*Journal of Advances in Biology & Biotechnology*

*Volume 27, Issue 11, Page 232-240, 2024; Article no.JABB.125117*
*ISSN: 2394-1081*

# Correlation and Path Coefficient Analysis in F2 Segregating Population of RNR-15048 x Dokra-dokri in Rice (*Oryza sativa* L.)

**Margam Bharath Kumar [a,b*], B. Vidhyadhar [a], R. Abdul Fiyaz [b], Ch. Anuradha [a] and D.Srinivasa Chary [a]**

[a] *Professor Jayashankar Telangana Agricultural University, Rajendranagar, Hyderabad, Telangana, India.*
[b] *ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad, Telangana, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: https://doi.org/10.9734/jabb/2024/v27i111608

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers,peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/125117

***Original Research Article***

***Received: 15/08/2024***
***Accepted: 17/10/2024***
***Published: 02/11/2024***

## ABSTRACT

The present experiment was conducted to study the correlation and path coefficient analysis in $F_2$ segregating population of RNR-15048 x Dokra-Dokri taken up in augmented complete block design with two checks at ICAR-IIRR, Hyderabad during the *Kharif*-2022. Character association of the yield attributing traits revealed significant positive association of single plant yield with plant height, panicle length, total number of tillers, number of productive tillers, panicle weight, number of filled grains per panicle, total grains per panicle, spikelet fertility and thousand grain weight. Hence,

---

**Corresponding author: E-mail: margambharath125@gmail.com;*

***Cite as:*** *Kumar, Margam Bharath, B. Vidhyadhar, R. Abdul Fiyaz, Ch. Anuradha, and D.Srinivasa Chary. 2024. "Correlation and Path Coefficient Analysis in F2 Segregating Population of RNR-15048 X Dokra-Dokri in Rice (Oryza Sativa L.)". Journal of Advances in Biology & Biotechnology 27 (11):232-40. https://doi.org/10.9734/jabb/2024/v27i111608.*

selection for these traits could be rewarding. Path coefficient analysis revealed that number of productive tillers per plant, panicle weight, total grains per panicle, thousand grain weight, panicle length, total number of tillers per plant exhibited positive direct effect and also significant correlation with grain yield per plant. This suggests that the correlation is driven by indirect effects, highlighting the importance of considering these causal factors while selecting traits for yield improvement. Based on residual effect there is a moderate amount of unexplained variance in the yield traits indicating other attributes besides the characters studied are also contributing for yield improvement.

*Keywords: F2 segregating population; correlation coefficient; path analysis; direct selection; rice.*

## 1. INTRODUCTION

Rice stands as one of the world's most vital cereal crops, serving as a carbohydrate or energy source for approximately half of the global population. Its significance extends beyond nutrition to have substantial economic and food security implications, especially in many Asian countries. Globally, rice is cultivated across 167.6 million hectares, yielding a total of 527.6 million tonnes with an average productivity of 4.17 tonnes per hectare [1]. Despite the considerable advancements in rice production and productivity brought about by the green revolution, further improvements have been constrained by a yield plateau, influenced by various biotic and abiotic factors. Ensuring future food security poses a significant challenge, especially for rice breeders in India, where rice is crucial for both food and nutritional security. To overcome the current yield limits, there is a need for rice varieties with higher productivity and adaptable agronomic traits. Hybridization presents a highly effective and practical approach for generating the desired variability which relies on the capacity to identify and select superior genotypes through a careful selection process. Selection criteria are usually based on yield or its components and can be executed either directly or indirectly. When traits are correlated, selecting for one trait can influence other related traits as well. Grain yield is affected by various component traits and knowledge of correlation between predictor factors and responder variables and their direct and indirect impacts on yield is crucial for effective yield improvement [2]. While correlation measures the degree of association between two traits, it does not explain the causal relationships. Path coefficient analysis offers insights into the direct and indirect effects of traits on yield. This method, when combined with correlation analysis, helps to clarify the cause-and-effect relationships between different traits [3]. Such comprehensive analysis supports breeders for estimating the degree and direction of association thereby employing suitable methods of selection. Therefore, present study has been taken to elucidate information on character associations and path coefficients in $F_2$ segregating generation for yield improvement.

## 2. MATERIALS AND METHODS

The experiment was carried out at Indian Council of Agricultural Research-Indian Institute of Rice Research (ICAR-IIRR), Rajendranagar, Hyderabad, during *kharif* 2022. The experimental trial was laid out in F1 plot at ICAR-IIRR field using Augmented Randomized Complete Block Design (ARCBD) consisting of 105 $F_2$ segregating population derived from RNR-15048 x Dokra-Dokri having low and high test weights respectivey presented in Table 1. The experimental area contains a total of five blocks. Prior determining individuals in each block, two checks were initially randomized. Each block was given a total of 24 entries, which included 22$F_2$'s and 2 checks. Twenty-five days old seedlings were transplanted in the main field with a spacing of 20 x 15 cm. All recommended cultural operations and plant protection measures were taken to ensure uniform and healthy crop stand as previously reported in Bharath et al. (2023). Each individual $F_2$ plant was recorded for Plant Height (cm), Total Number of Tillers per plant (TNT), No. of Productive Tillers per plant (NPT), 1000 grain weight (TGW) (gm), Single plant yield (SPY) (gm). Average of three panicles per plant were recorded for Panicle length (PL) (cm), Panicle weight (PW), No. of filled grains per panicle (NFG), No. of unfilled grains per panicle (NUFG), Total No. of grains per panicle (TGP) and Spikelet fertility (SF) (%).

**Table 1. Charcters of the parents of the intra-specific cross studied in the present investigation**

| Parents | Characters |
|---|---|
| RNR-15048 | Short slender grain type with low glycemic index (51.72), good cooking quality, low test weight of 12.9 g and resistant to blast developed from the cross between MTU1010 and JGL 3855. |
| Dokra-Dokri | Longest and boldest grain with 14 mm long, high in protein (6.06%) low in fiber with high test weight of 40.5 g. |

## 2.1 Statistical Analysis

Correlation was worked out using the formulae suggested by Weber and Moorthy [4]. Partitioning of the correlation coefficients into direct and indirect effects was carried out using the procedure suggested by Wright [5] and elaborated by De Wey and Lu [6]. The characterization of path coefficients was carried out as suggested by Lenka and Mishra [7] using R studio (*version* 3.5.2).

# 3. RESULTS AND DISCUSSION

## 3.1 Correlation Coefficient Analysis

In order to identify the critical traits that may be used for crop improvement through appropriate breeding program, Selection based on correlation is essential as it provides thorough understanding of the strength and direction of the relationship between yield and its contributing traits given in Table 1, Fig. 1. “Studies on inter-character associations for the yield component traits revealed significant and positive association of Plant height with panicle length, panicle weight, no. of filled grains, total no. of grains, spikelet fertility, thousand grain weight and single plant yield while negative significant correlation with number of unfilled grains per panicle” [8]. These results are in accordance with Saketh et al. [9] for single plant yield, Devi et al. [10], Deepthi et al. [11], Faysal et al. [12], Heera et al. [13], Thuy et al. [14] for panicle length. Panicle length registered significant positive correlation with panicle weight, number of filled grains per panicle, Total no. of grains, spikelet fertility, thousand grain weight and single plant yield which indicates improvement in panicle length would improve grain number per panicle and single plant yield. These results are in accordance with Santhipriya et al. [15], Kiran et al.[16] for number of filled grains per panicle and with total grains per panicle by Bhargava et al*.* [17]. “Number of productive tillers per plant exhibited a positive significant association with panicle weight,number of filled grains, spikelet fertility and single plant yield while negative non-significant association with number of unfilled grains. Similar findings with number of filled grains per panicle” were reported by Archana et al. [18] and Sahithi et al*.* [8]. “Panicle weight exhibited significant positive correlation with number of filled grains, total grains per panicle, spikelet fertility, thousand grain weight and single plant yield indicating a scope for simultaneous improvement of these traits through selection. Number of filled grains per panicle exhibited positive significant association with total grains per panicle, spikelet fertility and single plant yield while negative significant association with number of unfilled grains per panicle. Therefore, it can be seen as an important element for achieving high yields. Number of unfilled grains per panicle registered negative significant association with panicle weight, no. of filled grains, spikelet fertility and single plant yield however association with grain yield per plant was significant and positive, highlighting the importance of balanced selection for these traits when aiming to improve grain yield. Spikelet fertility registered a positive significant correlation with panicle length, panicle weight, number of filled grains per panicle and single plant yield while negative significant association with number of unfilled grains. Similar findings of spikelet fertility with number of filled grains per panicle” were reported by Nath and Kole [19] and Sahithiet al*.* [8]. “Thousand grain weight registered a positive significant association with plant height, panicle length and panicle weight which indicates improvement in panicle weight would improve thousand grain weight. Single plant yield had significant positive association with plant height, panicle length, total number of tillers, number of productive tillers, panicle weight, number of filled grains, total grains per panicle, spikelet fertility and thousand grain weight. Similar findings of positive significant association of single plant yield with plant height” were reported by Panika et al. [20], Sahithi et al. [8], Pathak et al. [21]. With panicle length by Abdul Fiyaz et al*.* [22], Panika et al. [20], Farheen et al. [23], Kiran et al. [16]. With panicle weight by Kulsum et al. [24], Panika et al. [20], Surjaye et al. [25].

With filled grains by Deepthi et al. [11], Ratnam et al. [26], Kiran et al. [16] with thousand grain weight by Kondi et al. [27], Satish Chandra et al. [28] thus ultimate increase in yield can be achieved by direct selection for these traits.

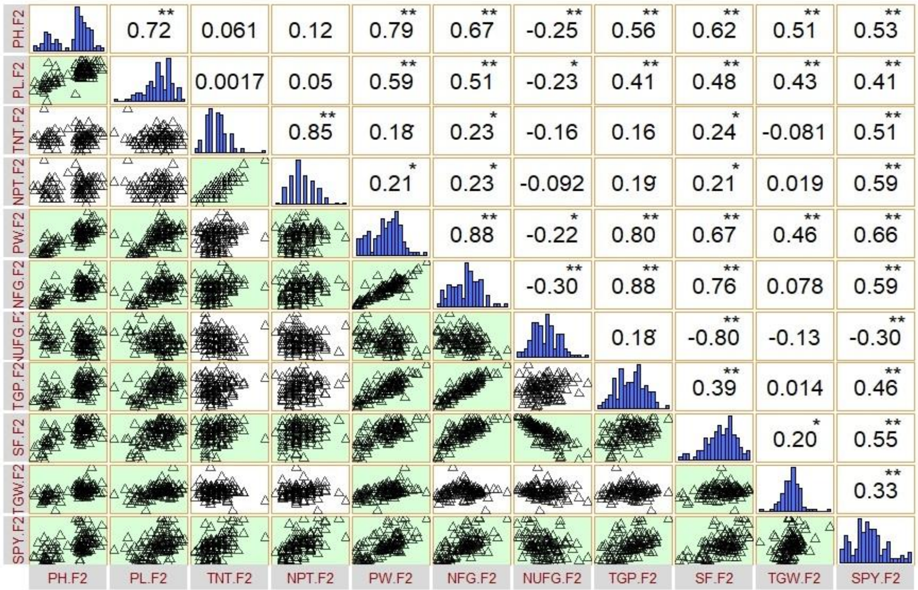

**Fig. 1. Estimates of correlation coefficients between yield and yield component traits in $F_2$ segregating population of cross RNR-15048 x Dokra-Dokri**

**Significant at 5%, ** Significant at 1%*

*PH- Plant height (cm), PL- Panicle length (cm), TNT- Total number of tillers per plant, NPT- Number of productive tillers per plant, PW- Panicle weight (gm), NFG- Number of filled grains per panicle, NUFG- Number of Unfilled grains per panicle, TGP- Total grains per panicle, SF- Spikelet fertility, TGW- Thousand grain weight (gm) and SPY- Single plant yield (gm)*

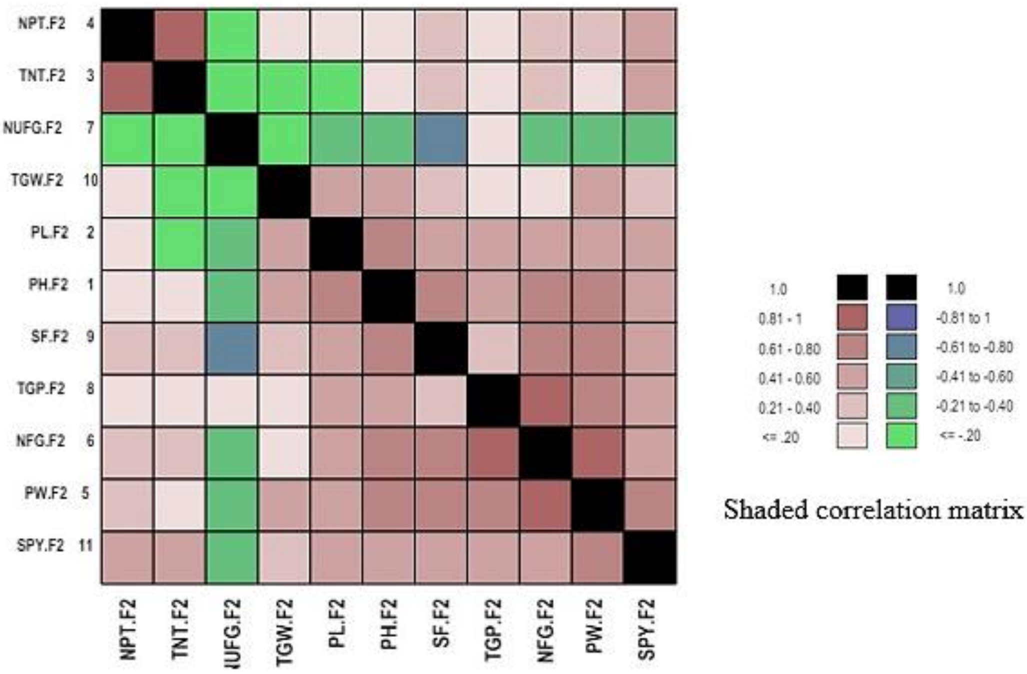

**Fig. 2 Correlogram visualizing the correlation among yield and yield traits**

**Table 2. Phenotypic path coefficient analysis representing direct and indirect effects on single plant yield by its contributing traits in $F_2$ population of RNR-15048 x Dokra-Dokri**

| | PH | PL | TNT | NPT | PW | NFG | NUFG | TGP | SF | TGW | SPY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PH** | **0.0046** | 0.0033 | 0.0003 | 0.0005 | 0.0036 | 0.0031 | -0.0012 | 0.0026 | 0.0028 | 0.0023 | 0.5297 |
| **PL** | 0.0397 | **0.0554** | -0.0001 | 0.0028 | 0.0329 | 0.0281 | -0.0125 | 0.0228 | 0.0266 | 0.0237 | 0.4132 |
| **TNT** | 0.0003 | 0 | **0.0059** | 0.005 | 0.0011 | 0.0014 | -0.0009 | 0.0009 | 0.0014 | -0.0006 | 0.503 |
| **NPT** | 0.0558 | 0.0238 | 0.4018 | **0.4733** | 0.0998 | 0.1079 | -0.0436 | 0.0898 | 0.0996 | 0.0089 | 0.5909 |
| **PW** | 0.3163 | 0.2365 | 0.0716 | 0.084 | **0.3986** | 0.3498 | -0.0887 | 0.317 | 0.2665 | 0.1842 | 0.6551 |
| **NFG** | -0.0891 | -0.0676 | -0.0307 | -0.0304 | -0.117 | **-0.1333** | 0.0398 | -0.1179 | -0.1015 | -0.0103 | 0.5916 |
| **NUFG** | 0.063 | 0.0563 | 0.0388 | 0.023 | 0.0555 | 0.0744 | **-0.2493** | -0.0453 | 0.1989 | 0.0334 | -0.2991 |
| **TGP** | 0.1173 | 0.0856 | 0.0334 | 0.0394 | 0.1652 | 0.1837 | 0.0377 | **0.2077** | 0.0819 | 0.003 | 0.4633 |
| **SF** | -0.0247 | -0.0192 | -0.0094 | -0.0084 | -0.0267 | -0.0304 | 0.0319 | -0.0158 | **-0.04** | -0.0081 | 0.5548 |
| **TGW** | 0.0465 | 0.0391 | -0.0086 | 0.0017 | 0.0423 | 0.0071 | -0.0123 | 0.0013 | 0.0185 | **0.0915** | 0.328 |

*Residual effect: 0.576; Direct effects are represented in bold values*

*PH- Plant height (cm), PL- Panicle length (cm), TNT- Total number of tillers per plant, NPT- Number of productive tillers per plant, PW- Panicle weight (gm), NFG- Number of filled grains per panicle, NUFG- Number of Unfilled grains per panicle, TGP- Total grains per panicle, SF- Spikelet fertility, TGW- Thousand grain weight (gm) and SPY- Single plant yield (gm)*

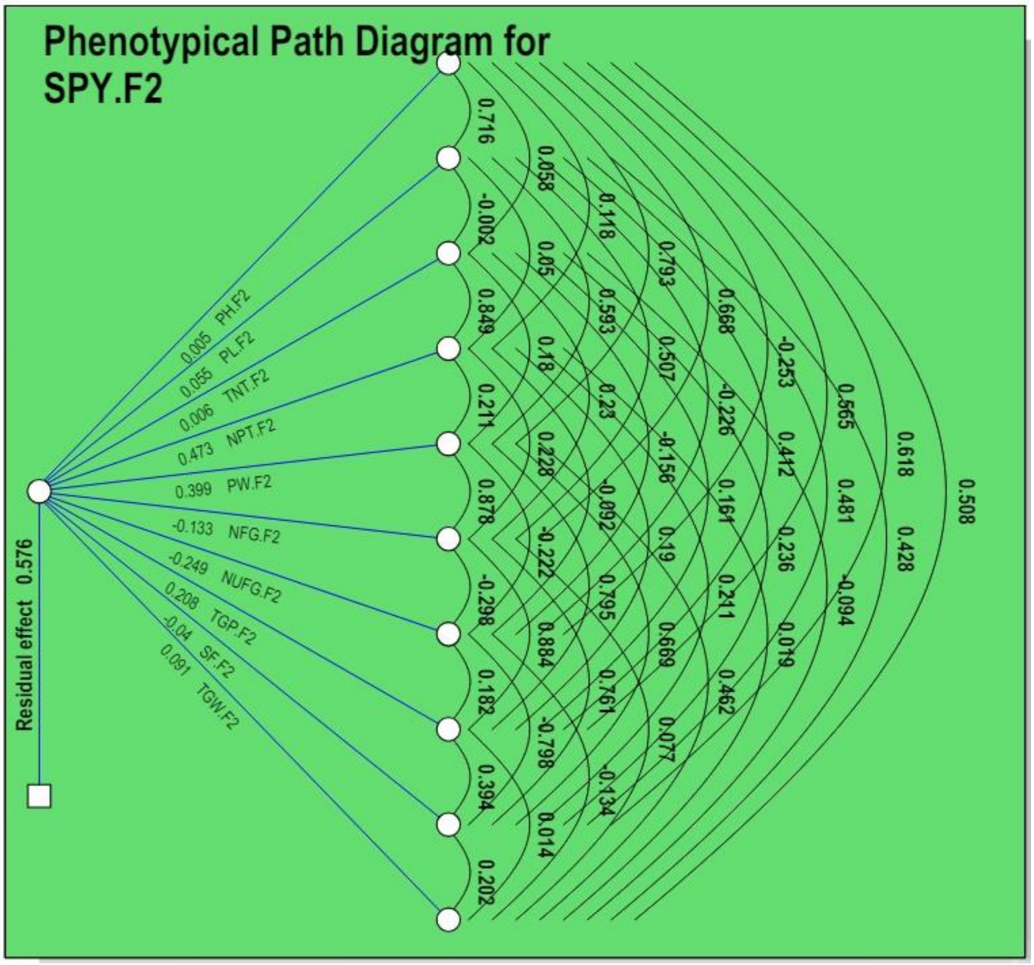


**Fig. 3. Phenotypical path diagram depicting direct and indirect effect of different traits on Single plant yield**

## 3.2 Path Coefficient Analysis

"Simple correlation alone does not accurately reflect how different traits contribute to yield. Therefore, phenotypic correlations were splited into direct and indirect effects using path coefficient analysis. It provides a more precise interpretation of the cause-and-effect relationships" [5]. The estimates of path coefficient analysis for yield and yield component characters are furnished in Table 2, Fig. 3. Among all the characters, the number of productive tillers per plant (0.4733) exerted maximum positive direct effect on plant yield followed by panicle weight (0.398), total grains per panicle (0.207) and thousand grain weight (0.091) which also showed significant and positive association with grain yield per plant in correlation studies. Therefore, these traits should be viewed as crucial selection criteria in all rice improvement programs, and it is advisable to directly select for these traits to enhance yield. Similar results of maximum positive direct effect on plant yield were reported by Sudeepthi et al. [29], Bhargava et al. [17] for number of productive tillers per plant, thousand grain weight and total grains per panicle; Kalaiselvan et al.[30] and Parimala et al.[31] for thousand grain weight. Further, panicle length (0.055), Total number of tillers per plant (0.005) and plant height (0.0046) recorded low to moderate positive direct effects on grain yield per plant. Similar result for plant height, total number of tillers per plant was obtained by Hani and Thouseem 2024; for plant height and panicle length by Paramanik et al. [32] and Maneesha et al. [33]. "Association of these traits was also noticed to be positive and significant with grain yield per plant. This suggests that the correlation is driven by indirect effects, highlighting the importance of considering these indirect causal factors when selecting traits for yield improvement. In contrast to positive direct effect, maximum negative direct effect on single plant yield was exhibited by number of unfilled grains per panicle (-0.249), number of filled grains per panicle (-0.133) and spikelet fertility (-0.04) probably due to competition for a common possibility such as nutrient supply. Similar results of negative direct effect were reported for number of filled grains per panicle, number of unfilled grains per panicle" by Hani and Thouseem 2024 and for spikelet fertility by Kalaiselvan et al .[30] and Bhargava et al.[17]. The residual effect in the present study was 0.576 at phenotypic level indicating other attributes besides the characters studied are also contributing for grain yield per plant [34-36].

## 4. CONCLUSION

Correlation studies revealed significant positive association of plant height, panicle length, number of productive tillers, panicle weight, number of filled grains, total grains per panicle, spikelet fertility and thousand grain weight with single plant yield indicating that the above traits can be considered for selection process. Some of the characters could not produce significant correlation with single plant yield which might be either due to very high negative direct effects. Critical analysis of results obtained from character association and path analysis indicated that number of productive tillers per plant, panicle weight, total grains per panicle, thousand grain weight, panicle length, total number of tillers per plant possessed both positive association and high positive direct effects. Hence, direct selection for these traits should be helpful in yield improvement. Based on residual effect there is a moderate amount of unexplained variance in the yield traits and therefore, other attributes besides the characters studied are also contributing for yield improvement.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

## ACKNOWLEDGEMENT

This is part of the author's PhD research work at Indian Institute of Rice Research. The author is highly grateful for the research facilities provided by the Indian Institute of Rice Research, Hyderabad and Professor Jayashankar Telangana Agricultural University.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Durand-Morat A, Mulimbi W. International rice outlook: International rice baseline projections. 2023-2033; 2024.
2. Meena D, Kumar M, Sandhya, Koli NR, Yamini T, Meena AK. Assessment of correlation and path coefficient analysis for yield and it's attributing traits in rice (*Oryza sativa* L.) genotypes. International Journal of Current Microbiology and Applied Sciences. 2020;9(7):3845- 3851.
3. Jayasudha S, Sharma D. Genetic parameters of variability, correlation and path coefficient for grain yield and physiological traits in rice (*Oryza sativa* L.) under shallow lowland situation. Electronic Journal of Plant Breeding. 2010;1(5):1332-1338.
4. Weber CR, Moorthy BR. Heritability and nonheritability relationships and variability of oil content and agronomic characters in the $F_2$ generation of soybean crosses. Agronomy Journal.1952;44:202-209.
5. WrightS. Correlation and causation. Journal of Agricultural Research. 1921; 20:557-585.
6. Dewey JR, Lu KH. Correlation and path coefficient analysis of components of crested wheat grass seed production. Agronomy Journal. 1959;51:515-518.
7. Lenka D, Mishra B. Path coefficient analysis of yield in rice varieties. Indian J. of Agri. Science.1973;43:376-379.
8. Sahithi M, Abdul Fiyaz R, Sameer Kumar CV, GS Laha. Genetic variability and character association studies for yield and yield related traits in rice (*Oryza sativa* L.). The Pharma Innovation Journal. 2023;12(9):598-602.
9. Saketh T, Shankar VG, SrinivasB, Hari Y. Correlation and path coefficient studies for grain yield and yield components in rice (*Oryza sativa* L.). International Journal of Plant & Soil Science.2023;35(19):1549-58.
10. Devi KR, Hari Y, Chandra BS, Prasad KR. Genetic association, variability and path studies for yield components and quality traits of high yielding rice (*Oryza sativa* L.)

Genotypes. International Journal of Bio-Resource and Stress Management. 2022;13(1):81-92.

11. Deepthi KP, Mohan YC, Hemalatha V. Genetic variability and character association studies for yield and yield related, floral and quality traits in maintainer lines of rice (*Oryza sativa* L.). The Pharma Innovation Journal. 2022;11(2):191-197.
12. Faysal ASM, Ali L, Azam MG. Genetic variability, character association, and path coefficient analysis in transplant Aman rice genotypes. Plants. 2022;11(21):2952.
13. Heera PK, Ram M, Kumar R, Murali S, Kumar A. Analysis of genetic variability, heritability and genetic advance for yield and yield associated traits in rice (*Oryza sativa* L.). Ecology Environment and Conservation. 2023;29:160-163.
14. Thuy NP, Nhu TTT, Trai NN. Genetic variability for micronutrients under an aerobic condition in local landraces of rice from different agro-ecological regions of Karnataka, India. Biodiversitas Journal of Biological Diversity. 2023;24(1):1-10.
15. Santhipriya C, Suneetha Y, Babu DR, Srinivasa VR. Inter-relationship and path analysis for yield and quality characters in rice (*Oryza sativa*L.). International Journal of Science, Environment and Technology. 2017;6(1):381–390.
16. Kiran AK, Sharma DJ, Subbarao LV. Correlation coefficient and path coefficient analysis for yield, yield attributing traits and nutritional traits in rice genotypes. The Pharma Innovation Journal. 2023;12(2):1978-1983.
17. Bhargava K, Shivani D, Pushpavalli SNCVL, Sundaram RM, Beulah P, Senguttuvel P. Genetic variability, correlation and path coefficient analysis in segregating population of rice. Electronic Journal of Plant Breeding.2021;12(2):549-555.
18. Archana RS, Rani MS. Correlation and path coefficient analysis for grain yield, yield components and nutritional traits in rice (*Oryza sativa* L.). International Journal of Chemical Studies. 2018;6(4):189-195.
19. Nath S, Kole PC. Genetic variability and yield analysis in rice. Electronic Journal of Plant Breeding. 2021;12(1):253-258.
20. Panika N, Singh Y, Singh SK. Genetic variability, correlation and path coefficient study of indigenous rice (*Oryza sativa* L.) accessions for different yield and quality contributing traits. Environment and Ecology. 2022;40:2777-2786.
21. Pathak V, Prasuna CH, Umakanth B.Genetic variability, association and diversity analysis of yield and its component traits in rice (*Oryza sativa*) germplasm. The Indian Journal of Agricultural Sciences. 2024;94(7):786–790.
22. Abdul Fiyaz R, Ramya KT, Chikkalingaiah AB, Gireesh C, RS K. Genetic variability, correlation and path coefficient analysis studies in rice (*Oryza sativa* L.) under alkaline soil condition. Electronic Journal of Plant Breeding.2011;2(4):531-537.
23. FarheenM, Murthy KGK, Mohan YC. Studies on correlation and path analysis for yield and morpho-physiological traits in elite rice (*Oryza sativa* L.) genotypes under Dry DSR System. International Journal of Bio-resource and Stress Management. 2023;14:546-553.
24. Kulsum U, Sarker U, Rasul M. Genetic variability, heritability and interrelationship in salt-tolerant lines of T. Aman rice. Genetika. 2022;54(2):761-776.
25. Surjaye N, Singh Y, Singh SK.Genetic variability, correlation and path coefficient study for various yield and quality traits in NPT lines of rice (*Oryza sativa* L.). Environment and Ecology.2022;40(1):115-122.
26. Ratnam TV, Kumar BR, Rao LS. Assessment of genetic variability, character association and path analysis for yield and quality traits in zinc and iron rich landraces of rice. Agricultural Science Digest. 2022;5678:1-6.
27. Kondi RKR, Kar S, Mandawi N. Study of genetic parameters, correlation and path analysis for yield and quality characters in fine scented rice genotypes. Oryza-An International Journal on Rice. 2022;59(1):20–30.
28. Satish Chandra B, Haritha T, Krishnaveni B, Swapna M. Character association studies for yield, nutritional and cooking quality characters in coloured rice (*Oryza Sativa* L.). Journal of Rice Research. 2024;17(1):65-71.
29. Sudeepthi K, Srinivas T, Kumar BR. Assessment of genetic variability, character association and path analysis for yield and yield component traits in rice (*Oryza sativa* L.). Electronic Journal of Plant Breeding. 2020; 11(01):144-148.

30. Kalaiselvan S, Subramanian A, Thirumurugan T, Rajanbabu V. Genetic variability and association studies in $F_2$ population of rice under sodicity. Electronic Journal of Plant Breeding.2019;10(2):601-613.
31. Parimala K, Surender R, Prasad H, Sudhee SK, Narender SK. Studies on genetic parameters, correlation and path analysis in rice (*Oryza sativa* L.). Journal of Pharmacognosy and Phytochemistry. 2020;9(1):414-417.
32. Paramanik S, Rao MS, Purkaystha S, Singamsetti A. Character association and path coefficient analysis in selected genotypes of rice (*Oryza sativa* L.). Biological Forum –An International Journal. 2023;15(10): 902-911.
33. ManeeshaM, Shankar VG, Srinivas B, Hari Y. Correlation and path coefficient analysis for grain yield, head rice recovery and quality traits in rice hybrids (*Oryza sativa* L.). International Journal of Plant & Soil Science. 2024;36(8):808-816.
34. Fentie DB, Abera BB, Ali HM. Association of agronomic traits with grain yield of lowland rice (*Oryza sativa* L.) genotypes. Int. J. Agric. Sci. 2021;8(3):2348-3997.
35. Hani, Thouseem N. Genetic variability, correlation and path analysis of yield and its attributing traits in rice (*Oryza sativa*L.). International Journal of Plant & Soil Science. 2024;36(8):1029-43.
36. Kumar MB, Vidyadhar B, Anuradha C. Genetic variability, heritability and genetic advance in $F_2$ segregating population of cross RNR-15048 x Dokra-Dokri in Rice (*Oryza sativa* L.). International Journal of Environment and Climate Change. 2023;13(12):965-972.




*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/125117*