

## **Determinacy in cotton: measurement and potential implications**

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### **Abstract**

Cotton is an indeterminate species. However, the term 'determinate' is applied to cultivars that terminate reproductive development comparatively abruptly and do not readily begin a second fruiting cycle. It has been suggested that low determinacy may have agronomic benefit when intermittent stresses interrupt reproductive development. We developed two objective measures of determinacy. The first reflects the speed with which a cultivar approaches the point where dry matter is monopolised by developing fruit. The second reflects the outcome of this process in terms of the declining rate of node production relative to the rate at which flowers are exerted on successive nodes up the main stem. Both were correlated to the breeders' subjective assessment of determinacy but were also strongly correlated to each other. It will be necessary to demonstrate the repeatability of this approach to assessing determinacy and to test its applicability under a range of conditions and with different groups of cultivars. Experiments to use these measures to explore whether low determinacy confers an advantage in conditions of intermittent drought stress, such as dry land cotton production, are underway.

### **Key words**

Development, fruit, partitioning, phenology, reproductive partitioning.

### **Introduction**

Cotton is an indeterminate species. The mainstem does not terminate in a reproductive meristem. The terminal is morphologically capable of continuing to produce new nodes that exert branches on which the fruit are born. 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. The concept of cotton crop 'determinacy' is used to describe how abruptly a cultivar tends to cut out and how readily it will start a second cycle of fruit production (1). A so-called determinate cultivar is one that cuts out abruptly and will not readily start a second fruiting cycle.

It has been suggested that cultivars with low determinacy are important for rainfed production because they allow growth to resume more readily after retardation due to drought stress. In irrigated crops, low determinacy may allow a higher degree of recovery from damage by insects later in the season. However, there is little documented evidence of the efficacy of these concepts.

The degree of determinacy is strongly associated with whether a cultivar is a short or long season type. Short season cultivars are widely considered determinate. While cultivars are described as determinate or indeterminate, there is no empirical evidence demonstrating the existence of such a trait independent of maturity type. As a preliminary step toward determining the value of determinacy as an agronomic trait, we explored whether varietal (genetic) variation in determinacy actually exists and how this might be characterised. The growth of eight cultivars, which have been qualitatively assessed as differing in determinacy and maturity, were studied in the field. The degree to which they differed in their ability to continue to produce new organs during increasing boll load was explored.

### **Materials and methods**

Three field experiments were conducted at Narrabri (30.31° S 149.78° E), Australia in the 1999-2000, 2000-2001 and 2001-2002 seasons. Each experiment included two sowing times so as to generate

variation in temperature and radiation regimes, which in turn would influence dry matter production and fruiting patterns. Cotton lines with known differences in timing of crop maturity and determinacy, as assessed by the CSIRO cotton breeding team, were used (Table 1).

Sowing times and lines were combined factorially. Plots (8 m by 18 m), containing eight rows spaced at 1 m, were sown in October (S1), and November (S2). Randomised complete block designs were used with three replications. The experiments were grown with full irrigation on a grey-clay soil utilising high input management and insect control as described in Hearn and Fitt (2).

**Table 1. Description of lines used in field experiments (P. Reid, personal communication).**

Name	Maturity	Determinacy
Tamcot HQ95	Very early	High
Siokra S-102	Early	Medium-high
89007-33	Early-medium	Medium-high
Siokra V-16	Medium-Late	Low
Selection 118	Late	Low
Sicot 189	Late	Low
CS 8S	Early	Medium
Albar G501	Very late	Low

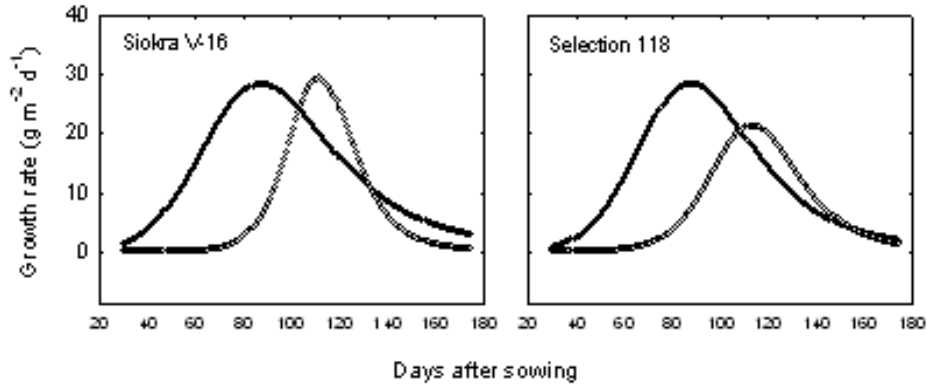
In the first two experiments, starting just prior to the appearance of the first square, destructive plant samples were taken from 1 m<sup>2</sup> quadrats approximately every two weeks. Total dry weight and dry weight of leaf (laminae), stem (including petioles), squares (flower buds), green bolls (capsules) and open bolls were determined.

In the third experiment, after the plants had reached first flower, the number of nodes above the highest open flower on the plant was counted each week. This number declines due to increasing boll load as the rate of node production slows but the rate at which flowers are exerted (and hence open) at successive nodes up the main stem remains constant.

## Results

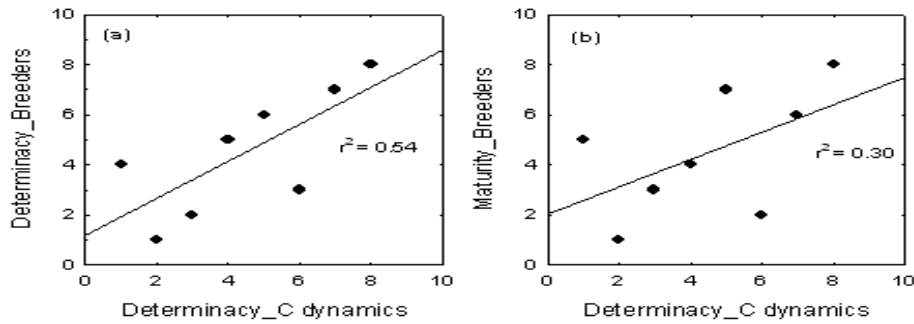
The cultivars differed in their pattern of dry matter accumulation and partitioning. Two examples of the variation of crop and fruit growth rate over time are presented in Figure 1. There appeared to be a tendency for cultivars that had been described by the breeder as determinate to approach the point where the fruit biomass accumulation rate matched the total dry matter accumulation rate more rapidly. By ranking the cultivars within each time of sowing according to the degree of abruptness with which they approached this point, that is the angle of intersection of the lines, and averaging this across the sowings and years, a determinacy ranking was derived. This was found to be well correlated with the breeders'

ranking (Figure 2a). However, since maturity and determinacy ranking of the breeder were highly correlated, our derived ranking also correlated with maturity (Figure 2b).

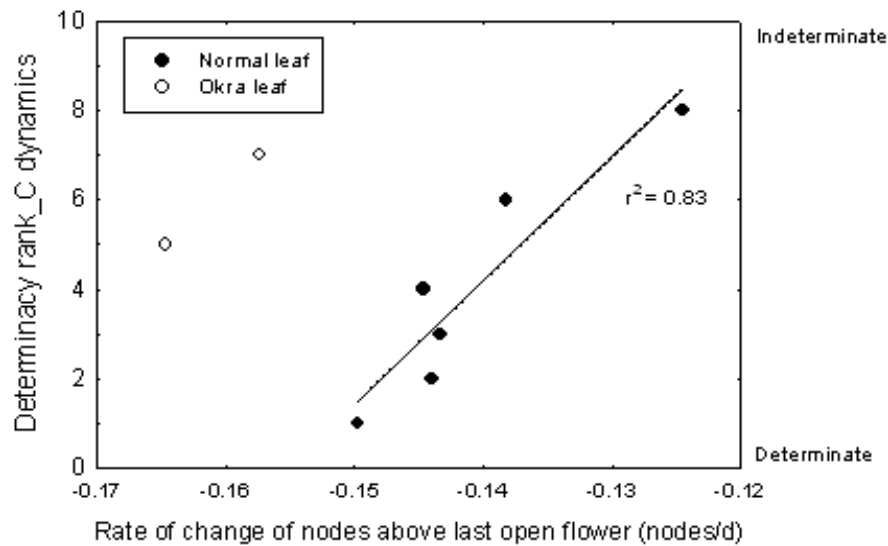


**Figure 1. Examples of crop growth rate (closed symbols) and reproductive growth rate (open symbols) used to derive determinacy ranking.**

In the third experiment an alternative measure was determined for each cultivar. This was derived from the rate of decline in the number of nodes above the highest open flower. The values ranged from -0.125 nodes per day for Albar G501 to -0.165 nodes per day for Siokra S-102. The rate was weakly associated with the breeders ranking for determinacy but well associated with the physiologically derived determinacy ranking except for the two okra leaf cultivars (Figure 3). The okra leaf cultivars were markedly offset from the regression line for the normal leaf cultivars.



**Figure 2. Comparison of rankings of cultivar determinacy (a) and maturity (b) from CSIRO breeding team (G.A. Constable, personal communication) with determinacy ranking derived from carbon dynamics.**



**Figure 3. Determinacy ranking of cultivars derived from carbon dynamics versus the rate of change of nodes above highest open flower as an alternative measure of determinacy.**

## Discussion

This is the first study that we are aware of to attempt to derive an objective, quantifiable measure associated with determinacy in cotton. That both the biomass accumulation and flowering rate indices were correlated to the breeders' field assessment suggested that they might provide a suitable basis for an index of determinacy. The measure based on rate of decline in nodes above last flower is the simpler of the two for field use. That the two measures were well correlated, even though they were derived from different experiments, indicated a likely link between the putative physiological process and the morphological outcome and thus adds weight to the validity of the more simple approach.

The offset of the two okra leaf cultivars in the correlation between the two indices (Figure 3) could relate to leaf-size profiles on okra compared with normal cultivars. Okra leaf cultivars have smaller individual leaves and this is exacerbated at higher node positions by declining temperatures (3). The result is a more rapid decline in canopy photosynthesis as the canopy ages and so, because of competition from the fruit, a more abrupt reduction in node production and hence the more rapid decline in the number of nodes above the highest open flower in the okra cultivars. This mechanism will be explored in more detail in future experiments, which will include more okra leaf cultivars.

Experiments are currently underway to assess whether those cultivars that were assessed as indeterminate show any greater ability to tolerate drought stress in terms of their ability to continue to produce fruit or reinstate fruit production after a stress.

## Acknowledgements

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## References

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