Original Research Article

Studies on Genetic Diversity and Path Analysis in rice germplasm *(Oryza sativa L.)*

Abstract (rewrite as per guidelines)

The present study was based on the germplasm evaluation experiment which involved the evaluation of 45 germplasms/lines including three checks *viz.* NDR-97, NDR2065 and Saraju-52. The experiment was conducted in Augmented Block Design with three replications. The field experiment under present investigation was conducted in *Kharif* season 2022 at the Crop Research Station (CRS), Masodha and lab experiments were conducted in the Seed Testing Laboratory, Seed Technology Section, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), situated between 26.47^{0}N latitude and 82.12^{0}E longitude and at an altitude of 113 meters above the mean sea level. The observation on the following traits was were recorded as pre guidelines. Days to 50% flowering, Days to maturity, Plant height (cm) ,Panicle bearing tillers/plant,Panicle length (cm)Grains/panicle,1000-grain weight (g),Germination(%),Speed of germination (Germination Index) ,Seedling length (cm),Seed viability ,Vigour Index-I ,Grain yield/plant (g.) The path coefficient analysis was worked out by using simple correlation among 13 characters to estimate the direct and indirect effect of different characters on grain yield per plant. The highest positive total effect (direct + indirect) on grain yield per plant is exhibited by panicle bearing tiller per plant (0.699) followed by germination % (0.360), seed viability (0.227) and vigour index – I (0.209). The highest number of genotypes appeared in the cluster – II(13), followed by cluster – III(8), cluster – IV(6), cluster – V(6), cluster – I(5), cluster – IX(5), cluster – VI(3), cluster – VII(1), and cluster – VIII(1). The maximum intra-cluster distance was observed in case of Cluster – IX (64641.91) followed by Cluster – V (5584.50), Cluster – VI (5363.09), Cluster – I (3918.44), Cluster – II (3483.30), Cluster – IV (3303.54), Cluster – VII(0.00) and Cluster – VII (0.00). The highest cluster mean for days to 50% flowering was recorded for Cluster-I (102.8) followed by Cluster – VII (99), Cluster-V (96.66), Cluster-VIII (96) Cluster IX (96), Cluster III (95.75) Cluster IV (95.65) Cluster VI (94.67) Cluster II (91.51).

Keywords : Genetic Divergence, Path Analysis, trait association.

Introduction (please used font and size as per guidelines of journal)

Rice is a primary cereal crop and a crucial food staple for a significant portion of the global population, along with wheat and corn. It accounts for approximately 20% of the world's dietary energy supply. The importance of rice extends beyond being a fundamental commodity and a main food source. It plays a vital role in addressing global concerns such as food security and development . Over 90% of the world's rice is grown and consumed in Asia, earning the region the title of the world's "rice bowl." This region is home to 60% of the world's population and two-thirds of its impoverished people (**Khush and Virk,** 2000). Recognizing the significance of rice, the United Nations General Assembly declared 2004 as the "International Year of Rice (IYR2004)" with the theme "Rice is Life." This initiative aimed to raise awareness about the importance of rice in global food security and the need to enhance rice production and productivity.

Rice cultivation takes place in over a hundred countries, with a total harvested area of approximately 165.27 million hectares, yielding an annual production of around 512.5 million metric tons (MMT). Currently, China leads in rice production, with a total output of 145.9 MMT, followed by India at second place with a production of 136 MMT in 202223 (**World Agriculture Production, USDA, June 2023**). In India, rice is grown in almost all states. Out of a total cultivated area of 141.00 million hectares, approximately 46.379 million hectares are dedicated to rice cultivation, resulting in a production of 130.29 million tonnes and an average productivity of 2809 kg per hectare (**Ministry of Agriculture and Farmer's Welfare, 2022-23).**

The top three rice-producing states in India are West Bengal, Uttar Pradesh, and Punjab, with productions of 16.65 MT, 15.66 MT, and 12.18 MT, respectively (**Economic Survey, 2021-22**). Among these states, Uttar Pradesh ranks second in rice production. It has the largest area under rice cultivation, covering 6.02 million hectares, and contributes approximately 12.81% to the total rice production in India, with an output of 15.66 million metric tons. The average productivity in Uttar Pradesh is around 2601 kg per hectare. However, while India leads in terms of the total rice cultivation area, its productivity is nearly half that of China. Rice, scientifically known as *Oryza sativa* L., is a crop that reproduces through self-pollination and belongs to the Gramineae (Poaceae) family, which comprises grasses. Within the genus Oryza, there are a total of 25 recognized species, with 23 being wild species and two being cultivated species. The cultivated species are "*Oryza sativa*" and "*Oryza glaberrima*" (Brar and Khush, 2003). Oryza sativa is grown worldwide, while Oryza glaberrima has been cultivated in West Africa for approximately 3,500 years. Rice is believed to have originated from a single domestication event around 8,200-13,500 years ago in the Pearl River Valley region of China, based on genetic evidence. Previously, archaeological evidence suggested that rice was domesticated in China's Yangtze River Valley region. From East Asia, it spread to Southeast and South Asia. It is thought that rice was introduced to Europe via Western Asia and arrived in America through European colonization.Rice refers to the seeds of the grass species Oryza sativa (Asian rice) or *Oryza glaberrima* (African rice). The cultivated varieties of Oryza sativa are commonly categorized into three subspecies: *Indica*, *Japonica*, and *Javanica*. Indica rice is cultivated in Indian conditions, Japonica rice is cultivated in Japanese conditions, and Javanica rice is cultivated in Indonesian conditions.

Indica: The variety of rice cultivated in India belongs to the Indica subspecies. Indica rice is distinguished by its slightly fuzzy leaves and pale green color. It does not have awns or has short and smooth awns. The fruit of Indica rice is called caryopsis, which is elongated, thin, narrow, and slightly flattened.

Japonica: The rice varieties cultivated and developed in Japan belong to the Japonica subspecies. These varieties are specifically adapted for cultivation in subtropical and warm temperate regions. Japonica rice varieties typically have grains that are oval or round in shape. They may possess awns or have leaves that are less narrow, with a dark green color.

Javanica: Javanica rice varieties, primarily found in Indonesia, exhibit specific characteristics such as a sturdy straw, long panicles with awned grains, a sparse tillering habit, a long growth duration, and low sensitivity to variations in day length.

Rice cultivation takes place in diverse ecosystems and soil types, ranging from waterlogged and poorly drained to well-drained conditions. It can be grown under both rainfed and irrigated conditions. Rice is primarily cultivated as an annual plant, but it can also be grown as a perennial, with the potential to produce ratoon crops for several years in tropical regions. Depending on the specific species, variety, and soil fertility, rice plants can reach heights of 1-1.8 meters or even taller. They have long, thin leaves that measure approximately 50-100 centimeters in length and 2-2.5 centimeters in width. Rice plants produce small, wind-pollinated flowers in branched arching to pendulous inflorescences that are 30-50 centimeters long. The edible seed of rice is known as a grain or caryopsis, which typically measures 5-12 millimeters in length and 2-3 millimeters in thickness. The duration of rice cultivation can vary significantly, with earlymaturing varieties ready for harvest in 85-90 days, while others may take up to 240 days to reach maturity. Rice cultivation is adaptable in terms of day length sensitivity, with some varieties being sensitive, some insensitive, and others influenced by temperature or a combination of factors.

Rice cultivation is well-suited to regions with abundant rainfall and low labor costs, as it is a labor-intensive crop and requires substantial water inputs. However, rice can be grown in diverse environments, including steep slopes or mountains, through the use of terrace systems that control water flow. Geographically, rice cultivation spans from approximately 39°N latitude in Australia to 45°N latitude in Japan and 50°N latitude in China. Rice crops thrive in a hot and humid climate, requiring high humidity, prolonged sunshine, and consistent water availability. The ideal temperature range for the entire life cycle of rice is between 21°C and 37°C. The crop specifically requires high temperatures during tillering and flowering, ranging from 26.5°C to 29.5°C. During ripening, the temperature should be around 20°C to 25°C. The rice-growing season varies across different regions of India, depending on factors such as temperature, rainfall, soil type, and water availability. Eastern and southern regions, which have favorable temperatures throughout the year, can cultivate two to three rice crops annually. In the northern and western regions where winter temperatures are lower, only one crop is typically cultivated from May to November.

India has three main seasons for rice cultivation: autumn, winter, and summer. The primary rice-growing season, known as "Kharif," is considered the winter rice season, with sowing taking place in June-July and harvesting occurring in November-December. While rice can be grown under various agro-climatic conditions and production systems, the most common method worldwide involves cultivating rice in submerged water, making it the only cereal crop that can be successfully grown in standing water. The rice kernel, also known as paddy or rough rice, is protected by the hull or husk. During the milling process, the hull and bran layers are typically removed, and sometimes a coating of glucose and talc is applied to give the kernel a glossy appearance. Brown rice, which retains the bran layer, is a nutritious source of thiamine, niacin, riboflavin, iron, and calcium. It contains about 8% protein and low levels of lipids. On the other hand, white rice is milled further to remove the bran, resulting in a loss of nutrition.

Correlation is a statistical measure used to determine the strength and direction of the relationship between two or more variables or characters. While correlation expresses the association between variables, it does not provide information about causality or which variable is dependent or independent. Therefore, the study of path coefficients becomes necessary. Path analysis, developed by Wright (1921) and first utilized for plant selection by **Dewey and Lu (1959)**, involves calculating standardized partial regression coefficients known as path coefficients. These coefficients split the correlation coefficient into measures of direct and indirect effects. In other words, path analysis helps determine the direct and indirect contributions of various independent characters to the dependent character, such as yield. It also estimates residual effects. By conducting path analysis, the relative importance of different yield components can be determined, facilitating the identification of the most crucial factors influencing yield.

The success of any crop breeding program relies on the availability of genetic variability within the germplasm. Germplasm serves as a valuable natural resource, providing the necessary traits for the development of successful crop varieties. However, the true value of germplasm can only be realized through proper evaluation, as evaluation provides an estimate of its potential value. Understanding the nature and extent of genetic variability, heritability, and genetic advances in the breeding materials at hand is crucial in establishing a sound breeding strategy. Genetic variability, being heritable, plays a vital role in selection programs. Seed vigor is a significant quality parameter that needs to be assessed alongside germination and viability tests in order to gain insight into the performance of a seed lot in the field or during storage. The concept of seed vigor encompasses multiple components and is a highly complex phenomenon that can be quantified. At the biochemical level, seed vigor involves energy, biosynthesis metabolism, coordination of cellular activities, and the transport and utilization of stored food reserves. During germination, seed vigor not only relates to the speed and uniformity of germination but also to the seedlings' ability to grow vigorously under various environmental conditions. Vigorous seeds have the potential to germinate rapidly and uniformly, and the emerged seedlings are capable of vigorous growth even under normal or relatively adverse field conditions.

Materials and Methods (please used font and size as per guidelines of journal)

The field experiment under present investigation was conducted in *Kharif* season 2022 at the Crop Research Station (CRS), Masodha and lab experiments were conducted in the Seed

Testing Laboratory, Seed Technology Section, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), situated between 26.47^{0}N latitude and 82.12^{0}E longitude and at an altitude of 113 meters above the mean sea level. This area falls in sub-tropical climatic zone. The climate of district Ayodhya is semi-arid with hot summer and cold winter. The majority of rainfall (nearly 80%) is received during the monsoon (only up to September) with a few showers in winter. The soil type of experimental site was sandy loam, low in organic carbon, phosphorus and rich in potash. The present study was based on the germplasm evaluation experiment which involved the evaluation of 45 germplasms/lines including three checks *viz.* NDR-97, NDR2065 and Saraju-52. The 45 germplasms together with three checks were evaluated in Augmented Block Design at Crop Research Station, Masodha in *Kharif* 2022.

Experimental Details: give proper subheading number

The experiment was conducted in Augmented Block Design with three replications. The whole experimental field was divided in 6 blocks and 10 plots of equal size. 10 entries including checks (7 genotypes + 3 checks) were accommodated in each block. The seeds were sown on 17 June 2022 in separate lines and 35 days (21 July 2022) old seedlings were transplanted as single seedling per hill in two rows of 2 meter each with 20 cm x 20 cm spacing. All the recommended cultural practices were followed to raise a good crop.

The fertilizers were applied @ 120 Kg nitrogen, 60 Kg phosphorus and 60 Kg potash per hectare through urea, DAP and MOP, respectively. The full dose of phosphorus and potash and half dose of nitrogen were applied as basal dose at final puddling and the remaining dose of nitrogen was applied in two split doses as top dressing at late tillering and panicle initiation stages of crop growth.

Results and discussion (please used font and size as per guidelines of journal)

Path Coefficient Analysis: give proper subheading number

The path coefficient analysis was worked out by using simple correlation among 13 characters to estimate the direct and indirect effect of different characters on grain yield perplant.The direct and indirect effects of different characters are depicted in Table 1.

The highest positive total effect (direct + indirect) on grain yield per plant is exhibited by panicle bearing tiller per plant (0.699) followed by germination % (0.360), seed viability

(0.227) and vigour index – I (0.209). The highest negative total effect (direct + indirect) on grain yield per plant is exhibited by day of 50% flowering (-0.333), followed by speed of germination (-0.133), and grain per panicle (-108). The highest positive direct effect on grain yield per plant was exhibited by panicle bearing per plant (0.609) followed by germination % (0.3332), seed viability (0.229) and vigour index - I (0.207), while highest negative direct effect were exerted by speed of germination (-0.334) followed by day to 50% flowering (-0.269) speed of germination (-0.133) and plant height. The highest positive indirect effect on grain yield per plant was exhibited by germination *via* panicle bearing tiller per plant (0.194) followed by vigour index – I *via* germination% (0.189), and seed viability via germination % (0.155). The highest negative indirect effect on grain yield per plant was exerted by vigour index – I *via* speed of germination (-0.159) followed by panicle length *via* panicle bearing tiller per plant (- 0.124). The remaining estimates of the indirect effect on grain yield per plant were too low to be considered. The residual effect observed was 0.533445 which indicates that some of the characters which might contribute to yield have not been included in the study. Similar results were observed by **Swapnil *et al.* (2020), Vennela *et al.* (2021), Ramacharyet al. (2022), Sanchika *et al.* (2022), Pushkarnath *et al.* (2022), Gayathri, N. K., & Padmalatha, Y. (2023), Heera *et al.* (2023), Zayed *et al.* (2023),Kujur *et al.* (2023), Renuprasathet al. (2023).**

Non-Hierarchical Euclidean cluster Analysis:

The non-hierarchical Euclidean cluster analysis was employed to study the genetic diversity existing in 45 rice genotype collection on the basis of 13 quantitative and qualitative characters. The pseudo F-test revealed that 9 cluster arrangements were most appropriate for grouping the 45 genotypes, therefore the 45 genotypes were accepted to be grouped into 9 non-overlapping clusters. The distribution of 45 rice line together with three checks in 9 clusters is presented in the Table 2.

Clustering pattern on the basis of D^2 analysis:

The highest number of genotypes appeared in the cluster – II(13), followed by cluster – III(8), cluster – IV(6), cluster – V(6), cluster – I(5), cluster – IX(5), cluster – VI(3), cluster – VII(1), and cluster – VIII(1).

Intra and inter-cluster distance:

The estimates of intra and inter-cluster distance for 9 clusters are presented in the Table 4. The maximum intra-cluster distance was observed in case of Cluster – IX (64641.91) followed by Cluster – V (5584.50), Cluster – VI (5363.09), Cluster – I (3918.44), Cluster – II (3483.30), Cluster – IV (3303.54), Cluster – VII(0.00) and Cluster – VII (0.00). The maximum inter-cluster distance was observed between the Cluster IX and VI (2737693.00) followed by cluster IX and V (1872224.00), Cluster - IX and I (17090.50), Cluster IX and II (1588888.00), Cluster IX and III (1216395.00), Cluster IX and IV (984808.50), Cluster IX and VII (89886.30), Cluster VIII and VI (816986.20), Cluster IX and VIII (575215.60), Cluster VI and VII (518544.70), Cluster IV and VI (446702.80), Cluster V and VIII (380930.00), Cluster VI and III (311079.50), Cluster VIII and I (310296.60), Cluster VIII and II (259591.80), Cluster VII and V (193216.80), Cluster VI and II (161363.90), Cluster VII and I (149829.00), Cluster V and IV (146809.30), Cluster VI and VI (128321.10), Cluster III and VIII (122951.50), Cluster II and VIII (109055.30), Cluster IV and I (105336.00), Cluster VI and V (87065.03), Cluster II and IV (76858..91), Cluster III and V (75361.38), Cluster IV and Cluster VIII (57670.59), Cluster III and I,(48134.76)Cluster VII and VIII(46650.46), Cluster VII and III (36131.96), Cluster III and II (29440.00), Cluster V and II (17021.14) Cluster IV and Cluster III (15404.02), Cluster IV and Cluster VII (13088.68), Cluster V and Cluster I (9719.23), Cluster I and Cluster II (8866.03).The given upper intra cluster distance data are presented descending order**.**

Cluster mean on the basis of D^2 analysis: The cluster means for the 13 characters under study are presented in Table 5.The highest cluster mean for days to 50% flowering was recorded for Cluster-I (102.8) followed by Cluster – VII (99), Cluster-V (96.66), Cluster-VIII (96) Cluster IX (96), Cluster III (95.75) Cluster IV (95.65) Cluster VI (94.67) Cluster II (91.51). The genotypes of Cluster-VIII were responsible for the highest cluster mean (127) for days to maturity, followed by Cluster-I (124.63), Cluster-IX (124.5) and Cluster-VII (124), Cluster IV (121.83). The genotypes with early maturity were concentrated in Cluster-II (112.39). Rest of the clusters possessed moderate cluster means for days to maturity.

The cluster means for plant height were recorded maximum for the Cluster-IX (135.30) followed by Cluster-I (130.83) Cluster V (122.19). The lowest cluster mean for plant height was observed for the Cluster-II (97.4). The remaining clusters showed moderate cluster mean for this character. The highest cluster mean for panicle bearing tillers per plant was observed in case of Cluster-I (14.89), followed by Cluster-II (13.56), Cluster-IX (13), Cluster-VII (11.8), Cluster-III (11.03) and Cluster-VIII (11) Cluster IV(10.73) Cluster V

(10.07). The lowest cluster mean for panicle bearing tillers per plant was exhibited in case of Cluster-VI (8.6).

The genotypes of Cluster-IX showed highest cluster mean (28.44) for panicle length, followed by Cluster-I (27.65), Cluster-VI (26.92), Cluster-VII (25.43), Cluster-III (25.21), Cluster IV (25.09), Cluster V (24.52), . The lowest cluster mean for panicle length was observed for Cluster-II (24.64) followed by Cluster-VIII (23.34). The maximum cluster mean for grains per panicle was recorded in case of Cluster-I (151.45) followed by Cluster-VIII (145.36), Cluster-IV (136.16), Cluster-III (135.35), Cluster-V (133.4) and Cluster-V (126.63). The Cluster-VII (40.21), Cluster II (114.71), Cluster VI (122.14) was recorded to have the lowest cluster mean for grains per panicle. The genotypes of Cluster-VI contributed for the highest cluster mean (27.28) for the 1000-grain weight, followed by Cluster-III (25.78), Cluster-IX (25.46), Cluster-IV (24.27) and Cluster – I (23.83). The lowest cluster mean for 1000-grain weight was exhibited by Cluster – VII (19.8) followed by Cluster-II (21.51), Cluster – II (21.51), Cluster – VIII (21.59) and Cluster – V (22.76). The cluster mean for germination percentage was recorded highest for Cluster – I (98.59) followed by Cluster-VI (94), Cluster – I (90.05), Cluster-V (87.36) and Cluster - VIII (86). The lowest cluster mean for germination percentage was exhibited by Cluster – IX (57.5), followed by Cluster – III (81.94), Cluster – VII (83) and Cluster – IV (84.17). The genotypes occurring in Cluster – III produced highest cluster mean (39.33) for speed of germination followed by Cluster – VI (38.68), Cluster-VII (34.33), Cluster – V (32.04), Cluster – IV (30.15), and Cluster – I (30.06). The highest cluster mean for seedling length was observed in case of Cluster-VI (20.52), followed by Cluster – V (17.41), Cluster – IX (17.25), Cluster – II (17.1), Cluster – III (16.04), and Cluster – I (16.03). The lowest cluster mean for seedling length was observed in case of Cluster – VIII (11.9, Cluster – VII (14.6) followed by Cluster – IV (15.06). The remaining clusters showed moderate cluster mean for this character. The cluster mean for seed viability was recorded maximum in case of Cluster – I (100), Cluster – VIII (100) followed by Cluster – VII (99), Cluster – VII (99), Cluster – V (96.85), Cluster – IV (96.67), and Cluster – III (95.38) .

The genotypes of Cluster – VI constituted to the highest cluster mean (1925.72) for vigour index-I, followed by Cluster – V (1638.27), Cluster – I (1576.42) and Cluster – II (1529.5). The lowest Cluster mean for vigour index-I was recorded in case of Cluster – IX (277.35) followed by Cluster – VIII (1023.4), Cluster – VII (1211.8), Cluster – IV (1260.07) and

Cluster – III (1371.3). The genotypes occurring in Cluster – I produced maximum cluster mean (58.55) for grain yield per plant, followed by Cluster – II (34.36) and Cluster IX (28.01). The lowest cluster mean for grain yield per plant was constituted by the genotypes of Cluster – VIII (12.00), followed by Cluster – VIII (13.16), Cluster – III (15.12), Cluster – VI (17.15), Cluster – VI (18.75), Cluster – IV (18.75), and Cluster – V (21.63). Similar result were reported by **Anyaoha*et al*. (2018), Devi *et al*. (2020), Lei *etal.* (2021), Akhtar *et al*. (2022).**

Conclusion

The highest positive total effect (direct + indirect) on grain yield per plant is exhibited by panicle bearing tiller per plant (0.699) followed by germination % (0.360), seed viability (0.227) and vigour index – I (0.209). The highest negative total effect (direct + indirect) on grain yield per plant is exhibited by day of 50% flowering (-0.333), followed by speed of germination (-0.133), and grain per panicle (-108). The highest positive direct effect on grain yield per plant was exhibited by panicle bearing per plant (0.609) followed by germination % (0.3332), seed viability (0.229) and vigour index - I (0.207), while highest negative direct effect were exerted by speed of germination (-0.334) followed by day to 50% flowering (-0.269) speed of germination (-0.133) and plant height. The highest positive indirect effect on grain yield per plant was exhibited by germination *via* panicle bearing tiller per plant (0.194) followed by vigour index – I *via* germination% (0.189), and seed viability via germination % (0.155). The highest number of genotypes appeared in the cluster – II(13), followed by cluster – III(8), cluster – IV(6), cluster – V(6), cluster – I(5), cluster – IX(5), cluster – VI(3), cluster – VII(1), and cluster – VIII(1) entries each. The maximum intra-cluster distance was observed in case of Cluster – IX (64641.91) followed by Cluster – V (5584.50), Cluster – VI (5363.09) had the largest intra-cluster distance. The highest cluster mean for days to 50% flowering was recorded for Cluster-I (102.8) followed by Cluster – VII (99), Cluster-V (96.66), Cluster-VIII (96) Cluster IX (96). These findings suggest towards formulating proper selection strategy to improve rice genotypes for grain yield and seed quality.

Table 1: Directandindirecteffectofdifferentcharactersongrainyieldper plantinRicegenotype (give proper spacing)

Characters	Day of maturity	Plant height (cm)	Panicle bearing tillers per plant	Panicle length (cm)	Grain/panicle	seed weight 1000 (g)	Germination (%)	Speed of germination	seedling length (cm)	Seed viability	Vigour index	Grain yield per plant (g)
Day of 50% flowering	0.247	0.15	-0.15	0.085	0.028	0.075	0.097	0.110	-0.119	0.052	-0.049	-0.333**
Day of maturity		0.088	-0.013	0.027	0.017	0.244	0.045	0.043	0.014	0.012	0.009	-0.088
Plant height (cm)			-0.084	0.419**	-0.004	0.268*	-0.265*	-0.047	-0.080	0.217	-0.129	-0.035
Panicle bearing tillers per plant				-0.203	-0.116	-0.053	0.318*	0.080	0.059	0.127	0.169	0.698**
Panicle length (cm)					-0.020	0.135	-0.059	-0.141	0.106	0.240	-0.049	0.042
Grain/panicle						-0.056	-0.042	0.174	0.010	-0.011	-0.023	-0.108
1000-seed weight(g)							0.118	0.158	0.252	0.293*	0.149	0.016
Germination (%)								0.500**	0.251	0.467**	0.568**	0.360**
Speed of germination									0.401**	0.218	0.476**	-0.133
seedling length (cm)										0.150	0.657**	0.021
Seed viability											0.326*	0.229
Vigour index -1												0.207

Table 2: Direct and indirect effect of different characters on grain yield per plant in Rice genotypes

Traits	Day of 50%flowering	Day ofmaturity	Plant height(cm)	Paniclebearing tillersperplant	Panicle length(cm)	Grain/panicle	1000-seedweight(	Germination (%)	Speed ofgermination	seedlinglength(cm)	Seedviability	Vigourindex-I	Grain yield perplant(g)
Dayof50% flowering	**-0.262**	-0.011	0.010	-0.091	0.013	0.002	0.005	0.032	-0.037	0.015	-0.001	-0.008	-0.333**
Dayofmaturity	-0.065	**-0.043**	0.006	-0.008	0.004	0.001	0.017	0.015	-0.014	-0.002	0.000	0.001	-0.088
Plantheight(cm)	-0.040	-0.004	**0.064**	-0.051	0.063	0.000	0.019	-0.088	0.016	0.010	-0.004	-0.020	-0.035
Paniclebearing tillersperplant	0.039	0.001	-0.005	**0.609**	-0.031	-0.006	-0.004	0.106	-0.027	-0.007	-0.002	0.026	0.699**
Paniclelength(cm)	-0.022	-0.001	0.027	**-0.124**	**0.152**	-0.001	0.010	-0.020	0.047	-0.013	-0.005	-0.008	0.042
Grain/panicle	-0.007	-0.001	0.000	-0.071	-0.003	**0.055**	-0.004	-0.014	-0.058	-0.001	0.000	-0.004	-0.108
1000-seedweight(g)	-0.020	-0.011	0.017	-0.032	0.020	-0.003	**0.071**	0.039	-0.053	-0.031	-0.006	0.023	0.014
Germination(%)	-0.025	-0.002	-0.017	**0.194**	-0.009	-0.002	0.008	**0.332**	-0.167	-0.031	-0.009	0.089	0.360**
Speedof germination	-0.029	-0.002	-0.003	0.049	-0.021	0.010	0.011	**0.166**	**-0.334**	-0.050	-0.004	0.074	-0.133
seedlinglength(cm)	0.031	-0.001	-0.005	0.036	0.016	0.001	0.018	0.083	**-0.134**	**-0.124**	-0.003	0.103	0.021
Seedviability	-0.014	-0.001	0.014	0.077	0.036	-0.001	0.021	**0.155**	-0.073	-0.019	**-0.019**	0.051	0.227
Vigourindex-1	0.013	0.000	-0.008	0.103	-0.007	-0.001	0.011	**0.189**	**-0.159**	-0.082	-0.006	**0.156**	0.209

Residual effect = 0.543445 *, ** significant at 1% and 5% level, respective

Table 3: Clustering pattern of 45(42+3) rice genotypes on the basis of non-hierarchical Tocher clustering analysis

Clusters	No of genotypes	Genotypes
I	5	TCN-2014, **NDR-2065©,** TCN-2054, TCN-2027, TCN-2067
II	13	TCN 2015, TCN-2056, TCN-2016, TCN-2029, TCN-2044, TCN-2028, TCN-2055, TCN-2068, TCN-2045, TCN-2066, TCN-2053, TCN-2031, TCN-2043
III	8	TCN-2049, TCN-2058, TCN-2020, TCN-2050, TCN-2038, TCN-2035, TCN-2025, TCN-2060
IV	6	TCN-2037, TCN-2046, TCN-2017, TCN-2034, TCN-2062, TCN-2061
V	6	TCN-2021, **NDR-97©,** TCN-2057, TCN-2022, TCN-2026, TCN-2040
VI	3	TCN-2039, TCN-2051, TCN-2036
VII	1	TCN – 2024
VIII	1	**SARAJOO-52©**
IX	5	TCN – 2052, TCN – 2064,

Table 4: Estimates of average intra and inter-cluster distances for the nine clusters in Rice genotypes:

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	**3918.44**	8866.03	48134.76	105336.00	9719.23	128421.10	149829.00	310296.60	1709050
II		**3483.30**	29440.00	76858.91	17021.14	161363.90	109055.30	259591.80	1588888.00
III			**3469.22**	15404.02	75361.38	311079.50	36131.96	122951.50	1216395.00
IV				**3303.54**	146809.30	446702.80	13088.68	57670.59	984808.50
V					**5584.50**	87065.03	193216.80	380930.00	1872224.00
VI						**5363.09**	518544.70	816986.20	2737693.00
VII							**0.00**	46650.46	898886.30
VIII								**0.00**	575215.60
IX									**64641.91**

Bold figures indicate the intra-cluster distance

Table 5: Estimates of cluster means for 13 characters of Rice genotypes by D^2 analysis

Character	Day of 50% flowering	Day of maturity	Plant height (cm)	Panicle bearing tiller per plant	Panicle length (cm)	Grain / Panicle	seed weight 1000	Germination %	Speed of germination	Seedling length (cm)	Seed viability	Vigour index	Grain yield per plant
Cluster I	102.8	124.63	130.83	14.89	27.65	151.45	23.83	98.59	30.06	16.03	100	1576.42	58.55
Cluster II	91.51	112.39	97.4	13.56	22.64	114.71	21.51	90.05	29.79	17.1	92.88	1529.5	34.36
Cluster III	95.75	119.88	112.25	11.03	25.21	135.35	25.78	81.94	39.33	16.04	95.38	1371.3	15.12
Cluster IV	95.67	121.83	117.4	10.73	25.09	136.16	24.27	84.17	30.15	15.06	95.67	1260.07	18.75
Cluster V	96.66	119.98	122.19	10.07	24.52	133.4	22.76	87.36	32.04	17.41	96.85	1638.27	21.63
Cluster VI	94.67	118.33	116.2	8.6	26.92	122.14	27.28	94	38.68	20.52	100	1925.72	17.15
Cluster VII	99	124	109.4	11.8	25.43	100.21	19.8	83	34.33	14.6	99	1211.8	12
Cluster VIII	96	127	108	11	23.34	145.36	21.59	86	27.08	11.9	100	1023.4	13.16
Cluster IX	96	124.5	135.3	13	28.44	126.63	25.46	57.5	20.58	17.25	92	277.25	28.01

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