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EFFECT OF SHADING ON PIGMENT CONTENT AND DISTRIBUTION IN THE COTTON CANOPY (*Gossypium hirsutum* L. cv. 'DELTAPINE 61')[1/]

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During a study of the effect of temporary shading on cotton, it was noted that top parts of shaded plants appeared to be a darker green color than non-shaded controls. The intensity of the green color in plants is normally associated with the chlorophyll and carotenoid contents. Since the literature on the subject is scarce and unspecific, the effect of temporary shading on the pigments of cotton leaves in various parts of the plant was studied.

Material and Methods. Cotton (*Gossypium hirsutum* L. cv. 'Deltapine 61') was planted on May 5, 1976, at the University of Arizona Campbell Avenue Farm, Tucson, Arizona, U.S.A. Normal cultural practices for cotton production were used. The plots were three rows, 1 m apart and 3 m long, with guard rows on each side and a row of about 0.5 m of excess plants at each end.

When the plants were three months old, the randomly assigned plots were covered with a green plastic screen to give a 50% shade condition, and the non-shaded ones were taken as controls.

The experiment was a split plot design with four replications. with main plots being shaded vs. unshaded; and top, medium and bottom positions of the plant canopy were assigned to sub-plots.

On the sixth day of shading, leaves were collected for analysis from five plants in each replication. The plant canopy was divided into three positions called TOP, MEDIUM and BOTTOM, and a pair of fully expanded leaves, at each position, was collected from each plant.

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The leaves were immediately dried to constant weight at 60°C in a forced-air oven and ground in a motor-driven Willey laboratory mill to pass a 60-mesh sieve.

The dried leaf powder was then submitted to 80% propanone extraction, and total chlorophyll and carotenoid pigments were analyzed spectrophotometrically according to the method of KIRK (*3*). Duplicate determinations of 250 mg samples were made for every replication.

Data were analyzed by appropriate analysis of variance according to BAUER (*1*).

Tests for significance of components of variance were based on F tests using the appropriate expectations of mean squares to indicate the correct test to use for each component. The least significant differences (LSD) test was used for comparison of main plot treatments (shaded and non-shaded), and sub-plot treatments (TOP, MEDIUM and BOTTOM).

Results and Discussion. The variance components for each plot and the analytical results are given in Tables 1, 2 and 3.

The average total dry matter chlorophyll values for TOP, MEDIUM and BOTTOM parts of the shaded plants were: 1.27, 1.29 and 1.13%. Similar values for non-shaded plants were: 0.82, 1.28 and 1.21%, respectively (Table 1). These results showed a slightly higher variation among shaded plants replications (lowest C.V. 8.77%) when compared with the non-shaded ones (highest C.V. 8.03%). These small discrepancies are probably due to the fact that the shaded plants were submitted to a stress, and such conditions, the metabolism of individual leaves was slightly altered to compensate for the stress suffered.

The TOP, MEDIUM and BOTTOM dry matter carotenoid contents for shaded plant were 1.03, 1.04 and 1.01 mg/g, respectively. Comparable values for non-shaded plants were: 0.83, 0.99 and 1.04 mg/g, respectively (Table 2). These

TABLE 1 - Effect of shading on total chlorophyll distribution in cotton leaves from three different positions. (Average values in percentage of the dry weight)

	SHADED			NON-SHADED		
Replication	TOP	MEDIUM	BOTTOM	TOP	MEDIUM	BOTTOM
1	1.07	1.14	0.98	0.88	1.29	1.29
2	1.32	1.28	1.15	0.79	1.29	1.09
3	1.40	1.46	1.26	0.83	1.29	1.32
4	1.28	1.29	1.13	0.77	1.27	1.14
$\bar{x}$	1.27	1.29	1.13	0.82	1.28	1.21
s	0.12	0.11	0.09	0.04	0.01	0.10
C.V. (%)	9.61	8.77	8.82	5.14	0.67	8.03

TABLE 2 - Effect of shading on total carotenoids distribution in cotton leaves from three different positions. (Average values in milligram per gram of dry weight)

	SHADED			NON-SHADED		
Replication	TOP	MEDIUM	BOTTOM	TOP	MEDIUM	BOTTOM
1	0.87	0.90	1.01	0.83	1.01	1.00
2	1.12	1.04	0.98	0.92	1.02	1.02
3	1.08	1.22	1.11	0.87	1.01	1.09
4	1.06	1.00	0.95	0.69	0.92	1.06
$\bar{x}$	1.03	1.04	1.01	0.83	0.99	1.04
s	0.09	0.11	0.06	0.08	0.04	0.03
C.V. (%)	9.31	11.12	5.94	10.33	4.10	3.35

TABLE 3 - Effect of shading on chlorophyll and carotenoid contents in cotton leaves from three different positions. (Comparison between averages)

	CHLOROPHYLL %			CAROTENOIDS mg/g		
	TOP	MEDIUM	BOTTOM	TOP	MEDIUM	BOTTOM
SHADED	1.27 a*	1.29 a	1.13 b	1.03 a	1.04 b	1.01 b
NON-SHADED	0.82 c	1.28 a	1.21 b	0.83 c	0.99 b	1.04 a

(*) Values followed by the same letter are not significantly different at the 1% level.

amounts and the ones for chlorophyll content are in close agreement with values obtained by other researchers (*2, 5*).

The data show a statistically significant difference in chlorophyll and carotenoid contents in younger TOP leaves between main plots and within sub-plots, even at a 1% level (Table 3).

Since the metabolism of carotenoid pigments is closely associated with chlorophyll content (*4*), the physiological basis for the discussion of the statistical

analysis of carotenoid content is the same as the preceeding discussion for chlorophyll. Under the conditions of this experiment, younger leaves are more likely to show the effects of stress by shading on pigment metabolism than are older ones. These results obtain because the intensity of light is much higher in the TOP position, which also contains the younger leaves, than in the lower positions where is low light penetration and mutual shading.

In this experiment, the chlorophyll content of TOP leaves under shading stress was 53% higher than that of plants in the non-shaded treatment. Carotenoids were 25% higher under the same comparative conditions.

The higher values of total chlorophyll in the TOP position for shaded plants confirme the field color observation. These higher contents in chlorophyll and carotenoid pigments could be explained by the delta-aminolevulinate mechanism proposed by KIRK (*3*) and KIRK and ALLEN (*4*).

RESUMO

(EFEITO DO SOMBREAMENTO NO TEOR E NA DISTRIBUIÇÃO DE PIGMENTOS EM ALGODOEIRO (*G. hirsutum* L. cv. Deltapine 61))

Clorofila e carotenóides totais foram determinados em plantas de algodão (*Gossypium hirsutum* L., cv. 'Deltapine 61') submetidas a 50 por cento de sombreamento, durante seis dias consecutivos, numa fazenda experimental da Universidade do Arizona, E.U.A. No período do sombreamento, coletaram-se as folhas, em três diferentes partes da planta, denominadas apical, mediana e basal. Folhas apicais, quando sombreadas, apresentaram teores de clorofila e de carotenóides totais 53 e 25 por cento mais altos que os dos controles não-sombreados.

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