STUDIES ON COMBINING ABILITY AND GENETIC RELATIONSHIP AMONG SOME EGYPTIAN AND EXOTIC RICE VARIETIES

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Abstract

General combining ability (GCA), specific combining ability (SCA) and some other genetic parameters were studied on some important characters of rice using 12 Egyptian and exotic rice varieties. The main objectives of the present investigation were to identify the genetic relationship among the varieties and to cluster these genotypes into groups according to their morphological characters. The present investigation was carried out at the experimental farm of RRTC, Sakha, Kafr El-Sheikh, Egypt during the rice growing seasons, 1998, 1999, 2000 and 2001. A half diallel crosses combination was conducted among the 12 parents to produce 66 F_1 hybrids arranged with their parents in a randomized complete block design with three replications. The results obtained were performed based on the means of the parental varieties and their F_1 crosses and also according to GCA and SCA effects for all the characters studied. The revealed a highly significant differences among genotypes, parents and their crosses for all traits. Both additive and non-additive genetic variances were found to be important with greater importance of additive genetic variance than non-additive in determining the inheritance of the charcters studied except the numbers of filled grains per panicle. Clustering varieties based on similarity of quantitative characters produced two large groups. The first group included all long duration varieties (average is 146.75 days) except Sakha 102. The second group included all short duration resistance varieties except Pi No.4. The morphological characters dendogram divided the varieties mostly according to their heading date. Also, the principal component analysis agreed with the results obtained by the dendogram analysis.

INTRODUCTION

In Egypt, the area planted to rice is about 450,000 hectare, which is about 15% of the total cultivated area during the summer season. The annual rice production is about 5-6 million tons and the national yield average is 9.1 t/h (RRTC National report, 2001), which is one of the highest in the world. A part of rice production is locally consumed as a preferred and essential staple food and the other part is exported. During the last twenty years, rice crop has been improved significantly in Egypt concerning yield average per unite area, grain quality, and other desirable characters such as short plant type, short growth duration, and disease resistance. Because of the great impact of these characters on rice production, RRTC strategy gave more attention to develop high yielding potential varieties with short growth duration (120-135 days), short stature (90-100Cm), and blast resistance.

There are many exotic varieties had been used to introduce these characters to the Egyptian varieties and to increase genetic variation to the Egyptian germplasm (RRTC report, 2002). However, there are many essential parameters need to be examined before introducing these exotic materials such as their combining abilities and their genetic relationship to the Egyptian varieties.

Combining ability implies the capacity of a parent to produce progenies when crossed with other parents. In breeding programs, information on combining ability clues to the nature of gene action, desirable parents and important yield traits may be found (Borgohain and Sharma 1998).

The study of genetic relationship is important for selection and prediction of progeny as well as for the conservation and characterization of germplasm. This genetic relationship in rice has been studied using quantitative traits which has important characters: (i) rice quantitative traits with high heritability values that can be easily scored (ii) rice databases available to be used (Dingkhun and Asch, 1999), and (iii) computer analyses for available quantitative traits.

Consequently, the aim of this research is to study combining ability (general and specific) of vegetative and yield and its components characters among some Egyptian varieties, promising lines and exotic varieties, and to cluster these genotypes into groups according to their morphological characters.

MATERIALS AND METHODS

This study was carried out at the experimental farm of RRTC, Sakha, Kafr El-Sheikh, Egypt, during the rice growing seasons of 1998, 1999, 2000 and 2001. The materials used were 12 rice varieties (*Oryza sativa* L.) that included eight Egyptian varieties and lines viz. Giza159, Giza176, Giza171, Giza177, Sakha101, Sakha102, Sakha 103, and Gz5310-20-3-3 along with four Japanese varieties, i.e. Pi No4, Toride1, Shin2 and Fuknishiki. The important information about these varieties and lines are presented in Table (1).

Two parallel experiments were conducted in 1998 in which the first experiment included a half diallel cross among 12 parents to produce 66 crosses, while the second one included 12 parents only. In the first experiment, the parental varieties and the resulting 66 F_1 hybrids were transplanted in 1999 in rows at distances of 20X20cm. The experiment was arranged in a randomized complete block design with three replications.

The F_1 and parents were grown in 1999 seasonand the recommended agricultural practices were applied. Vegetative and yield and its component characters were recorded for all genotypes. Vegetative characters included heading date, plant height, number of tillers per plant and flag leaf area while yield and its components included grain yield per plant, 1000 - grain weight, panicle length, number of panicles per plant, number of spikelets per panicle and number of filled grains per panicle.

In the second experiment, the parental varieties were planted and evaluated for three years and the data of the vegetative and yield and its component characters were recorded.

Data analysis

F_1 grain yield data was analyzed on plot mean basis. Analysis of variance for RCB was firstly performed for F_1 diallel set. The effects of blocks and genotypes were assumed to be fixed. When the differences among genotypes were significant, further appropriate analysis was carried out. Therefore, general and specific combining ability estimates (additive and non-additive effects) were obtained following Griffing's (1956) method 2, model 1. All statistical parameters and analysis of variance were computed by IRRISTAT and MSTAT-Cpc software.

Parent's averages of the recorded data of the three-year experiments for the vegetative traits and yield and its component trails were calculated. In order to detect patterns of genetic relationship in the varieties, data analysis on the means of clearly defined 13 quality traits was initially performed based on the Euclidean distance matrix. The analysis was conducted using the Numerical Taxonomy and Multivariate Analysis system, Version 2.1 (NTSYSpc; Rolhf, 2000). The output was analyzed using an agglomerative hierarchical clustering method with complete linkage strategy. Firstly, the data was subjected to analysis to produce a matrix of dissimilarity values and the phenotypic distance between each pair of lines was estimated as Euclidean distance. Secondly, cluster analysis was then conducted on the Euclidean distance matrix with un-weighted pair-group method based on arithmetic average (UPGMA) to develop a dendogram. Finally, Principle Component Analysis (PCA) was carried out.

RESULTS AND DISCUSSION

Mean Performance for vegetative characters:

Mean performance of the twelve parents and their F_1 of the diallel cross for vegetative characters are presented in Table (2). Concerning growth duration, the F_1 mean value ranged from 148.67 days for the cross Giza 176 x Giza 171 to

119.67 days for the cross Giza 176 x Fukunishiki. Also, the highest mean performances of the parents were those of Giza 171 (154.67), Giza 159 (145.67), Giza 176 (144.33) and Sakha 101 (141.33), while, the lowest values were Gz5310-20-3-2 (119.33), Fukunishiki (121.33), Sakha 103 (125.33) and Giza 177 (125.33).

As for plant height, the highest value was 149.34 cm in the cross Giza 159 x Sakha 101 and the lowest values were 95.57cm in the cross Sakha 101 x Sakha 103 and 96.93 in the cross Pi No.4x Fukunishiki. Also, the highest mean performance of the parents was that of Giza 171 (134.87) and Giza 159 (133.80), while the lowest values were those of Sakha 101(91.67), Gz5310-20-3-2 (93.5) and Giza 177 (95.70).

With respect to the number of tillers per plant, the highest value of the mean performance appeared in the cross Toride1 x Sakha 101 (29.0), Toride1 x Sakha 102 (28.0) and Giza 159 x Giza 176 (27.0), while the lowest values were in the crosses Pi No.4 x Fukunishiki (15.0), Pi No.4 x Giza 177 (16.67), and Pi No.4 x Shin2 (17.0). As for the parents, the highest parent values were those of Sakha 101, Giza 176 and Giza 171, which showed 27.03, 26.07 and 24.23, respectively.

For flag leaf area, the highest mean performances were in the crosses Pi No.4x Gz5310-20-3-2, Giza 171 x Gz5310-20-3-2, Sakha 102 x Gz5310-20-3-2, Giza 171 x Giza 177 and Giza 171 x Sakha 101 with values 48.16, 47.32, 44.19, 42.74 and 42.34 respectively. Whereas, the lowest value was recorded 25.08 in the cross Shin2 x Sakha 103. On the other hand, the highest parents were Giza 159 (46.43), Giza 176 (41.87), Gz5310-20-3-2 (41.60) and Sakha 101 (41.43), while the lowest values were observed in Fukunishiki (18.54), Giza 177 (23.06) and Sakha 101 (25.54).

Analysis of variance for vegetative characters:

Seventy-eight genotypes were tested using analysis of variance, which included 12 parents and 66 crosses. The data showed that the genotype mean squares were significant. Griffing method was used for estimating the portion of additive and non-additive gene action involved in the inheritance of the characters studied, Griffing method estimated the variance due to general combining ability and specific combining ability.

Table (3) shows the partitioning of total variance among genotypes into general and specific combining ability for vegetative characters. These characters were heading date (duration), plant height, number of tillers per plant and flag leaf area.

The mean squares for these characters showed highly significant differences among genotypes, parents and their crosses for all traits. Also, both general and specific combining ability variances were found to be highly significant for all vegetative characters. This indicates the importance of both additive and non additive genetic variance in determining the inheritance of the studied vegetative characters. The GCA/SCA variances were greater than unity for the mentioned characters, suggesting greater importance of additive genetic variance in the inheritance of characters studied. Abd El-Hafez *et al.* (1992), Ramalingam *et al.* (1993), Borgohain and Sharma (1998), Meenakshi and Amirthadevarthinam (1999) and Abd El-Aty *et al.* (2002) reported that additive gene action played the major role in the inheritance of these characters under non stress condition. While, El-Hissewy and El-Kady (1992), El-Mowafi (1994) and Verma *et al.* (1995) showed additive, non-additive and dominance controlling the inheritance of these characters. Moreover, Borgohain and Sharma (1998) and Abd El-Aty *et al.* (2002) reported that additive x additive, additive x dominant were important for inheritance of these characters except plant height and number of tillers per plant which were controlled by additive genes.

General combining ability for vegetative characters:

Table (4) presents the general combining ability effects of the parental lines for vegetative characters studied. Heading date was highly significant and negative for Pi No.4, Fukunishiki, Shin 2, Sakha 102, Giza 177, Gz5310-20-3-2 and Sakha 103, indicating that these varieties could be good combiners for earliness. On the other hand, five parents were highly significant and positive, viz. Giza 171, Giza 176, Sakha 101, Giza 159 and Toride1.

With respect to plant height, eleven parents gave significant values, out of which, seven showed negative values namely, Pi No. 4, Sakha 103, Sakha101, Gz5310-20-3-2, Fukunishiki, Giza 177 and Giza 176. However, the negative values of GCA effects for plant height proves that theses parents could be useful in the local breeding program for producing short stature plants. The rest of the parents (four) showed positive significant values, i.e. Giza 159, Giza 171, Toride1 and Shin2. Concerning general combining ability for number of tillers per plant, all parental varieties were highly significant except Sakha 102. Six parents gave positive significant values namely, Sakha 101, Giza 176, Giza 171, Sakha 103, Giza 159, and Trode1, suggesting that these varieties could be considered as good combiners for number of tillers per plant. Whereas, five varieties gave negative significant values viz. Pi No.4, Shin2, Giza 177, Fukunishiki and Gz5310-20-3-2.

As for flag leaf area, shown in (Table 4), all parents gave highly significant values except Giza 177 and Gz5310-20-3-2. The data showed that five parents gave positive significant values; Giza 159, Giza171, Sakha 101, Sakha 102 and Giza 176. These data indicate that these varieties were the best combiners for flag leaf area and could be used for improving leaf area characters in rice breeding programs. Also, five clutivars gave negative significant values for flag leaf area namely, Shin2, Fukunishiki, Sakha 103, Pi No.4 and Toride1.

According to the above results, it could be concluded that Sakha 103 is the best combiner for short duration, short stature and number of tillers per plant, while Sakha 101 is a good combiner for plant height, number of tillers per plant and flag leaf area.

Specific combining ability for vegetative characters:

Specific combining ability effects of the F_1 crosses for vegetative characters studied are shown in Table (5). Heading date (duration) showed that twenty-seven crosses were negatively significant. The highest negative value was −16.048 for the cross Giza 176 x Fukunishiki and the lowest value was −0.595 for the cross Giza 176 x Sakha 101. While, thirty-four crosses revealed positive and significant specific combining ability effects ranging from 22.69 for the cross Fukunishiki x Giza 177 to 0.595 for the cross Shin2 x Sakha 102. On the other hand, five crosses gave non-significant effects for this character. Generally, the combinations showing negative significant specific combining ability effects could be useful in breeding for earliness.

For plant height character, Table (5) showed that thirty-four crosses were significantly positive for specific combining ability effects. The values of SCA effects ranged from 22.526 for Giza 159 x Sakha 101 to 0.907 for cross Giza 171 x Sakha 103. While, twenty-five crosses were significantly negative and the highest negative value was −24.817 for cross Giza 159 x Giza 176 and the lowest negative value was −0.883 for cross Giza 177 x Sakha 102. The rest of the crosses (seven) were not significant. Therefore, the best combination that showed significant negative effect could be suitable for mechanical harvesting.

In regard to number of tillers per plant, twenty-three crosses were significantly positive for specific combining ability effect. The values ranged from 5.149 for cross Toride1 x Sakha 102 to 0.573 for cross Giza 171 x Sakha 101. While, twenty-seven crosses were significantly negative and ranged from −4.841 for Giza 177 x Sakha 101 to −0.770 for cross Shin2x Giza 177. Also, sixteen crosses were not significant for this character. Generally, the best combinations that recorded significant positive for specific combining ability can be used in rice breeding programs for improving tillering ability character.

Concerning flag leaf area, the data showed that twenty-three crosses were negatively significant for specific combining ability effect. The heighest negative value was –9.887 for the cross Giza 177 x Sakha 101 and the lowest negative value was –2.016 for the cross Giza 176 x Shin 2. On the other sides, twenty crosses were significantly positive and ranged from 10.738 for cross Giza 177 x Gz5310-20-3-2 to 2.053 for the cross Giza 171 x Shin 2. The rest of the crosses (twenty) were not significant for this character. Therefore, it can be concluded that the hybrid Giza 176 x Fukunishiki was the best combination for short duration, short stature and flag leaf area, the hybrid Giza 171 x Toride1 was god for short duration, short stature, number of tillers per plant and flag leaf area, while, the cross Giza 176 x Giza177 was superior concerning the four vegetative characters except number of tillers per plant. Accordingly, it could be recommended that these combinations could be used in rice breeding programs.

Performance of different genotypes of yield and its component characters:

Table (6) presents mean performance for twelve parents and their F_1 of the diallel crosses for seven yield characters. These characters were grain yield per plant, 1000-grain weight, panicle weight, number of panicles per plant, number of filled grains per panicle, panicle length, and number of unfilled grains per panicle.

For grain yield per plant, the data showed that complete to over dominance was observed in most of the crosses (thirty crosses) which gave the highest grain yield per plant. The best crosses among the thirty crosses were Giza 171 x Giza 177 (107.50gm), Toride1 x Sakha 102 (93.60) grams per plant, Giza 171 x Fukunishiki (91.40) and Giza 176 x Fukunishiki (89.57). While, the lowest values resulted from the cross Pi No.4x Fukunishiki (33.77) grams per plant. However, the parental lines Sakha 101, Giza 176, Giza 171 Sakha 103 and Giza 159 showed the highest mean performance recording 62.47, 62.37, 58.40, 58.40, 57.60, and 57.33 gm/plant, respectively.

The mean performances of 1000-grain weight for 66 crosses ranged from 20.60 gm. to 31.50 gm. The highest mean values resulted from the crosses Giza 177 x Gz5310-20-3-2, Fukunishiki x Sakha 102, Fukunishiki x Sakha 103 and Fukunishiki x Gz5310-20-3-2 (Table 6). While, the lowest values were obtained from the crosses Giza 159 x Giza 177, Giza 176 x Sakha 103, Fukunishiki x Giza 177, Giza 171 x Fukunishiki, and Giza 159 x Sakha 102. The parents Gz5310-20-

3-2, Giza 177, Sakha102, Fukunishiki and Sakha 103 gave the highest 1000-grain weight; 29.30, 28.53, 27.73, 27.47 and 27.33 gm, respectively.

As for number of panicles per plant, the parents Sakha 101, Giza 176 and Sakha 103 showed the highest mean values 24.57, 24.10 and 22.53, respectively. While, the crosses Toride1 x Sakha 101, Toride1 x Sakha 102, Giza 159 x Giza 176, Gz5310-20-3-2 x Sakha 103, Giza 159 x Sakha101, Giza 176 x Giza 171 and Giza 171 x Toride1 gave highest mean values, 28.33, 26.0, 25.19, 24.67, 24.33, and 24.33, respectively. At the same time, the lowest values were 13.33 for the cross Pi No.4x Fukunishiki, 15.67 for cross Pi No.4x Shin2and 15.67 for cross Giza 177 x Sakha 101.

For the number of filled grains per panicle, the highest parents were Giza 171, Sakha 103, Sakha 101 and Shin 2, which gave 180.33, 180.0, 165.33 and 161.67 respectively. Also, the highest crosses were Giza 159 x Giza 171 (232.33), Giza 171 x Gz5310-20-3-2 (227.33), Giza 171 x Pi No.4(201.33), Sakha 101 x Sakha 103(189.67) and Toride1 x Sakha 103 (186.67). While, the lowest crosses were Giza 171 x Giza 177 (71.6), Pi No.4x Sakha 103 (78.0), Pi No.4x Giza 177 (81.67) and Pi No.4x Fukunishiki (86.33).

As for panicle length, the parents Sakha 101, Toride1, Giza 176 and Sakha 102 gave the highest values that ranged from 23.10 to 24.10. On the other hand, the crosses Sakha 102 x Gz5310-20-3-2, Giza 159 x Sakha 102 and Giza 176 x Fukunishiki gave the highest mean values; 26.17, 25.67 and 25.40 respectively. Also, the lowest values were 19.63 (Pi No.4x Sakha 103) and 19.97 (Pi No.4x Sakha 102).

For number of unfilled grains per panicle, the parent values ranged from 9.67 to 20.33. Also, the highest crosses were Fukunishiki x Giza 177, Giza 159 x Giza 171, Shin2x Gz5310-20-3-2 and Shin2x Sakha 103 which gave 18.0, 16.67, 16.33, and 16.33 respectively. While the lowest crosses were Giza 177 x Sakha 101, Pi No.4x Gz5310-20-3-2, Pi No.4x Giza 177 and Toride1 x Shin2which gave 2.0, 7.33, 7.67 and 7.67, espectively.

Analysis of variance for yield and its component characters:

Table (7) shows the partitioning of the total variance among genotypes into general combining ability and specific combining ability for seven yield characters. The mean squares revealed highly significant differences among parents and their crosses for all traits. Both general combining ability and specific combining ability variances were found to be highly significant for all traits studied indicating the importance of both additive and non-additive genetic variance in determining the inheritance of the seven yield characters. The

GCA/SCA variance was greater than unity for all traits except for number of unfilled grains per panicle suggesting the greater importance of additive genetic variance in the inheritance of these characters except for number of filled grains per panicle. El-Keready *et al.* (1994) and El-Abd (1995) found that additive and non additive were important in the inheritance of these characters. Also, El-Malky (1997) showed that additive effect was important in number of panicle per plant and non-additive was important in other yield characters. Whereas, Abd El-Aty *et al.* (2002) and El-Refaee (2002) showed the additive variance effects were important in all yield characters.

General combining abilityof yield and its component characters:

Table (8) shows general combining ability effects of seven yield characters. For grain yield per plant, nine parents were highly significant and three parents were not significant. The positive significant parents were Giza 176, Sakha 101 and Giza 171. While, the negative significant were Giza 159, Pi NO.4, Shin 2, Giza 177, Sakha 102, and Sakha 103. Generally, the varieties that were significant positive could be good combiners for grain yield per plant.

As for number of panicles per plant, the general combining ability effects of six varieties were highly significant and positive (Table 8) indicating that these varieties could be considered as good combiners for high number of panicles per plant. On the other hand, the other six parents showed significant negative values and considered as poor combiners for this character.

Concerning 1000-grain weight, seven parents gave significant and highly significant positive values, i.e. Gz5310-20-3-2, Sakha 103, Fukunishiki, Sakha 102, Sakha101, Giza 177, and Toride1 (Table 8) suggesting that these varieties could be good combiners for this character, while four varieties gave significant negative values as poor combiners.

For panicle length, the data showed that only four parents gave highly significant positive values, Sakha 101, Sakha 102, Toride1 and Giza 176 proving that these varieties could be used in breeding programs.

With respect to number of filled grains per panicle, the data showed that five varieties gave highly significant positive values, Giza 171, Giza, 159, Gz5310-20-3-2, Shin2and Sakha 101 (Table 8). This result indicated that these varieties could be good combiners for this character, however six varieties were poor combiners since they recorded highly significant negative values for this character.

Number of unfilled grains per panicle, Table (8) showed that three varieties were highly significantly negative, viz. Toride1, Giza 177, and Pi No.4

while three varieties were highly significant positive, i.e. Giza171, Shin2 and Sakha 101. From the previous results, it could be concluded that Sakha 101 and Giza 176 could be used as good combiners for all yield characters.

Specific combining abilityof yield and its component characters:

Table (9) shows specific combining ability effects for 66 F1s for yield characters. As for grain yield per plant, the data showed that twenty-four crosses showed highly significant positive estimates of specific combining ability effects. The highest estimates were obtained for the crosses Giza 171 x Giza 177 (41.85), Toridel x Sakha 102 (34.78), Fukunishiki x Giza 177 (32.65), Giza 171 x Pi No.4(26.27), and Giza 159 x Gz5310-20-3-2 (24.14). Generally, these combinations could be used as the best crosses for grain yield per plant. On the other hand, twenty-six crosses gave highly significant negative values, and sixteen crosses were found to be non-significancant for SCA effects indicating that they are poor combinations.

For number of panicles per plant, twenty one crosses gave highly significant positive values of SCA and could be recommended as good combinations to be utilized in the breeding program. On the other hand, twenty-six crosses gave highly significant negative values and nineteen crosses were found to be non-significant for this character, thus, they are considered poor combinations (Table 9).

As for 1000 grain weight, twenty crosses showed highly significant and positive SCA (Table 9) indicating that they are good combinations for this character. Out of the positive twenty crosses, the highest and the best one was Fukunishki X Sakha 102.

As for panicle length, thirty-one crosses showed significantly positive estimates of SCA effects. Out of which, four crosses namely, Sakha 102 x Gz5310-20-3-2, Giza 159 x Sakha 102, Giza 176 x Fukunishiki and Giza 176 x Pi No.4 revealed the highest values (Table 9) and considered as good combiners for this character. On the other hand, twenty-two crosses gave highly significant negative values and thirteen crosses were non-significant for SCA effects for this character.

The estimates of SCA effects of number of filled grains per panicle showed that twenty two crosses exhibited highly significant positive, the highest one was 76.26 for Fukunishiki x Giza 177 and the lowest was 4.97 with Shin2x Gz5310-20-3-2. Also, thirty-one crosses were highly significant negative, ranging from –50.24 (Toridel x Sakha 101) to –5.31 (Giza 171 x Fukunishiki). However, thirteen crosses were non-significant in this trait.

Number of unfilled grains per panicle, the data in Table (9) revealed that seventeen crosses indicated highly significant positive values of specific combining ability effects that ranged between 6.60 in cross Fukunishiki x Giza 177 and 1.26 in Toride1 x Sakha 102. While, twenty-two crosses exhibited highly significant negative values ranging from –4.20 in Pi No.4x Sakha 102 to –1.20 in Gz5310-20-3-2 x Sakha103. On the other hand, twenty-seven crosses were non-significant in the number of unfilled grains per panicle. According to the above results, the best combination that could be used in breeding programs are Giza 171 x Giza 177, Toride1 x Sakha 102, and Shin2x Sakha 101.

Clustering of the varieties based on similarity of agronomic characters:

Genetic relationships among individuals and populations can be measured by similarity of number of quantitative characters as reported by Zhang *et al.*, (1995) and Dinghuhn and Asch (1999). The characters used for this purpose in the present study were, duration, plant height, number of tillers per plant, flag leaf area, grain yield per plant, number of panicles per plant, 1000 grain weight, number of filled grains per panicle, number of unfilled grains per panicle, and panicle weight. Normality was checked for all traits, which indicated that most traits had good approximations of normal distributions.

Tables (10) and (11) showed the mean performance and similarity matrix of eleven morphological agronomic characters for twelve parents. Clustering varieties based on similarity of quantitative characters produced two large groups (Fig.1). The first group (GI) included; Giza 159, Giza 171, Giza 176, Sakha 101 and Sakha 102. This group included all long duration varieties (average is 146.75 days) except Sakha 102. Although, Sakha 102 is of short duration, it included in this group because it has high value for flag leaf area. This group was divided into two subgroups, the first subgroup included Giza 159 and Giza 171 in which both varieties have the highest values for duration character. Second subgroup included Giza 176, Sakha 102, and Sakha 101, out of which two were long duration varieties (Giza 176 and Sakha 101) and the last one (Sakha 102) was variety short duration. The reason that Sakha 102 included in this group is that it has morphological characters similar to Giza 176 like flag leaf area, panicle length and panicle weight. With respect to the second group (GII), it included all short duration varieties except Pi No.4. This group (GII) divided into two subgroups according to their origin. The first one included the Japanese differential varieties, while the second group included the Egyptian varieties. However, Fukunishiki was in a special subgroup, although, it is a short duration variety but it has some specific characters that made it different from other varieties.

In other wards, the morphological characters dendogram divided the varieties mostly according to their heading date. Also, the principal component analysis Figure (2) agreed with the results obtained by the dendogram analysis (Fig. 1).

Finally, the correlations between Euclidean distance and the SCA of vegetative and yield and its components characters were calculated (Table 12). The results indicated that there were no significant correlations exist. This is may be due to that there is poor linkage among the genes controlling the morphological traits under-study.

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Table 1. Origin, country of release and blast reaction based on two-year evaluation of the 12 studied parental rice varieties and lines.

No.	Variety	Country of release	Origin	last reaction*
1	Giza 159	Egypt	Giza 14/Agami M1.	7
2	Giza 176	Egypt	Calrose 76/Giza 172//Gz 242	5
3	Giza 171	Egypt	Nahda / Calady 40	7
4	Pi No.4	Japan	TA 820b / Norin 8	5
5	Toride1	Japan	TKM1/NORIN 8*5	3
6	Shin 2	Japan	KAMANO-O/KAIRYOAIKOKU	2
7	Fuknishiki	Japan	KINKIUS45/KINKIUS11//ZENTH/3/KINKIUS45/KINKIUS11/4HATSUNISHIKI	2
8	Giza 177	Egypt	Giza171/YomjiNo.1//Pi No.4	3
9	Sakha 101	Egypt	Giza176 / Milyang 79	3
10	Sakha 102	Egypt	Gz 4098-7-1/ Giza 177	2
11	Gz5310-20-3-3	Egypt	Gz3707-4-2-2/ Gz4096-7-1	2
12	Sakha 103	Egypt	Giza 177/Suweon 349	2

*Blast reaction from 1 to 3 = Resistant
Blast reaction from 4 to 10 = Susceptible

Table 2. Mean performance of parental varieties and their F_1 crosses for vegetative characters.

Genotype	Heading date (day)	Plant height (cm)	No. of tillers/plant	Flag leaf area (cm²)
Giza 159	145.67	133.80	23.00	46.43
Giza 176	144.33	103.83	26.07	41.87
Giza 171	154.67	134.87	24.23	37.80
Pi No. 4	122.67	107.33	23.67	30.02
Toride 1	133.67	114.40	21.40	34.96
Shin 2	126.67	111.50	18.37	32.49
Fukunishiki	121.33	99.53	21.67	18.54
Giza 177	125.33	95.70	20.80	23.06
Sakha 101	141.33	91.67	27.03	25.94
Sakha 102	125.67	109.70	23.00	41.43
Gz 5310-20-3-2	119.33	93.57	18.63	41.60
Sakha 103	125.33	102.97	24.00	22.89
Giza 159 / Giza 176	143.67	107.00	27.00	36.25
Giza 159 / Giza 171	145.67	131.37	22.33	36.39
Giza 159 / Pi No. 4	136.67	134.13	21.00	33.63
Giza 159 / Toride 1	141.67	138.80	20.67	35.08
Giza 159 / Shin 2	140.67	145.57	18.67	38.05
Giza 159 / Fukunishiki	135.33	141.33	23.00	41.70
Giza 159 / Giza 177	131.33	141.33	22.33	39.93
Giza 159 / Sakha 101	143.67	149.34	25.67	33.93
Giza 159 / Sakha 102	125.67	145.27	22.33	31.93
Giza 159 / Gz 5310-20-3-2	140.67	132.03	24.67	40.30
Giza 159 / Sakha 103	123.67	108.00	22.33	36.05
Giza 176 / Giza 171	148.67	141.97	25.33	31.95
Giza 176 / Pi No. 4	138.67	113.90	22.67	34.47
Giza 176 / Toride 1	146.67	122.30	24.00	33.90
Giza 176 / Shin 2	139.67	128.03	21.33	29.22
Giza 176 / Fukunishiki	119.67	110.97	21.67	32.38
Giza 176 / Giza 177	130.00	112.30	20.67	38.17
Giza 176 / Sakha 101	145.67	109.60	22.67	33.22
Giza 176 / Sakha 102	145.00	111.97	22.33	37.55
Giza 176 / Gz 5310-20-3-2	147.33	121.90	22.67	34.37
Giza 176 / Sakha 103	148.00	118.87	23.00	37.34
Giza 171 / Pi No. 4	133.33	134.00	21.00	41.79
Giza 171 / Toride 1	137.67	124.53	25.33	41.52
Giza 171 / Shin 2	135.33	134.70	21.00	34.98
Giza 171 / Fukunishiki	136.00	130.23	23.67	31.79
Giza 171 / Giza 177	142.67	126.93	24.00	42.74
Giza 171 / Sakha 101	147.67	115.83	25.33	42.34
Giza 171 / Sakha 102	142.33	131.60	19.67	35.57
Giza 171 / Gz 5310-20-3-2	143.00	131.57	20.03	47.32
Giza 171 / Sakha 103	145.33	123.10	24.33	34.73

Table (2). Cont.

Pi No. 4 / Toride 1	126.33	108.53	19.33	30.28
Pi No. 4 / Shin 2	127.33	103.73	17.00	34.41
Pi No. 4 / Fukunishiki	125.00	96.93	15.00	26.85
Pi No. 4 / Giza 177	129.67	103.73	16.67	34.55
Pi No. 4 / Sakha 101	135.33	103.30	20.33	35.78
Pi No. 4 / Sakha 102	122.33	104.90	20.03	35.30
Pi No. 4 / Gz 5310-20-3-2	127.67	100.13	19.33	48.16
Pi No. 4 / Sakha 103	120.33	101.27	19.33	31.03
Toride 1 / Shin 2	135.67	114.23	21.00	29.38
Toride 1 / Fukunishiki	135.00	113.13	20.33	31.47
Toride 1 / Giza 177	135.33	119.10	21.67	31.07
Toride 1 / Sakha 101	134.00	118.80	29.00	36.05
Toride 1 / Sakha 102	135.33	121.00	28.00	35.30
Toride 1 / Gz 5310-20-3-2	136.67	122.73	23.00	28.16
Toride 1 / Sakha 103	137.67	114.87	22.67	30.84
Shin 2 / Fukunishiki	122.33	121.43	24.00	30.24
Shin 2 / Giza 177	129.67	114.60	18.67	29.49
Shin 2 / Sakha 101	139.67	121.10	24.00	37.10
Shin 2 / Sakha 102	128.33	119.10	20.33	30.69
Shin 2 / Gz 5310-20-3-2	123.67	111.93	18.00	25.75
Shin 2 / Sakha 103	125.33	108.37	23.67	25.08
Fukunishiki / Giza 177	148.67	132.17	24.00	34.17
Fukunishiki / Sakha 101	135.33	107.50	21.67	29.67
Fukunishiki / Sakha 102	126.00	106.20	21.00	28.70
Fukunishiki / Gz 5310-20-3-2	122.67	102.67	21.00	29.01
Fukunishiki / Sakha 103	122.67	105.57	19.33	27.50
Giza 177 / Sakha 101	126.33	107.20	18.00	25.74
Giza 177 / Sakha 102	128.33	113.47	19.33	40.13
Giza 177 / Gz 5310-20-3-2	125.33	110.27	19.67	28.48
Giza 177 / Sakha 103	126.67	112.87	24.00	42.63
Sakha 101 / Sakha 102	141.67	116.63	25.00	32.88
Sakha 101/ Gz 5310-20-3-2	143.67	108.20	24.00	35.05
Sakha 101 / Sakha 103	142.67	95.57	22.33	42.43
Sakha 102/ Gz 5310-20-3-2	128.33	115.73	22.00	44.19
Sakha 102 / Sakha 103	125.33	113.03	22.33	29.84
Gz 5310-20-3-2/ Sakha 103	128.33	110.37	26.33	31.73
LSD at 5%	1.54	2.61	1.92	6.88
LSD at 1%	2.02	3.43	2.53	9.06

** = Significant at 1 % level

* = Significant at 5 % level

Table 3. Mean squares of general and specific combining ability effects and GCA/SCA for vegetative characters.

Sov.	d.f	Heading date (day)	Plant height(cm)	No. of tillers/plant	Flag leaf area(cm²)
Reps.	2	0.286	0.716	0.274	1.120
Genotypes	77	235.449**	551.289**	20.041**	98.69**
G.C.A.	11	1023.518**	2288.876**	55.868**	275.197**
S.C.A.	66	104.105**	261.691**	14.070**	69.234**
Error	154	0.308	0.885	0.481	6.166
GCA/SCA		9.831	8.746	3.970	3.974

** = Significant at 1 % level
* = Significant at 5 % level

Table 4. Estimates of GCA effects of the parental lines evaluated for vegetative characters.

Parent	Heading date (day)	Plant height (cm)	No. of tillers / plant	Flag leaf area (cm²)
Giza 159	3.806**	5.873**	0.568**	3.731**
Giza 176	6.758**	0.944**	1.235**	1.523**
Giza 171	8.567**	2.573**	0.887**	3.221**
Pi No. 4	-5.647**	7.165**	-1.861**	-1.208**
Toride 1	1.591**	.949**	0.673**	-0.757**
Shin 2	-3.290**	.875**	-1.689**	-4.413**
Fukunishiki	-5.433**	3.753**	-0.718**	-3.736**
Giza 177	-2.980**	2.435**	-1.032**	-0.187
Sakha 101	5.111**	5.953**	1.715**	1.695**
Sakha 102	-3.361**	0.103	0.20	1.600**
Gz5310-20-3-2	-2.933**	4.659**	-0.485**	0.581
Sakha 103	-2.194**	7.270**	0.687**	-2.047**
L.S.D. at 0.05	0.135	0.227	0.169	0.606
at 0.01	0.639	0.322	0.240	0.859

** = Significant at 1 % level
* = Significant at 5 % level

Table 5. Estimates of SCA effects of 66 F_1 crosses for vegetative characters.

Genotype	Heading date (day)	Plant height (cm)	No. of tillers/plant	Flag leaf area (cm²)
Giza 159 / Giza 176	-1.286**	-24.817**	3.040**	-3.130**
Giza 159 / Giza 171	-1.095**	-13.967**	-1.279**	-4.881**
Giza 159 / Pi No. 4	4.119**	8.538**	0.135	-3.016**
Giza 159 / Toride 1	1.881**	4.090**	-2.732**	-2.020*
Giza 159 / Shin 2	5.762**	10.930**	-2.370**	4.606**
Giza 159 / Fukunishiki	2.571**	12.326**	0.992**	7.579**
Giza 159 / Giza 177	-3.548**	11.007**	0.640*	2.267*
Giza 159 / Sakha 101	0.357	22.526**	1.226**	-5.615**
Giza 159 / Sakha 102	-9.167**	12.609**	-0.412	-7.793**
Giza 159 / Gz 5310-20-3-2	5.405**	3.921**	2.426**	1.862
Giza 159 / Sakha 103	-12.333**	-17.493**	-1.079**	0.242
Giza 176 / Giza 171	-1.048**	13.449**	1.054**	-6.920**
Giza 176 / Pi No. 4	3.167**	5.121**	1.135**	0.033
Giza 176 / Toride 1	3.929**	4.407**	-0.065	-0.982
Giza 176 / Shin 2	1.810**	10.214**	-0.370	-2.016*
Giza 176 / Fukunishiki	-16.048**	-1.224**	-1.008**	2.474*
Giza 176 / Giza 177	-8.167**	-1.210**	-1.693**	2.711*
Giza 176 / Sakha 101	-0.595*	-0.391	-2.441**	-4.117**
Giza 176 / Sakha 102	7.214**	-3.874**	-1.079**	0.309
Giza 176 / Gz 5310-20-3-2	9.119**	10.604**	-0.241	-1.853
Giza 176 / Sakha 103	9.048**	10.190**	-1.079**	3.742**
Giza 171 / Pi No. 4	-3.976**	11.704**	-0.184	5.661**
Giza 171 / Toride 1	-6.881**	-6.877**	1.616**	4.940**
Giza 171 / Shin 2	-4.333**	3.364**	-0.355	2.053*
Giza 171 / Fukunishiki	-1.524**	4.526**	1.340**	-2.147*
Giza 171 / Giza 177	2.690**	-0.093	1.988**	5.580**
Giza 171 / Sakha 101	-0.405	-7.674**	0.573*	3.302**
Giza 171 / Sakha 102	2.738**	2.242**	-3.398**	-2.363*
Giza 171 / Gz 5310-20-3-2	2.976**	6.754**	-2.560**	9.399**
Giza 171 / Sakha 103	4.571**	0.907*	0.602*	-0.563
Pi No. 4 / Toride 1	-4.000**	-3.139**	-1.636**	-1.858
Pi No. 4 / Shin 2	1.881**	-7.866**	-1.608**	5.992**
Pi No. 4 / Fukunishiki	1.690**	-9.039**	-4.579**	-2.322*
Pi No. 4 / Giza 177	3.905**	-3.555**	0.402	1.822

Table 5. cont.

Pi No. 4 / Sakha 102	-3.048**	-4.720**	-0.317	0.786
Pi No. 4 / Gz 5310-20-3-2	1.857**	-4.941**	-0.479	-5.332**
Pi No. 4 / Sakha 103	-6.214**	-1.189**	-1.651**	0.159
Toride 1 / Shin 2	2.976**	-6.479**	-0.141	0.427
Toride 1 / Fukunishiki	4.452**	-1.951**	-1.779**	1.844
Toride 1 / Giza 177	2.333**	2.698**	-0.132	-2.109**
Toride 1 / Sakha 101	-7.095**	5.916**	4.454**	0.989
Toride 1 / Sakha 102	2.714**	2.266**	5.149**	0.334
Toride 1 / Gz 5310-20-3-2	3.619**	8.545**	0.645*	-5.787**
Toride 1 / Sakha 103	3.881**	3.297**	-0.851**	-0.475
Shin 2 / Fukunishiki	-3.333**	6.423**	4.249**	4.270**
Shin 2 / Giza 177	1.548**	-1.729**	-0.770*	-0.033
Shin 2 / Sakha 101	3.452**	8.290**	1.816**	5.699**
Shin 2 / Sakha 102	0.595*	0.440	-0.155	-0.619
Shin 2 / Gz 5310-20-3-2	-4.500**	-2.182**	-1.984**	-4.537**
Shin 2 / Sakha 103	-3.571**	-3.129**	2.511**	-2.582*
Fukunishiki / Giza 177	22.690**	21.467**	3.592**	3.970**
Fukunishiki / Sakha 101	1.262**	0.318	-1.489**	-2.408*
Fukunishiki / Sakha 102	0.405	-7.032**	-0.460	-3.283**
Fukunishiki / Gz 5310-20-3-2	-3.357**	-5.820**	0.045	-1.957
Fukunishiki / Sakha 103	-4.429**	-0.301	-2.793**	-0.839
Giza 177 / Sakha 101	-9.857**	-1.300**	-4.841**	-9.887**
Giza 177 / Sakha 102	0.286	-0.883*	-1.812**	4.591**
Giza 177 / Gz 5310-20-3-2	-3.143**	0.462	-0.974**	-6.040**
Giza 177 / Sakha 103	-2.548**	5.681**	2.188**	10.738**
Sakha 101 / Sakha 102	5.524**	5.802**	1.107**	-4.541**
Sakha 101/ Gz 5310-20-3-2	7.095**	1.714**	0.611*	-1.352
Sakha 101 / Sakha 103	5.357**	-8.101**	-2.227**	8.656**
Sakha 102/ Gz 5310-20-3-2	0.238	3.597**	0.307	7.887**
Sakha 102 / Sakha 103	-3.500**	3.516**	-0.532	-3.869**
Gz 5310-20-3-2/ Sakha 103	-0.929**	5.395**	3.973**	-0.926
LSD at 5% LSD at 1%	0.450 0.634	0.755 1.070	0.563 0.799	2.016 2.859

** = Significant at 1 % level

* = Significant at 5 % level

Table 6. Mean performance of parental varieties and their F_1 crosses for yield and yield components.

Genotype	Grain yield/ plant (g)	1000-grain weight (g)	Panicle weight (g)	No. of panicles /plant	No. of filled grains/ panicle	Panicle length (cm)	No. of unfilled grains/ panicle
Giza 159	57.33	24.07	3.29	20.57	141.67	20.67	14.67
Giza 176	62.37	25.37	2.61	24.10	122.67	23.13	12.33
Giza 171	58.40	22.13	3.69	21.30	180.33	22.70	15.33
Pi No. 4	44.03	23.83	1.46	21.33	145.00	22.13	19.67
Toride 1	50.47	25.60	2.18	19.57	149.00	23.17	9.33
Shin 2	49.33	24.93	2.11	16.40	161.67	21.07	15.00
Fukunishiki	44.50	27.47	2.12	19.80	86.67	18.97	20.33
Giza 177	49.63	28.53	2.98	19.50	132.67	20.33	10.69
Sakha 101	62.47	25.37	2.32	24.57	165.33	24.10	11.33
Sakha 102	50.13	27.73	2.40	20.57	153.33	23.10	10.33
Gz 5310-20-3-2	53.87	29.30	2.24	19.50	146.00	19.97	9.67
Sakha 103	57.60	27.33	2.57	22.53	180.00	19.63	11.67
Giza 159 / Giza 176	70.08	23.07	3.26	25.19	126.33	20.67	10.67
Giza 159 / Giza 171	67.12	23.13	3.15	21.33	232.33	22.13	16.67
Giza 159 / Pi No. 4	58.87	25.03	2.94	19.67	172.00	23.30	11.00
Giza 159 / Toride 1	55.87	23.73	2.81	19.33	159.00	22.90	11.00
Giza 159 / Shin 2	40.41	21.77	2.31	18.00	153.33	21.63	12.33
Giza 159 / Fukunishiki	52.47	23.97	2.49	21.00	166.00	23.30	11.00
Giza 159 / Giza 177	40.83	20.60	3.25	21.00	139.00	22.53	11.00
Giza 159 / Sakha 101	55.67	26.77	2.84	24.33	158.00	24.57	12.00
Giza 159 / Sakha 102	73.63	21.80	2.47	21.00	161.67	25.67	14.00
Giza 159 / Gz 5310-20-3-2	83.40	23.30	3.65	23.67	160.67	23.53	12.00
Giza 159 / Sakha 103	44.93	28.70	3.07	21.33	172.67	22.97	12.00
Giza 176 / Giza 171	53.50	23.10	2.66	24.33	133.00	24.23	14.67
Giza 176 / Pi No. 4	71.50	26.13	3.18	21.67	114.67	24.40	12.33
Giza 176 / Toride 1	76.83	24.20	3.48	23.00	140.00	22.73	11.00
Giza 176 / Shin 2	76.70	22.43	4.28	19.33	113.00	23.20	10.67
Giza 176 / Fukunishiki	89.57	27.10	3.83	20.00	153.67	25.40	10.67
Giza 176 / Giza 177	61.33	26.63	3.00	19.33	109.67	22.10	11.67
Giza 176 / Sakha 101	84.37	22.90	2.01	21.67	142.00	23.60	13.00
Giza 176 / Sakha 102	77.23	24.80	3.62	21.67	165.33	22.90	12.67
Giza 176 / Gz 5310-20-3-2	69.47	27.07	3.99	22.00	183.67	22.73	13.67
Giza 176 / Sakha 103	65.60	21.10	3.19	21.67	100.67	23.73	13.00
Giza 171 / Pi No. 4	88.20	24.30	4.04	19.67	201.33	23.93	12.67
Giza 171 / Toride 1	59.77	26.40	2.58	24.00	128.33	22.47	12.67
Giza 171 / Shin 2	50.33	23.87	4.02	20.33	166.67	21.73	9.67
Giza 171 / Fukunishiki	91.40	21.33	4.00	22.67	142.00	23.53	13.00
Giza 171 / Giza 177	107.50	22.97	4.61	22.67	71.67	22.67	10.67
Giza 171 / Sakha 101	65.47	24.40	3.45	23.33	136.33	23.37	10.00
Giza 171 / Sakha 102	45.43	25.27	3.40	17.33	143.67	22.20	15.67
Giza 171 / Gz 5310-20-3-2	63.30	23.83	3.41	17.67	227.33	23.43	15.33
Giza 171 / Sakha 103	61.13	26.30	3.10	21.33	145.67	22.33	13.67

Table 6. Cont.

Pi No. 4 / Toride 1	51.90	25.30	2.38	18.00	126.00	23.70	15.67
Pi No. 4 / Shin 2	42.87	24.23	2.41	15.67	117.00	21.13	15.33
Pi No. 4 / Fukunishiki	33.77	24.87	2.43	13.33	86.33	21.37	10.00
Pi No. 4 / Giza 177	55.13	26.33	2.05	18.33	81.67	20.50	7.67
Pi No. 4 / Sakha 101	84.47	29.20	2.65	18.67	125.67	23.10	9.000
Pi No. 4 / Sakha 102	44.33	27.37	1.53	18.33	84.33	19.97	10.33
Pi No. 4 / Gz 5310-20-3-2	52.47	23.60	2.49	17.67	118.33	20.47	7.33
Pi No. 4 / Sakha 103	45.33	26.87	2.02	17.33	78.00	19.63	9.67
Toride 1 / Shin 2	54.20	27.63	3.34	19.33	145.00	24.23	7.67
Toride 1 / Fukunishiki	56.93	27.30	3.64	18.67	144.33	24.97	12.67
Toride 1 / Giza 177	41.03	26.80	2.77	20.33	131.00	23.53	10.67
Toride 1 / Sakha 101	73.60	26.27	3.57	28.33	90.00	23.13	9.67
Toride 1 / Sakha 102	93.60	23.97	3.57	26.00	119.00	22.60	11.67
Toride 1 / Gz 5310-20-3-2	69.63	27.27	3.34	21.67	136.33	21.97	12.33
Toride 1 / Sakha 103	61.33	26.77	3.73	21.33	186.67	24.67	11.00
Shin 2 / Fukunishiki	59.87	27.43	3.20	22.33	123.00	24.40	12.00
Shin 2 / Giza 177	42.70	25.17	2.51	17.00	143.00	20.93	9.33
Shin 2 / Sakha 101	73.73	25.47	2.89	22.33	156.00	24.10	11.67
Shin 2 / Sakha 102	56.93	24.03	2.36	18.33	133.67	24.77	14.00
Shin 2 / Gz 5310-20-3-2	53.23	27.60	2.37	15.67	152.00	24.30	16.33
Shin 2 / Sakha 103	55.60	25.10	1.84	22.33	141.00	22.50	16.33
Fukunishiki / Giza 177	92.57	21.20	3.90	23.00	197.33	23.50	18.00
Fukunishiki / Sakha 101	80.27	26.93	3.29	19.67	162.00	24.07	15.00
Fukunishiki / Sakha 102	55.37	31.17	2.51	19.33	103.33	23.60	9.00
Fukunishiki / Gz 5310-20-3-2	56.23	29.80	3.21	18.67	119.00	22.27	8.67
Fukunishiki / Sakha 103	55.83	30.80	2.93	16.67	86.67	21.67	9.00
Giza 177 / Sakha 101	63.83	26.77	2.43	15.67	137.00	22.63	2.00
Giza 177 / Sakha 102	47.10	25.33	2.49	17.33	164.33	23.23	9.67
Giza 177 / Gz 5310-20-3-2	54.20	31.50	2.62	17.33	126.00	22.83	10.67
Giza 177 / Sakha 103	66.53	27.37	2.30	22.67	155.67	23.43	14.33
Sakha 101 / Sakha 102	70.93	26.30	3.03	22.67	166.67	24.33	12.33
Sakha 101/ Gz 5310-20-3-2	62.27	26.77	3.41	22.00	103.00	22.23	14.33
Sakha 101 / Sakha 103	80.00	26.87	3.02	20.00	189.67	22.60	14.00
Sakha 102/ Gz 5310-20-3-2	56.40	27.30	3.25	20.00	167.33	26.17	16.67
Sakha 102 / Sakha 103	49.87	26.50	3.50	20.33	109.33	24.37	12.00
Gz 5310-20-3-2/ Sakha 103	77.37	29.10	3.75	24.67	111.00	23.33	11.00
LSD at 5%	11.78	2.06	2.65	0.82	15.11	1.22	3.83
LSD at 1%	15.50	2.71	3.49	1.08	20.11	1.60	5.04

** = Significant at 1% level

* = Significant at 5% level

Table 7. Mean squares of general and specific combining ability effects for yield and its components.

SOV	d.f	Grain yield/ plant (g)	No. of panicles plant	1000-grain weight (g)	Panicle weight (g)	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle
Reps	2	1.8443	0.3229	0.7462	0.1246	0.1991	21.86	0.244
Genotypes	77	669.804**	21.325**	16.877**	1.278	6.607**	30881.1**	21.466**
GCA	11	1087.13**	55.766**	48.397**	2.6826**	10.588**	4785.41**	16.54**
SCA	66	600.249**	15.585**	11.624**	1.0439	5.9431**	2805.22**	22.287**
Error	154	18.056	0.553	0.9173	0.0880	0.1926	30.387	1.9103
GCA/SCA		1.811	3.578	4.163	2.5697	1.781	1.705	0.742

** = Significant at 1% level
* = significant at 5% level

Table 8. Estimates of GCA effects of the parental varieties for yield and its component characters.

Genotype	Grain yield/ plant (g)	No. of panicles /plant	1000-grain weight (gm)	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle
Giza 159	-2.734**	0.721**	-1.665**	-0.173**	18.480**	0.310
Giza 176	8.864**	1.512**	-1.003**	0.365**	-6.901**	-0.024
Giza 171	6.060**	0.742**	-1.724**	0.037	18.933**	1.381**
Pi No.4	-6.542**	-1.848**	-0.172	-0.856**	-16.329**	-0.476**
Toride1	-0.870	0.876**	0.245*	0.522**	-1.567*	-0.952**
Shin2	-5.970**	-1.672**	-0.641**	-0.099	2.956**	0.429**
Fukunishiki	0.327	-0.853**	0.966**	0.010	-11.925**	0.048
Giza 177	-2.556**	-0.872**	0.316*	-0.592**	-7.306**	-0.881**
Sakha 101	8.108**	1.495**	0.433**	0.784**	1.504*	0.405**
Sakha 102	-2.458**	-0.243*	0.440**	0.646**	0.099	-0.214
Gz5310-20-3-2	-0.151	-0.419**	1.602**	-0.285**	4.766**	-0.119
Sakha 103	-2.077**	0.562**	1.202**	-0.359**	-2.710**	0.095
L.S.D at 0.05% at 0.01%	1.37 1.47	0.18 0.26	0.23 033	0.11 0.15	1.35 1.91	0.27 0.34

** = Significant at 1% level
* = Significant at 5% level.

Table 9. Estimates of SCA effects for sixty-six crosses evaluated for yield and its component characters.

Genotype	Grain yield/ plant (g)	No. of Panicles /plant	1000-grain weight (g)	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle
Giza 159 / Giza 176	13.810**	2.405**	0.095	-2.360**	-25.55**	-1.850**
Giza 159 / Giza 171	1.658	-0.659**	0.883*	-0.565**	54.617**	2.745**
Giza 159 / Pi No. 4	5.602**	0.265	1.231**	1.394**	29.546**	-1.064
Giza 159 / Toride 1	-2.669	-2.792**	-0.486	-0.284	1.784	-0.588
Giza 159 / Shin 2	-13.029**	-1.578**	-1.567**	-0.929**	-8.40**	-0.636
Giza 159 / Fukunishiki	-7.267**	0.603*	-0.974*	0.628**	19.14**	-1.588*
Giza 159 / Giza 177	-16.017**	0.622*	-3.690**	0.463*	-12.47**	-0.659
Giza 159 / Sakha 101	-11.847**	1.589**	2.360**	1.121**	-3.288	-0.945
Giza 159 / Sakha 102	16.686**	-0.006	-2.614**	2.359**	2.784	1.674**
Giza 159 / Gz 5310-20-3-2	24.145**	2.836**	-2.276**	1.156**	-3.549	0.088
Giza 159 / Sakha 103	-12.395**	-1.478**	3.524**	0.663**	16.59**	-0.636
Giza 176 / Giza 171	-23.564**	1.551**	0.188	0.997**	-19.33**	1.079**
Giza 176 / Pi No. 4	7.038**	1.475**	1.669**	2.059**	-2.407	0.603
Giza 176 / Toride 1	6.700**	0.084	-0.681	-0.989**	8.16**	-0.255
Giza 176 / Shin 2	10.666**	-1.035**	-1.562**	0.099	-23.35**	-1.969**
Giza 176 / Fukunishiki	18.236**	-1.187**	1.498**	2.190**	32.189**	-1.588*
Giza 176 / Giza 177	-7.114**	-1.835**	1.681**	-0.508*	-16.43**	0.341
Giza 176 / Sakha 101	5.255**	-1.868**	-2.169**	-0.384*	7.09**	0.388
Giza 176 / Sakha 102	8.688**	-0.130	-0.276	-0.946**	31.83**	0.674
Giza 176 / Gz 5310-20-3-2	-1.386	0.379	0.829*	-0.182	45.49**	1.579*
Giza 176 / Sakha 103	-3.326	-0.935**	-4.739**	0.892**	-30.02**	0.698
Giza 171 / Pi No. 4	26.275**	0.244	0.557	1.651**	58.42**	-0.469
Giza 171 / Toride 1	-7.563**	1.853**	2.240**	-0.927**	-29.33**	-2.993**
Giza 171 / Shin 2	8.103**	0.734*	0.593	-0.039	4.474	-1.040
Giza 171 / Fukunishiki	22.873**	2.248**	-3.548**	0.651**	-5.31**	-2.993**
Giza 171 / Giza 177	41.856**	2.267**	-1.264**	0.387*	-80.26**	-2.731**
Giza 171 / Sakha 101	-8.175**	0.567	0.052	-0.289	-24.40**	1.650**
Giza 171 / Sakha 102	-20.008**	-3.695**	0.912*	-1.318**	-15.66**	1.936**
Giza 171 / Gz 5310-20-3-2	-4.748*	-3.185**	-1.683**	0.513**	63.33**	0.174
Giza 171 / Sakha 103	-4.989**	-0.499	1.183**	-0.179	-10.85**	1.960**
Pi No. 4 / Toride 1	-2.828	-1.556**	-0.412	1.199**	3.593	4.531**
Pi No. 4 / Shin 2	-6.762**	-1.342**	-0.593	-1.749**	-9.93**	-2.183**
Pi No. 4 / Fukunishiki	-22.159**	-4.495**	-1.567**	-0.622**	-25.71**	-4.136**
Pi No. 4 / Giza 177	2.091	0.525	0.550	-0.887**	-35.00**	-1.874**
Pi No. 4 / Sakha 101	20.760**	-1.509**	3.300**	0.337	0.189	-1.826**
Pi No. 4 / Sakha 102	-8.806**	-0.104	1.460**	-2.65**	-39.74**	-4.207**
Pi No. 4 / Gz 5310-20-3-2	-2.980	-0.595	-3.469**	-1.227**	-10.40**	-1.969**
Pi No. 4 / Sakha 103	-8.187**	-1.909**	0.198	-1.987**	-43.26**	-4.183**
Toride 1 / Shin 2	-1.100	-0.399	2.124**	0.975**	1.641	0.960
Toride 1 / Fukunishiki	-4.663*	-1.885**	0.450	1.599**	17.52**	-0.659
Toride 1 / Giza 177	-17.680**	-0.199	0.600	0.768**	-0.43	-0.731

Table 9. Cont.

Toride 1 / Sakha 101	4.222*	5.434**	-0.050	-1.008**	-50.24**	-0.016
Toride 1 / Sakha 102	34.789**	4.839**	-2.190**	-1.4.3**	-19.83**	1.269*
Toride 1 / Gz 5310-20-3-2	8.515**	0.682*	-0.219	-1.106**	-7.16**	-0.159
Toride 1 / Sakha 103	2.141	-0.633*	-0.319	1.668**	50.64**	0.626
Shin 2 / Fukunishiki	3.369**	4.329**	1.469**	1.654**	-8.33**	-4.040**
Shin 2 / Giza 177	-10.914**	-0.985**	-0.148	-1.210**	7.04**	-2.445**
Shin 2 / Sakha 101	9.455	1.982**	0.036	0.580**	11.23**	-1.397*
Shin 2 / Sakha 102	3.222	-0.280	-1.405**	1.385**	-9.69**	1.555*
Shin 2 / Gz 5310-20-3-2	-2.785**	-2.771**	1.000*	1.849**	4.974*	3.793**
Shin 2 / Sakha 103	1.508**	2.915**	-1.100**	0.123	0.451	3.579**
Fukunishiki / Giza 177	32.656*	4.196**	-5.721**	1.247**	76.26**	6.603**
Fukunishiki / Sakha 101	8.825	-1.404**	-0.105	1.437**	32.11**	2.317**
Fukunishiki / Sakha 102	-4.642**	-0.099	4.121**	0.109	-25.14**	-3.064**
Fukunishiki / Gz 5310-20-3-2	-6.082**	-0.590	1.593**	-0.294	-14.14**	-3.493**
Fukunishiki / Sakha 103	-4.556**	-3.571**	2.993**	-0.820**	-39.00**	-3.374**
Giza 177 / Sakha 101	-3.859	-5.485**	0.379	-0.394*	2.498	0.245
Giza 177 / Sakha 102	-10.025**	-2.080**	-1.062*	0.344	31.23**	-1.469**
Giza 177 / Gz 5310-20-3-2	-5.232**	-0.904**	3.943**	0.875**	-11.76**	-0.564
Giza 177 / Sakha 103	9.027	2.448**	0.210	1.599**	25.37**	2.888**
Sakha 101 / Sakha 102	3.144**	0.886**	-0.212	-0.032	24.76**	-0.088
Sakha 101/ Gz 5310-20-3-2	-7.830**	0.396	-0.907*	-1.101**	-43.57**	1.817**
Sakha 101 / Sakha 103	11.829**	-2.585**	-0.407	0.340	-0.430	1.269*
Sakha 102/ Gz 5310-20-3-2	-3.130	0.134	-0.381	2.971**	22.16**	4.769**
Sakha 102 / Sakha 103	-7.737**	-0.514	-0.781*	1.244**	-28.35**	-0.112
Gz 5310-20-3-2/ Sakha 103	17.456**	3.996**	0.657	1.142**	-31.35**	-1.207*
LSD at 5%	3.45	0.60	0.78	0.36	4.48	1.12
LSD at 1%	4.89	0.86	1.10	0.51	6.35	1.59

** = Significant at 1 % level
 * = Significant at 5 % level

Table 10. Means of 12 parental rice cultivars of different traits (average of two years).

No.	Variety	Growth duration (day)	Plant height (cm)	No. of tillers/ plant	Grain yield/ plant	No. of grains /panicle	Panicle weight	No. of panicles/ plant	Panicle length (cm)	No. of unfilled grains/ panicle	Flag leaf area	1000 grain weight (g)
1	Giza 159	146	135	22	53.3	141.6	3.11	20.20	21.10	15.73	46.17	24.1
2	Giza 176	144	103	25	61.2	126.7	2.67	23.55	22.96	12.17	41.04	25.1
3	Giza 171	155	134	23	58.4	178.0	3.59	21.50	22.80	16.02	36.95	22.3
4	Pi No 4	123	108	23	42.6	165.0	1.50	21.40	21.61	20.83	31.76	23.7
5	Toride 1	134	110	19	44.4	144.0	2.02	19.20	23.34	10.67	36.08	25.0
6	Shin 2	126	108	18	48.9	154.0	2.22	16.10	20.98	16.00	32.90	24.2
7	Fukinishki	121	100	21	43.3	87.5	1.90	19.80	19.48	20.67	18.97	26.0
8	Giza 177	125	95	21	46.2	137.5	3.10	20.50	20.64	10.20	24.18	27.2
9	Sakha 101	143	92	27	65.2	167.0	2.70	25.44	24.15	11.57	28.12	25.8
10	Sakha 102	126	110	23	54.2	165.3	2.77	21.40	23.20	11.20	42.02	26.0
11	Gz5310-20-3-2	119	93	19	43.2	143.4	2.29	18.95	20.04	10.53	42.40	28.1
12	Sakha 103	120	104	23	54.7	170.0	2.66	22.96	20.10	13.10	25.20	27.5

Table 11. Similarity matrix for 12 varieties based on 11 morphological characters.

	Giza 159	Giza 176	Giza 171	Pi No 4	Toride 1	Shin 2	Fukinishki	Giza 177	Sakha 101	Sakha 102	Gz5310-20-3-2	Sakha 103
Giza 159	0.00											
Giza 176	3.68	0.00										
Giza 171	2.80	4.24	0.00									
Pi No 4	4.79	4.96	5.55	0.00								
Toride 1	4.01	4.07	5.12	3.86	0.00							
Shin 2	4.13	5.23	5.35	3.59	2.75	0.00						
Fukinishki	5.98	5.95	7.48	4.22	5.04	4.31	0.00					
Giza 177	4.95	4.40	5.95	4.89	3.59	3.86	4.23	0.00				
Sakha 101	5.70	2.81	5.07	5.70	5.42	6.52	7.14	5.10	0.00			
Sakha 102	3.51	2.74	4.23	4.23	2.92	4.01	5.95	3.51	3.73	0.00		
Gz5310-20-3-2	5.22	5.20	7.00	4.90	3.43	3.57	4.81	2.91	6.49	3.81	0.00	
Sakha 103	4.89	4.17	5.57	4.21	4.37	4.38	4.79	2.55	4.22	3.16	3.78	0.00

Table 12. Correlation of Euclidean distance with SCA effects of the 66 F_1 crosses for vegetative and yield and its components characters.

Variables	Heading date (day)	Plant height (cm)	No. of tillers/ plant	Flag leaf area (cm²)	Grain yield/ Plant (g)	No. of Panicles /plant	1000-grain weight (g)	Panicle weight (g)	Panicle length (cm)	No. of filled grains/ panicle	No. of unfilled grains/ panicle
All hybrids	- 0.022	0.185	.038	.172	.120	.034	.018	-.154	.070	-.026	-.239
GI X GI hybrids	- 0.07	0.458	0.387	0.097	- 0.6	0.317	0.574	0.193	0.272	- 0.627	- 0.23
GII X GII hybrids	- 0.042	- 0.076	- 0.094	- 0.107	0.013	- 0.071	- 0.627	- 0.359	- 0.283	- 0.147	- 0.336
GI X GII hybrids	0.01	0.07	- 0.008	0.038	0.195	0.014	0.001	- 0.225	- 0.044	0.064	- 0.22

* Correlation is significant at the 0.05 level.

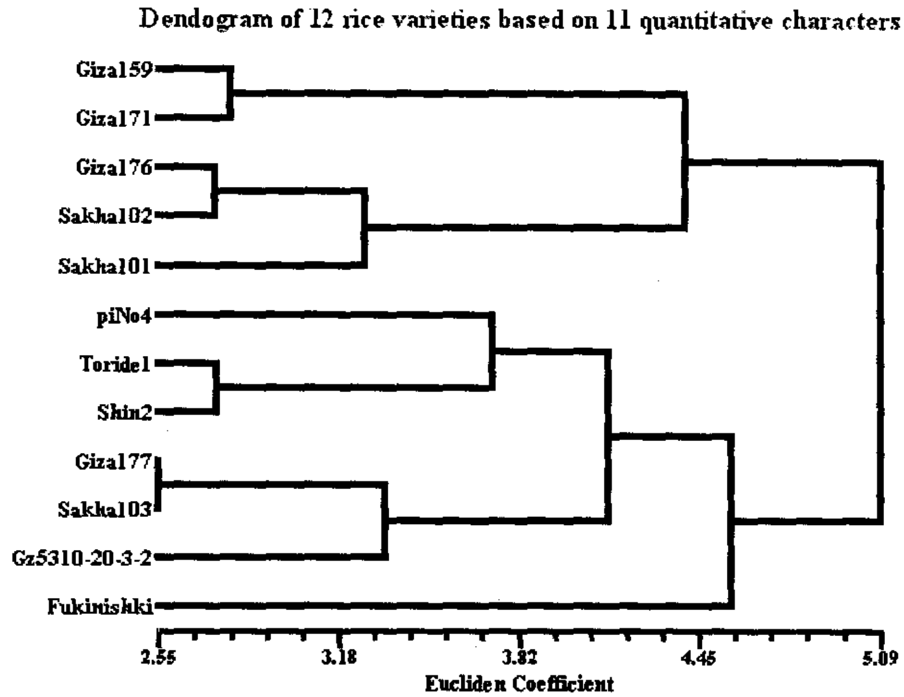

Figure 1. Cluster diagram for 12 varieties classified by 11 morphological quantitative characters.

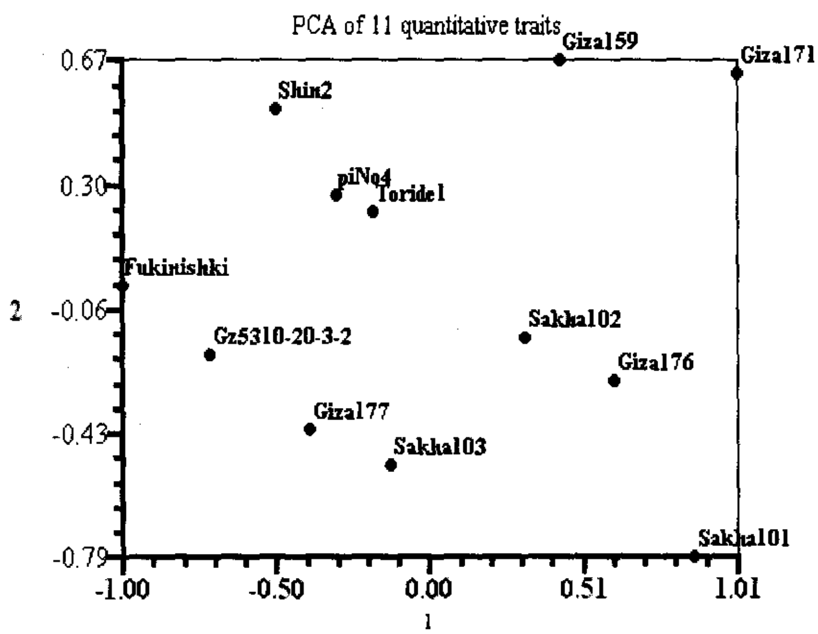

Figure 2. Principal component analysis (PCA) of characters associated with 12 rice varieties, PC1 (heading date) and PC2 (plant height).

القدرة على الائتلاف والعلاقة الوراثية بين بعض أصناف الأرز المصرية والمستوردة

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أجريت هذه الدراسة في مزرعة مركز البحوث والتدرب في الأرز – سخا- كفر الشيخ – مصر خلال مواسم الزراعة ١٩٩٨، ١٩٩٩، ٢٠٠١،٢٠٠٠ وقد استخدم ١٢ صنفا لهذه الدراسة. وكان الهدف من الدراسة:

١- دراسة بعض الصفات الكمية الهامة باستخدام نظم الهجن الدورية بين ١٢ صنفا من الأرز.

٢- استخدام بعض الصفات الكمية المورفولوجية لعمل شجرة لاظهار مدى التشابه بين الأصناف المستخدمة فى الدراسة.

وقد شملت الدراسة ١٢ تركيبة وراثية، سبعة أصناف مصرية وهى جيزة١٥٩، جيزة ١٧٦، جيزة ١٧١، جيزة ١٧٧، سخا ١٠١، سخا ١٠٢، سخا ١٠٣، السلالة المبشرة ٥٣١٠ وأربعة أصناف يابانية (بي آي نمبر ٤ ، تريدو ١ ، شين٢ ، فيوكونيشكى) وكانت الصفات الكمية للصفات الخضرية هي: تاريخ التزهير ، طول النبات ، عدد الفروع الخضرية ومساحة ورقة العلم بينما صفات المحصول ومكوناته كانت: محصول النبات الفردي وزن الألف حبة وطول السنبلة وعدد الداليات للنبات الفردي وعدد الحبوب الكلية بالسنبلة وعدد الحبوب الممتلئة بالسنبلة.

وتم تحديد أفضل الهجن طبقا للصفات المدروسة فكان تباين الصفات الخضرية عالي المعنوية للآباء والهجن الخاصة بها وكان التباين الوراثي المضيف والغير مضيف هاما جدا في وراثة تلك الصفات وكان التباين المضيف أكثر أهمية من الغير المضيف للصفات الخضرية.

وبالنسبة للمحصول ومكوناته فكان التباين الوراثي للصفات عالي المعنوية لجميع التراكيب الوراثية والآباء والهجن وكان التباين الوراثي المضيف والغير مضيف هاما جدا في تحديد التوارث في سبع صفات محصولية. أيضا وضحت أهمية التباين المضيف في توارث كل هذه الصفات ماعدا صفة عدد الحبوب الممتلئة بالسنبلة.

وقد أظهرت الشجرة الناتجة عن درجة التشابه في الصفات الكمية انقسامها إلى مجموعتين كبيرتين. المجموعة الأولى والتي شملت كل الأصناف طويلة فترة النمو (متوسط ١٤٧يوما) ماعدا الصنف سخا ١٠٢. بينما المجموعة الثانية والتي شملت كل الأصناف قصيرة فترة النمو والمقاومة لمرض اللفحة ماعدا الصنف بي آي ٤. وقد أظهرت النتائج أن العامل المؤثر في تقسيم الشجرة كان بناءا على تاريخ التزهير. أيضا قد أكد ذلك تحليل العوامل الأساسية حيث جاء موافقا لتلك النتائج.