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Correlations and Path Coefficient Analysis between Leaf Chlorophyll Content, Yield and Yield Components in Cotton (*Gossypium hirsutum* L.) under Drought Stress Conditions

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Abstract

In this study 20 genotypes, including 2 cultivars and 18 advanced cotton lines were grown under induced drought stress conditions. Twenty cotton genotypes were evaluated in terms of leaf chlorophyll content, number of boll per plant, boll weight, seed cotton weight per boll, number of monopodial branches, number of sympodial branches, 100 seed weight, plant height, ginning out turn and seed cotton yield. According to results of analysis of variance there were significant differences among the genotypes in terms of leaf chlorophyll content, seed cotton weight per boll, 100 seed weight, plant height and ginning out turn. There were significant correlations between leaf chlorophyll content, seed cotton yield ($r = 0.231^{*}$) and ginning out turn ($r = 0.320^{**}$), however positive but non- significant correlations were observed among leaf chlorophyll content and other investigated characteristics except for plant height and 100 seed weight. Phenotypic correlations were also partitioned into path coefficients, keeping seed cotton yield as the resultant variable and other components as causals. Path analysis revealed that leaf chlorophyll content, plant height, number of monopodial branches, ginning out turn and 100 seed weight had direct effect on seed cotton yield under drought stress conditions. Partitioning through path coefficient analysis revealed that leaf chlorophyll content may be one of the indicators in the improvement of seed cotton yield in cotton under drought stress conditions.

Keywords: correlation, cotton (*Gossypium hirsutum* L.), leaf chlorophyll, path analysis, yield, yield components

Introduction

Cotton is an important crop in many developing countries. The yield of the crop is dependent upon the environment in which it is grown and the management practices of the cropping system. Drought is a major limiting factor in cotton production in many regions of the world. Plant breeders continue their search for an effective and efficient method for the identification of drought tolerance in large segregating populations. Plant physiologists have found chlorophyll content to be a valuable tool to monitor plant stress response. The chlorophyll content meter (CCM), in particular the Minolta SPAD 502 provides a rapid and non-destructive diagnosis of plant N status and has been widely applied to assessment of chlorophyll content index in crop plants such as corn, wheat, cotton, rice as well as other agricultural species (Patrick, 2007). The chlorophyll content meter is useful for improving nitrogen and fertilizer management and is ideal for crop stress, leaf senescence, plant breeding, health determination and other studies (Merzlyak and Gitelson 1995, Peñuelas and Filella 1998, Gitelson *et al.* 2003) Determination of the relationships of the chlorophyll content, yield and yield components facilitates selection of high yielding varieties from breeding materials (Singh, 2001). Genomic dissection studies indicated that, the genetic control of chlorophyll content was also markedly influenced by water regime but showed only modest association with productivity (Saranga *et al.* 2008). Recently researchers concentrated on relationships between leaf chlorophyll and plant morphology.

Yield is a complex quantitative trait, considerably affected by environment. Therefore, selection of genotypes based on yield is not effective. Selection has to be made for the components of yield. Bhatt (1972) reported that only correlation studies not clearly reveal such sort of information and inadequate knowledge interrelationships of heritable traits may lead to negative results. On the other hand, path coefficient analysis measures the direct and indirect effect for one variable upon another and permits the separation of the correlation coefficient into components of direct and indirect effect (Dewey and Lu, 1959).

The aim of this study was to determine interrelationships of leaf chlorophyll content with seed cotton yield, yield components and to partition the observed genotypic correlations into their direct and indirect effects.

Material and methods

This study was conducted in the experimental field of the Southeastern Anatolia Agricultural Research Institute during the cotton growing season of 2008 in Diyarbakir, Turkey. The experimental design was arranged in the completely randomized block design with four replications. Twenty cotton genotypes were used as plant material. The planting was made with combine cotton drilling machine on 5 May 2008; all plots received 120 kg ha^{-1} N and 60 kg ha^{-1} P_2O_5. Half of the N and all P_2O_5 were applied at sowing time and the remaining N was given at the square stage as ammonium nitrate.

Each plot consisted of 4 rows, of 12 m long at planting and only 10 m length at harvest. Between and within the row spacing was 0.70 m and 0.20 m, respectively. The experiment was thinned and hoed two times by hand and three times with machine and only once herbicides were applied just before sowing. Insects were monitored throughout the experiment and decided that no insect control was necessary during growing season. The experiment was carried out under induced drought stress conditions (irrigation time interval was increased from 10 days to 20 days) by irrigating only 4 times throughout the growing season. In the first and the last irrigations the traditional timing (irrigation time interval is 10 days, totally 8 times irrigation throughout the growing season.) was followed, but eventually a total of only 250 mm water was applied by increasing the time interval between irrigations.

Leaf chlorophyll content was measured by a Minolta SPAD-502 chlorophyll meter at third week of blooming. Leaf chlorophyll readings were taken on the fifth fully expanded leaf below the terminal of the plant as described by Johnson and Saunders (2003). Chlorophyll content, plant height, number of boll per plant, number of monopodial branches and number of sympodial branches were taken from randomly selected twenty plants in each plot.

At maturity, 25 well developed open bolls were cut off with hand randomly from each genotype in each plot for boll weight, seed cotton weight per boll, and 100 seed weight measurement. Plots were harvested twice by hand on October 14, and on 5 November in 2008. The four rows of each plot were harvested to determine of lint yield and seed cotton yield. Statistical analysis were performed using JMP 5.0.1 statistical software (SAS Institute Inc. 2002) and the means were grouped with LSD (0.05) test. In the study, the estimates of phenotypic and genotypic correlation coefficient were worked out separately for each set by using the formulae suggested by Singh and Chaudhary (1985). Genotypic correlation was partitioned into path coefficient using the technique outlined by Dewey and Lu (1959).

Results and discussion

Correlation coefficient analysis

Correlation coefficients between leaf chlorophyll content, yield and yield components of cotton are presented in Tab. 1. As shown in Tab., leaf chlorophyll content was positively and significantly correlated with the seed cotton yield (r = 0.231*) and ginning out turn (r = 0.320**). This information indicated that an increase in leaf chlorophyll content had increased seed cotton yield, which increased ginning out turn in the present plant material. These results were confirmatory by Reddy and Kumari (2004) who reported significant and positive association between chlorophyll index and seed cotton yield. The similar correlations were found between leaf chlorophyll content and yield for cotton and other crops (Araus *et al*. 1998; Feibo *et al*. 1998; Bronson *et al*. 2003; Kabanova and Chaika, 2001; Ramesh *et al*. 2002; Boggs *et al*. 2003 and Rodriquez *et al*. 2004). Seed cotton yield was positively and significantly correlated with ginning out turn (r=0.272*). Similar results were reported by (Akbar *et al.* 1994; Alam 1995; Hussainn *et al*. 1998; Azhar *et al.* 1999). Furthermore, seed cotton yield showed positive but non-significant association with other investigated components. Ginning out turn was negatively and significantly correlated with 100 seed weight as advocated by Kıllı *et al.* (2005). Plant height had positive and significant correlation with number of boll per plant (r=0.436**), number of sympodial branches (r = 0.415**), as well as with boll weight (r = 0.289**) and seed cotton weight per boll (r=0.329**). Similar results were reported by (Naveed *et al*. 2004, Rauf *et al.* 2004). Number of monopodial branch was correlated with number of boll per plant (r=0.325**). Similar report was given by Iqbal *et al.* (2006). Number of sympodial branch was correlated with number of boll per plant (r=0.285**). Number of boll per plant was correlated with boll weight (r = 0.254**) as advocated by Manzoor and Azhar (2000) and seed cotton weight per boll (r=0.256**). Finally, boll weight was positively and significantly correlated with seed cotton weight per boll (r=0.985**). The results of correlation coefficient analysis revealed that leaf chlorophyll content was positively and significantly correlated with the seed cotton yield and ginning out turn, an increase in the leaf chlorophyll content may induce positive impacts on seed cotton yield under drought stress conditions.

Path coefficient analysis

Path coefficient analysis permits a through understanding of contribution of various characters by partitioning the correlation coefficient into components of direct and indirect effects. The direct and indirect effects of investigated characters on seed cotton yield are presented on Tab. 2. According to the path coefficient analysis, number of monopodial branches (0.125), plant height (0.263) and ginning out turn (0.312) had positive direct effect on seed cotton yield. Similar results were reported by Baloch *et al.* (2001). Chlorophyll content (0.155) had positive direct effect on seed cotton yield as advocated by Reddy and Kumari (2004), also it had positive indirect effect via ginning out turn (0.100). 100 seed weight had positive direct effect on seed cotton yield (0.241), but it had negative indirect effect via ginning out turn (-0.110). From the Tab. it can be seen that the direct effect of seed cotton yield per boll is negligible (0.067). Number of sympodial branch had negative direct effect (-0,026) on seed cotton yield but

Tab. 1. Correlation coefficients between leaf chlorophyll content, yield and yield components of cotton

	CHL	PH	NMB	NSB	NBP	BW	SCW	SCY	GOT
PH	-0.0814								
NMB	0.1071	-0.0628							
NSB	0.0251	0.4154**	-0.1009						
NBP	0.0513	0.4362**	0.3253**	0.2846*					
BW	0.1352	0.2888**	0.0894	0.0553	0.2538*				
SCW	0.1422	0.3287**	0.0646	0.0727	0.2557*	0.9847**			
SCY	0.2312*	0.1946	0.1743	0.1062	0.0970	0.1152	0.1254		
GOT	0.3195**	-0.0135	0.0342	0.1271	-0.0445	-0.1863	-0.1578	0.2722*	
100 SW	-0.0723	-0.1334	0.1816	-0.0152	-0.1113	0.2020	0.1672	0.1132	-0.3522**

CHL: Chlorophyll content (SPAD reading), NBP: Number of boll per plant, BW: Boll weight (g), SCW: Seed cotton weight per boll (g), NMB: Number of monopodial branches (no/plant), NSB: Number of sympodial branches (no/plant), 100 SW: 100 Seed weight (g), PH: Plant height (cm), GOT:Ginning Out Turn (%) and SCY: Seed Cotton Yield (kg ha^{-1}); **, * significant at 1 and 5 % probability level, respectively

it had positive indirect effect via plant height (0.109).On the other hand, number of boll per plant and boll weight had negative and non-significant direct effect on seed cotton yield. Similar findings were reported by Alishah *et al*. (2008), Manzoor and Azhar (2000) and Baloch *et al*. (2001). Thus in light of the results obtained in the present literature. Therefore, further investigation is required on the leaf chlorophyll content and physiological studies. In the present study, correlation analysis and partitioning through path coefficient analysis revealed that leaf chlorophyll content may be one of the indicators in the improvement of seed cotton yield in cotton under drought stress

Tab. 2. Path analysis of yield component traits on seed cotton yield

	CHL	NBP	BW	SCW	NMB	NSB	100 SW	PH	GOT	Genotypic Correlation Coefficient with SCY
CHL	0,155	-0,001	-0,006	0,010	0,013	-0,001	-0,017	-0,021	0,100	0,231 *
NBP	0,008	-0,025	-0,011	0,017	0,041	-0,007	-0,027	0,115	-0,014	0,097
BW	0,021	-0,006	-0,042	0,066	0,011	-0,001	0,049	0,076	-0,058	0,115
SCW	0,022	-0,006	-0,041	0,067	0,008	-0,002	0,040	0,086	-0,049	0,125
NMB	0,017	-0,008	-0,004	0,004	0,125	0,003	0,044	-0,017	0,011	0,174
NSB	0,004	-0,007	-0,002	0,005	-0,013	-0,026	-0,004	0,109	0,040	0,106
100 SW	-0,011	0,003	-0,009	0,011	0,023	0,000	0,241	-0,035	-0,110	0,113
PH	-0,013	-0,011	-0,012	0,022	-0,008	-0,011	-0,032	0,263	-0,004	0,195
GOT	0,050	0,001	0,008	-0,011	0,004	-0,003	-0,085	-0,004	0,312	0,272 *

Diagonal values represents the direct effect; CHL: Chlorophyll content (SPAD reading); NBP: Number of boll per plant; BW: Boll weight (g), SCW: Seed cotton weight per boll (g); NMB: Number of monopodial branches (no/plant), NSB: Number of sympodial branches (no/plant), 100 SW: 100 Seed weight (g), PH: Plant height (cm), GOT: Ginning out turn (%), SCY: Seed cotton yield (kg ha-1)

study, it can be advised that trait such as leaf chlorophyll content, plant height, number of monopodial branches, 100 seed weight and ginning out turn should be considered as target trait for improvement of seed cotton yield under drought stress conditions.

Conclusion

This study was carried out under induced drought stress conditions. Previous experiments carried out showed significance of yield components such as boll weight, number of boll per plant, number of monopodial branches, number of sympodial branches, seed cotton weight per boll, 100 seed weight and plant height on seed cotton yield.

There is limited information between leaf chlorophyll content and yield contributing characters of cotton in the conditions in addition to yield components.

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