# Genetics of Some Agronomic and Yield Traits in Rice (*Oryza Sativa* L.)

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**Abstract:** ***Six rice genotypes (FARO20 and FARO52 as female parents and FARO31, FARO39, FARO45 and FARO46 males) were crossed in a line x tester mating fashion to develop eight (8) $F_1$ hybrids. The parents along with the $F_1$ population were evaluated during the off season in 2010 at the screen house of the Institute for Agricultural Research (I.A.R), Samaru in a completely randomized design with three replicates to obtain information on estimates of genetic variations, combining ability and heritability. Data were taken on seedling vigour, plant height, number of tillers, days to 50% flowering, panicle length, panicle weight, yield per plant and 1000grain-weight. Results from analysis of variance showed highly significant differences among the genotypes for all the traits. This is an indication of the presence of considerable amount of genetic variability in the materials, which could be used to initiate selection for population improvement. Estimates of variance due to GCA and SCA and their ratios revealed preponderance of non-additive gene action for all characters except for days to 50% flowering. Positive GCA and SCA effects were observed among the lines and testers for yield per plant and other agronomic characters studied. Broad sense heritability estimates were high for all the traits coupled with high genetic advance for yield per plant, 1000grain-weight, panicle weight, number of tillers and plant height, while the lowest genetic advance was observed in panicle length.***

**Keywords:** Combining ability, genotypes, heritability, yield components

## 1. Introduction

Rice is the seed of a monocot plant and morphologically, is an annual grass and one of the most important cereal crops. Although it can grow in diverse environments, it grows faster and more vigorously in wet and warm conditions. This plant develops a main stem and many tillers which may range from 0.6 to 6.0 meters (floating rice) in height [6]. The inflorescence of rice is known as panicle which bears single flowered spikelets. Typically rice flower is different than those of other cereals in having six stamens. Blooming of flowers takes place between 8-11 a. m [1]. After the appearance of panicle from boot leaf, most of the flower bloom between two to four days. Blooming of the spikelets starts at the apex of panicle and then proceeds downwards [1]. Rice flower is normally self pollinated and the crossing range varies from 0-3 % [8].

Breeding programs depend on the knowledge of key traits, genetic systems controlling their inheritance, and genetic and environmental factors that influence their expression. The considered characters in rice breeding may include reduced plant height; moderate tillering, short and erect leaves, large and compact panicles, and earliness of maturation [20], [22], [18], [39] and [23]. To plan an efficient development program, it is necessary to have an understanding of the breeding systems coupled with statistical analysis of inheritance data [40], [37]. Yield of paddy rice is a complex quantitative character controlled by many genes each interacting with the environment and is the product of many factors called yield components. Thus, selection of parents based on yield alone is often misleading. Therefore, there is the need to study the relationship between yield and its contributing characters in other to get better understanding of inheritance and select or identify superior genotypes. In view of this, present study was designed to determine the combining ability as well as the gene action on yield and yield components.

## 2. Methodology

The experiment was conducted in the screen house of Institute for Agricultural Research (I.A.R.) Ahmadu Bello University Samaru, Zaria ($11^0$11'N, $7^0$38'E), 600m above sea level in the Northern guinea savanna within the period of June 2010 to July 2011.The plant materials for this study comprised two lines of rice used as female parents viz: FARO 52, FARO 20, and four testers used as male parents FARO 31, FARO 39, FARO 45 and FARO 46. The entire six genotypes were obtained from National Cereals Research Institute (N.C.R.I) Badeggi. Rice (*Oryza Sativa L*) is a self pollinated; thus pollens were generally controlled to ensure progeny of known parentage. Hand emasculation was carried out and female plants were pollinated with selected male varieties to produce $F_1$ hybrids (crosses). Line x tester mating fashion was used to produce eight $F_1$ crosses. The parents and $F_1$ hybrids were evaluated in the Screen house. The six parents and their eight $F_1$ hybrids making a total of fourteen entries were evaluated in the screen house at Samaru. Plots were laid in a completely randomized design with three replications. Each genotype was assigned into six plastic pots of 25cm in diameter filled with soils, each pot containing three seedlings per pot. The pots were well labeled accordingly and arranged randomly in rows on platform and watered once daily. All other cultural practices were carried out according to the recommendation of National cereals research institute. Data were collected on the following agronomic characters plant height (cm), number of tillers per plant, days to 50% flowering, 1000 grain weight (g), panicle length (cm), panicle weight (g) and Yield per plant (g).

## 3. Results

The Mean squares from the analysis of variance for all traits measured are presented in Table 1. The results depicted highly significant differences among the rice genotypes for all the characters studied. Genotypic mean squares were further partitioned into parents, crosses and parents' vs. crosses. The parents showed significant differences for all traits. However, the crosses revealed the existence of highly significant differences for all the traits except for seedling vigour for which the differences was not significant. Parent's vs. crosses showed highly significant differences for all the traits. However, non significant differences existed among lines and testers for these traits. Estimates of variance due to general combining ability ($\sigma^2 gca$) effects were lower than those of variance due to specific combining ability ($\sigma^2 sca$) effects for all the traits except for days to 50% flowering for which the variance was due to general combining ability ($\sigma^2 gca$) effects. The ratio of variance due to general to specific combining ability ($\sigma^2 gca/\sigma^2 sca$), were less than unity for all the traits and degree of dominance being greater than unity.

The proportional contribution of lines, testers and their interaction for the traits studied is presented in Table 2. It is evident from the table that lines played important role towards plant height and days to 50% flowering indicating predominant maternal influence for these traits. Testers were more important for number of tillers, and 1000-grain weight. It revealed preponderance influence for these traits. The contribution of line x tester were high for seedling vigour, panicle length, panicle weight and yield per plant.

The estimates of General combining Ability (GCA) effects of males and females are presented in Table 3. Among the female (lines) parents, FARO20 was a good combiner for most of the traits studied because it has high positive GCA effects for number of tillers and panicle length and as well as high negative GCA effects for plant height. The other female parent, FARO52 was found to be a good combiner for, days to 50% flowering, panicle weight, 1000grain weight and yield per plant. Among the testers FARO45 was observed to be a good general combiner as it exhibited high negative GCA for plant height and exhibited high positive GCA for number of tillers, 1000-grain weight and yield per plant. Another tester, FARO31 exhibited positive GCA effects for panicle length, panicle weight and yield per plant. FARO39 had high negative GCA for days to 50% to flowering.

Specific combining ability (SCA) effects are presented in Table 4. The cross combination FARO52 x FARO31 was the best specific cross combination with the highest positive SCA effects for grain yield along with desirable SCA effects for all other traits except for panicle length, and seedling vigour. This was followed by the cross FARO20 x FARO39 which had desirable SCA effects for yield per plant and other traits which include panicle weight and panicle length. The cross FARO52 x FARO45 exhibited desirable SCA effect for most of the characters except for days to 50% flowering, plant height, and number of tillers. The cross FARO20 x FARO46 had desirable SCA effects for all characters except for panicle length.

Heritability and genetic advance estimates for the eight characters studied are presented in Table 5. High broad sense heritability were recorded for all the traits studied, yield per plant recorded the highest broad sense heritability estimates which was followed by numbers of tillers. Panicle length recorded the least broad sense heritability estimates of 0.6202.

Narrow sense heritability estimates were high for panicle length, panicle weight and yield per plant; yield per plant recorded the highest narrow sense heritability estimates. Other traits recorded moderate narrow sense heritability estimates with the values ranged from 0.1158 for number of tillers to 0.2923 for1000-grain weight.

Genetic advance estimates express as percentage of mean ranged from 8.1482 (panicle length) to 51.9551 (yield per plant). Yield per plant recorded the highest genetic advance estimates which were followed by 1000-grain weight, seedling vigour and days to 50% flowering expressed moderate genetic advance estimates. Panicle length recorded the least genetic advance estimates of 8.1482.

## 4. Discussion

The presence of significant differences was observed among the parents for all the traits measured. This result indicates that appreciable amount of genetic variability exist in the parent inbred lines used for the crosses. [12], pointed out that the amount of improvement that can be achieved by selection among a number of crosses is dependent on the amount of variation between the crosses and the intensity of selection, since selection is ultimately applied to the crosses. Therefore, this result implies that the inbred parents that produced these crosses which showed significant differences for these traits could be selected for genetic improvement in grain yield and other agronomic traits. The relative estimates of variance due to specific combining ability ($\sigma^2 sca$) effects were predominant for all the characters studied. Thus, indicating the predominance of non additive component, except for days to 50% flowering which is preponderance of additive components of genetic variation indicating both additive and non additive gene variation are important. The ratio of variances ($\sigma^2 gca/\sigma^2 sca$) due to general and specific combining ability effects ranged from -0.2785 to 0.8739. Similar results indicating the predominance of non additive gene action for the above traits mentioned were reported earlier by [5], [25], [31] and [14].
The maximum contribution to the total variance of plant height and 50% days to flowering were made by female parents indicating predominant maternal influence for these traits. Testers were more important for number of tillers, and 1000-grain weight. It revealed preponderance influence for these traits. Line × tester interactions contributed more than lines and testers for seedling vigour, panicle length, panicle weight and yield per plant. This finding is in agreement with that of [38] who reported significant contribution of line × tester for yield per plant.

Combining ability refers to the ability of a parent to transmit desirable performance to its hybrid progeny or crosses. [11] pointed out that combining ability of parents gives useful information on the choice of parent's in terms of expected performance of their progenies. Negative GCA effect is required for plant height and days to 50% flowering, to protect the crop from lodging and for earliness. In the present investigation, among the lines, FARO20 was found to be a good general combiner in the right directions for plant height, number of tillers per plant and panicle length. These findings are in accordance with those of [15] and [32] both reported several parents with desirable GCA effects for plant height in rice. The line FARO52 also showed positive GCA effect for panicle weight, 1000-grain weight and yield per plant.

Among testers FARO 45 and FARO 46 exhibited both positive and negative GCA effects for plant height and number of tillers per plants respectively, which are potential parents for use in subsequent breeding programmes aim at generating new varieties with more number of tillers per plant. These results are in line with those of [15] and [3] who registered promising lines and testers with high GCA effects for number of tillers per plant. Testers FARO31 and FARO45 with positive GCA effects can play a vital role in increased yield per plant. The parents with high GCA effects can be utilized for hybridization programme for selection of superior recombinants in segregating progenies as suggested by [27].

Specific combining ability effect is the index to determine the usefulness of a particular cross combination in the exploitation of heterosis. Short statured plant height is desirable trait of rice crop. Four hybrids FARO20 x FARO39, FARO20 x FARO45, FARO52 x FARO39 and FARO52 x FARO45 expressed positive SCA effects reflecting an increase in plant stature, therefore these were undesirable. The remaining four hybrids, FARO20 x FARO31, FARO20 x FARO46, FARO52 x FARO31 and FARO52 x FARO46 showed negative SCA lying in the category of average effects. The cross FARO52 x FARO46 exhibited the best showing negative SCA effect for plant height indicating that improvement in plant height in term of intermediate or short statured can be brought by exploitation of hybrid vigour in this cross combination. Number tillers per plant and increased panicle length are also desirable traits for rice increased yield per plant. The cross combinations FARO52 x FARO31 and FARO20 x FARO46 possess positive SCA effects for number tillers per plant. These results are in conformity with the reports of [19], [33] and [32] had similar SCA estimates relating to number of tillers per plant and recommended potential high tillering hybrids for the development of hybrid variety(s) or cultivar(s). FARO52 x FARO31 and FARO20 x FARO39, recorded positive SCA effect for panicle weight, while FARO20 x FARO46 exhibited positive SCA effects for 1000-grain weight. These results are in line with the findings of [28] and [34]. Yield per plant is the ultimate objective of rice breeding programmes. The cross combinations, FARO20 x FARO39 and FARO52 x FARO31 had positive SCA effect for yield per plant indicating relative importance of non additive gene effects for this traits. [10] reported that non-additive gene effects were predominant for yield and its components. In the present study, it was observed that cross combinations, which expressed high SCA effects for grain yield, invariably exhibited positive SCA effects for one or more yield related traits also. [36] and [26] found good specific cross combinations in rice. None of the cross combinations were found to be good specific cross combinations for all the characters studied. Generally, in most of the good specific cross combinations at least one low general combiner parents were involved for all the characters along with grain yield. It also indicated both additive and non-additive types of gene action. While selecting the best specific combination for yield, it would be important to give due considerations to yield related traits.

Heritability estimates provide the information about index of transmissibility of the quantitative characters of economic importance and are essential for an effective crop breeding strategy. High broad sense heritability was exhibited for all the eight characters studied. [9] classified heritability estimates as low (5-10%), medium (10-30%) and high (>30%). Accordingly, all of the agronomic characters considered showed high broad sense heritability constituting high breeding value which has more additive genetic effects which is important for crop improvement. Similar results have been reported by [7], [17], [24], [29] and [16]. Although, the presence of high heritability values indicates the effectiveness of selection on the basis of phenotypic performance, it does not show any indication to the amount of genetic progress for selecting the best individuals which is possible by using the estimates of genetic advance. High heritability coupled with high genetic advance were observed for yield per plant followed by 1000grain-weight, panicle weight, number of tillers per plant, and plant height. Hence, heritability with high genetic advance indicates the preponderance of additive gene action and such characters could be improved through selection. Similar results were also reported by [35], [30, [4], [29] and [16]. Days to 50% flowering revealed high heritability and moderate genetic advance. However, [21] and [2] reported high estimates of broad sense heritability along with low genetic advance for days to 50% flowering proposing that selection for these characters must be taken in advance generations.

Narrow sense heritability measures the relative importance of the additive portion of the genetic variance that can be transmitted to the next generation of offspring [13]. A high value for narrow sense heritability therefore, indicates that the additive gene action is important for controlling the character, while a low value signifies non additive gene influence. Moderate narrow sense heritability value would mean that both additive and non additive gene action are important in influencing the expression of the character, and that an appreciable amount of variation exist for improvement. The estimate of narrow sense heritability were high for panicle length, panicle weight and yield per plant indicating the presence of additive gene action controlling these characters, On the other hand, seedling vigour, plant height, number of tillers, days to 50% flowering, 1000grain-weight, were due exhibited moderate narrow sense heritability values which indicates that both additive and non additive gene action are important in influencing the expression of the character.

## Conclusion

Parents that exhibit high combining abilities in hybridization programs could be more useful to plant breeders than those with low combining ability effect. However, positive GCA and SCA effects were observed among the genotypes for yield per plant and other agronomic characters studied.

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**Table 1:** Mean squares from Analysis of variance for different agronomic characters in rice

| Sources | df | SV | PLH | NT | DTF | PANL | PANW | 1000GW | Y/P |
|---|---|---|---|---|---|---|---|---|---|
| Rep | 2 | 0.0264 | 38.5 | 1.2695 | 34.381 | 1.3067 | 4.1295 | 5.8095 | 5.7874 |
| Treatment | 13 | 0.7295** | 434.42** | 14.3968** | 316.0092** | 4.9484** | 39.5639** | 97.1795** | 45.2778** |
| Parents | 5 | 0.5209** | 656.49** | 26.4009** | 329.6000** | 2.1582* | 36.0179** | 936556** | 31.3049** |
| Crosses | 7 | 0.0971 | 287.55** | 7.3000** | 250.4226** | 6.8095** | 35.0095** | 106.2321** | 39.7893** |
| P vs. C | 1 | 6.2000** | 352.17** | 4.8420* | 707.1607** | 5.8717** | 89.1746** | 51.4306** | 153.5620** |
| Lines | 1 | 0.2204 | 916.37 | 18.0267 | 782.0417 | 0.6017 | 14.7267 | 222.0417 | 9.1267 |
| Testers | 3 | 0.0126 | 183.82 | 6.2828 | 201.8194 | 1.5133 | 15.5033 | 110.1528 | 19.6872 |
| L x T | 3 | 0.1404 | 181.67** | 4.4789** | 121.8194* | 14.1750** | 61.2767** | 63.7083** | 70.1122** |
| Error | 26 | 0.0798 | 41.09 | 0.9849 | 40.2784 | 0.839 | 6.0267 | 5.3223 | 4.3307 |
| $\sigma^2gca$ | | 0.0026 | 40.9461 | 0.8529 | 41.1235 | 1.4575 | 5.1291 | 11.3765 | 6.1895 |
| $\sigma^2sca$ | | 0.0202 | 46.86 | 1.1647 | 27.1803 | 4.4453 | 18.4167 | 19.462 | 21.9272 |
| $\sigma^2gca/\sigma^2sca$ | | 0.1287 | 0.8739 | 0.7323 | 1.513 | 0.3279 | 0.2785 | 0.5845 | 0.2823 |

*Significant at 0.05 probability level, ** Significant at 0.01 probability level. Key: SV = seedling vigour, PLH = plant height, NT= numbers of tillers, DTF= days to 50% flowering, PANL = panicle length, PANW= panicle weight, 1000GW= thousand grain weight Y/P=yield per plant

**Table 2:** Proportional contribution of lines, testers and their interactions to total variance in rice

| Source | SV | PLH | NT | DTF | PANL | PANW | Y/P | 1000GW |
|---|---|---|---|---|---|---|---|---|
| Due to lines | 32.43 | 45.53 | 35.83 | 44.61 | 1.26 | 6.01 | 3.28 | 29.86 |
| Due to testers | 5.58 | 27.40 | 37.46 | 34.54 | 9.52 | 18.98 | 21.21 | 44.44 |
| Due to line x testers | 61.99 | 27.08 | 26.71 | 20.85 | 89.21 | 75.01 | 75.52 | 25.70 |

**Table 3:** Estimates of GCA effects for different agronomic traits

| | SV | PLH | NT | DTF | PANL | PANW | 1000GW | Y/P |
|---|---|---|---|---|---|---|---|---|
| **Lines** | | | | | | | | |
| Faro 20 | -0.0958 | -6.1792 | 0.8667 | 5.7083 | 0.1583 | -0.7833 | -3.0417 | -0.6167 |
| Faro 52 | 0.0958 | 6.1792 | -0.8667 | -5.7083 | -0.1583 | 0.7833 | 3.0417 | 0.6167 |
| S.E. (gca lines) | 0.0815 | 1.8505 | 0.2865 | 1.8321 | 0.2644 | 0.7087 | 0.666 | 0.6007 |
| **Testers** | | | | | | | | |
| Faro 31 | -0.0208 | 6.5708 | -1.3083 | -0.0417 | 0.6167 | 1.3500 | -5.5417 | 1.1417 |
| Faro 39 | 0.0292 | 2.4042 | -0.0750 | -7.375 | -0.1500 | -0.8167 | 1.1250 | -0.5417 |
| Faro 45 | -0.0542 | -5.6458 | 1.1750 | 6.7917 | 0.1167 | 1.3333 | 4.7917 | 1.7083 |
| Faro 46 | 0.0458 | -3.3292 | 0.2083 | 0.6250 | -0.5833 | -1.8667 | -0.3750 | -2.3083 |
| S.E. (gca testers) | 0.1153 | 2.6169 | 0.4052 | 2.5910 | 0.3739 | 1.0022 | 0.9418 | 0.8496 |

**Table 4:** Estimates of SCA effects for different agronomic traits

| Crosses | SV | PLH | NT | DTF | PANL | PANW | 1000GW | Y/P |
|---|---|---|---|---|---|---|---|---|
| FARO20x FARO31 | 0.0958 | -6.0208 | 0.4667 | -4.375 | -0.975 | -3.5500 | 1.8750 | -4.2667 |
| FARO20x FARO39 | -0.0958 | 6.0208 | -0.4667 | 4.375 | 0.975 | 3.5500 | -1.8750 | 4.2667 |
| FARO20x FARO45 | -0.1542 | 1.8792 | -0.7667 | 4.9583 | 1.725 | -0.9167 | -4.7917 | -0.2833 |
| FARO20x FARO46 | 0.1542 | -1.8792 | 0.7667 | -4.9583 | -1.725 | 0.9167 | 4.7917 | 0.2833 |
| FARO52x FARO31 | -0.1042 | -2.5375 | 0.9833 | -3.2083 | -1.575 | 4.1333 | 2.2083 | 4.0667 |
| FARO52 x FARO39 | 0.1042 | 2.5375 | -0.9833 | 3.2083 | 1.575 | -4.1333 | -2.2083 | -4.0667 |
| FARO52 x FARO45 | 0.1625 | 6.6792 | -0.6833 | 2.625 | 0.8250 | 0.3333 | 0.7083 | 0.4833 |
| FARO52 x FARO46 | -0.1625 | -6.6792 | 0.6833 | -2.625 | -0.8250 | -0.3333 | -0.7083 | -0.4833 |
| S.E. (sca effect) | 0.1631 | 3.7009 | 0.573 | 3.6642 | 0.5288 | 1.4147 | 1.3320 | 1.2015 |

**Table 5**. Estimation of heritability and genetic advance for different agronomic traits

| | SV | PLH | NT | DTF | PANL | PANW | Y/P | 1000GW |
|---|---|---|---|---|---|---|---|---|
| $H^2_b$ | 0.7307 | 0.7614 | 0.8195 | 0.6953 | 0.6202 | 0.6497 | 0.8432 | 0.7591 |
| $h^2_n$ | 0.2341 | 0.1435 | 0.1158 | 0.2270 | 0.3271 | 0.3562 | 0.3935 | 0.2923 |
| G A | 19.7059 | 28.0454 | 33.0801 | 17.1409 | 8.1482 | 35.2416 | 51.9551 | 36.9468 |

Key: $H^2_b$ = broad sense heritability, $h^2_n$ = narrow sense heritability, GA = genetic advance, SV = seedling vigour, PLH = plant height, NT= numbers of tillers, DTF = days to 50% flowering, PANL = panicle length, PANW= panicle weight, 1000GW = thousand grain weight, Y/P = yield per plant