Effects of different tillage after oilseed rape on the increase of diseases and pests

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Abstract
This study demonstrates the impact of occurrence of clubroot and *Delia radicum* in dependence of different tillage management after oilseed rape harvest. Two experimental field trials were carried out at two locations in Lower Saxony, Germany. In one trial, flat tillage (two weeks after harvest) and low tillage (five weeks after harvest) and no tillage were investigated with regard to clubroot disease development in volunteer rape. It was shown that the flat tillage was performed just in time to control clubroot successfully for a short time. A second tillage would have been necessary to ensure long term efficacy. In the second trial four tillage types were applied (disc harrow, cultivator, plough and no tillage) to examine their impact on cabbage root fly occurrence. As a result, it can be stated that all tillage types led to a reduced hatch of the flies. However, within the tillage types no different effects could be determined. Further studies on the temporal occurrence of clubroot using PCR showed that the pathogen was detected in plant tissue already after 4 days.

Introduction
With an acreage of 1.4 million hectares rapeseed is the most important oil crop in Germany. Since the 70s, rapeseed production increased constantly. The rising production of rapeseed and the high proportion of rapeseed in crop rotation lead to a higher risk of disease and pest pressure. In particular, those diseases for which treatment is difficult might spread more rapidly. Furthermore, high fuel prices and a restricted time period for tillage treatments increased efforts to apply more cost-efficient tillage practices. After harvest, the unprocessed stubbles often remain on the soil surface for several weeks. As a result volunteer rape and weeds can grow unhindered. This can lead to the spread of special diseases such as clubroot (*P. brassicae)* but may also increase pests pressure by species such as cabbage root fly (*D. radicum*).
In this project, the influences of time variable tillage on the spread of clubroot and cabbage root fly were studied. In addition, a laboratory experiment was carried out to investigate the course of *P. brassicae* infection in more detail.

Materials and Methods
Field trials
In 2010 two field trials different soil tillage systems were applied after oilseed rape harvest at two farm locations in Lower Saxony, Germany.
The soil at the location of Hattorf was sandy loam which was strongly infested with clubroot. The trial covering an area of 0.54 ha was split into plots of equal size, where three different tillage systems were practiced (Table 1).

Tab. 1: Field trial in Hattorf

Variants	T1 1 day after harvest	T2 ca. 14 days after T1	T3 4 weeks after T1
1	Chaff + mill of straw	---	---
2	Chaff + mill of straw	Cultivator flat (5-10 cm)	---
3	Chaff + mill of straw	---	Cultivator low (15 cm)

The clubroot disease was recorded weekly by examining the specific disease symptoms of the roots of 200 plants of volunteer rape per variant. To determine the influence of climate conditions on the development of the pathogen, weather data from the nearest official weather station were used.
The soil at the location of Groß Twülpstedt was loamy sand which was moderately infested with cabbage root fly. The trial covering an area of 2.4 ha was split into plots of equal size, where four different tillage systems were practiced (Table 2).

Tab. 2: Soil tillage techniques applied in Groß Twülpstedt

Variants	T1 10 days after harvest	T2 3-4 weeks after harvest
1	---	---
2	Disc harrow flat (5 cm)	---
3		Cultivator low (15 cm)
4		Plough deep (25 cm)

The hatched of the cabbage root flies was monitored by 8 photoeclectors in each variant, which were placed at a distance of 10 meters after soil tillage. A 5% sodium benzoate solution was used as fishing liquid. The number of flies caught was counted during a period of four weeks.

Laboratory trials

The aim was to detect *P. brassicae* infection prior to the development of visible symptoms. Oilseed rape cv. Highlight seedlings, which were germinated for 7 days in plastic pots filled with soil, were inoculated with 2 ml spore suspension (1×10^7 spores/ml) placed on each root neck. Control plants were treated with 2 ml H_2O. The plants were incubated in a greenhouse at 25 ºC and a 12-h photoperiod (natural light supplemented with artificial lighting). To ensure infection, the soil was kept saturated with water for the first week after inoculation. Afterwards the plants were fertilized and watered as required. Seedlings were harvested at 3, 5, 10 and 21 days after inoculation. The roots were washed with H_2O and examined for disease symptoms. Total DNA was extracted from the sample used as a template in the PCR protocol according to Rogers and Bendich (1985).

Results and Discussion

Field trials

In the field trial at Hattorf volunteer rape emerged one week after harvest of the pre-crop due to the wet weather conditions in late summer. In the untreated control, the first clubroot symptoms on volunteer rape were visible after 19 days from emergence. The infection increased in this variant from 30% up to 70% within the following three weeks (Fig. 1). Before treated with flat cultivator no disease symptoms were visible in volunteer rapeseed. After flat tillage treatment volunteer rapeseed emerged new within 7 days and clubroot symptoms were detected already after 12 days of emergence. The extreme rainfall, which resulted in high soil moisture led to this accelerated symptom development. Before low tillage treatment volunteer rape grew within four weeks and showed heavy infection with clubroot up to 55 %, but after tillage no further germination was observed.

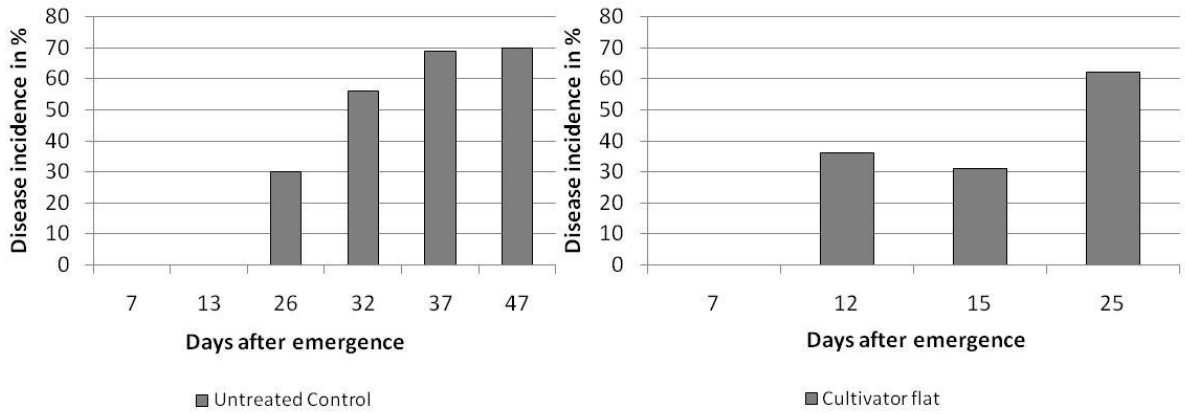
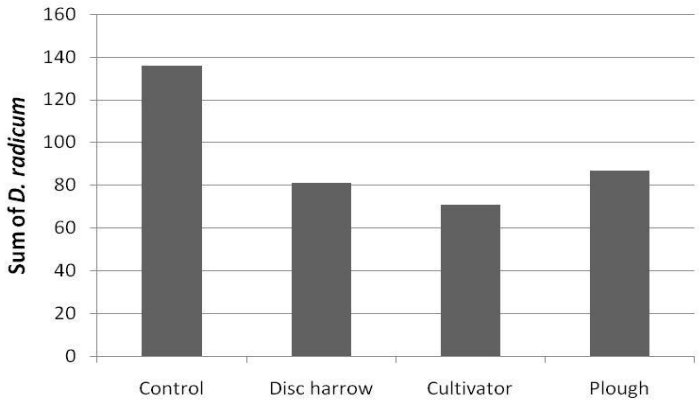


Fig. 1: Development of clubroot on volunteer rape depending on the tillage

The field experiment in Hattorf showed that the development of clubroot disease can be controlled by soil tillage. However, the type and number of treatments necessary to reduce the disease efficiently is strongly dependent on the local weather conditions. It could be shown that the disease incidence increased within a shorter time period when the soil moisture content ranged about 80 % after rainfall. This is accordance with results from Monteith (1924), who reported typical symptoms of clubroot at 70 to 80 % soil moisture but not fewer than 45 % soil moisture. Although the timing of flat tillage was optimal, a second tillage treatment would have been necessary to improve the treatment efficacy due to persistent high soil moisture. The low tillage was performed too late, as the disease incidence in the volunteer rape amounted already to 55 %. It seems to be essential to control the vounteer rapeseed in rainy years by repeated soil tillage treatments in order to prevent the expansion of clubroot inoculum in the field.

The results from the field trial Groß Twülpstedt showed that the peak of hatching of *D. radicum* was independent from the mode of tillage.
In Figure 2, the sum of cabbage root flies (*Delia radicum*) trapped in different tillage systems is shown. The number of *D. radicum* was reduced by all tillage systems, but the obtained reduction varied in a similar range from 36-48 %. It should be clarified with continuing investigations whether the efficacy can be further improved. Finch & Skinner (1980) and Dosdall et al. (1996) also compared different soil tillage systems to reduce the hatch of *Delia* spp. In their trials higher levels of controls up to 75 % were achieved with plough and disc harrow treatments.



Type of tillage	Disc harrow	Cultivator	Plough
Reduction in according to the control in %	40	48	36

Fig. 2: Sum of the number of hatched *Delia radicum* depending on the tillage.

Laboratory trials

By using the PCR method, the clubroot pathogen could be detected in rapeseed root extracts as few as 4 days after inoculation. Clubroot disease symptoms were not visible until 21 days after inoculation, when a slight swelling could be observed upon careful examination of the roots. Cao et al. (2007) could detect similar results with same primer and PCR method. Further investigations are necessary to analyse the survival and vitality of these spores in young tissue, before the optimal timing of clubroot control by soil tillage can be given.

References

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