Phytotoxicity of Wheat Leachates and Ferulic Acid to Germination and Radicle Elongation of Canola

S. Bruce[1] and O. Christen[2]

[1] CSIRO Plant Industry, Canberra, ACT.
Institute of Agronomy and Crop Science, Martin-Luther-University Halle-Wittenberg, Germany.

Key words

Allelopathy, stubble, germination, radicle elongation.

ABSTRACT

Leachates of three Australian wheat varieties (cvs. Janz, Swift and Diamondbird) were tested for phytotoxic effects on germination and radicle elongation of 6 German canola varieties (cvs. Artus, Express, Accord, NPZ 9815, Maplus and Fornax). To assess the possible role of ferulic acid in the leachate response, the effects of ferulic acid on germination and radicle elongation were compared with the response to the leachates. Varietal differences in both the toxicity of the wheat leachates and the sensitivity of the canola occurred. Janz was toxic to both germination and radicle elongation and Fornax was the most sensitive of the canola varieties. Both germination and radicle elongation were negatively affected by ferulic acid, although ferulic acid could not fully explain the germination response to the leachates. However, the effects of the leachates and ferulic acid on radicle elongation caused a similar pattern of suppression indicating that ferulic acid may explain a proportion of the suppressive effect of wheat leachates.

INTRODUCTION

Studies in the United States and Australia have shown that retained wheat residues can reduce yield (5,6). More recently, there has been evidence for reduced yields of canola crops sown into retained wheat residues. Investigations into poor growth under crop residues have demonstrated that phytotoxins released during the decomposition of plant residues may be contributing to the decline (5,3,4,7,6). Research has identified phenolic acids to be the main components contributing to wheat phytotoxicity (3). In particular, ferulic acid has been found to be one of the most toxic of the phenolic acids to the growth of wheat seedlings (3). The greatest research effort into the effect of phytotoxins on plant growth has been directed toward the effects of cereal and weed residues on the growth of cereals and legumes. Of the literature reviewed, none have examined the phytotoxic impact of wheat residues, nor the impact of phenolic acids on canola growth. The aims of this study were to examine the phytotoxicity of Australian wheat leachates on the germination and growth of German canola varieties and to compare this with the effect of ferulic acid.

METHODS

Wheat residues (cvs. Janz, Swift and Diamondbird) collected from Wagga Wagga NSW in December 1998 were air-dried and cut into 3 cm lengths. Stubble extracts were prepared by agitating 20 g of stubble in 250 mL of distilled water for 4 hours at room temperature (the concentration used was determined in a preliminary trial). The leachate was decanted, centrifuged to remove particulate matter, passed through a millipore filter (Millipore 0.45 µm) to remove micro-organisms and stored at 4?C until use. A 2 mM solution of ferulic acid was prepared using distilled water. The concentration chosen was based on preliminary experiments. A germination and a radicle elongation bioassay was used to determine the phytotoxic effect of stubble residues and ferulic acid. For the germination bioassay, 20 sterilised seeds of 6 German canola varieties (cvs. Artus, Express, Accord, NPZ 9815, Maplus and Fornax) were placed in separate petri-dishes and replicated 3 times. Distilled water was used as a control. Four mL of the leachates and ferulic acid were added to separate petri-dishes. Each dish was placed in a climate control cabinet in a randomised block design at 28?C under constant light (236 µE/sec/m2), provided by fluorescent and incandescent bulbs. Germination counts were made after 24 hours. For the radicle elongation bioassay, canola varieties were germinated 48 hours before the commencement of the experiment. Five seeds with radicle length of 2 mm were selected and placed in each sterile petri-dish and radicle length measured after 48 hours. Data was analysed using ANOVA.

RESULTS AND DISCUSSION

Varietal differences in both the toxicity of the leachates and the sensitivity of the canola occurred for both germination and radicle elongation. Janz caused the greatest delay in germination for all canola varieties (Figure 1a). Radicle elongation was reduced by all leachates, with Janz and Diamondbird being generally the most toxic (Figure 1b). Canola cvs. Fornax and Accord were the most sensitive for germination, however only the radicle elongation of Fornax was most negatively affected. Similar effects have been noted by Bruce et al. (2) who found that Janz leachate was the most toxic to germination and radicle elongation of the Australian canola cultivar.

Ferulic acid showed a similar pattern of toxicity to the leachates, although ferulic acid could not fully explain the germination response to the leachates. In particular it was most dissimilar to the effect of Janz on the canola varieties, indicating that other chemicals may be involved in the suppressive activity of Janz leachate. However, the effects of the leachates and ferulic acid on radicle elongation caused a similar magnitude of suppression indicating that ferulic acid may explain a proportion of the suppressive effect of the wheat leachates. Guenzi and McCalla (3) also found that germination was less affected than radicle elongation by ferulic acid.

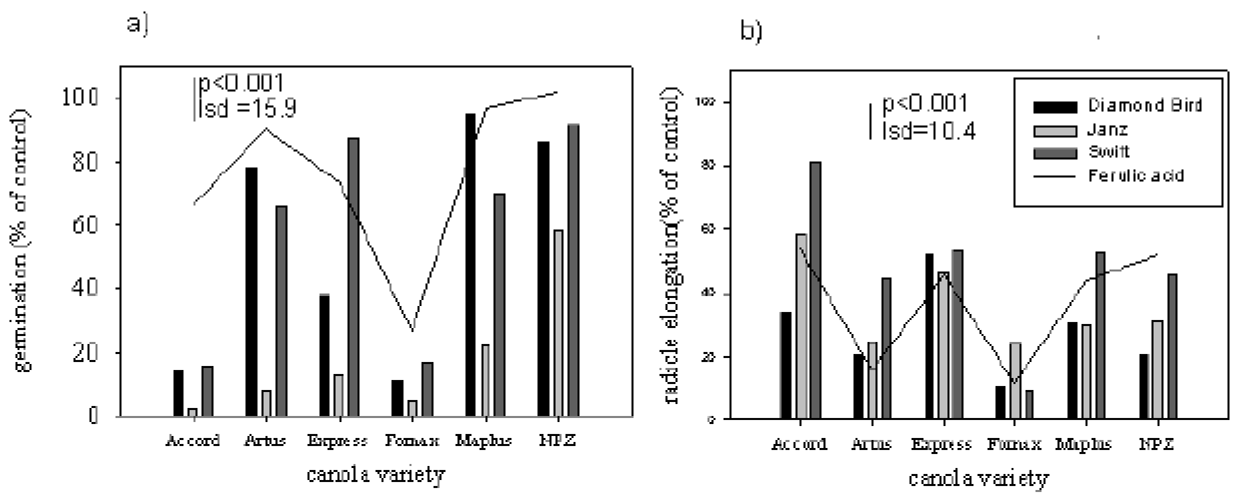

Figure 1: Effect of wheat leachates and ferulic acid on a) germination and b) radicle elongation of 6 canola varieties.

There was no correlation between germination and radicle elongation in the response to the leachates indicating that the phytotoxins involved may be different for the different processes. A similar effect was observed for ferulic acid. An(1) also noted that there was no correlation between radicle elongation and germination in response to the application of leachates from *Vulpia* sp. residues.

CONCLUSION

Although these laboratory studies demonstrate that crop residues contain water-soluble substances which depress germination and radicle elongation; and that ferulic acid has a similar pattern of toxicity to the canola varieties, the extent to which ferulic acid can explain the suppressive effect still needs to be determined. Further work includes chemical analysis of wheat residues, and tracking of the chemicals from the residue through the soil system and into the canola plant.

REFERENCES

1. An, M.1995. PhD Thesis, Charles Sturt University, Wagga Wagga.

2. Bruce, S.E., J.A.Kirkegaard, S.Cormack, and J. Pratley. 1999. Proceedings of the 10th International Rapeseed Congress, Canberra, CD.

3. Guenzi, W.D. and T.M. McCalla. 1966. Agron. J. 58, 303-304.

4. Kimber, R.W.L. 1967. Aust.J.Agric. Res. 18, 361-374.

5. McCalla, T.M. and T.J. Army. 1961. Ad. Agron. 13, 125-196.

6. Purvis, C.E. 1990. Aust.J.Agric. Res. 41,225-242.

7. Putnam, A.R. and L.A. Weston. 1986. In: The science of allelopathy. Ed. A. R. Putnam and C. S. Tang. John Wiley & Sons, New York.