

S86/951

6/86 - 6(89)

C

1484/DAN25L

1

FINAL REPORT TO COTTON RESEARCH COUNCIL

Project Number: DAN 25L

Title: EFFECT OF TILLAGE PRACTICE ON NITROGEN FERTILISER STRATEGY AND SOIL STRUCTURE

Organisation: NSW Agriculture & Fisheries
Address: Agricultural Research Station
PMB Myall Vale Mail run
Narrabri 2390 Tel: 067-931105

Research staff: Dr G A Constable, Senior Research Scientist

Administrative contact: Ms S M Berridge,
Professional Officer (Industry funds). Tel: 02-2175102

- Aims:
1. Assess plant response to nitrogen fertiliser applied in different ways.
 2. Develop soil and plant tests to predict N fertiliser rates in cotton.
 3. Monitor soil structure under different tillage systems.
 4. Develop improved management systems for soil and fertiliser.

Summary of results:

This project was needed to assess the N fertiliser requirements of cotton under new tillage systems currently being adopted, particularly since the structure of cracking clay soils is prone to degradation under intensive cultivation and traffic of continuous cropping. With little chance of extreme drying and cracking to restore soil structure, the trend towards continuous cropping may force soil management towards systems that allow maintenance and natural regeneration of soil structure. Such systems are likely to be based on permanent beds with minimum disturbance. Following is a summary of results; a detailed report is appended.

1. Overall, the best method of N application was in the hill before sowing. Anhydrous ammonia and urea gave similar performance. With cotton grown in rotation with wheat, there was less fertiliser N required, and the method and timing of application was less critical. For continuous cotton, more fertiliser was required and it was important to apply the fertiliser before sowing.
2. Soil and plant N tests were a good guide to N status.
3. Under continuous cotton, minimum tillage was superior to a system where the soil was completely disturbed. In fact in the last season, minimum tillage continuous cotton had equal yield to a fallow treatment.
4. We conclude that minimum tillage can be highly recommended for continuous cotton rotations. Issues such as pest, weed and disease carry-over need to be assessed for each situation.

Funds provided from other sources

The total budget from CRC averaged \$30,150 per year. NSW Agriculture & Fisheries paid the salaries of all permanent staff associated with this project over the three years. Office, administrative, laboratory and field facilities and the majority of operating costs were also provided by the Department on Narrabri Agricultural Research Station (total contribution approximately \$200,000 per year).

Difficulties

No major difficulties were encountered. As with any field experiment, the climate played a role in affecting yield levels and treatment responses. Emergence was impaired in the second season due to cold wet weather. At the other extreme, very high yields were obtained in the last season.

Recommendations for future research

The tillage treatments were always imposed as early as possible. We believe the differences between minimum and 'maximum' tillage would have been even greater if soil preparation had been done later. Experiments comparing dates of soil preparation could benefit our future recommendations to industry. The apparent ability of the soil at this site to recover from compaction needs to be compared with other soil types.

Application of results to industry

These results clearly demonstrate that minimum tillage has a role in the cotton industry. Individual fields will need to be assessed for moisture content before any tillage operation. In addition there are other issues such as *Heliothis* pupae, disease incidence, or weed infestation, which should influence decisions about soil preparation. These results have already been extended to industry (references below), and are being utilised in SOILpak.

List of publications

Constable, GA. (1988). Managing cotton with nitrogen fertiliser. **AGFACT** P5.3.4.

Constable, GA. (1988). Effect of tillage practice and rotation on nitrogen fertilizer strategy. *Australian Cotton Conference*, Surfers Paradise. pp 289-293.

Rochester, IJ. and Constable, GA. (1988) Urea or anhydrous ammonia ?
The Australian Cottongrower. 9 (2), 10-11.

Rochester, IJ. (1989). Aspects of nitrogen cycling in a grey clay used for irrigated cotton production. M. Rur. Sci. thesis, University of New England, 163 pp.

Publications in preparation:

Rochester, IJ., Constable, GA. and MacLeod, DA. (1990). Mineral N dynamics in a fallow grey clay. *Aust. J. Soil Res.*

Constable, GA. and Rochester, IJ. (1990) Petiole nitrates. *Commun. Soil Sci. Plant Anal.*

Constable, GA., Rochester, IJ. and Daniells, IG. (1990) Tillage and nitrogen fertilizer strategies. *J. Tillage Res.*

DETAILED RESULTS

Effect of tillage practice on nitrogen fertiliser strategy and soil structure

G A Constable, I J Rochester and I G Daniells

Nitrogen is the major fertiliser element used on cotton, with most areas having no other nutrient deficiencies. The direct cost of nitrogen fertiliser use ranges from \$80 to \$120 per hectare, but excessive N can create other increases in production cost such as added insect control and defoliation requirements as well as fibre quality problems. It is therefore important for a grower to use the optimum rate of N for his situation. This project was needed to assess the N fertiliser requirements of cotton under new tillage systems currently being adopted, particularly since the structure of cracking clay soils is prone to degradation under intensive cultivation and traffic of continuous cropping. With little chance of extreme drying and cracking to restore soil structure, the trend towards continuous cropping will force soil management towards systems that allow maintenance and natural regeneration of soil structure. Such systems are likely to be based on permanent beds with minimum disturbance.

One of the aims of this project was to assess the N fertiliser requirements of cotton under the more enlightened tillage systems currently being adopted. The application method for nitrogen fertiliser may change as the tillage system changes. For example, true minimum tillage is inconsistent with an anhydrous ammonia application shank working down the centre of each hill at 20 to 30 cm depth, particularly in wet soil. The alternatives are often less convenient than the traditional method and to date there has been little research in comparing methods of application.

The project involved a large experiment on Narrabri Agricultural Research Station comparing three soil preparation treatments:

1. **Continuous cotton minimum tillage.** Permanent beds with minimal soil disturbance at soil preparation.
2. **Continuous cotton 'maximum' tillage.** Soil preparation involved discing, deep ripping, chiselling and re-listing between cotton crops.
3. **Cotton - wheat rotation.** Wheat was sown into cotton hills after picking and slashing. After wheat harvest, the field was direct listed for cotton.

Each of these main treatments had nitrogen fertiliser applied as anhydrous ammonia or urea before sowing or as anhydrous ammonia as a sidedressing or as urea in the irrigation water.

Each treatment had a range of fertiliser rates from nil to 225 kg N/ha. The experiment was run for three full seasons. Measurements included soil structure assessment, soil nitrogen, crop establishment, plant nitrogen status, nitrogen fertiliser recovery, root development, lint yield and quality.

Yield and nitrogen response

Figure 1 shows the effect of N fertiliser and tillage on lint yield in three seasons. Cotton grown after wheat has had the heaviest yield in every season, while maximum tillage has yielded the least. Averaged over three seasons, the yield difference between rotation and maximum tillage was 6%, so long as optimum fertiliser rates were used. There were large responses to N fertiliser in each season. The greatest N responses were obtained in the lowest yielding treatments.

Table 1 presents calculated optimum N fertiliser rates from these experiments. In keeping with previous results, cotton grown in rotation with wheat required about 50 kg N/ha less fertiliser, although the actual amounts varied with season (soil N status included in Table). On average the shape of the N response was such that it took 45 kg N/ha to achieve the last 5% of economic yield. This extra yield, though economically significant, was achieved at the expense of 3 to 8 days delay in maturity.

Table 1. Yield and optimum N fertiliser rates for each tillage treatment with DP90. Also shown are soil nitrate and petiole nitrate values from unfertilised treatments. Yields in brackets are for optima which were outside the range of N treatments imposed. Abbreviations: W = wheat rotation; N = min till; X = max till.

Season	Treatment	Max yield kg lint/ha	Opt N rate kg N/ha	Soil nitrate	Petiole nitrate
				in Sept ppm	at flowering ppm x 10 ⁻³
1986-87	W	1585	119	16	18.4
	N	1549	188	11	12.6
	X	1507	198	8	11.1
1987-88	W	1605	173	3	6.9
	N	1528	182	4	9.1
	X	(1483)	(277)	3	11.3
1988-89	W	2720	143	13	17.6
	N	2759	197	12	12.8
	X	2586	206	8	7.3

Plant and soil tests

Responses to N fertiliser were consistent with plant and soil nitrogen data (Table 1).

Petiole nitrates

Each treatment was sampled for petiole nitrate throughout the early part of every season. The values shown in Table 1 are for samples at first flowering, and Figure 2 shows all values for the 1986/87 season. The rapid decline in petiole nitrates during crop growth was consistent within every season. It is therefore essential to have an accurate estimate of the stage of crop growth (hence the use of day degrees). We have standardised on petiole nitrate at 750 day degrees from sowing as the best point for assessing a cotton crop. It is necessary to sample the crop regularly up to this point to accurately make this measurement, and give time to sidedress a deficient crop before any yield reduction occurs.

Figure 3 shows the association between crop N fertiliser requirement to achieve optimum economic yield, and petiole nitrate at 750 day degrees from sowing. This relationship shows that the critical petiole nitrate value at that stage is 21,500 ppm. Crops with lower levels of petiole nitrate require sidedressing in steps of about 25 kg N/ha for every 1,000 ppm below the critical level (eg 19,500 ppm requires 50 kg N/ha).

Soil nitrates

A detailed study of the cycling of mineral N was undertaken as part of Mr IJ Rochester's M. Rur. Sci. Thesis. This study has given us a greater understanding of the reasons for the dynamic changes which occur with soil N samples.

An annual cyclical pattern of nitrate accumulation and dissipation was identified in a fallow grey clay. The pattern was regular during the three years studied, with maximal values (to 34 ppm NO₃-N) occurring in autumn (May) and minimal values (to 7 ppm NO₃-N) in late winter (August). Ammonium levels were low, except for short periods coinciding with cultivation and incorporation of crop residues. Multiple regression using temperature and soil water conditions largely explained the variation in nitrate N (Figure 4). The regular cycle of soil nitrate lagged the annual temperature cycle by approximately three months. The identification of this pattern will enable prediction of crop response to applied N from soil nitrate levels several months earlier than that currently possible. Laboratory incubation studies using similar soil also identified temperature and soil water as highly significant in determining the soil's mineral N status. Regression equations derived from these data simulated the cyclical pattern of nitrate observed in the field when given the temperature and soil water conditions operating in the field study. It was postulated that immobilization and remineralization of N by the soil biomass were responsible for the oscillations in nitrate N levels and these processes appeared to be determined by temperature and soil water conditions. Temperature appeared to be the major determining factor, as low or declining temperatures produced a net N immobilization and high or increasing temperatures produced a net N mineralization.

Nitrogen application method

In general there was only a small difference in N response when applied as different forms or methods, particularly with a wheat rotation where all methods gave similar yields. There has been a poorer response to N when applied in the furrow as a sidedressing in continuous cotton.

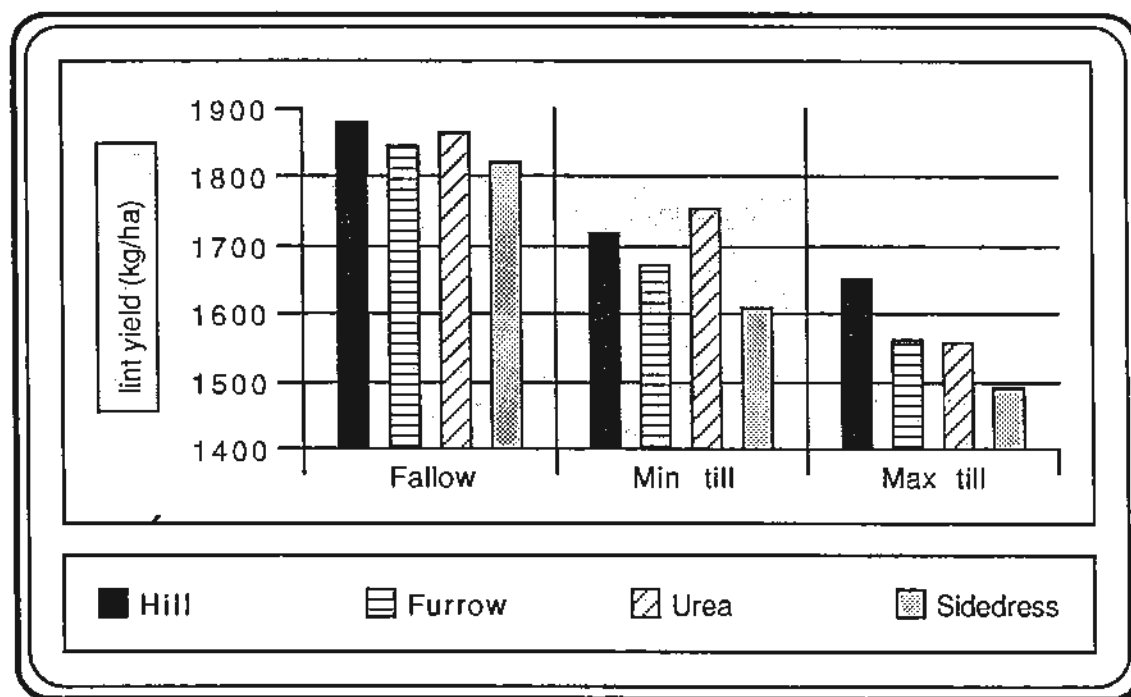
The following figure summarises the three seasons data. Abbreviations:

Hill = Anhydrous ammonia in the hill before sowing,

Furrow = Anhydrous ammonia in the furrow before sowing,

Urea = Urea in the hill before sowing,

Sidedress = Anhydrous ammonia in the hill after sowing.



On the basis of these results we recommend the application of some N in the hill before sowing, especially with continuous cotton.

Water run urea at the first irrigation sometimes gave similar performance to sidedressing anhydrous ammonia, but never better than presowing applications.

Cultivar

Even though yield levels of each cultivar varied, it was found that the optimum N rate was identical for both DP90 and Siokra. There were indications that Sicala required slightly less N fertiliser than other cultivars, but this trend was not consistent.

Root profiles

Figure 5 shows root profiles for each tillage treatment in the three seasons. There was greater root development in cotton following wheat than in continuous cotton. Where treatments had some soil compaction (eg max-till), root development was generally reduced at the 20 to 30 cm level. All treatments had significant root development down to 120 cm, and there were no indications that max-till required more frequent irrigation.

Soil structure

Measurements of soil shrinkage (an index of soil structure and compaction) are still being processed. The data shows only small differences between rotation and tillage treatments. We did not expect large differences with these soil measurements because yield differences were less than 10%. It should be noted that all soil preparation operations were performed as early as possible, so there were no instances where late soil preparation left poor seedbeds. Further, this soil type appears to recover from compaction quite rapidly; the factors controlling this recovery (such as clay mineral type) deserve further study, particularly the comparison with other soils.

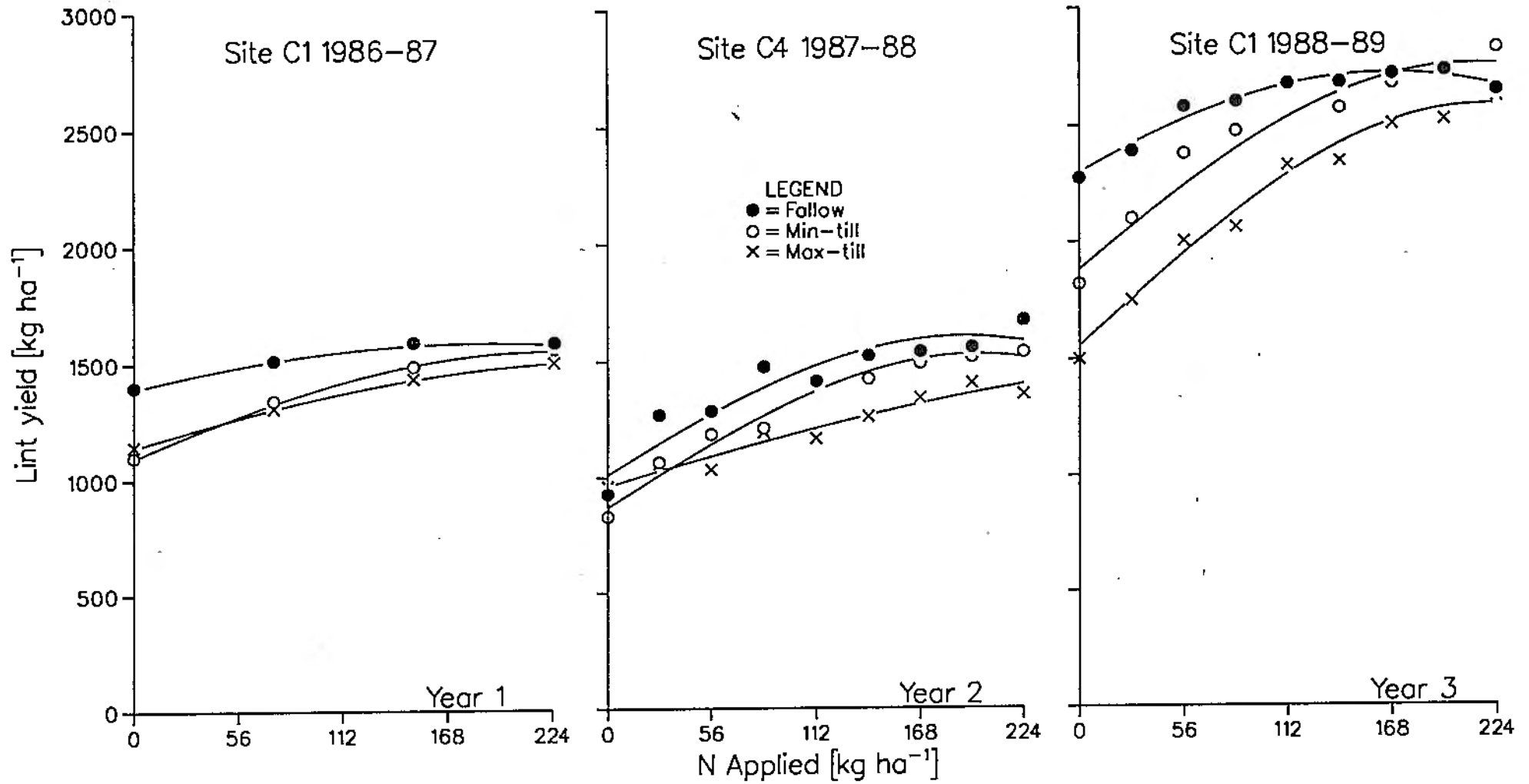


Figure 1 Response to N application over three growing seasons.

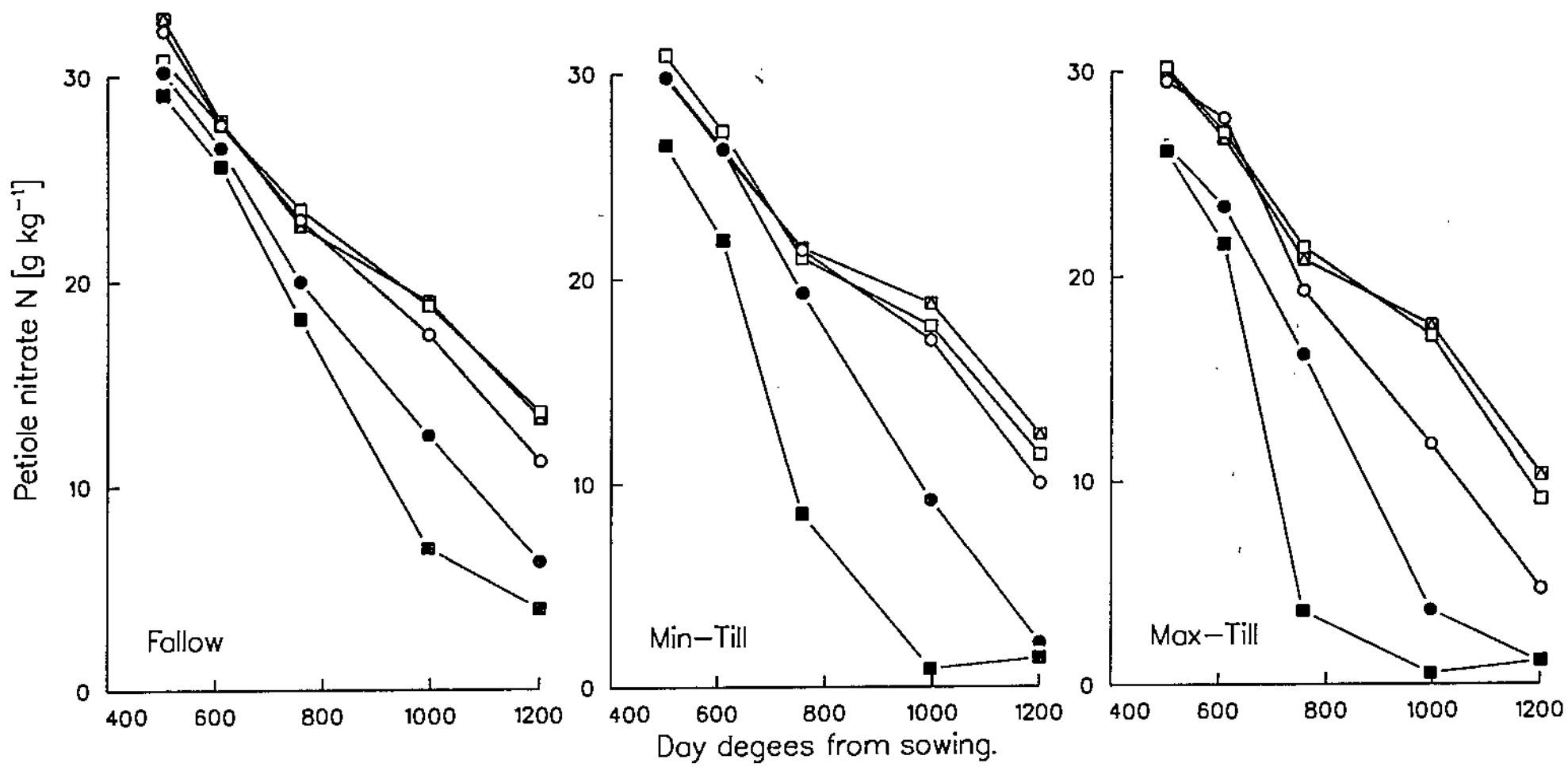


Figure 2 Petiole nitrate N determined during the 1986/87 season.

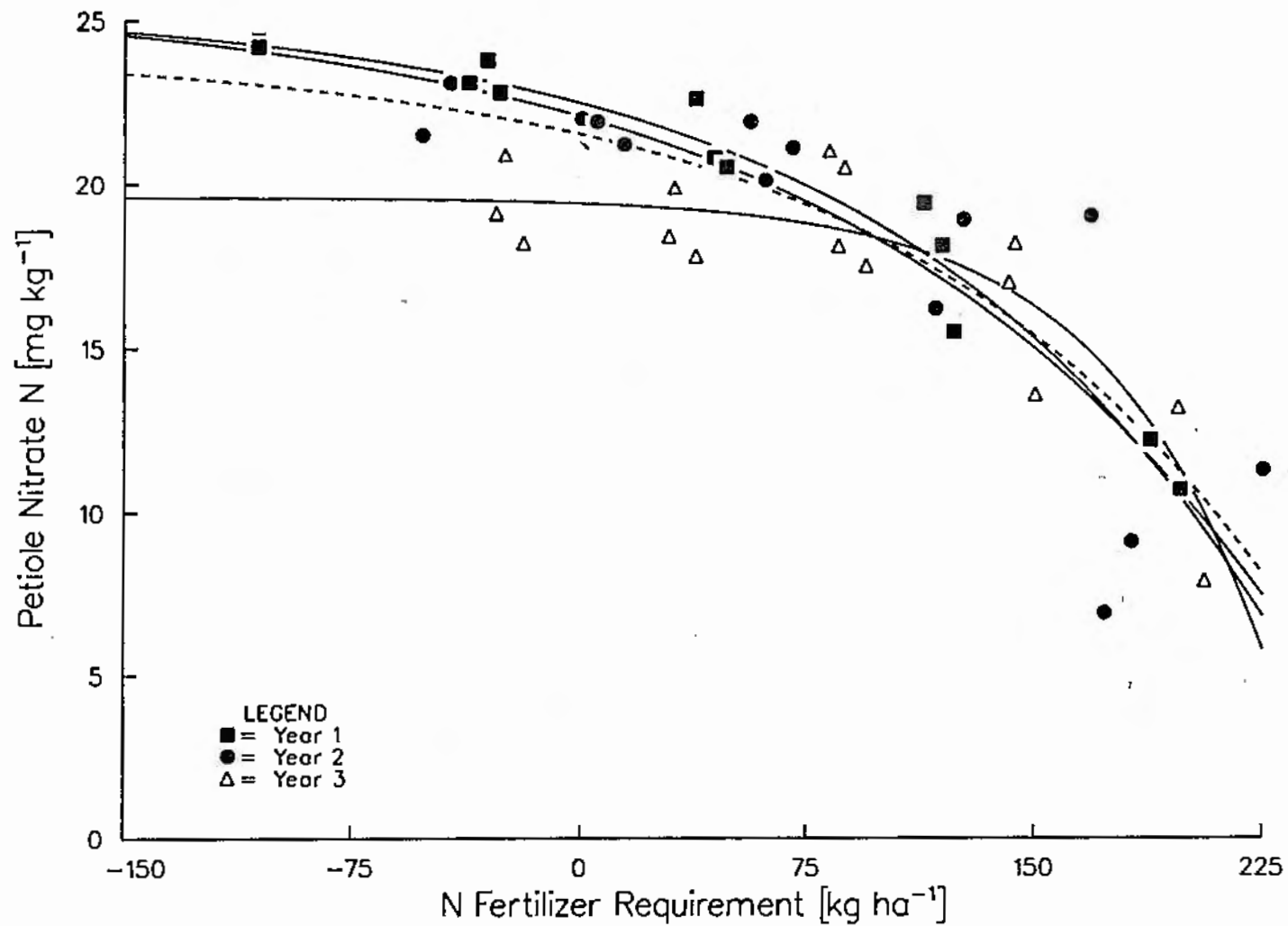


Figure 3 N fertilizer requirement according to petiole nitrate N level at 750 day degrees.

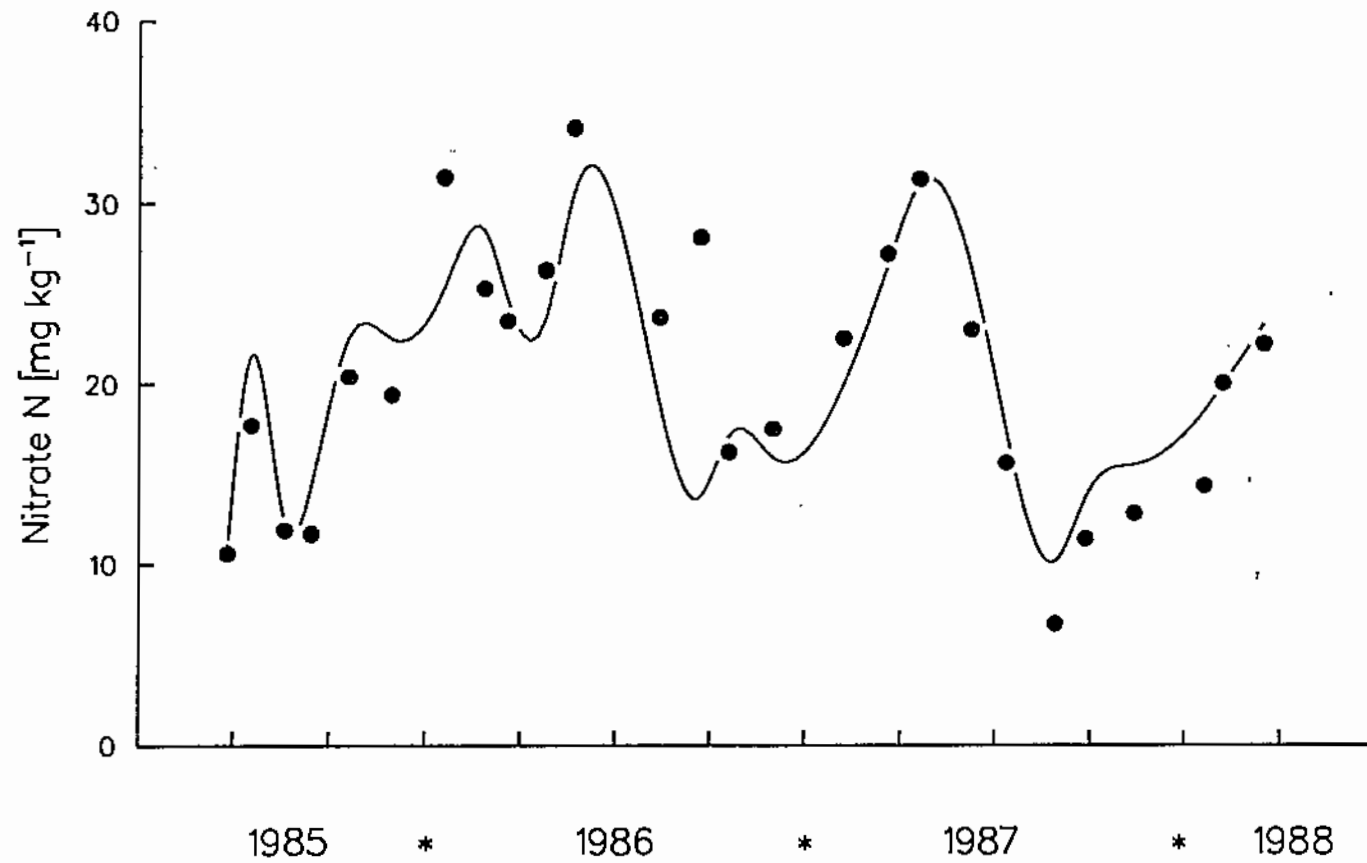


Figure 4 Levels of nitrate N observed in fallow grey clay sampled to 30 cm depth. The fitted line illustrates the annual cyclical pattern of soil nitrate.

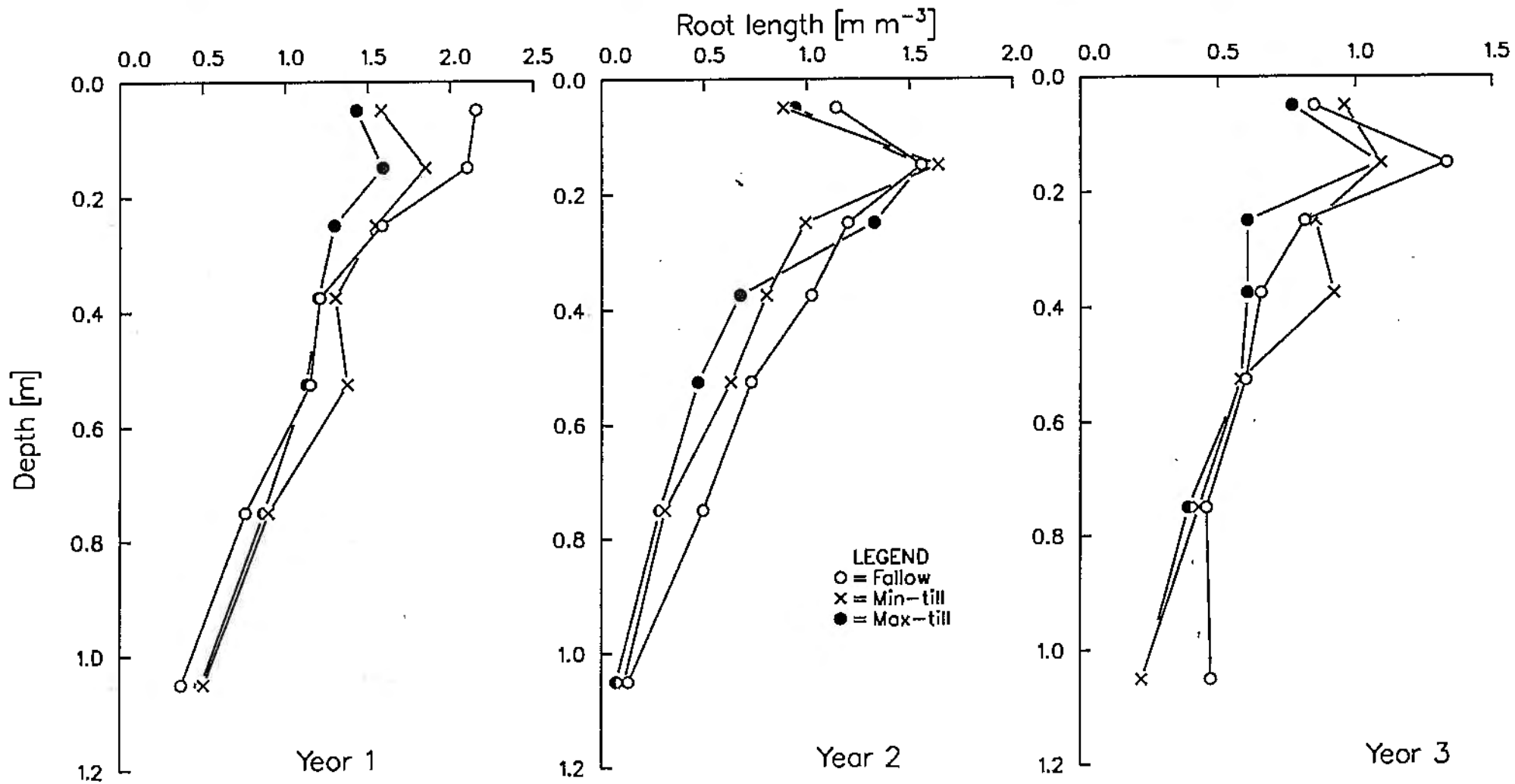


Figure 5 Root profiles in the three tillage treatments over three years.