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Principal component analysis of morpho-physiological traits in rice germplasm accessions (*Oryza sativa* L.) under rainfed condition

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Abstract
The current investigation was carried out to determine the genetic diversity among 207 rice germplasm accessions under rainfed condition by using principal component analysis. In this study, PC1 had the contribution from the traits *viz.*, canopy temperature which accounted 16.063% to the total variability. Flag leaf width and flag leaf area has contributed 15.425% to the total variability which came under PC2. The remaining variability of 12.024%, 9.896%, 8.732% and 6.727% was consolidated in PC3, PC4, PC5 and PC6 by various traits like grain breadth, days to 50% flowering, grain length and flag leaf length. The cumulative variance of 68.867% of total variation among 17 characters was explained by the first six axes. Thus the results of principal component analysis revealed, wide genetic variability exists in this rice germplasm accessions. The genotypes having low canopy temperature will be considered in selection criterion under rainfed condition. The genotypes *i.e.*, IC299924, IC335860, IC336076, IC369303, IC371899, IC376408, IC376584, IC377168, IC381834, IC447325, IC459645, IC577038, IC579065, IC580716 were found in better yield as well as low canopy temperature under rainfed condition. These genotypes can be utilized as donor in breeding programme for rainfed condition.

Keywords: Rice, Germplasm, Rainfed, Morpho-physiological traits, Genetic diversity, PCA

Introduction
Rice (*Oryza sativa* L.) is one of the major and staple food for more than half of the world's population. Approximately 90% of the world's rice is grown and consumed in Asia, whereas 50% of the population depends on rice for food [12]. The increase in atmospheric temperature and water scarcity causes harmful effects on growth and yield of the rice crop by affecting its phenology and yield components [11].

Developing rice plants under rainfed ecosystem is one of the famous methods to increase crop production. However, this approach requires an understanding of phenological mechanisms at different developmental stage [4]. Gene banks are stewards of the world crop diversity and represent large potential source for various traits [10]. In crop improvement programme, breeders want to retain a pool of assorted desirable donors for enhancement of yield, quality and tolerant against biotic and abiotic stresses [6].

Principal component analysis is one of the important tools of diversity analysis. This technique is very helpful for identification of plant characters that categorize the distinctiveness among promising genotypes [2]. Considering the importance of PCA this study is conducted on rice germplasm accessions with an objective to identification of the Morpho-physiological traits responsible for the yield differences among the rice genotypes.

Materials and Methods
A total of 207 rice germplasm accessions (landraces) received from NBPGR, New Delhi. These genotypes were evaluated in augmented design [3] with seven checks *i.e.*, Pusa Basmati 1, Jaya, NDR97, Annada, Swarna, IR64 and Karma Mahsuri during *Kharif*-2014 in light texture soil under rainfed condition at Research-cum-Instructional farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. These checks were replicated and each plot consisted of two rows of 2.90 m. length and spacing between row x row is 40 cm. The standard agronomic packages of practices were followed throughout the season for regular growth of crop.

Data for the seventeen Morpho-physiological traits were recorded from all genotypes as well as replicated checks at suitable growth stage. All genotypes were measured and data were recorded of traits are presented in Table 1. The recorded observations were analyzed by using XLSTAT 2014 software.

Table 1: List of traits measured for this study

S. N.	Trait	Method of measurement
1	Days to 50% flowering	The number of days from sowing to 50% flowering days.
2	Flag leaf length (cm)	The length from the base to the tip of the flag leaf.
3	Flag leaf width (cm)	The width, at the centre of flag leaf in centimeters.
4	Flag leaf area (cm^2)	Length x Width x k (Factor 0.75)
5	Plant height (cm)	The average of height from the base to the tip of last leaf.
6	Panicle length (cm)	From the panicle base to the tip of last spikelet of panicle.
7	Number of tillers	Counting of the tillers.
8	Panicle Harvest Index	(Filled grain weight/ Panicle weight) × 100
9	Spikelet fertility percentage	(Number of fertile spikelets /Total Number of spikelets) × 100
10	1000 grain weight (gm)	One thousand seeds were counted and weighed
11	Grain length (mm)	Average length of ten grains was recorded
12	Grain breadth (mm),	Average breadth of ten grains was recorded by
13	Grain length:bredth ratio	Grain length / Grain breadth
14	Soil Plant Analysis Development (SPAD)	Chlorophyll meter (SPAD-502 plus, Minolta France SA, Currieres-sur-Seine, France)
15	Relative Water Content (%)	(Fresh weight -Dry weight)/(Turgid weight-Dry weight) × 100
16	Canopy Temperature (^{0}C)	Used Infrared thermometry at noon when sky was clear
17	Grain yield kg/m^2	Weighing the total grains per m^2.

Results and Discussion

Principal component analysis was performed to reveal the pattern of data matrix for determination and identification of selection criteria. The result of PCA explained the genetic diversity among the rice accessions.

The current research, PCA was performed for seventeen yield and Morpho-physiological traits in rice accessions. According to Brejda *et al.* (2000), data were considered in each components with Eigen value >1 which determined at least 10% of the variation. The higher Eigen values were considered as best representative of system attributes in principal components. Only six components (PCs) showed more than 1 Eigen value and exhibited about 68.867% cumulative variability, therefore these six PCs were used for further explanation. The PC1 showed 16.063% variability among traits, while PC 2, PC 3, PC 4, PC 5, and PC 6 exhibited 15.425%, 12.024%, 9.896%, 8.732% and 6.727% variability respectively (Table 2).

Table 2: Eigen value, contribution of variability and Eigen vectors for the principal component axes in rainfed condition

		Principal Components (PCs)					
		1	**2**	**3**	**4**	**5**	**6**
	Eigenvalue	2.731	2.622	2.044	1.682	1.484	1.144
	Variability (%)	16.063	15.425	12.024	9.896	8.732	6.727
	Cumulative %	16.063	31.489	43.512	53.409	62.141	68.867
S. No.	**Traits**	**Factor loadings after Varimax rotation**					
1	Days to 50% flowering	-0.099	0.081	0.019	0.948	0.006	-0.090
2	Flag leaf length (cm)	0.013	0.184	0.012	-0.087	0.030	0.963
3	Flag leaf width (cm)	-0.021	0.989	0.007	0.077	-0.001	-0.056
4	Flag leaf area (cm^2)	-0.013	0.893	0.017	0.008	0.016	0.425
5	Plant height (cm)	-0.083	0.146	0.068	0.240	0.064	0.118
6	Panicle length (cm)	-0.033	0.101	0.001	0.107	0.060	0.068
7	Number of tillers	-0.042	-0.046	-0.079	-0.042	-0.017	-0.020
8	Panicle Harvest Index	-0.091	-0.037	-0.008	0.016	-0.009	0.080
9	Spikelet fertility percentage	-0.016	-0.032	-0.002	-0.108	-0.127	0.028
10	1000 grain weight (gm)	0.020	0.043	0.241	-0.078	0.175	0.064
11	Grain length (mm)	0.028	0.012	-0.075	0.011	0.968	0.029
12	Grain breadth (mm)	-0.039	0.016	0.969	0.013	0.076	0.021
13	Grain length:bredth ratio	0.044	-0.006	-0.804	-0.015	0.577	0.012
14	Soil Plant Analysis Development	-0.262	-0.026	0.012	0.043	-0.018	-0.008
15	Relative Water Content (%)	-0.024	-0.039	-0.021	0.032	0.009	0.001
16	Canopy Temperature (^{0}C)	0.938	-0.032	-0.064	-0.103	0.039	0.013
17	Grain yield kg/m2	-0.180	-0.008	0.026	-0.013	-0.030	0.094

The PC1 accounts for as more variability in data and each subsequent components accounts for much of the remaining variability possible. Only highly loaded traits (having absolute value within 10% of the highest factor loading) within each principal components, were retained for factor clarification. Rotated component matrix revealed that the PC 1 which accounts for the highest variability percentage *i.e.*, 16.063. Within each PC, only highly loaded factors or traits (having absolute values within 10% of the highest factor loading) were retained for further explanation. Rotated component matrix revealed that the PC1 which accounted for the highest variability (16.063%) was highly loaded with traits such as canopy temperature (0.938) (Table 2). The first component representing the significance of this PC for drought related traits *i.e.*, canopy temperature. The genotypes having low canopy temperature will be considered in selection criterion under rainfed condition. The genotypes *i.e.*, IC299924, IC335860, IC336076, IC369303, IC371899, IC376408, IC376584, IC377168, IC381834, IC447325, IC459645, IC577038, IC579065, IC580716 were found low canopy temperature as well as better yield under rainfed condition.

The second principal component accounted for 15.425% of total variability, was highly loaded with trait flag leaf width (0.989) and flag leaf area (0.893) indicating its importance for altering rice genotypes with respect to grain yield. The PC3 showed 12.024% of the variability was highly loaded with grain breadth (0.9769) representing the significance of this PC for grain related traits. The fourth principal component exhibited 8.97 % of total variability and variable *i.e.*, days to 50% flowering (0.95) showed significant variation in flowering time which can be play important role for selection of genotypes on the basis of their duration. The PC 5 was showed 8.73% variability for the traits flag leaf width and flag leaf area (0.988 and 0.893) respectively, while, PC6 which showed 6.39% variability was highly loaded with flag leaf length (0.96) indicating usefulness of this PC for drought thorough avoidance mechanism. The leaves related traits are very important in drought breeding programme because the major part of the starch in rice grains at harvest is the photosynthetic product of the leaves (source), which is translocated from the leaves directly to the growing grains (sink) after flowering for grain development, Venkateswarlu and Visperas (1987) [13].

Thus, PCA revealed principal discriminatory characteristics such as canopy temperature, flag leaf width, flag leaf area, grain breadth, days to 50% flowering, grain length, and flag leaf length, in diverse PCs which are responsible for the observed genotypic variation within a group of genotypes. Important characters coming together in different PCs have tendency to remain together, which may be kept into consideration during utilization of these characters in drought breeding programme to bring about rapid improvement for yield and other associated traits. Scree plot (Fig.1) explained the percentage of variation associated with each principal component obtained by drawing a graph between Eigen values and principal component numbers. The PC1 showed 16. 063 % variability with Eigen value 2.731 which then declined gradually. Elbow type line is obtained which after 6th PC tended to straight with little variance observed in each PC. From the graph, it is clear that the maximum variation was observed in PC1.Variables from two component showed that 31.49 variability (Fig. 2).

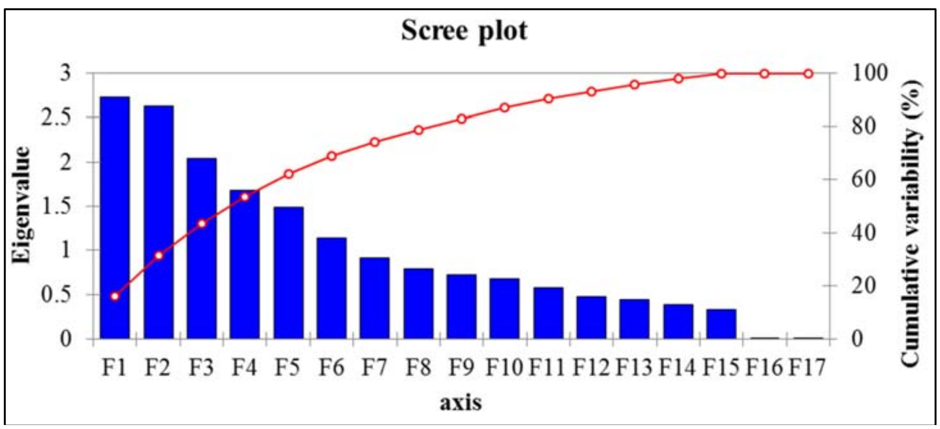

Fig 1: Scree plot showing Eigen values and percentage of cumulative variability

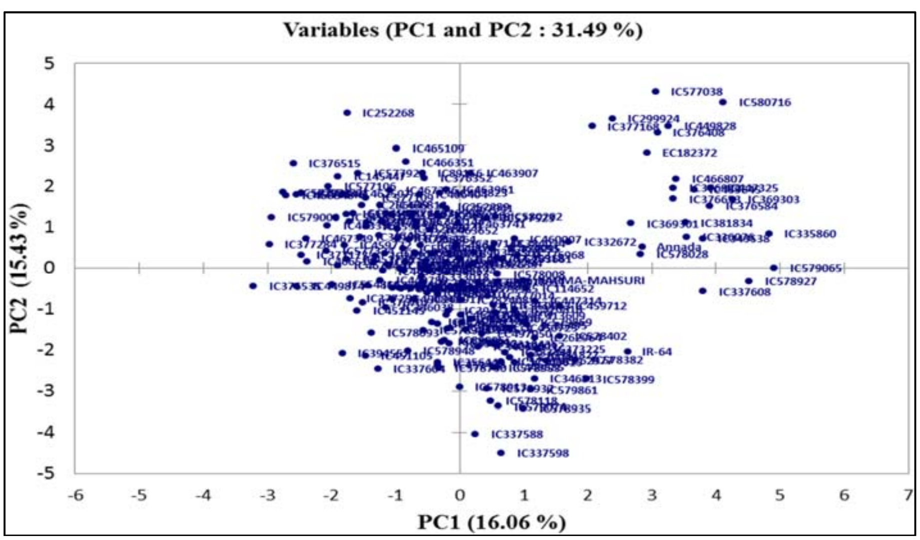

Fig 2: Distribution and grouping of 207 rice accessions across first two components based on PCA

In this study number of phenotypic traits can be identified with the help of principal component analysis, which are responsible for the observed genotypic variation present within each component. Consequently, traits coming collectively in various principal components and contributing towards elucidation the variability and have the propensity to remain together this may be kept into consideration during utilization of these characters in breeding program. This result concurrence with Kumar *et al.* 2015; Mahendran *et al.*,2015; Gana *et al.*,2013; Maji and Shaibu, 2012; Chakravorty *et al*., 2013[6,8,5,9, 2].

Conclusions

The sufficient amount of variability present in rice accessions. The Morpho-physiological value of the each trait measures the importance and contribution of each component. The results of PCA revealed that the first six principal components explained 68.867% of the total variations, thus suggesting that traits such as canopy temperature, flag leaf length, flag leaf width, grain breadth, days to flowering, grain length and flag leaf length were the principal discriminatory characteristics. Therefore, the important characters coming collectively in various PCs and contributing towards explaining the variability and have the tendency to remain together this may be kept into consideration during utilization of these traits in drought breeding program.

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