INHERITANCE OF PHOTO-THERMO SENSITIVE GENIC MALE STERILITY IN RICE

By

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B.Sc. Agric. Sc. (Genetics), Tanta University, ٢٠٠٤

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ABSTRACT

Rizk Mohamed Ali AbdAllah: Inheritance of Photo-Thermo sensitive Genic Male Sterility in Rice. Unpublished Ph.D. Thesis, Department of Genetics, Faculty of Agriculture, Ain Shams University, ٢٠١٢.

Different rice lines involved four diverse Photo-Thermosensitive Genic Male Sterile (PTGMS) lines; PTGMS-٥١, PTGMS-٥٦, PTGMS-٦٢ and PTGMS-٨٠ were used as "female lines". Five restorer lines; Giza ١٧٧R, Giza ١٨٢R, JRL-٩٥, JRL-٩٧ and JRL-٢٥٢ were used as "male testers" with their $F_{١}$ hybrids in line x tester design to study the performance of some agronomic, yield-related and panicle traits. Hybrid rice proved to be an effective and economical way to increase rice production output by at least ١٥-٢٠% higher yield than commercial varieties. PTGMS-٥١ x JRL-٢٥٢ and PTGMS-٨٠ x JRL-٢٥٢ hybrids showed highly significant values for yield-related traits.

PTGMS-٥١ x Giza ١٧٧R and PTGMS-٦٢ x Giza ١٧٧R were the best hybrids for agronomic traits. In addition, PTGMS-٨٠ x JRL-٢٥٢, PTGMS-٨٠ x JRL-٩٧ and PTGMS-٥١ x Giza ١٧٧R gave the best combining abilities (general and specific) and heterosis for panicle traits and yield-related traits.

For molecular genetic analysis, four RAPD primers were used to identify the diversity between the different genotypes. SSRs primer pair; RM١٢٥٢١ showed two bands with the fertile genotypes and hybrids and one band with the sterile PTGMS lines, therefore, this primer can be used to discriminate PTGMS from restorer lines and hybrids.

Key words: Rice, PTGMS, Combining ability, Heterosis, RAPD, SSRs.

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LIST OF ABBREVIATIONS

PTGMS	Photo-Thermo Sensitive Genic Male Sterility
FG/Pn	Number of filled grains / panicle
GCA	General combining ability
GW	١٠٠-grain weight
HDG	Number of days to heading
Ht	Plant height
LSD	Least significant difference
MP	Heterosis versus mid parents
PB/Pn	Primary Branches / Panicle
PCR	Polymerase Chain Reaction
PnL	Panicle length
PnW	Panicle weight
RAPD	Random Amplified Polymorphic DNA
SCA	Specific combining ability
SH	Heterosis versus the check variety
SpFert	Spikelets fertility
SSRs	Simple Sequence Repeats
Ti/P	Number of tillers / plant
Yld/P	Grain yield / plant

N.B. Most of these abbreviations were copied from:

Standard Evaluation System for Rice, ٣rd Edition, June, ١٩٨٨, International Rice Testing Program.

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١. INTRODUCTION

Rice (*Oryza sativa* L.) is the world’s most important food crop and a primary source of food for more than half of the world’s population. More than ٩٠٪ of the world’s rice is grown and consumed in Asia, where ٦٠٪ of the world’s people live. Rice accounts for ٣٥–٧٥٪ of the calories consumed by more than three billion Asians. Major increases in rice production occurred during last four decades due to the adoption of green revolution technology. However, the rate of growth of rice crop has slowed down. Whereas rice production increased at the annual growth rate of ٢,٤٩٪ during ١٩٧٠–١٩٩٠, the annual growth rate was ١,٧٠٪ during ١٩٩٠–٢٠٠٠ and only ١,٢١٪ during ٢٠٠٠–٢٠٠٦. World rice stocks are at the lowest level since ١٩٧٤ and price of rice is showing upward trend in the domestic and international markets. The population of rice consumers is continuing to increase and the demand for rice is also going up due to improved living standards particularly in Africa. According to various estimates, ٣٠٪ more rice should be produced by ٢٠٣٠. To meet this challenge rice varieties with higher yield potential and greater yield stability are needed. Although yield potential of rice is ١٠ tons per hectare, farmers, on the average, harvest about ٥ tons per hectare from irrigated lands. This yield gap is due to the losses caused by biotic and abiotic stresses **(Khush and Jena, ٢٠٠٩).**

Exploitation of heterosis has played a significant role to increase productivity of several crops. Availability of suitable pollination control systems and the extent of outcrossing between female and male parents, existence of exploitation level of heterosis and feasibility of hybrid seeds production on large scale are the key factors for determining the success of commercial exploitation of heterosis in any crop.

China is the first country to exploit commercially heterosis in rice. Hybrid rice technology was successfully developed in ١٩٧٦ using male sterility-fertility restoration system (**Anonymous, ١٩٧٧)**. The success story of commercial hybrid rice cultivation in China, India, Vietnam, Philippines, and Bangladesh, has encouraged Egypt to adopt this technology. The development of hybrid rice technology and the adaptation of hybrid to Egyptian environments offer one approach to the problem of matching food supply to expected demand (**Bastawisi *et al.*, ٢٠٠٣)**.

Combining ability is a measure of gene action (additive and non-additive) the general combining ability (GCA) effects largely involve additive gene effects, whereas, specific combining ability (SCA) represents only non-additive gene action. The presence of non-additive genetic variance offers scope for exploration of heterosis. The parents with good GCA could be used to obtain hybrids with strong heterosis and SCA (**Yang *et al.*, ٢٠٠٠; El-Mowafi, ٢٠٠١a; El-Mowafi and Abou-Shousha, ٢٠٠٣)**. Develop hybrid rice with higher yield, better grain quality and multi-resistance is very important, and is the key to breed Cytoplasmic Male Sterility (CMS) lines with good combining ability in well adapted varieties.

Two-line systems based on photo/thermo-sensitive genic male sterile (P/TGMS) lines are known. They are affected by nuclear recessive gene (*P/TGMS*), and the environment effects the gene(s) expression, therefore, the P/TGMS also is called environmental genic male sterile (EGMS). The EGMS lines are sterile in long day (LD) and / or high temperature (HT), while become fertile in short day (SD) and / or low temperature (LT). During the sterile phase, they could be used to produce hybrid seeds through crossing them with normal fertile male line. The EGMS lines possess many advantages: (١) higher selection and utilization; (٢) not sensitive to cytoplasmic type and sterile lines having different cytoplasmic types could be breed easily; and (٣) resources of restoring genes are wide ranging which could be used as restoring lines provided they are not the heterozygotes of this recessive genic male sterile gene. Thus up to date achievements in research of genetic breeding of rice can be collected and utilized for exploitation of heterosis (**Attia, ٢٠٠١**).

The objectives of this investigation were to:

١) Study the magnitude of PTGMS genotypic variation and the magnitude of both general and specific combining abilities.

٢) Assess the potentiality of heterosis expression for agronomic, panicle and yield-related traits.

٣) Estimate the genetical behavior and heritability for different traits.

٤) Apply molecular genetic analyses to study the diversity and the phylogenetic relationships among some PTGMS lines, non PTGMS (testers) and their hybrid combinations using RAPD and SSRs-PCR techniques.

٢. REVIEW OF LITERATURE

Photo-thermosensitive genic male sterility system is controlled by nuclear gene expression, which is influenced by environmental factors such as temperature, day length, or both.

Combining ability refers to the ability of a genotype to transfer its desirable traits to its progenies. General combining ability (GCA) is the average performance of a parent in a series of crosses. Specific combining ability (SCA) is the deviation in the performance of a hybrid from the performance predicted on the basis of the general combining ability of its parents.

The term heterosis, often used synonymously with hybrid vigor, refers to the superiority of the F ١ hybrid over its parents. Heterosis may be positive or negative. Both positive and negative heterosis are useful in crop improvement, depending on the breeding objectives. For example, positive heterosis is desired for yield, but we look for negative heterosis for traits like days to maturity and height.

Molecular genetic analysis are useful techniques to detect genetic variation among different genotypes.

٢,١. Photo-Thermo sensitive genic male sterility (PTGMS)

Chen *et al.* (٢٠٠٠) crossed four photoperiod-thermo-sensitive genetically male sterile rice lines, Pei'ai ٦٤s, N٤٢٢s, ١٠٨s and LS٢s, with ١٢ ecotypes of Asian cultivated rice in order to select heterotic two-line japonica hybrids for north China based on the analysis of F١s. The best ecotypes for crossing with each of the male sterile lines to give heterotic hybrids are indicated. The $F_١$s between LS٢s line and the javanica and north China ecotype (the latter including local and