



# REPORTS

## Part 1 - Summary Details

Please use your TAB key to complete part 1 & 2.

**CRDC Project Number:** CRC 32C

**January Report:**  Due 29-Jan-01

**August Report:**  Due 03-Aug-01

**Final Report:**  Due within 3 months of project completion

**Project Title:** Purchase of minirhizotron for the study of root dynamics in cotton-based farming systems

**Project Commencement Date:** 01/07/2001 **Project Completion Date:** 30/6/2002

**Research Program:** Soils

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**COTTON RESEARCH AND DEVELOPMENT CORPORATION**



# **FINAL REPORT**

## **Purchase of Minirhizotron for the Study of Root Dynamics in Cotton-Based Farming Systems**

**CRC 32C**

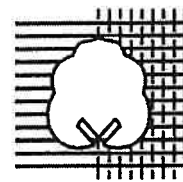
**July 2001 to June 2002**

**Dr. N.R. Hulugalle, Australian Cotton Research Institute, Narrabri, NSW 2390**

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**NSW Agriculture**



**Australian Cotton  
Cooperative Research Centre**

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## 1. Executive Summary

The minirhizotron system was purchased and field use commenced in January 2002.

A standard operating procedure (SOP) and protocols for using it under field conditions is being defined at present. Technical staff in the soil management program were also trained in its use. Mr. Peter Roberts, an honours student from the Department of Crop Science at Sydney University, commenced a project on root dynamics of irrigated cotton under different tillage systems during 2001-02.

Initial results suggest 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. Minimum-tilled cotton has more roots in the furrows than intensively-tilled cotton. Root/shoot ratios during early crop growth (up to December, before irrigation commences) are in the order of 4, and not around 0.2-0.4 as previously thought. Root growth appears to take place primarily through existing soil cracks, and not through the bulk soil.

## 2. Introduction

Considerable information is available on the above-ground crop growth patterns. However our knowledge of plant root growth is limited. High yielding crops rely on the development of effective root systems. Effective root growth is fundamental for maximising water use efficiency and nutrient uptake. Yet we know little about the rate of development of secondary, tertiary and fine feeder roots and how current farming systems affects them.

The single key factor limiting our ability to study secondary and fine root systems is having a suitable technique to measure their growth. Traditional methods of core sampling followed by root-washing is laborious, destructive and losses of roots can occur during root washing. More recently, however, with the advent of minirhizotron systems which can be installed *in-situ*, and associated video camera, and "frame grabbing" and image analysis software the dynamics of root growth can be studied. The changes in root number viewed at regular intervals through the minirhizotron systems can then be related to changes in root mass.

Some benefits of improving our ability to study root growth include:

- Improving existing crop models (such as Ozcot, Cottonlogic) to provide more accurate predictions of water use, nutrient requirements, crop growth and yield expectations. The impact of different farming systems (rotations, soil management, herbicides) on root growth can also be more clearly defined.
- Soil borne diseases and their impact on root growth at the soil surface and the subsoil can be better understood.
- In order qualify for governmental support and grants related to greenhouse gas emissions, agricultural industries will be required to quantify their emissions. When monitoring CO<sub>2</sub> emissions, one of the hardest components of the carbon cycle to quantify is the C deposited by the roots in soil during the life of the plant ("rhizodeposition"). The primary cause of this has been the absence of appropriate sampling and measurement systems. If the cotton industry is to effectively measure its carbon balance monitoring root dynamics is essential. Access to a minirhizotron system will allow effective monitoring to occur.

## 3. Aims And Objectives

- Purchase minirhizotron system
- Define standard operating procedure (SOP) and protocols for field use of the system
- Train staff in use of the system

## 4. Achievement Of Objectives And Problems Faced During The Project

The system was purchased, observation tubes installed by January 2002 and observations commenced during the cotton season of 2002. Mr. Tim Weaver, technical officer, and Mr. Lloyd Finlay. Technical assistant, have been trained in the use of the system and are competent in its use.

The major problems faced during this past year were:

- SOP remains incomplete and is being refined. This was part of an honours project (see later) which will be submitted in December 2002.
- Some questions arose during the season whether the angle of tube installation had impacted on the results. Alternative methods for tube installation and observations will be tested during this coming winter on wheat and vetch crops.

- The data/image analysis software (RooTracker) has yet to be tested, as the computer purchased for its use through NSW Agriculture was delivered with an incompatible software profile. This problem was rectified only recently.
- Due to the terrorist attack on the World Trade Centre in New York on September 11, 2001 some delays occurred in its arrival. The minirhizotron system is derived from imaging systems developed for submarine warfare by the US Navy. Consequently, due to its potential military use, the US government imposed a temporary restriction on its export. We eventually received the system by January 2002, not September 2001 as originally planned.

#### **4. Dissemination Of Information**

Information obtained during this project has been disseminated through the following media:

- Article in May-June issue of "Australian Cottongrower".
- Presentation to Sydney University final year crop science students on field instrumentation for cotton systems (March 2002).
- Presentation to NSW Agriculture Plant Industries' board of management (April 2002) on filed experiments and techniques used at ACRI.

#### **5. Usefulness Of Research Results To Other Researchers, Growers and Industry**

The minirhizotron can identify rooting patterns and carbon exchange under cotton systems. It can also be used by other projects such as those of Drs. Milroy and Lei to identify rooting patterns of cotton varieties and seedlings, and it will be used by a PhD student who will attempt to quantify belowground carbon sequestration under cotton.

#### **6. Methods of Communicating Findings**

Journal and Cottongrower articles; field days; conference papers.

#### **7. Changes To The Intellectual Property Register**

No changes are required to the intellectual property register.

#### **8. Research Highlights**

Root observation tubes were installed in the long-term tillage-rotation experiment at ACRI in the minimum- and intensively-tilled continuous cotton plots. Root dynamics of cotton were monitored. Mr. Peter Roberts, an honours student from the Department of Crop Science at Sydney University. Root samples were taken in December by core sampling (followed by staining). Length was evaluated by the line-intersect method, their mass determined and C and N content determined with a LECO analyser. This data was used to derive a length:mass calibration for the minirhizotron. Root observations were made between January and March at 7-12 day intervals.

Root observation tubes were also been installed during June 2002 in wheat and vetch plots at ACRI. Observations have not commenced as yet.

Root growth of minimum-tilled cotton on 17 December 2001 decreased sharply at a depth of 35-cm (Fig. 1). This is probably caused by the existence of a compaction layer at this depth. At other depths, however, 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/m<sup>2</sup> in the 0-60 cm depth (= 0.31 kg C/m<sup>2</sup>) in the bed and intensive tillage resulted in 0.97 kg of roots/m<sup>2</sup> (= 0.31 kg C/m<sup>2</sup>). However, minimum-tilled cotton resulted in more roots in the furrows (0.94 kg/m<sup>2</sup> = 0.32 kg C/m<sup>2</sup>) than intensively-tilled cotton (0.76 kg/m<sup>2</sup> = 0.26 kg C/m<sup>2</sup>). Above-ground growth of cotton at this

time was such that minimum tillage resulted in  $0.21 \text{ kg dry matter/m}^2$  and intensive tillage in  $0.17 \text{ kg dry matter/m}^2$ . 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 assumed. This information could be of use to researchers involved in developing cotton crop management models such as CottonLogic and OzCot.

This root mass is, however, 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 (Fig. 2).

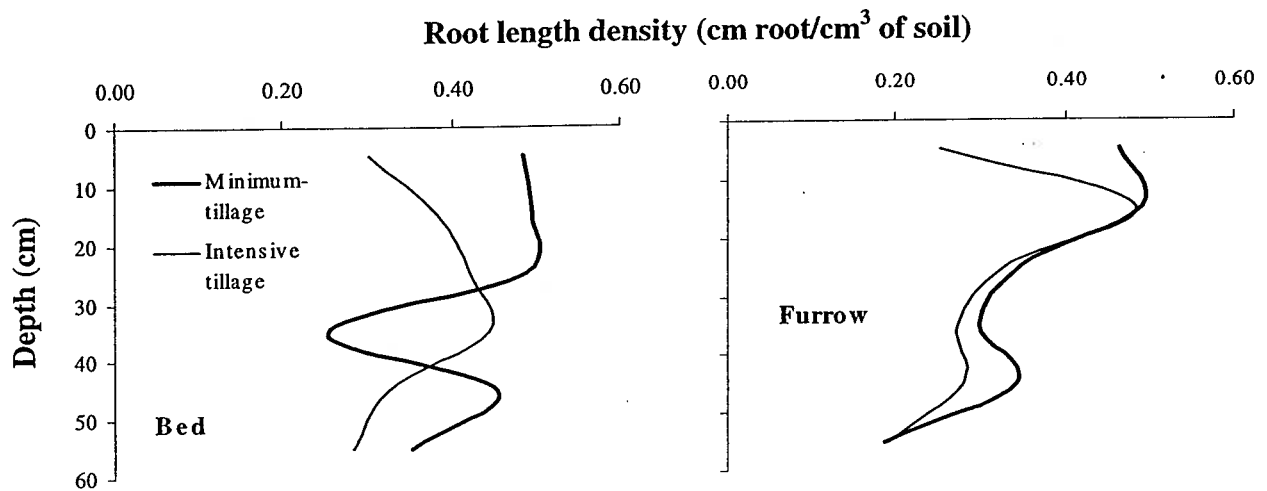


Fig. 1. Root growth under minimum and intensively-tilled continuous cotton, 17 December 2001

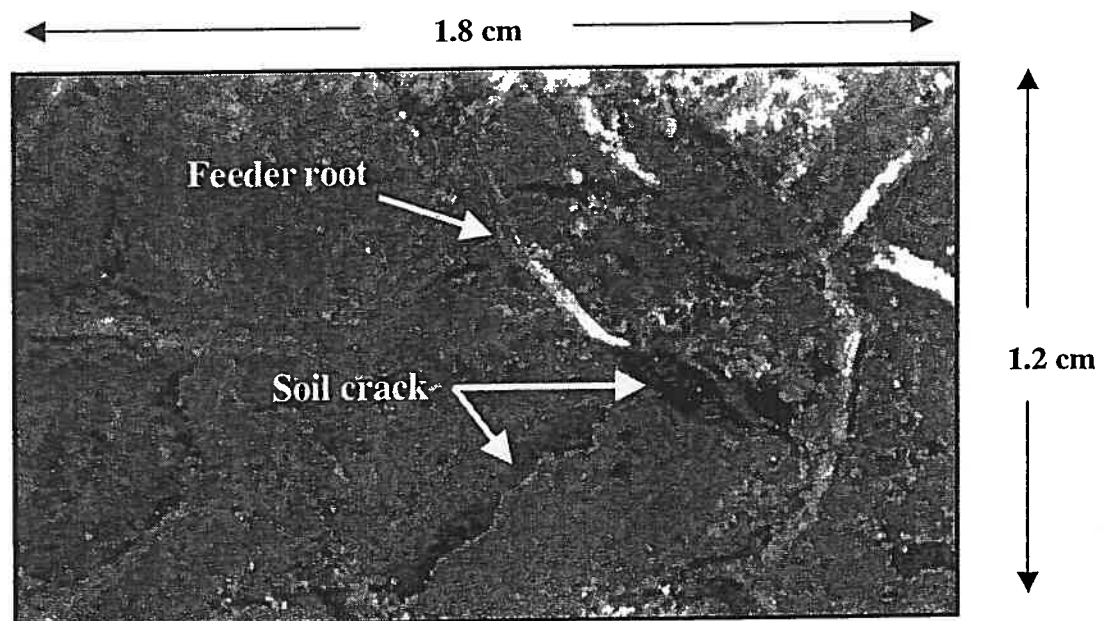


Fig. 2. Feeder roots growing through soil cracks at 50 cm depth on 13 March 2002

## 9. Links To Other Projects

- DAN 145 C – Operational costs for cotton experiments III
- CSP 139C – Application of crop simulation with the Australian Cotton Industry
- CRC12C – Long term effects of cotton rotations on the sustainability of cotton soils II
- CRC 3.1.28AC – Maintaining profitability and soil quality in cotton farming systems
- PhD studentship (pending) - Sequestration of carbon below ground in cotton fields by arbuscular mycorrhizal fungi and cotton roots

## 10. Publications

N. Hulugalle, P. Entwistle, P. Roberts, and L. Campbell (2002). Root growth of rotation crops and cotton. *Aust. Cottongrower*, 23(3), 74-76.

## 11. Appendix 1: Budget

Financial Year	2001 /2002
<b>Capital Items</b>	
Minirhizotron system and associated software	\$75,000
<b>Total Capital</b>	\$75000
<b>Total Funds</b>	<b>\$75,000</b>