

THE BENEFITS OF ROTATION CROPPING TO COTTON

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The past two decades have seen a rapid expansion in the area devoted to cotton in Australia. Cotton production systems have evolved over this period, from growing continuous cotton for many years, to the introduction of winter cereal, fallowing and more recently, legume crops. The sustainability of cotton production is becoming increasingly important. The inclusion of rotation crops in cotton-growing systems will improve their sustainability.

While it is acknowledged that lint yields have not declined, even from fields having produced cotton crops continuously for up to ten years, this can be largely attributed to improved varieties and management practices. When we consider the long term sustainability of our cropping systems, maintaining or improving our resource base is of prime importance. An opportunity cost is associated with growing rotation crops or fallowing. As no rotation crop produces a gross margin equivalent to cotton, growers face a dilemma when choosing to grow cotton continuously, whilst being aware that their soil resource might be depleted.

Many researchers are involved in the evaluation of rotation cropping in several cropping systems experiments being conducted throughout the cotton production area. As well, many growers have been testing various rotation systems and are providing practical and proven information on the positive and negative aspects of these systems.

Disease reduction and soil biology

The effect of some pathogens on cotton production has been greatly reduced by the availability of resistant cultivars. However, for most diseases, only partial resistance is present and selection pressure is exerted on the pathogens. From a disease control aspect, the greatest benefit from rotation cropping arises from the additional time available for the level of pathogen inoculum in the soil or on residues to decline. A long fallow will provide the same benefit, but with other complications. It is crucial to avoid selecting a rotation crop that is an alternative host or carrier of a cotton disease. Table 1 outlines our knowledge in Australia on the potential of rotation crops to host or carryover major cotton diseases.

Table 1. Potential for rotation crops to host or carryover cotton diseases

Crop	Verticillium wilt	Fusarium wilt	Seedling disease	Black root rot
Cereals	No	Unknown	No	No
Sunflower	Some lines	Unknown	Unknown	No
Safflower	Unknown	Unknown	Unknown	No
Soybean	No	Unknown	Yes	Yes
Dolichos	No	Unknown	Yes	Yes
Peanut	No	Unknown	Yes	Yes
Chickpea	No	Unknown	Yes	Yes
Faba Bean	No	Unknown	Yes	Yes

Research is under way to investigate Fusarium wilt in a range of crops. As cotton diseases are favoured by warmer soil temperatures, summer crops are more likely hosts than winter crops. Growers should not necessarily eliminate a particular crop from consideration in a rotation because it has some potential for disease carryover, but should be aware that special management practices are needed to reduce its impact (eg. thorough early stubble incorporation and use of chemical fungicides for controlling seedling disease after soybean).

Allelopathy is another factor influencing crop selection; Hulugalle indicates some legume seeds (chickpea) and stubble (cowpea) contain toxins which reduce cotton establishment.

Rotation crops generally encourage the presence of VAM fungi which are essential for good early season growth. Measurements of VAM levels are being conducted at the three CRC Cropping Systems Experiments (CRC Annual Report, 1995). At the Merah North site in 1994/5, six week old cotton in the long-fallow system lacked the early vigour and growth apparent in all other systems, as the VAM colonisation level was reduced by 62%.

Weed control

The use of rotation crops for weed control has many possibilities including the chance to reduce herbicide inputs and to rotate chemical groups, to lessen the potential for weeds to develop resistance. However, the rotation crops must be well managed to maximise aggressiveness and competition, the key components of successful weed control by a crop. Rotation cropping enables weed problems to be tackled in various ways. Kylie May (Aust. Cottongrower, May 1994) stated that a well grown wheat crop, due to its intensive water use and effective ground cover was an important step in the summer nut grass reduction program used at 'Norwood'. After a winter crop, cultivation and/or contact herbicides can be used

during the summer to control problem summer weeds. John Marley (QDPI) has shown in many trials that barley is more competitive against weeds than wheat. However, some rotation crops can create additional or new weed problems. Many winter pulse crops provide little ground cover, especially during spring, and as few herbicides are registered for these crops, serious weed problems can be created for succeeding cotton crops.

Changes in weed spectrums and levels in the three CRC Experiments are being monitored. At Merah North in 1995/6, the Dolichos treatment had Peach Vine counts of 30 /m², whereas the continuous cotton treatment had 0.1 /m², a result of an establishment problem and lack of suitable herbicides for Dolichos. Nevertheless, experienced Dolichos growers, Dave Anthony and Peter Glennie have both commented favourably on the effectiveness of the species for weed suppression. A high level of management skill is required to use rotation crops successfully for weed control, especially with legume crops. Poor control in one season can produce a legacy which lasts a lifetime.

The choice of rotation crops for cotton is severely restricted by the use of residual herbicides in the cropping system (Steve Walker's project - Darling Downs). Herbicide (and insecticide) drift may create further concern where rotation crops are grown in close proximity to cotton.

Herbicide-resistant cotton will add a new dimension to weed control in the future, as will new herbicides which require little or no incorporation and therefore, less soil cultivation.

Soil structure improvement and restoration

Soil structural improvement has long been recognised by cotton growers as one of the major benefits of crop rotation, although these improvements are difficult to quantify. The cone penetrometer gives a good indication of soil strength as measurements are obtained by pushing a steel probe into the soil to 45 cm to indicate the difficulty that cotton roots have in moving through the soil. Hulugalle has shown that a wheat-cotton rotation may have lower soil strength in the subsoil, resulting from better soil drying by the root system and greater infiltration of water.

At the CRC Merah North site, a faba bean crop produced a marked reduction in soil strength, compared with continuous cotton, especially as the soil dries. As this effect was more noticeable below 30 cm depth, better root development and growth of subsequent crops should be apparent. Growers may be concerned that the reduction in soil strength at depth may contribute to subsoil compaction, but this has not been observed. However, this phenomenon does explain the anecdotal evidence reporting reduced draught when cultivating soil after legume crops.

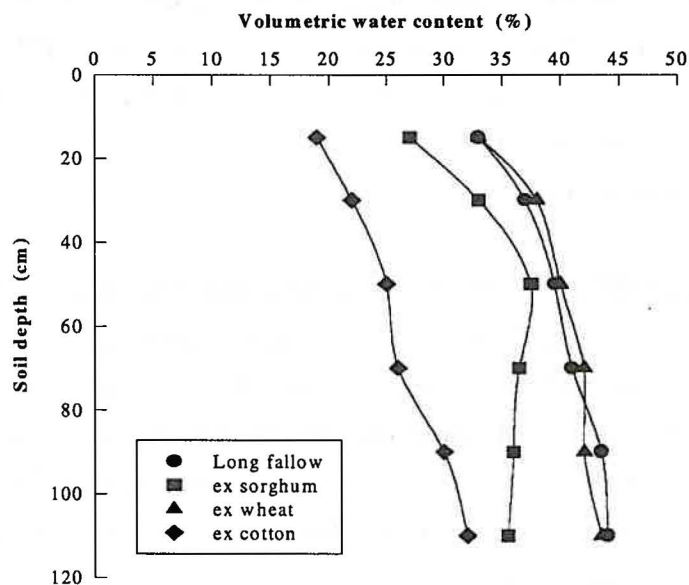
McGarry (World Cotton Conf. 1994) emphasises the importance of repeated wet-dry cycles to regenerate good soil structure. Cowpea is less effective than cotton in ameliorating sub-soil compaction on a heavy cracking clay because of its shorter growing season and can create a weed problem for following crops. When choosing a rotation crop, the probability of rainfall at harvest must be considered, as wet trafficking can undo any potential improvement. In principle, the longer the crop growth period, the greater the opportunity for additional wet-dry cycles.

Water use

Improved water use by the subsequent cotton crop is one indication that a rotation crop has improved soil structure. In an experiment comparing a cotton-wheat rotation minimum tillage system with a continuous cotton system at ACRI, Hulugalle and Entwistle have reported that the cotton crop in the rotation system was able to extract 21% more water from the soil profile (January) and extracted most of this additional water from 30-80 cm depth. Lint yields have consistently been higher in the rotation system.

It is important to consider the water-use efficiency of rotation crops, especially in a water-limited environment. In dryland cotton systems, it is of paramount importance that soil water be stored as efficiently as possible. Below, Figure 1 indicates how different crop rotation sequences influence soil water storage in a dryland cotton system.

Figure 1. *The soil moisture profiles at the Warra CRC Experiment site in April 1996. Treatment 1 (●) has been fallow since cotton picking in April 1995, treatment 2 (■) had sorghum (5.8 t/ha) in 1995/6, treatment 3 (▲) had wheat (0.4 t/ha) in 1995 and treatment 4 (◆) had cotton (4.4 b/ha) in 1995/6.*



Nutritional considerations

The benefits of legumes and other rotation crops to cotton are being measured and compared in the CRC Cropping Systems Experiments and at ACRI. Legume crops have the potential to fix large amounts of atmospheric N through their association with Rhizobia bacteria found in their nodulated root systems. Even after grain is harvested from these crops, a considerable proportion of the fixed N is retained in the soil system - net N inputs of up to 120 kg N/ha are possible. See the paper of Rochester (this conference). Recent experiments have indicated the N requirement for cotton following a legume crop (eg Dolichos) can be at least halved, relative to where cotton follows cotton. Growers should aim to replace the nutrients removed from their farm in produce to sustain the chemical fertility of their soil.

Cotton yields

Besides the CRC cotton cropping system experiments, several other systems experiments have been conducted (Hearn, Constable, McKenzie, etc). Most have concentrated on cereal crops, although more legume crops have been included in recent experiments. Lint yields achieved in these experiments have increased by some 30% over the past decade and the highest yields have followed rotation crops. (See posters for the most recent yield data from the CRC experiment sites)

Cotton stubble management

Growers have been encouraged for some time to incorporate cotton stubble rather than to rake and burn it. Essentially, cotton stubble should be managed as any other stubble, even though its nutrient content may be lower than that of rotation crops. Pupae destruction operations can be performed at the same time. However, the timeliness of these operations is paramount in order to successfully grow rotation crops in the following winter.

Insect management

Robert Mensah's research indicates the very important role lucerne strips can play in the control of mirids and acting as a refuge for *Heliothis* predators. Many summer crops (including grain legumes) might act as refuges as part of the Ingard insect management plan.

However, rotation crops may exacerbate insect problems in cotton crops. For example, mites can infest winter crops planted in cotton stubble and reinfest the newly sown cotton crop. Wheat is known to encourage wireworms and other winter crops (faba bean and chickpea) may host aphids, thrips and *Heliothis* in some seasons, which can infest adjacent seedling cotton crops, necessitating spraying in some instances.

