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Effects of Water Deficit on Growth and Yield of Cotton Cultivar Sri Sumrong 60

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ABSTRACT

The objectives of this study were to determine the effects of water deficit on growth yield and yield components of cotton (*Gossypium hirsutum* L.). The study has been conducted in the dry season of 1996 (January-July, 1996) at National Corn and Sorghum Research Center, Pak Chong, Nakhon Ratchasima. The experimental design was Randomized Complete Block with 4 replications. The cultivar Sri Sumrong 60 was used in this experiment. Treatments composed of full irrigation applied weekly (T1), stress period at the beginning of square producing stage (T2) and stress period at the early blooming stage (T3). Mid-day leaf water potential (Ψ_l) was used as an indicator for water deficit, when Ψ_l reached about –2.5 MPa, the irrigation was resumed again. The results revealed that plant height, number of nodes per plant and height to node ratio of T2 and T3 were statistically lower than of T1 during stress period. The production of reproductive organs of T2 and T3 was significantly reduced. Ten days after reirrigation, the recovery and rapid growth occurred in T2 and T3. Thus, total seed cotton yield of T2 and T3 was not significantly different from T1. However, T3 gave the greatest seed cotton yield, approximately 3 ton ha^{-1}.

Key words: cotton, water deficit, yield component and growth

INTRODUCTION

Water deficit can decrease yield of cotton tremendously by reducing the production and retention of fruits, and leaves (McMichael *et al.*, 1973; Guinn and Mauney, 1984). In Thailand, cotton is often grown as a secondary crop in rainfed areas. Planting date of each cotton planting area is normally in June-July, depends on the distribution of rainfall. During this period rainfall is erratic. Dry spots can be found on some areas. In some areas, rainfall in the period ranges between 100 and 200 mm and in some years is far below 100 mm (Rajatapitim, 1986). Putthagosa (1994) stated that the alternative possibility to increase yield of cotton was to plant them in dry season, replacing rice in the paddy field. Thus, the study on the effects of water deficits on cotton cultivars Sri Sumrong 60, which have been widely planted in Thailand, is essential. Therefore, the objectives of this study were to determine the effects of water deficit on growth, fruiting pattern, yield and yield components of cotton cultivar Sri Sumrong 60.

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MATERIAL AND METHODS

The experiment was conducted during the dry season of 1996 (January-July, 1996) at National Corn and Sorghum Research Center, Pak Chong, Nakhon Ratchasima Province. Soil type of the experimental plot is a reddish brown lateritic soil. The experimental design was Randomized Complete Block design with 4 replications. Treatments composed of full irrigation applied everyweek (T1), stress period at the beginning of square producing stage (T2) and stress period at the early blooming stage (T3). Mid-day leaf water potential (Ψ_l) was used as an indicator for water deficit, when Ψ_l of the stress plots had been depleted up to –2.5 MPa, the irrigation was resumed. According to Hearn and Constable (1984), the value –2.5 MPa, correspond to rather severe stress for cotton. Ψ_l was determined with a pressure chamber (PMS Instrument Co. Model 1002) on two terminal unfolded leaves per replications of each treatment at 14.00-15.00 h at 3 days interval throughout the stress period. Cultivar Sri Sumrong 60 was planted using the spacing of 1.00 x 0.20 m, in 10 row plot of 10 m long. Seeds were treated with imidacloprid at the rate of 5 g per one kg of seed prior to planting in order to protect cotton seedling from sucking insects at the early stage of growth. Five seeds were sowed per hill and thinning was done at 21 days after emergence (DAE). Fertilizer formula 15-15-15 was broadcasted at the rate of 250 kg/ha. Sprayings of monocrotophos, endosulfan, cyfluthrin, and fipronil for insect control were done every week after 30 DAE.

Every 20 days from 30 DAE until harvest, plant mapping was performed on 15 plants, which had been randomly selected. Mapping consisted of plant height, number of nodes per plant, position of squares, green bolls, open bolls, node of first branch, and number of fruiting sites on fruiting branches. Yield was determined from two central rows of each plot, from 128 DAE (23 May) to 198 DAE (24 July).

RESULTS

1. Climatic data and Ψ_l

The stress treatment of T2 and T3 were initially imposed at 27 and 55 DAE, respectively. The average maximum, minimum, and mean tempera-ture during period were 32.7, 18.2, and 25°C; respectively (Figure 1). The relative humidity was 68.3%. Crop evapotranspiration (ET crop) of T2 and T3 were at 3.05 mm while T1 was at 3.19 mm. ET crop was determined according to pan evaporation method (Doorebos and Pruitt, 1984). During stress period, light showers were observed approximately 36.5, 10.2, 18, 8.4 and 13.4 mm at 34, 44, 67, 80 and 89 DAE, respectively (Figure 1). Hence, the fluctuation of Ψ_l was observed during the period of stress (Figure 2). Based on these phenomenons, it can be concluded that there were two short period of stress (Ψ_l<-2.0 MPa) in T2 and T3 from 62-76 and 83-85 DAE. Irrigation was, then, resumed at 89 DAE. Thus, the period of stress of T2 was 28 days longer than of T3.

2. Vegetative growth

Plant height and number of main stem nodes per plant of T2 and T3 were significantly lower than in T1 during stress period from 59-99 DAE (Figure 3a, b). From 139 DAE until harvesting, plant height of T2 and T3 were significantly higher than those of T1, but number of node of all treatments were not significantly different. Height to node ratio (HNR) between internode 4-9 in T2 and 6-9 in T3 were significantly shorter than in T1 (Figure 3c), but were longer from internode 12-14.

3. Fruiting pattern

The fruiting pattern of T1 (Figure 4a), the cumulative number of fruiting sites of squares,

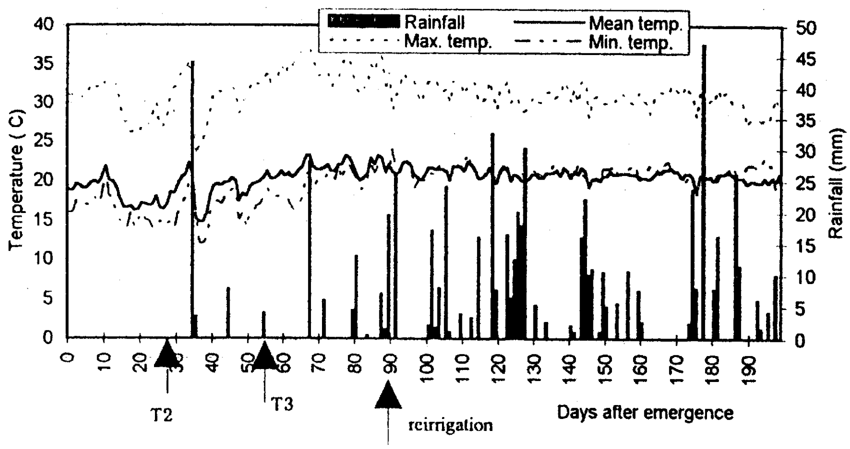

Figure 1 The distribution of rainfall (mm) and temperature (maximum, minimum, and mean temperature) during crop season (from 16 January-31 July 1996). Arrows indicate the starting points of T2, T3 and reirrigation.

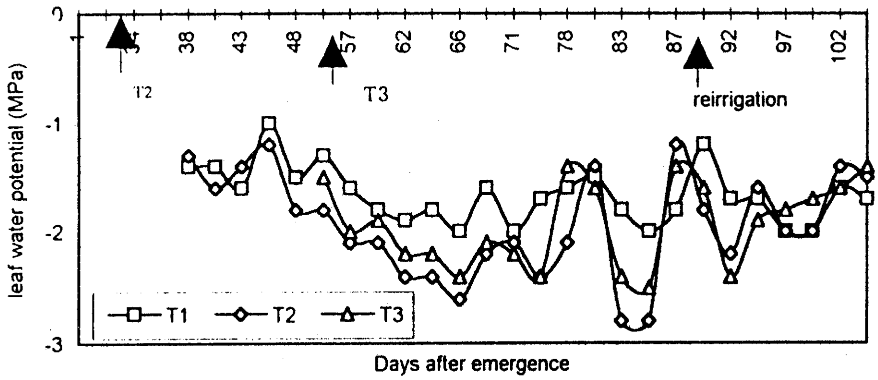

Figure 2 Mid-day leaf water potential of cotton grown in 3 water regimes. Arrows indicate the starting points of stress periods of T2 and T3 and reirrigation.

green bolls and open bolls have been fitted to the polynomial order 2, 3 and 4 (R^2 = 0.99, 0.88 and 1.00), respectively. The cumulative number of squares produced per plant gradually increased from 39 to 159 DAE. Total number of square production was 76.8 squares per plant. Peak of green boll produced was at 80 DAE and gradually decreased to zero at 198 DAE. Boll opened initially at approximately 114 DAE as estimated from the curve. The number of open bolls did not changed from 159 to 198 DAE.

The fruiting pattern of T2 (Figure 4b), the cumulative number of fruiting sites of squares, green bolls and open bolls were fitted to the polynomial order 4, 5 and 3 (R^2 = 0.99, 0.98 and 1.00), respectively. The cumulative number of fruiting sites or squares produced was rather stable from 59-99 DAE, then increased sharply from 100-159 DAE. Total number of square production was 73.5 squares per plant. Number of green boll

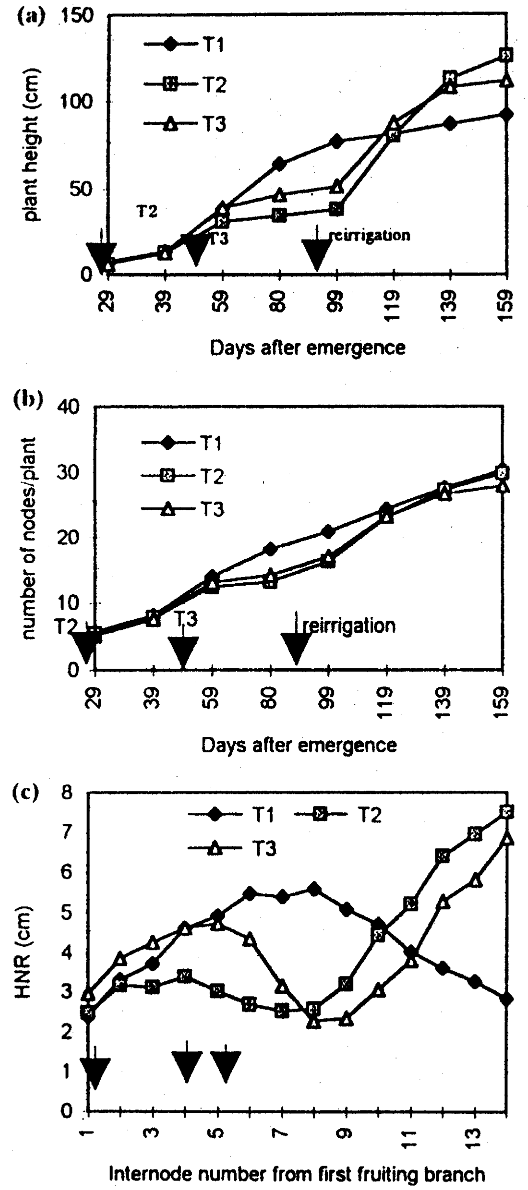

Figure 3 Vegetative growth of cotton plants grown in 3 water regimes: (a) plant height, (b) number of nodes on the mainstem per plant, (c) height to node ratio (HNR) or internode length at harvest. Arrows indicated the starting points of stress periods of T2 and T3 and reirrigation.

production exhibited two peaks, at 80 and 159 DAE, respectively. Boll opened initially at about 108 DAE as estimated from the curve, remained rather stable from 119-159 DAE and increased in a small number at harvest.

The cumulative number of fruiting sites of squares, green bolls and open bolls of T3 (Figure 4c) have been fitted to the polynomial order 4, 5 and 3 (R2 = 0.99, 0.98 and 1.00), respectively. The cumulative number of fruiting sites or squares produced slightly increased from 59-99 DAE, then greatly increased from 100-159 DAE. Total number of square production was 74.2 squares per plant. Number of green boll production exhibited two peaks, at 80 and 139 DAE, respectively and similar to those of T2. Boll opened initially at about 111 DAE, estimated from the curve, remained rather stable from 119-159 DAE and increased in a small number at harvest.

4. Yield and yield components

The cumulative seed cotton yield of no water stress treatment (T1) increased from 128 to 175 DAE (Table 1). However, in T2 and T3, the cumulative seed cotton yield was rather stable from 128 to 156 DAE and then increased from 156 to 198 DAE. Total seed cotton yield of T2 or T3 were not significantly difference from T1. But T3 tends to give the greatest seed cotton yield while T2 gave the lowest seed cotton yield among treatments imposed. Cumulative number of harvestable bolls per plant also showed similar pattern as seed cotton yield. T3 had the highest number of harvestable bolls and its number significantly difference from T2 but it was not different from T1 (Figure 4a, b,c). The average boll weight of T1 was greater than T2 and T3. Boll sizes of T2 and T3 were not significantly different from each other (Table 1).

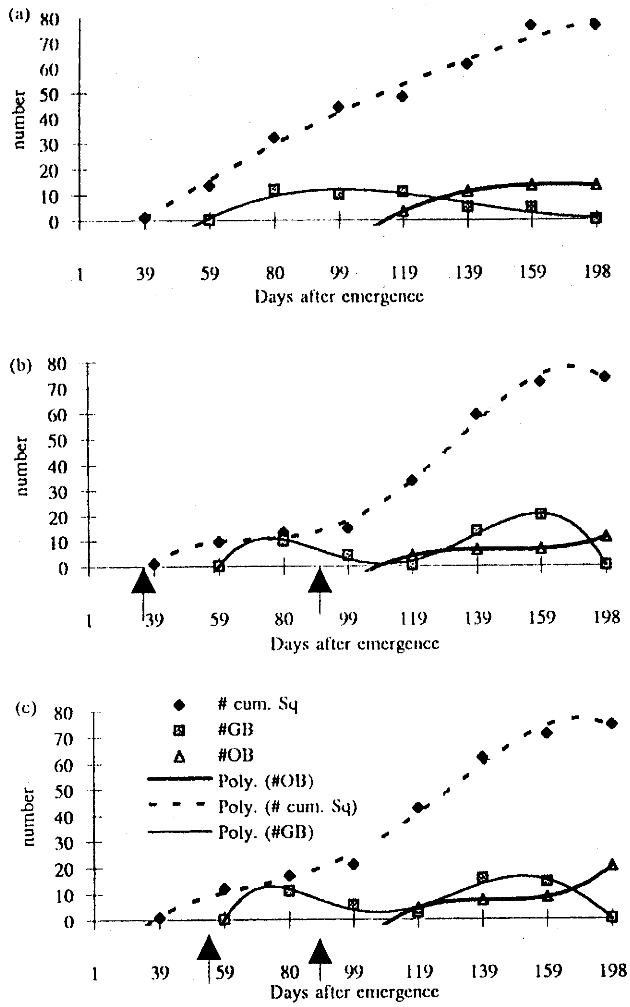

Figure 4 Fruiting pattern of cotton grown in 3 water regimes: (a) T1, (b) T2, (c) T3. Left arrow indicates the initial stress treatment and right arrow indicates reirrigation.

Table 1 Seed cotton yield and average boll weight of cotton variety Sri Sumrong 60 grown in 3 water regimes.

Treatment	Seed-cotton yield (kg/ha) at					avg. boll
	128DAE	141DAE	156DAE	175DAE	198DAE	wt.(g)
1	712 a	1750 a	2173 a	2662 a	2815 ab	4.6 a
2	467 b	575 b	612 b	1572 b	2314 b	4.0 a
3	575 ab	818 b	886 b	1909 b	3009 a	3.8 b
Average	585	1048	1223	2047	2712	4.10
C.V. (%)	20.98	13.86	13.36	11.52	13.75	5.51
LSD (0.05)	212	251	283	408	464	0.40

Mean within a column followed by the same latter are not significantly different at P>0.05, tested by Student-Newman keuls method.

DISCUSSION

1. Effects of water stress on plant growth

The HNR during stress periods were shorter than in well watered periods because water stress reduced the elongation of the main stem (Hake *et al.,* 1992). Wrona and Kerby (1994) also found that stresses during development of nodes 7-18 were reflected in low HNR. The stress period in T2 occurred initially earlier and took longer time than in T3. Thus, the initial point of short internode in T2 appeared on the lower node. After first re-watering, the effects of water stress was relieved so that the HNR of T2 and T3 increased from internode 12 upward because of the increasing of elongation rate of the main stem during second cycle of vegetative growth stages. The HNR of T1 decreased due to increasing boll load. Therefore, plant height at harvest of T2 and T3 was significantly higher than of T1. However, node production is much less sensitive to water stress; all treatments have nearly the same number of nodes at harvest.

2. Effects of water stress on fruiting pattern

Fruiting patterns of T2 and T3 obviously differed from T1 (Figure 4). However, fruiting pattern of T2 and T3 followed similar pattern. Because stress periods given were almost nearly at the same time partly due to rainfall occurrence during the stress period (Figure 1, 2). Number of cumulative squares of T2 and T3 were significantly lower than those of T1 (Figure 5). Due to water stress, photosynthesis was reduced (Ackerson *et al.,* 1997; and Karami *et al.,* 1980) and that would cause the cessation of new square during the stress period. However, total square production of all treatments was not different at harvest.

The development of squares into green bolls appeared nearly at the same time in all treatments. During stress period, stressed plants in T2 and T3 were able to produce less number of squares (14.8 and 21.0 square/plant at 99 DAE, respectively) and few square developed in to green bolls (4.0 and 5.5 bolls/plant, respectively). It was due to the limitation of the assimilate which favorably partitioned to

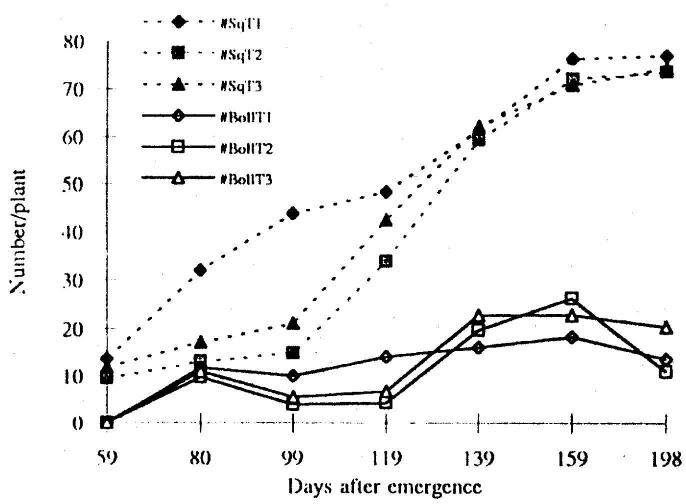

Figure 5 Number of total square and number of boll survival per plant of cotton grown in 3 water regimes.

retained bolls (Jordan, 1983, cited by Oygaz *et al.*, 1992). The remaining bolls were abscised due to competition of assimilate from active boll. While number of bolls survival of T1 was higher, i.e. 10 boll/plant at 99 DAE. Number of retained bolls on cotton plant is the most important yield component that must be taken into account for seed cotton yield (*Grimes et al.*, 1969). Number of boll survival of stressed cotton in T2 and T3 were significantly lower than those of well-watered cotton in T1 from 99-119 DAE (P=0.05) because of the limitation of cumulative square production during stress (Figure 5).

Stressed cotton plants were able to recover when received a favorable condition such as re-watering. Stressed cotton would be able to prolong vegetative growth, and new fruits were produced as a second cycle of reproductive growth, because cotton is an indeterminate growth habit crop. The number of boll survival of T2 and T3 were much higher than those of T1 at 139 (P<0.10) and 159 DAE (Figure 5). Moreover, the final number of bolls retained on cotton plant in T3 was significantly greater. The final number of retained bolls in T2 was low because a lot of fruits abscission occurred due to the increase in active boll loading (Guinn and Mauney, 1984b; Guinn, 1985).

3. Effects of water stress on yield, yield component and crop duration

According to the fruiting patterns (Figure 4), there are two cycles of green bolls production in stressed treatments. In T2, a first boll load appeared from 60-108 DAE (48 days) whereas the second boll load appeared from 120-197 DAE (77 days). In T3, a first boll load appeared from 60-111 DAE (51 days) whereas the second boll load appeared from 120-197 DAE (77 days). Thereby, the total period of boll load of two cycles of T2 and T3 were 125 and 128 days, respectively. The duration of boll load of T1 was from 60 to 160 DAE (100 days). Thus, the duration of the stress in T2 and T3 were longer than of well-watered cotton in T1. Therefore, the carrying capacity, which is the boll load that can reduce square production and setting number of square to zero (Hearn and Constable, 1984), of the stressed plants also occurred at two stages of growth period, firstly at 119 DAE and secondly at 198 DAE. The carrying capacity of T3, T1 and T2 were 101, 67.5% and 55 boll m^{-2}, respectively. Hence, total seed cotton yield of T3 was 6.4, and 23.1% higher than of T1 and T2, respectively.

CONCLUSION

From this experiment, it was found that water stress affected the vegetative and reproductive growth of cotton by reducing the HNR and altering the fruiting pattern of cotton plant. The patterns of fruit production of stressed cotton were obviously differed from well-watered cotton. When favorable condition occurred such as well water supplied, stressed cotton plant was able to resume its growth again because of the indeterminate growth habit. In this study, the yield of cotton receiving water stress at beginning of square producing stage and the blooming stage were not significantly differed from the well watered plant.

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