ON THE CONCENTRATION OF ACETIC ACID IN STRAW AND SOIL

by J. M. LYNCH, K. B. GUNN and LYNDA M. PANTING

Agricultural Research Council, Letcombe Laboratory, Wantage, Oxon OX12 9JT

KEY WORDS

Acetic acid Barley Diffusion Silt loam Straw Water absorption Wheat

SUMMARY

Freshly harvested wheat straw contained 0.096 g water g⁻¹ dry straw and 180 mM acetic acid. The straw absorbed water more rapidly from wet soil. The concentration of acetic acid fell to about 10 mM within 6 h of incorporation of straw in the soil and then remained relatively constant for a period of 12 days, irrespective of soil moisture content. In soil at its maximum water holding capacity after gravitational drainage, the decline in acetic acid concentration (c) with distance (d) from wheat or barley straw was exponential, with c = c₀e⁻ⁿᵈ where c₀ is the concentration of acetic acid at the straw surface and n is a constant (0.46 for barley and 0.42 for wheat straw). The presence of acetic acid seems to be a major cause of poor establishment and growth when seeds and seedling roots come into contact with straw.

INTRODUCTION

The microbial degradation of straw under anaerobic conditions in solution ⁵, ⁹, ¹⁰ and in soil ², ³, ⁶, ⁷, ⁸ leads to the formation of acetic acid and smaller amounts of propionic and butyric acids. This has provided a potential explanation for adverse effects of straw on plant establishment and crop growth⁴. We have now examined whether acetic acid accumulates at localised sites in soil and the effects of soil moisture on accumulation.

METHODS

Determination of the acetic acid and water contents of straw

Using a simple tensiometer we established the moisture characteristic curve for the drying of a silt loam (Hamble series) passed through a 2.8 mm sieve and packed to a bulk density of 1.1. Plant pots were then filled with soil (1250 g) compressed to a bulk density of 1.1 and wetted from the bottom to produce the required moisture content. Wheat (Triticum aestivum) straw was cut into sections (7 cm

length), each with a node in the centre. Nylon string was attached to one tip of each piece of straw. The straw was then inserted vertically in the soil 2 cm below the surface and the holes backfilled with soil. Six pots were used for each moisture content and twenty sections of straw were inserted singly over twenty holes into each pot. The pots were incubated at 25°C in the dark. They were weighed daily and any loss in weight compensated by addition of water. At intervals, two sections of straw were removed from each pot. One was weighed, dried at 100°C and re-weighed to constant weight to determine the moisture content of the straw (w ml). The other was added to distilled water (2 ml) and shaken mechanically for 1.5 hours. The acetic acid content (A mM) of this solution was then measured by gas chromatography. The effective concentration of the acid in the straw (c mM) was calculated from:

\[ c = \frac{A}{w} \]

If the water content of the straw was expressed as W ml g⁻¹ dry straw, the acid in the straw (D μmoles g⁻¹ dry straw) was calculated from:

\[ D = cW \]

Movement of acetic acid from straw

Six cylinders of the sieved silt loam, 25 cm high and divided half-way along by a 2.5 cm layer of wheat or barley (Hordeum vulgare) straw, were contained in sheet nylon tubes (13 cm in diameter) closed at the top and bottom. The soil was brought to maximum water-holding capacity by drainage of flooded soil under gravity overnight (50 g water 100 g⁻¹ soil) and incubated at 8°C in the dark for 3 weeks. The straw layers were excised and separate zones of soil were taken from above and below the straw. The sections were extracted with distilled water (400 ml) using a blender and filtered through a membrane (0.22 μm); the filtrate was analysed for acetic acid. The effective concentration of the acid in the soil (c mM) was then calculated from:

\[ c = \frac{A}{x} \]

where A is the measured concentration and x is the volume of water in the section of soil. The concentration of acid in the layer of straw was estimated in the same way.

RESULTS

The moisture characteristic curve for the drying of the soil showed that when the soil moisture contents were 46, 40 and 30 g 100 g⁻¹ soil, the water potentials were -6, -9 and -40 mbar (or -0.6, -0.9 and -4 kPa) respectively.

When straw was added to the soil, water was taken up more rapidly at high water potential (Fig. 1, Table 1). The maximum water holding capacity of the straw was reached within 48 h in the wet soil and the water content (W) of straw correlated (r = 0.883, accounting for 85% of the variation) with time (t) by the equation W = 0.484 + 0.167t - 0.00132t². The corresponding equation (r = 0.864, accounting for 96% of the variation) for the drier soil was W = 0.333 + 0.0242t - 0.0000592t².