HELPING PLANTS FIGHT THEIR OWN BATTLES

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INTRODUCTION

Growing concern in recent years about the effects of pesticides and fungicides on the environment has led to an increased interest in alternative plant protection methods worldwide. Enhancing plants' own natural defence systems in order to provide broad spectrum resistance against a range of fungal, viral and bacterial pathogens is an attractive and viable alternative. The process, known as Systemic Induced Resistance (SIR), requires prior exposure of the plant to a locally infecting pathogen, an avirulent form of a pathogen or special chemicals. This exposure results in a 'sensitisation' of the plant leading to a rapid resistance response on subsequent pathogen attack. The protection thus provided in both treated and distal tissues is usually in the form of decreased lesion numbers or disease severity.

It is likely that SIR is dependent upon the activation of several different mechanisms and is therefore stable (Kuć, 1982) with little chance of pathogens developing resistance to it.

BIOTIC INDUCTION

Pathogens themselves can be used as inducers of resistance in plants. Infection with local lesion-forming pathogens results in a

limited number of plant cells in contact with the invading pathogen dying rapidly. This is similar to the 'hypersensitive response'(Dixon *et al.*, 1994) This response is the precursor of the systemic signal that triggers induced resistance. By limited prior inoculation with local lesion-forming pathogens, it is possible to induce systemic resistance.

Induced resistance can also be accomplished by inoculating the plant with an avirulent isolate prior to challenge with a virulent isolate, as shown by Biles and Martyn (1989) with Fusarium wilt in watermelon. Gessler and Kuć (1982) found that inoculation of cucumber with Fusarium protected against root as well as foliar pathogens.

Protection can last from 4-5 weeks with a single induction and to fruiting following a booster (Kuć and Richmond, 1977). However, a lag of 3 - 5 days between induction and the appearance of protection has been reported in most systems.

Plants in which biologically induced systemic resistance has been reported include alfalfa, *Arabidopsis*, barley, broad bean, cucumber, green bean, musk melon, potato, tobacco, tomato, watermelon, red clover, rice (for reviews see Deverall 1995; Kessmann *et al.* ,1994a), and cotton (Brock *et al.* ,1994).

The use of microorganisms to induce SIR in the field seems to be feasible but would most likely be restricted to a few crops grown on a small scale (Kessmann *et al.*, 1994b).

CHEMICAL INDUCTION

There are numerous reports of chemical compounds inducing resistance to disease (for reviews see Deverall, 1995; Kessmann *et al.* 1994a). However, few meet the criteria set for classification as true 'plant activators' (Kessmann *et al.* 1994b)

The criteria are:

- the treated plants are resistant to the same spectrum of diseases as those in which SIR was induced biologically.

- there is a lack of direct antimicrobial activity, with no conversion of the compound *in vivo* into antimicrobial metabolites.

- there is an induction of the same pre-infectional biochemical processes as seen in systemic plant tissues after biological induction of SIR.

Salicylic acid, a naturally occurring plant compound, meets all three criteria and can be classified as an activator. The application of salicylic acid or aspirin to the leaves of plants induces resistance to pathogens in most systems studied (for review see Raskin, 1992).

The first generation of synthetic 'activators' were developed by Ciba-Geigy as 2, 6 - dichloroisonicotinic acid (INA) and its methyl ester derivative. Both were used extensively in research and proved highly effective in protecting a range of plant species, including cotton (Brock *et al.*, 1994),green bean (Dann and Deverall, 1995), cucumber, rice and tobacco (Métraux *et al.*, 1991).

Recently, a second synthetic 'plant activator' developed by Ciba-Geigy and intended for commercial use was released. The compound, benzo(1,2,3)thiadiazole-7-carbothioic acid S-methyl ester (BTH) sprayed onto leaves induces resistance to a range of diseases in species including tobacco, Arabidopsis, wheat and rice and lasts for up to the entire season (Görlach *et al.* 1996).

Synthetic activators appear to mimic the biological induction of SIR (Kessmann *et al.*, 1995). They require the same lag period following application for the appearance of resistance and provide the same broad range of protection.

The development of synthetic activators means the use of SIR in the field is even more practicable as few of the limitations of biotic activators apply. Application and storage of the synthetic activators can utilise equipment already in use with pesticides and herbicides. On first signs of disease in the crop, the activator can be applied and resistance will be achieved before the outbreak becomes severe.

SYSTEMIC INDUCED RESISTANCE IN COTTON

Systemic induced resistance in cotton has been demonstrated in glasshouse trials using INA against *Alternaria* leaf spot (Brock *et al.*, 1994 ; Colson unpublished), with significant decreases in lesion numbers observed. Treatment with INA also promoted SIR against the foliar pathogen, *Xanthomonas campestris* pv. *malvacearum* (bacterial blight), resulting in fewer lesions (Brock, 1992).

A research project on SIR against *Alternaria* leaf spot, *Verticillium* wilt and black root rot, funded by the CRDC was started in July 1993. The severity of *Verticillium* wilt was reduced by treatment with INA in four to six week old glasshouse-grown plants compared with controls (Colson, unpublished).

Field trials in the last two cotton seasons have shown the enormous potential for SIR in field situations. Treatment with INA was found to decrease disease severity otherwise observed in untreated mature Siokra 1-4 and Sicala V-2 plants growing in *Verticillium* infested soil in the 94/95 and 95/96 seasons at Narrabri, NSW in (Colson, unpublished). One application of INA following the outbreak of *Alternaria* at Bourke, NSW and Moree, NSW in the 95/96 season decreased lesion numbers in mature Pima cotton plants compared with untreated plants (Colson, unpublished). Application of INA earlier in the season, prior to disease outbreak, and also following an *Alternaria* outbreak could lessen lesion numbers and the impact of the disease considerably.

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