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RESEARCH ARTICLE

Impact of drought stress on leaf chlorophyll content in maize cultivars (*Zea mays* L.)

■ **ROSHNI VIJAYAN**

SUMMARY

The aim of this study was to measure the effect of drought stress on leaf chlorophyll content and stress resistance in maize cultivars for this target, an experiment using 10 maize genotypes in four replications and with two conditions (moisture stress and normal irrigated) in a Randomized Complete Block Design in the 2007 to 2008 agricultural years in Coimbatore region was carried out. To calculate the amount of stress tolerance on genotypes, Fernandez stress tolerance indexes (STI). The results of analysis of variance showed that the effect of replication, conditions, genotypes and interaction between genotype and conditions were significant for yield and chlorophyll content at 0.01 percentage level. According to the results, genotypes 3 (UMI 61) and 8 (IBET IE 1256-6) have the highest chlorophyll index and the amount of yield. Genotypes 6 and 8 were the highest value of this index and as the most tolerant genotypes were selected. And also genotypes number 3 and 7 were the most critical ones. According to the results of last year at this year drought stress had a negative effect on genotypes 8 and 6 yields in both conditions, but these genotypes can maintain its yield and chlorophyll content and finally resistance to drought stress. So these genotypes can be useful in Tamil Nadu area, especially drought affected areas.

Key Words : Resistance, Leaf chlorophyll, Drought stress, Corn, maize

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Plants under natural and agricultural conditions are exposed to stress constantly. Drought limits lant growth and field crops production more han any other environmental stresses (Zhu, 2002).

Drought stress is one of the environmental factors limiting photosynthesis of plants (Malakouti *et al.*, 2005). Two photic systems II (PS II) is very sensitive to inhibitory environmental factors and drought stress results in damage to PS II reaction centres.

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Drought is one of the most important a-biotic stress actor (Dash and Mohanty, 2001), which affects almost every aspect of plant growth. The drought tolerance of plants can e characterized by growth response, changes in water elations of tissues exposed to low water potential, accumulation of ions in tissues and stomatal conductance of eaves, etc. (Dash and Mohanty, 2001).

Chlorophyll concentration has been known as an index for evaluation of source (Zobayed *et al.*, 2005), therefore, decrease of this can be consideration as a non stomata limiting factor in the drought stress conditions. There are reports about decrease of chlorophyll in the drought stress conditions (Kuroda *et* *al.*, 1990). Also, it is reported that chlorophyll content of resistant and sensitive cultivars to drought and thermal stress reduced. Chlorophyll and higher carotenoids with stress tolerance in plants is associated (Sairam, 1994; Kraus *et al.*, 1995 and Pastori and Trippi, 1992) with chlorophyll fluorescent measuring a relatively new technology that in recent years can study the effects of different stresses including drought, salinity and temperature on photosynthetic efficiency (or yield) of leaves in the farm (or field) and greenhouse conditions convention is used (Baker and Rosenqvist, 2004; Ort, 2002; Rapacz *et al.*, 2001; Rizza *et al.*, 2001 and Zobayed *et al.*, 2005). Climate changes in recent decades, leading to a decrease in the rainfall amount and distribution of it in the arid and semi arid regions of the world including the middle East. So it seems according to the patterns of occurrence of drought changing, changing the appropriate strategies for reducing the difference between actual yield and yield potential of crops in these areas is necessary (Ort, 2002). These are factors that affect the amount of chlorophyll and they are as follows:

– The light intensity in the amount of leaf chlorophyll and even that of different chloroplasts array has an effect in the leaf cell. Chlorophyll in a shadow-friendly plant is more then that of a light-friendly plant.

– Temperature is involved in chlorophyll efficiency and its yield, a plant which has 4 carbon at a temperature of 30 to 45°C and that with 3 carbon at a temperature of 10 to 25°C, has the best chlorophyll yield.

– The age of leaf and its chlorophyll content is directly related, that is when the leaf emergence until its full growth, photosynthetic growth rate increases and then gradually decreases.

Yellow and old leaves due to the loss of chlorophyll, lose their photosynthetic power (Ahmadi, 1985) and Pastori and Trippi (1992) expressed that resistant genotypes of wheat and corn had higher chlorophyll content than sensitive genotypes under the oxidative stress. Ashraf *et al*. (1994) also reported that drought stress will reduce concentration of chlorophyll b more than chlorophyll a. For the first time, accumulation of proline in plant tissues that have missed water was reported in 1954 (Zobayed *et al.*, 2005). The water synthesis of chlorophyll is very important, after a heavy rain the amount of chlorophyll increases, but in the arid time its value decreases. On the other hand, if the soil is water saturated, leaves chlorophyll content decreases. The amount of leaf water needed to maintain the maximum amount of chlorophyll should be high (Bohrani and Habili, 1992). In green plants chlorophyll tissue in leaves under environmental stress in susceptible cultivar is decreased but with an increased resistance. Leaves in the susceptible cultivar have a darker green colour. Rapid loss of chlorophyll in cold-sensitive cultivars causes a decrease in photosynthetic activity. Several environmental factors cause chlorosis (yellowing) in plants. Chlorophyll is one of the basic pigments in plants, with its concentration reduction causing chlorosis, reduction in both growth and yield (Khosh and Ando, 1995) and Morgan (2007) reported that plants under environmental (peripheral) stresses lose their green chlorophyll tissues. It is known that environmental stresses in terms of chlorophyll degradation have similar effects on plants. In 1969, a chlorophyll measurement method was proposed; a stress leaves pass under a light of extract heat was compared. Terbea (2000) for the evaluation of this new technique sunflower hybrids and inbred lines were used.

Also Zaeifizade and Goliov (2009) reported that resistant cultivars have more chlorophyll. In studying the relationship between genotype and environmental (drought and normal) conditions, it was reported that the amount of chlorophyll content and superoxide desiotaz (SOD) in drought resistant cultivars increases during drought stress. So to study the effect of drought stress on leaf chlorophyll content and stress resistance in maize cultivars this experiment was done in Ardabil area.

MATERIAL AND METHODS

This experiment was carried out to study the relationship between leaf chlorophyll content and drought tolerance of maize lines, using 10 cultivars of maize (Table A), in a Randomized Complete Block Design of 4 replications (2 full irrigation and 2 drought stress) of crops in the Tamil Nadu region in 2007 to 2008. Irrigation was performed according to local custom and corn need for both of conditions to flowering stage and stress treatment was exposed to stress after flowering. Stress treatments included:

– Whole irrigated (100% used water based on the plant demand at various growing stages).

– Limited irrigation (water supply until a thesis and after wards drought employing as water with holding until the end of growing stage).

Manually using seeds in five rows with 50 cm of each other in 2 m length were sown. Area of each plot

Table A : Details of the 10 cultivars of maize used

Sr. No.	Genotype	Source / Origin
1.	UMI 285	Selection from [96123 (Sarhaelx Suwan1)x (Suwan)]
2.	COH(M) 5	UMI 285 * UMI 61
3.	UMI 61	Selection from (Taiwan DMR13)
4.	IBET IE1207-6	Department of Millets, Coimbatore
5.	IBET IE 1554-5	Department of Millets, Coimbatore
6.	IBET IE 1224-9w	Department of Millets, Coimbatore
7.	IBET IE 1051-5	Department of Millets, Coimbatore
8.	IBET IE 1256-6	Department of Millets, Coimbatore
9.	IBET IE 1253-8	Department of Millets, Coimbatore
10.	IBET IE 1076-5	Department of Millets, Coimbatore
11.	IBET IE 1182-5	Department of Millets, Coimbatore
12.	Hyd .R`06. 2199-1	Department of Millets, Coimbatore
13.	Hy R`06 6143-16	Department of Millets, Coimbatore

was equal to 4 m. Immediately, after planting the farm was irrigated to saturate the soil moisture profiles in the developed zone of the root and based on all treatments to be the same and in addition germination easily done. Chlorophyll content of the flag leaves with a chlorophyll meter device CCI-200 which manufactured by Opti-science company was measured. This device is measuring the chlorophyll content index of leaves.

In order to determine the sensitivity and resistance of the evaluated lines under drought conditions was used of the following indicator:

The stress tolerance index (Fernandez, 1992).

STI=(YPi)(YSi)/(YP)2

Which in the formula, YPi : Genotype yield in the surface without stress (adequate irrigation), YSi : Genotype yield in the stress surface (lack of irrigation surface), YP: The yields average in the surface without stress.

For variance analysis of the measured traits were used of the average data, obtained from each plot. Analysis of variance of the obtained data using the statistical software MSTATC was done. Due to lack of significant differences observed between the blocks being consistent of them, analysis of variance based on a Complete Randomized Block Design experiment was carried out. For Comparison of the test, the data obtained from the multi domain Duncan's comparison test was used. And the Excel software was used for charting. The biplot display was also used to identify tolerant and high yielding genotypes using Minitab16 software, based on principal component analysis.

RESULTS AND DISCUSSION

Results of ANOVA showed significant differences among hybrids, replication, conditions and interaction between genotype for yield and chlorophyll in both conditions ($P < 0.01$) (Table 1), which demonstrated existence of high diversity among hybrids studied for drought tolerance. The average for index of chlorophyll content in full irrigation conditions was 61.93 and 44.71 in the drought conditions. Corn genotypes were tested in terms of chlorophyll content index in leaves, its showed

Table 1 : Analysis of variance results for the chlorophyll yield figures

S.O.V	M S		
	Df	Yield	Chlorophyll
Replication	3	0.22*	12.39**
Condition	1	37.45**	2849.54**
Genotype	9	8.92**	658.44**
G×C	9	1.15**	84.87**
Error	57	0.028	11.50
CV	-	6.34	9.35

* and ** indicate significance of values at P=0.05 and 0.01, respectively

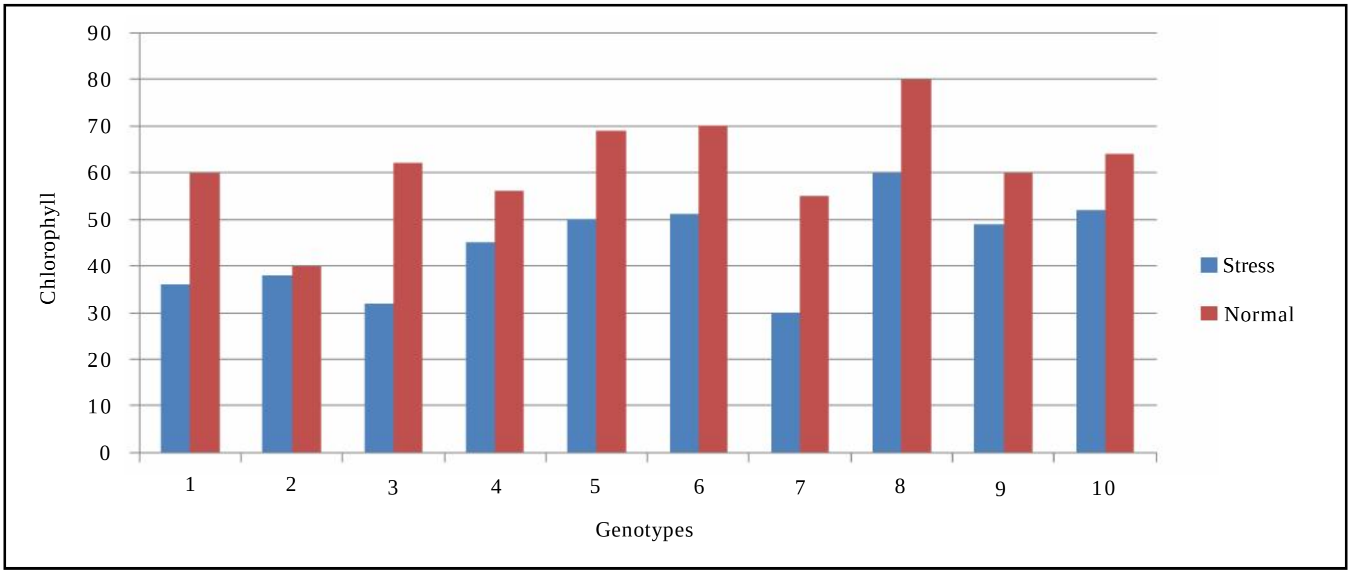

Fig. 1 : Mean of leaf chlorophyll content in terms of normal and stress conditions

0.01 significant difference in the possibility level. The comparison of genotypes (Fig. 1) showed that genotype number 8 had the highest chlorophyll compared to other genotypes during full irrigation with 80.31 and during stress condition with 61.4. In the meantime, genotype 2 with 42.1 in irrigation conditions had the lowest amount of chlorophyll, but when the stress condition was applied to it, it had the lowest change rate. Genotype 2 can be referred to as one of the most tolerant genotypes in terms of destruction of its chloroplast during stress condition. Shao *et al.* (2004) stated that chlorophyll could stops in severe water shortages. At first year of this experiment (2007-08) we saw that genotypes 3 (UMI 61) and 8 (IBET IE 1256-6) had the highest value of yield and chlorophyll content.

The height of STI indicating the rate of drought tolerance of the specific genotype that leads to the increase of its potential yield. Accordingly, genotypes 6 and 8 had the highest value of index and there were the most tolerant genotypes selected (Table 2). And also genotypes number 3 and 7 were the most critical ones. Fernandez (1992), in study the yield of genotypes in two environments and without drought stress than plants in two environments appears to be divided into four groups: studied the yield of genotypes in two environments (with and without drought stress), the plants were divided into four groups:

- The genotypes that have high yield in stress and non-stress environments (group A).
- The genotypes that have high yield only in non-stress environments (group B).
- The genotypes that have high yield in stress environments (group C).
- The genotypes that have weak yield in stress and

Table 2 : Stress tolerance index rates in the genotypes

Genotype	STI	Yp	Ys
1	0.56	4.49	3.95
2	0.59	4.98	3.77
3	0.55	4.85	3.59
4	0.7	5.32	4.16
5	0.83	5.82	4.53
6	1.35	7.62	5.60
7	0.4	4.49	2.85
8	1.12	6.59	5.37
9	0.8	5.84	4.33
10	0.99	6.38	4.92

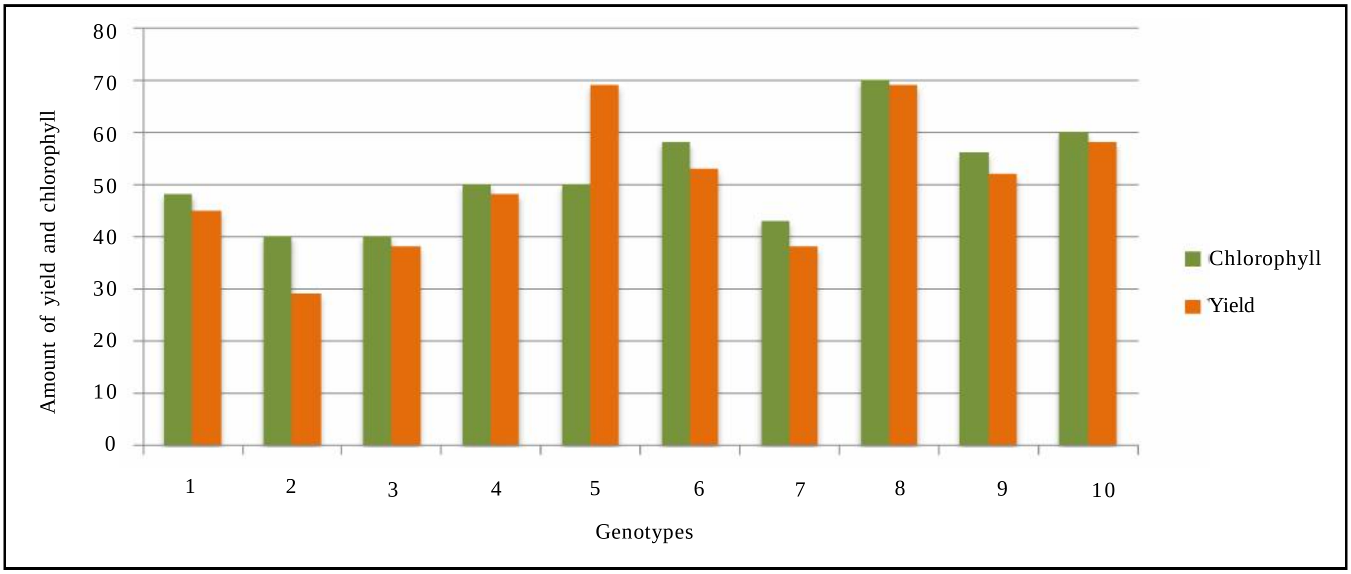

Fig. 2 : The interaction between chlorophyll and yield

non-stress environments (group D).

Sio-Se *et al.* (2006) stated, it seems this index is reliable index being able to identify high-yielding, drought tolerant genotypes under both environmental conditions.

Fernandez thought it appropriate to base his selection for stress group A on the criterion that it can be recognized from other groups. High STI value represents a higher drought tolerance of specific genotypes, and it causes a higher rise in potential yield of genotype. A graph was plotted (multiplied by 10) to show the unit of yield data and chlorophyll content, and the amount of chlorophyll interaction and yield (Fig. 2). According to the chart, genotypes 6 and 8 had the greatest amount of chlorophyll and yield.

Variation due to genotypes was significant for all characters in two conditions (rainfed and moisture stressed). The mean comparison of traits which was observed in this study in an irrigated site showed that 3 (UMI 61) and 8 (IBET IE 1256-6) had the highest grain yield value. According to the results of Fig. 2, these genotypes showed the highest value of chlorophyll content Shahriari (1999) stated that in plants under the drought stress, the green tissues (chlorophyll) in leaves of a resistant cultivars increase. According to these results, it can be concluded that in cultivars 8 and 10 which were the most stress tolerant cultivars, chlorophyll levels were increased and it caused a more stress tolerance of these cultivars and ultimately to obtain the most yield of these two cultivars. Sadeghzadeh *et al.* (2009) stated that due to the changes in the patterns of drought that occurred during the growth of the plant, high yield and stability of its soil water deficit, the best way is the selection of drought tolerant cultivars, according to this theory both the genotypes 8 and 10 are selected according to their high yield. Khazaei has expressed that the water deficit stress has a different physiological effects on the plant; that is the type and extent of damage depend on the stress intensity and plant resistance. Thus if the chloroplast of leaves was damaged, photosynthesis in plant cannot occur and will be lost. Our results concur partly with observations made by Khayatnezhad *et al.* (2011), who reported that the total yield decreased with increasing water deficit.

Finally results showed that the genotypes 3 (UMI 61) and 8 (IBET IE 1256-6) were resistant to stress. So it seems in genotypes, the resistant genes to drought exist, and they can be used in breeding programmes for the drought resistance. According to the results genotypes 3 (UMI 61) and 8 (IBET IE 1256-6) Able to maintain their yield sustainability. So It is suggested that to obtain more accurate results, this test be done at new cropping years and yield stability analysis to be done.

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