INHERITANCE OF AGRONOMIC TRAITS AND GENETIC MARKERS FOR DROUGHT TOLERANCE IN MAIZE

By

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B.Sc. Agric. Sc. (Agronomy), Al-Azhar University, 2004

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ABSTRACT

Mahmoud Shawky Abd El-Latif: Inheritance of Agronomic Traits and Genetic Markers for Drought Tolerance in Maize. Unpublished Ph. D. Thesis, Department of Agronomy, Faculty of Agriculture, Ain Shams University, 2014.

This investigation was conducted at Giza Agricultural Research Station of the Agricultural Research Center (ARC) in the seasons from 2011 to 2013, to estimate some genetic parameters for grain yield and yield related traits, using the six populations *i.e.* P_1, P_2, F_1, F_2, BC_1 and BC_2 of the two maize crosses (*Zea mays*, L.) *viz.* Gz-602 × Gz-628 (Cross I) and Sd-7 × Sd-63 (Cross II) under drought stress condition (preventing the 4th and 5th irrigations during flowering stage) and to study the relationship between the ISSR-PCR and field results in an attempt to develop molecular markers for drought tolerance.

Results of analysis of variance indicated significant differences among the studied generations of each cross for all studied traits. The genetic variances within F_2 population were also found to be significant for all traits studied in the two crosses, therefore needed genetically parameters were estimated.

The scaling test values of A, B, C and D were significant for different traits studied, suggesting the presence of non-allelic interaction. F_2 deviation (E1) and backcross deviation (E2) were significant, with few exceptions, retiring the contribution of epistatic gene action in the inheritance of the studied traits.

The six parameters model showed that the dominance gene effect (d), followed by the additive gene effect (a) and the additive × dominance (ad) type of epistatic gene action contributed with the large part of genetic component controlling the inheritance of the studied traits compared to the dominance × dominance (dd) additive × additive **(**aa**)** and type of epistatic gene effects.

Moderate to high heritability estimates in broad sense were detected in most of the traits studied with values ranged from 51.58% for chlorophyll content in cross II to 95.12% for ear height in cross II. Low to moderate heritability estimates in the narrow sense were detected in most of the studied traits with values ranging from 14.56% for plant height in cross I to 63.39% for leaf proline content in cross II.

The expected genetic advance of the F_2 mean ($\Delta g\%$) for the studied characters were found to be moderate to high with values which ranged from 2.24% for silking date in cross I to 17.89% for number of rows per ear in cross II

Concerning biochemical results, the primers 14-A, 44-B, HB-08, HB-13 and HB-15 showed close relationship for drought tolerance segregates in the F_2 generation and thus it could be used as markers assistant selection for drought. Therefore, the ISSR-PCR analysis could be considered as reliable molecular markers associated with drought tolerance in maize that can be utilized during breeding programs *via* marker-assisted selection.

Key Words: Maize (*Zea mays*, L.), Drought tolerance, Heterosis, Inbreeding depression, Potence ratio, Gene action, Heritability, Genetic advance, Correlation, Path coefficient and ISSR-PCR.

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INTRODUCTION

Maize (*Zea mays*, L.) is one of the most important cereal crops in the world and Egypt. Worldwide, the total acreage of maize was 160.65 million hectares in 2013; the total production was 855.20 million tons, with an average productivity of 5.51 tons of grain ha^{-1} **(F.A.O., 2013)**. According to this report, Egypt grown 0.75 million hectares (1.78 million feddans) in 2013 and produced 7 million tons of grains, with an average yield of 9.33 tons/ha (25.30 ardabs/feddan). According to the same report, Egypt ranks the fourth in the world with respect of average productivity after USA, France and Italy. However, the local production of maize is not sufficient to satisfy the local consumption. So Egypt imports every year about five million tons of maize grains. The problem in the future is that there will be no available maize grain in the producing countries for export, because they will use it in the manufacture of ethanol; a new alternate energy source.

To reach self-sufficiency of maize production in Egypt, efforts are devoted to extend the acreage of maize; in the new reclaimed desert soils and to improve the maize productivity from unit area. Growing maize in the sandy soils of the desert which is characterized by low water holding capacity would expose maize plants to drought stress and cause great losses in grain yield.

Breeding drought tolerant hybrids is discouraged by a perception that drought tolerant hybrids are low yielding in non-drought environments, implying that a yield penalty occurs when irrigation water is adequate. Drought tolerant germplasm might be specifically adapted to low yield environments. **Moreno *et al*., (2005)** reported that traits that confer drought tolerance lack positive relationship with high yield potential.

Highest productivity is the main target of corn breeders. For achieving this goal more information about genetic parameters such as heritability, nature of gene action, heterotic effect and expected genetic advance under selection for yield and related traits especially under drought stress are needed for successful breeding program. However, such information are extensively studied under normal irrigation by many investigators as **Barakat (2003), Amer and Mosa (2004), El-Shouny *et al.* (2005)**, **Abou-Deif (2007), Wannows *et al.* (2010), and El-Badawy (2012).**

Information on such mentioned genetic parameters under drought stress (**Iqbal *et al.* 2009; Parentoni *et al.* 2010 and Iqbal *et al.* 2011)** are not relatively enough to formulate suitable breeding program for developing genotypes in such conditions**.**

Inter-Simple Sequence Repeat (ISSR) markers are highly polymorphic, which makes them useful for studies on genetic diversity, phylogeny, genetic coding, genomic mapping and evolutionary biology **(Idris *et al*., 2012).**

The main objectives of this study were to:

1. Study the genetic parameters for the correlated yield traits with drought tolerance.
2. Attempt to obtain genotypes of maize tolerant to drought stress.
3. Study the relationship between the ISSR-PCR and field results in an attempt to identify drought tolerant genotypes by using this technique.

REVIEW OF LITERATURE

The available review of literature on maize development for drought tolerance *via* six populations *i.e.* P_1, P_2, F_1, F_2, BC_1 and BC_2 will be presented under the following main headings:

1. Drought tolerance.
2. Heterosis, inbreeding depression and potence ratio.
3. Genetic components of variance.
4. Phenotypic and genotypic coefficients of variability (PCV and GCV), heritability and genetic advance.
5. Correlation and path coefficient analysis.
6. Molecular markers.

1. Drought tolerance:

Drought seems to be rather difficult to define and more difficult to quantify. A working definition to drought may be as the inadequacy of water availability, including precipitation and soil moisture storage capacity, in quantity and distribution during the life cycle of a crop to restrict the expression of its full genetic yield potential **(Singh, 2005)**. Moisture stress may also be defined as the inability of plants to meet the evapotranspirational demand. Moisture stress is likely to develop to a different rate in different plant organs along this gradient **(Blum, 1988)**.

Drought resistance may be defined as the mechanism(s) causing minimum loss of yield in a drought environment relative to the maximum yield in constraint-free *i.e.* optimal environment of the crop **(Singh, 2005)**. **Levitt (1980)** suggested that the term ‘drought resistance’ should include both ‘tolerance’ and ‘avoidance’ mechanisms. Some authors prefer the term ‘dehydration’ to ‘drought’ and consequently refer to ‘dehydration tolerance’ **(Boyer, 1996 and Turner, 2003)**. Drought and drought tolerance were used in terms of yield in relation to a limited supply of water. Plants with better growth under limited water supply were considered to be drought-tolerant **(Boyer, 1996 and Moser, 2004)**.

2. Heterosis, inbreeding depression and potence ratio:

El Hosary *et al*. (1990) estimated heterosis under two planting dates in a complete diallel cross set among eight maize inbred lines for grain yield per plant and its components. They reported that the average heterosis for grain yield per plant relative to check variety ranged from -29.11 to 53.01%.

El Hosary and Sedhom (1990) reported that heterosis values for grain yield per plant relative to check variety ranged from 20.59 to 67.61, 17.73 to 37.03 and 15.08 to 51.05% under two nitrogen levels and combined data, respectively.

El Hosary *et al* (1994) found that heterosis values for grain yield per plant relative to check variety ranged from -33.70 to 36.62 and from -42.68 to 31.63% in the first and second seasons, respectively.

Younis *et al*. (1994) used F_1 and F_2 populations of two single crosses of maize and estimated that the average degree of dominance values 1.10, 1.22 and 2.17 for days to silking, plant height and ear height, respectively.

Galal *et al*. (1994) used the six populations method of four maize crosses to estimate heterosis and inbreeding depression for grain yield and its components, plant and ear height and days to silking. They reported that heterosis and inbreeding depression had the highest values for grain yield per plant (193.60 and 39.90 %, respectively) followed by number of kernels per row (85.70 and 24.80%, respectively).

Hassib (1997) found that the percentage of heterotic effects of the F_1 hybrids for grain yield per plant relative to both grand mean and check variety ranged from -48.81 to 38.18% and from -58.85 to 11.08%, respectively.