

Summary

Influence of vesicular arbuscular mycorrhizas on growth, nutrition and yield of cotton

A growth disorder of cotton has been observed in irrigated cracking clay soils in fields at Galathera Creek, north of the Australian Cotton Research Institute (ACRI) for several years. The condition has since been found at other sites. Affected plants were stunted and grew slowly during the first half of the season and yielded poorly. Growth of stunted plants improved in mid-season but too late for substantial recovery of yield. Yield showed little or no improvement when P and Zn fertilisers were applied. Preliminary observations suggested that a lack of vesicular arbuscular mycorrhizal (VAM) development may have been adversely affecting cotton nutrition. The aim of projects UNE7C and UNE17C was to determine the cause of the early season growth disorder (Galathera syndrome) and the role of VAM with regard to growth, development and yield of cotton.

Interactions among cotton growth, VAM fungi, soilborne pathogens and chemical and physical characteristics of the soil were investigated. The causes of the early season growth disorder were thus identified by a process of elimination.

Three soil groups (A, B, and C) which corresponded to patterns of yield and early season growth were identified in fields near Galathera Creek. Stunting of cotton was greatest in group A and B soils. Cotton growth and yield was relatively good in group C soils. Group B sites showed a recovery of yield later in the season while group A sites did not. Group A and B soils had lower pH, finer texture and higher P, Zn, Mn and exchangeable Mg, K and Na than group C soils. Thus, paradoxically, the greatest stunting occurred in the more fertile soils with the more favourable pH for cotton growth. The stunting of seedlings at an early stage was not consistent with some potential physical and chemical causes of stunting, including sodicity, compaction, manganese toxicity and waterlogging.

At some sites cotton had a high relative dependency (up to 92%) on VAM fungi for successful growth. In other words, 92% of the shoot growth of cotton was enabled by the presence of the VAM fungi. This growth benefit was primarily due to transport of P and Zn from the soil to the plant by the VAM fungi.

Cotton growth in the field was closely related to levels of VAM colonisation in roots: the more stunted the plants, the lower the level of colonisation. However, the lack of VAM colonisation in stunted cotton was not due to low numbers of VAM fungi in the soil. Rotation with dolichos lablab (a green manure crop used in fields with stunted cotton) did not affect the VAM development, growth and yield of cotton in comparison to bare fallow. Since soil P was higher in soil with stunted cotton, those plants were less dependent on VAM fungi for P supply and this accounted partly for the lower levels of VAM development. However, soilborne microorganisms were also inhibiting VAM development.

Sterilisation of soils in which cotton growth was stunted consistently increased cotton growth, which indicated that pathogenic soilborne microorganisms were causing the stunting. Viruses and nematodes were discounted as possible pathogens. Few fungi other than VAM fungi were observed colonising cotton roots from poor growth sites. Black root rot and verticillium wilt were least frequent in the stunted cotton. Therefore pathogenic fungi were not a cause of the disorder.

Several observations indicated that soilborne bacteria were responsible. First, the application of bacterial antibiotics (penicillin and streptomycin) to soil increased cotton

growth. Secondly, under the microscope bacteria were observed inside browned root cells and bacteria streamed out from the cut surfaces of browned roots. Rapid development of root browning was a symptom of stunted cotton. Thirdly, in laboratory studies bacteria isolated from browned cotton roots were shown to be pathogenic to cotton seedlings, causing root browning and stunted root growth. All the isolates of bacteria from cotton roots that were highly pathogenic belonged to a species of *Pseudomonas*. These bacteria were shown to inhibit VAM development in cotton. These pathogenic bacteria occur widely through cotton growing soils. The pathogenic species of *Pseudomonas* has been isolated from soil at the Australian Cotton Research Institute where early season stunting of cotton does not occur.

All these observations have contributed to a picture of the effects of soil ecosystems on cotton growth. The VAM fungi had the dominant effect on cotton growth in soils which did not show early season stunting (group C soils) and were less important in the more fertile soils that support stunted cotton growth (group A soils). Conversely soilborne pathogens had the dominant effect on cotton growth in group A soils, but also cause a slight reduction of growth in apparently healthy cotton.

In conclusion, the early season growth disorder is caused primarily by certain soilborne bacteria which inhibit growth and VAM development of cotton in nutrient rich, heavy clay soils. There may be further species of pathogenic soilborne bacteria than those isolated and tested so far. The severity of the early season growth disorder is undoubtedly linked to soil properties but the specific properties which tip the balance of the soil ecosystem to favour the pathogenic soilborne bacteria are yet to be identified. Current knowledge of the distribution of the disorder is inadequate. Potential directions for research of control procedures have been identified.