Vol 23, No 3, page 74 May-June, 2002 The Australian Cottongrower

# Root growth of rotation crops and cotton

By Nilantha Hulugalle, Peter Entwistle, Peter Roberts and Lindsay Campbell

Many Australian cotton growers sow rotation crops after irrigated cotton. Commonly used rotation crops include wheat, faba bean and field pea. Research suggests that in cracking clay soils, wheat is a better rotation crop than legumes such as field pea and faba bean due to several factors, namely:

• Wheat results in better soil structure, is more tolerant of salinity and sodicity;

• Wheat is able to recycle N leached during the cotton season, is more profitable and is not an alternative host for black root rot of cotton; and,

• It is also easier to manage than many legumes.

But legumes sown after cotton can greatly increase soil N.

In this article we present results relating to rotation crop and cotton root growth in two trials in the lower Namoi valley. These results show that N fertilised wheat produces more deep roots than do either unfertilised wheat or faba beans. Consequently, N fertilised wheat is able to dry out and crack the soil more, thereby improving soil structure more than either unfertilised wheat or faba beans.

The higher subsoil root density of N fertilised wheat also means that it can extract more nutrients from depth than unfertilised wheat and faba beans. In back-to-back cotton systems, the cotton crop produces a large amount of roots before irrigation commences. Many of these roots die off during the irrigation season, most probably due to waterlogging, but reappear after irrigation stops in March.

## TRIAL SITES

We measured root growth of wheat and grain legumes in a trial located at “Glen Arvon”, near Wee Waa, and that of cotton in a trial at the Australian Cotton Research Institute (ACRI), near Narrabri. The soils in both trial sites are cracking grey clays.

### “Glen Arvon” trial

FIGURE 1: Root densities in a 100 by 100 cm profile face under wheat and grain legume crops (November 1995)

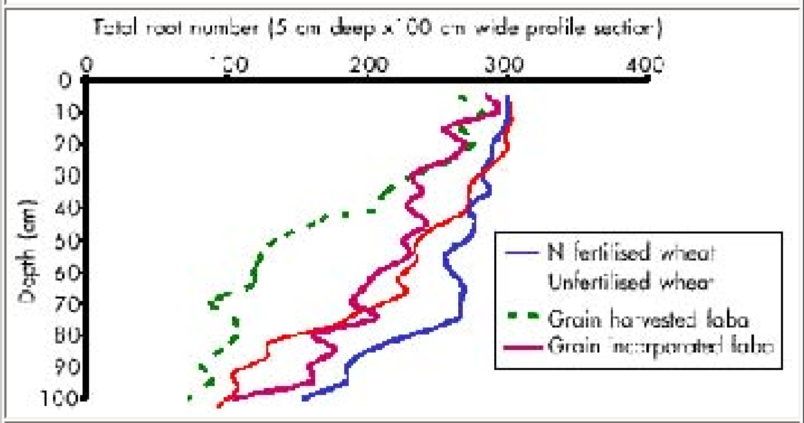



FIGURE 2: Profile water content under the rotation crops (July-December 1997)

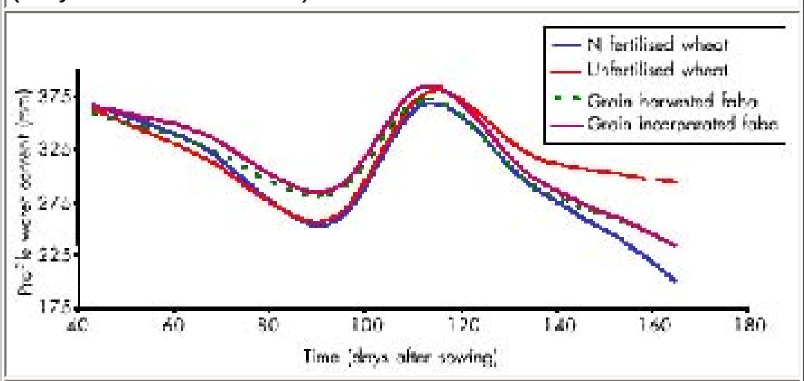
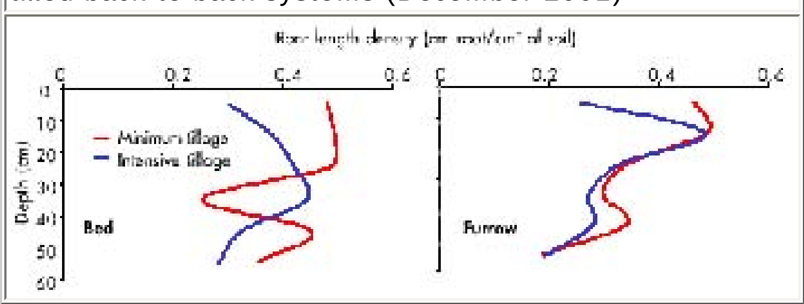



FIGURE 3: Root growth under minimum and intensively tilled back to back systems (December 2001)



The crop rotations used were cotton followed by N fertilised wheat (urea at 140 kg N/ha in 1993; 120 kg N/ha thereafter), unfertilised wheat, unfertilised grain legumes (chickpea in 1993; faba bean thereafter) where the grain was either harvested or not harvested but incorporated into the soil during land preparation. The trial plots were cultivated with an aer-way cultivator after cotton and stubble incorporated into the beds. Before cotton was sown, rotation crop stubble was incorporated with a disc-plough and the beds reformed on the same spot.

We measured root growth of the rotation crops in November 1993 and 1995 with a 5cm x 5cm root grid which was one metre wide and one metre deep. After digging a trench with a back-hoe at right angles to plant rows, the grid was placed on the exposed profile face between two ex-cotton rows and the root number in each 5cm x 5cm square counted and recorded.

Results (for 1995 only) are shown as the total root number in each 5cm deep by one metre wide depth increment in the soil profile. Soil water content in the 20–120 cm depth was measured with a neutron probe and that in the surface 20 cm by soil sampling.

## ACRI trial

Cotton root growth was measured in two of the treatments in the trial. These were: intensive (discing+chiselling+pulling up of beds) or minimum tillage (slashing of cotton followed by root cutting, bed renovation and “go-devilling”), both of which were sown to back-to-back cotton. This was the 16th year of the trial.

We measured root growth of cotton on December 17, 2001 by core sampling, followed by washing and staining to allow separation of live from dead roots.

Between January and March we measured root growth at approximately weekly intervals with a minirhizotron which was inserted into the soil through clear plastic root observation tubes (similar to neutron probe access tubes). The minirhizotron (a video camera system) is connected to a field computer with software which is able to “grab” root images at specified depths (see photo, page 72). Measurements were taken both in beds and furrows.

Crops in both sites were flood irrigated.

## Root growth of wheat and faba bean

In 1995, root densities in the subsoil were in the order of N fertilised wheat > unfertilised wheat=grain-incorporated faba bean > grain-harvested faba bean (Figure 1). The high subsoil root density of the N fertilised wheat was probably due to the application of N fertiliser at sowing.

There was little difference in soil surface root densities of the rotation crops. Root growth was higher in the rotations which had the greater nutrient input (N fertilised wheat and grain-incorporated faba) when compared with those with lower nutrient inputs (unfertilised wheat and grain harvested faba).

The faba bean had a higher proportion of their root systems in the surface 30 cm, whereas the reverse was true for the wheat. Root concentration in soil cracks was common under faba bean and chickpea in both years, whereas this was less frequent under wheat in 1993 and relatively infrequent in 1995.

Profile water depletion was faster with the wheat crops until grain filling commenced (Figure 2). Thereafter because of nutrient stress, water depletion by the unfertilised wheat fell sharply such that it was in the order of N fertilised wheat > grain-incorporated faba bean = grain-harvested faba bean > unfertilised wheat.

Seasonal water extraction was highest with N fertilised wheat. This means that the N fertilised wheat is able to dry and crack the soil more and thereby improve soil structure more than either unfertilised wheat or faba bean. At the same time the higher subsoil root density of N fertilised wheat means that it can extract more nutrients from depth than either unfertilised wheat or faba bean.

## COTTON ROOT GROWTH

Root growth of minimum-tilled cotton on December 17, 2001 decreased sharply at a depth of 35 cm (Figure 3). This is probably caused by the existence of a compaction layer at this depth. But at other depths, minimum tillage resulted in more roots than intensive tillage. The net result was that total root mass was similar under both tillage systems.

Minimum tillage resulted in 0.94 kg of roots per square metre in the bed and similarly, intensive tillage resulted in 0.97 kg of roots per square metre. But minimum-tilled cotton resulted in more roots in the furrows (0.94 kg per square metre) than intensively-tilled cotton (0.76 kg per square metre).

Above-ground growth of cotton at this time was such that minimum tillage resulted in 0.21 kg dry matter per square metre and intensive tillage in 0.17 kg dry matter per square metre. Root/

shoot ratios during early crop growth (until December, before irrigation commences) are, therefore, in the order of 4–6, and not around 0.2–0.4 as previously thought. This information could be of use to researchers involved in developing cotton crop management models such as CottonLogic.

But this root mass is not maintained during the irrigation season (January–March). The minirhizotron images showed that under irrigated conditions cotton loses a major proportion of its fine root mass, and survives on its tap root.

With the end of the irrigation season in March, most of the fine root mass is replaced. Root growth appears to take place primarily through existing soil cracks, and not through the bulk soil (see photo, previous page).

The Cotton Research and Development Corporation and Australian Cotton CRC provided funding (Projects DAN 83C and CRC32C) for this research. Thanks to James Kahl for providing the site to conduct part of this research. Also to Stephen Milroy and Mark Hickman for their comments on this article.

Australian Cotton Co-operative Research Centre and NSW Agriculture, Narrabri, NSW 2390. 2 School of Land, Water and Crop Sciences, University of Sydney, NSW 2006.