Determining physiological cutout in ultra-narrow row cotton

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Abstract

Cotton is a perennial plant that is grown as an annual crop. Production of new fruiting sites continues until the demand on the resource supply by developing fruit leaves no surplus for the initiation of new leaves and fruiting sites. This stage is termed physiological cutout. The timing of physiological cutout is strongly correlated to the timing of crop maturity. Determining cutout is important for managing the crop to ensure that there has been sufficient time to produce yield and that unfavourable conditions at harvest are avoided. For conventionally spaced crops (1 m row spacing), previous studies have related timing of physiological cutout to the time at which the number of nodes above the highest white flower (NAWF) declines to four. Data were collated from six field experiments conducted over four seasons to investigate whether ultra-narrow row cotton (UNR, rows < 40 cm apart) production systems affect (1) the response of NAWF vs. days after sowing, and (2) the relationship between physiological cutout and physiological maturity. Across the experiments the UNR crops reached NAWF = 4 significantly earlier than conventionally spaced crops. However, the timing of cutout was not a good indicator of crop maturity in UNR crops as there were no differences between row spacings in time to 60% mature bolls. Further investigations are needed to determine whether using a different number of NAWF can be linked to crop maturity or whether other tools will need to be developed to assist with late season crop management decision (e.g. determining the timing of last irrigation) for UNR crops.

Key Words

cotton, row spacing, nodes above white flower, maturity, cutout

Introduction

Cotton is an indeterminate species. The timing of crop maturity is determined by when the plant stops producing new fruit (‘cutout’) due to the demand on the assimilate supply by growing fruit leaving none for the initiation of new fruiting sites (Hearn 1994). Cotton growers need to manage the timing of cutout for their particular region and season as it has important implications for maintaining both cotton yield and fibre quality. An early cutout and thus early maturity may reduce yield (Bange and Milroy 2004), while a late cutout can lower fibre quality as harvest preparation (chemical defoliation) and the harvest operation may cause increased trash and more immature fibre as a result of cold and wet conditions (Bange *et al.* 2010). Monitoring the timing of cutout also has important implications for application of growth regulants and late season pest and irrigation management.

To optimize yield and quality, the timing of cutout should allow for all the fruit on the plant to mature and open. This time can be estimated by predicting the date when the last effective flower is produced. A technique that has been employed by growers in conventionally spaced (1m rows) crops to monitor when and how quickly they are approaching cutout is to track the number of nodes above the last white flower present on the plant (NAWF). Previous research has shown that when the last effective flower is produced (the time of physiological cutout) it coincides with when NAWF equals 4 (Bourland *et al.* 2001; Bourland *et al.* 1992). Other studies have shown that at this time the crop has attained 98% of it harvestable yield (Hake *et al.* 1996a).

Few studies have investigated the use of NAWF for determining cutout in ultra-narrow spaced cotton systems (UNR - rows < 40 cm apart). UNR cotton plants tend to be smaller with fewer fruiting branches resulting in less fruit per plant (Brodrick *et al.* 2010) compared to conventionally spaced cotton. These differences may change the time course of NAWF as well as the relationship of physiological cutout to

NAWF=4. These relationships need to be assessed to ensure they provide appropriate tools for managing UNR crops. To assess the utility of the NAWF approach to assist in late season management of UNR cotton, growth and NAWF data from conventionally and UNR spaced crops grown in Australia were collated and compared.

Methods

The development of NAWF and the relationship of NAWF=4 to physiological cutout between UNR and conventionally spaced systems were compared by collating data from six experiments grown across four years near Narrabri, Australia (Table 1). All crops were provided with appropriate nutrition and used commercial insect control. All crops were fully irrigated with the exception of Exp. 2 that had a treatment with the second last irrigation skipped. Management was similar across all experiments and treatments.

Table 1. Sowing date, treatments and varieties in Exps. 1 to 6.

Exp	Sowing Date	Treatments	Variety
1	10 Oct 2001	Variety Conventionally Spaced	Eight varieties differing in morphology, background and maturity, listed in Bange and Milroy (2004)
2	13 Nov 2002	Variety Conventionally Spaced Late stress (skipped second last irrigation)	As above
3	16 Nov 2001	UNR Conventionally Spaced	Sicala V-3RRi
4	10 Oct 2002	UNR Conventionally Spaced	Sicala V-3RRi
5	23 Oct 2003	UNR Conventionally Spaced	Sicala V-3RRi
6	17 Oct 2006	UNR Conventionally Spaced	Sicot 71BR

UNR and conventionally spaced production systems were compared in four experiments (Table 1). UNR plots consisted of six rows spaced 0.25 m apart on a 2 m bed sown with 36 plants/m^2 and conventionally spaced plots of two rows spaced 1 m apart on a 2 m bed sown with 12 plants/m^2.

In all experiments starting just before first square, 1 m^2 plant samples were harvested approximately every 10 days and leaf area, dry weight of fruit, leaf and stem determined. Crop growth rate and fruit growth rate were derived from the differential of the logistic function of average total dry matter and fruit dry matter versus days after sowing (DAS). Physiological cutout (carbon balance equals zero) was calculated as the days after sowing where fruit growth rate equalled crop growth rate (Bange and Milroy 2004). Mean values of NAWF for each row spacing were determined from regressions of the NAWF against DAS. NAWF was measured weekly from first flower on 10 plants in each plot (Hake *et al.* 1996b). To determine maturity (60% bolls open), four to five successive counts and harvests of open bolls in 2 m^2 of each plot were taken in all experiments.

Results

In experiments 3 to 6 the UNR crops reached NAWF = 4 significantly earlier (8 d) than the conventionally spaced crops (Figure 1). Across all experiments there was a significant linear relationship between physiological cutout and the DAS when NAWF = 4 (Figure 2). Stepwise linear regression analysis showed that for this relationship, UNR and conventionally spaced treatments did not differ significantly. However, in experiments 3 to 6 DAS to 60% open bolls (crop maturity) did not differ significantly between row spacing treatments (Table 2).

Table 2. Days after sowing to crop maturity in UNR and conventionally spaced treatments in Exps. 3 to 6. (n.s = no significant difference).

Experiment	UNR	Conventionally Spaced	LSD
3	144.3	148.8	n.s.
4	146.0	148.3	n.s.
5	156.1	150.0	n.s.
6	174.0	177.7	n.s.

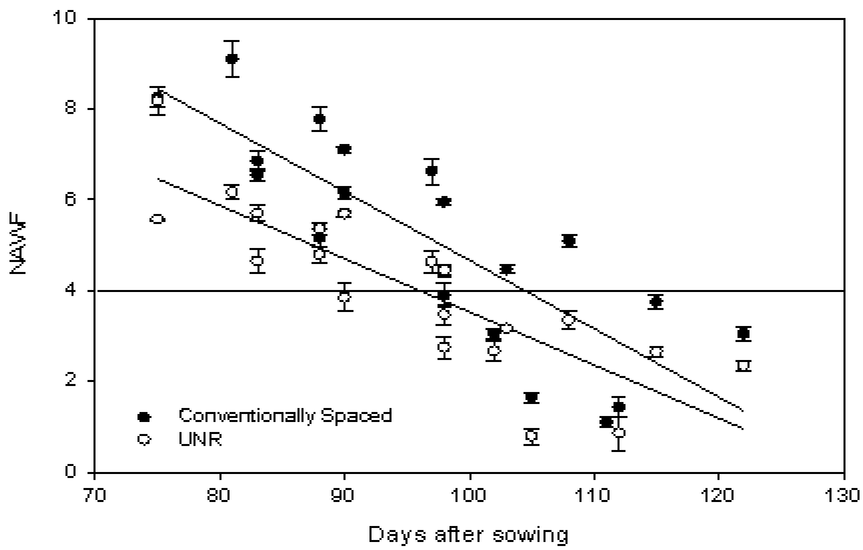

Figure 1. Average nodes above white flower versus days after sowing for conventionally spaced and UNR treatments in Exps. 3 to 6. Error bars are two standard errors of the mean.

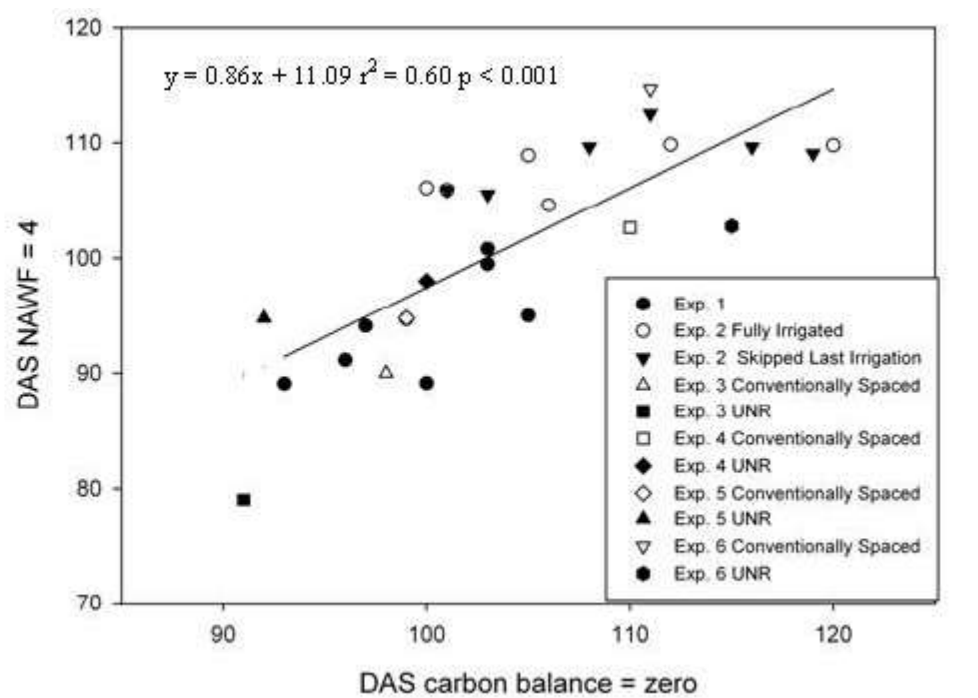

Figure 2. Relationship between physiological cutout (carbon balance equals zero) and DAS to NAWF equal 4 for Exps. 1 to 6.

Discussion

The aim of this study was to determine whether using NAWF=4 could be used as a tool to estimate cutout and assist in making late season management decisions in UNR spaced crops grown in Australia. We showed that the relationship between physiological cutout (carbon balance equals zero) and NAWF=4 was not affected by row spacing. Using a relationship of physiological cutout to NAWF=4 using a carbon balance approach for whole crop growth (CGR=FGR) was the first attempt of this kind for both conventional and UNR crops. Across four seasons and six experiments carbon balance = zero showed a significant linear relationship to NAWF =4. Bourland et al. (1992) used a carbon balance approach that employed leaf photosynthesis and boll growth and were able to demonstrate that cutout and the last effective flower occurred at NAWF=5 for a conventionally spaced crop in Arkansas. Others have used last effective flower and % of final yield as an indicator of cutout and compared these to the number of NAWF to further assess this relationship and found that effective flowering contributing to yield can range from NAWF 3 to 6 across a range of environments (Bednarz and Nichols 2005; Viator *et al.* 2008).

Physiological cutout has been linked to crop maturity in conventionally spaced cotton (McConnell *et al.* 1995). However, for UNR spaced crops in this study, although they reached NAWF=4, and hence cutout much earlier than the conventionally spaced crops, this did not translate into differences in crop maturity. Gwathmey et al. (1999) in Tennessee U.S.A. also found that NAWF was earlier for UNR compared with conventionally spaced cotton and that using the same NAWF to estimate cutout in conventionally spaced cotton crops did not represent last effective flower contributing to the timing of maturity in UNR. Their study also showed that as much as 98% of yield of the crop had not yet been set by cutout in UNR compared with the conventionally spaced systems. Viator et al. (2008) assessed NAWF between conventionally spaced and 19-25 cm UNR spaced rows across a wide range of environments in the U.S.A concluded that last effective boll in UNR crops occurred NAWF 2 and at NAWF 3 for conventionally spaced crops.

Further investigations into the relationship between physiological cutout, NAWF and crop maturity are needed to determine the utility of NAWF approach for UNR crops in Australia. Last effective flower and maturity may be predicted by a different number of NAWF than currently used in conventionally spaced crops or possibly other monitoring techniques could be needed to be developed to assist with late season crop management decisions (e.g. timing of late pest control; last irrigation) in UNR crops.

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