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GENETIC STUDIES OF AROMATIC RICE GENOTYPES FOR YIELD AND YIELD-RELATED TRAITS

[a]Babar Ali Shiakh*, [b]Abdul Aziz Baloch, [b]Tariq Majidano, [a]Nazia Nahyoon, [c]Shabana Memon, [c]Ghazala Soomro, [d]Sadaf Memon, [c]Saeeda Soomro

[a] *Directorate Agriculture Research Center, Tando Jam, Pakistan.*
[b] *Oilseed Research Institute, Tando Jam, Pakistan.*
[c] *Department of Plant Breeding and Genetics, Sindh Agriculture University Tando Jam, Pakistan.*
[d] *Department of Crop Genetics and Breeding, Collage of Agronomy Sichuan Agriculture University, Chengdu 611130, P.R. China.*

A B S T R A C T

Rice is one of the world's most important cereal seeds and staple foods, providing a significant source of calories and nutrition for a large portion of global production. The current research aims to investigate correlation, heritability, and genetic studies for various rice genotypes for yield and its components. The experiment was laid out at the Students Experimental Farm, Department of Agronomy Sindh Agriculture University Tando Jam during the Kharif season 2022-2023. Seven genotypes viz. Super Basmati, Kisan Basmati, Chenab Basmati, Noor Basmati, Basmati-200, IRRI-8, and Basmati-385 were used to evaluate potential varieties for yield-related traits. The results showed that all the genotypes were highly significant at a probability level <0.01 for all the traits studied. The mean performance observed that the genotypes. Basmati-385 attained a shorter height (89.27 cm), number of tillers plant^{-1} (11.26), and number of seeds panicle^{-1} (80.733) Though, the cultivar. Basmati-2000 (31.867 cm) recorded the longest panicle in basmati rice, followed by IRRI-8, Super Basmati (27.600 & 27.00 cm). Similarly, high 1000-seed weight (g) was recorded in IRRI-8 (22.100 g) followed by Noor Basmati, Basmati-385, and Super Basmati (21.780, 20.560 & 20.357 g), respectively. Seed yield plant^{-1} (g) was maximum observed in Kisan Basmati (16.037 g) followed by Chenab Basmati (15.287 g) and Basmati-385 (12.310 g). Correlation analysis depicted a positive and significant association of yield with panicle length (cm), number of seeds panicle^{-1}, and thousand-seed weight (g) (r= 0.677**, 0.427**, 0.535**), respectively. Heritability estimates observed high heritability (h^2= 82.3 %) with genetic advance (6.06 GA).

Keywords: Basmati rice, Correlation analysis, Heritability, Seed yield.

Corresponding Author: Babar Ali Shiakh
Email: babarali987el@gmail.com
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INTRODUCTION

Basmati is an important type of rice with long, slender seeds with a pleasant aroma (Abdelsatar et al., 2020). Historically it is concluded that the conventional quality of basmati is ecologic precise in terms of atmospheric and edaphic attributes and can only be attained when basmati traits are cultivated in the conventional basmati field which is known as 'kallar tract' in Pakistan specially in the Punjab province. Pakistan annually earns approximately 2 billion US$ through its exports. In 1926 rice research station was established, at that time (27) basmati rice cultivars were produced in Pakistan for Basmati rice growers (Cox et al., 2012).

The cultivar 'Basmati 370' was the ever first basmati cultivar which was released in 1933 in rice farming by Rice Farm, Kala Shah Kaku. This cultivar "Basmati 370" is utilized as the 'mother variety' for all basmati varieties released hereafter. On the other hand's famous cultivar 'Basmati Pak' with an extra-length of seed was released by Rice Research Institute, Kala Shah Kaku by using 'mother variety' as a parent cultivar through a traditional hybridization technique in the year of 1968. The world's

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famous cultivar 'Super Basmati' rice was released by RRI KSK in 1996, which is still popular at national and international market due to its outstanding cooking quality and aroma. Rice (*Oryza sativa* L.) is a semiaquatic annual grass grown in the Kharif season.

The main two species of rice are *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice) cultivated in the world. Oryza sativa (Asian rice) the former species is cultivated in the instant of *Oryza glaberrima* species, which is blocked in the region of West Africa. Oryza sativa (Asian rice) is widely cultivated Asian rice which includes three subspecies: *indica*, *javonica*, and japonica which changes in kernel shape, and dimensions. India, Pakistan, Thailand, Vietnam, and the United States in the export marketing year 2019–20 produced 501.3 million tons the rice global production, According to (FAO, 2020).

Rice's physical properties are necessary to understand which is categorized as chemical, and physio-chemical properties. In resemblance to other cereals, rice is eaten as whole grain, consequently, knowing the physical properties (Bhattacharya, 2011). Earlier rice was cultivated and exported by its size, shape, and weight grain, and physical properties were the principal importance. According to USDA (2020) rice shape was observed by its dimensions like length, width, and thickness. Important criteria of rice quality are suggested its color mostly by smuts color is affected (Fernández-Luqueño et al., 2014; Saito et al., 2019).

In more than 100 countries rice is a major food crop and produced by various methods throughout the year. In the globe rice production systems described (a) transplanted rice and (b) direct-seeded rice. However direct seeded rice is classified into three main types; (1) dry-seeded rice (2) wet-seeded rice (3) water-seeded rice (Ali et al., 2021). Rice plays an important role in bringing exchange to almost 200 million people in the world. Saving of water in rice production system are highly objective in drought areas where water saving is the main objectives of farmers which helps to ensure food security in the subjected areas there are important methods of water saving in rice production including Aerobic rice, Alternate wetting and drying, and raised beds are conventional rice growing systems. Moreover, the water-saving rice varieties are developed by breeding and biotechnological approaches for hybrid varieties which may be subjected to this situation (Matloob et al., 2022; Zhang et al., 2017).

MATERIALS AND METHODS

The present research/experiment was carried out during the Kharif season 2022 at Students Experimental Farm, Department of Agronomy Sindh Agriculture University Tando Jam. The experimental design used Randomized Complete Block Design (RCBD) within Three Replication by maintaining Row to Row distance of 20 (cm), Plant to Plant distance of 20 (cm) & Plot size was 15x15 sq. Ft.

Planting Material

The current study was conducted on seven genotypes of rice viz. Super Basmati, Kisan Basmati, Chenab Basmati, Noor Basmati, Basmati-200, IRRI-8 and Basmati-385.

Parameters Studied

Observations were recorded of morphological characters, plant height (cm), number of tillers plant^{-1}, panicle length (cm), number of seed panicle^{-1}, 1000-seed weight (g), biological yield plant^{-1}, seed yield plant^{-1} (g), and harvest index (%).

Statistical Analysis

The data was analyzed by the analysis of conflict suggested by Gomez and Gomez (1984). The least significant difference (LSD) was evaluated at a 5% probability level. The heritable characteristics were estimated by Allard (1960) and correlation was estimated by (Jones, 1994).

RESULTS

To evaluate the new lines of rice genotypes (*Oryza sativa* L.), the current investigation was laid out through the crop year 2022-2023, Sindh Agriculture University Tando Jam. The experimental material WAS based on seven Basmati rice genotypes viz. Super Basmati, Kisan Basmati, Chenab Basmati, Noor Basmati, Basmati 2000, IRRI-8, and Basmati-385). The examinations were recorded in plant stature, number of tiller plant^{-1}, panicle length, number of seeds panicle^{-1}, 1000-seeds weight, bio-mass plant^{-1}, seed mass plant^{-1}, and harvest index (%).

The results were achieved from eight main characters collected by seven improved basmati rice line varieties. Present performance displayed that the mean squares of analysis were significantly different at $p \leq 0.01$ probability level for almost all the characters viz. plant stature, number of tiller plant^{-1}, panicle length, number of seeds panicle^{-1}, 1000-seeds weight, bio-mass plant^{-1}, seed yield plant^{-1} and harvest index (%).

Mean Performance

The mean performance of several characteristics showed variation among genotypes for yield and related traits. The taller plant stature was recorded in Super Basmati and Basmati 2000 (123.93 and 110.80 cm), respectively. However, Noor Basmati attained shorter plant stature (81.93 cm) & Basmati-385 (89.27 cm). The number of tillers plant^{-1} appeared greater in Super Basmati (11.653) followed by IRRI-8 and Basmati-385 (11.267). However, a lower number of tillers was produced by Chenab (9.130) followed by Basmati-2000 (10.200). Basmati-2000 (31.867 cm) recorded the longest panicle in basmati rice followed by IRRI-8, Super Basmati (27.600 & 27.00 cm). The number of seeds panicle^{-1} was produced in Basmati-385 (80.733) followed by Chenab Basmati (60.06) respectively. Significantly maximum 1000-seed weight (g) was measured in IRRI-8 (22.100 g) followed by Noor Basmati, Basmati-385, and Super Basmati (21.780, 20.560 & 20.357g), respectively. Grain yield plant^{-1} was found greater in Kisan Basmati (16.037g) followed by Chenab Basmati (15.287 g) and reduced seed yield was found by Noor Basmati (14.133g). grain yield plant^{-1} (g) was seen as a minimum in Basmati-385 (12.310g) and Basmati 2000 (12.533g). Seed yield showed significant variation among cultivars for seed yield plant^{-1}. The highest bio-mass plant^{-1} was observed in Basmati-2000 (89.023) followed by IRRI-8 (80.297g) compared to other Basmati rice advance varieties. The harvest index was observed higher in Chenab Basmati (24.060) followed by Kisan Basmati (21.070), whereas in lower harvest index was interpreted in Basmati-2000 (14.110) and IRRI-8 (16.453).

Table 1 Mean squares from analysis of conflict in quantitative characters of conflict basmati rice (*Oryza sativa* L.) genotypes.

Source of conflict	Replications	Genotypes	Error
D.F	2	6	12
Plant stature(cm)	0.013	612.797**	0.642
Number of productive tillers plant^{-1}	0.38443	2.242**	0.14937
Panicle length (cm)	2.211	50.139**	0.269
Number of seeds panicle^{-1}	0.391	464.972**	0.377
Thousand-seed Weight (g)	0.253	14.605**	0.305
Seed yield plant^{-1} (g)	0.642	6.261**	1.444
Bio-mass plant-1 (g)	1.239	252.830**	1.049
Harvest index (%)	1.466	32.232**	2.131

** = Highly significant (P<0.01), ns = non-significant

Table 2 Mean performance of various quantitative traits of basmati rice (*Oryza sativa* L.) genotypes.

Genotypes	Plant stature(cm)	Number of productive tillers plant^{-1}	Panicle length (cm)	Number of seeds panicle^{-1}	Thousand-seed weight (g)	Seed yield plant^{-1} (g)	Bio-mass plant-1 (g)	Harvest index (%)
Super Basmati	123.93	11.653	27.000	47.977	20.357	12.753	64.250	19.843
Kisan Basmati	95.07	11.210	19.000	42.733	15.970	16.037	76.077	21.070
Chenab Basmati	92.13	9.130	22.333	60.067	17.753	15.287	63.533	24.060
Noor Basmati	81.93	10.867	24.800	49.133	21.780	14.133	79.267	17.827
Basmati-2000	110.80	10.200	31.867	58.800	19.193	12.533	89.023	14.110
IRRI-8	103.20	11.267	27.600	53.467	22.100	13.213	80.297	16.453
Basmati-385	89.27	11.267	24.800	80.733	20.560	12.310	71.150	17.307
Mean	99.475	10.799	25.342	56.13	19.673	13.752	74.799	18.667
LSD 5%	1.425	0.687	0.923	1.092	0.982	2.138	1.822	2.597

Correlation Coefficient (r) Analysis among Different Traits

A correlation analysis of many yield-related characteristics gives acceptable choice criteria for offspring with yield. It therefore has a link with the genetic source of comparison via pleiotropic effects (Laghari et al., 2012). In the current investigations, plant stature exhibited a positive non-significant connection with the number of tillers (r= 0. 258 ns). Whereas, plant height (r=0.525**), and number of tiller plant^{-1} (r=0.002ns) exhibited a positive significant relationship with non-significant panicle length (cm). The number of seeds panicle^{-1} exhibited non-significant (r= -0.260ns, - 0.153ns) as well as a positive significant (r=0.500**) association with the panicle length. The plant height and number of tiller plant^{-1} have non-significant (r=0.023ns, 0.324ns) while the length of panicles (cm),

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number of seeds panicle^{-1} observed to have positive but significant (r= 0.554**, 0.511**), significant and actual relation of bio-mass plant^{-1} exhibited in panicle length (r=0.492**) have a positive significance. However, the non-significant was observed with plant height (r=0.050ns), number of tillers pant^{-1}, number of seeds panicle^{-1} (r=0.054ns, -0.108 ns), and thousand-seed weight (r=0.173ns). Panicle length, number of seeds panicle^{-1}, and thousand-seed mass all showed a direct and significant relationship with bio-mass plant^{-1} (r= 0.677**, 0.427**, 0.535**) other features, such as plant height, number of tiller plant^{-1} (cm) and biological yield pant^{-1} (g) (r=0.344ns, 0.667ns, and 0.161ns) respectively non-significant. Harvest index recorded a positive significant and critical relationship with the plant stature (r=0.469**), number of tiller plant^{-1} (r=0.406**), panicle length (r=0.727**), however negative and positive correlation was observed by thousand-seed mass (r=-0.501**), bio-mass plant^{-1}(r= -0.748**) & seed mass plant^{-1} (r= 0.763**). While the number of seeds panicle^{-1} recorded a non-significant correlation (r= -0.206ns).

Heritability Estimates

Singh and Ciccarelli's heritability estimates (h^2) were reported (1996). In the Genetic variability studies in basmati rice in both quantitative and qualitative characters (Mohammad et al., 2011) In the current research, the plant height observed maximum genetic conflict **(**δ^2g) 204.05 and phenotypic conflict (δ^2p) 204.692 for this characteristic, which reflected the highest heritability (h^2 = 99.6 %) and the genetic advance was low (1.661 G. A) in basmati rice varieties. The number of tiller plant^{-1} was highly influenced by the genetic constitutions of the offspring. The genetic conflict and phenotypic conflict recorded genotypic and phenotypic conflict (δ^2g= 1.605; δ^2p=o.3.049), which showed high heritability estimates of 52.3% and genetic advance of (9.47 G. A) for tillers per plant. The panicle length (cm), the genetic conflict **(**δ^2g) measured16.623 & the phenotypic conflict (δ^2p) 16.892, respectively which disclosed heritability (h^2 = 98.7%) and genetic advance (4.168G.A) observed for panicle length. The number of seeds panicle^{-1} genetic conflict **(**δ^2g) was observed at 154.865 and phenotypic conflict (δ^2p) at 155.242, with high heritability (h^2= 99.7 %) and genetic advance (2.238) for number of seeds panicle^{-1}. The genotypic conflict observed for the character thousand-seed weight recorded (δ^2g=4.766) with valuable expected selection response phenotypic conflict (δ^2p=5.071), and imposing maximum heritability (h^2= 93.9%) and the genetic advance (5.43 G. A). Bio-mass plant^{-1} showed genetic conflict (δ^2g = 83.927) to its phenotypic conflict (δ^2p = 84.976); as a consequence, high heritability (h^2 = 98.7 %) was found in biological yield plant^{-1}. However, the genetic advance was (2.785G. A). For seed yield plant^{-1}, the genetic conflict (δ^2g= 0.6975) and phenotypic conflict (δ^2p= 0.8468) respectively, which estimated high heritability (h^2= 82.2%) and genetic advance (6.06 G. A). Harvest index, the genetic conflict (δ^2g) observed10.033 and phenotypic conflict (δ^2p) was 12.164, respectively, which also estimated high heritability (h^2=82.4%) and genetic advance (13.273 G. A).

Table 3: Correlation coefficient (r) among various basmati rice genotypes for different traits.

Genotypes	Plant stature (cm)	No: of tillers plant^{-1}	Panicle length (cm)	No: of seeds panicle^{-1}	1000-seed weight	Bio-mass plant^{-1}	Seed yield plant^{-1}
Number of tillers plant^{-1}	0.258ns						
Panicle length	0.525**	0.002ns					
Number of seeds panicle^{-1}	-0.260ns	-0.153ns	0.500**				
Thousand-seed weight	0.023ns	0.324ns	0.554**	0.511**			
Biological yield	0.050ns	0.054ns	0.492**	-0.108ns	0.173ns		
Seed yield plant^{-1}	0.344*	0.667**	0.677**	0.427**	0.535**	0.161ns	
Harvest index	0.469**	0.406**	0.727**	-0.206ns	-0.501**	-0.748**	0.763**

Table 4: Genotypic and phenotypic coefficient of variability, heritability and genetic advance of 8 characters of seven basmati rice (*Oryza sativa* L.*)* genotypes.

Characters	(δ^2g)	(δ^2p)	h^2s	G. A
Plant stature(cm)	204.05	204.692	99.6	1.661
No. of tiller plant ^{1}	1.605	3.049	52.6	9.47
Panicle length (cm)	16.623	16.892	98.7	4.168
No. of seeds panicle^{-1}	154.865	155.242	99.7	2.238
Thousand-seed weight(g)	4.766	5.071	93.9	5.43
Biological yield plant^{-1}	83.927	84.976	98.7	2.785
Seed yield plant^1(g)	0.6975	0.8468	82.3	6.06
Harvest index (%)	10.033	12.164	82.4	13.273

(δ^2g) = Genotypic conflict, (δ^2p) = Phenotypic conflict, (G.A) = Genetic Advance

DISCUSSION

Basmati rice is an important food as well as a cash crop in Pakistan (Lagad et al., 2017). Basmati rice is aroma rice grown around the world and is exported over through the countries (Haider et al., 2022). The Basmati fine rice and traditional aromatic rice have a great demand both in the national and international market (Mannan et al., 2012). An experiment was conducted on different Basmati rice varieties to measure genotype production and yield characteristics. The mean square of the analysis showed significant differences at probability level $P \leq 0.01$ for almost all the traits viz. plant stature, number of tiller plant^{-1}, panicle length, number of seeds panicle^{-1}, 1000-seeds weight, bio-mass plant^{-1}, seeds yield plant^{-1}, and harvest index (%). These findings are in agreement with different researchers (Zheng et al., 2016).

The mean performance result showed that maximum plant stature was recorded in Super Basmati and Basmati 2000 (123.93 and 110.80 cm), respectively. Whereas Noor Basmati attained shorter plant stature (81.93 cm) & Basmati-385 (89.27 cm). The number of tiller plant^{-1} revealed a higher number of tillers in Super Basmati (11.653) followed by IRRI-8 and Basmati-385 (11.267). The research showed that the basmati rices the advanced genotype had more vegetative and reproductive capacity than the cultivar. Basmati-2000 (31.867 cm) recorded the longest panicle in basmati rice advance, followed by IRRI-8, Super Basmati (27.600 & 27.00 cm). The minimum length was recorded by Kisan basmati (19.00 cm) and other genotypes. The maximum number of seeds panicle^{-1} was produced in Basmati-385 (80.733) followed by Chenab Basmati (60.06) respectively while the minimum number of seeds panicle^{-1} was recorded in Kisan Basmati (42.733) followed by Super Basmati and Noor Basmati (47.977 & 49.133). Significantly maximum 1000-seed weight was measured in IRRI-8 (22.100 g) followed by Noor Basmati, Basmati-385, and Super Basmati (21.780, 20.560 & 20.357 g), as compared to varieties having minimum 1000-seed weight, Kisan Basmati (15.970 g) and Chenab Basmati (17.753 g). Grain yield plant^{-1} (g) was maximum observed in Kisan Basmati (16.037 g) followed by Chenab Basmati (15.287 g) and reduced seed yield was found by Noor Basmati (14.133 g). Grain yield plant^{-1} (g) was observed minimum in Basmati-385 (12.310 g) and Basmati 2000 (12.533 g). Significant variation was found among the genotypes for seed yield plant^{-1}. Different rice varieties differ in yield potential and yield formation as in tillers' behavior, seeds/panicle, and seed size weight (Ghoneim et al., 2018). The highest bio-mass plant^{-1} was observed in Basmati-2000 (89.023) followed by IRRI-8 (80.297 g) compared to other Basmati rice advance varieties. While minimum biological yield of plants was measured in Chenab Basmati (63.533 g) and Super Basmati (64.250 g), respectively. The harvest index was observed higher in Chenab Basmati (24.060) followed by Kisan Basmati (21.070), whereas in lower harvest index was interpreted in Basmati-2000(14.110) and IRRI-8 (16.453). Seed yield in rice is a complex character, quantitative, and an integrated function of several component traits (Froese et al., 2011).

Plant stature (r=0.525**) and number of tillers plant^{-1} (r=0.002ns) exhibited a positive significant relationship with non-significant plant height. Plant tallness and number of tiller plant^{-1} exhibited non-significant (r= -0.260ns, -0.153ns) as well as a positive significant (r=0.500**) association with the panicle length. The plant height, number of tillers plant^{-1} have a non-significant (r=0.023ns, 0.324ns) while the panicle length, number of seeds panicle^{-1} was observed to have positive but significant (r= 0.554**, 0.511**). Bio-mass plant^{-1} exhibited in panicle length (r=0.492**) has a positive significance. While the non-significant was observed with plant height (r=0.050ns), number of tillers pant^{-1}, number of grains panicle^{-1} (r=0.054ns, -0.108 ns) and thousand-seed weight (r=0.173ns). panicle length, number of grains panicle^{-1} and thousand-seed weight (g) all showed a positive and significant relationship with grain yield plant^{-1} (r= 0.677**, 0.427**, 0.535**) other features, such as plant height, number of tiller plant^{-1} (cm) and bio-mass plant^{-1} (g) (r=0.344ns, 0.667ns, and 0.161ns) respectively non-significant. Rao et al. (2017) evaluated four rice cultivars, indica in seeded, indica mixture, japonica innate, and japonica hybrid, researchers examined the relationships between yield and other agronomic qualities. Harvest index % recorded positive significant and critical relationship with plant height (r=0.469**), number of tillers plant^{-1} (r=0.406**), PL (r=0.727**), however negative and positive correlation was observed by thousand-seed weight (r=-0.501**), Grain yield plant^{-1} (r= -0.748**). Whereas the number of seeds panicle^{-1} recorded a non-significant correlation (r= -0.206ns). Thiele et al. (2020) likewise saw to have a huge and positive relationship with panicle length connected with the number of complete spikelet's and sterile spikelet.

In both quantitative and qualitative characteristics, heritability has had a significant role (Mohammad et al., 2011). The identity plant tallness maximum genetic variation was encouraged (δ^2g) 204.05 and phenotypic conflict (δ^2p) 204.692 for this feature, which had the highest heritability (h^2 = 99.6 %) and the genetic advance was low (1.661 G.A) in basmati rice varieties. The character number of tiller plant^{-1}recorded genotypic and phenotypic conflict (δ^2g= 1.605; δ^2p=3.049), which revealed high heritability estimates of 52.6% and genetic advance of (9.47 G.A). Plant stature(cm), δ^2g measured 16.623 and δ^2p showed 16.892, respectively which revealed heritability (h^2 = 98.7%) and genetic advance (4.168G.A) for the trait panicle length. For seeds panicle^{-1} δ^2g was exhibited as 154.865 and δ^2p as 155.242, showing maximum heritability (h^2= 99.7 %) for the character number of seeds panicle. The genotypic conflict estimates for the trait thousand-seed weight seed recorded as δ^2g=4.766 with valuable expected selection response phenotypic conflict (δ^2p=5.071), and imposing maximum heritability (h^2= 93.9%) and the genetic advance (5.43 G.A). Plant with more variability or conflicts has a better chance of exploiting, gaining productive hybridization, and the broad sense variability in separation generation throughout breeding programs (Divakara et al., 2010). Seed yield plant^{-1}, the genetic conflict (δ^2g= 0.6975) and phenotypic conflict (δ^2p= 0.8468) respectively, which showed high heritability (h^2= 82.3%) and genetic advance (6.06 G. A). whereas the trait harvest index, the genetic conflict (δ^2g) was observed at 10.033 and phenotypic conflict (δ^2p) at 12.164, respectively, which also estimated high heritability (h^2=82.4%) and genetic advance (13.273 G. A). Heritability estimates paired with genetic progress are usually more powerful than heritability estimates alone in determining genetic gain under selection (Mohammadi and Richon, 2009).

CONCLUSIONS

Basmati varieties are used for their aroma and taste and are consumed more in Pakistan. It was concluded that significant differences were observed among the rice genotypes. However, the Basmati genotypes Basmati-385, and Super Basmati performed very well for most of the characteristics. Basmati-385 and Noor Basmati also produced more seed weight and yield. Significant and positive associations were exhibited among the genotypes. The inheritance pattern revealed high heritability estimates for yield characters. Hence, these varieties can be used for further breeding programs.

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