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Combined selection for yield and four quality characteristics in rice (Oryza sativa L.) with two breeding methods

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Abstract

The effectiveness of two selection methods (Honeycomb Pedigree and Single Panicle Descent) for yield and four quality characteristics (total milling yield, grain vitreosity, grain length and grain ratio length/width) was studied in an F2 rice population (No 1992). After five cycles of selection the best five lines from each method were further evaluated for two years in a complete randomized block design with four replications together with the original F1 hybrid and the rice control variety Strymonas.

Honeycomb Pedigree selection was more effective than the Single Panicle Descent method for the improvement of all the characteristics studied. The only exception was total milling yield which had the same annual gain under both selection methods. The best five lines of the 1st selection method surpassed those of the 2nd selection method by 6.3% for yield, 21.9% for grain vitreosity, 0.9% for grain length and 3.2% for grain ratio length/width.

The genetic material (best five lines) selected with Honeycomb Pedigree differed significantly and surpassed the F1 by 76.9% in grain vitreosity, 1.3% in grain length and 5.4% in grain ratio length/width, while the genetic material selected after application of Single Panicle Descent differed significantly and surpassed the F1 only for grain vitreosity and grain ratio length/width. Differences were not noticed between the genetic material selected by the two methods and the F1 for the rest characteristics studied.

Finally, the best selected lines with the two methods surpassed significantly the control variety for all characteristics studied with the only exception the total milling yield.

It was concluded that both selection methods were effective for the improvement of rice. Honeycomb selection, however, was more effective.

Keywords

- Rice, Honeycomb Pedigree, Single Panicle Descent, yield, quality
- Greece.

Introduction

Combined selection for yield and quality characteristics should be the aim of the rice breeder. Fasoulas (1993) mentioned that application of the Honeycomb Pedigree selection in an F2 population (without competition) should be effective for both yield and quality characteristics. Mckenzie and Lambert (1961) and Sneep (1977) suggested that the selection must be applied for high-yielding genotypes in the F2 and the successive segregating generations. Simmonds (1979) reported that the classical pedigree selection was also effective in early generation selection (under competition) only for characteristics with high heritability such as grain size. De Pauw and Shebeski (1973), McGinnis and Shebeski (1968) pointed out that selection of single plants in the segregating generations in wheat was effective for simple heritable traits and ineffective for yield . The same was also confirmed in barley by Hanson et al. (1978). Sakai (1951) mentioned that competition between the individuals in a segregating genetic material is considerable and it has as a result the reduction of reliability of their selection. He considered that bulk method of selection would be preferred than the pedigree method. Finally, according to Nagai (1962) a rigorous pedigree selection in early generations might have as a result the losing of desirable genotypes which could be selected in later generations as homozygotes.

The objective of this study was to evaluate the effectiveness of two selection methods, namely Honeycomb Pedigree (without competition) and Single Panicle Descent (under competition) for a combined selection for yield and four quality characteristics (i.e. total milling yield, vitreosity, grain length and grain ratio length/width) in an F2 rice population.

Materials and methods

The F2 population used was obtained from the American rice hybrid No 1992. The work was carried out in the experimental station of Kalochori-Thessaloniki. During the year 1989, 1607 F2 plants from the above population were grown in a honeycomb design with an interplant distance of 1 m. Application of Honeycomb Pedigree (H.P.) selection for yield (selection pressure 5,3%) had as a result the selection 79 plants, which were further evaluated for four quality characteristics : Total milling yield, vitreosity, grain length and grain ratio length/width. Only plants with a good yielding ability and good quality characteristics were advanced in the next generations. The F3, F4, F5 and F6 generations were made up from 28 F2, 30 F3, 30 F4 and 20 F5 plants, respectively. The rice variety Strymonas (Japonica type) was used as a control. Finally, the best five lines were selected from the population for further evaluation in the F7 and F8 generations.

In parallel with the H.P. selection, the Single Panicle Descent (S.P.D.) a modified pedigree method (Brim, 1966) was also used. For this, seeds of one panicle from each F2 plant of the population were planted in one line. In the years 1990 and 1991, 1567 F3 and 1333 F4 lines were grown respectively. The row length was 1 m and the distance among the rows was 40 cm. Negative selection was applied only for plant types with late maturity and disease susceptibility. In the year 1992, 892 lines were grown in rows. Every 10th row was sown with the control variety Strymonas. The 15% higher yielding lines were selected after application of the moving average (Knott, 1972). In the following year (F6 generation), 135 lines were planted in a contiguous control experiment. Application of the moving average had as result the selection of 40 lines. The selected

lines outyielded the moving average by at least 10%. These lines were further evaluated for the aforementioned quality characteristics. The best five lines were selected for further evaluation in the F7 and F8 generations.

One experiment was carried out in each of the years 1994 and 1995. This included the best five lines selected from each selection method, the F1 hybrid and the rice variety Strymonas as a control. The complete randomized block design with four replications was used. The yield and the quality characteristics : total milling yield, vitreosity, grain length and grain ratio length/width were studied.

The quality evaluation was done on grains with 14% moisture content. The total milling yield was estimated from two samples 100 g each of pure rough rice. The vitreosity was estimated on two samples of 30 milled grains. For this, the grains were placed on a glassy table lighted with a 60 W light intensity. Grains with short spots of pearl were considered as chalky. The above characteristics were expressed in percent. The grain length and width were evaluated from two samples of 30 milled grains each with a micrometer, thus the ratio length/width was finally obtained.

Results and discussion

The best five lines resulted after five cycles of selection with Honeycomb Pedigree (without competition) differed significantly and surpassed the best five lines selected after application of the Single Panicle Descent (under competition) by 6.3% for yield, 21.9% for grain vitreosity, 0.9% for grain length and 3.2% for grain ratio length/width (Table1). Total milling yield had the same gain under both selection methods. In addition, the genetic material resulted from the 1st selection method differed significantly and surpassed the F1 by 76.9% in grain vitreosity, 1.3% in grain length and 5.4% in grain ratio length/width, while the genetic material selected after application of Single Panicle Descent differed significantly and surpassed the F1 by 49.7% in grain vitreosity and 2.2% in grain ratio length/width. Differences were not noticed between the genetic material selected by the two methods and the F1 for the rest characteristics studied. Finally, the best selected lines with the two methods surpassed significantly the control variety for all characteristics studied with the only exception the total milling yield. It is obvious that although application of H.P. at the first generations had as result the selection of only a small portion of the grown plants, yet higher grain yield and generally higher rates for quality characteristics were succeeded as compared with the genetic material selected after application of S.P.D. method in which selection was applied in later generations. These results are in agreement with those reported by Fasoulas (1993) and Kulkarni (1991).

Table1. Mean values of five characteristics studied in the genetic material of the five best Selected Lines (S.L.) after five cycles of selection with Honeycomb Pedigree (H.P.) and Single Panicle Descent (S.P.D.) methods, of the F1 hybrid and the control variety in two years (1994 and 1995).

Selected Lines	Grain yield	Total milling yield	Vitreosity	Grain length	Grain ratio length/width
	kg/ha	%	%	mm	
S.L.H.P.5	8902 a	68.8 a	78.0 a	6.46 a	2.93 a
S.L.S.P.D.5	8377 b	68.9 a	64.0 b	6.40 b	2.84 b
F1	8614 ab	68.8 a	44.1 c	6.38 b	2.78 c
Control variety	7385 c	68.5 a	45.8 c	6.33 c	2.41 d

Means in each column with the same letter are not significantly different at Ñ=0.05.

The mean values of five characteristics of the best Selected Lines(S.L.) obtained after five cycles of selection with the Honeycomb Pedigree (H.P.) and the Single Panicle Descent (S.P.D.) methods, of the F1 hybrid and the control variety in two years (1994 and 1995), are given in Table 2.

Table 2. Mean values of five characteristics of the best Selected Lines (S.L.) obtained after five cycles of selection with the Honeycomb Pedigree (H.P.) and the Single Panicle Descent (S.P.D.) methods, of the F1 hybrid and the control variety in 1994 and 1995.

Selected Lines	Grain yield	Total milling yield	Vitreosity	Grain length	Grain ratio length/width
	kg/ha	%	%	mm	
S.L.H.P.1	8896 bc	68.4 de	66.8 d	6.43 bc	2.91 c
S.L.H.P.2	9379 a	68.4 de	83.6 b	6.44 bc	2.91 c
S.L.H.P.3	8656 cd	69.6 b	87.8 a	6.48 b	2.96 b
S.L.H.P.4	8293 de	68.6 cde	66.6 d	6.41 cd	2.91 c
S.L.H.P.5	9284 ab	69.0 bc	85.1 ab	6.53 a	2.98 ab
S.L.S.P.D.1	8056 ef	69.4 b	61.9 e	6.28 g	2.65 f
S.L.S.P.D.2	8258 de	67.2 f	74.8 c	6.55 a	2.85 d
S.L.S.P.D.3	9043 abc	69.5 b	34.3 g	6.31 fg	2.84 d
S.L.S.P.D.4	7646 fg	70.2 a	73.6 c	6.47 b	3.00 a
S.L.S.P.D.5	8880 bc	68.1 e	75.3 c	6.36 de	2.86 d
F1	8614 cd	68.8 cd	44.1 f	6.38 d	2.78 e
Control variety	7385 g	68.5 cde	45.8 f	6.33 ef	2.41 g

Means in each column with the same letter are not significantly different at Ñ=0.05.

The S.L. 2 and 5 obtained after application of Honeycomb Pedigree method surpassed the F1 hybrid for all the characteristics studied except total milling yield. The S.L.1, 3 and 4 had similar yielding ability with the F1 hybrid. The S.L. 3, however, was better than the F1 for all the quality characteristics studied. The S.L. 1 was superior to the F1 in three of the four quality characteristics and the S.L. 4 was superior for two quality characteristics.

All the S.L. resulted from H.P. method outperformed the control variety for all the characteristics studied except total milling yield. The S.L. 2, 3 and 5 obtained from the Single Panicle Descent method had the same grain yield with the F1 hybrid, but they were better for 3, 2 and 2 quality characteristics respectively. The S.L. 1 and 4 had lower grain yield than F1, but they were better in two quality characteristics. The S.L. 1 and 2 resulted from the S.P.D. method showed higher grain yield than control variety but lower grain length and total milling yield. The S.L. 3 had higher grain yield than control variety and it was better for two quality characteristics. The S.L. 4 had the same grain yield with the control variety but it was better for all quality characteristics studied. Finally, the S.L. 5 was superior to the control variety for grain yield and two quality characteristics.

The best Selected Lines 2 and 5 resulted from the Honeycomb Pedigree method were better than the best Selected Line 2 resulted from the Single Panicle Descent method. All the Selected Lines were better than the F1 hybrid except 1 and 4 of the second selection method. Thus, it could be supported that both methods were effective for the improvement of rice, when combined selection for yield and quality was applied. The Honeycomb Pedigree selection, however, was more effective than Single Panicle Descent.

Conclusions

Both selection methods studied were effective for the improvement of rice. Honeycomb Pedigree method, however, was more effective than Single Panicle Descent for all the characteristics studied. The only exception was total milling yield for which both selection methods were equally effective.

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