SIGNIFICANCE OF SOME AGRONOMIC INDICES IN MAIZE BREEDING PROGRAMS

BY

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Approval Sheet

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ABSTRACT

Mahmoud Bayoumy Abdel–Gawad El–Koomy, Significance of some agronomic indices in maize breeding programs, Unpublished Doctor of Philosophy Thesis, Agronomy Department, Faculty of Agriculture, Ain Shams University, 2005.

Fourteen genotypes of maize (*Zea mays*. L.) included six inbred lines, ***i.e,*** Gm-2, Gm-4, Gm-18, Gm-21, Sd-7 and Sd-63; and eight hybrids ***i.e***. SC21, SC22, SC23, SC24, TWC321, TWC322, TWC323 and TWC324 were tested under three irrigation regimes *i.e*. 100, 85 and 70% of evapotranspiration (ET) at Gemmieza Agric. Res. Sta. Drought stress caused significant reductions in grain yield and its components as well as stomatal conductance (SC) photosynthetic efficiency, chlorophyll content (Chl) and leaf area index (LAI) while days to 50% tasseling and silking and canopy temperature depression (CTD) were increased. Differences among maize inbred lines and among hybrids were significant at 30, 45 and 60 days after planting (DAP) for the same studied traits, except for LAI of the inbreds at 30 DAP and CTD for the hybrids at 30 and 60 DAP.

Grain yield was 84.6, 68.4 and 46.3 g/plant for inbreds and 201.6, 186.0 and 148.6 g/plant for hybrids when irrigated by 100%, 85% and 70% of ET, respectively. Correlation coefficients between grain yield and estimated physiological traits for hybrids were highly significant.

Mathematical prediction equations for grain yield and the five physiological traits were deduced at 30, 45 and 60 DAP. Leaf Area Index and photosynthetic efficiency were the most important traits that directly affected maize grain yield.

Key words: Maize, Corn, *Zea mays* L., Inbred lines, Hybrids, Leaf area index (LAI), Photosynthetic efficiency (PE), Canopy temperature depression (CTD), Stomatal conductance (SC), Chlorophyll (Chl) content, Evapotranspiration (ET), Heritability, Prediction equations.

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I NTRODUCTION

Egypt has a long and a broad record of maize improvement research extending over more than thirty years. Intensive efforts have been made on the national basis to develop high-yielding hybrids in the form of non-lodging, short, tolerant to biotic and abiotic stresses, ***i.e.*** drought tolerance. In maize breeding program, the need to identify superior genotypes as early as possible is greet. Physiological selection indices were suggested to make such process easy. **Hanson and Nelson (1980)** reported that, the ideal screening techniques should be rapid, accurate, non-destructive to plant tissues or plant organs, applicable to large number of germplasm in early growth stages and has a high creditability in relation to actual performance of crop under field conditions. However, the studied parameters are proposed to three groups; yield, related yield traits, different light interception measurements and photosynthetic pigments content. Recent development in technology has provided us with many types of equipments that make such measurements easy and applicable.

The new stady state prometer (LI 6200) portable photosynthesis system makes rapid, simultaneous measurements of photosynthetic rate and stomatal conductance with minimal change to the environment, which is related to the stomata closure. Canopy temperature might be best used for evaluating plant adaptability to drought. Light intensity and hence, canopy interaction to solar radiation can be also recorded by this apparatus.

Leaf area index measurements with LAI 2000 Plant Canopy Analyzer take only a small fraction of time required to directly measurements. Measurements with LAI 2000 are also very rapid and non-destructive when compared to other indirect techniques. The flag leaf or the top-most ear leaf area can be also measured.

These measurements are closely related to the canopy interaction of solar radiation.

Chlorophyll meter, SPAD/502 can be used to measure the amount of chlorophyll present in the plant tissue. This can be simply achieved by inserting a leaf and closing the measuring head with no necessary to cut the leaf. Such measurement is very close to the photosynthetic efficiency.

Some other extracted indices like specific leaf weight (SLW) specific leaf area (SLA) and harvest index (HI) may help plant breeders in selecting and improving the promising genotype(s).

The main objectives of the present investigation were:

1. To examine the efficiency and creditability of some physiological parameters as screening criteria in maize breeding for drought tolerance
2. To estimate the correlation coefficients among grain yield and other physiological parameters that are related to maize yield.
3. To identify highly correlated traits that can help in constructing a selection index that helps in improving maize yield under water stress conditions.
4. Developing mathematical equations to predict the expected grain yield as early in growth as possible.

REVIEW OF LETERATURE

Maize plant ranks the second after rice among grain crops with regard to its sensitivity to the unsuitable water stress. Drought, high osmotic pressure of the soil solutes and also excess of available water are considered among the main factors affecting growth, physiological activities and grain yield of maize genotypes. However, results of many researchers on the relation of certain physiological indices and yield parameters of maize plants under drought conditions will be reviewed under suitable titles:

I. Solar interception and photosynthetic efficiency indices in relation to maize yield:

I.1. Solar interception:

Moursi (1979) revealed that maize genotypes differed greatly in fixing solar energy and its transformation to dry matter. Therefore, the efficiency of maize plants to capture solar energy and produce high dry weight was attained at a maximum level during the period of 55-75 days after planting. The lack of capture solar energy per unit area during the early stages of plant life was due mainly to the pronounced decrease in LAI and the interception of plant canopy to the solar energy.

Schmidt and Colville (1979) found that artificially shaded leaf tissues continued contributing to grain yield although with greatly reduced efficiency per unit leaf area.

Dale *et al* (1980) mentioned that growth and duration of green leaf area of crop determine the percentage of incident solar radiation intercepted by the crop canopy and thereby, influence photosyn-thesis, evapotranspiration and hence final yield. While, **Wilhelm and Nelson (1984)** found that leaf area is suggested to be used as the preferred base because of its association with radiation interception. Furthermore, genetic control of carbon dioxide exchange rate (CER) per unit leaf area appeared to be independent diffusive resistance, leaf senescence and total plant dry weight. However, **Jacobs *et al* (1989)** concluded that during the day-time, crop resistance of a well-watered crop depends on light intensity and available energy while the aerodynamic resistance depends mainly on wind speed. On the other hand, **Muchow et *al* (1990)** reported that the solar radiation response was related to the amount of incident radiation and to the fraction of radiation intercepted by the crop. Moreover, **Blum (1996)** indicated that before flowering, the reduction in leaf area index and intercepted radiation under stress were largely a result of impaired leaf expansion and changed leaf display. While, **Tung and Haith (1998)** found that the beneficial effects of longer growing season and increased water supply were generally overcome by the detrimental impacts of increased evapotranspiration and reduced solar radiation during plant maturity stages. Also, **Calvino *et al* (2003)** showed that differences in the radiation-temperature quotient during the period bracketing flowering among locations and years were small (< 6%). They suggested that these environmental variables did not affect grain number. Yield increased in response to increased water availability, but the response was not linear. While, **Lizaso *et al* (2003)** mentioned that the accumulation of incident photosynthetica-lly active radiation (PAR) intercepted by the canopy, and from the efficiency with which the intercepted PAR is converted into dry matter. The expansion and duration of green leaf area determines the fraction of incident radiation intercepted by the crop. Leaf blades also provide the main path for transpiration and carbon harvesting.

I.2. Leaf area index:

Mughah and Stewart (1984) found that the highest maximum evapotranspiration rate (9.0 mm/day) was reached at LAI of 3.0. While, **Parrol and Cassel (1986)** reported that leaf area, number of active leaves per plant, plant height and specific leaf weight of maize plants were clearly reduced when plants were subjected to water stress by decreasing available moisture level in the soil. Moreover, **Ibrhim *et al* (1992)** found that leaf area/plant was significantly increased with the decrease in irrigation period. While, **Kasele *et al* (1994)** showed that irrigation level had no effect on leaf area index. Whereas, **Xianshi *et al* (1998)** found that the area of individual leaves was permanently decreased for those leaves developed during the drought-stress period, so that plant leaf area was initially decreased, the stressed plants were nearly equivalent to control plants. However, **Steduto and Hasiao (1998)** suggested that the overall canopy processes appeared to be largely dictated by leaf area index (LAI) where water stress developed gradually over a long period. Moreover, **Sanguineti *et al* (1999)** detected that differences in morphophysiological traits affecting water status, such as canopy and root architecture, leaf area index, leaf angle, thickness of leaf lamina, …***etc*** could explain the contrasting associations between bulk-leaf ABA concentration and grain yield observed at different quantitative trait loci (QTL) regions. While, **Shah and Paulsen (2003)** found that moisture stress did not affect viable leaf area at the low temperature during the first week of treatment. When combined with high temperature, drought stress diminished leaf area rapidly. Meanwhile, **Lizaso *et al* (2003)** indicated that leaf area strongly influences crop growth and the accurate simulation of green leaf area development during the growing season is a fundamental component of crop growth simulation. The most limiting stress is used to reduce the rate of leaf expansion and shorten the longevity of leaves that have reached 50% expansion. However, expansion and longevity are fundamentally different processes. Leaf expansion of earlier leaves is more sensitive to stresses than the expansion of later leaves.