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## White clover soil fatigue: an establishment problem on large and intensive dairy farms

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**Introduction** In recent years a new constraint, clover soil fatigue, has appeared for the establishment of white clover (*Trifolium repens*) in Denmark. Increasing dairy farm size has led to more intensive use of clover in crop rotation schemes in the grazing areas located at convenient distances from stables. It has become common practice to establish new clover/grass in the fields just after ploughing clover/grass swards, and soil fatigue is becoming more common. On fatigued land the clover plants emerge, then become stunted and eventually disappear within the same year. The problem tends to cover the full field area. Obviously, this is a major constraint since the importance of N-inputs derived from fixation is growing in Danish dairy farming.

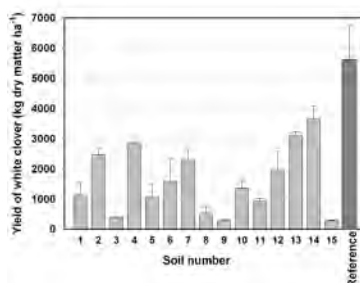
**Materials and methods** Soil samples were collected in spring 2004 from grass/clover pastures on 15 dairy farms where pronounced establishing problems were seen in the past few years. A sample from a field, in which clover had not been grown for at least 20 years served as reference. To study the soil fatigue phenomenon, white clover was undersown to spring barley in these soils in pots (27 x 35 cm containers, 31 l) in three replications, and clover and cover crop growth and dry matter yields were studied. In search of possible microbial causes of the problem, samples of clover plants and of top-soil around plants were collected 6-7 weeks after sowing, from farms which reported clover soil fatigue and from selected pots in the pot experiment. For reference, samples collected from soils with no history of soil fatigue were also studied. Plant roots were indexed by size and branching, analyzed for presence of clover cyst nematodes (*Heterodera trifolii*) and stem nematode (*Ditylenchus dipsaci*) by microscopy, and fungi isolated from the surface disinfected roots and identified.

**Results** In the pot experiment, clover yields from fatigued soils (FS) were considerably lower than from the reference soil (RS) (Figure 1). Pronounced fatigue was found in soils 3, 9 and 15, which yielded only 6% of the RS yield. Five to eight weeks after sowing many of the clover seedlings died, and the production of surviving plants was very low for the rest of the season. In 6 to 7 week old plants, there were no stem nematodes but roots from FS had significantly more clover cyst nematodes per root and root indices were significantly less than roots from RS, clearly indicating that the cyst nematode plays an important part in the soil fatigue. However, the most unambiguous indication for this was the finding that while cysts had formed in a very high proportion of roots from FS, in roots from RS only few nematodes were found (J2 larval stage). Since cyst formation requires about five weeks to complete, this indicates that in FS, an unknown factor may have triggered hatching of cysts and subsequent attacks at the very beginning of plant germination. Table 1 highlights these findings by comparing of roots from soils where management practices were exactly the same, and only the previous crop types differed. Numbers of cysts were comparable in FS and RS soils, hence, high cyst densities do not explain the fatigue. Of 43 fungal taxa obtained from roots, *Fusarium*- and *Cylindrocarpon*-species were the most common in plants from both FS and RS. A complex of some of these species may have aggravated the problem on FS, entering plant roots through wounds made by nematodes, but, so far, its possible role is not clear.

**Table 1** Clover cyst nematodes in plants and soil with or without soil fatigue from pot experiment and from two fields in a grass-arable system. Results from 2004

	Pot experiment		Grass-arab. rot.	
	+	-	+	-
Clover soil fatigue				
Previous crop (2003)	G/C <sup>2</sup>	Barley	G/C	Maize
Days from sowing to sampl.	46	46	50	50
Root index <sup>1</sup>	3.2	4.6	2.9	4.5
Nematode/root (number)	6.6	2.7	7.8	1.2
Roots with cysts (%)	73	0	70	0
Roots with ripen cysts (%)	23	0	60	0
Cysts/kg soil (number)	95	70	380	100
Filled cysts/kg soil (numb.)	0	15	10	5

<sup>1</sup>Root index 1-5 (1 is a thin root <2 cm without branching and 5 is >3 cm with more adventitious roots) <sup>2</sup>grass/clover



**Figure 1** Clover yield in pot experiment after harvest of spring barley. Standard deviation is shown

**Conclusions** The main reason for white clover soil fatigue was attack of clover cyst nematode.