LEAF NITROGEN GRADIENTS IN COTTON CANOPIES VARY WITH ONTOGENY AND NITROGEN SUPPLY

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Abstract

Leaf nitrogen (N) concentration usually declines with depth in plant canopies. For use in a framework to scale-up from leaf photosynthesis to canopy radiation use efficiency, we quantified the leaf N gradients in the canopies of three cotton crops. Stratified cuts were taken regularly, starting around the time of first square, and the leaf area index (LAI) and leaf N concentration in each layer determined. The slope of the regression of specific leaf nitrogen (SLN, g N/m^2 leaf) against cumulative LAI from the top of the canopy increased with ontogeny. It was also more marked under low N supply than high supply.

Key words: Gossypium hirsutum, leaf nitrogen, nitrogen distribution, ontogeny

Radiation use efficiency (RUE) of cotton crops varies with ontogeny and leaf N accounts for part of this variation (6). Hammer and Wright (2) have developed a framework which can be used to scale-up from leaf photosynthesis to canopy RUE. The framework allows for the leaf N gradients within canopies and calculates photosynthesis by leaves at different levels in the canopy as a function of their N status and light receipt. This paper presents canopy gradients of SLN for use within this framework with the aim of exploring the mechanism by which ontogeny and leaf N affect RUE. The final purpose is to improve the response to nitrogen within the CERCOT cotton crop simulation.

Methods

Measurements were made on two field experiments grown on a uniform grey clay at Narrabri, NSW. The crops were sown on a 1 m row spacing with 10 plants/m^2. Full irrigation and commercial insect control were used. In Experiment 1, cotton (cultivar Siokra L22) was sown on 11 Oct. 1995. On 9 Aug., 150 kg/ha of N was applied as anhydrous ammonia. Each plot was 175 m 5 4 rows and there were three replicates. In exp 2, two N treatments were established: nil and 150 kg/ha as anhydrous ammonia applied on 28 Aug. Cultivar Sicala V2i was sown on 14 Oct 1996. A completely randomised design and four replicates were used. Plots were 75 m 5 4 rows. Each fortnight, beginning around the time of first square, 1 m^2 destructive samples were taken. The canopy was cut in four successive strata of equal vertical thickness. The leaf area (hence LAI) in each layer was measured and the leaves dried and weighed. N concentration (g N/g DM) was determined using a near infrared refractometer or a Leco machine, both calibrated against the Kjeldahl method.? Sampling continued until the period of maximum boll growth was over and the crop was approaching maturity. Seven stratified harvests were made in Experiment 1 and six in Experiment 2.

Results and discussion

In Experiment 1, pooling data across all samplings, a strong linear relationship was found between *ln* SLN and cumulative LAI from the top of the canopy (Fig. 1). The production of branches by the cotton plant means that at any height in the canopy there are leaves of a variety of ages. Nevertheless, clear N gradients were still apparent. This is consistent with the hypothesis that leaf N concentration is influenced by light receipt as well as age (3, 5). In Experiment 2 the gradient varied with ontogeny and became steeper ($P<0.01$) as the reproductive sink increased (Fig. 2). In contrast, N gradients in sunflower were more uniform in the reproductive than in the vegetative phase (7). This difference may be due to the indeterminate nature of cotton and/or the different distribution of reproductive sinks in the canopy. In Experiment 2, the gradient was greater for the low N treatment than for the high N treatment ($P<0.001$) (Fig. 1). A non-uniform N distribution in plant canopies results in higher canopy photosynthesis than a uniform distribution by maximising N in leaves which receive the most light (4), although alternative

reasons for the existence of gradients have been proposed (1). The greater N gradient in the low N treatment may reflect a mechanism that increases the efficiency with which limited N is used in photosynthesis. Investigations into the possible causes of ontogenetic changes in N gradients in cotton and their implications are continuing.

Conclusion

Leaf N gradients in cotton canopies were found to vary with N supply and ontogeny. In contrast to published data on other species they became steeper in the reproductive phase.

Acknowledgments

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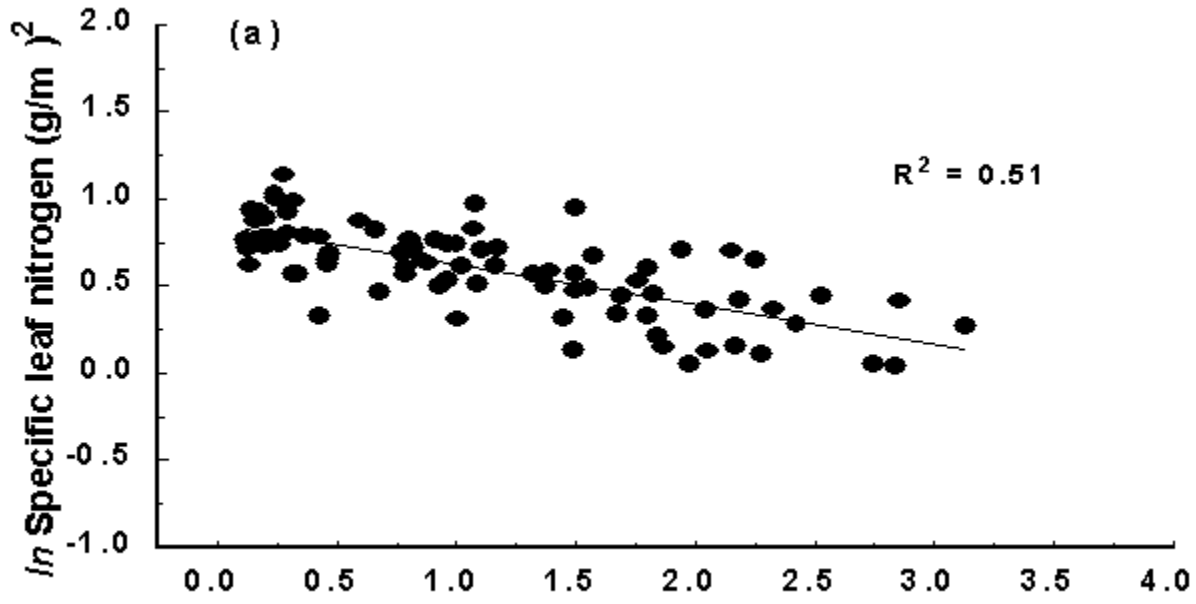
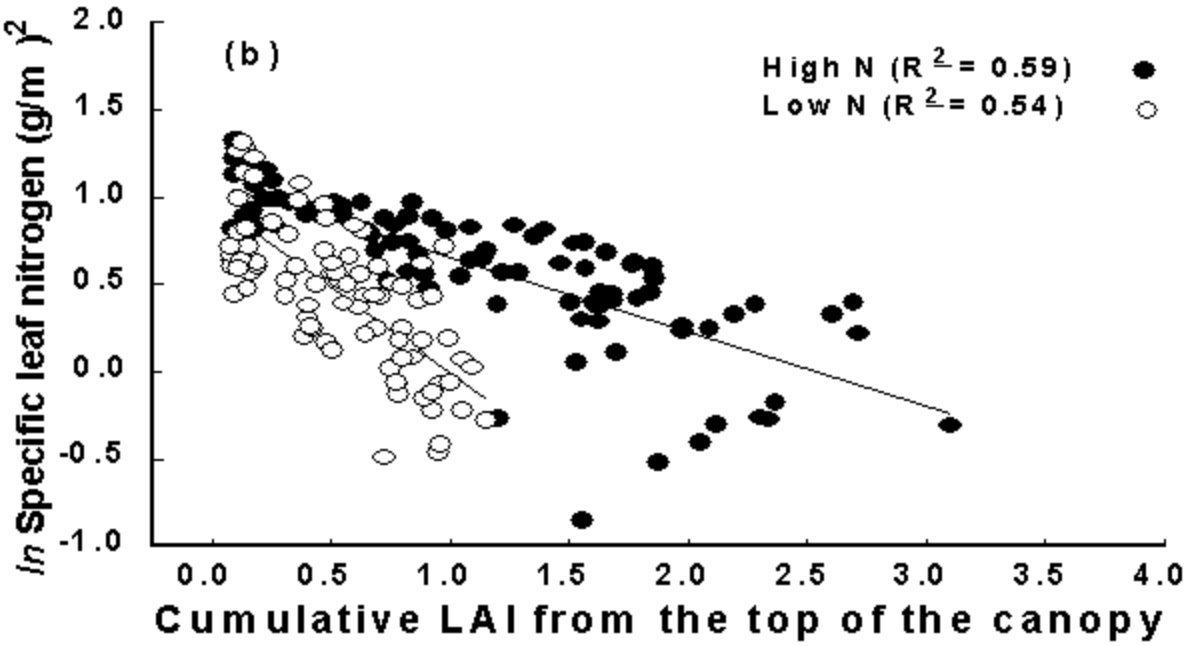
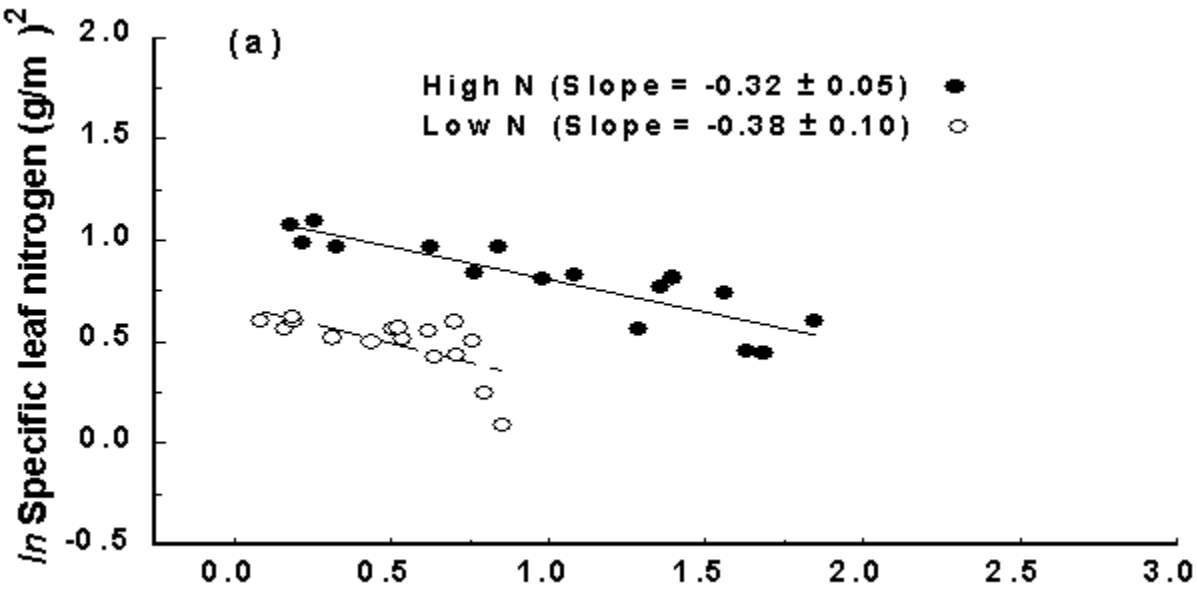
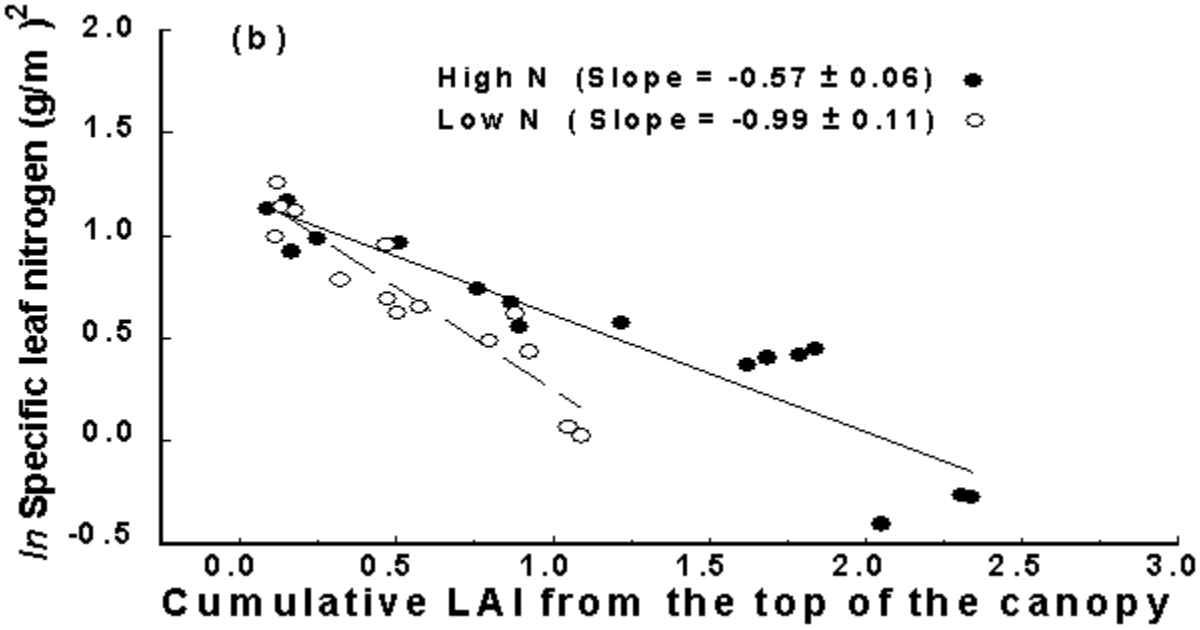



(b)
High N (R^2 = 0.59)
Low N (R^2 = 0.54)
ln Specific leaf nitrogen (g/m)^2
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Cumulative LAI from the top of the canopy


(a)
High N (Slope = -0.32 ± 0.05)
Low N (Slope = -0.38 ± 0.10)
ln Specific leaf nitrogen (g/m)^2
2.0
1.5
1.0
0.5
0.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0


(b)
High N (Slope = -0.57 ± 0.06)
Low N (Slope = -0.99 ± 0.11)
ln Specific leaf nitrogen (g/m)2
2.0
1.5
1.0
0.5
0.0
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Cumulative LAI from the top of the canopy