ROOTS AND SHOOTS IN CAHOOTS: IMPROVING THE GROWTH OF COTTON AFFECTED BY BACTERIAL STUNT

David B. Nehl[1], Anowar H. Mondal[1], Stefan Henggeler[2]
[1]NSW Agriculture, Australian Cotton Research Institute, Myall Vale Mail Run, Narrabri NSW 2390.
[2]Auscott Ltd, Wee Waa Road, Narrabri NSW 2390.

Introduction

Bacterial stunt is a disease in which soilborne bacteria colonise cotton roots and inhibit the growth and mycorrhizal development of the plant. Brown discolouration develops rapidly in the roots of stunted plants. Stunting is relatively uniform and, therefore, may only be noticeable when parts of a field are affected and parts not. Stunting tends to be more severe in heavy clay soils, even though these soils may have high levels of nutrients such as phosphorus (Nehl et al., 1996a, 1996b). In some cases crop growth picks up mid-season and yields are acceptable but yield loss of up to 50% occur when cotton is severely affected. There are few options for control of bacterial stunt. Eradication of the pathogenic bacteria from soil is impractical. Permanent bed systems appear to have lifted yields, although the relative patterns of stunting across fields remain. At present the best option for control is to optimise management of the crop.

Table 1. Characteristics of clay soils in the Edgeroi Data Set (McGarry et al., 1989).

Depth	N	P	K	Na	ESP	pH	O C
0-10 cm	17.61	39.31	16.08	14.65	3.649	7.86	1.31
10-20 cm	9.115	21.66	10.83	21.35	5.032	8.383	0.95

Values are the means of 134 sites that had > 40 % clay. Depths are significantly different ($P<0.001$).
N = nitrate-N (mg kg^{-1}); P = bicarbonate-P (mg kg^{-1}); K = exchangeable-K (mmol (K^+) kg^{-1}); Na = exchangeable-Na (mmol kg^{-1}); ESP = exchangeable sodium percentage; OC = organic carbon (%).

Cracking clay soils in the Namoi valley are more fertile at the surface (Table 1). As the soil surface dries roots lose access to the most fertile part. We have recently investigated the potential of using mulches and extra water to increase early season growth and maturity by increasing root growth in the most fertile part of the top soil.

Mulches

In a commercial irrigated cotton field in 1997/98, early season growth and subsequent boll production were increased by 62 % and 50 % respectively when 2 m beds were covered with a lucerne-hay mulch at 24 days after sowing (Figure 1A & B). Root growth in the upper 10 cm of the profile was dramatically increased (Figure 1C). In the hay mulch treatments, 70 % of the total root mass recovered was in the top 10 cm of soil, compared to 59 % in the bare treatment (Figure 1C). The hay maintained soil moisture and roots grew right to the surface. Nitrogen (2 applications of 25 units ha^{-1}) was applied in an extra hay treatment to account for any loss of N which may have occurred in due to extra moisture in the soil. Nitrogen uptake, measured in January, did not vary between treatments. Hence N release from the hay, which was essentially dry during the first six weeks after mulching, was not an important factor.

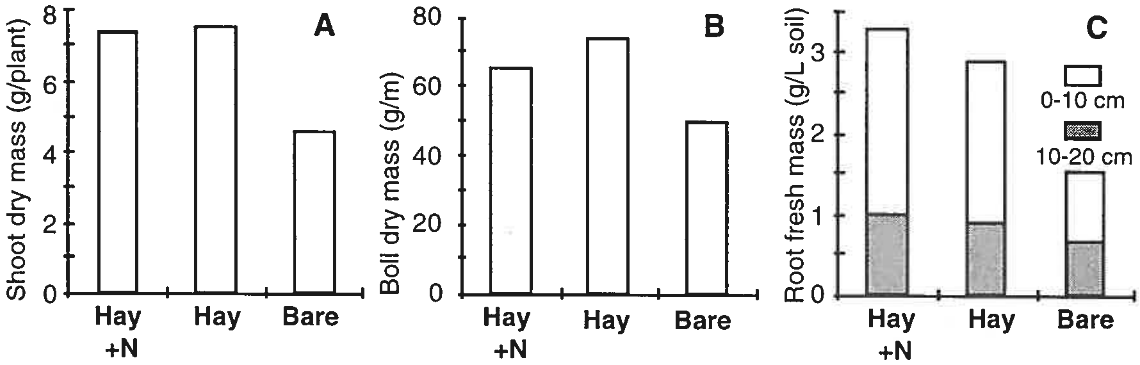

Figure 1. Mulching with lucerne hay 24 days after sowing in a furrow irrigated field increased (A) shoot growth in December, (B) boll production in January and (C) root growth near the soil surface in January. Hay = hay mulch. +N = additional nitrogen (50 units ha^{-1}). Bare = untreated.

Supplementary water

Supplementary water was applied to furrow irrigated cotton crops by a number of methods. In the field as the hay experiment, similar increases in early shoot, boll and root growth were obtained by providing a constant water table (CWT) in the centre of double beds (Figure 2). In the CWT treatment, 57 % of the total root mass recovered was in the top 10 cm of soil, compared to 38 % in the bare treatment (Figure 2C). The CWT maintained soil moisture close to field capacity but without waterlogging. Boll production closely matched the pattern of shoot growth (Figure 2A & B). A mulch of lucerne hay was used to reduce evaporative moisture loss from the plots. The effect of the mulch alone (Figure 2) was not as great as in the mulch experiment (Figure 1), reflecting the later starting date of this experiment.

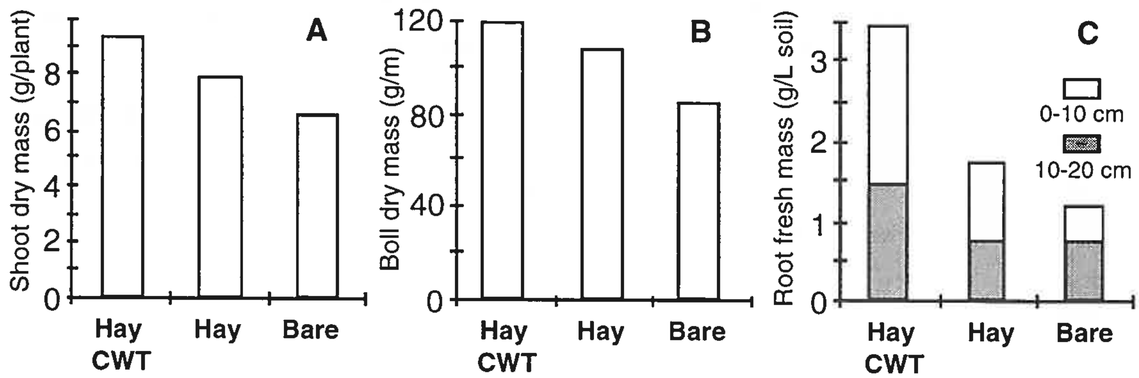

Figure 2. Maintaining moisture at the soil surface in a furrow irrigated field increased (A) shoot growth in December, (B) boll production in January and (C) root growth near the soil surface in January. Hay = hay mulch. CWT = constant water table in the centre of the 2 m bed. Bare = untreated.

A second soil moisture experiment was conducted in furrow irrigated fields that were affected by bacterial stunt to a greater (Field 19) and a lesser (Field 4) degree.

Supplementary water was applied periodically by either drip irrigation or a wick running down the centre of the 2 m beds. Hay mulch was used in these treatments to prevent evaporative loss. Again, early cotton growth and subsequent boll production were accelerated by these treatments (Table 2). In Field 4, seed cotton yield was increased by 14 to 19 %. Despite the early increases in growth and boll production in Field 19, the control plants (bare) finished as well as those in the other treatments (Table 2).

Table 2. Maintaining moisture at the soil surface in furrow irrigated fields increased shoot growth in December, boll production in January and seed cotton yield.

		Drip Hay	Wick Hay	Hay	Bare
	Shoot dry mass (g/plant)	11	12	-	7
Field 19	Boll dry mass (g/m)	119	121	-	81
	Seed cotton (kg/m)	0.61	0.62	-	0.61
	Shoot dry mass (g/plant)	16	16	12	11
Field 4	Boll dry mass (g/m)	177	111	134	125
	Seed cotton (kg/m)	0.61	0.60	0.58	0.51

Wick = periodic application of extra water with a wick buried in the centre of the 2 m bed. Drip = periodic application of extra water with drip lines on top of the bed. Hay = hay mulch. Bare = untreated.

In a third experiment, an additional furrow irrigation was applied in November to large field plots in a furrow irrigated field where bacterial stunt occurs. Shoot growth and N uptake in December were increased by 46 % and 31 % respectively, suggesting that the extra water gave the plants greater access to nutrient reserves in the soil. However, this early growth increase did not result in greater boll production. By January the N content of cotton given the November irrigation had fallen below that of cotton with the conventional irrigation schedule. Consequently, cotton given the extra irrigation cut out early and, although it had 15 % more lint in open bolls in March, there was ultimately no increase in yield.

Conclusion

The growth increases caused by mulching and maintaining soil moisture were associated with proliferation of roots in the topsoil. Furthermore, the proportion of roots was greater near the surface, suggesting that greater access to the fertile layer of topsoil was responsible for the improvement. The effect of these treatments on the bacterial stunt pathogens is currently being determined. There is clearly potential to increase early season growth by optimising conditions for the plant in these nutrient rich soils, even in soils not badly affected by bacterial stunt (Field 4, Table 1).

The early gains in cotton growth with mulching and extra soil moisture resulted in advanced crop maturity. However, with a long hot season in 1997/98, cotton growth and yield in the control treatments ultimately caught up. The experiments were conducted in fields that were managed for conventional crops, not the experimental treatments. The challenge now is to convert the gains in early season growth into yield increases. Our treatments need to be adapted for broadacre farming: covercrops and drip systems are the subject of further research.

Acknowledgments

Thanks are extended to the staff of Auscott Narrabri for cooperation with field trials and to Dr J. Triantifilis for access to the Edgeroi Data Set. This research was funded by the Cotton Research and Development Corporation as part of the Cooperative Research Centre for Sustainable Cotton Production.

References

McGarry, D., Ward, W. T. & McBratney, A. B. (1989). *Soil studies in the lower Namoi valley - Methods and Data 1: The Edgeroi data set.* CSIRO Division of Soils: Australia.

Nehl, D. B., Allen, S. J. & Brown, J. F. (1996a). Mycorrhizal colonisation, root browning and soil properties associated with a growth disorder of cotton in Australia. *Plant and Soil* **179**, 171-182.

Nehl, D. B., Allen, S. J. & Brown, J. F. (1996b). Bacterial stunt of cotton: a balance between beneficial and harmful soil microbes. In *Proceedings of the 8th Australian Cotton Conference* pp. 683-690. Australian Cotton Growers Research Association: Broadbeach, Australia.