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Temperature requirements for cotton

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Cotton originated in hot, dry regions and prefers those conditions to achieve maximum production. Although cotton is now modified and adapted to grow in a broad range of environments, temperature during the growing season—both by its range and duration—has a dominant influence on sowing date, growth rates, fruiting, yield and fibre quality. Cotton therefore does best in areas with a long, hot season. The higher the average temperature (within reason), the faster cotton will grow and develop. The longer and hotter the season, the higher the potential yield.

Length of season varies from year to year, determined by the date of the last spring and first autumn frosts and by the level of spring and autumn temperatures. In New South Wales, north and north western production areas (such as Mungindi, Collarenebri and Bourke) enjoy a longer season than southern and more easterly areas (such as Breeza, Trangie and Hillston).

Prevailing temperatures limit cotton production—particularly in cooler seasons, at different sowing dates and in different locations. Although soils and other environmental factors influence production of reliable yields, temperature is the dominant environmental factor affecting crop development and yield.

EFFECTS OF TEMPERATURE

Temperature influences cotton production in several ways: it determines the earliest date for sowing, and affects the rate of plant growth and development, fibre quality, and the length of the growing season.

Timely sowing into a warm seedbed guarantees good seedling vigour, allows maximum time for growth and development of the crop, and ensures maximum yield at the earliest date. Photo: A. J. Shaw.

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Table 1. Effect of soil temperature on seedling emergence

Soil minimum temperature at 10 cm (° C)	*Seeds emerging and surviving (%)*	*Days to complete emergence*
10	56	29
14	73	17
18	90	5

Sowing time. During spring, soil temperature determines the earliest date of sowing. You can start sowing cotton when soil minimum temperatures at 10 cm depth exceed 14° C for at least three days. In most areas this temperature is reached in late September. Because of the variability of the Australian climate, soil temperatures often rise in mid September, then fall again in late September or October.

Growth and development. Warm soil encourages rapid, uniform emergence, and the speed of plant growth is directly related to temperature (see Table 1). As is shown in Figure 1, the higher the average temperature, the fewer the number of days from sowing to squaring (production of flower buds). As the average temperature drops, the length of this period increases rapidly. For example, a drop in average temperature from 26 to 25° C will lengthen the time from sowing to squaring by about three days; but a drop from 18 to 17° C will lengthen it by 14 days. At 12° C, all cotton development ceases. This value is used in calculating day degrees (see below, under that heading).

Fibre quality. During fibre development (January to March), temperature has a strong influence on quality, particularly fibre diameter (micronaire). A reduction in micronaire can incur high price penalities. In cool seasons or in cooler areas, or with late sowings, a greater proportion of fibre develops during February and March, so reductions in micronaire are more likely.

Length of growing season. Frost will stop growth of cotton plants or even kill them, so the date of the first frost in autumn determines the end of the season. Bolls that are not fully developed by this date are unlikely to open for harvest. The date of first frost therefore also determines date for the last effective flower (one that will produce a mature boll) for a given region—see later section.

Day degrees

Heat accumulation, calculated progressively during the season to monitor the crop's progress, is expressed as 'day degrees' or heat units. Daily

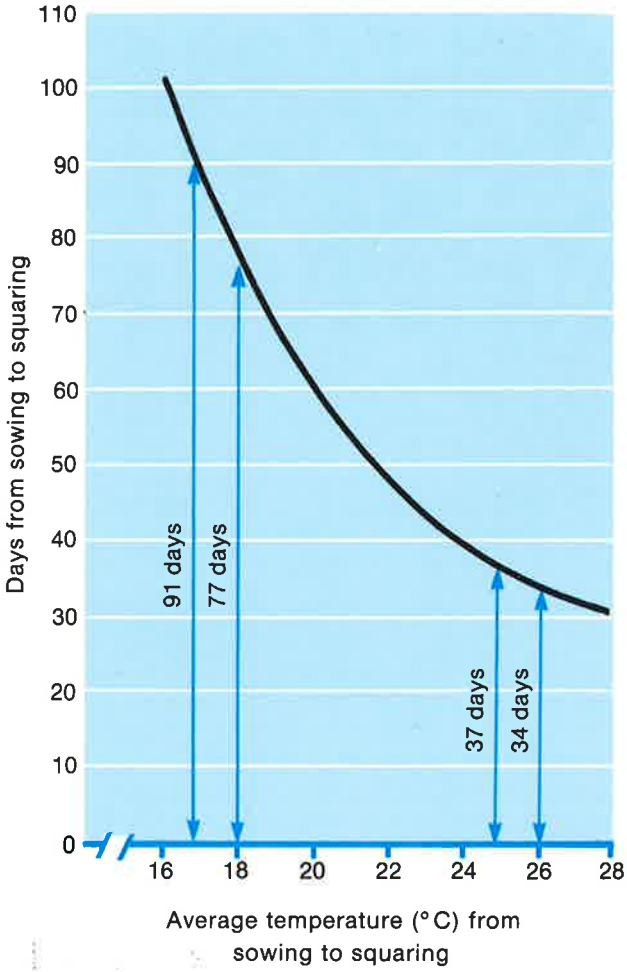

Figure 1. Plant growth is much faster in warmer climates.

values are summed over the developmental phase of a crop or over a season, and a crop's actual progress can be monitored for comparison with its potential development.

Day degrees (DD) are determined by subtracting 12° C from both the daily maximum (Tmax) and the daily minimum (Tmin) temperature and averaging them according to the following equation (note that if the minimum is less than 12° C a value of zero is used):

$$\text{day degrees} = \frac{(\text{Tmax} - 12) + (\text{Tmin} - 12)}{2}$$

Examples

Maximum = 35, minimum = 15: $\text{DD} = \frac{(35 - 12) + (15 - 12)}{2} = 13$

Maximum = 20, minimum = 10: $\text{DD} = \frac{(20 - 12) + (0)}{2} = 4$

Typical values for the total number of day degrees between sowing and some developmental phases are shown in Table 2.

The day degree values are presented as a guide: actual values in the field can be slightly less or greater depending on other factors such as cultivar, soil condition, pest attack, disease, and herbicide damage. One major factor

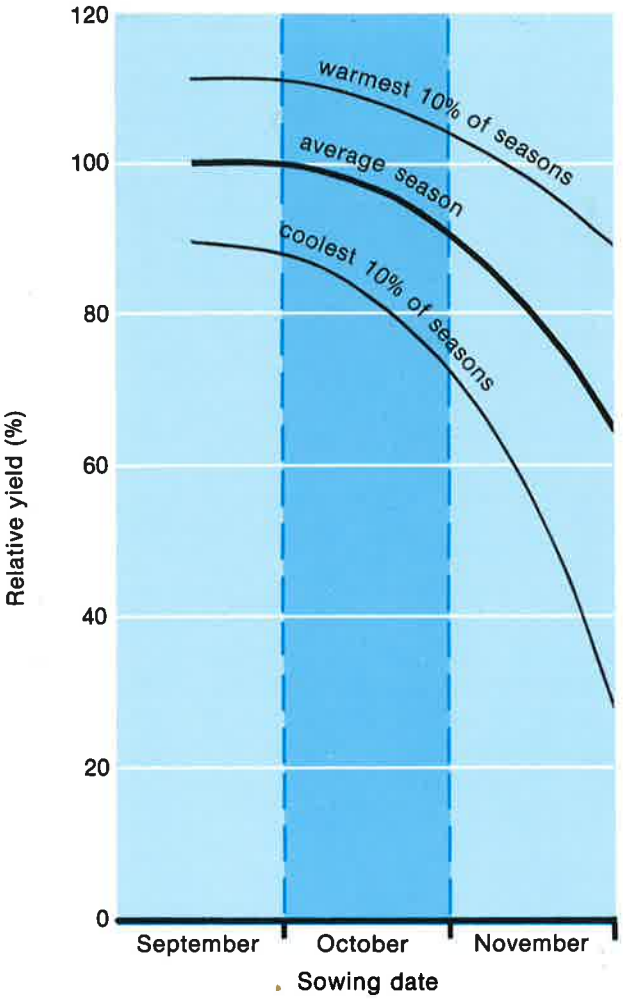

Figure 2. Crops sown after mid October show a drop in yield. The effect is most marked in cool seasons.

affecting seedling growth rate is chilling injury (cold shock). It has been found that a daily minimum temperature below 11°C injures cotton plants, resulting in delayed growth the following day, regardless of the maximum temperature. On average, the day degree requirements for flowering detailed in Table 2 are increased by 5.2 for each day that the minimum temperature falls below 11°C.

SOWING DATE

As outlined earlier, soil temperature determines the beginning of sowing, with 14°C minimum a critical value. It is also wise not to sow much earlier than the expected last frost, as seedlings may be killed and resowing may be necessary.

Research results and commercial experience emphasise the importance of early sowing (late September/early October) in all cotton-growing areas. This is especially so in areas with a short growing season, if high and profitable yields are the goal. Early sowing allows maximum time for crop growth and development and ensures maximum yield potential at the earliest date.

If you are farming in an area with a short growing season, you must take calculated risks

Table 2. Total day degrees for some phases of development: typical values

Phase	*Total day degrees*	*Days at 28/20° C**
Sowing to final emergence	80	7
Sowing to squaring	505	42
Sowing to flowering	777	65
Flower to open boll	750	63

*Day/night

at sowing time: plant early, but try to avoid late frosts and cold snaps. There is, however, a limit to just how early cotton can be sown. Although mid September sowings are possible, these stands face a greater risk of frost damage, and may suffer severely from slow emergence, seedling disease, poor early vigour and exposure to herbicide damage.

Sometimes, no matter how vigilant you are, there are times when you cannot achieve the ideal sowing date, for example:

- Rain may delay soil preparation and sowing.
- Frost, herbicide or hail damage may destroy an established stand so that resowing is necessary.
- On a large cotton property it may take a long time to sow the full area, so the last fields are sown up to three weeks after the first fields.

It is therefore important to understand the precise response of cotton to sowing date, remembering that temperature will determine the rate of growth and development of the cotton plant.

The effect of sowing date on yield of cotton at Narrabri is shown in Figure 2. These data are derived from experiments on Deltapine types at Narrabri Agricultural Research Station and show that sowings before mid October have similar yields. After that date, yield falls rapidly, maturity is delayed and there is a decline in fibre micronaire.

Separate experiments in recent seasons have shown that the cultivar Siokra is more suited to late sowings (late October, early November) than Deltapine types. Siokra is best sown in early October, but the decline in yield is less than in Deltapine if Siokra is sown later.

Also shown in figure 2 is the expected variation in crop yields over a range of seasons. Cooler seasons are likely to produce lower yields, particularly from late sowings. For this reason, in an area such as Narrabri, you should finish sowing by 10 November to be certain of achieving profitable yields. Latest sowings could be after 10 November in areas north and west of Narrabri, but should be earlier in areas further east and south.

Table 3. Long-term minimum temperatures and total day degrees, central and northern NSW

Location	*Sept*	*Oct*	*Nov*	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*
	Daily minimum temperature °C								
Goondiwindi	8.9	12.7	16.4	19.2	20.1	19.2	16.5	12.8	9.0
Narrabri	7.5	12.0	15.1	17.8	19.2	19.3	16.8	12.2	7.9
Trangie	5.9	9.6	13.5	16.5	17.9	17.3	14.9	11.3	7.4
Hillston	7.1	10.8	13.6	16.2	18.2	18.2	15.4	10.8	6.9
	Day degrees per month								
Goondiwindi	169	252	356	452	478	399	353	228	159
Narrabri	149	223	308	403	430	390	355	228	140
Trangie	114	186	269	375	415	350	302	185	119
Hillston	132	206	258	366	422	370	316	192	109

VARIATION BETWEEN PRODUCTION AREAS

Table 3 lists the long-term minimum temperatures and total day degrees for several areas in central and northern New South Wales.

These data show that minimum temperatures and day degrees per month are lower in more southerly areas, especially in autumn and spring. Long-term temperature records indicate that the months during the growing season in which the minimum temperatures are less than 11°C on 14 per cent of their days are:

- Hillston—October, November, December, March and April.
- Trangie, Narrabri, Goondiwindi—October, November and April.

This means that cotton crops in southerly areas are likely to suffer cold shock on more days than those in the north.

Table 3 also shows that September sowings are likely to experience more cool nights than October sowings. Hence September-sown crops are likely to suffer cold shock on more days, and will rarely yield higher, than October sowings.

The lower day degrees at Trangie and Hillston indicate that the potential yield in these regions is about 20 per cent lower than that at Narrabri. The longer days and drier summer weather in the south could be some advantage but are unlikely to make up for the cooler nights in spring and autumn.

Differences in climate between one growing season and another are important. The observations in Table 3 are based on long-term average figures, but seasonal differences in temperature can cause yields to vary significantly from the average. In hot droughty seasons, southern crops may yield just as well as those in the north; but in years when spring and autumn temperatures are cooler than average, crop development will be delayed and there will be a greater drop in yield.

When making comparisons, temperature variation **across** a region is also important. For example, Trangie (which was used in this comparison because long-term temperature figures are readily available) is cooler than the rest of the Macquarie cotton-growing area because it is located on the south eastern section.

Variation in the length of the growing season is illustrated by the date of the last effective flower, which blooms about 650 day degrees before the first autumn frost. This date is significant because it can influence decisions on pest control, irrigation and defoliation. The date of last effective flower in three of the areas is: Goondiwindi—13 March; Narrabri—4 March; Trangie—19 February. Hillston would be similar to Trangie.

Again these values are averages: the range at Narrabri is such that in 10 per cent of years the date of last flower is earlier than 21 February; in another 10 per cent of years the date is later than March 12.

Lower average yields can be expected in southern and eastern areas because of their shorter seasons, cooler autumns and springs, greater number of 'cold shock' days and lower total day degrees. How much lower they are will vary considerably from season to season depending on crop management and temperatures.

SUMMARY

- Cotton needs hot, dry conditions to achieve maximum production.
- There is little growth and development below 12°C, the base temperature used in day degree calculations. Below 11°C plants suffer cold shock.
- Begin sowing when minimum soil temperature at 10 cm depth is 14°C for at least three days. Earliest sowing dates in most regions are mid to late September.
- Sowings before mid October generally have similar yield potential. Yield declines rapidly for sowings after that date. Sowings after mid November are risky in all but the hottest areas.
- On average, cotton yields are lower in the more southern and eastern growing areas where seasons are shorter. Regional differences in yield will be less noticeable in longer, hotter seasons than in cooler years.

FURTHER READING

Climatic Averages, Australia, 1988. Bureau of Meteorology. Canberra, Australian Government Publishing Service. For sale from the Australian Government Bookshop, 120 Clarence Street, Sydney—phone (02) 29 1940 (or AGPS Phone Shop, Canberra—(008) 02 6148).

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