# SURVIVAL OF COTTON FRUITING FORMS AFTER A TEMPORARY LIGHT REDUCTION AS AFFECTED BY FRUIT AGE AND PLANT STRUCTURE

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## Abstract

Periods of low light intensity occur frequently during the reproductive growth of cotton in humid and sub-humid tropics. This paper reports the effects of a 4-days and an 8-days exposure of plants to low light intensity on the survival rate of fruiting forms according to their age and position. Age of fruits was a major determinant of survival rates after the stress. Consequences of excessive abscission on boll distribution and final yield are discussed according to the duration and timing of the stress

## Introduction

In humid and sub-humid tropics where cotton is grown during the rainy season, severe light reduction is often observed during cloudy and/or rainy days. For example, in some cotton growing areas of Thailand, daily global radiation may fall below 14.6 MJ $m^{-2}.d^{-1}$ (the minimum radiation taken into account in the GOSSYM simulation model) during several consecutive days. Such conditions are likely to promote shedding of fruiting forms (Goodman, 1955 and Jenkins et al., 1990) as a result of a deficiency of photosynthate (Guin, 1974). In addition, rain which often accompanies cloudy days may also cause shedding through mispolination of open flowers (Cogné, 1974) and/or through waterlogging (Hodgson, 1982 ).

After a four-days exposure of cotton plants to low light intensity, Guin (1974) reported an increase of abscission of floral buds (squares) and young fruits (bolls) associated with a reduction in net photosynthesis. However, variation in time and duration of shading was not considered as well as the age and position of the abscissed fruiting forms. In fact, fruit survival after a temporary nutritional stress such as light reduction is poorly documented. It should provide a better understanding of competition for assimilates between fruiting forms.

Our objective was to study the effects of timing and duration of a reduction in light intensity on seed-cotton production with a special emphasis on the survival of fruiting forms according to their age and position.

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## Materials and Methods

Trials were conducted with *Gossypium hirsutum* Thai cultivar SSR60 grown during the dry season (December to April) in order to minimize the occurence of cloudy days.

### Field trials

Two field trials were conducted at Suwan Farm Research station. Planting date was December, 15, 1994 and February 1, 1995 respectively. Plant population (1.7 $plants.m^{-2}$ with 1.25m between rows), irrigation and pest management were similar in both trials. However, there was no fertilizer application in the second trial. At 85 Days After Emergence (DAE), a black net providing a 60% light reduction was added for a period of 4-days or 8-days. The shading device was designed for covering 5 consecutive plants on a row. 5 devices per treatment were displayed at random in each trial and 5 groups of 5 consecutive plants not exposed to light reduction were chosen at random for control. During the period of light reduction daily solar radiation averaged 19.4 $MJ.m^{-2}.d^{-1}$ (+/- 3.2) in the first trial and 19 $MJ.m^{-2}.d^{-1}$ (+/-3.7) in the second trial.

### Pot trial

Individual plants were grown out-doors in 25 liter pots and were watered every day. Plants were kept free of insects damage by the means of insecticide spray performed every 10 days together with a 1mm mesh net that enclosed the growing area. Daily solar radiation avaraged 17.8 $MJ.m^{-2}.d^{-1}$ (+/- 3.1). Light reduction consisted in transferring pots for a period of 8 days under a black net providing a 60% light reduction. After exposure to shading, pots were returned to initial conditions. Treatments were: (T0) no exposure, (T1) exposure at 43 Days After Emergence (DAE), (T2) exposure at 63 DAE and (T3) exposure at 76 DAE. There were 20 pots per treatment dispatched at random in the growing area.

### Plant monitoring

In all treatments each fruiting site of 20 plants (pot trial) or 25 plants (field trials) were inspected at two-day intervals according to the procedure described by Constable (1991). Plant inspection was interupted during the exposure to light reduction. At harvest, open-bolls were harvested individually for yield determination.

## Results and discussion

### Fruit survival after exposure to shading

Subjecting plants to low light intensity increased fruiting forms abscission after two days and excessive abscission rate was recorded up to 10 days after plants were returned to normal conditions (data not shown). Thus, retention rate of fruiting forms mapped at the onset of light reduction was studied at 10 days after the end of exposure. Fruit survival patterns sh owed similar trends in all trials. As shown in Figure 1, excessive abscission that can be attributed to low light intensity was observed only with squares and young bolls (anthesis occured 20 to 22 days after square appearance). Young bolls abscissed the most but young and old squares were affected in a similar extent by light reduction (Fig.1). Abscission rates increased by almost 20% after a 4-days exposure and doubling the time of shading was associated with a two-fold increase of abscission. Contrastly, survival of bolls aged more than 30 days since square appearance (about 10 days after anthesis) were not affected by light reduction (Fig.1). Low abscission probability of old bolls has been reported by several authors (Hearn and da-Roza, 1985; Lieth et al., 1986 and Constable, 1991). It suggests the existence of a critical stage in boll development beyond which a boll will no longer absciss when a nutritional stress occurs. According to our observations, young bolls whose demand for photosyntates starts to increase exponentialy after anthesis (Wullschleger and Oosterhuis, 1990) would be the least competitive and absciss the most, followed by old squares and young squares.

After an early exposure to low light intensity (pot trial) excessive abscission was also high (70% increase) despite the presence of squares only. Abscission rate of young squares (0-5 days) was lower than that of older squares (72% for 64 squares mapped and 98% for 110 squares mapped respectively). At that stage, competition between squares was probably low since their requirement in assimilates is very small in comparison with assimilate supply (Constable and Rawson 1980) but competition with vegetative growth is likely to become accentuated during light reduction.

The effect of position on the abscission rate of all fruit-age categories as well as that of young bolls is illustrated in Figure 2 . Fruiting forms located on the first position on the sympodia abscissed less than those on other positions (Fig.2). This trend was observed also with each fruit-age category (data not shown). The proximity to the mainstem-leaf which is an important source of photosyntates for fruit growth (Wullschleger and Oosterhuis) could provide a competitive advantage to P1 fruits (Kerby and Buxton, 1981). However, fruit survival of other positions was not strictly inversely proportional to their distance to the mainstem (Fig.2). For example, there was no clear difference in survival between P2 and P3 fruiting sites.

**Seed-cotton production**

Severe reduction in seed-cotton and boll production were observed in field trials after an 8-day shading was imposed at 85 DAE (Table 1). The magnitude of reduction was close between the two trials despite a large diffrerence in the level of production. When the time of exposure was reduced to 4 days yield performances were slightly decreased in both trials but not significantly (Table 1).

In the pot trial, boll and seed-cotton production per plant were significantly reduced when plants were exposed to an 8-days light reduction at 63 DAE and at 76 DAE (Table 2). Early exposure (43 DAE) which occured prior the beginning of anthesis (56 DAE) did not affect yield nor the final boll load (Table 2). In this treatment almost all squares that appeared prior and during the light reduction abscissed. But this loss was compensated by a better fruit retention on upper nodes compared to that of the control plants as illustrated in Fig.3. Loss of fruiting forms associated with late exposures to light reduction occured on upper nodes and no significant compensation was observed (Fig. 3). This was probably the consequence of insuficient time for compensatory reproductive growth due to the fact that plant watering was stopped at the end of boll-opening of the control plants. Jones et al. (1996) reported that late-season flower loss was the most injurious to yield when growth duration was limited.

In all trials, average boll size was not affected significantly by the treatments (data not shown).

## Summary

After cotton plants were subjected to low light intensity, excessive abscission of fruiting forms was observed in all trials. Abscission rate increased with the duration of shading. Survival of fruiting forms depended mainly on fruit age and in a lesser extent on fruit position . Squares close to anthesis and young bolls abscissed the most but when bolls passed a critical stage (which needs to be defined more precisely) their survival rate was not affected by the stress . P1 fruiting forms had a competitive advantage compared to other positions. The incorporation of age and spatial distribution of fruiting forms into a description of fruiting dynamics (as illustrated partially in Fig.3) provides a valuable framework for the prediction and analysis of the effect of a temporary light reduction on the final yield. Significant yield reduction was observed only after an 8-days shading at mid or late flowering stage when time left for compensatory reproductive growth was limited.

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Table 1. Effects of the duration of shading at 85 Days After Emergence on boll and seed-cotton production (field trials)

| | Bolls. $m^{-2}$ | Seed-cotton ($g.m^{-2}$) |
|---|---|---|
| Trial 1 | | |
| control | 39.4 a | 185.6 a |
| 4-days | 35.9 a | 172.3 a |
| 8-days | 27.9 b | 128.3 b |
| Trial 2 (no fertilization) | | |
| control | 15.2 a | 74.3 a |
| 4-days | 12.9 a | 60.9 a |
| 8-days | 9.5 b | 44.6 b |

*Different letters indicate significant differences according to Newmans and Keuls test (0.05)*

Table 2. Effects of timing (Days After Emergence) of an 8-days shading on boll and seed-cotton production per plant (pot trial)

| Time of shading | Bolls. plant $^{-1}$ | Seed-cotton ($g.pl^{-1}$) |
|---|---|---|
| T0 control | 15.6 a | 61.8 a |
| T1 43 DAE | 15.8 a | 62.7 a |
| T2 63 DAE | 11.8 b | 48.4 b |
| T3 76 DAE | 12.1 b | 44.6 b |

Different letters indicate significant differences according to Newmans and Keuls test (0.05)

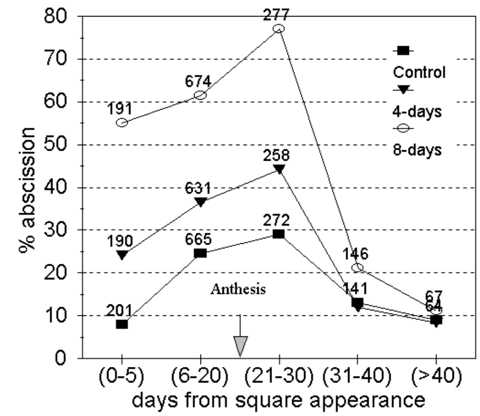


Figure 1. Effect of shading duration on abscission rate of fruiting forms according to fruit age at the onset of shading (85 DAE). Labels indicate the number of fruiting forms in each age-category.

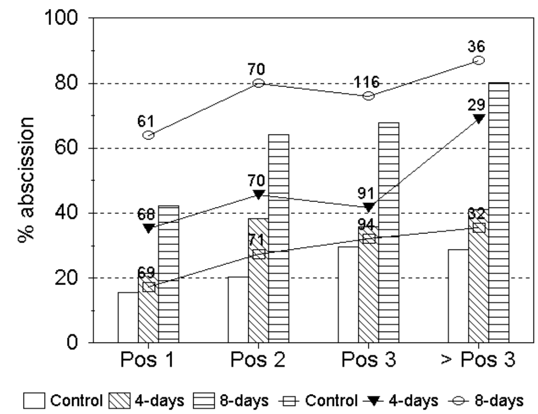


Fig. 2. Effect of shading duration on abscission rate of all age-categories of fruiting forms (bars) and (21-30)-days fruits (lines) according to their position on sympodia. Labels indicate the number of fruiting forms monitored in each category.

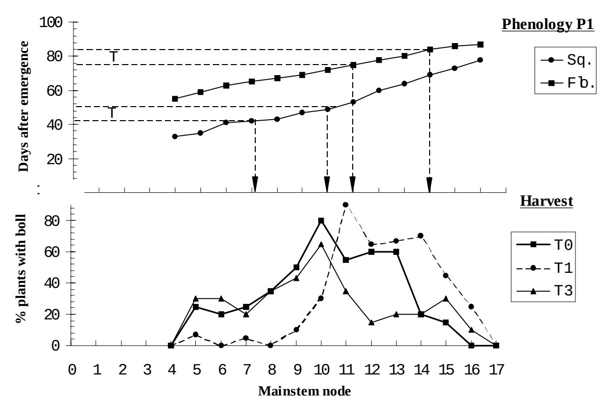


Fig. 3. Progression along the mainstem of square appearance and flowering stages on P1 fruiting sites and effects on the timing of an 8-days exposure of plants to low light intensity on boll distribution at harvest.