Rice stubble: Allelopathic effect on cotton

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Abstract
Five rice variety stubbles were evaluated to assess their root length inhibition impact on two cotton varieties. It was found that all five rice stubbles, when incorporated into a pasteurised soil mix (70 % sand, 30 % loam), had a significant inhibitory effect on average root length of both cotton varieties. This has particular implications for the southern Australian cotton production region which is characterised by a short growth season and cooler establishment temperatures than the northern cotton production areas.

Keywords
Oryza sativa, Gossypium hirsutum, allelopathy, germination.

Introduction
Rice is a rotation crop in southern Australian irrigated cotton farming systems. Farmer experiences suggest that cotton yields are lower in fields following a rice crop compared to fields planted with cotton. Several mechanisms have been investigated to account for the inhibitory effect preceding rice crops have on the following cotton crop. Inundation of the rice bay can lead to nutrients, primarily phosphorus and zinc, becoming bound in the soil and thus less available to the emerging cotton crop (Yuan and Ponnamperuma 1966). Arbuscular mycorrhizal fungi (AMF) levels in soil have also been shown to be lower following a rice crop compared with wheat or cotton, further reducing the ability of cotton to access nutrients (Moore et al. 2015).

Challenges to cotton production in southern growing regions relate to shorter growing seasons and cooler crop establishment temperatures and necessitate strong cotton emergence and early vigour. Preceding crop residues, in the cooler climate, can persist into following crops. Studies have confirmed that rice plants and their residues can release compounds with allelopathic activity; Phenolic compounds (e.g. p-salicylic, p-coumaric, vanillic, syringic, ferulic, p-hydroxybenzoic, and mandelic acids) are often considered as the dominant allelochemicals (Chung et al. 2001; Seal et al. 2004) present in rice residue, although this view is not universally accepted (Olofsdotter et al. 2002). In this study we explored the impact of stubble residues from rice varieties on cotton seed germination and early growth.

Methods
Stubble preparation
Stubble from 5 rice varieties (Langi, Sherpa, Topaz, Kyeema and Reiziq) were dried for 72 h at 40 °C, ground and screened through a 0.5 mm sieve.

Soil preparation
A mixture of 70 % sand and 30 % loam were homogenised in a cement mixer then pasteurised in a steam steriliser at 70 ^{o}C for 60 mins.

Experiment 1
Soil mix (130 g) was added to each experimental pot (120 mL Sardset® container with 1 drainage hole in the base) and mixed with 1 g of the designated rice stubble treatment. Rice stubble treatments were evaluated against two cotton varieties 71BRF and 74BRF. Two controls were utilised, one with 1 g of vermiculite to simulate the mulching effect and one with soil mix only. Pre-germinated cotton seeds from each of the two cotton varieties were uniformly selected and sown into each experimental pot at a depth of 10 mm. Pots were watered until field capacity, then were covered with their original screw-top lid (lid on for 48 hours) and placed inside an aluminium tray with a 10 mm layer of perlite in the base. Water was added to the tray to a

height of 5 mm to prevent experimental pots from drying out quickly. The growth cabinet was set on a day/night cycle of 12 hr/12 hr and a temperature regime of 25 °C/20 °C. Plants were grown for 7 days before root elongation measurements were taken. The experiment had 5 replicates and was arranged in a randomised block design, with the exception of the Sherpa treatments which only had 4 replicates due to limited material.

Experiment 2
Stubble and soil were prepared in accordance with experiment 1. In this experiment one rice variety (Langi) and one cotton variety (74BRF) were selected for use. Samples were prepared as for experiment 1 with different Langi stubble weights (1 g, 0.33 g and 0.11 g) incorporated.

Results
No differences in effects were seen between cotton varieties, therefore cotton variety data were combined. In Experiment 1, root lengths of cotton seed were reduced by more than 70 % by the presence of stubble although there were no significant differences between stubbles of different rice varieties (Figure 1).

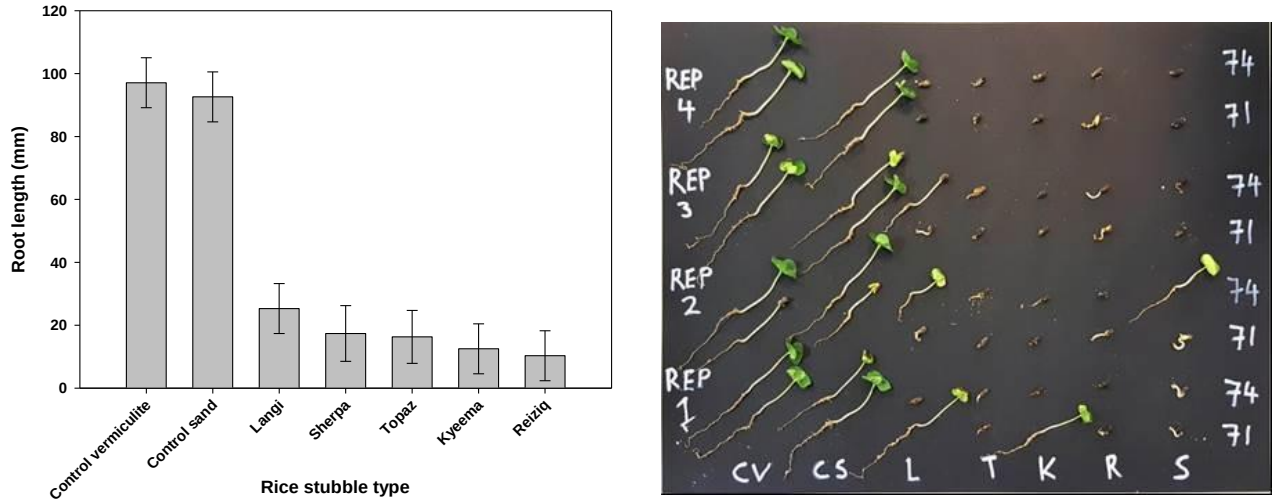

Figure 1. (Left) Effect of rice variety stubble treatments on root length of cotton seedlings (P < 0.05) relative to Control with sand and vermiculite and Control with sand. Rice stubble varieties: Langi, Topaz, Kyeema, Reiziq and Sherpa. Bars denote standard error of the mean. (Right) Pictorial representation of the effect of rice stubbles on cotton seedling early growth. Treatments (bottom horizontal) comprised: CV = Control with vermiculite mixed through to simulate stubble; CS = Control-sand only; and stubble of rice varieties, L = Langi, T = Topaz, K = Kyeema, R = Reiziq, S = Sherpa. The four replicates (left vertical axis) and two seed types (right vertical axis) are labelled.

Experiment 2 outcomes indicated that increasing stubble incorporation reduced average root length of cotton seedlings. The incorporation of 1 g of stubble reduced cotton seedling root growth by greater than 80 % whilst 0.33 g reduced it by approximately 70 % (Figure 2).

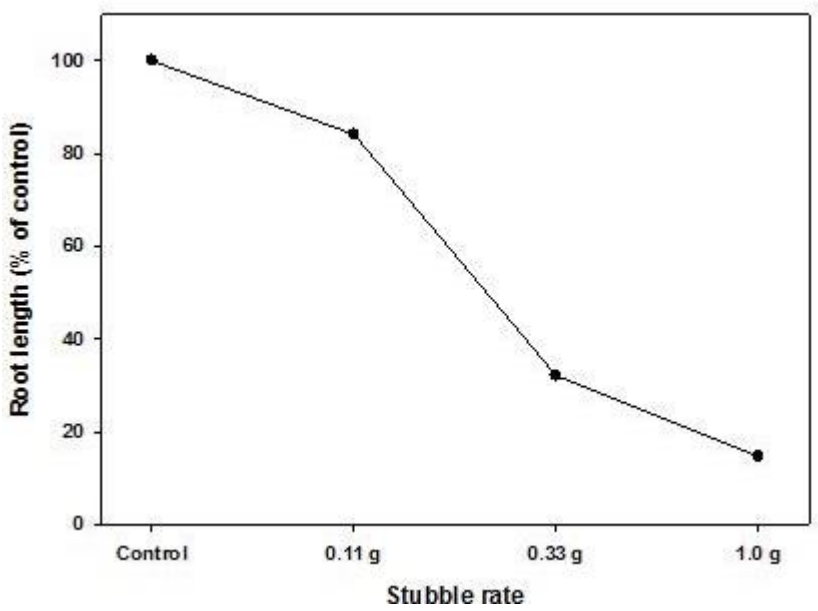

Figure 2. Average percentage reduction in cotton root length with increasing levels of rice stubble (cv Langi) incorporated into pasteurised soil (70 % sand, 30 % loam). Control comprised of soil and vermiculite with no stubble.

Conclusion

This study indicates that residual rice stubble can have an inhibitory effect on the emergence and early vigour of cotton seedlings in areas of cooler temperatures and low summer rainfall. For the five rice varieties evaluated, all significantly reduced the average root length of both cotton varieties. The impact of the effect was directly related to the stubble load.

References

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