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**FINAL REPORT ON PROJECT UNE 3L:
SOIL FACTORS AFFECTING IRRIGATED COTTON PRODUCTION**

Project Number: UNE 3L

Project Title: Soil factors affecting irrigated cotton production

Field of Research: The cotton crop
Field Code: 2.1, 2.2 & 2.3

Organisation: University of New England.

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Introduction

Research on irrigated soils used for cotton production at the Agricultural Research Centre, Narrabri, over the past six years has identified several areas of concern. Information in these areas is needed to improve soil management and thereby cotton production. Unfortunately, limitations on manpower and time have prevented further research on the identified problems being carried out.

Many of the problems are well defined, and it was perceived that a modest input of research resources would elicit information of scientific and practical value. As such, these problems would make excellent Honours projects to be carried out by final year Rural Science students.

Funds were sought from Council for operating costs, travel and casual labour to encourage students to partake in projects based at Narrabri. It was envisaged that two projects would be investigated within each academic year.

Objectives

The objectives of the project were:

- i) Students would obtain research experience in soil and nutrition aspects of cotton production. At the Narrabri Research Centre they would come into contact with established cotton researchers and become familiar with how a research centre operates, particularly in the conduct of field trials. On graduating, this experience and training would enhance their value as agronomists in the cotton industry.
- ii) The projects would provide information on interactions of compaction, soil moisture, aeration, slope, duration of irrigation, and soil chemical factors on cotton plant growth.

Projects Undertaken

The following projects were carried out during the course of the project:-

1987 - 88

Stephen Buster: "The effect of six summer grain legumes grown with different durations of irrigation on the subsequent nitrogen uptake and yield of cotton".

Christine L Hartigan: "The use of plant tissue analysis in assessing plant and soil nutrient status and fertilizer requirements with practical reference to nitrogen".

1988 - 89

Susan Forsell: "Iron chlorosis: causes and correction".

Darren Radford: "Cotton phosphorus nutrition on Australian grey clay soils in New South Wales and Queensland".

1989 - 90

Ken M Arnott Jr: "Compaction of a cracking clay during seed-bed preparation: effects on soil physical properties and cotton growth".

Cynthia A Lamb: "The interaction of soil physical condition and nutrient uptake on irrigated cotton".

Ivan McLeod: "The factors affecting iron chlorosis, and the use of chelates for its amelioration".

Of the students listed above, four are currently employed in the cotton industry, three as agronomists and one in marketing. I believe that their careers have greatly benefited from the support provided by the Cotton Research Council for Project UNE 3L.

Project Summaries

Each student produced a theses approximately 12,000 words long, consisting of (i) a review of the published literature relevant to the topic being investigated and (ii) a report written in the form of a scientific paper on the experimental work conducted at Narrabri Research Centre. Abstracts of the experimental work described in (ii) are given below. Full details are given in the theses, copies of which can be provided by the Department of Agronomy and Soil Science, University of New England.

- 1 Buster, S:** The effect of six summary grain legumes grown with different durations of irrigation on the subsequent nitrogen uptake and yield of cotton.

The use of grain legumes in rotation cropping is relatively new in Australia, particularly in irrigated farming systems. In 1986-87, six summer grain legumes (soybean, cowpea, mung bean, navy bean, adzuki bean and pigeon pea) were grown on a cracking grey clay soil under three durations of irrigation and four field slopes. Cotton was then grown on the plots under the same irrigation regimes the following season. The effects of residual nitrogen (N) and irrigation time on the cotton were evaluated.

As irrigation time extended from 4 to 16 and 32 hours, N up-take by the cotton decreased by 15%. Lint yield decreased 11% over the same irrigation time. Cotton grown after soybean had the highest N uptake (60.1 kg N/ha) and after adzuki beans the lowest (46.7 kg N/ha), with the other species in between. In terms of apparent recovery of fertiliser (90 kg N/ha) applied before the legumes, the soybean treatment had the largest apparent N recovery rate (2.03) and the navy bean treatment the least (0.87). It is concluded that irrigation times and a prior crop of soybeans offer the greatest potential for residual N benefit to cotton (about 40 kg N/ha). Of the other legume species, mung bean and cowpea offer the greatest potential for residual N benefit to cotton in the following season.

- 2. Hartigan, C.:** Evaluation of petiole nitrogen as a means of predicting response to foliar-applied nitrogen fertiliser in cotton.

The effect of duration of irrigation, soil N fertility and foliar N application on plant growth, yield and associated petiole nitrate levels in cotton was investigated at Narrabri, NSW. A cracking grey clay soil was furrow-irrigated for 4, 16 and 32 hours to assess the response to foliar N at various levels of waterlogging and soil N fertility. Soil N was applied at 120, 160 and 200 kg/ha. Foliar N was applied at 0, 20, and 40 kg/ha as 20 kg/ha applications at the first and second irrigations. Petiole nitrate samples were collected from youngest, full-matured leaves 16, 9 and 5 days before the first irrigation, and 4 and 7 days afterwards. Petiole nitrate levels declined more rapidly over time where soil N was low. Increased severity of waterlogging and low soil N level decreased the rate of petiole nitrate recovery following irrigation and increased the lint yield response to foliar N. Petiole nitrate concentrations measured 7 days after the first irrigation were highly correlated ($r^2=0.85$) with

lint yield response to foliar application at the second irrigation. The results confirmed that lint yield response to foliar N can be positive or negative under various waterlogging and soil N conditions, and that petiole nitrate levels can be used to predict crop requirement for foliar N.

3. **Forsell, S.:** The amelioration of waterlogging damage in flood irrigated cotton using foliar application of iron chelate.

Waterlogging after flood irrigation in the Namoi Valley results in yield losses which can be generally alleviated by nitrogen application. Poor response to nitrogen in very wet conditions suggested that iron chlorosis may be a limiting factor. Iron was applied at three rates: nil, 0.2 and 1.0 kg Fe/ha as the iron chelate EDTA at two experimental sites. One site received a single spray of iron two days prior to the first irrigation and the second site both after heavy rain and one day prior to the first irrigation. Sampling was carried out on days 3, 5 and 7 after irrigation. Active iron content of the leaves increased with iron application, but no effect was noted on leaf chlorophyll. On day 7, iron application increased the photosynthetic rate. Leaf chlorophyll decreased significantly over the week after irrigation. Non-significant trends were noted in boll number, boll weight and dry matter production at around day 45 after first irrigation. Final lint yields showed similar trends. The poor response may be due to the low deficiency of iron occurring in this particular season, or to insufficient iron being applied in only one spray over the waterlogging stress period.

4. **Radford, D.:** Cotton phosphorus nutrition on Australian grey clay soils in New South Wales and Queensland. (This abstract includes results from a field experiment conducted near Trangie by a later student, A McKay).

Glasshouse and field studies are reported to examine the phosphorus (P) fertilizer response for Australian cotton production. Phosphorus fertilizer is not regularly used with cotton although the crop is commonly grown on heavy clay soils with medium to low levels of available phosphorus. A glasshouse experiment using soil from 5 irrigation valleys which produce cotton examined growth (at 51 days from sowing) response to P applied at 0, 25, 50, 100 and 200 kg ha. Shoot dry weights showed strong P responses on 4 of the 5 soils; growth on one soil was depressed by an unknown factor. P uptake was also strongly increased by P fertilizer applications; one soil from Queensland (St. George) and one from central New South Wales (Trangie) showed the largest responses in P uptake.

With this large response from the Trangie soil in mind, a field experiment examined P uptake and yield response from P fertilizer applied at 0, 10, 20, 40 and 80 kg ha. Whilst dry matter and P uptake were again increased by P application, no significant effects were observed in square numbers, boll numbers or cotton yield (lint or seed). The crop was infected in later growth by *Verticillium* wilt (*Verticillium dahliae*) which may have reduced yield response, particularly at the highest rate of applied P.

5. **Arnott Jr. K.:** Compaction of a cracking clay during seed-bed preparation:- effects on soil physical properties and cotton growth.

The effects of two methods of seed-bed preparation were compared: (i) using heavy listing equipment pulled by a crawler when the soil was wet, and (ii) using light lilliston equipment pulled by a wheel tractor when the soil was dry. The tillage effects of the listing and lilliston rigs and the compacting effects of the crawler and tractor were considered independently.

Soil physical conditions and cotton growth were influenced by the compacting effect of the crawler, but not by the tillage effects of the listing rig. The structure of the soil trafficked by the crawler was generally massive to a depth of 60 cm, and a "plowpan" had developed at a depth of 30 to 40 cm. The soil trafficked by the wheel track showed little evidence of soil damage. Root growth into the compacted layer was restricted because of low aeration and mechanical impedance and plants in this treatment extracted less water than the plants of the treatment trafficked by the wheel tractor. The plants of the compacted row were shorter and had lower yields.

6. Lamb, C.A.: Changes in nutrient uptake by cotton during an irrigation cycle.

A field trial was conducted at Togo Station, Narrabri, to investigate the effect of compaction on the nutrient uptake pattern of cotton. Petiole samples were collected from the rows under the tractor (wheel-track row) and the rows furthest from the tractor (guess row). Petioles were analysed for nitrogen, potassium, magnesium, calcium, phosphorus, manganese, copper, iron, and zinc. Data was collected daily so that changes throughout the irrigation cycle could be observed. The depletion of moisture from the soil profile during the irrigation cycle was monitored by neutron moisture meter measurements.

The trends in the uptake patterns over time indicated that the uptake of all nutrients was affected by aeration and water stresses. Plants in the compacted rows tended to suffer less from waterlogging and more from water stress; the reverse was generally true for plants in the non-compacted rows. The physiological data collected (plant height and yield) clearly indicated that the plants in the compacted rows were not as productive as plants in the non-compacted rows.

While the rate of nutrient uptake in the compacted rows was generally quite high for much of the irrigation cycle, water stress prior to the irrigation severely limited uptake of most nutrients. This trial suggests that nutrient uptake would be increased by applying less water more frequently.

7. McLeod, I.: The factors affecting iron chlorosis in flood irrigated cotton, and the use of iron chelates in its amelioration.

A field experiment was conducted to determine the factors affecting iron chlorosis of cotton in a cracking grey clay under furrow irrigation, and to evaluate the use of foliar and soil applied iron chelates (FeEDTA) for its amelioration. A split-split plot design was used, and consisted of three irrigation main treatments (4, 16 and 32 hours duration), three foliar iron sub-treatments (0, 200, 400g Fe/ha), and eight sub-sub-treatments (control, soil iron (5 and 20kg/ha), foliar zinc (1kg/ha), soil phosphorus (30kg/ha), soil CaCO₃ (5000kg/ha), foliar nitrogen (10kg/ha) and foliar zinc + foliar nitrogen (1 + 10kg/ha)). Active iron, photosynthesis and leaf colour were measured after the first and second irrigations. Dry matter yields, boll number, boll weight and final yields were also recorded. Increasing the time of irrigation from 4 to 32h had no effect on photosynthesis and dry matter yields, but did reduce active iron levels in the youngest mature leaf (YML) at the first irrigation by 8.9% and final yields by 10.4%. Foliar iron at 400g/ha significantly increased active iron levels in the YML at both the first and second irrigation, but only increased photosynthesis in the first irrigation when no other sub-treatments were applied. Foliar iron had no significant effect on dry matter and final yields. Foliar Zn, soil iron (20kg/ha), and CaCO₃ reduced photosynthesis in the first irrigation each by 23% when foliar iron was applied at 400g/ha, but had no significant effect on final yields. Final yields responded positively to both foliar nitrogen and soil phosphorus. Heavy

hailstorms late in the season reduced treatment differences in dry matter cuts and final yields, but the results confirm that increased waterlogging is primarily responsible for iron chlorosis of cotton in early vegetative growth, particularly with soils high in CaCO_3 . The use of iron chelates as ameliorants requires further investigation.

PUBLICATIONS ARISING FROM THE PROJECT

The publication of papers from the above projects has inevitably been delayed on account of the death in October, 1990 of Arthur Hodgson, who co-supervised the projects. Shortly before his death he wrote a paper for the 5th Australian Cotton Conference entitled "Micronutrients - are they important under waterlogging?" (See pp 165 - 170 of the Conference Proceedings). This paper was based upon results obtained in projects by Forsell and McLeod. The following paper based on Radford's project is about to be submitted to "Plant and Soil".

Radford, D., MacLeod, D. A., Hodgson, A., Jessop, R. S., and McKay, A.
"Phosphorus Fertilizer response in Australian Cotton Production".

Research papers based on projects by Buster and Hartigan are in preparation and will be submitted in the near future.

Results obtained in the other projects need to be supplemented by further work before submission to scientific journals. However, the material combined in them is well suited to publication as advisory communications, such as "The Australian Cottongrower". These articles will be prepared during the course of this year.