sp. *spinaciae* conidia: a two-topped temperature curve

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Irregularities in the epidemiological development of spinach downy mildew (*Peronospora farinosa* (Fr.) Fr. f. sp. *spinaciae* Byford) in the field led us to a closer examination of the infection cycle of the fungus. The first step, concerning the germination of conidia in relation to different temperatures, already gave remarkable characteristics.

Little experimental work with this fungus has been carried out. From the thirties three authors can be cited: Hiura (1929), Cook (1937) and Richards (1939). All three found germination curves with temperature optima within a range from 8 to 15 °C.

Our early experiments confirmed these findings, but later experiments during which germination was prolonged to over 24 h instead of the 8 h in the early experiments, suggested a second optimum at 25 °C. Table 1 shows the results of five experiments with IPB 100 (physiologic race 1), IPB 200 (physiologic race 2), IPB 300 (physiologic race 3), all three descending from regular multiplications of the fungus in Dutch glasshouses, and ADR 100 (physiologic race 1), of German origin. Experiments 1 through 4 were carried out on petri dishes with water agar placed in incubators at temperatures ranging from 0 to 30 °C. Experiment 5 was carried out on young leaves of spinach plants cv. Huro, placed in climate cabinets with almost the same temperature range as used in the incubators. In all experiments light was excluded during the germination period. The incubation time was 26 h. The petri dishes as well as the spinach leaves were placed at their respective temperatures some hours before the start of the experiments. The conidia used as an inoculum were formed on young spinach leaves at 15 °C during the night before application.

The results of the experiments shown in Table 1 show a rather wide optimum range between approximately 5 and 15 °C, a somewhat narrow optimum at 25 °C and a gap between the two optima at approximately 20 °C. In experiment 1 the depression at 20 °C is not so low as in the other cases, but the difference with the 15 °C and 25 °C results remains remarkable.

Germination at temperatures up to about 20 °C was completed within 8 h and followed the normal S-shaped progress curve. At temperatures over 20 °C only a small percentage of the conidia followed the pattern mentioned. Most conidia showed a time lag of 6 to 8 h before germination started; after some 20 h germination of these conidia was completed.

The second optimum has not been reported for *P. farinosa* f. sp. *spinaciae*. For downy mildew of beet (*P. schachtii* Fuckel, nowadays called *P. farinosa* (Fr.) Fr. f. sp. *betae* Byford), Leach (1931) mentioned a remarkable increase of conidia

Table 1. Germination percentages of spinach downy mildew conidia in relation to temperature.

Temp. (°C)	Experiments ¹				
	1 IPB 100 (race 1)	2 IPB 200 (race 2)	3 IPB 300 (race 3)	4 ADR 100 (race 1)	5 IPB 300 (race 3)
0	16.6	3.3		15.8	
2			62.8		26.7
5	62.5	80.8	73.8	34.3	50.0
10	80.5	82.1		64.7	
13.5			58.3		36.3
15	83.4			58.5	
16.5		58.9	65.0		18.4
20	74.3	64.5	25.3	31.8	9.2
23.5			50.7		30.1
25	81.2	81.5	74.7	71.2	59.8
28			68.0		26.3
30	0.4	0.5		0.0	

¹ Experiments 1 through 4 were carried out on petri dishes with water agar and experiment 5 on young spinach leaves of cv. Huro.

Tabel 1. Kiemingspercentage van conidiën van valse meeldauw op spinazie in relatie tot verschillende temperaturen.

germination at 25 °C after 24 h with a maximum after 48 h of incubation. The same phenomenon has been found with tobacco blue mould (*P. tabacina* Adam) by Clayton and Gaines (1945). In both cases the authors did not give special attention to this phenomenon, that could be of epidemiological importance.

At this moment, the explanation is a matter of speculation. One possibility is that at temperatures over 20 °C only the fastest spores germinate at once, following the normal pattern, but that most of the spores use a certain period of high temperatures for a hypothetical and unexplained transformation, which cannot yet be seen through the microscope. Fitzpatrick (1930) in his book 'The lower fungi – Phycomycetes', already mentions the existence of different types of germination for *Phytophthora* and *Plasmopara*, dependent on environmental factors. Further investigations are in progress.

Samenvatting

Kieming van Peronospora farinosa f. sp. spinaciae conidia: een twee-toppige temperatuurcurve

Bij verschillende herkomsten van *P. farinosa* f. sp. *spinaciae* werden twee optima geconstateerd in de curve welke het verband aangeeft tussen conidiënkiemingspercentage en temperatuur.

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References

- Clayton, E.E. & Gaines, J.G., 1945. Temperature in relation to development and control of blue mold (*Peronospora tabacina*) of tobacco. J. agric. Res. 71: 171-182.
- Cook, H.T., 1937. Germination of conidia of *Peronospora effusa* from spinach. Phytopathology 27: 124.
- Fitzpatrick, H.M., 1930. The lower fungi – Phycomycetes. McGraw Hill Book Comp., New York: 331 pp.
- Hiura, M., 1929. Studies on some mildews of agricultural plants. III. On the downy mildew of spinach. Agriculture Hort., Tokyo 4: 10-22.
- Leach, L.D., 1931. Downy mildew of the beet caused by *Peronospora schachtii* Fuckel. Hilgardia 6: 203-251.
- Richards, M.C., 1939. Downy mildew of spinach and its control. Bull. Cornell Univ. agric. Exp. Stn 718: 29 pp.

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