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Relations between soil water potential and disease in wheat seedlings infected by Puccinia recondita

M. C. COWAN[1] and J. C. ZADOKS

Laboratory of Phytopathology, Agricultural University, Wageningen

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Abstract

The effect of soil water potential on wheat seedlings infected with *Puccinia recondita* was studied. The seedlings were grown in soil of which the initial water potential was -200 Jkg^{-1}, -500 Jkg^{-1}, or -800 Jkg^{-1}. Uredospore production per seedling was retarded when the soil water potential was low, and soil water potential decreased more rapidly near the roots of diseased seedlings than it did near the roots of uninoculated seedlings.

Introduction

Transpiration of wheat plants increases when plants become diseased with rust, as described by Johnston and Miller (1934), Murphy (1935), Bever (1937), and Parodi and Bitzer (1969). These authors had not limited the supply of water to the diseased plants. The following experiment was designed to explore the effect of a limited water supply on the first leaf of the wheat seedling either with or without brown rust (*Puccinia recondita* f. sp. *triticina*). The water supply was expressed in terms of soil water potential (Slatyer and Taylor, 1960).

Materials and methods

Soil columns were prepared from transparent plastic sleeves of 2 cm ⌀, 55 cm long, sealed at the bottom, which were filled with a commercial potting soil (Triomf No 17). The soil had been sieved through a sieve of mesh 2.5 mm, and dried until the water potentials in each of three batches were approximately -200 Jkg^{-1}, -500 Jkg^{-1}, and -800 Jkg^{-1}. In each soil column, a three-days-old seedling 'Peko' was planted, and the lip of the sleeving was closed around the emerging coleoptile with a loop of wire. The columns were set at an angle of 45°, so that the roots could be observed at the lower sides. The slanting columns were placed in a growth chamber at a temperature of 19 ± 1 °C and a relative humidity of 85 ± 3%, the latter corresponding to a water potential of about -22.000 Jkg^{-1}. Illumination was by fluorescent tubes (Philips TLM 40 W 33 RS), with a diurnal cycle of 16 h light and 8 h dark, providing 4.25 W m^{-2} visible light at the tops of the columns. Tissue produced by the seedlings after the first leaf was removed daily.

Seven days after planting, half of the 32 seedlings in each water potential treatment

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Fig. 1. Changes in soil water potential with time in soil columns containing one wheat seedling per column, either uninoculated (heavy line) or infected with *Puccinia recondita* (narrow line). There were three water potential ranges, high (continuous line), intermediate (broken line), and low (dotted line), and measurements were made at three positions in the columns (seed region, Fig. 1a; intermediate region, Fig. 1b; root tip region, Fig. 1c).

Fig. 2. Changes in fresh weight (upper pair of lines) and dry weight (lower pair of lines) of the first leaves of wheat seedlings with time. Experimental details as in Fig. 1. Three soil water potential ranges (high. Fig. 2a; intermediate, Fig. 2b; low, Fig. 2c).

Fig. 3. Changes in percentage water content of the first leaves of wheat seedlings with time. Experimental details as in Fig. 1. Three soil water potential ranges (high, Fig. 3a; intermediate, Fig. 3b; low, Fig. 3c). LWC = Leaf Water Content. FR.WT. = fresh weight.

Fig. 4. Cumulative uredospore production per seedling with time. Experimental details as in Fig. 1. Three soil water potential ranges, high (continuous line), intermediate (heavy dotted line), and low (dotted line).

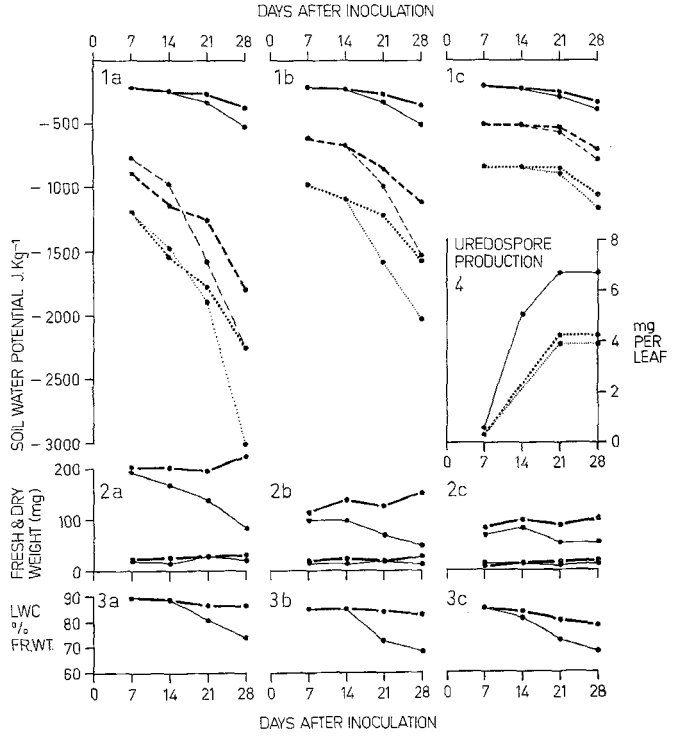

Fig. 1. Veranderingen van de waterpotentiaal met de tijd, gemeten in grondkolommen met één tarwe kiemplant per kolom. De dunne lijnen gelden voor tarweplanten geïnoculeerd met Puccinia recondita, de dikke lijnen voor ongeïnoculeerde planten. De drie bereiken van de waterpotentiaal zijn aangeduid als hoog (getrokken lijn), intermediair (gebroken lijn) en laag (gestippelde lijn). Metingen werden verricht op drie hoogten in de grondkolom, ter hoogte van het zaad (Fig. 1a), tussenin (Fig. 1 b) en ter hoogte van de worteltoppen (Fig. 1c).

Fig. 2. Veranderingen in versgewicht (bovenste lijnenpaar) en drooggewicht (onderste lijnenpaar) van het eerste blad van tarwekiemplanten in de loop van de tijd. Voor experimentele gegevens zie onder Fig. 1. De drie waterpotentiaal bereiken in de grond zijn weer hoog (Fig. 2a), intermediair (Fig. 2b) en laag (Fig. 2c).

Fig. 3. Veranderingen van het watergehalte in procenten bij het eerste blad van tarwekiemplanten, in de loop van de tijd. Zie onder Fig. 1 voor experimentele details. Waterpotentiaal bereiken in de grond: hoog (Fig. 3a), intermediair (Fig. 3b) en laag (Fig. 3c). LWC = watergehalte van het blad. FR.WT. = vers gewicht.

Fig. 4. Cumulatieve uredosporenproduktie per kiemplant uitgezet tegen de tijd. Experimentele gegevens als onder Fig. 1. Waterpotentiaal van de grond in drie bereiken, hoog (getrokken lijn), intermediair (vet gestippelde lijn) en laag (gestippelde lijn).

were inoculated with uredospores of *P. recondita* f. sp. *triticina*, isolate No. 1037 (Mehta and Zadoks, 1970). In the following, time will be expressed in days after inoculation. After the first pustules opened (day 6), uredospores were collected daily from each leaf with a cyclone collector, and the dry weight of each collection was determined.

On days 7, 14, 21 and 28, four infected and four uninfected seedlings in each water potential treatment were analysed; samples of soil were taken from three positions in the columns, and the water potentials were calculated from the moisture content and a calibration curve (moisture content versus water potential), which had previously been determined by the method of Monteith and Owen (1958).

Results

The results are presented in Figures 1 to 4. Soil water potential decreased most rapidly at the upper ends of the columns (Fig. 1a, b, c), where the bulk of the root system was situated. On day 14, the water potential in the upper regions of columns containing diseased plants was higher than the water potential in the controls (Fig. 1a, intermediate and low treatments). This suggests that during the previous period, transpiration was greater in healthy plants than in diseased plants. From day 21 onwards, the water potential in the columns containing diseased plants decreased faster than that in the columns containing healthy controls. The rate of decrease of water potential became more rapid with time throughout the experiment, indicating that the uptake of water was not seriously inhibited in the water potential range investigated. Fresh weights (Fig. 2) of diseased leaves were less than those of healthy leaves, and fresh leaf weights decreased with decreasing soil water potential. There was little variation among dry leaf weights. The water content of the leaves, expressed as a percentage of the fresh weight, decreased more rapidly in diseased plants than in healthy plants from day 7 onwards (Fig. 3). The uredospore production in mg dry weight per seedling leaf (Fig. 4) was greater at high than at low soil water potential. The highest rate of spore production occurred between days 7 and 14, when differences in water potential between columns containing healthy and diseased plants were not yet detectable. Fig. 1 shows that these differences became visible on day 21, when sporulation had almost ceased. It may be concluded that leaves with senescent pustules showed more evapotranspiration than leaves with actively sporulating pustules.

Samenvatting

Relaties tussen waterpotentialen in de grond en ziekteverschijnselen bij tarwekiemplanten geïnfecteerd met Puccinia recondita

Tarwekiemplanten werden geplaatst in plastic kolommen (een plant per kolom) gevuld met grond van bekende waterpotentiaal. Bij een deel der planten werd het eerste blad geïnoculeerd met bruine roest. De spruit boven het eerste blad werd regelmatig weggeknipt. Periodiek werden bepaald (veelal middels destructieve bemonstering) vers en droog gewicht van het eerste blad, roestsporenproduktie, en waterpotentiaal van de grond op drie niveau's in de kolommen. Voor de resultaten zie Fig. 1 t/m 4. Twee weken na inoculatie gaan zieke planten geleidelijk meer water verdampen dan onbehan-

delde planten (Fig.1). Vers gewichten van zieke bladeren waren kleiner dan die van onbehandelde planten (Fig.2). Het watergehalte van zieke bladeren werd lager dan dat van onbehandelde bladeren (Fig.3). De uredosporenproduktie was bij hogere grondwaterpotentiaal groter dan bij lagere potentiaal (Fig.4).

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Addresses

M. C. Cowan: Pye Research Centre, Stowmarket (Suffolk), England.

J. C. Zadoks: Laboratorium voor Fytopathologie, Binnenhaven 9, Wageningen, the Netherlands.

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