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Effect of seeders and tillage equipment on vertical distribution of oilseed rape stubble

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Abstract

When the spreading of a disease depends on the proportion of infected residues remaining at soil surface it is of crucial importance to analyse the effects of tillage practices on the vertical distribution of stubble. This is the case with phoma stem canker (blackleg), whose epidemics are initiated in autumn, by air-borne ascospores released from stubble located at the soil surface. We compared initial vertical distribution of oilseed rape residues to those observed after sowing and various tillage operations (rotary harrowing, stubble disking, chiselling and mouldboard ploughing). Almost 20% of the initially buried residue was brought back to soil surface with seeding. Rotary harrow brought 40% of the residue buried in the 0–10 cm layer up to the surface and left unburied about 70% of surface residue. Stubble disking appeared to be more efficient for residue burial than chiselling. Mouldboard plough was the only tool that buried all residues. A simple model was developed that predicted burial and return to the soil surface of potentially infected residues as a function of tillage practices used after harvest. Simulation of different tillage sequences showed that the order in which tools were used also affected location of residues. Our results highlighted the importance of tillage in the cultural control of phoma stem canker and will contribute to the definition of integrated pest management strategies for oilseed rape.

Keywords: Integrated pest management; Cultural control; Conventional tillage; Conservation tillage; *Leptosphaeria maculans*; *Brassica napus*

1. Introduction

When caused by a fungus, spreading of a disease often depends on the proportion of residues from the preceding crop left at the soil surface. This is the case for instance with phoma stem canker or blackleg whose causal fungus is *Leptosphaeria maculans*, asexual stage *Phoma lingam*. It is one of the most severe diseases affecting oilseed rape crops (*Brassica napus*) worldwide. This disease occurs in the main growing areas (Australia, Canada and Europe) and can result in major yield losses (Hall, 1992; West et al., 2001). Soil tillage should improve the control of the pathogen if proper stubble management reduces the risk of contamination in the spreading area (Alabouvette and Brunin, 1970; Kharbanda and Tewari, 1996; Leake, 2000). Epidemics are initiated in autumn by the primary inoculum, i.e. ascospores produced on infected residues. These ascospores, spread over

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several kilometres by wind, only appear if infected debris is totally or partially exposed to solar radiation (Lacoste, 1963). Spores can develop on the residues of previous rape crops when residues are left on the soil surface or brought back to the soil surface by tillage.

Thus, to prevent the development of this disease, stubble management by tillage should examine: (i) the effect of tillage and sowing on residue burial, especially that of stems, which are usually chopped and represent the main residual biomass after harvest and (ii) the effect of tillage and sowing on the return to the soil surface of residues from 0 to 10 cm soil layer. Indeed, this layer is the most intensively tilled, due to stubble breaking, seed bed preparation and sowing. These residues in the 0–10 cm layer are either previously buried residues or the upper part of the main roots that are located at this level after harvest. The roots are particularly dangerous because they are the main long-term support for the mycelium, as their high lignin content renders them resistant to decomposition (Alabouvette and Brunin, 1970; McNish, 1979; Turkington et al., 2000b). Thus, both burial and rising to the soil surface should be taken into account when evaluating the effect of tillage. These two processes may explain the conflicting effects of tillage on the risk of ascospore production sometimes reported in the literature. For instance, mouldboard ploughing limits sporulation by incorporating most of the surface residues into the soil and by increasing their decomposition rate (Turkington et al., 2000a). However, ploughing may also induce ascospore production by bringing buried residues back to the soil surface (Turkington et al., 2000b).

Conventional tillage with mouldboard ploughing is being replaced by conservation tillage (where tillage is reduced or suppressed) in many countries. This means that a smaller proportion of surface residues are buried, but this proportion depends on the type of tool used (disks or tines, fixed or not). Furthermore, sowing practices can also modify the location of residues in the soil, near the sowing line.

In this paper, we present the results of a field experiment carried out to analyse the effect of different types of soil tillage on the proportion of surface residues buried and the proportion of residues located in the 0–10 cm layer that rose up back to the surface. For this, we used coloured residues to follow the movement of potentially infected residues in the soil. The results were used to design a simple model of transfer between the two soil compartments: surface and 0–10 cm.

2. Materials and methods

2.1. Site characteristics

In October 2002, a field experiment was carried out at the INRA Experimental Station at Grignon, Yvelines (1°58′E, 48°51′N) in the western Paris region on a loamy slit Calcic Cambisol (FAO classification). Texture of the 0–30 cm horizon was 29% clay, 61% silt and 10% sand. Bulk density was 1.5 g cm^{-3}.

2.2. Experiment characteristics

Methods were derived from studies dealing with the effects of soil tillage on location of weed seeds (Cousens and Moss, 1990; Colbach et al., 2000) or vertical distribution of cereal straw (Staricka et al., 1991) in soil. Residues were 5 cm long pieces of the main stem of mature oilseed rape plants.

Tools studied were: drill seeder, rotary harrow, stubble disk, chisel and mouldboard plough (Table 1).

Table 1
Characteristics of the five tools used in the experiment

Code	Tool (manufacturer)	Working depth (cm)	Tool characteristics	Tractor Speed (km h^{-1})
S	Seeder (Naudet)	5	21 hooves (working width of 3 m)	6
RH	Rotary harrow (Howard)	8	12 tine pairs (working width of 3 m)	3.5
SB	Stubble breaker (John Deere)	8	12 carve disks in front and 13 smooth disks at the back (working width of 2.3 m)	6
C	Chisel (Duro)	18	11 tines on 3 levels (working width of 3 m)	5
P	Mouldboard plough (Huard)	30	2 shares with a skim-coulter (working width of 2 m × 0.35 m)	4