Original Research Article

Principal Component Analysis and Character Association for Yield Components in Rice (*Oryza sativa* L.) Genotypes of Salt Tolerance under Alkaline Condition

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A B S T R A C T

The present research work was conducted at high and normal salt stress soil condition to study the inherent genetic variation existing among the 78 accessions including seven standards (checks) varieties *viz.*, CSR36, CSR10 , CST7-1, CSR27, Usar Dhan 3 for salinity and alkalinity tolerant, while Sambha Sub1 as for general stress, and PUSA 44 as salt stress sensitive were grown in Augmented Randomized Block Design as parents for developing new rice varieties to break the yield barrier under *sodic* land. Grain yield showed highly significant and positive association ship with filled grains panicle^{-1} followed by spikelet fertility, plant height, and test weight can be used as selection criteria for yield improvement under high stress environment. Principal Component Analysis revealed that first three principal components addressed 80.038 (%) of the total variability which was represented by the first five principal components. CARI Dhan 11, CSRC(S) 47-7-B-B-1-1, IR52280-117-1-1-3, CSR 2016-IR18-10, CSA 2016-IR18-6 6 had high Principal Factor score in factor 1 indicated that they had high variation for spikelet fertility (%). Similarly, Principal Factor score for NDRK 11-24, KR15006, NDRK 11-21, CSR36 ©, Usar Dhan 3 © were showed high variation in factor 2 which representing the productive tillers plant-1, 1000 seed weight.

Introduction

More than half of the world populations depend on rice for their survival. It plays a pivotal role in food security of many countries. Rice crop is interwoven in the cultural and social life of millions of Asian. Salinity and alkalinity are growing problems worldwide. It can either be natural or primary or secondary or men made salinity. Primary salinity of soil and ground water is due to the weathering of naturally saline rocks or by deposition of oceanic salt carried by the wind and rain affects 130 m ha out of the global land area (Szaboles, 1994). Millions of hectares land in the humid regions of south and Southeast Asia are technically suited for rice production but are left uncultivated or are grown with very low yields because of salinity and other soils problem. Salinity is a growing problem worldwide. It can either be natural or primary or secondary or men made

salinity. Primary salinity of soil and ground water is due to the weathering of naturally saline rocks or by deposition of organic salt carried by the wind and rain. Secondary salinity is due to human-activities like unreliable irrigated schemes and source of water. Successive salinity in the soil has the divesting effect on plant growth reducing crop yields worldwide that leads complete crop failure in worst affected areas.

Various abiotic stresses i.e. flood, drought, and salinity and biotic stresses like pests and diseases are needs to more attention because they are directly hurdle in rice production. Among the abiotic stresses, drought is the strongest constraint, affecting nearly a third of the total rice area in Asia and causing significant economic losses to poor rice producers in the region. Salinity, though not as big a stress as drought and flood, still affects 10 m ha of coastal and inland areas. But, growing rice is the only option available to farmers in the saline-prone coastal regions where nothing else can be grown, and this crop is critical to the food security of these resource-poor farmers.

Prior to identifying new an approach to break the yield barrier, it is pertinent to study the correlation for yield and its components in the rice germplasm suitable for sodicity and clustering them into different groups based on the diversity among the accessions. Principal component analysis is a statistical procedure which commonly used for compression, reduction and transformation of data. The original large data set, which involves many variable just a few variable called the principal components. In other words, principal component analysis (PCA) transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal component. This technique assist in identification of traits that help in

distinguishing selected genotypes based on similarities in one or more traits and classify the genotypes into separate groups (Ariyo, 1987 and Nair *et al.,* 1998). PCA is use to identify the traits with high variability; correlations reveal the strength of relationship between various yield and its components. Trait association assist the breeder to understand the mutual component traits on which selection can be based for genetic improvement (Chakravorty *et al.,* 2013, Ravikumar *et al.,* 2015). Information on correlation, direct and indirect effects contributed by each character towards yield will be an extra advantage in aiding the selection process and helps the breeder to design his selection strategies for improving the grain yield (Ravindra Babu *et al.,* 2012). The present investigation is carried out "Principal Component Analysis and character association for yield components in rice (*Oryza sativa* L.) genotypes of salt tolerance under alkaline condition".

Materials and Methods

The experiment was conducted during *kharif* 2017 and 2018 as transplanted irrigated rice at Crop Research Farm, Nawabganj and Seed Multiplication Farm Bojha, Chandra Sheker Azad University of Agriculture and Technology, Kanpur (U.P.) India. The experimental materials comprising of 71 rice genotypes and seven standards (checks) varieties *viz.*, CSR36, CSR10, CST7-1, CSR27, Usar Dhan 3 for salinity and alkalinity tolerant while, Sambha Sub1 as for general stress, and PUSA44 as salt stress sensitive were grown in Augmented Randomized Block Design with replications of check. The experiment was conducted in three environments taking into consideration of soil types and days of sowing. E-1: Environment I, Year 2017, high stress, pH 9.8, Ec 1.43 dsm^{-1}, Seed Multiplication Farm, Bojha**,** E-2:Environment II, Year 2018, high

stress, pH 9.8, Ec1.41 dsm[-1], Seed Multiplication Farm, Bojha,E-3: Environment III, Year 2018, Normal stress, pH 8.8, Ec0.96 dsm[-1] CRF, Nawabganj. Each genotype was grown in seven-row of 01m length following 15 cm row to row and plant to plant spacing. Recommended package of practices was adopted to raise a healthy crop. Data was recorded from ten selected plants on traits viz., days to 50% flowering, plant height (cm),Total No. of tillers plant[-1],number of panicle bearing tillers plant [-1],panicle length (cm),filled grain panicle[-1],spikelet fertility percentage,1000 - grain weight (g),stress score at reproductive stage, grain yield per plant , and the mean data was used for statistical analysis.

Results and Discussion

Analysis of variance of all the traits except panicle length and filled grains panicle[-1] under study was found to be highly significant. Days to 50 percent flowering ranged from 77.0 (CSR-2748-4441-193) to 127.33 (CR 2851-S-B-1-B-B-1) with a mean of 99.19 days. The plant highest varied from 63.86 cm (TR 09027) to 153.83(CARI Dhan 11)) with mean value of 94.12 cm. The highest total tillers plant[-1] was recorded in CSR-2748-197(17.6), while lowest in IR84649-81-4-1-3B-CR3397-S-B-4(7.23) with mean of 12.56. The average number of productive tillers plant[-1] was 9.74 with highest 14.73 in CSR10 and lowest in IR84649-81-4-1-3B-CR3397-S-B-4(5.5). The panicle length ranged from 17.48 cm (KR 15016) to 26.03 cm(CSR 2016-IR18-12) with mean of 21.63. Filled grains panicle[-1] was found highest in RP-320-4-3-2-1(156.33) and lowest in CSR 2016-IR18-16(64.66) with mean of 117.44. Spikelet Fertility % was varied from 65.84(CSR 2016-IR18-16) to 87.19 (CSA 2016-IR18-6) with mean value of 77.04. The highest test weight was recorded in NDRK 11-21(27.23), while lowest in CR 2851-S-B-

1-B-B-1(17.20) and mean of 21.77 gram. Thirteen genotypes were showed highest Stress score at Reproductive Stage. These were observed as very sensitive to alkalinity. Out of 78 genotypes, only five entries were found tolerant to high salt stress. The highest grain yield per plant was recorded in KS - 12(38.12 gram) and lowest in CR 2851-S-B-1-B-B-1(8.58 gram) (Table 1 and 2).

Correlation studies

To find out the relationship existing among the characters under study with grain yield plant[-1] and its associated characters were estimated (Table 3). Genotypic correlation coefficient between most of the characters was higher in magnitude than the phenotypic correlation coefficients indicating strong association between various characters under study and the genotypic expression of the association was comparatively less influenced by the environmental fluctuations than phenotypic. The economic trait i.e. grain yield showed highly significant and positive association ship with filled grains panicle[-1] followed by spikelet fertility, plant height, 1000-grain weight. Therefore, these characters emerged as most important associates of grain yield in rice under high stress condition (Nayak *et al.,* 2001, Qamar *et al.,* 2005; Babar *et al.,* 2009; Jayasudha and Sharma 2010; Yadav *et al.,* 2011; Yadav *et al.,* 2012; Ratna *et al.,* 2015; Akhilesh Kumar Yadav *et al.,* 2016 and Kumar *et al.,* 2018).

Test weight was exhibited positive association with plant height (cm), tiller plant[-1], productive tillers plant[-1], panicle length (cm), spikelet fertility and grain yield at both level of genotype and phenotype level which augurs well for providing correlated response during selection for improving these characters. The above observations of strong positive associations between yield and yield components are in agreement with the

available literature in rice (Yadav *et al.,* 2011; Yadav *et al.,* 2012; Ratna *et al.,* 2015; Akhilesh Kumar Yadav *et al.,* 2016; Kalyan *et al.,* 2017 and Prakash *et al.,* 2018.

Significant and positive association of spikelet fertility (%) was observed with plant height (cm), tiller plant [-1], productive tillers plant [-1], filled grains panicle [-1], test weight, and grain yield at both genotypic and phenotypic level that yield can be improve simultaneously (Yadav *et al.,* 2011; Yadav *et al.,* 2012; Akhilesh Kumar Yadav *et al.,* 2016; Kalyan *et al.,* 2017; and Prakash *et al.,* 2018). Grains per panicle showed positive and significant relationship with plant height (cm), tiller plant[-1], panicle length (cm), spikelet fertility, and grain yield at both genotypic and phenotypic level that these yield contributing traits can be improve simultaneously (Yadav *et al.,* 2012; Ratna *et al.,* 2015; Akhilesh Kumar Yadav *et al.,* 2016; Kalyan *et al.,* 2017; Prakash *et al.,* 2018).

Panicle Length (cm) reflected positive relationship with plant height (cm) tiller plant [-1], productive tillers plant [-1], filled grains panicle [-1], test weight, and grain yield at both genotypic and phenotypic level that these yield contributing traits can be improve simultaneously (Yadav *et al.,* 2011; Manikya and Reddy, 2011; Ratna *et al.,* 2015 and Prakash *et al.,* 2018).

Productive tillers plant[-1] exhibited positive relationship with plant height (cm), tiller plant[-1], filled grains panicle[-1], panicle length, filled grains panicle[-1], spikelet fertility (%), test weight, and grain yield at both genotypic and phenotypic level that these yield contributing traits can be improve simultaneously (Yadav *et al.,* 2012, Ratna *et al.,* 2015; Akhilesh Kumar Yadav *et al.,* 2016; Kalyan *et al.,* 2017; Prakash *et al.,* 2018). Thus, filled grains panicle[-1]; spikelet fertility,

plant height, 1000-grain weight can be used as selection criteria for yield improvement under high stress environment.

Principal component analysis

To find out independent impact of all the traits under study principal component analysis was conducted. The first five components in the PCA analysis with Eigen values > 1 contributed 80.032 percent variability existing in the rice varieties for yield contributing characters in the study explained by the first five axes with an Eigen value of greater than unity indicates that, the identified traits within the axes exhibited great influence on the phenotype of germplasm lines (Table 4 and Figure 1). Remaining components with Eigen values < 1 contributed 19.968 percent variability. Principal component 1 (PC 1) with Eigen value 3.349 contributed 33.485 percent of total variability. PC 2 with Eigen value of 1.375 and PC 3 with Eigen value 1.175 contributed 13.752 percent and 11.750 percent to total variability respectively. It was concluded that maximum variation was present in first PC. So selection of genotypes from this PC will be useful.

The differentiation of the genotypes into different clusters was because of relatively high contribution of few characters rather than small contribution from each character.

The positive and negative loading show the presence of positive and negative correlation trends between the components and the variables. Therefore, the above mentioned characters which load high positively or negatively contributed more to the diversity and they were the ones that most differentiated the clusters (Vishnu *et al.,* 2014; Ravi Kumar *et al.,* 2015 and Gour *et al.,* 2017).

Table.1 Mean performance of 78 genotypes for 10 characters in *Oryza sativa* L in three environments

S. No.	Character	Days to 50% flowering	Plant height (cm)	Tillers/Plant	Productive Tillers/plant	Panicle Length (cm)	Filled grains/panicle	Spikelet Fertility (%)	Test Weight	Stress score at reproductive stage	Grain Yield g/plant
1	CARI Dhan 10	85.33	82.90	8.53	5.67	19.06	149.33	76.28	19.00	2.00	31.46
2	CARI Dhan 11	85.33	153.83	15.83	12.43	23.39	134.67	82.40	20.73	1.00	36.08
3	CARI Dhan 6	104.00	105.63	11.10	9.17	20.92	130.67	83.92	23.40	2.00	27.45
4	CR 2851-S-1-6-B-B-4	121.33	76.67	10.93	8.93	21.83	105.67	74.83	19.67	7.00	12.35
5	CR 2851-S-B-1-2B—1	96.67	92.07	15.03	11.27	19.55	122.67	75.10	23.47	3.00	27.00
6	CR 2851-S-B-1-B-B-1	127.33	104.53	14.33	10.67	21.07	96.00	71.54	22.68	7.00	8.58
7	CR 3437-1*-S-200-83-1	105.00	90.17	11.50	8.43	23.33	138.67	77.91	17.20	5.00	22.28
8	CR 3878-245-2-4-1	95.33	102.00	10.70	9.27	22.09	123.67	75.44	20.82	3.00	28.48
9	CR 3880-10-1-9-2-2-1	101.00	79.37	11.57	6.37	18.81	114.00	73.88	19.80	3.00	24.16
10	CR 3881-4-1-3-7-2-3	114.00	112.10	13.50	10.03	21.14	121.00	73.37	19.97	7.00	12.88
11	CR 3883-3-1-5-2-1-2	94.00	116.20	7.70	5.60	20.22	97.67	72.50	23.47	3.00	23.92
12	CR 3884-244-8-5-11-1-1	99.33	67.40	11.33	7.67	22.11	104.00	78.89	22.57	7.00	9.47
13	CR 3887-15-1-2-1	91.67	116.20	11.07	9.53	19.25	113.67	71.53	17.90	2.00	31.41
14	CR 3890-35-1-3-4	104.33	113.07	14.67	10.20	24.99	132.67	80.89	22.70	2.00	35.92
15	CR 3904-162-1-5-1	125.33	97.07	7.33	5.67	22.75	94.67	69.56	22.33	7.00	10.87
16	CR3881-M-3-1-5-1-1-1	94.33	98.10	13.33	10.20	22.52	115.00	71.22	20.28	3.00	30.96
17	CR3882-7-1-6-2-2-1	92.67	77.47	10.27	8.07	24.57	126.67	78.47	19.01	3.00	24.57
18	CR3884-244-8-5-6-1-1	100.67	96.68	15.10	10.27	22.13	111.67	77.62	18.82	7.00	14.58
19	CR3903-161-1-3-2	119.33	104.67	10.33	8.07	18.93	114.67	76.93	22.67	6.33	19.95
20	CSA 2016-IR18-6	91.00	113.87	13.17	11.93	20.87	149.00	87.20	22.83	1.00	36.72
21	CSAR 1604	92.33	78.23	10.33	7.60	19.82	122.67	73.28	24.60	3.00	27.81
22	CSAR 1610	91.33	90.20	11.77	9.00	20.43	112.67	68.92	23.73	2.00	29.88
23	CSAR 1628	105.33	104.51	9.93	7.90	19.67	78.67	67.50	24.03	5.00	18.94
24	CSAR1620	96.67	83.23	13.50	11.87	20.99	151.67	84.42	23.30	2.00	36.77
25	CSR 2016-IR18-1	96.67	75.53	12.00	9.33	21.61	119.67	76.69	21.54	7.00	16.41
26	CSR 2016-IR18-10	94.33	121.23	13.80	11.00	19.48	123.67	79.85	22.62	1.00	37.10
27	CSR 2016-IR18-11	108.33	103.07	13.37	10.17	19.75	120.67	76.64	20.83	5.00	18.28
28	CSR 2016-IR18-12	95.33	103.20	12.03	9.03	26.03	103.67	72.35	24.37	3.00	31.87
29	CSR 2016-IR18-14	114.00	77.28	12.87	10.93	19.90	108.33	77.49	18.97	6.67	12.34
30	CSR 2016-IR18-15	105.00	88.70	13.23	8.80	24.37	105.67	71.78	21.30	3.00	25.74
31	CSR 2016-IR18-16	105.67	84.03	12.43	7.67	24.97	64.67	65.84	22.48	3.00	19.41
32	CSR 2016-IR18-17	100.00	102.80	14.60	12.67	20.60	120.33	79.20	24.61	3.00	27.18
33	CSR 2016-IR18-18	99.67	103.83	10.77	8.60	24.58	115.00	77.35	24.37	3.00	30.28
34	CSR 2016-IR18-2	116.33	94.00	11.17	8.17	24.70	121.67	78.02	21.57	4.33	23.75
35	CSR 2016-IR18-3	107.33	85.03	11.93	9.93	20.91	128.00	85.47	24.65	3.00	26.07
36	CSR 2016-IR18-5	110.33	90.48	15.00	12.67	25.60	79.33	70.20	20.83	3.00	23.17
37	CSR 2016-IR18-7	95.33	101.23	13.07	9.37	21.04	99.00	83.14	22.43	5.00	20.38
38	CSR 2016-IR18-8	96.00	102.60	11.50	9.33	24.13	124.00	75.81	22.50	2.00	30.78
39	CSR 2016-IR18-9	81.33	75.57	13.90	11.00	18.70	98.33	74.85	22.13	5.00	12.61
40	CSR RIL-01-IR165	101.67	106.40	10.77	7.93	22.23	121.00	79.11	21.88	2.00	32.93
41	CSR-2748-197	84.00	102.07	17.87	13.93	22.75	120.33	77.19	20.77	2.00	30.88
42	CSR-2748-4441-193	77.00	125.23	9.43	7.10	23.41	118.67	82.54	23.50	1.00	35.22
43	CSR-2748-4441-195	95.00	82.93	14.60	11.97	22.46	119.67	75.47	18.73	2.00	27.26
44	CSRC(S)47-7-B-B-1-1	87.00	137.87	11.17	7.57	20.56	102.67	77.49	19.03	3.00	30.90
45	CSR-C27SM-117	92.00	96.27	12.93	10.73	18.25	105.00	72.18	24.90	2.00	33.95
46	IR 83421-6-B-3-1-1 CR 3364-S-2	96.33	91.20	14.77	11.20	20.69	119.00	76.51	23.53	3.00	21.30
47	IR10206-29-2-1-1	105.67	105.80	10.77	7.50	19.88	120.00	79.06	18.07	7.00	16.90
48	IR52280-117-1-1-3	93.33	128.30	12.87	9.40	25.31	116.00	72.27	22.55	2.00	34.62
49	IR84649-81-4-1-3B-CR3397-S-B-4	96.00	95.27	7.23	5.50	19.80	108.33	81.69	22.69	3.00	28.51
50	KR 15010	78.00	74.97	10.50	8.77	24.94	129.33	79.04	17.73	7.00	17.92
51	KR 15016	82.00	87.17	11.80	9.23	17.48	136.00	79.81	18.77	5.00	20.18
52	KR15006	78.67	90.83	15.77	12.77	25.92	134.00	83.16	25.23	3.00	29.33
53	KS -12	84.00	70.03	14.53	11.50	21.79	113.00	84.86	25.24	1.00	38.12

54	NDRK 11-20	86.00	94.50	16.13	12.03	21.04	123.67	76.29	23.37	2.00	29.08
55	NDRK 11-21	86.00	92.77	12.17	9.60	21.44	99.00	75.46	27.23	3.00	29.36
56	NDRK 11-22	94.33	100.23	12.93	10.27	22.07	103.00	67.10	24.67	3.00	20.91
57	NDRK 11-24	84.67	91.17	10.97	8.47	23.65	124.67	76.73	25.43	2.00	31.66
58	PAU 3835-12-1-1-1	103.33	86.94	16.00	11.67	20.74	121.33	82.45	22.00	5.00	22.03
59	PAU 3835-36-6-3-3-4	84.67	77.53	10.43	8.43	23.80	109.67	69.57	21.70	5.00	18.40
60	PAU 4254-14-1-2-2-2-4-1	115.33	101.40	12.43	9.83	21.26	114.33	72.53	21.07	5.00	16.38
61	PAU 5563-23-1-1	108.00	75.53	10.27	8.33	20.46	104.33	71.37	18.50	5.00	26.08
62	PAU 7114-3480-1-1-1-0	85.67	103.70	12.17	10.00	22.07	140.00	80.51	20.90	2.00	28.05
63	RAU 1397-14	104.67	85.23	15.33	12.60	19.60	111.00	79.52	20.40	2.00	32.86
64	RP 5440-302-100-7-6-3-2	110.00	66.40	13.53	9.27	19.98	113.00	79.09	18.07	5.00	16.25
65	RP 5687-420-111-5-4-2-1	115.00	100.87	14.13	8.40	22.63	140.33	81.22	19.70	7.00	18.23
66	RP 5694-36-9-5-1-1	109.00	107.07	16.80	13.53	23.13	113.00	76.76	20.85	5.00	17.80
67	RP-320-4-3-2-1	115.33	67.27	11.53	7.67	24.29	156.33	75.90	18.80	7.00	10.85
68	RP-5683-101-85-30-2-3-1	96.00	71.53	10.27	8.70	18.21	113.00	78.15	23.00	3.00	19.86
69	Sambha Sub1	120.00	87.97	15.43	12.83	18.71	128.00	77.64	22.58	7.00	19.59
70	TR 09027	87.00	63.87	13.33	11.10	19.60	87.33	72.42	18.63	5.33	13.05
71	TR 09030	95.67	87.53	11.60	9.20	21.21	122.33	83.21	21.65	2.00	35.03
72	CSR10 ©	88.67	77.03	16.93	14.73	19.29	117.33	81.76	22.03	1.78	30.43
73	CST7-1 ©	106.33	94.30	15.40	12.17	22.71	131.00	79.60	21.30	4.78	21.05
74	CSR36 ©	106.67	101.07	14.30	12.00	23.14	136.00	83.61	24.50	1.56	31.59
75	CSR27 ©	95.67	95.60	10.23	8.17	21.88	125.67	83.51	24.33	2.00	30.85
76	Sambha Sub1 ©	120.67	77.73	14.13	11.70	20.03	122.67	79.94	21.60	4.78	25.83
77	UsarDhan 3 ©	115.00	95.43	13.53	11.50	24.13	131.67	79.86	23.50	2.00	29.89
78	PUSA44 ©	93.67	79.23	10.27	8.17	20.10	115.00	76.51	19.60	7.00	18.21
	Mean	**99.20**	**94.12**	**12.56**	**9.74**	**21.63**	**117.44**	**77.04**	**21.77**	**3.75**	**24.73**
	C.V.	2.74	2.63	7.08	9.87	3.10	18.48	5.90	2.58	6.26	20.06
	C.D. 5%	4.38	3.99	1.43	1.55	1.08	35.00	7.32	0.90	0.38	8.38
	C.D. 1%	5.79	5.27	1.89	2.04	1.43	46.22	9.68	1.19	0.50	10.59

Table.2 Analysis of variance Augmented R.B.D. (Summary) for 78 genotypes for 10 characters in *Oryza sativa* in alkaline soil

Source of variance	DF	Days to 50% flowering	Plant height (cm)	Tillers/Plant	Productive Tillers/plant	Panicle Length (cm)	Filled grains/panicle	Spikelet Fertility (%)	Test Weight	Stress score at reproductive stage	Grain Yield g/plant
Block (ignoring Treatments)	2.00	11.50	371.15**	28.50**	3.58	16.48	428.20	45.30**	2.65**	4.66**	48.20**
Treatment (eliminating Blocks)	78.00	132.50***	172.50**	6.51	5.62	5.08	618.40	59.38***	7.85***	1.93	27.12**
Checks	7.00	253.00***	380.25**	19.50**	16.89**	6.58	861.25	50.89**	9.27***	2.10	30.08**
Checks+Var vs.Var.	72.00	123.50 ***	151.40**	6.30	3.77	5.83	599.25	60.06***	7.74***	1.92	26.88**
ERROR	13.00	16.50	45.20	5.78	4.08	6.52	215.57	7.38	0.23	0.86	6.20
Block (eliminating Check+Var.)	2.00	47.25	105.20	1.67	1.22	5.63	58.91	14.57	0.06	0.19	5.63
Entries (ignoring Blocks)	78.00	131.24	172.00**	7.68	4.82	5.32	730.26	60.17***	7.92***	2.05**	28.23**
Checks	7.00	253.20***	380.25**	20.15**	16.89**	6.51	961.52	50.89**	9.27***	2.10	30.08**
Varieties	71.00	123.25***	148.25**	6.67	4.50	5.28	718.40	60.71***	7.65***	2.06**	27.23**
Checks vs. Varieties	1.00	48.30	830.40**	35.80**	27.80**	1.78	220.34	76.03**	20.06***	0.92	91.45**
ERROR	13.00	16.20	45.30	6.30	4.08	5.48	215.57	7.38	0.23	0.86	6.20
Ci – Cj	1.00	6.70	10.30	4.10	3.58	3.52	26.12	4.83	0.85	1.65	4.43
BiVi - BiVj	1.00	11.33	19.50	7.08	5.63	6.58	45.24	8.37	1.47	2.85	7.67
BiVi - BjVj	1.00	12.40	18.25	8.75	6.71	7.38	48.36	8.95	1.57	3.05	8.20
Ci – VI	1.00	10.33	17.50	5.68	5.08	7..78	39.49	7.31	1.28	2.49	6.70

Table.3 Genotypic and Phenotypic correlation among 10 different characters in *indica* rice genotype

Character		Days to 50% flowering	Plant height (cm)	Tillers/Plant	Productive Tillers/plant	Panicle Length (cm)	Filled grains/panicle	Spikelet Fertility (%)	Test Weight	Stress score at reproductive stage	Grain Yield g/plant
Days TO 50% Flowering	G	1.0000	-0.0754	0.0174	-0.0387	-0.0013	-0.1842	-0.1765	-0.1426	0.5135	-0.5147
	P	1.0000	-0.0642	0.0255	-0.0322	0.0028	-0.0642	-0.1150	-0.1398**	0.5000 ***	-0.4072 ***
Plant Height (cm)	G		1.0000	0.0418	0.0233	0.1603	0.1222	0.0889	0.1473	-0.3369	0.4372
	P		1.0000	0.0325	0.0165	0.1502**	0.0335	0.0279	0.1367**	-0.3305 ***	0.3447***
Tiller plant [-1]	G			1.0000	0.9227	0.0722	0.1143	0.2043	0.0397	-0.1103	0.0771
	P			1.0000	0.8874	0.0693	0.1316 **	0.1996 **	0.0514	-0.1060	0.1118
Productive Tillers plant [-1]	G				1.0000	0.0024	0.1353	0.2600	0.1264	-0.2053	0.1751
	P				1.0000	0.0129	0.1716 **	0.2591 ***	0.1257	-0.1860**	0.1920
Panicle Length (cm)	G					1.0000	0.0545	-0.0680	0.0878	-0.1105	0.1324
	P					1.0000	0.0543	-0.0206	0.0715	-0.1044	0.1140
Filled grains panicle [-1]	G						1.0000	0.7002	-0.1850	-0.2733	0.2182
	P						1.0000	0.6124 ***	-0.0617	-0.1118	0.4234 ***
Spikelet Fertility %	G							1.0000	0.0975	-0.2705	0.3190
	P							1.0000	0.0853	-0.1710**	0.3920 ***
Test Weight	G								1.0000	-0.4352	0.4057
	P								1.0000	-0.4197 ***	0.3331 ***
Stress Score at reproductive stage	G									1.0000	-0.9630
	P									1.0000	-0.7935 ***
Grain Yield Kg/ha	G										1.0000
	P										1.0000

Table.4 Total variance explained by different principal component

Principal components	Eigen value	Percent variability	Cumulative variability
1	3.349	33.485	33.485
2	1.375	13.752	47.237
3	1.175	11.750	58.987
4	1.034	10.339	69.326
5	1.071	10.713	80.038
6	0.733	7.332	87.370
7	0.427	5.392	92.762
8	0.103	3.310	96.072
9	0.051	2.315	98.387
10	0.003	1.613	100.000

Table.5 Principal factor analysis; factor loading of different characters (unrotated)

	PCI	PCII	PCIII	PCIV	PC V
Eigene Value (Root)	**3.349**	**1.375**	**1.175**	**1.034**	**1.071**
% Var. Exp.	**33.485**	**13.752**	**11.750**	**10.339**	**10.713**
Cum. Var. Exp.	**33.485**	**47.237**	**58.987**	**69.326**	**80.038**
Days to 50% Flowering	0.266	0.125	0.531	0.320	0.029
Plant Height (cm)	-0.491	0.142	0.116	0.191	0.172
Tillers Plant $^{-1}$	-0.211	-0.148	-0.479	0.625	0.341
Productive Tillers Plant $^{-1}$	0.229	-0.375	0.359	0.302	0.219
Panicle Length (cm)	-0.162	-0.288	-0.185	-0.169	-0.247
Filled Grains Panicle $^{-1}$	-0.410	0.393	0.155	-0.124	-0.218
Spikelet Fertility (%)	-0.432	0.230	0.328	0.237	0.035
1000 Seed Weight (g)	-0.209	-0.537	0.368	0.043	-0.363
Stress score at reproductive stage	0.339	0.409	0.086	-0.042	0.211
Grain Yield (gm/plant)	-0.227	-0.237	0.196	-0.525	0.721

Table.6 Principal factor analysis; factor loadings (VARIMAX Rotation) of different

	1 Factor	2 Factor	3 Factor	4 Factor	5 Factor
Root	0.999	1.003	0.986	0.995	1.017
☐ ²% Explained	9.992	10.031	9.860	9.952	10.165
☐ ~ ²Cum Explained	19.984	40.047	59.767	79.671	100.000
Days to 50% Flowering	-0.107	-0.181	0.775	0.019	0.014
Plant Height (cm)	-0.547	-0.030	-0.015	0.106	0.113
Tillers/ Plant	-0.093	-0.046	-0.164	0.795	0.156
Productive Tillers / Plant	0.156	-0.591	0.094	0.071	-0.374
Panicle Length (cm)	0.054	-0.006	0.071	0.014	0.810
Filled Grains/ Panicle	-0.507	0.197	-0.154	-0.219	-0.202
Spikelet Fertility (%)	-0.614	-0.085	0.136	0.027	-0.046
1000 Seed Weight (g)	-0.100	-0.641	-0.022	-0.117	0.195
Stress score at reproductive stage	0.081	0.372	0.521	-0.080	0.045
Grain Yield (gm/plant)	-0.047	-0.154	-0.173	-0.527	0.317

*factor loading are significant criteria being ≈ 0.60

Table.7 Principal factor score of 71 genotype and 7 check in three principal components

	Genotype	PCA I	PCA II	PCA III
		X Vector	Y Vector	Z Vector
1.	CARI Dhan 10	-17.139	-8.065	19.790
2.	CARI Dhan 11	-30.640	-8.841	19.886
3.	CARI Dhan 6	-20.240	-10.665	24.249
4.	CR 2851-S-1-6-B-B-4	-8.365	-6.026	24.826
5.	CR 2851-S-B-1-2B—1	-17.354	-10.312	21.063
6.	CR 2851-S-B-1-B-B-1	-12.864	-6.095	26.051
7.	CR 3437-1*-S-200-83-1	-14.040	-5.669	21.102
8.	CR 3878-245-2-4-1	-18.643	-9.484	22.069
9.	CR 3880-10-1-9-2-2-1	-14.575	-7.596	20.611
10.	CR 3881-4-1-3-7-2-3	-15.028	-3.840	23.867
11.	CR 3883-3-1-5-2-1-2	-21.641	-9.142	24.438
12.	CR 3884-244-8-5-11-1-1	-10.125	-7.141	22.161
13.	CR 3887-15-1-2-1	-20.951	-7.447	20.808
14.	CR 3890-35-1-3-4	-22.361	-11.290	21.955
15.	CR 3904-162-1-5-1	-11.955	-6.766	28.162
16.	CR3881-M-3-1-5-1-1-1	-18.121	-9.639	20.096
17.	CR3882-7-1-6-2-2-1	-15.051	-9.823	19.757
18.	CR3884-244-8-5-6-1-1	-14.164	-3.853	20.320
19.	CR3903-161-1-3-2	-14.543	-5.791	27.319
20.	CSA 2016-IR18-6	-23.515	-11.302	22.048
21.	CSAR 1604	-15.773	-11.517	22.284
22.	CSAR 1610	-18.154	-12.147	21.257
23.	CSAR 1628	-16.510	-8.775	25.421
24.	CSAR1620	-17.186	-12.283	21.849
25.	CSR 2016-IR18-1	-11.156	-6.663	21.811
26.	CSR 2016-IR18-10	-24.208	-10.482	22.052
27.	CSR 2016-IR18-11	-15.871	-6.207	23.121
28.	CSR 2016-IR18-12	-20.410	-12.879	22.205
29.	CSR 2016-IR18-14	-8.944	-5.333	23.165
30.	CSR 2016-IR18-15	-16.310	-10.754	20.969
31.	CSR 2016-IR18-16	-15.406	-12.120	21.251
32.	CSR 2016-IR18-17	-18.961	-11.314	23.041
33.	CSR 2016-IR18-18	-20.060	-12.087	23.769
34.	CSR 2016-IR18-2	-15.350	-9.338	24.384
35.	CSR 2016-IR18-3	-16.030	-11.529	24.501
36.	CSR 2016-IR18-5	-15.169	-12.262	21.331
37.	CSR 2016-IR18-7	-17.963	-7.300	22.226
38.	CSR 2016-IR18-8	-20.300	-11.919	21.881
39.	CSR 2016-IR18-9	-13.439	-8.050	18.921
40.	CSR RIL-01-IR165	-20.628	-10.347	23.098
41.	CSR-2748-197	-20.777	-10.633	17.109
42.	CSR-2748-4441-193	-27.526	-11.365	21.459
43.	CSR-2748-4441-195	-15.783	-10.408	18.462
44.	CSRC(S)47-7-B-B-1-1	-25.675	-5.506	21.268
45.	CSR-C27SM-117	-19.162	-12.244	22.356
46.	IR 83421-6-B-3-1-1 CR 336	-17.245	-10.576	20.915

47.	IR10206-29-2-1-1	-14.892	-2.122	23.347
48.	IR52280-117-1-1-3	-25.176	-11.146	21.487
49.	IR84649-81-4-1-3B-CR3397-	-18.442	-9.311	24.472
50.	KR 15010	-12.399	-5.510	18.224
51.	KR 15016	-15.098	-4.586	19.329
52.	KR15006	-20.248	-13.414	18.777
53.	KS -12	-17.852	-15.181	19.584
54.	NDRK 11-20	-19.779	-11.510	18.808
55.	NDRK 11-21	-19.531	-13.351	22.450
56.	NDRK 11-22	-18.634	-11.927	21.782
57.	NDRK 11-24	-20.250	-13.654	21.334
58.	PAU 3835-12-1-1-1	-14.629	-7.778	21.354
59.	PAU 3835-36-6-3-3-4	-13.926	-9.684	19.961
60.	PAU 4254-14-1-2-2-2-4-1	-14.769	-7.301	24.183
61.	PAU 5563-23-1-1	-10.767	-7.289	22.637
62.	PAU 7114-3480-1-1-1-0	-20.941	-9.744	19.957
63.	RAU 1397-14	-15.732	-10.515	20.992
64.	RP 5440-302-100-7-6-3-2	-9.452	-6.061	20.683
65.	RP 5687-420-111-5-4-2-1	-14.534	-3.569	22.898
66.	RP 5694-36-9-5-1-1	-16.583	-7.756	21.724
67.	RP-320-4-3-2-1	-7.954	-5.471	22.031
68.	RP-5683-101-85-30-2-3-1	-13.449	-10.442	22.466
69.	Sambha Sub1	-10.784	-6.358	25.069
70.	TR 09027	-9.799	-7.156	18.227
71.	TR 09030	-17.977	-10.924	21.723
72.	CSR10 ©	-16.021	-11.992	18.718
73.	CST7-1 ©	-15.322	-8.264	21.706
74.	CSR36 ©	-20.008	-13.169	23.312
75.	CSR27 ©	-19.879	-11.980	23.408
76.	Sambha Sub1 ©	-11.074	-8.849	24.388
77.	Usar Dhan 3 ©	-17.581	-13.054	23.998
78.	PUSA44 ©	-11.487	-4.921	21.809

Fig.1 SCREE Plot graphical representation
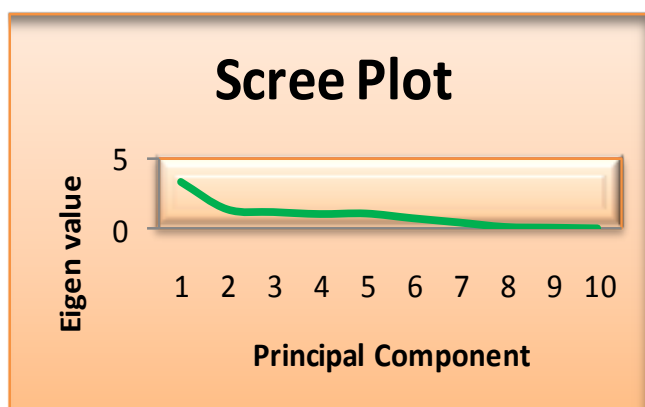
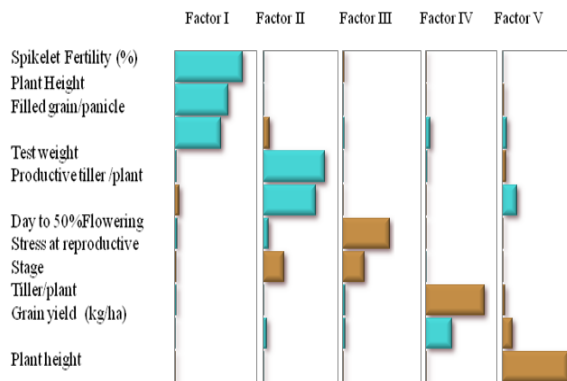**Fig.2** Principal factor 1 and 2 plotting
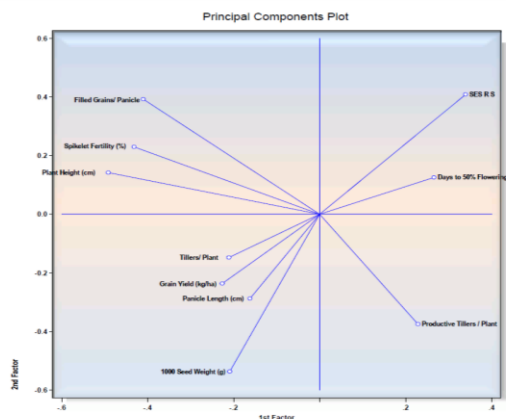
Fig.3 Character association VARIMAX Rotation

For PC 1 had high positive component loading from Stress score at reproductive stage (0.339), Days to 50% Flowering (0.266) and Productive Tillers Plant $^{-1}$ (0.229) whereas plant height (-0.491), spikelet Fertility (%) (-0.432), filled grain panicle^{-1} (-0.410), grain yield (-0.227), 1000 seed weight (g) exhibited high negative loading; contributed mostly towards 33.485 percent of total variability. In the second principal component (PC-II) high positive component loading was observed from Stress score at reproductive stage (0.409), Filled Grains Panicle $^{-1}$(0.393), Spikelet Fertility (%) (0.230), Plant Height (cm) (0.142) and Days to 50% Flowering (0.125) followed by high negative loading from thousand grain weight (-0.537) productive tiller plant $^{-1}$(-0.375), panicle length (-0.288), grain yield (-0.237) and tiller plant $^{-1}$(-0.148) are the traits majorly contributing to variability (13.752) created by PC 2.

Total variability (11.750) created by PC 3 were due to the traits Days to 50% Flowering (0.531), Test Weight (g) (0.368), Productive Tillers Plant-1 (0.359), Spikelet Fertility (%) (0.328), Plant Height (cm) (0.116), Filled Grains Panicle^{-1} (0.155) Stress score at reproductive stage (0.086) for positive loadings and tiller plant^{-1} (-0.479) and panicle length (-0.185) showed the high negative values. From the three PCs it was clear that among all the ten variables, Stress score at

reproductive stage, Days to 50% Flowering and Productive Tillers Plant[-1] had high value which is agreement with Chahal and Gosal, 2002 who showed that characters with largest absolute value closer to unity within the first principal component influence the clustering more than those with lower absolute value closer to zero. From this study, it was concluded that a good hybridization breeding program can be initiated by the selection of genotypes from the PC1 as it contributed maximum toward diversity with maximum eigene value (Table 5 and Figure 2).

The failure of principal factor analysis without rotations to give the precise idea of character association with respective principal factor dedicate next alternative factor analysis i.e. with varimax rotation factor loading of different traits with varimax rotation are presented in Table 6. Result from Table 6 and Figure 3 was clearly reflected high loading of spikelet fertility (-0.614), filled grain panical[-1] (-0.507), plant height (-0.547) on the first factor (PF1). The second factor (PF2) showed high loading of test weight and productive tiller plant[-1]. Days to 50% flowering (0.775) and stress score at reproductive stage (0.521). Among these principal factor, factor 1 (PF1) can be interpreted as spikelet fertility factor while factor 2 and 3 can be designated as test weight factor and days to 50% flowering, respectively.

Principal factor score for all the genotype were estimated in all three factors. These score can be utilized to purpose precise selection indices whose intensity can be decided by variability explained by each of principal factor. High principal score for a particular genotype in a particular factor denoted high values for the variable that particular principal factor is representing in that particular genotype.

Critical Perusal of Table 4 reflected that genotype CARI Dhan 11, CSRC(S) 47-7-B-

B-1-1, IR52280-117-1-1-3, CSR 2016-IR18-10, and CSA 2016-IR18-6 had high Principal Factor score in factor 1 for spikelet fertility (%). Similarly, NDRK 11-24, KR15006, NDRK 11-21, CSR36 (C), Usar Dhan 3 (C) had high variation for factor 2 which representing the productive tillers plant[-1], 1000 seed weight (g). The factor 3 which represent variation for the days to 50% flowering included genotype CR 3904-162-1-5-1, CR3903-161-1-3-2, CR 2851-S-B-1-B-B-1, CSAR 1628, CSR 2016-IR18-3 (Table 7).

In conclusion the central idea of principal component analysis is to reduce the dimensionality of a data set in which there are a large number of interrelated variables, while retaining as much as possible of the variation present in the data set. The results of the PCA revealed that the 80.038 (%) of the total variability was explained by the first five principal components. CARI Dhan 11, CSRC(S) 47-7-B-B-1-1, IR52280-117-1-1-3, CSR 2016-IR18-10, CSA 2016-IR18-6 6 had high PF score in factor 1 indicating that they had high variation for spikelet fertility (%). Similarly, PF score NDRK 11-24, KR15006, NDRK 11-21, CSR36 ©, Usar Dhan 3 © were high variation in factor 2 which representing the productive tillers plant-1, 1000 seed weight.

References

Akhilesh Kumar Yadav, R.P. Vyas, and V.K. Yadav.*2016.* Study on character association and path coefficient in rice, *Progressive Research – An International Journal.*11 (4): *498-501.*

Anjan Kumar Sinha and P. K. Mishra. 2015. Identification of Important Agro-Morphic Characters of Traditional Rice (*Oryza sativa* L.) of West Bengal for Crop Improvement through Principal Component analysis the *ECOSCAN,* 9(1&2): 541-546.

Annu, B.V.S. Sisodia and V. N. Rai. 2016. An application of principal component analysis for pre- harvest forecast model for rice crop based on biometrical characters *Journal of Applied and Natural Science*, 8 (3): 1164– 1167.

Ariyo ON. 1987. Mulitvariate analysis and choice of parents in Okra (*A. esculentus*). Annals of Applied Biology, 116: 335-341.

Ashim Chakravorty, Ghosh, P.D. and Sahu, P.K. 2013. Multivariate analysis of phenotypic diversity of landraces of rice of West Bengal. American *Journal of Experimental Agriculture*, 3(1): 110-123.

Atul Kumar Pachauri, AK Sarawgi, S Bhandarkar and GC Ojha. 2017. Agro-morphological characterization and morphological based genetic diversity analysis of Rice (*Oryza sativa* L.) germplasm. *Journal of Pharmacognosy and Phytochemistry*, 6(6): 75-80.

Babar, M., Khan, A.A., Arif, A; Zafar, Y. and Arif, M.2009.Path analysis of some leaf and panicle traits affecting grain yield in double haploid lines of rice (*Oryza sativa* L), *J. Agri. Res*.2009, 45 (4): 245-252.

Chahal,G.S. and Gosal, SS.2002.Principal and procedure of plant breeding, biotechnology and conventional approaches. *Narosa publication house. Inc.,*New Delhi India.

Escobar-Hernandez, A., Troyo-dieguez, E., Garcia-hern and ezcontreras, J.L., Murillo-amador, B. and Lopez-aguilar, R.2005. Principal component analysis to determine forage potential of salt grass *Distichlis spicata* L. (Grrene) in coastal ecosystems of Baja Califoniasur, Mexico. *Tech. Pecu. Mex*. 43: 13-25.

FAO. Land and Plant Nutrition Management Service; 2008. Retrieved from: http://www.fao.org/ag b/agl /agll/spush/.

Flowers T J, Flowers S A. 2005. Why does salinity pose such a difficult problem for plant breeders? *Agric Water Manag*, 78: 15–24.

Gana A. S., Shaba S. Z. and Tsado E. K. 2013. Principal component analysis of morphological traits in thirty-nine accessions of rice (*Oryza sativa* L.) grown in a rainfed lowland ecology of Nigeria. Journal of Plant Breeding and Crop Science, Vol. 5(x), pp. 120-126.

Gomez, K.A. and Gomez, K.K. 1984. Statistical analysis for agricultural research, 2nd Ed. John Eilly & Sons,New York.

Gour, L., Maurya, S.B., Koutu, G.K., Singh, S.K., Shukla, S.S., & Mishra, D.K. 2017. Characterization of rice (Oryza sativa L.) genotypes using principal component analysis, including scree plot & rotated component matrix. *International Journal of Chemical Studies*, 5 (4): 975-983.

Hamsa Poorna Prakash, O.P. Verma, Amit Kumar Chaudhary and Mohammad Amir. 2018. Correlation and Path Coefficient Analysis in Rice (Oryza sativa L.) for Sodicity Tolerance *International Journal of Current Microbiology and Applied Sciences.* Volume 7 Number 07.

Jayasudha, S. and Sharma, Deepak. Genetic parameters of variability, correlation and path-coefficient for grain yield and physiological traits in rice (*Oryza sativa* L.) under shallow lowland situation. *Electronic Journal of Plant Breeding,*2010 1 (5): 1332-1338.

Kalyan, B., K.V. Radha Krishna1 and L.V. Subba Rao. 2017.Correlation Coefficient Analysis for Yield and its Components in Rice (*Oryza sativa* L.) Genotypes

Int.J.Curr.Microbiol.App.Sci 6(7): 2425-2430.

Leonard, K. and Peter, R.J. 2009. Finding Groups in Data: An Introduction to Cluster Analysis. pp.344.

Mahendran, R., P. Veerabadhiran, S. Robin & M. Raveendran. 2015. Principal Component Analysis of Rice germplasm accessions under high temperature Stress *IJASR*, Vol. 5, Issue 3, pp. 355-360.

Maji AT, Shaibu AA. 2014.Application of principal component analysis for rice germplasm characterization and evaluation *Journal of Plant Breeding and Crop Science*. 4(6): 87-93.

Manikya M and Reddy TD. 2011. Studies on genetic divergence in medium duration elite rice genotypes (*Oryza sativa* L.) *J. Res. ANGRAU* 39.

Nachimuthu VV, Robin S, Sudhakar D, Raveendran M, Rajeswari S, Manonmani S. 2014. Evaluation of Rice Genetic Diversity and Variability in a Population Panel by Principal Component Analysis *Indian Journal of Science and Technology.* 7(10): 1555-1562.

Nair NV, Balakrishnan R, Sreenivasan TV. 1998. Variability of quantitative traits in exotic hybrid germplasm of sugarcane. Genetic Resources and Crop Evolution, 45: 459-464.

Nayak, A.R., Chaudhary, D. and Reddy, J.N. *2004.* Inter-relationship among qualily characters in scented rice. *Indian Journal of Agricultural Research,* 37 (2): 126-127.

Ojha, GC, AK Sarawgi, Bhawana Sharma and Mangla Parikh. 2017. Principal component analysis of morphophysiological traits in rice germplasm accessions (*Oryza sativa* L.) under rainfed condition *International Journal of Chemical Studies*; 5(5): 1875-1877.

Qamar, Zia Ul; Cheema, A. A., Ashraf, M., Rashid, M. and Tahir, G.R. 2005. Association analysis of some yield influencing traits in aromatic and non-aromatic rice. *Pak. J. Bot.* 37 (3): 613-627.

Ratna, M., S. Begum A. Husna S. R. Dey and M. S. Hossain. 2015. correlation and path coefficients analyses Bangladesh J. Agril. Res. 40(1): 153-161 in basmati rice.

Ravikumar, B.N.V.S.R., NagaLumari, P., Rao, V. R. M. P., Girija, R. P.V., Satyanarayana, N., Chamundeswari, K., Mohan V., Suryanarayana, Y., Bharathalakshmi, M., and Reddy, A.V. 2015. Principal component analysis and character association foryield components in rice (*Oryza sativa* L.) cultivars suitable for irrigated ecosystem. *Current Biotica.* 9(1): 25-35.

Ravikumar, B.N.V.S.R., P. Naga Kumari, P. Venkata Ramana Rao, M. Girija Rani, P.V. Satyanarayana, N. Chamundeswari, K. Mohan Vishnuvardhan, Y. Suryanarayana,M. Bharathalakshmi and A. Vishnuvardhan Reddy. 2015. Principal component analysis and character association for yield components in rice (Oryza sativa L.) cultivars suitable for irrigated ecosystem ISSN 0973-4031 *Current Biotica*. 9(1):25-35.

Ravindra Babu, V., Shreya, K., Kuldeep Singh, D., Usharani, G. and Siva Shankar, A. 2012. Correlation and path analysis studies in popular rice hybrids of India. *International Journal of Scientific and Research Publications,* 2(3): 1-5.

Sonu Kumar, MP Chauhan, Amit Tomar, Ravindra Kumar Kasana and Nimit Kumar. 2018. Correlation and path coefficient analysis in rice (*Oryza*

sativa L.). Vol. 7, Issue 6.

Sudhir K Pathak, G Roopa Lavanya, G Suresh Babu and Neha Srivastava. 2018. Evaluation of rice germplasm for genetic diversity on yield characters by principal component analysis, *The Pharma Innovation Journal*; 7(4): 661-664.

Szabolcs, I. Soils and salinisation. In: M. Pessarakli. (Ed.), 1994. Handbook of Plant and Crop Stress. New York: Marcel Dekker. 3–11 pp.

Vishnu, V.N., Robin S., Sudhakar, D., Raveendran, M., Rajeswari, S. And Manonmani, S. 2014. Evaluation of Rice Genetic Diversity and Variability in a Population Panel by Principal Component Analysis. *Indian Journal of Science and Technology,* 7(10), 1555–1562.

Yadav, V.K., Singh, Y, Soni, S.K., and Yadav A.K. 2011. Genetic Divergence Analysis in salt tolerance rice (*Oryza Sativa* L.) genotypes *Plant Archives*. 11(2): 593-595.

Yadav, V.K., Soni, S.K. and Singh, S.P. 2012. Genetic studies for Yield and component Traits in world mini core rice collections under sodic soils, *Progressive Research.* 7(2):219-222.

Yadav, V.K., Soni, S.K., Singh, D. and Singh, S.P. 2012. Non-Hierarchical Euclidean Cluster Analysis to Design Desirable Salt Tolerance Rice (*Oriza sativa* L.) Genotypes under Irrigated Ecology, *Progressive Research.* 7(2):219-222.