ATTEMPTED BIOFUMIGATION OF CARROT FIELDS WITH *BRASSICA JUNCEA* PELLETS AND LEEK MATERIAL

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Introduction

Biofumigation denotes the use of plant material to treat fields infected with diseases or nematodes (Kierkegaard & Matthiessen 2004). The plants are usually *Brassica* species like *B. juncea, Sinapis alba or Raphanus sativus*, but also *Allium* species have been used (Arnault et al. 2006). The principle in biofumigation is that the plant material is macerated and incorporated in the soil where it releases toxic substances. In *Brassica* species, this is mostly isothiocyanates liberated from glucosinolates by an enzymatic process. In *Alliums,* the toxic substances are various sulphides liberated after maceration and incorporation. In carrot fields in Denmark there can be a problem with build up of soil borne diseases and nematodes. The diseases are mostly soil borne diseases like *Sclerotinia, Pythium, Rhizoctonia, Rhexocercosporidium, Mycocentrospora, Streptomyces* and on the organic soils the nematodes are carrot-cyst nematodes (*Heterodera carotea*). The aim of this work was to test if biofumigation could be used to reduce the number of nematodes as well as the incident of disease attacks on cool stored carrots.

Material and Methods

Experiments were performed on two farms (Lammefjord: 55°46'; 11°25' and 55°47'; 11°25', respectively) with fields infected with carrot-cyst nematodes and also various soil borne fungal diseases. The soils are reclaimed sea bed and high in organic matter (5-10% humus). The treatments were application of 3 t/ha of 'Biofence' (pellets of dried *Brassica juncea*, company CRA –ISCI, Italy) and 100 t/ha of chopped leek (*Allium porrum*) material. The treatments were applied in the beginning of April. Control plots were left as bare soil and all treatments were performed with or without black plastic film covering just after incorporation. The plastic film was sealed with soil around the edges of the plots. The leek material (whole freshly harvested leeks) was chopped in a wood chip machine (LOMA, Denmark) just before spreading on the plot area. The experimental area (10 x 17 = 170 m^2) was set up in beds (1.65 m wide) and the individual plot area was 5.0 x 1.60=9.0 m^2. The leek and Biofence material were incorporated with a rotovator (Fobro, Switzerland) and the

control plots were also rotovated. Temperature in 5 cm depth in the soil was recorded by data loggers (Tinytag). The Statistical design was in blocks with three replicates (2 x 2 x 3 = 12 plots). The nematode concentrations in the soil were recorded by soil samples (20 cm deep) before treatment and 2 weeks after treatment. After 2 weeks of treatment the plastic covering was removed and carrots (var. 'Bolero') were sown over the whole plot area. At harvest of carrots in the beginning of November the plot soil was again analyzed for nematodes. About 80 kg of carrots from each plot were cool stored (1°C and > 95% Rh) in wooden crates until March the following year. In March the degree of fungal storage diseases were assessed as well as the degree of visual nematode attacked carrots.

Results and discussion

The daily temperature in the soil (5 cm depth) during treatment with the biofumigants was between 9 – 18° C and there were only minor differences between covered and non covered plots. The results of the analysis of number of nematodes in soil samples showed no significant effects of the biofumigation treatments or plastic covering (Fig 1a,b). The number of viable eggs concentration in soil samples before treatment, two weeks after treatment and again at harvest of the carrots showed no statistical differences of 'Biofence' or 'leek material' when compared with the control. The variation in the number of nematodes in the field area was very large. For example, the number of viable eggs in control plot samples taken within two weeks did not show a significant correlation. The reasons for that are not known but might be affected by both sample technique and nematode analysis or heterogeneous distribution of the nematodes within the experimental plots.

In the results of the degree of fungal disease attack in cool stored carrots there were also no significant effects of the biofumigation treatments or plastic covering (Fig. 2a,b). The stored carrots were also assessed for visual nematode attack and this result was also not significant regarding the biofumigation treatment (Fig. 2a,b).

The reason for the failing effect of our biofumigation treatments could be the high content of organic carbon in the fields (Humus 5-10%). High organic carbon tends to absorb the liberated isothiocyanates according to Gimsing & Kirkegaard (2009) and this may also be the case with the sulphides liberated from leek. Again there could be a soil-type dependant effect of the biofumigation principle like shown in the results by Michel (2008) in experiments with *Verticillium dahliae* were the clay content of the soil had significant effects on the result.

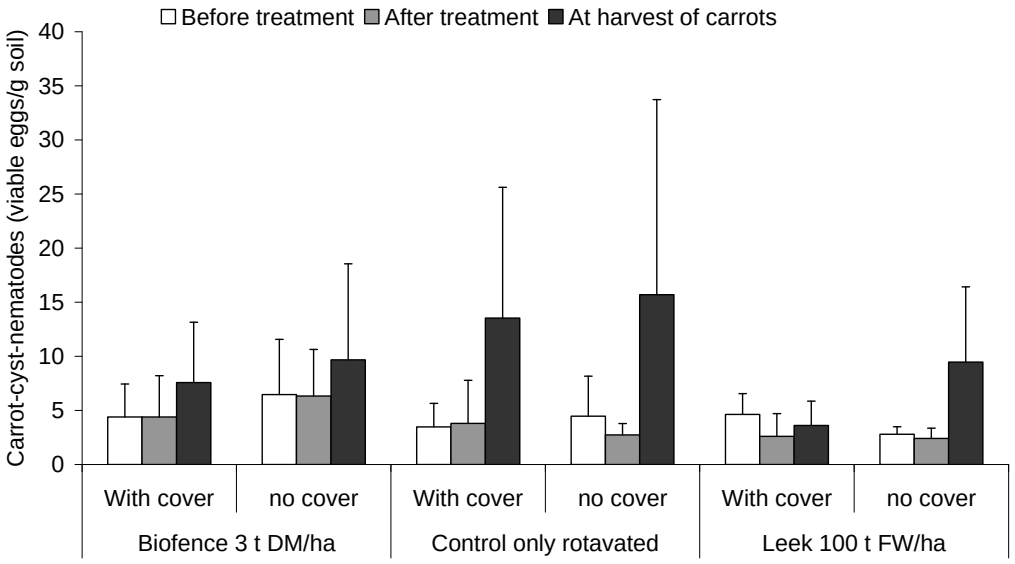

Figure 1a: Carrot-cyst-nematodes in soil on Farm A. The numbers of viable eggs in soil samples were assessed in May before treatment, two weeks after biofumigation and at harvest of carrots in November. Bars are SE (n=3).

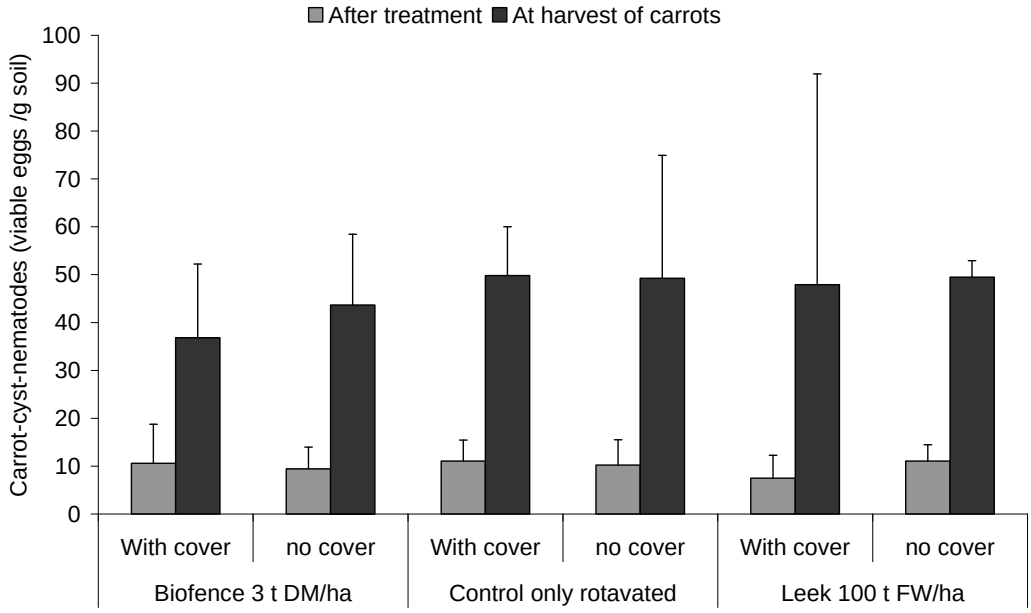

Figure 1b: Carrot-cyst-nematodes in soil on Farm B. The numbers of viable eggs in soil samples were assessed two weeks after biofumigation and at harvest of carrots in November. Bars are SE (n=3).

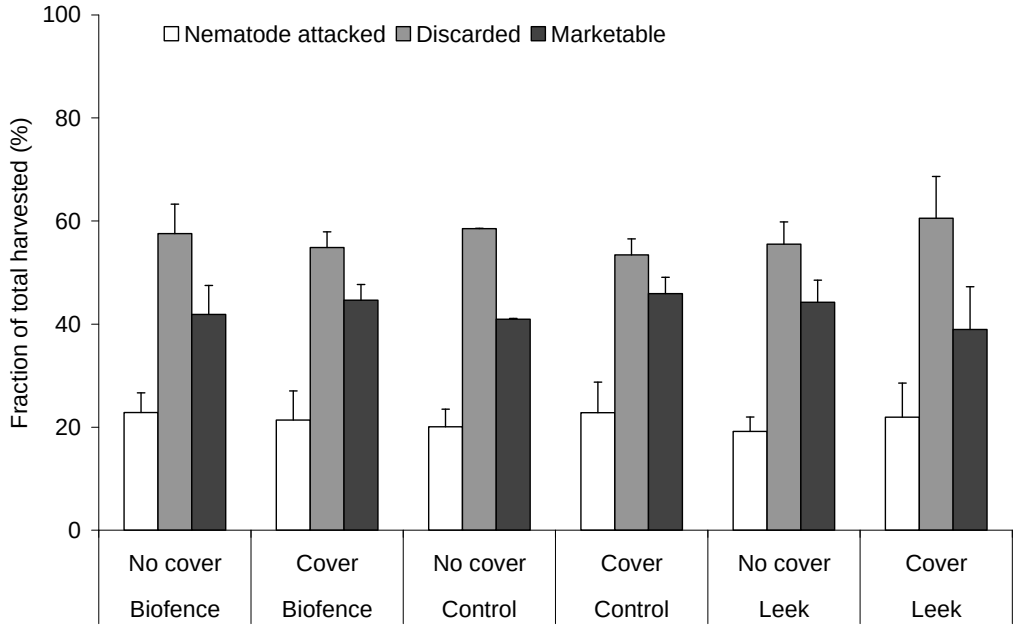

Figure 2a: Carrot fungal diseases and nematode attack on Farm A. Quality grading of carrots stored 5 month until March the following year. Bars are SE (n=3).

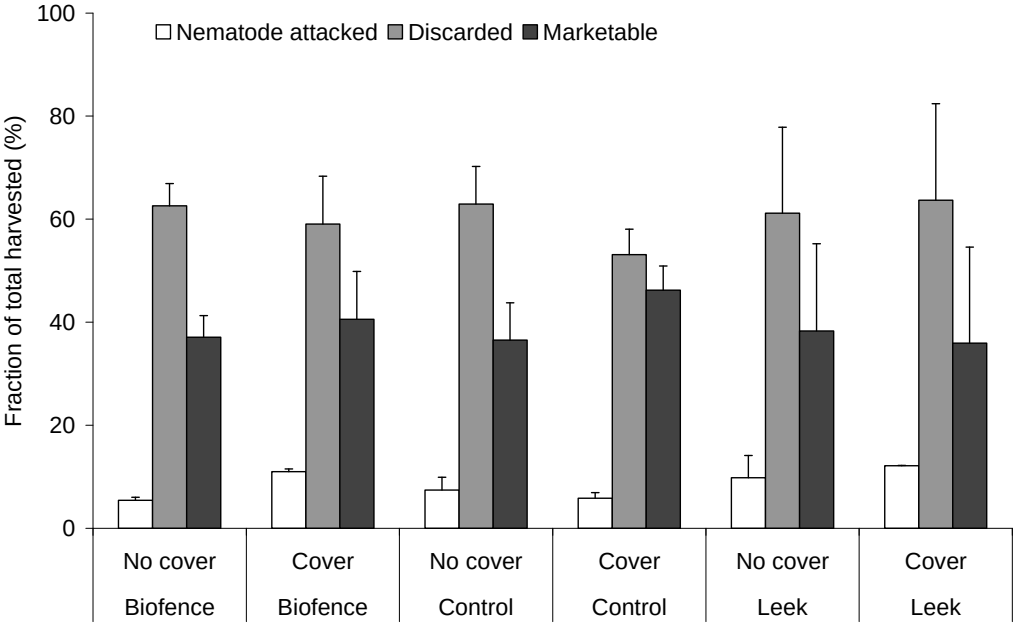

Figure 2b: Carrot fungal diseases and nematode attack on Farm B. Quality grading of carrots stored 5 month until March the following year. Bars are SE (n=3).

The soil temperature during our biofumigation treatment was relatively low (daily between 9-18°C) and this slows down the enzymatic process of liberating isothiocyanates from the *B. juncea* pellets. According to Springett & Adams (1989) and Schütze (pers. communication) the optimum temperature for myrosinase activity is over 30°C. If the average temperature of about 14°C in our experiment is critically low for myrosinase activity, then the more Northern countries have a challenge with biofumigation. The experimental area was not irrigated after incorporation of the biofumigation material, but the water content in the spring soil was near field capacity.

Conclusion

No significant effect of the biofumigation treatment with either 'Biofence' or 'leek material' on the number of carrot-cyst-nematodes in soil samples nor fungal disease attacks in carrots after storage could be detected. The reasons for the failing effects have to be investigated in future experiments.

References

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