GENETIC IMPROVEMENT OF MAIZE FOR TOLERANCE TO SOME ABIOTIC STRESS CONDITIONS

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SHABOON ABD El-AZIZ MANSOUR SHABOON
B.Sc. Agric. Sci. (Agronomy), Fac. Agric., Minufiya Univ., Egypt, 1998
M.Sc. Agric. Sci. (Agronomy), Fac. Agric., Cairo Univ., Egypt, 2004

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APPROVAL SHEET

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Approved by:

Dr. HAMDY Y. EL-SHERBIENY …………………………...
Chief Researcher, Field Crops Res. Inst., ARC

Dr. MAZHAR M.F. ABD-ALLA …………………………...
Professor of Agronomy, Fac. Agric., Cairo University

Dr. MOHAMED REDA A. SHABANA …………………………...
Professor of Agronomy, Fac. Agric., Cairo University

Dr. AHMED MEDHAT M. AL-NAGGAR …………………………...
Professor of Agronomy, Fac. Agric., Cairo University

Date: / / 2009

SUPERVISION SHEET

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SUPERVISION COMMITTEE

Dr. AHMED MEDHAT MOHAMED AL-NAGGAR
Professor of Crop Breeding, Fac. Agric., Cairo University

Dr. MOHAMED REDA ALI SHABANA
Professor of Crop Breeding, Fac. Agric., Cairo University

Dr. ATEF ABD EL- KADER MAHMOUD
Chief Researcher, Field Crops Res. Inst., ARC

Name of Candidate: Shaboon Abd El-Aziz Mansour Shaboon
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Supervisors: Dr. Ahmed Medhat Mohamed Al-Naggar, Dr. Mohamed Reda Ali Shabana and Dr. Atef Abd El- Kader Mahmoud.
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ABSTRACT

The present study was carried out in 5 seasons during 4 years from 2004 to 2007 at the field of Sids Agric. Res. Sta., ARC. The main objectives were to develop new maize populations of increased tolerance to drought and/ or low-N stresses and evaluate predicted and actual gains from one cycle of S_1 recurrent selection. Two sets of 121 S_1's were developed from the local population Giza 2, the 1st set was evaluated under high- (HN) and low-N (LN) and the 2nd under well-water (WW) and intermediate water-stress (IWS) conditions. The highest yielding 18 lines(15%) were selected under each environment. Intercrossing of the four groups of 18 S_2's was done in separate blocks. The resulted 4 populations (Giza 2-LN, Giza 2-HN, Giza 2-IWS and Giza 2-WW) along with Giza 2 were evaluated for 43 traits under 4 environments (HN, LN, IWS and SWS). Results indicated wide genetic variation among S_1 progenies for most studied traits under all selection environments. Broad sense heritability estimates were generally higher under low-N and water-stress than under non-stress conditions. Results indicated that anthesis-silking interval, ears plant^{-1} and stay green traits could be valuable criteria in increasing the selection efficiency for both low-N and drought tolerance. Actual superiority in grain yield over Giza 2 due to one cycle of S_1 recurrent selection were shown by the three improved populations [(Giza 2-IWS, (26.01%), Giza 2-LN, (21.88%) and Giza 2-HN, (23.22%)] under low-N and by Giza 2-IWS (22.56%) and Giza 2 HN (9.74%) under water stressed target environment. Grain dry matter (GDM), total above ground dry matter and total N content were the best predictors of genotypic performance of economic and biological nitrogen use efficiency and nitrogen uptake efficiency, respectively. GDM proved to be a good predictor for measuring all nitrogen use efficiency traits.

Key words: Maize, Recurrent selection, Nitrogen use efficiency, Low-N tolerance, Drought tolerance, Selection environment, Target environment, Alternative criteria, Population improvement.

DEDICATION

I dedicate this work to whom my heart felt thanks; TO THE SOUL OF MY FATHER , AND MY MOTHER AND TO MY WIFE and MY CHILDREN for their patience and help, as well as to MY SISTERS and BROTHERS For all the support they lovely offered along the period of my post graduation.

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world as well as in Egypt. Worldwide, the total acreage of maize was 160.65 million hectares in 2008; the total production was 791.5 million tons, with an average productivity of 4.93 tons of grain ha^{-1} (Report of USDA, 2009). According to this report, Egypt grew in 2008 0.72 hectares (1.71 million feddans) and produced 6.17 million tons of grains, with an average yield 8.58 tons ha^{-1} (25.24 ardabs/feddan). (One feddan (fed) = 4200 m^2 and one ardab (ard) = 140 Kg). 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 desert and to improve the maize productivity from unit area. Growing maize in the sandy soils of the desert, characterized by low water holding capacity and low soil nitrogen would expose maize plants to drought and low N stresses which cause great losses in grain yield.

Nitrogen is the most important nutritive element for the worldwide production of maize. Because of high price ratios between fertilizer and grain, limited availability of fertilizer, and low purchasing power of farmers, nitrogen status of Egyptian soils is low, especially in newly-reclaimed soils. As a result, maize yield potentiality will not be achieved, so breeding for tolerance to low N is therefore very necessary. Loss of maize grain yield due to low N stress alone varies from 10 to 50% (Wolf *et al.,* 1988, Logrono and Lothrop, 1996). Two basic approaches could be further used to improve maize productivity in a sustainable fashion in areas with low nitrogen (Kamara *et al.*, 2005 and Meseka *et al.,* 2006). First, innovative agronomic practices could be developed to make better use of nitrogen from organic matter and nitrogen inputs from biological fixation and atmospheric deposition. The second approach would be to lower crop demand for nitrogen through breeding (Smith *et al.,* 1995). It could be achieved *via* selection for low-N tolerance with high nitrogen use efficiency and high potential.

Breeding for tolerance to an abiotic stress such as drought or low-N is difficult because the genetic mechanism that controls the expression of such tolerance in crop plants is poorly understood and because of the polygenic nature of such a complicated character (Rossiele and Hambling, 1981; Kebede *et al.,* 2001).

The population improvement of maize for increasing drought and/or low-N tolerance could result in producing improved populations that could be used directly as new open-pollinated cultivars or indirectly as suitable sources for extracting improved inbred lines which could be used in developing drought and/or low-N tolerant single and 3-way cross hybrids. Population improvement can be achieved *via* a number of selection procedures; one of them is the recurrent selection. The main advantage of recurrent selection is to increase the frequency of favorable alleles for the quantitative traits with maintenance of the additive genetic variance (amenable to selection) of such traits in the improved population. Since drought or low-N tolerance is expressed polygenically, this suggests that recurrent selection could be an appropriate and effective breeding method for improving maize germplasm for such traits (Hallauer and Miranda, 1988).

S_1 recurrent selection is widely used as an easy and highly efficient procedure for intra-population improvement in maize. Selection based on S_1 progeny performance is effective in utilizing the additive genetic variance in a better way than other intra-population improvement methods and presents an opportunity for selection against major deleterious recessive genes that become homozygous with inbreeding (Genter, 1971 and 1973; Tanner and Smith, 1987; Hallauer and Miranda, 1988).

In the last decades, efforts of plant breeders were devoted to improve drought tolerance as well as low-N tolerance in maize populations *via* S_1 recurrent selection. They were able to improve grain yield productivity in each cycle of S_1 recurrent selection by an average increase reached to 14.6% per cycle under drought stress (Edmeades *et al.*, 1996; Edmeades *et al.*, 1999; Edmeades and Chapman, 1999; Al-Naggar *et al.*, 2004) and to 12.8% under low-N stress (Laffite *et al.,* 1997; Omoigui *et al.* 2006).S_1 recurrent selection for increased drought tolerance was associated with a significant reduction in anthesis-slking