International Journal of Biology Sciences

ISSN Print: 2664-9926
ISSN Online: 2664-9934
IJBS 2025; 7(1): 156-160
www.biologyjournal.net
Received: 15-10-2024
Accepted: 19-11-2024

Vilash Bharti
Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Ravindra Kumar Verma
Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Abhinav Sao
Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Sweta Soni
Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Vilash Bharti
Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Genetic studies for estimation of yield determinants in advance breeding lines of rice (*Oryza sativa* L.)

Vilash Bharti, Ravindra Kumar Verma, Abhinav Sao and Sweta Soni

DOI: https://dx.doi.org/10.33545/26649926.2025.v7.i1c.283

Abstract

The current study evaluated 53 (49+4) rice genotypes during *Kharif*, 2023 for seed yield and its component traits at Rice Research unit Farm, Department of Genetics and Plant Breeding, IGKV, Raipur. The experiment was conducted in Randomized Block Design with in two replications to calculate correlation and path analysis. Grain yield per plant demonstrated a significant positive correlation with several traits, including days to 50 flowering, effective tiller per plant, number of spikelets per panicle, number of filled spikelets per panicle, 1000 seed weight (g) and harvest index. This suggests that selecting genotypes based on these characteristics would be rewarding for improving grain yield, as they have complementary effects on yield outcomes. Days to 50 flowering, effective tiller per plant, number of filled spikelets per panicle and 1000 seed weight exhibit a direct positive effect on grain yield per plant. This indicates that selecting genotypes based on these traits will lead to an increase in grain yield per plant.

Keywords: Rice**,** correlation and path analysis

Introduction

The world's most significant and widely produced food crop is paddy. Asia is where rice is mostly grown and consumed. India is the country with the most paddy area worldwide and is the world's second-largest producer, after China. The nation has also become a significant rice consumer. In India, it is one of the most widely grown food crops in terms of location, yield, and consumer demand. More than half of the world's population gets their nourishment from this grain, which is the most consumed cereal in the world. Rice is a member of the *Oryza* genus and the *Poaceae* family. It is made up of about 20 wild species in addition to the two cultivated species, *Oryza glaberrima* and *Oryza sativa*. In West Africa, *Oryza glaberrima* (2n=24 AA) is grown on a small scale, while *Oryza sativa* (2n=24 AA) is the predominant species that is widely cultivated (Kanwar *et al*., 2017) [5]. Association mapping, also known as association disequilibrium, is a technique used to assess the relationship between morphological traits and genetic variation. Understanding how each characteristic has contributed significantly to yield and how they are associated with one another would be helpful in the selecting process. The degree of relationship between yield, grain quality, and its characteristics is determined by correlation, which also offers a clear explanation of how these factors are related to grain quality and yield. According to Babu *et al*. (2012) [1], a breeder may eventually be able to organize his own approach to improve grain output and quality with the help of such an analysis. Wright created the idea of path analysis in 1921, but Dewey and Lu were the first to apply it to plant selection in 1959. Simply, path coefficient analysis divides the correlation coefficient into direct and indirect effects using a standardized partial regression coefficient. To determine the direct and indirect effects of various quantitative characters on grain yield per plant, the path coefficient analysis was performed using the correlation coefficient between the characters. Grain yield improvement is the prime objective of plant breeders for several decades but demand for good quality rice is also increased in current decade as living standard of people are being gradually improved.

Materials and Methods

The experimental material consists of 49 Genotypes of rice along with 4 checks *viz*. Swarna, CG Dhan-1919, NDR-8002 and Pooja. The experiment was laid out in puddled field condition by following Randomized Complete Block Design. The experimental area was divided into 2 replications each consisting of 53 treatments including 4 checks were planted. On the 30th of June 2023, seeds of all genotypes were sown in nursery beds at IGKV, Raipur and 20 to 25 days old seedlings were transferred to the main field on the 21st of July, 2023. Days to 50 flowering, height of the plant (cm), number of effective tillers per plant, panicle length (cm), number of filled spikelets per panicle, total number of spikelets per panicle, percentage of spikelet fertility (%), 1000 grain weight (g), harvest index (%) and grain yield per plant (g) were recorded.

Results and Discussion

Grain yield per plant showed significant and positive relation with spikelets fertility 1000 seed weight and harvest index whereas, significant negative correlation was recorded by plant height.Considering direct effects of yield and yield contributing characters on grain yield per plant, number of filled spikelets per panicle (1.93) showed highest positive direct effect on grain yield followed by effective tillers per plant (1.35), days of 50% flowering (1.24) and 1000 seed weight (0.04).Number of spikelets per panicle (-1.42) showed highest negative direct effect on grain yield followed by harvest index (-1.31), plant height (-1.17), spikelet fertility (-0.79) and panicle length (-0.36).The trait number of spikelets per panicle (0.509) and harvest index (0.782) have significant positive correlation with grain yield but also have negative direct (-1.42 and -1.31) effect with itself, respectively. High positive direct effect on grain yield was exhibited by effective tillers, followed by Number of filled spikelets per panicle and harvest index at phenotypic level. Based on direct and indirect effect recorded for the traits under present investigation, it was observed that the high positive direct effect on seed yield was exhibited by of filled spikelets per panicle (1.93) showed highest positive direct effect on grain yield followed by effective tillers per plant (1.35), days of 50% flowering (1.24) genotypic level.

Range and Mean of each character

The range for number of days to 50 flowering was 103.82 DAS with the varies from 92 DAS (R 2734-14-1, R 2754-42-1, R 2735-121-1, R 2696-72-2) to 123 (DAS) (Pooja), the range for plant height varies from 93.17 cm (CG Dhan 1919), to 129.75 cm (R 2430-385-1-64-1) with a mean of 107.67 cm, the varies for effective tillers per plant varies from 4.40 (R 2418-281-2-218-1) to 8.80 (R 2754-42-1), with a mean of 6.54, the varies from panicle length varies from 21.22 cm (R 2742-24-1) to 27.95 cm (R 2412-283-1-47-1) with a mean of 24.27 cm, the varies for number of spikelets per panicle varies from 35.17 (R 2696-72-2)to 266.67 (R 2771-14-1), with a mean of 124.34, the varies from number of filled spikelets per panicle was with the varies from 57.33 (R 2695-17-1) to 158.50 (CG Dhan 1919) with a mean of 104.33, the range of spikelets fertility was with the varies from 56.69 (R 2771-14-1) to 93.33% (R 2746-72-1) with a mean of 85.10, the range for 1000 seed weight variess from 16.50 g (R 2418-246-1-2-36-1) to 32.10 g (NDR 8002 (C)), with a mean of 23.23 g, the range of harvest index was with the varies from 14.23 (R 2771-21-1) to 40.32 (CG Dhan 1919) with a mean of 27.23 and the range grain yield per plant was with the range of 8.04 g (R 2696-72-2) to 20.40 g (R 2404-49-1-5-1) with a mean of 13.19 g.

Table 1: Experimental materials used in the study

S. No.	Entry	S. No.	Entry
1.	R 2735-122-1	28.	R 2758-27-1
2.	R 2742-24-1	29.	R 2444-449-1-423-1
3.	R 2771-70-1	30.	R 2037-22-1-19-1
4.	R 2748-14-1	31.	R 2696-72-2
5.	R 2772-20-1	32.	R 2418-301-3-256-1
6.	R 2772-43-1	33.	R 2701-12-1
7.	R 2771-21-1	34.	R 2697-154-1
8.	R 2734-14-1	35.	R 2696-71-1
9.	R 2754-42-1	36.	R 2695-17-1
10	R 2771-20-1	37.	R 2694-39-1
11	R 2746-76-1	38.	R 2418-281-2-218-1
12	R 2761-4-1	39.	R 2366-42-1-1-1
13	R 2734-29-1	40.	R 2695-5-1
14	R 2734-47-1	41.	R 2430-382-2-63-1
15	R 2750-61-1	42.	R 2699-25-1
16	R 2747-93-1	43.	R 2430-382-1-62-1
17	R 2771-14-1	44.	R 2444-448-1-421-1
18	R 2769-1-1	45.	R 2404-49-1-5-1
19	R 2738-56-1	46.	R 2451-340-3-336-1
20	R 2748-62-1	47.	R 2412-283-1-47-1
21	R 2746-72-1	48.	R 2430-385-1-64-1
22	R 2734-10-1	49.	R 2418-246-1-2-36-1
23	R 2772-1-1	50.	Swarna (C)
24	R 2768-1-1	51.	NDR 8002 (C)
25	R 2735-121-1	52.	Pooja (C)
26	R 2734-117-1	53.	CG Dhan 1919 (C)
27	R 2748-10-1		

Correlation coefficient analysis

At genotypic level, grain yield per plant showed significant and positive relation with spikelets fertility (%), 1000 seed weight and harvest index (%) whereas, significant negative correlation was recorded by plant height. This trait exhibited significant highly positive correlation with traits effective tillers per plant (0.810) followed by number of filled spikelets per panicle (0.790), harvest index (0.782), days of 50% flowering (0.645), number of spikelets per panicle (0.509), 1000 seed weight (0.430) and significant highly negative correlation with plant height (-0.476). This trait exhibited significant highly positive correlation with traits grain yield per plant (0.645) followed by number of filled spikelets per panicle (0.518), panicle length (0.490), plant height (0.480), number of spikelets per panicle (0.471) and significant highly negative correlation with effective tillers per plant (-0.323).

This trait exhibited significant highly positive correlation with traits panicle length (0.545) followed by days of 50% flowering (0.480), number of spikelets per panicle (0.388), number of filled spikelets per panicle (0.348) and significant highly negative correlation with effective tillers per plant (-0.645), harvest index (-0.575), grain yield per plant (-0.476), 1000 seed weight (-0.388). This trait exhibited significant highly positive correlation with traits grain yield per plant (0.810) followed by spikelet fertility (0.680), harvest index (0.698) and significant highly negative correlation with plant height (-0.645), number of spikelets per panicle (-0.554), panicle length (-0.426), number of filled spikelets per panicle (-0.331), days of 50% flowering (-0.323). This trait exhibited significant highly positive correlation with traits plant height (0.545) followed by days of 50% flowering (0.490), number of spikelets per panicle (0.288) and significant highly negative correlation with effective tillers per plant (-0.426), spikelet fertility (-0.378). This trait

exhibited significant highly positive correlation with traits number of filled spikelets per panicle (1.055) followed by grain yield per plant (0.509), days of 50% flowering (0.471), plant height (0.388), harvest index (0.274) and significant highly negative correlation with 1000 seed weight (-0.630), effective tillers per plant (-0.554). This trait exhibited significant highly positive correlation with traits number of spikelets per panicle (1.055) followed by grain yield per plant (0.790), days of 50% flowering (0.518), plant height (0.348), panicle length (0.288) and significant highly negative correlation with 1000 seed weight (-0.372), effective tillers per plant (-0.331).
This trait exhibited significant highly positive correlation with traits effective tillers per plant (0.680) followed by 1000 seed weight (0.499) and significant highly negative correlation with panicle length (-0.378). This trait exhibited significant highly positive correlation with traits spikelet fertility (0.499) followed by grain yield per plant (0.430) and significant highly negative correlation with number of spikelets per panicle (-0.630), plant height (-0.388), number of filled spikelets per panicle (-0.372). This trait exhibited significant highly positive correlation with traits grain yield per plant (0.782) followed by effective tillers per plant (0.698), number of spikelets per panicle (0.274) and significant highly negative correlation with plant height (-0.575). In our research, the extent of genotypic correlation (r_g) was elevated in comparison to phenotypic correlation (r_p), indicating a robust genetic association between the traits; however, the phenotypic value is diminished due to substantial environmental interaction. These results are in conformity with the findings of Singh *et al*. (2019) [15], Singh *et al*. (2020) [14], Nath *et al.* (2021) [9], Noatia *et al*. (2021) [11], Manivelan *et al*. (2022) [8], Saketh *et al*. (2023) [12] and Saran *et al*. (2023) [13].

Table 2: Correlation coefficient among yield its components

Traits		DF(Days)	PH (cm)	ET	PL (cm)	TS	FS	SF (%)	1000 SW (g)	HI (%)	GY (g)
DF(Days)	P	1.00									
	G	1.00									
PH (cm)	P	0.40 **	1.00								
	G	0.48 **	1.00								
ET	P	-0.28 **	-0.43 **	1.00							
	G	-0.32 *	-0.64 **	1.00							
PL (cm)	P	0.40 **	0.51 **	-0.29 **	1.00						
	G	0.49 **	0.54 **	-0.42 **	1.00						
TS	P	0.21 *	0.22 *	-0.18	0.08	1.00					
	G	0.47 **	0.38 **	-0.55 **	0.14	1.00					
FS	P	0.37 **	0.26 **	-0.18	0.27 **	0.65 **	1.00				
	G	0.51 **	0.34 *	-0.33 *	0.28 *	1.05 **	1.00				
SF (%)	P	-0.007	-0.07	0.14	-0.08	-0.20 *	0.12	1.00			
	G	0.19	-0.21	0.68 **	-0.37 **	0.12	-0.12	1.00			
1000 SW (g)	P	-0.12	-0.31 **	0.06	-0.19	-0.34 **	-0.27 **	0.15	1.00		
	G	-0.14	-0.38 **	0.15	-0.21	-0.63 **	-0.37 **	0.49 **	1.00		
HI (%)	P	0.10	-0.25 **	0.33 **	0.001	0.15	0.28 **	0.08	0.10	1.00	
	G	0.16	-0.57 **	0.69 **	0.01	0.27 *	0.24	0.12	0.08	1.00	
GY (g)	P	0.13	-0.05	0.32 **	0.11	0.14	0.38 **	0.20 *	0.11	0.73 **	1.00
	G	0.64 **	-0.47 **	0.81 **	0.02	0.50 **	0.79 **	-0.05	0.43**	0.78 **	1.00

DF-Days to 50% flowering, PH-Plant height, ET-Effective tillers per plant, PL-Panicle length, TS-Total spikelets per panicle, FS-Filled spikelets per panicle, SF-Spikelet fertility, 1000SW-1000 seed weight, HI-Harvest index, GY-Grain yield per plant.
*, ** significant at 5% and 1% level, respectively

Path coefficient analysis

After considering direct effects of yield and yield contributing characters on grain yield per plant, number of filled spikelets per panicle (1.93) showed highest positive direct effect on grain yield followed by effective tillers per plant (1.35), days of 50% flowering (1.24) and 1000 seed weight (0.04). Number of spikelets per panicle (-1.42) showed highest negative direct effect on grain yield followed by harvest index (-1.31), plant height (-1.17), spikelet fertility (-0.79) and panicle length (-0.36). The trait number of spikelets per panicle (0.509) and harvest index (0.782) have significant positive correlation with grain yield but also have negative direct (-1.42 and -1.31) effect with itself, respectively. Based on direct and indirect effect recorded for the traits under present investigation, it was observed that the high positive direct effect on seed yield was exhibited of filled spikelets per panicle (1.93) showed highest positive direct effect on grain yield followed by effective tillers per plant (1.35), days of 50% flowering (1.24) at genotypic level.

This trait showed positive direct (1.24) effect on grain yield per plant. However, positive indirect effect of days to 50% flowering on grain yield was *via* number of spikelets per panicle (1.91). Negative effect of this trait on grain yield per plant was mainly *via* plant height (-0.75), number of spikelets per panicle (-0.61), effective tillers per plant (-0.59), harvest index (-0.31), panicle length (-0.18), spikelet fertility (-0.06) and 1000 seed weight (-0.01), Plant height had negative direct (-1.17) effect on grain yield. However, this trait showed positive indirect effect on grain yield *via* number of filled spikelets per panicle (1.82), harvest index (1.08), days of 50% flowering (0.74) and spikelet fertility (0.19). Negative effect of this trait on grain yield per plant was mainly *via* number of spikelets per panicle (-1.33), effective tillers per plant (-1.18), panicle length (-0.17) and 1000 seed weight (-0.03).
Effective tillers per plant showed positive direct (1.35) effect on grain yield per plant. However, positive indirect effect of effective tillers per plant on grain yield was *via* number of spikelets per panicle (1.89), plant height (1.01), 1000 seed weight (0.61) and panicle length (0.25). Negative

effect of this trait on grain yield per plant was mainly *via* number of filled spikelets per panicle (-1.74), spikelet fertility (-1.04), harvest index (-1.02) and days of 50% flowering (-0.50). Panicle length had negative direct (-0.36) effect on grain yield. However, this trait showed positive indirect effect on grain yield *via* number of filled spikelets per panicle (1.51), days of 50% flowering (0.75) and spikelet fertility (0.30). Negative effect of this trait on grain yield per plant was mainly *via* plant height (-0.86), effective tillers per plant (-0.78), number of spikelets per panicle (-0.50), harvest index (-0.03) and 1000 seed weight (-0.01).

Number of spikelets per panicle showed negative direct (-1.42) effect on grain yield per plant. However, positive indirect effect of Number of spikelets per panicle on grain yield was *via* number of filled spikelets per panicle (1.52), effective tillers per plant (1.02) and days of 50% flowering (0.68). Negative effect of this trait on grain yield per plant was mainly *via* plant height (-0.61), harvest index (-0.52), spikelet fertility (-0.10), panicle length (-0.05) and 1000 seed weight (-0.02). Number of filled spikelets per panicle showed positive direct (1.93) effect on grain yield per plant. However, positive indirect effect of number of filled spikelets per panicle on grain yield was *via* days of 50% flowering (1.12) and spikelet fertility (0.99). Negative effect of this trait on grain yield per plant was mainly *via* panicle length (-1.10), effective tillers per plant (-0.61), number of spikelets per panicle (-0.58), plant height (-0.55), harvest index (-0.40) and 1000 seed weight (-0.01). Spikelet fertility had negative direct (-0.79) effect on grain yield. However, this trait showed positive indirect effect on grain yield *via* effective tillers per plant (1.25), plant height (0.34), days of 50% flowering (0.30), panicle length (0.14) and 1000 seed weight (0.02). Negative effect of this trait on grain yield per plant was mainly *via* number of filled spikelets per panicle (-0.65), number of spikelets per panicle (-0.42) and harvest index (-0.24). 1000 seed weight showed positive direct (0.04) effect on grain yield per plant. However, positive indirect effect of 1000 seed weight on grain yield was *via* number of spikelets per panicle (2.15), plant height (0.61), effective tillers per plant (0.28) and panicle length (0.08). Negative effect of this trait on grain yield per plant was mainly *via* number of filled spikelets per panicle (-1.95), spikelet fertility (-0.40), days of 50% flowering (-0.22) and harvest index (-0.16).

Harvest Index had negative direct (-1.31) effect on grain yield. However, this trait showed positive indirect effect on grain yield *via* effective tillers per plant (1.31), number of filled spikelets per panicle (1.17), plant height (0.90), days of 50% flowering (0.25) and 1000 seed weight (0.01). Negative effect of this trait on grain yield per plant was mainly *via* number of spikelets per panicle (-0.94), spikelet fertility (-0.60) and panicle length (-0.01). Number of filled spikelets per panicle, effective tillers per plant, days of 50% flowering and 1000 seed weight recorded high positive direct effect on seed yield per plant at genotypic level. Singh *et al*. (2019) [15], Saketh *et al*. (2023) [12], Saran *et al*. (2023) [13], Kujur, *et al*. (2023) [6], Kumar *et al*. (2023) [7] and Nikhil *et al*. (2023) [10] also reported similar results, which implies that direct selection for these traits would improve the single plant yield.

Table 3: Direct and indirect effects of different yield contributing characters on grain yield per plant

Trait	Days of 50% flowering	Plant height (cm)	Effective tillers per plant	Panicle length (cm)	Number of spikelets per panicle	Number of filled spikelets per panicle	Spikelet fertility	1000 seed weight (g)	Harvest Index (%)	Grain yield per plant (g)
Days of 50% flowering	1.24	-0.75	-0.59	-0.18	-0.61	1.91	-0.06	-0.01	-0.31	0.64 **
Plant height (cm)	0.74	-1.17	-1.18	-0.17	-1.33	1.82	0.19	-0.03	1.08	-0.47**
Effective tillers per plant	-0.50	1.01	1.35	0.25	1.89	-1.74	-1.04	0.61	-1.02	0.81 **
Panicle length (cm)	0.75	-0.86	-0.78	-0.36	-0.50	1.51	0.30	-0.01	-0.03	0.02
Number of spikelets/ panicle	0.68	-0.61	1.02	-0.05	-1.42	1.52	-0.10	-0.02	-0.52	0.50**
Number of filled spikelets/ panicle	1.12	-0.55	-0.61	-1.10	-0.58	1.93	0.99	-0.01	-0.40	0.79**
Spikelet fertility	0.30	0.34	1.25	0.14	-0.42	-0.65	-0.79	0.02	-0.24	-0.05
1000 seed weight (g)	-0.22	0.61	0.28	0.08	2.15	-1.95	-0.40	0.04	-0.16	0.43 **
Harvest Index (%)	0.25	0.90	1.31	-0.01	-0.94	1.17	-0.60	0.01	-1.31	0.78**

Conclusion

Grain yield per plant showed significant and positive relation with spikelets fertility (%), 1000 seed weight and harvest index (%) whereas, significant negative correlation was recorded for plant height and would result in improvement of yield. Selection for these traits could be considered as the criteria for higher seed yield, as they were mutually and directly associated. The path analysis studies revealed that high positive direct effect on grain yield was exhibited by effective tillers, followed by Number of filled spikelets per panicle and harvest index at phenotypic level. Based on direct and indirect effect recorded for the traits under present investigation, it was observed that the high positive direct effect on seed yield was exhibited by of filled spikelets per panicle showed highest positive direct effect on grain yield followed by effective tillers per plant, days of 50% flowering genotypic level. The characteristics listed above can be used directly as selection criteria in rice yield improvement programs.

Acknowledgement

The authors are highly grateful to the Department of Genetics and Plant Breeding, Indira Gandhi Krishi Vishwavidyalaya, Raipur for technical and financial support in the whole course of post graduate research work of first author.

References

1. Babu VR, Shreya K, Dangi KS, Usharani G, Nagesh P. Genetic variability studies for qualitative and quantitative traits in popular rice (*Oryza sativa* L.) hybrids of India. Int J Sci Res Pub. 2012;2(6):1-5.
2. Bhinda MS, Karnwal MK, Choudhary MK. Estimates of genetic variability, heritability and genetic advance for yield contributing and quality traits in advanced

breeding lines of rice (*Oryza sativa* L.). Int J Adv Biol Res. 2017;7(2):229-233.
3. Demeke B, Dejene T, Abebe D. Genetic variability, heritability, and genetic advance of morphological, yield related and quality traits in upland rice (*Oryza sativa* L.) genotypes at Pawe, northwestern Ethiopia. Cogent Food Agric. 2023;9(1):2157099.
4. Dewey DR, Lu KH. A correlation and path coefficient analysis of components of crested wheat grass production. Agron J. 1959;52:515-518.
5. Kanwar MK, Verma RK, Sarawagi AK, Markam NK, Lahre R. Studies on morphology characterization of rice germplasm. Res Environ Life Sci. 2017;10(4):330-333.
6. Kujur VK, Sao A, Singh MK, Tiwari A. Genetic variability, heritability and association analyses for yield and related characters in rice germplasm (*Oryza sativa* L.). The Pharma Innovation J. 2023;12(4):2236-2240.
7. Kumar PAS, Delvadiya IR, Murali S, Ginoya AV. Unraveling the genetic architecture of rice (*Oryza sativa* L.) using variability, correlation, path analysis and diversity analysis: insights for crop improvement strategies. Int J Plant Soil Sci. 2023;35(15):32-39.
8. Manivelan K, Hepziba SJ, Suresh R, Theradimani M, Renuka R, Gnanamalar RP. Inherent variability, correlation and path analysis in lowland rice (*Oryza sativa* L.). Biol Forum - An Int J. 2022;14(2):771-778.
9. Nath S, Kole PC. Genetic variability and yield analysis in rice. Electron J Plant Breed. 2021;12(1):253-258.
10. Nikhil AS, Gaibriyal ML, Reddy INB, Raju EB. Study on genetic variability for quantitative and quality parameters in rice (*Oryza sativa* L.). Int J Plant Soil Sci. 2023;35(19):1529-1541.
11. Noatia P, Sao A, Tiwari A, Nair SK, Gauraha D. Genetic dissection of yield determinants in advance breeding lines (ABLs) of rice (*Oryza sativa* L.) under irrigated conditions of Chhattisgarh, India. Int J Plant Soil Sci. 2021;33(20):119-131.
12. Saketh T, Shankar VG, Srinivas B, Hari Y. Correlation and path coefficient studies for grain yield and yield components in rice (*Oryza sativa* L.). Int J Plant Soil Sci. 2023;35(19):1549-1558.
13. Saran D, Gauraha D, Sao A, Sandilya VK, Kumar R. Correlation and path coefficient analysis for yield and yield attributing traits in rice (*Oryza sativa* L.). Int J Plant Soil Sci. 2023;35(18):94-101.
14. Singh KS, Suneetha Y, Raja DS, Srinivas T. Principal component analysis for yield and quality traits of coloured rice (*Oryza sativa* L.). The Pharma Innovation J. 2020;9(7):456-462.
15. Singh RK, Maurya CL, Kumar M, Lal K, Kumar A. Character association and path coefficient analysis for seed yield and quality traits in rice (*Oryza sativa* L.). J Pharmacogn Phytochem. 2019;8(3):514-517.
16. Wright S. Correlation and causation. J Agric Res. 1921;20:557-587.