The Effect of Irrigation and Nitrogen Fertilizer on Nitrate Nitrogen Concentration in Cotton Petioles

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INTRODUCTION

Determination of the petiole nitrate nitrogen concentration (PNN) in the youngest fully expanded leaf (YFEL) of cotton is a useful indicator of plant nitrogen status. In a review of literature Hearn (1981) reported for various phenological stages, levels of petiole nitrate-nitrogen (PNN) adequate for crop growth. These declined from 14000 - 25000 mg kg^{-1} at first square to 2000 mg kg^{-1} at first open boll. He reported a critical level of 2000 mg kg^{-1} above which growth would not decline.

On cracking clay soils, transient waterlogging following irrigation has been found to reduce lint yield in cotton (Hodgson and Chan 1982). These losses in lint yield have been minimised by foliar applications of nitrogen prior to irrigation (Hodgson 1984), inferring that temporary nitrogen stress occurs in cotton following irrigation.

At Emerald, Queensland cotton is predominantly grown on cracking clay soils. Hence we thought that PNN would fluctuate in response to an irrigation event with lowest values occurring shortly after irrigation. We determined PNN levels under different irrigation treatments and rates of nitrogen to indicate whether nitrogen concentration in the plant was limiting yield.

METHODS

Studies were carried out over two seasons, 1984/85 and 1985/6 on a basaltic cracking clay soil (BUg, McDonald and Baker 1986). In the 1984/85 season, petioles of the YFEL from the main stem of cotton plants were sampled over time from three replicates of a single irrigation treatment (50% depletion of PAWC) at two nitrogen rates (60 and 240 kg ha^{-1}).

In the 1985/86 season the effect of irrigation duration and nitrogen rate on the response of cotton to nitrogen was tested. At 42 days after sowing (DAS), cotton grown under two nitrogen rates (60 and 240 kg ha^{-1}), was furrow irrigated for periods of either 1,4 or 11 days. In the 4 and 11 days treatments, a small flow of water was maintained in the furrow after the initial irrigation event for the length of the treatment period. At peak flower (73 DAS), irrigation was applied as a second 1 day treatment and to another treatment for 4 days at two nitrogen rates (60 and 240 kg ha^{-1}). In each experiment thirty petioles of the YFEL were sampled between 7am and 9am one day prior to and on several days following irrigation events. These were dried, ground and analysed for nitrate nitrogen (Span and Lyons, 1985).

Seed cotton was mechanically harvested from 2 rows of plants, 10 m in length. Cotton was ginned on a sawtooth gin and lint yields calculated.

In 1985/86 gravimetric water content and bulk density was measured on undisturbed soil cores (0.1 m dia x 0.1 m L), collected at the completion of each irrigation treatment. Soil porosity was calculated.

RESULTS AND DISCUSSION

Significant differences ($P<0.05$) in PNN levels were found between time, nitrogen rate and their interaction in 1984/5 and between the main effects and interactions of time, irrigation treatment and nitrogen rate in 1985/6.

In both years a significant decline in PNN occurred between the sample prior to the first irrigation (approximately 40 DAS), and the samples at approximately 57 DAS (Figures 1 a,b). This period coincided with the commencement of square production and an increase in the rate of crop growth in each year (Ockerby, unpublished data).

In the 1985/6 experiment the rate of decline in PNN in the four day irrigation treatment was greater than in the one day treatment. However, following removal of the 4 day irrigation event PNN remained constant in the 60 kg N ha^{-1} treatment and recovered in the 240 kg N ha^{-1} treatment to a level similar to the one day treatment. In the 11 day treatment PNN declined to a lower level than in the 4 day treatment and did not recover as rapidly when water was

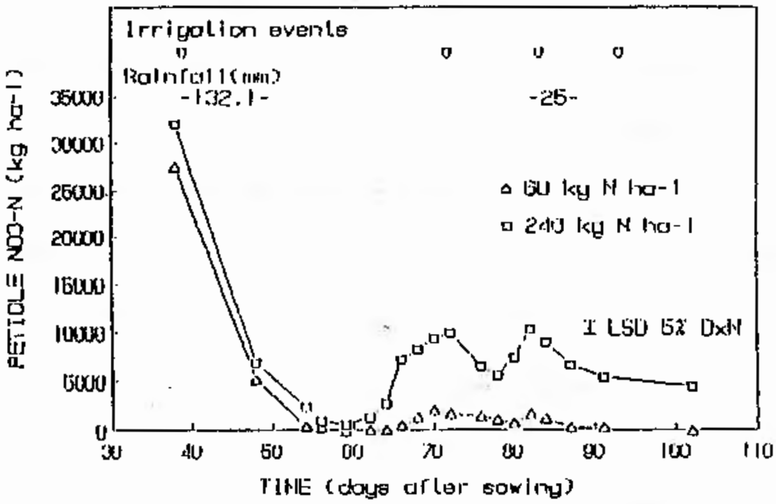

Fig.1a Effect of Nitrogen Rate on Petiole NO3-N Concentration of Cotton with Time of Sowing in 1984/5

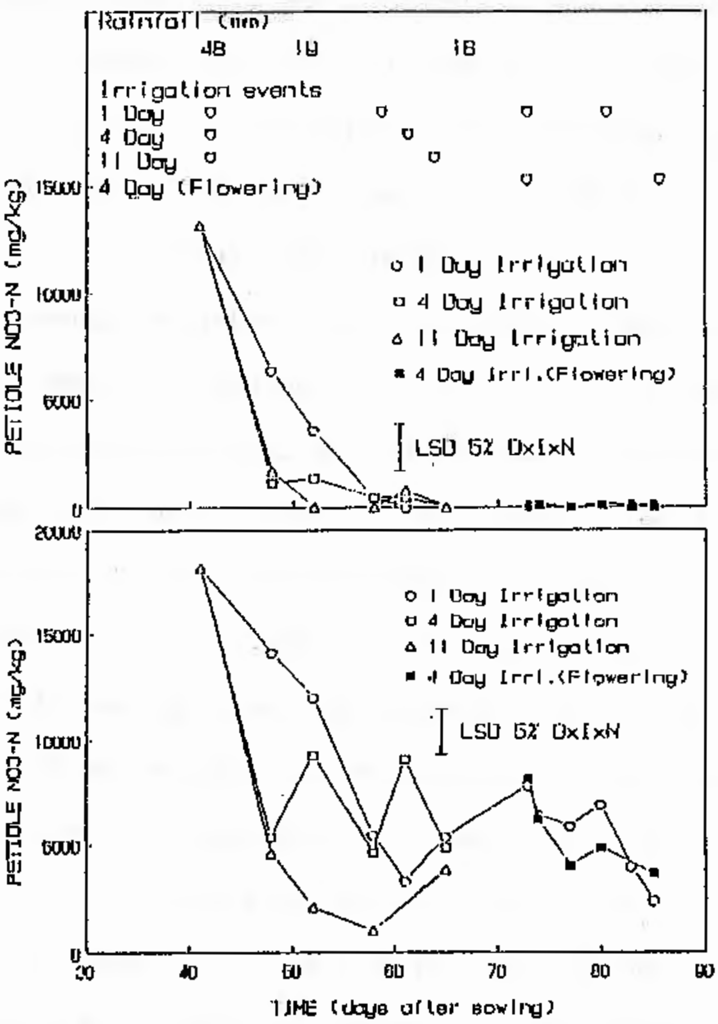

Fig.1b Effect of Irrigation Duration on Petiole NO3-N Concentration of Cotton for 60 kg Nha-1 (top) and 240 kg Nha-1 (bottom)

removed. The magnitude of the fall in PNN with the 11 day treatment was similar to the fall recorded in 1984/85 when rain was recorded following irrigation. In both treatments, PNN fell below the critical level of 2000 mg kg^{-1} and only recovered to adequate levels when 240 kg N ha^{-1} was applied.

In the 1984/5 experiment PNN was higher on the day prior to or following the irrigation event than at any other sampling time. This was also found in 1985/6 for the one day irrigation treatment for the 240 $kgha^{-1}$ rate of nitrogen. Maximum difference in PNN between nitrogen rates was found at this time. Minimum levels in all treatments were found 4-5 days after the cessation of the irrigation event.

In 1984/5 lint yield of the 60 kg Nha^{-1} treatment (1123 kg ha^{-1}) was significantly lower ($P<0.05$) than yield of the 240 kg Nha^{-1} treatment (1418 kg ha^{-1}). Mean yield of this irrigation treatment (50% depletion of PAWC), was 1169 kg ha^{-1} and this was lower than the yield of other irrigation treatments (30, 80, 100% depletion of PAWC) at 1517, 1422 and 1240 kg ha^{-1} respectively. The lower yield with irrigation at 50% depletion of PAWC was probably due to rainfall occurring immediately after irrigation in this treatment (Ockerby unpub. data). In the 1985/6 experiment lint yields were lower for the 60 kg Nha^{-1} treatment than the 240 kg Nha^{-1} treatment (Table 1). Further when the period of irrigation was increased to four days, yields decreased for the 60 kg Nha^{-1} treatment but not for the 240 kg Nha^{-1} treatment. When the irrigation period was increased to 11 days yields were reduced for both rates of nitrogen.

Rain following irrigation in 1984/5 caused a greater reduction in PNN levels and lint yields than an 11 day irrigation period in 1985/6, particularly at the 240 kg ha^{-1} rate of nitrogen. Presumably, in 1984/5 the eight rainfall events on 41, 44, 46, 48, 51, 52, 53 and 54 DAS totalling 132.1 mm, were sufficient to saturate the ridge and maintain it at a moisture content above which either or both nitrogen availability and root activity were reduced. In 1985/6 water was applied via the furrows and only 19 mm of rain fell during the first irrigation events. Measurements of air filled porosity in 1985/6 found adequate levels for plant functions at the 0-10 cm depth (0.24 m^3m^{-3}) and near adequate levels at the 10-20 cm depth (0.08 m^3m^{-3}) at the completion of the 11 day irrigation treatment. This suggests that maintaining a high ridge may reduce the effects of waterlogging particularly if surface drainage is a problem.

Table 1. Effect of Nitrogen Rate and Irrigation Period on Lint Yield (Kg ha^{-1}) in 1985/6

Nitrogen Rate (Kg ha^{-1})	Irrigation Period (days)			
	First Irrigation			Flowering Irrigation
	1	4	11	4
60	1615	1477	1241	1482
240	2181	2253	1865	2188

Petiole levels below 2000 mg kg^{-1} have been correlated with reduced growth and yield in cotton (MacKenzie et al. 1963). In both experiments, lint yield reductions in the 60 kg ha^{-1} nitrogen treatment were associated with long periods when PNN was less than 2000 mg kg^{-1}. When 240 kg Nha^{-1} was applied, PNN levels of less than 2000 mg kg^{-1} were only recorded when rain followed irrigation in 1984/5 and when irrigation was applied for eleven days in 1985/6. In both cases yields were reduced. Our data supports that of McKenzie et al. (1963) in that yield losses will occur if PNN levels fall below 2000 mg kg^{-1}.

CONCLUSIONS

Results suggest that with normal furrow irrigation on this soil, PNN levels should not decline to a level where nitrogen stress in the plant is indicated. However, if rain falls or water remains in the furrow for extended periods following irrigation, plant nitrogen status is likely to fall to a level where reductions in yield will result.

Sequential sampling indicated that PNN levels would fall following an irrigation event on these soils and increase as soil water deficits increased. In some treatments lower than critical levels of PNN were found only in samples taken 4-5 days after the cessation of irrigation or rainfall events. These low levels were associated with reduced lint yields. This data indicates that the practice of taking samples at random during irrigation cycles may introduce errors in PNN caused by the soil water status at sampling. Less variable measurements of PNN trends during crop growth can be obtained by sampling, either immediately prior to irrigation for comparison against known levels of adequacy, or 4-5 days following irrigation to determining the lowest levels of PNN.

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