GENETIC STUDIES ON EARLINESS IN WHEAT

BY

KHALED IBRAHEM MOHAMED GAD
B.Sc. Agric. Sci. (Genetics), Fac. Agric., Al-Azhar Univ., 1994
M. Sc. Agric. (Genetics), Fac. Agric., Zagazig Univ., 1998

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APPROVAL SHEET

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SUPERVISION SHEET

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ABSTRACT

This work was carried out at the experimental field of ARC in Giza during 2004/2005 through 2006/2007 seasons and the Molecular Genetics and Genome Mapping Laboratory (MGGM) at AGERI, ARC, Giza, Egypt. The main objectives were to determine intra- and inter-allelic gene interactions controlling the inheritance of earliness and yield traits, to assess the genetic variability among six wheat genotypes and to identify RAPD markers associated with earliness in bread wheat. Six populations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of each of four crosses between late and early maturing parents were produced and field evaluated in RCB design with 3 replicates. Significant and positive gene effects due to additive (a) and dominance (d) type of gene action occurred in 61.15 % of cases. Additive was larger than dominance effect in 38.9 % of cases and the opposite was true in 47.2 % of cases. Significant digenetic epistatic gene effects were exhibited in 78.7 % of cases for all 3 types of epistasis (aa, ad and dd), indicating that epistatic gene effects were generally important in the inheritance of the studied earliness and yield traits. Narrow- sense heritability was the highest (90.0 %) for grain filling rate, medium (52.63 %) for grain yield/plant and the lowest (17.77 %) for grain filling period. The genetic variability and relationship among six wheat genotypes that differ in earliness trait, were investigated using 11 RAPD primers. The number of polymorphic amplicons was 41 out of a total of 91 amplicons, thus revealing a level of 45.05 % polymorphism. The genetic relationships among the 6 wheat genotypes was examined using the Dice coefficient and a dendrogram was constructed according to the UPGMA analysis. Four out of the six wheat genotypes were characterized by 23 positive and/ or negative RAPD markers. Bulked segregant analysis (BSA) was used to rapidly identify markers associated to earliness. Out of 10 primers, only 2 primers revealed two positive and two negative markers associated with earliness trait. Further studies are required to confirm the linkage between these RAPD markers and earliness.

Key words: Wheat, earliness, six populations, generation mean analysis, inter-allelic interactions, RAPD, bulked segregant analysis.

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important and strategic cereal crops all over the world. It provides over 20% of calories and protein for human nutrition, and is staple food for over 35% of the world's population in more than 40 countries. In Egypt, wheat is the main winter cereal crop used as a staple food for urban and rural societies and the major source of straw for animal feeding. However, total wheat consumption has increased drastically due to over population growth by about 2.5% per year. Egypt imports about 45% of its wheat requirements. This reflects the size of the problem and the efforts needed to increase wheat production. Thus, increasing production per unit area appears to be one of the important factors for narrowing the gap between wheat production and consumption. Wheat breeders in Egypt are trying to develop new early maturing high-yielding cultivars, which is considered a difficult task due to the negative relationship between earliness and grain yield .

Developing new early-maturing bread wheat *(Triticum aestivum* L.) cultivars without loss of inherent yielding ability is an objective of the Wheat Breeding Program in Egypt. Yield losses due to certain stresses may be minimized in early-maturing cultivars, since they would escape such stresses that might occur late in season (Clarke *et al.,* 1984 for drought and Menshawy, 2005 for heat stress). In Egypt, the success of wheat to be cultivated in the rainfed area of the Northern Coast and late planting in the North Delta, may depend entirely on the early maturing cultivars. Moreover, many investigators reported that early-maturing cultivars are higher yielding under drought conditions than late ones (Fischer and Maurer, 1978 and Kheiralla *et al.,* 1993).

The possibility of inter cropping wheat and cotton in Egypt has also increased interest in high-yielding early-maturing wheats (Menshawy, 2007). Early harvest of the wheat crop is critical to allow cotton sufficient time to develop and produce an adequate yield.

A better understanding of earliness inheritance and type of gene action would help wheat breeders to efficiently improve early maturing high- yielding cultivars. Several scientists found that maturity in wheat is oligogenic trait (Johnson *et al.,* 1966 and Shehab El-Din, 1997) while others reported the polygenic control (Edwards *et al*., 1976). Modifying factors have also been suggested (Klaimi and Qualset, 1973 and Pinthus, 1963).

Additive gene action is evidently accounted for a large amount of the variation for number of days to heading (Bhatt, 1972; Avey *et al.,* 1982; Menshawy, 2000 and 2005), number of days to maturity (Menshawy, 2000, 2005 and 2007) and grain filling duration and rate (Rasyad and Van Sanford, 1992; Beiquan and Kronstad, 1994; Mou and Kronstad, 1994 and Menshawy, 2004). But dominance also was important (Crumpacker and Allard, 1962; Avey *et al.,* 1982 and Menshawy, 2005) for earliness trait, while epistasis was reported in few studies [Amaya *et al.,* 1972; Ketata *et al.,* 1976 for earliness and Przulj and Mladenov, 1999 for grain filling traits].

To exploit different types of gene action involved in earliness inheritance and grain filling traits of some Egyptian bread wheat genotypes, information regarding their relative magnitude and estimates of combining ability are essential. This will help wheat breeders in their identification of parents and selection strategies to develop early-maturing and high-yielding cultivars.

Traditionally, the assessment of the genetic variation in crop plants has been conducted on basis of phenotypic and cytogenetic characters, which frequently lack the resolving power needed to identify individual genotypes (Teshale *et al* ., 2003). In the last decade, molecular markers such as RFLP, RAPD, ISSR, AFLP have been used to assess genetic variation at the DNA level, allowing an estimation of degree of relatedness between individuals without the influence of environmental variation (Gupta *et al* .,1999).

Randomly amplified polymorphic DNA (RAPD) is a useful method for generating molecular markers (Welsh and McClelland, 1990) that can be used to construct linkage maps, to identify varieties (He *et al*.1992) and to assess genetic diversity (Koller *et al.,* 1993). It is characterized by its low technical input and small quantity of plant DNA needed for the analysis (Hernandez *et al.,* 1999 and Manabe *et al* .,1999). Also, RAPD based fingerprinting was used successfully in wheat to assess genetic diversity (He *et al*.,1992, Dhaliwal *et al.,*1993; Cao *et al*.,1999 Kudriavtsev *et al*.,2003; Munshi *et al*.,2003 ; Maric *et al*., 2004 and Abd-El-Haleem *et al*., 2009) and to identify DNA markers associated with drought tolerance (Malik *et al.,*2000 ; Abdel-Twab *et al*., 2003 and Al-Naggar *et al*.,2004), yield and some stress physiological traits (Nachit *et al.,* 2000), resistance to Fusarium head blight (Sun *et al*., 2003), and salinity tolerance (Mehboob-ur-Rahman *et al.,* 2004).

Therefore, the objectives of this investigation were to:

1. Determine the intra- and inter-allelic gene interactions controlling the inheritance of earliness and yield traits in four crosses of bread wheat *via* six generations mean analysis.
2. Study heterosis, heritability and expected genetic advance from selection in segregating generations of the four wheat crosses.
3. Assess the genetic diversity at the molecular (DNA) level among wheat genotypes that differ in earliness traits.
4. Identify RAPD markers associated with earliness in wheat *via* bulked segregant analysis (BSA).

REVIEW OF LITERATURE

1. Inheritance of earliness in wheat

A better understanding of earliness inheritance and type of gene action would help wheat breeders to efficiently improve early maturing high- yielding cultivars. Several scientists found that maturity in wheat is an oligogenic trait (Johanson *et al.,* 1966 and Shehab El-Din, 1997) while others reported the polygenic control (Edwards *et al*., 1976). Modifying factors have also been suggested (Klaimi and Qualset, 1973 and Pinthus, 1963).

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Mou and Kronstad (1994) determined the model of inheritance, combining ability and heritability estimates for grain filling rate (GFR) and grain filling duration (GFD) in 4 × 4 diallel cross of wheat. Estimates of the genetic components resulting from the diallel cross indicated that a primary part of genetic variability for the grain filling characters was associated with additive gene action. However, dominance effects also appeared to be involved in the inheritance of

GFD and kernel weight. Data showed that narrow sense heritability estimates ranged from 0.79 for kernel weight to 0.89 for GFR. The results suggested that selection in early generations for both duration and rate of grain filling and kernel weight will be expected and effective in changing these characters in their genotypes.

Sharma (1994) estimated heritability of grain filling period (GFP) and the response to selection for long and short GFP in six genetically diverse populations of spring wheat under normal and late sowing dates. The estimates of heritability (h^2) for GFP always were higher under normal sowing date conditions compared with late sowing date. The (h^2) values ranged from high (86%) to intermediate (56 %).

Haro and Allan (1997) studied some earliness components using isolines of bread wheat differing in heading date. The results indicated that heading date is a genetically complex trait and strongly affected by environmental factors. The data also showed that grain filling period was strongly influenced by environment and only partially associated with heading date.

Moghaddam *et al*. (1997) used fifty-three pure lines of bread wheat to estimate genetic variation and heritability for thirteen developmental and quantitative characters. They reported that heritability estimates were high for days to booting, heading and anthesis. But, the expected genetic advance was low for these traits.

Khalifa *et al*. (1998a) found that additive and non-additive genetic effects were predominated and played a major role in the inheritance of earliness characters in durum wheat. The ratio $(H_1/D)^{1/2}$ showed partial dominance for days to heading, days to anthesis and