# Genetic diversity: Its role in improving rice production

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# Genetic diversity: its role in improving rice production

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**Abstract.** Collecting indigenous rice cultivars has become keen interest for rice research and breeders. Genetic resources of rice (Oryza sativa L.) are preserved as a pool of useful genes utilized directly to achieve the objectives of current breeding programs, as well as to benefit future breeding works.

The International Network for Genetic and Evaluation of Rice (INGER) based at the International Rice Research Institute (IRRI) has made a significant contribution in improving the genetic resources in Egypt. Through INGER, many economic traits could be transferred to the local materials through conventional breeding program, wide hybridization and biotechnology.

Breeding for drought tolerance program, for example, included two main parts:

❏ Screening of some exotic rice varieties introduced through INGER under drought conditions at Sakha and New Valley. The results of this experiment concluded that some of these entries performed well under drought conditions at both locations. Consequently, one or more of these entries could be released as a drought tolerant variety and/or as a source for drought tolerance character in the local breeding program.

❏ Pedigree nursery for drought tolerance which includes different segregating generation of some crosses affected between some drought tolerant donors, came through INGER and the Egyptian varieties. A total of 1914 crosses/lines were planted in 1997 growing scason and 192 crosses/lines had been selected as a drought tolerant lines to be tested in 1998 season.

Breeding of salinity tolerance, as another example, also consists of:

❏ Screening test conducted under the saline conditions at Sirw location and a set of some introduced varieties through IRSATON (INGER) together with the local varieties were tested. Some of these entries proved to be salinity tolerant and they could be used as a donor for this character.

❏ Pedigree nursery for salinity tolerance, the different segregating populations of 100 crosses between the local and exotic varieties were screened in 1997 season. A total of 649 lines were selected as a saline tolerant lines.

❏ Primary yield test that included 20 promising lines together with the commercial varieties were tested under the saline conditions. One or more of these lines could be promoted as a new variety in the near future.

Consequently, widen the genetic diversity would help in solving many of rice production constrains occurs in the Mediterranean countries including Egypt. Urgent need for a genetic resource center for the Mediterranean region became very essential. The primary objective of this center is to collect and reserve seeds of different rice species as hardware for genetic resources. An additional objective is to supply information related to genetic resources as software to the rice growing countries in the reglon.

## Introduction

Faced with an exploding population and limited water, Egyptian rice yield, though already quite high by world standards, must continue to increase to still higher and higher levels and to set new world records through the strengthening of and continuation of the already successful breeding research and releasing high yielding rice varieties. It is well known that the water requirement of rice is larger than that of any other crop of similar duration. It varies with the duration of the variety grown, soil, climate and cultivation practices. In Egypt, Nour et al. (1994) stated that the total water requirements of rice was ranged between 13 417 $m^3$/ha and 13 875 $m^3$/ha, which in general is considered a serious problem because of the limited irrigation water available from the Rive Nile. Accordingly, the problems of reducing the water requirements of rice has received remarkable attention and has been the major objective in the National Rice Research Program in Egypt. Therefore, this objective has been receiving attention of breeders in Egypt. Reducing the total water requirements through breeding should be possible through evolving ear-

liness and drought tolerance to the high yielding varieties. Earliness is a valuable character, provided it is no associated with loss in yield. Besides, drought tolerance is also in demand for areas that are constantly under the threat of crop failure, due to the drought conditions created by the shortage of irrigation water during different growth stages. On the other hand, salinity- tolerant varieties are badly needed for presently cultivated saline soils and newly reclaimed lands. Salt affected areas are increasing dramatically in the northern part of the Nile Delta. Breeding for saline tolerance is in progress and a further program of hybridization between saline-tolerant varieties and different required characters has been taken up.

Finally, the potential of plant breeding depends on the genetic diversity of the source materials. For further improvement of major characteristics of rice cultivars, breeders must scarch l~or better genetic resources from the genetic collections.

The present investigation reviews the breeding activities for incorporation earliness, drought tolerance and salinity tolerance in the newly developed rice varieties.

## I – Breeding for earliness

The national breeding program in Egypt depends mainly on the pedigree breeding method for achieving its goal. For this purpose, different genetic resources were used to consist the genetic stock. Out of this genetic stock a number of selected donor varieties cover all the needed characteristics was grown in the hybridization plots to develop new crosses considered as base of genetic variability for selection. Different segregating generations were grown and single plant selection method was followed.

F2 nursery comprised 271 crosses, each cross included 400-1000 single plants. At maturity, 1622 individual plants were selected on the basis of the plant type, agronomic traits and pests (Diseases & Insects) reactions. Number of F2 populations planted and selected are listed in Table 1.

In the pedigree nursery (F3- Fn) 3463 breeding lines in various generations were planted at Sakha under normal soil. About 2806 single plants and 41 bulks (promising lines) were selected according to earliness plant type, disease and insects resistance as well as grain quality characteristics. The number of the planted crosses/lines and selected for advancing to the next immediate generations, as well as the best selected lines from Fll are detailed in Table 1.

**Table 1. Pedigree nursery contents - Sakha, 1997**

| | **Planted** | | **Selected** | | **Bulk** | | |
|---|---|---|---|---|---|---|---|
| **Generation** | Crosses | Lines/ plants | Crosses | Lines | Crosses | Lines | Remarks |
| ***Normal Soil:*** | | | | | | | |
| F2-population | 271 | 400-1 000 | 108 | 1 622 | – | – | |
| F3 | 142 | 1 876 | 103 | 524 | – | – | |
| F4 | 104 | 819 | 59 | 553 | – | – | |
| F5 | 67 | 550 | 2 | 107 | – | – | |
| Fn | 54 | 518 | – | – | 26 | 41 | |
| **Total** | **638** | **3 463** | **202** | **2 806** | **26** | **41** | |
| ***Saline Soil:*** | | | | | | | |
| F2-population | 69 | – | | 47 | – | – | Bulk selection method |
| F3 | 60 | – | 60 | 470 | | | |
| F4 | 22 | 179 | 13 | 178 | – | – | |
| F5 | 18 | 159 | 3 | 40 | – | – | |
| **Total** | **169** | **8** | **1 23** | **688** | **–** | **–** | |

As a final result, 41 lines were selected from Fn, generation to be tested in the yield trial in 1998. Table 2, shows the performance of the best 10 lines of these newly selected strains. It is clear that, no. of days for heading were ranged between 93 to 99 days besides, the grain yield was differed from 1.07 to 1.27 kg/m2. These means that these lines possess earliness and high yielding ability. Furthermore, Table 2, clarifies that most of the other agronomic and quality characters are within the required limits for the breeding objectives.

**Table 2. Best selected lines of Fn, 1997**

| No. | Plot No. | Pedigree | Heading (days) | Plant height (cm) | No. of panicles (#) | 100-grain weight (g) | Milling (%) | G. C. | Amylose content (%) | Grain yield/ /m2 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3247 | GZ 5826-18-1-3-1 | 94 | 106 | 20 | 2.8 | 74.0 | 70 | 17.6 | 1.20 |
| 2 | 3248 | GZ5828-3-1-1-1 | 94 | 105 | 24 | 2.3 | 73 1 | 65 | 18.2 | 1.21 |
| 3 | 3254 | GZ5830-64-1-1-1 | 93 | 105 | 20 | 2.7 | 73 6 | 75 | 19 2 | 1 16 |
| 4 | 3257 | GZ 5831-10-1-3-1 | 95 | 105 | 21 | 2.5 | 71.7 | 60 | 18.2 | 1.09 |
| 5 | 3354 | GZ590~25-2-1-1 | 98 | 96 | 20 | 2.5 | 738 | 80 | 186 | 1.27 |
| 6 | 3369 | GZ5917-5-2-3-1 | 97 | 101 | 23 | 2.5 | 73 2 | 80 | 178 | 1.11 |
| 7 | 3370 | GZ5920-5-2-1-1 | 95 | 100 | 18 | 2.1 | 72.9 | 75 | 17.6 | 1.07 |
| 8 | 3374 | GZ5934-9-2-1-1 | 99 | 93 | 24 | 2.4 | 64.8 | 80 | 19.4 | 1.17 |
| 9 | 3440 | GZ5973-32-3-1-1 | 95 | 89 | 24 | 2.1 | 728 | 80 | 17.4 | 1.14 |
| 10 | 3448 | GZ6001-11-1-1-1 | 95 | 95 | 23 | 25 | 67.8 | 183 | 17.0 | 1.13 |

## II – Breeding for drought tolerance

This program consists of two main categories i.e. 1) Pedigree nursery for drought tolerance, and 2) Screening of some new promising lines under drought conditions. Both were flush irrigated every 14 days through all growth stages to expose the plants to severe drought stress. Meanwhile, all other recommendations were followed.

### 1. Pedigree nursery for drought tolerance

The contents of this nursery are listed in Table 3. A total of 1914 crosses/lines were planted from the different segregating generations under the drought conditions at Sakha.

**Table 3. Pedigree Nursery for Drought Tolerance-Sakha, 1997**

| Generation | Planted | | Selected | |
|---|---|---|---|---|
| | Crosses | Lines | Crosses | Lines |
| New crosses | | | 15 | |
| Fl | 14 | – | 14 | 42 |
| F2 | 8 | 24 | 8 | 48 |
| F3 | 132 | 1 876 | 21 | 102 |
| **Total** | **164** | **1 914** | **58** | **192** |

From the previous table, about 192 lines belonging to different generation proved to be drought tolerant during 1997 season.

## 2. Screening experiment

Forty six local new promising lines were evaluated under drought condition in Sakha and New Valley, in a randomized complete block design with three replications, each line was transplanted in 4 rows/replicate. Flush irrigation was used every 14 days. Besides, all other recommendations were followed. The results showed that 8 entries performed better than the tolerant check IET 1111 and the local check Sakha 102, regarding most of the agronomic character as well as the grain yield and its component (Table 4). These entries were earlier in heading by about 4-12 days than the two check varieties.

Moreover they yielded more than the checks and maximized in the two entries GZ 5594-7-1-2-1 (4.02 tons/ha) and GZ 5844-28-1-1-1 (3.73 tons/ha). Accordingly, it can be concluded that one or more of these entries could be selected as a drought tolerant strains.

**Table 4. The best selected entries grown under drought conditions at Sakha, 1997 season**

| Entries | Plant height | Panicle length | Heading date | No. of tillers/ m² | No. of panicle/ m² | Grain (T/ha) |
|---|---|---|---|---|---|---|
| GZ 5594-7-1-2-1 | 67.57 | 16.77 | 92.00 | 448.63 | 430.00 | 4.02 |
| GZ 5844-21 - 1 - 1 - 1 | 66.40 | 15.90 | 91.67 | 485.00 | 467.00 | 3.73 |
| GZ 5721-19-1-3-1 | 62.53 | 15.67 | 95.67 | 308.00 | 282.00 | 3.67 |
| GZ 3607-2-4-1- 1 | 63.60 | 16.47 | 93.33 | 315.00 | 304.67 | 3.58 |
| GZ 5722-24-3-1-1 | 62.40 | 15.50 | 95.33 | 301.33 | 281.67 | 3.50 |
| GZ 5721-19-1-1-1 | 64.94 | 14.53 | 90.00 | 392.33 | 319.67 | 3.48 |
| GZ 5630-41-1-2-1 | 60.27 | 16.33 | 94.67 | 316.00 | 302.00 | 3.48 |
| GZ 5319-11-1-2-1 | 72.03 | 17.27 | 96.67 | 381.33 | 308.00 | 3.44 |
| IET 1114 (ck) | 73.83 | 18.43 | 102.00 | 326.00 | 300.00 | 3.33 |
| Sakha 102 (ck) | 61.06 | 15.90 | 100.00 | 354.33 | 274.00 | 3.11 |

# III – Breeding for salinity tolerance

Breeding of salinity tolerance consists of:

- ❏ Screening test conducted under the saline conditions at Sirw location and a set of some introduced varieties through IRSATON (INGER) together with the local varieties were tested. Some of these entries proved to be salinity tolerant and they could be used as a donor for this character.
- ❏ Pedigree nursery for salinity tolerance, the different segregating populations of 100 crosses between the local and exotic varieties were screened in 1997 season. A total of 649 lines were selected as a saline tolerant lines.
- ❏ Primary yield test that included 20 promising lines together with the commercial varieties were tested under the saline conditions. One or more of these lines could be promoted as a new variety in the near future.

**Table 5. Contents of national breeding program for salinity tolerance, 1997**

| Materials | # Entries/Crosses | Remarks |
|---|---|---|
| Salinity observation nursery | 150-200 | Screening nursery (seedling & adult stages) |
| F2 crosses | 70-80 | Bulk |
| F3 generation | 50 | Bulk |
| F4 lines | 450 | Five rows/line |
| Fs lines | 170 | Five rows/line |
| Fn lines | 50 | Five rowsAine |
| IROSSTON | 30 | Three row/line |
| Regional Y.T. | 30 | Replicated Y.T. |
| Final Y.T. | 12 | Replicated Y.T. |

Three newly bred lines namely GZ 5310-20-3-2, GZ 5385-29-3-2 and GZ 5830-63-1-2 proved to be salinity tolerant. Besides, they possess good yielding ability under saline conditions ranging from 5.40 tons/ha and 5.55 tons/ha.

Finally, in 1997, 89 lines were tested in the regional and preliminary yield trials. According to the results obtained, some of promising entries exhibited higher yield than the respective check varieties either traditional or improved (Table 6). These entries in addition to their high yielding ability were earlier in maturity, shorter in plant height, have better level of resistance to blast disease and superiority of grain quality especially the milling percent.

**Table 6. Best promising entries in the regional and preliminary yleld trial, 1997**

| Entries | Yield (t/ha) | GD * days | Plant height (cm) | Blast reac. Leaf | Blast reac. Neck | Grain test Type | Grain test Mill. (%) |
|---|---|---|---|---|---|---|---|
| GZ 5688-10-3-3 | 11.1 | 130 | 97 | 2 | R | Sh | 74 |
| GZ 5591-1-1-1-1 | 10.4 | 126 | 90 | 2 | R | Sh | 72 |
| GZ 5584-23- 1-2- 1 | 11.2 | 134 | 99 | 2 | R | S h | 72 |
| GZ 5603-3-2-2-1 | 10.7 | 129 | 96 | 2 | R | Sh | 72 |
| GZ 5721-19-1-1-1 | 10.5 | 129 | 100 | 2 | R | Sh | 71 |
| GZ 5830-50-3-2-1 | 10.3 | 129 | 93 | 2 | R | Sh | 73 |
| GZ 5602-26-1-3-1 | 11.8 | 131 | 95 | 2 | R | Sh | 71 |
| GZ 5612-16-2-2-1 | 10.8 | 129 | 90 | 2 | R | Sh | 72 |
| GZ 5830-63-1-2-1 | 11.6 | 129 | 95 | 2 | R | Sh | 73 |
| GZ 5830-63-2-1-1 | 10.8 | 130 | 95 | 2 | R | Sh | 71 |
| GZ 5385-3-2-3-1-1 | 10.8 | 137 | 108 | 2 | R | Sh | 75 |
| **Mean** | **10.9** | **130** | **96** | **2** | **R** | Sh | 72 |
| Giza 176 | 9.4 | 150 | 98 | 7 | S | Sh | 69 |
| Giza 177 | 9.6 | 125 | 94 | 3 | R | Sh | 73 |
| Giza 178 | 9.7 | 138 | 96 | 2 | R | Sh | 71 |
| Sakha 101 | 10.9 | 140 | 89 | 2 | R | Sh | 72 |
| Sakha 102 | 9.7 | 128 | 103 | 2 | R | Sh | 72 |
| Giza 181 | 9.7 | 148 | 95 | 2 | R | | 69 |
| **Mean** | **9.8** | **138** | **96** | **2.7** | **SR** | **Sh-L** | **71** |
| Giza 171 | 8.4 | 161 | 137 | 8 | S | Sh | 72 |

* GD = Growth duration

It is clear from Table 6 that most of these new lines were earlier than the commercial varieties. Their respective average were 130 days with 8 days difference than the duration of the commercial ones. Moreover, the average of grain yield of the new promising lines was 10.9 tons/ha under the normal soil comparing with 9.8 tons/ha of that of the commercial varieties. In addition, the grain yield was maximized in case of the lines GZ 5602-26-1-3-1 (11.8 tons/ha), GZ 5830-63-1-2-1 (11.6 tons/ha), GZ 5584-23-1-2-1 (11.2 tons/ha) and GZ 5688-10-3-3 (11.1 tons/ha). These findings concluded that one or more of these new promising lines will be released as a new variety in Egypt to cover most of the breeding objectives including reducing the water requirements for rice.

## References

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