ROTATIONS ESSENTIAL TO MAINTAIN COTTON YIELDS IN THE MACQUARIE VALLEY

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Introduction

The long term production of cotton in the same field often leads to low yields, even with large amounts of nitrogen (N) and phosphorus (P) fertiliser. In the Macquarie Valley of NSW this is often due to soil compaction and poor soil structure (McKenzie *et al.*, 1991). Initially, the problem was corrected by deep ripping the soil, but experiments have shown that drying the soil with crops such as wheat and safflower can produce similar benefits (Hodgson and Chan, 1984). Rotation crops such as wheat are also used to reduce the incidence of diseases such as Verticillium wilt.

In 1992, a survey of cotton growers in the Macquarie, Namoi and Gwydir Valleys was conducted to find out how widely rotations are used, which rotation crops are used, and what problems growers had encountered with rotations. The survey found that rotation crops were widely used, but the choice of rotation crop was mainly based on convenience e.g. it did not need irrigation, it could be sown late, or it was easy to sell. Many growers were interested in using legumes and other crops, but lacked the information to make sound decisions. Can legumes extract as much moisture as cereals, what soil structure benefits do they give, which crop provides the best disease break, are typical of the questions growers had about rotation crops.

The experiment reported on in this paper is one of a series of crop rotation experiments established by the CRC for Sustainable Cotton Production. These experiments have a broad aim of examining the effects of different rotation sequences on sustainability, which includes soil structure and fertility, pest and disease control, cotton yields and economic returns. This paper reports the effects of 7 different rotation sequences in the Macquarie Valley on the growth and yield of subsequent cotton crops.

Materials and Methods

In 1993, a large scale field experiment with 3 replications commenced at Warren in the Macquarie Valley of NSW, to compare 7 different rotations (Table 1). Prior to the experiment starting, the field grew cotton for 3 consecutive seasons. All operations are done with commercial equipment, and each plot is 40 m wide by 700 m long. The whole field is planted with cotton every second year to facilitate comparison of the treatments. So far the rotations have gone through 2 cycles with cotton grown over the entire field in 1994-95 and 1996-97.

The yield of machine picked cotton was measured by making a module from the centre 24 or 32 rows of each plot. The modules were weighed as they were brought into the gin yard. Knowing the area of cotton put into each module, the yield of seed cotton could then be calculated. The cotton from each rotation was ginned separately, to give a turn out % for each treatment. The lint yield of each rotation could then be calculated.

Table 1. The 7 rotations used in the experiment

1	Continuous cotton	Grows a cotton crop every year
2	Long fallow	Cotton every2nd year. Cotton stubble is slashed and ground left as fallow between cotton crops.
3	Field peas	Cotton every 2nd year. Field peas are sown into standing cotton stubble which is later slashed. In October the field peas are sprayed with Roundup then ploughed in as green manure. Area remains fallow until the next cotton crop.
4	Wheat - low input	Cotton every 2nd year. Wheat is sown into the standing cotton stubble which is later slashed. The wheat is harvested for grain. Wheat seed rate 40 kg/ha, with 85 kg/ha of DAP fertiliser. Area remains as fallow from wheat harvest to the next cotton crop.
5	Wheat - high input	As for Wheat- low input except; wheat seed rate 100 kg/ha, with 85 kg/ha of DAP and 180 kg/ha of urea fertiliser. In 1993 this rotation also received 1 spring irrigation.
6	Wheat + Lablab	Cotton every 2nd year. Low input wheat follows the cotton. After the wheat is harvested Lablab purpureus is sown into the wheat stubble and incorporated as green manure after 3 months growth.
7	1993 Wheat + Lablab + fertiliser 1995 Faba beans	For the first rotation cycle this treatment was the same as 6 except that extra fertiliser (11 kg N/ha, 24 kg P/ha, 73 kg K/ha) was applied prior to the 1994-95 cotton crop. In 1995 faba beans were used instead of wheat and Lablab because of problems growing Lablab. The faba beans were treated as a green manure crop the same as the field peas.

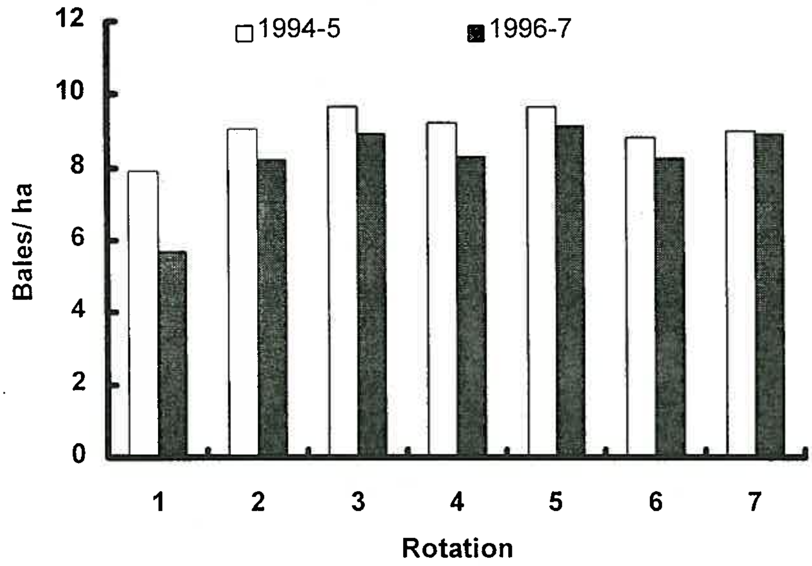
As well as lint yield, plant height, dry matter, number of nodes, squares and bolls were measured at regular intervals in both seasons. Plant samples taken in December, 1996, were analysed for nutrients, while each plot was assessed for the presence of black root rot in 1994 and 1996.

Results and Discussion

At the end of the first rotation cycle (1994-95), the continuous cotton rotation yielded less ($P<0.01$) than all others but the differences between the other 6 rotations were not significant (Cooper *et al.*, 1996). Yields in 1996-97 followed a similar pattern to 1994-95 (Fig. 1), with continuous cotton yielding less ($P<0.001$) than all other treatments.

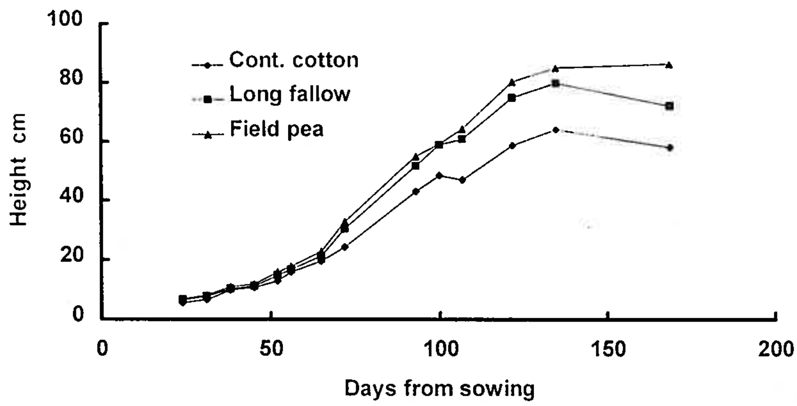
Continuous cotton yields in 1996-97 were down 28% on those in 1994-95. For the other 6 rotations average yields were down 6% on those in 1994-95.

Figure 1. Lint yields in 1994-95 and 1996-97



The growth of the cotton plants followed a similar pattern to lint yield. For all measurements the continuous cotton treatment was the worst, with little difference between the other 6 rotations. Amongst the other 6 rotations, the field pea rotation was often the best and long fallow the worst. For the sake of clarity, only data for the field pea, long fallow, and continuous cotton rotations are presented in the following figures.

Figure 2. Change in plant height over time in 1996-97



Plant height was the first and most consistent parameter to show significant differences between the rotations. Just 24 days after sowing, plants in the continuous cotton rotation were shorter than all other rotations (Fig. 2). Over time the differences became greater, and by March the long fallow rotation was significantly ($P<0.01$) shorter than the field pea rotation. Throughout most of the season continuous cotton had less squares per unit area, with no difference between the other rotations (Fig. 3). At all sampling dates the field pea rotation had the most dry matter, followed by long fallow, with continuous cotton having the least dry matter (Fig. 4). The dry matter data were variable and many of the differences were not statistically significant.

Figure 3. Change over time in squares per unit area in 1996-97

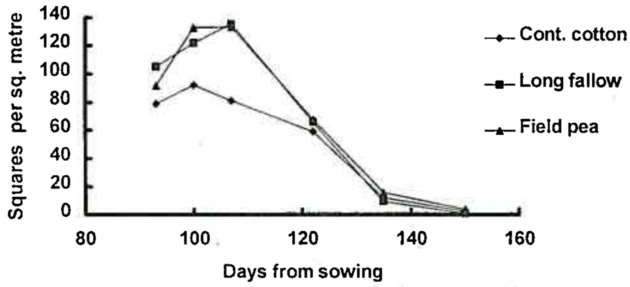
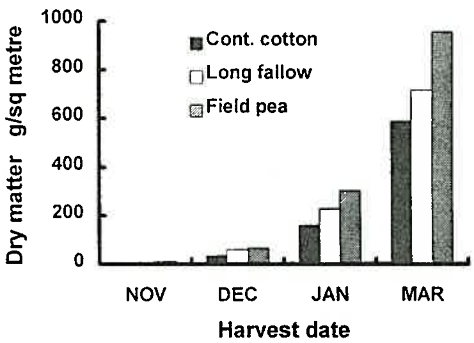


Figure 4. Total plant dry matter at 4 harvest dates in 1996-97

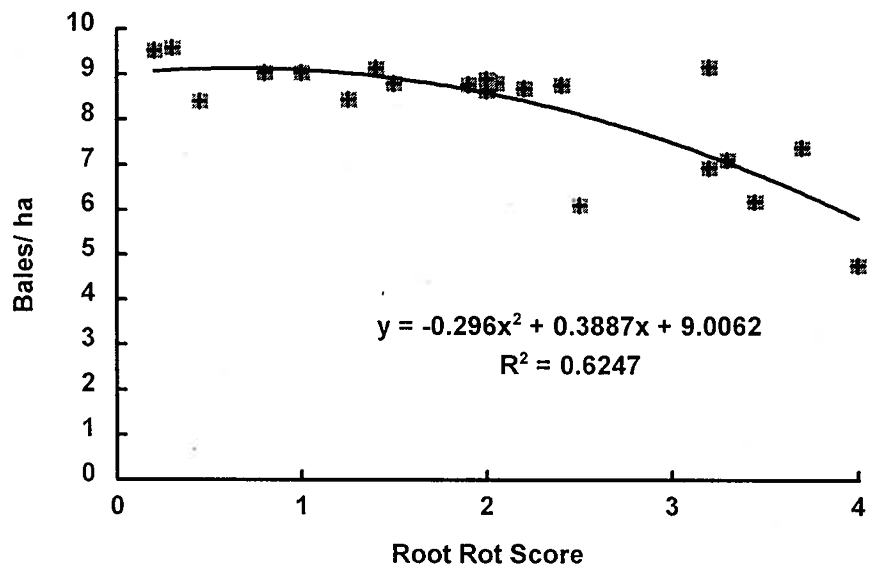


As the previous results show, all aspects of crop growth were affected in the continuous cotton rotation, and effects were apparent very early in the growth of the crop. Explaining why those differences occurred is not so clear cut.

To look for differences in nutrient uptake, cotton plants were analysed for nitrogen, phosphorus, and potassium in December 1996 and again in March 1997. The only significant difference was low potassium in the continuous cotton rotation in March. Changes in soil properties also showed little correlation with differences in cotton yield. Compaction in all treatments has decreased during this experiment (1993 to 1997). This is probably because minimum tillage and permanent hills were used with all rotations since the experiment started. Under this management system there are few machinery passes to damage soil structure, which is also helped by the retention of all crop residues. What was strongly correlated with cotton yield was the incidence of black root rot in November 1996 (Fig. 5).

This trial again demonstrates the fact that repeatedly growing the same crop over a long period is doomed to failure. Continuous cotton production with conventional tillage, encountered problems with compaction and poor soil structure. The use of permanent hills, minimum tillage, and retaining crop residues, seems to have eliminated most of the soil structure problems with continuous cotton production. However, it should be pointed out that during this trial there has not been a wet cotton harvest, when most damage to soil structure is thought to occur. Now though, disease build up has again led to a yield decline. This emphasises the need for rotations if any agricultural industry is to survive in the long term.

Figure 5. Lint yield of 1996-97 cotton crop versus black root rot score in November 1996



Acknowledgments

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