ARTICLE / INVESTIGACIÓN

Estimation of path coefficient analysis for some quantitative traits in Rice (*Oryza sativa* L.) genotypes

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Abstract: A field experiment was conducted at the Al Mushkab Rice Research Station (AMRR), Najaf, Iraq, during the rice growing season of 2018-2019 in Randomized Complete Block Design (RCBD) for the aim of estimating the path coefficient in 15 introduced and local genotypes of rice. The path coefficient was estimated for the number of days from planting to 50% flowering, the number of days from flowering to physiological maturity, plant height, leaf area index, number of branches/panicle, number of panicles / m^2, number of grains/panicles, infertility percentage (sterility %), 1000 grains weight (gm), biological yield (kg. ha^{-1}) and harvest index (HI %) with grain yield kg, $ha.^{-1}$. The results of the study concluded that the trait of harvest index is an effective selection criterion for improving Rice grain yield because it achieved the highest overall positive effect, i.e., the highest positive genotypic correlation amounted to 0.761, and this trait also achieved a high direct positive effect on grain yield amounted to 0.83833.

Key words: Rice, Genotypes, Path, Coefficient, Harvest Index.

Introduction

Rice (*Oryza sativa* L.) is one of the food crops whose average consumption is constantly increasing, especially in the Arab world. It was cultivated with an area of 55525 hectares, an annual production of (265900) tons, and a productivity rate of 4.78 tons.ha^{-1}. This yield in the United States of America and China is 8.11 and 6.86 t. ha^{-1}, respectively[1]. Rice is the principal food for over half the world's humans. About 480 million metric tons of milled rice are produced every year. China and India alone have 50% of the rice grown and consumed. Rice is critical for food security and gives up to 50% of the nutritional caloric supply for millions in Asia, Latin America, and Africa[2,3]. Nearly 90% of the world's rice crop is produced in Asian countries. It plays a crucial role in food security in Iraq and different countries[4].

In Iraq, rice is an essential summer crop. It comes in third place after wheat and barley in terms of cultivated area and production. Still, Iraq is a country that imports cereals and its rice production are not enough to meet the needs of its population (1.1 million tons was imported in 2017)[5,6]. Genetic improvements, primarily through selection, are an essential means in the hands of plant breeders to increase the yield. Plant breeders need to carefully select the most critical associated traits that are phenotypically and genetically related, directly or indirectly, to the grain yield to use them as selection indices. Since the simple correlation measures the relationship in its abstract form, the path coefficient determines traits' direct and indirect effects on the yield based on genetic correlations[7]. The path-coefficient analysis is simply a standardized partial regression coefficient, which measures one variable's direct and indirect impact upon another and permits the separation of the correlation coefficient into components of direct and indirect effect[8]. In agriculture, path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield[9,10]. Path coefficient analyses evaluate each trait's direct and indirect contribution to the product could be estimated by picking up appropriate features for indirect selection[11]. Based on the preceding, this research aimed to determine the traits most related to grain yield and count them as selective indices for plant breeders to use in improving grain yield by analyzing the path factor.

Materials and methods

A field experiment was conducted during the summer agricultural season of 2018 at Al-Mashkhab Rise Research Station (AMRRS) affiliated with the Agricultural Research Department / Ministry of Agriculture, which is (22 km southeast of the center of Najaf governorate) and located within 44.31 east longitude. It is 31.89 in north latitude and 70 m above sea level. Rice seedlings were prepared in cultivation and by seedling method on 17/6/2018 for all the genotypes shown in Table (1), which were obtained from the genome bank at the Rice Research Station in Al-Mishkhab. The experiment was carried out using a Randomized Complete Block Design (RCBD) with three replications. The path coefficient was estimated for the number of days from planting to 50%, the number of days from planting to physiological maturity, plant height, leaf area index, number of branches/panicle, number of panicle /m^2, number of grains/panicle, infertility percentage (%), the weight of 1000 grains (gm), biological yield and harvest index (%) with grain yield kg. $ha.^{-1}$. The experiment was fertilized with the full amount

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of fertilizer to the crop, as Dab fertilizer (P_2O_5 46% N 18%) was added at a rate of 120 kg. ha.$^{-1}$ mixed with soil before planting, urea (46%) N fertilizer was added with an amount of 280 kg. ha.$^{-1}$, in two batches, the first 12 days after seedlings, and the second batch a month after the first batch, and for all experimental units[12]. The rest of the soil and crop service operations were conducted as needed. After confirming the existence of genetic correlations between the studied traits, the path coefficient analyzes were entered into. The path coefficient is the standardized partial regression coefficient corresponding to the results of the regression analysis that (13) established in segmenting the correlation coefficient between two variables into direct effects (Cause) in effect (Effect) and indirect effects of the cause in effect, through other causes, as figure 1. The Path analysis was done according to Dewey and Singh[8,14]. The following scale was adopted to clarify the importance of direct and indirect effects, based on (15): Table 2.

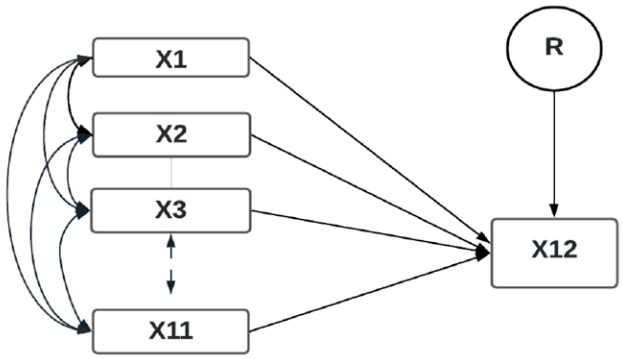

Figure 1. Path Coefficient diagram depicting interrelationships among traits.

Results

The path coefficient analysis was carried out at the level of genotypic correlation coefficients for the eleven studied traits to partition the correlation coefficient between each of the studied traits and the yield into its direct and indirect effects to determine the traits that most influence the grain yield and describe them as selectin on indices to improve the yield. This is illustrated in Table (3).

Number of days from planting to 50% flowering

The number of days from planting to 50% flowering achieved a little negative direct effect with grain yield of -0.15505 and positive indirect effects that ranged from 0.78733 through plant height, which has a high impact, to 0.05041 through non-fertility percentage (%), which was unimportant It is neglected. The number of days from planting to 50% flowering also achieved adverse indirect effects ranging from -1.47859 for the number of days from cultivation to physiological maturity, in which the product was very high, to -0.03332, which was unimportant and neglected. As for the value of the total effect, the genetic correlation coefficient was Few and negative as it reached -0.188.

Number of days to physiological maturity

The trait of the number of days from planting to physiological maturity achieved the value of the total effect; that is, the genetic correlation coefficient was few and negative, reaching -0.225 with grain yield .it is also achieved a very high negative direct impact with grain yield of -1.52125 this agree with Jeke[16]. The positive indirect effects ranged from 0.77503 through plant height, in which the product was

Genotypes' name	Pedigree
1. Amber 33	Local (Iraqi)
2. Amber al-Baraka	Introduced from India
3. Amber Furat	Technology& Science Ministry/ Baghdad
4. Amber Baghdad	Technology& Science Ministry/ Baghdad
5. Amber Menathera	Technology& Science Ministry/ Baghdad
6. Sumar	Technology& Science Ministry/ Baghdad
7. Dijlah	Introduced from China
8. Ghadeer	Introduced from IRRI (Philippines).
9. Brnamge -4	Introduced from IRRI(Philippines).
10. Dorfak	Sepidrood/Salari- Iran
11. Gohar	Pusa1238-1/Pusa1238-81-6-Iran
12. Khazar	IR2071-625-1-52/TANU7456-Iran
13. Shiroudi	Khazar / Deylamani – Iran
14. Neda	Amol3/Hassansarayee/sangetarom-Iran
15. Nemat	Amol3/sangetarom-Iran

Table 1. Rice genotypes used in the study.

The value of direct and indirect effects	Importance
From zero – 0.09	Not essential and neglects (Negligible)
from 0.10 - 0.19	Low
from 0.20 - 0.29	Moderate
from 0.30 - 0.99	High
from one or more	Very high

Table 2. The importance of direct and indirect influences.

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	Total (genotypic correlations)
X1	-0.15505	-1.47859	0.78733	0.32093	0.41121	0.08025	-0.18299	0.05041	-0.03332	0.32204	-0.30973	**-0.188**
X2	-0.15070	-1.52125	0.77503	0.31489	0.42352	0.07917	-0.20247	0.07441	-0.02848	0.44019	-0.42963	**-0.225**
X3	-0.13392	-1.29337	0.91158	0.38273	-0.05960	0.04012	-0.05335	-0.00801	-0.00775	0.44876	-0.38717	**-0.160**
X4	-0.11750	-1.13109	0.82381	0.42351	-0.14500	0.01869	-0.09568	0.03614	-0.07251	0.43036	-0.40887	**-0.238**
X5	-0.06625	-0.66944	-0.05646	-0.06380	0.96241	0.09921	-0.31828	0.16253	-0.01456	-0.04982	0.09037	**0.076**
X6	0.07838	0.75864	-0.23037	-0.04985	-0.60142	-0.15875	0.10302	0.03052	0.03055	0.31765	0.07965	**0.358***
X7	-0.06999	-0.75984	0.11997	0.09997	0.75567	0.04035	-0.40536	0.26310	-0.03828	0.31260	0.17094	**0.489****
X8	0.02582	0.37399	0.02412	-0.05056	-0.51677	0.01601	0.35235	-0.30268	0.03796	-0.42802	-0.29716	**-0.765****
X9	0.02820	0.23642	-0.03854	-0.16759	-0.07647	-0.02647	0.08468	-0.06270	0.18323	-0.20086	0.13573	**0.096**
X10	-0.05615	-0.75296	0.45999	0.20494	-0.05391	-0.05670	-0.14248	0.14568	-0.04138	0.88934	-0.40526	**0.191**
X11	0.05729	0.77963	-0.42101	-0.20655	0.10375	-0.01508	-0.08265	0.10729	0.02967	-0.42992	0.83833	**0.761****

Residual effect =0.00013* and ** indicate significance at 5% and 1% level of probability, respectively.X1= Days from planting to 50 % flowering, X2 = Days from growing to physiological maturity, X3 = Plant height, X4 = Leaf Area Index, X5 = Branches/panicle, X6 = N. panicles / m2, X7 = N. grains/panicle, X8 = Sterility %, X9=1000 grain weight, X10= Biological yield, X11 = Harvest Index and X12 = Grain yield

Table 3. Estimates of direct and indirect effects and the total effect of yield attributing traits on grain yield.

high, to 0.42352 through the number of branches/panicles, which was also increased. The characteristic of the number of days from planting to physiological maturity, adverse indirect effects, ranging from -1.52125 through the number of days from planting to 50% flowering, in which the product was very high, to -0.02848 through the weight of 1000 grains (g), which was unimportant and neglected. As for the value of the total effect, the genetic correlation coefficient was few and negative, reaching -0.225.

Plant height (cm)

The direct effect of plant height was high, amounting to 0.91158. There were positive and negative indirect effects, the highest of which was achieved through the characteristic of biological yield, which was a high and positive effect on grain yield and amounted to 0.44876 and a very high and negative indirect effect on grain yield through the characteristic of the number of days from cultivation to physiological maturity reached -1.29337. Still, the plant height trait achieved a small total effect of -0.160.

Leaf Area Index (LAI)

The direct effect of the leaf area index was high and amounted to 0.42351. There were positive and negative indirect effects, which were highly positive, on the grain yield through the characteristic of plant height, which amounted to 0.82381 and negative and very high in its impact on the grain yield through the part of the number of days from planting to. The physiological maturity reached -1.13109, and the leaf area index trait had a small negative effect of -0.238.

Number of branches/panicles

The direct effect of the number of branches/panicles was high, amounting to 0.96241. There were positive and negative indirect effects, which were highly positive, on the yield of grains through the characteristic of the biological substance, which amounted to 0.9037, and negative and high impact on the grain yield through the feature of the number of days from cultivation to physiological maturity. It reached -0.66944, and the characteristic of the number of branches/panicles achieved a total effect that was not important and neglected, which amounted to 0.076.

Number of panicles, / m²

The direct effect of the number of panicles / m² was low and negative, amounting to -0.15875. Still, there was a positive and high indirect effect on the grain yield through the characteristic of the number of days from planting to physiological maturity, which amounted to 0.75864 and a negative and high indirect effect on the grain yield through the feature of the number the branches/ panicle, reached -0.60142, in addition to other positive and negative effects. The element of the number of panicles/m² achieved a total result of 0.358.

Number of grains /panicles

The trait of the number of grains/panicle achieved a positive indirect effect through the number of branches/panicle, high with a grain yield of 0.75567 and indirect, negative and high -0.75984 through the number of days from planting to physiological maturity. The trait of the number of grains/ panicles also had a high direct negative effect of -0.40536 And other positive and negative effects. The value of the total impact, the value of the genetic correlation coefficient, was tall and positive, reaching 0.489.

Infertility percentage (Sterility %)

The direct effect of the percentage of infertility (%) was high and harmful, amounting to -0.30268. There were positive and negative indirect effects for the rest of the traits. They were highly influential and favorable on the grain yield through the days from cultivation to physiological maturity, which amounted to 0.37399 and negative and high. The grain yield through the trait number of branches/panicle reached -0.51677, and the trait of infertility percentage (%) achieved a high, negative total effect of -0.765.

1000 grain weight (gm)

The direct effect of the weight of 1000 grains (gm) was low, amounting to 0.18323, but there were positive and negative indirect effects for the rest of the traits. They were highly and positively affecting the grain yield through the characteristic of the number of grains/panicle, which amounted to 0.8468 and negative through most of the studied traits, and the weight characteristic was achieved. One thousand tablets (gm) have a low total effect of 0.096.

Biological yield (kg/ha)

The biological yield trait achieved a high positive indirect effect through plant height with a grain yield of 0.45999 and a high negative indirect impact through the number of days from planting to physiological maturity -0.75296, as well as positive and negative effects through the rest of the traits. The biological yield trait achieved a high direct result of 0.88934. As for the value of the total impact, that is, the genetic correlation coefficient, it was few and negative, as it

amounted to -0.191. Biological yield has also been identified as a significant direct contributor towards grain yield exerted a high positive immediate effect (0.8481) by Mervat MA[18].

Harvest Index (%)

The direct effect of the harvest index was high, reaching 0.83833. There was a positive and high indirect effect on grain yield through the characteristic of the number of days from planting to physiological maturity, which amounted to 0.77963. An indirect, negative and high effect through the characteristics of plant height and biological yield, which were -0.42101 and -0.42992, respectively, which was reflected in achieving a high total positive effect of 0.761 and this is consistent with what (19,20) stated that the trait of harvest index achieved a direct and high total effect with grain yield. It can be concluded from the preceding that the harvest index is an effective selection criterion to improve Rice grain yield because it achieved the highest overall positive effect, i.e., the highest positive genetic correlation. It also achieved a high direct positive effect on grain yield. The residual effect determines how best the causal factors account for the variability of the resultant factor, the grain yield kg. ha.$^{-1}$. In the present study, the residual effect was shallow at the genotypic level (Table 3), indicating that the characters selected in this study contributed to the yield.

Discussion

Path coefficient analysis provides a view into interrelationships by separating the correlation coefficients into direct and indirect effects of characters. In crops, path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield. The rice breeders used the path coefficient analysis to estimate the desirable features in the selection to enhance the grain yield. The correlation among traits under study indicated that the short flowering period would provide more time to increase the full-grain number per panicle. This will be improved by reducing sterility. An increase in panicle number per m^2 will improve the final grain yield, which was panicle number per m^2 and grain number per panicle and harvest index correlated positively to yield traits. These results agree with the results of (21-28). Current knowledge about trait relationships helps in the appropriate selection process due to the increased share of crop improvement[29]. Breeding programs aim to increase rice production by using more genetic types and applying effective selection methods to increase yield through yield traits. Identifying the relationship between creation and yield traits via correlation analysis is an essential step[30], but dividing the influence of features into direct and indirect effects by path analysis is more critical for them a selection of yield traits[31,32]. The importance of path analysis is partitioning the correlation coefficient into its components; the first component is the path coefficient, which measures the direct effect of a predictor variable upon its response variable. The second component is the indirect effect of a predictor variable on the response variable through other predictor variables.

Conclusions

Path analysis revealed that harvest indexes are the most critical component characters that could be used as selection indices for further improvement in grain yield under any climatic condition. Hence natural selection of these traits can be made in rice breeding programs. Progress in these traits will result in simultaneous improvement in grain yield.

Author Contributions

For research articles with one author, M.A.Al-anbari. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

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Informed Consent Statement

Not applicable.

Data Availability Statement

Path coefficient analyses evaluate each trait's direct and indirect contribution to yield could be estimated by picking up appropriate features for indirect selection.

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Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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