CAN YOU AFFORD WATERLOGGING ON YOUR FARM?

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Introduction

Each furrow irrigation waterlogs most of the root zone of cotton in cracking clay soils. This deprives the roots of oxygen, they take up less water and nutrients, and this reduces growth and yield. Recent research at Narrabri has measured how much yield is lost through waterlogging, how much can be recovered by the tactical use of foliar applied N fertilizer, and to what extent irrigation management can reduce waterlogging.

Extent of yield loss

Waterlogging substantially reduces the growth and yield of cotton in cracking clays (Hodgson 1982; 1984), but loamy or sandy soils are not affected to the same extent. The extent of yield loss in cracking clays varies with the severity of waterlogging and the yield potential of the crop. Fig. 1 shows firstly, that in a high-yielding season (1984-85) waterlogging decreases yield more rapidly than in lower-yielding seasons. Secondly, more yield is lost during the first few days of waterlogging than during extended waterlogging. Table 1 shows that as the number of days of waterlogging per season increases from 5 to 25, the average loss of lint yield per day decreases from 38 to 19 kg/ha. However, total yield loss (days x loss/day) increases from 190 to 480 kg/ha. Most fields in the Namoi, Gwydir and Macquarie Valleys lie between these levels in a dry season. This means that waterlogging reduces yield by almost 1 bale/ha, even in dry seasons in the best-drained fields of these valleys. Less damage occurs in fields with steep slopes at Emerald (Yule 1984).

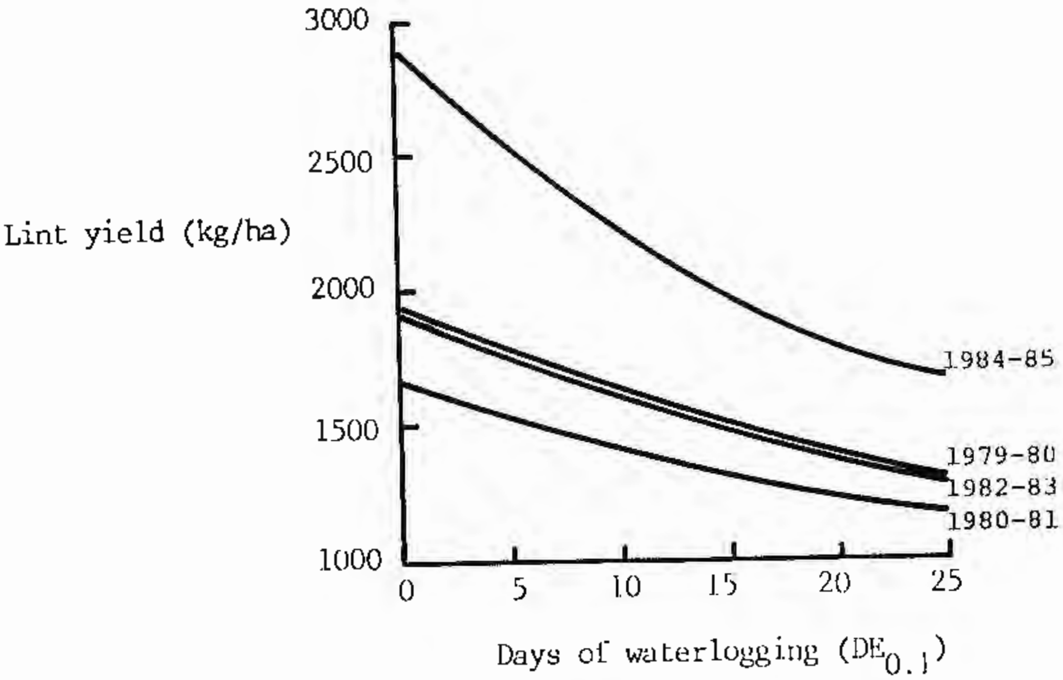

Fig. 1. The relationship between lint yield and the number of days of waterlogging during the season for four seasons at Narrabri.

Table 1. The effect of the number of days of waterlogging during a season on average lint yield loss per day and total loss for the season.

Waterlogging per season (days)	Average yield loss/day (kg/ha)	Total yield loss/season (kg/ha)	Lost profit when \$/bale is \$180	\$200	\$220
5	38	190	152	169	186
15	26	390	312	347	381
25	19	480	384	427	469

Poor fertilizer recovery

When water displaces air from the soil during furrow irrigation or heavy rainfall, oxygen reserves are quickly used up and roots cannot respire. They absorb less water and nutrients from the soil, which produces deficiencies in the leaves. Wilting is not noticed because cotton stomates close during waterlogging and keep the leaves turgid (Sojka and Stolzy 1980). However, nutrients become deficient and reduce leaf activity, plant growth and lint yield.

During the first 3-4 days of waterlogging after irrigation, most of the yield loss is due to less N being absorbed from the soil by the waterlogged roots. The N that *is* absorbed may be less efficiently used by the leaves (Hearn and Constable 1984). Much of the yield lost through temporary waterlogging can be recovered by supplying N directly to the leaves as a foliar spray of urea. Fig. 2 shows that as the severity of waterlogging increases, the response to foliar N increases up to a limit. Beyond this limit, further additions of foliar N are ineffective, and other factors then limit yield. Table 2 shows that when the period of irrigation increased from 4 to 16 h/irrigation, the response to foliar N increased from 2.8 to 8.4 kg lint/kg N, or from 168 to 506 kg lint/ha for the season. Response to 5 kg foliar N/ha in the 32 h irrigation treatment averaged 10.5 kg lint/kg N, but higher rates were of no additional benefit. This implies that other factors, such as the reduced supply of carbon dioxide to leaves as stomates close, the increased production of toxins, or deficiencies of other nutrients, may become important after extended waterlogging.

In the cool, wet 1983-84 season, foliar N was ineffective in increasing yields because other factors, including low temperature and low solar radiation, kept yields low whether or not the crop was adequately supplied with N. In the hot, dry 1984-85 season, superfluous levels of soil N enabled luxury uptake of N prior to waterlogging, which the plant could use during waterlogging to maintain yields. Foliar sprays were therefore not needed.

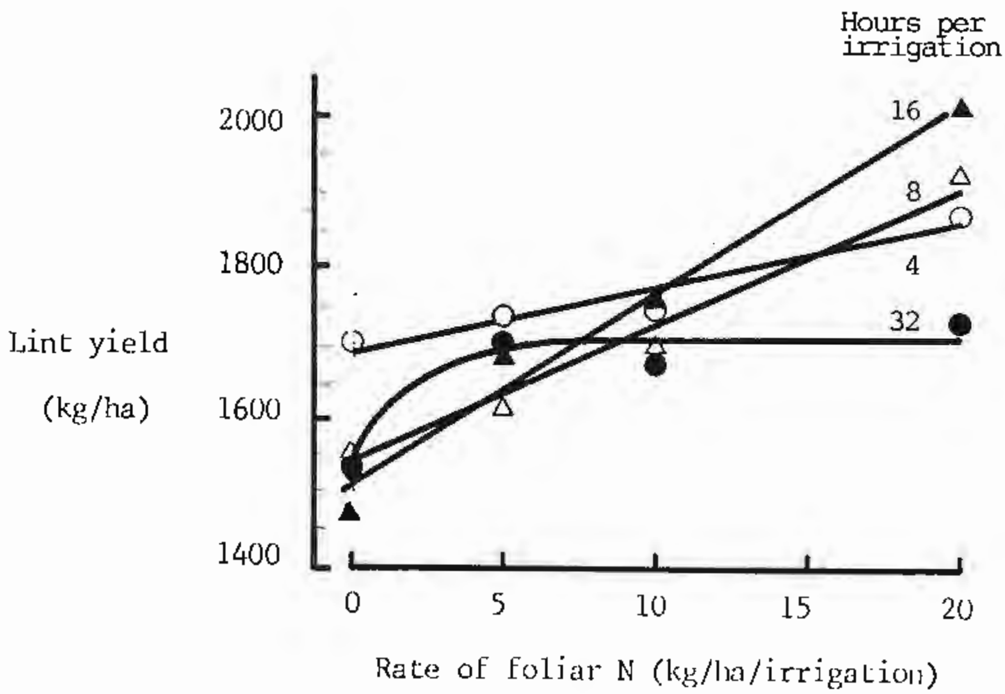

Fig. 2. The yield response to foliar applied N fertilizer at four levels of waterlogging.

Table 2. The effect of waterlogging on the average yield response per kg of foliar applied N, on the total yield response for the 1982-83 season, and the costs and profit recovered by applying foliar N as 'Easy-N'.

Period of irrigation (hours)	Average lint yield response (kg/ha per kg N)	Total lint yield response (kg/ha per 60 kg N)	Cost of foliar N ($)	Price/bale: $180	$200	$220
				Recovered profit $/ha:		
4	2.8	168	81	53	68	83
8	5.9	356	81	204	235	267
16	8.4	506	81	324	369	414
32	10.5[1]	158	36	90	104	118

[1]This rate of response applies only to the first 5 kg N/ha per irrigation or 15 kg/ha for the season.

Costs of foliar N were calculated as $1 per kg of N plus $7 per application.

In 1985-86, it was confirmed that waterlogging damage and the response to foliar N decrease at high levels of soil applied N. Table 3 shows that at the optimum rate of soil applied N (160 kg/ha), waterlogging decreased lint yield by 5.5% and foliar N increased yields by 4.0% in the most severe treatment, but there was no increase in the least waterlogged treatment. Foliar N slightly decreased gin out-turn, which is the usual effect of applying N fertilizers.

Table 3. The effect of waterlogging and foliar N on seed cotton and lint yields at the optimum rate of soil-applied N (160 kg/ha) in 1985-86.

Period of irrigation (hours)	Rate of foliar N (kg/ha per season)	Seed cotton yield (kg/ha)	Lint yield (kg/ha)	Gin out-turn (%)
4	0	4698	1932	41.1
	60	4760	1884	39.6
32	0	4354	1819	41.8
	60	4688	1892	40.3

Impact of irrigation management

Minimum waterlogging requires rapid irrigation and quick removal of excess water. Rapid irrigation can be achieved by running more, larger siphons on shorter fields. Slope and furrow depth largely determine the rate of drainage in these soils because through-drainage is negligible when the soil is wet. Table 4 shows the effect of increasing periods of irrigation at various slopes used in different experiments. Increasing the period of irrigation from 4 to 32 h increased average waterlogging by 1.4 days/irrigation. However, decreasing the slope from 1:1300 to 1:2000 increased average waterlogging by 3.3 days/irrigation. These results indicate that waterlogging can be reduced by rapid irrigation and by increasing field slope. Circumstantial evidence suggests that slope may be more important. This aspect is being studied in current experiments.

Table 4. Mean days of waterlogging per irrigation in the top 0.2 m of soil for four waterlogging treatments compared at different field slopes used in different experiments.
Note: slopes were not factorially combined with irrigation treatments.

Period of irrigation (h)		Days of waterlogging per irrigation			
	Season:	1979-80	1980-81	1984-85	Mean
	Slope:	1:1300	1:1650	1:2000	
4		0.9	1.2	4.1	2.1
8		1.2	1.8	4.7	2.6
16		1.6	2.1	4.4	2.7
32		2.2[1]	2.4	5.8	3.5
Mean		1.5	1.9	4.8	2.7

[1]Estimated as a missing plot using seasons as replications since no 32 h treatment was imposed in the 1979-80 experiment.

Can you afford waterlogging?

Insidious losses of yield from waterlogging or other factors become increasingly important as the price of cotton declines. The best counter-measure to low prices is to reduce unnecessary costs and to produce optimum yield, which is the yield that produces the largest difference between costs and returns.

Foliar application of N prior to irrigation is a relatively low-cost method of increasing yields otherwise reduced by waterlogging (Table 2). We now know that foliar N is not effective under cool, overcast conditions, or when luxury levels of soil N are available to the plant before waterlogging. However, at recommended rates of soil applied N, foliar N has consistently increased the yields of waterlogged cotton when applied one day before irrigation under hot, sunny conditions. Foliar N should therefore be considered when conditions suit, such as on fields with limited slope and low to optimum soil fertilizer levels during hot, dry conditions. Soil and plant tissue testing may be used as a guide to potential susceptibility to waterlogging and response to foliar N. This role of testing has had only limited research and Greg Constable's paper will have more on this aspect. A word of caution: the petiole nitrate test will not show increased N immediately after foliar sprays because

(1) the urea goes directly into the leaf blade and not via the petiole, and (2) the form of N in urea is not nitrate. Some nitrate is present in 'Easy N', but (1) still applies.

Rapid irrigation should be practised at every irrigation, though increasing field slope may be more effective. Future research should clarify this point.

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