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Evaluation of Yield and Grain Quality Characters in Rice Hybrids using Diallel Genetic Design

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ABSTRACT. Five parental lines, Bg 350, Bg 400 – 1, Bg 380, H_4 and Bg 34 – 6 selected from a previous experiment were crossed in a 5X5 half diallel design to produce 10 F_1 hybrids in order to evaluate them for grain quality characters as well as some morphological and yield characters.

Significant additive genetic variation was observed in all the characters, indicating significant differences between the parents. Heterosis was observed in tiller number, panicle number, number of filled grains per panicle and 100 – grain weight. In these characters, Wr/Vr graph indicated that dominance was complete. Over dominance was not indicated. Where residual dominance was identified, significant epistatic effects were shown to be operative by the high C.V. value for (Wr – Vr). Directional dominance was also observed in many characters.

The results clearly showed very little heterosis, and where it was present, heterosis was not due to over dominance and hence no justification for production of F_1 hybrids. On the other hand, highly significant additive genetic variation between parents showed that there is a high possibility of extracting superior recombinant inbred lines from these crosses and hence a high probability of improving these characters by making use of efficient selection procedures.

INTRODUCTION

Rice breeding has been carried out in Sri Lanka with much success with regard to improvement in yield as well as producing resistance to diseases and pests. Grain quality has now become important in order to improve the nutritional status of the improved varieties. This has to be combined with good morphological as well as yield characters.

This study was therefore, carried out to produce F_1 hybrids from crosses of selected parents and to evaluate their performance compared

to their respective parents. It was intended to study the genetic architecture of grain quality characters in particular so that appropriate hybridization and selection procedures can be applied later to produce either superior F_1 hybrids or recombinant inbred lines. The decision about which of these should be produced must depend on the evidence obtained from the study of the genetic architecture of the characters under consideration.

Diallel genetic design has been used by many scientists to study grain quality characters in rice. Singh and Richharia (1977, 1980) reported GCA and SCA values for some yield and grain characters of a 6x6 diallel. Using the procedures of Jinks (1954) and Hayman (1954 a, b, 1958), they reported additive and dominance effects as well as over dominance and partial dominance. Most other experiments of diallels indicated only GCA and SCA values (Rao *et. al.*, 1980; Rahman *et. al.*, 1981; Maurya and Singh 1977; Haque *et. al.*, 1981 and Srivastava *et. al.*, 1978). It has been observed that the best parents almost always give best GCA values and it is not worthwhile carrying out a diallel experiment for this purpose only. More useful methods of analyzing diallel data have been described.

An analysis of variance for the complete diallel design was given by Hayman (1954 a). In the present study, reciprocal differences were not considered. The analysis appropriate to this half diallel table as described by Morley Jones (1965) was used in this study to extract as much genetic information as possible of the characters under study.

MATERIALS AND METHODS

Five parental rice varieties selected from the results of an experiment carried out by Perera *et. al.*, (1989) were used in a 5 x 5 half diallel crossing programme carried out at the Faculty of Agriculture, University of Peradeniya.

The parents used were Bg 350, Bg 400 – 1, Bg 380, H_4 and Bg 34 – 6. The half diallel hybridization procedure produced 10 F_1 hybrids. These 10 hybrids together with their 5 parents were grown at Peradeniya in the *Yala* season of 1990 using a randomized complete block design with 2 replications.

Normal cultural practices were carried out under irrigation. Many morphological, yield as well as grain quality characters were evaluated of which the following are considered in this study :

Plant height (cm), days to heading, tiller number per plant, panicle number per plant, number of filled grains per panicle, kernel length (mm), kernel breadth (mm), kernel shape (length/breadth), brown rice protein % and 100 - grain weight.

The grain quality characters were measured at the Central Agricultural Research Institute, Gannoruwa.

The method of Morley Jones (1965) was applied in the analysis of the half diallel table. Using the same model as Hayman, the determination of the sums of squares corresponding to additive effects (a), to mean dominance (b_1), to additional dominance effects that can be accounted for by genes having one allele present in only one line (b_2) and to residual dominance effects (b_3) is a direct application of fitting constants by least squares.

Where there was significant dominance, the type of dominance was determined by Wr/Vr graph (Mather & Jinks, 1971). The C.V. of (Wr+Vr) tested directional dominance. Where residual dominance effects were identified, test for epistasis was carried out by observing C.V. of (Wr - Vr) (Mather & Jinks, 1971).

RESULTS

Plant height

Analysis of variance indicated significant differences between the parents (Table 1) due to additive gene effects. H_4 had the highest mean value of 130.8 cm whilst Bg 34-6 the lowest value of 88 cm (Table 2). Mean dominance effects were not significant and hence no heterosis was observed although b_2 was significant showing directional dominance. This was further substantiated by a high C.V. for (Wr+Vr). Hence the shortest F_1 hybrid with a height of 88.5 cm may have been due to directional dominance. Very low C.V. for (Wr - Vr) indicated that significant residual dominance effects (b_3) is not due to epistasis but solely in the form of independently distributed dominance effects. The

Table 1. ANOVA of morphological, yield and grain characters.

Item	Plant height	Days to heading	Tiller number	Panicle number	Grains/ panicle
a	*	*	*	*	*
b_1	ns	ns	*	ns	*
b_2	*	ns	*	*	*
b_3	*	*	*	*	*

Item	Kernel length	Kernel breadth	Kernel shape	Protein %	100-grain weight
a	*	*	*	*	*
b_1	ns	ns	ns	ns	*
b_2	ns	ns	ns	*	*
b_3	ns	ns	ns	*	*

a = additive gene effects
b_1 = mean dominance effect
b_2 = additional dominance effect
b_3 = residual dominance effect
* = significant at P = 0.05
ns = not significant

Table 2. Mean values of best parent and F_1 hybrid.

Character	Best parent	Best F_1
Plant height (cm)	H_4 (130.8) (H)	H_4 x Bg 34-6 (119.1)
	Bg 34-6(88.0) (L)	Bg 350 x Bg 380 (88.5)
Days to heading	Bg 34-6(80.8) (L)	Bg 350 x Bg 34-6 (82.0)
Tiller number	Bg 350 (24.1)	Bg 350 x H_4 (24.7)
Panicle number	Bg 350 (19.4)	Bg 350 x H_4 (19.8)
Grains/panicle	Bg 400-1 (200.2)	Bg 400-1 x Bg 380 (204.8)
Kernel length (mm)	Bg 380 (7.2) (H)	Bg 350 x Bg 380 (6.9)
	Bg 34-6 (5.6) (L)	Bg 350 x Bg 34-6 (5.8)
Kernel breadth (mm)	Bg 350 (2.5) (L)	Bg 350 x Bg 34-6 (2.5)
Kernel shape	Bg 350 (2.7) (H)	Bg 350 x Bg 380 (2.6)
	Bg 34-6 (1.9) (L)	Bg 380 x Bg 34-6 (2.1)
B.R. Protein %	Bg 350 (9.2)	Bg 400-1 x Bg 34-6 (8.5)
		Bg 380 x Bg 34-6 (8.5)
100-grain weight (g)	Bg 380 (3.3)	Bg 380 x Bg 34-6 (3.1)

(H) = Highest value
(L) = Lowest value

significant positive intercept of Wr/Vr graph indicated partial dominance (Figure 1).

Days to heading

Highly significant additive gene effects were observed between the parents (Table 1). Bg 34-6 was the earliest to reach heading (80.8 days) (Table 2). Heterosis was not observed in the hybrids (Table 2). Significant residual dominance effects were not due to epistasis as C.V. for (Wr - Vr) was extremely low (Table 3). The Wr/Vr graph indicated partial dominance (Figure 2).

Table 3. Tests for directional dominance (Wr + Vr) and Epistasis (Wr - Vr).

Character	C.V. of (Wr + Vr)	C.V. of (Wr - Vr)
Plant height	0.36	0.16
Days to heading	0.13	0.04
Tiller number	0.80	0.81
Panicle number	0.79	0.82
Tilled grains/panicle	0.75	1.59
Brown rice protein %	1.15	-
100 - grain weight	0.58	-

Vr = Variance of parents
Wr = Parent - offspring covariance
C.V. = Coefficient of variability

Tiller number

Highly significant additive and dominance effects were observed (Table 1) indicating significant differences between the parents as well as significant heterosis, directional dominance and residual dominance effects. Of the parents, Bg 350 had the largest number of tillers (24.1) and of the hybrids, Bg 350 x H_4 had the highest mean of 24.7 (Table 2). The C.V. for (Wr - Vr) was high indicating significant epistatic

effects (Table 3). The intercept of Wr/Vr graph did not differ significantly from zero suggesting complete dominance (Figure 3).

Panicle number

Significant differences were observed between parents due to additive gene effects. Although directional dominance was present, heterosis was not observed (Table 3). Of the parents, Bg 350 had the largest number of panicles (19.4) (Table 2). The intercept of Wr/Vr graph was not significant from zero, indicating complete dominance (Figure 4).

Number of filled grains/panicle

Significant additive and dominance effects were observed indicating significant differences between the parents, presence of heterosis, directional dominance as well as residual dominance effects (Table 1). Of the parents, Bg 400 – 1 had the largest number of grains (200.1) whilst of the hybrids, Bg 400 – 1 x Bg 380 had the highest mean of 204.8 (Table 2). The Wr/Vr correlation indicated complete dominance (Figure 5). Both the C.V.'s of (Wr + Vr) and (Wr – Vr) were high indicating directional dominance and epistatic effects respectively (Table 3).

Kernel length (L)

Significant differences were observed between the parents indicating additive genetic variation (Table 1). Bg 380 had the longest grains (7.2 mm) and Bg 34 – 6 the shortest (5.5 mm) (Table 2). No significant dominance effects were observed. F_1 hybrids did not show heterosis.

Kernel breadth (B)

Results were similar to kernel length. Significant differences were observed between parents indicating additive gene effects (Table 1). Bg 34 – 6 had the highest mean value of 2.9 mm and Bg 350 the lowest of 2.5 mm (Table 2). No significant dominant gene effects were observed.

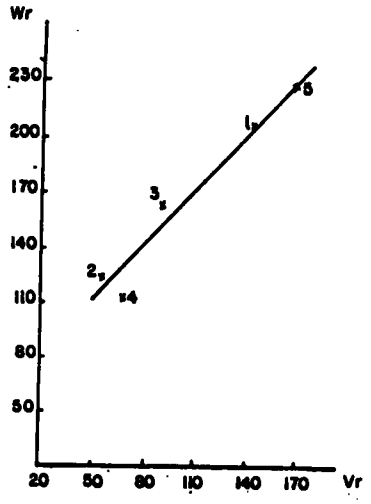

Figure 1. Covariance/variance graph for plant height (cm).

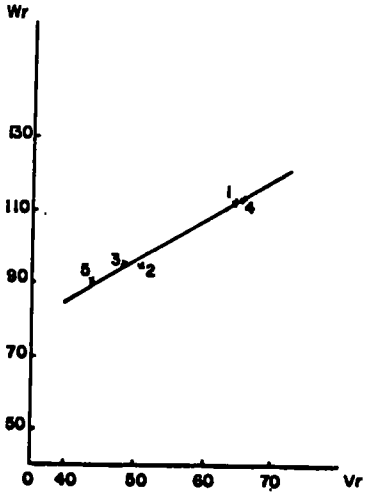

Figure 2. Covariance/variance graph for days to heading.

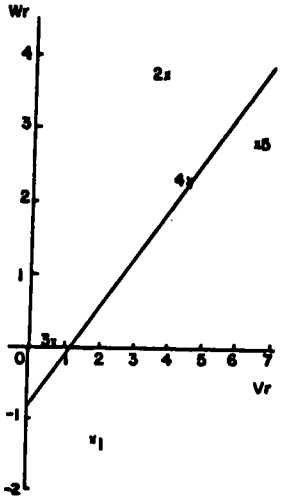

Figure 3. Covariance/variance graph for number of tillers per plant.

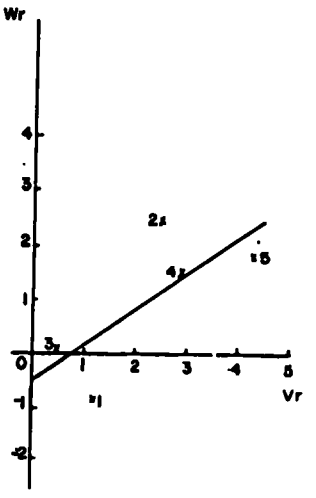

Figure 4. Covariance/variance graph for number of panicles per plant.

Kernel shape (L:B ratio)

Results were similar to those of kernel length and kernel breadth. Only significant additive gene effects were observed (Table 1). Bg 350 had the highest ratio of 2.7 whilst Bg 34-6 the lowest of 1.9 (Table 2). Dominance was absent.

Brown rice protein %

Significant additive gene effects indicate significant differences between the parents (Table 1). Bg 350 showed the highest mean value of 9.2% (Table 2). Heterosis was absent, although significant directional dominance and residual dominance were observed. High C.V. for (Wr+Vr) indicated the presence of directional dominance (Table 3). The intercept of Wr/Vr graph did not differ significantly from zero indicating complete dominance (Figure 6).

100-Grain weight

Significant additive as well as dominance effects were observed (Table 1). Bg 380 had the largest grain weight of 3.275 g and the best F_1 hybrid was Bg 380 x Bg 34-6 with a grain weight of 3.08 g (Table 2). Directional dominance was indicated and further substantiated by a high C.V. for (Wr+Vr). The Wr/Vr graph indicated that dominance was complete (Figure 7).

DISCUSSION

Analysis of variance as described by Morley Jones (1965) was used in this study and it indicated that significant additive gene effects caused the differences between the parents for all the characters studied. Except for tiller number and number of filled grains per panicle, the best parents were better than any of the F_1 hybrids. This clearly indicates that a large number of genes are segregating between the parents for these characters.

There was no over dominance and where dominance was identified such as in tiller number, panicle number, number of filled grains per

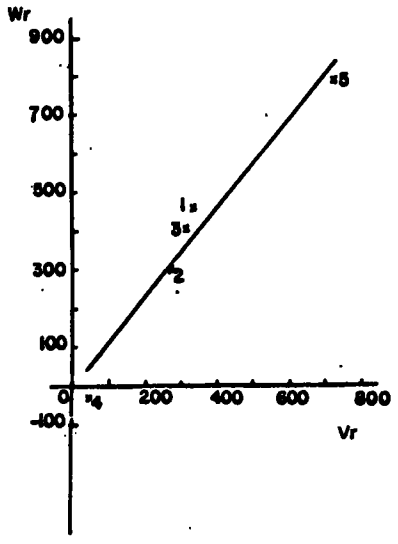

Figure 5. Covariance/variance graph for number of filled grains per panicle.

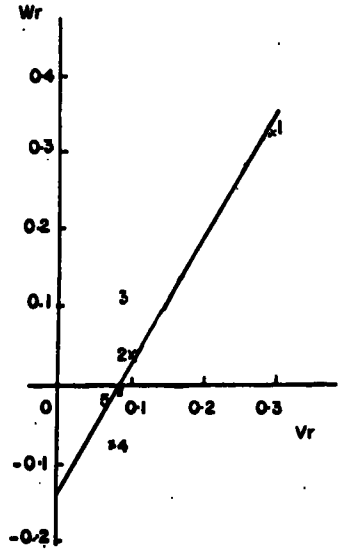

Figure 6. Covariance/variance graph for brown rice protein %.

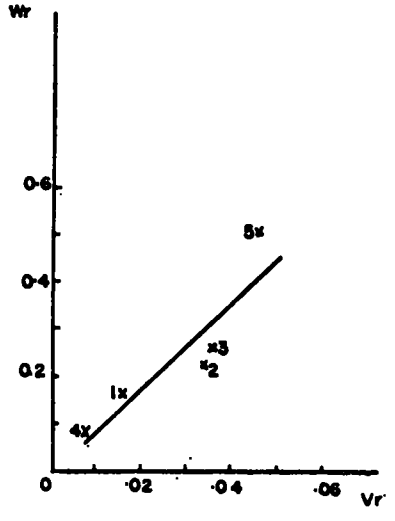

Figure 7. Covariance/variance graph for 100-grain weight (g).

panicle and 100-grain weight, dominance was complete, as shown by the Wr/Vr graph. Hence it will be quite easy to extract superior recombinant inbred lines from these crosses if an efficient selection procedure is practiced.

Although heterosis was observed in tiller number, panicle number, number of filled grains per panicle, protein % and 100- grain weight, it was not due to over dominance. Of these, better parental performances were observed in protein % (9.2% vs 8.5%) and 100-grain weight (3.3 *vs.* 3.1). Significant additive gene effects were also observed in all the characters that showed heterosis. Hence heterosis may have been due to dispersed dominant genes and possibly due to epistatic effects since significant epistasis was identified in all these characters.

The Wr/Vr graph indicated further that dominance when present was either partial or complete and hence no evidence of over dominance for any of the characters.

(Wr+Vr) substantiated the evidence for directional dominance from the analysis of variance. (Wr-Vr) indicated presence of epistatic effects where residual dominance was indicated in the analysis of variance.

The results indicated that there is no justification for the production of F_1 hybrids of rice for any of these characters. Significant additive gene effects observed in all characters indicated that it will be possible to produce recombinant inbred lines from all these crosses that will be superior to the hybrids as well as to their parents in all the characters studied.

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