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Correlation analysis for yield and quality contributing characters involved in rice (*Oryza sativa* L.) genotypes

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Abstract
The experiment was carried out to explore genotypic and phenotypic correlation coefficient analysis in 30 rice elite genotypes for ninteen characters. The highest positive significant genotypic and phenotypic correlation coefficient was observed between grain yield plot^{-1} and grain yield plant^{-1} (0.98) followed by days to flowering and days to maturity (0.96), grain length and decorticated grain length (0.93), grain breadth and decorticated grain breadth (0.93), decorticated grain length breadth ratio and grain length after cooking (0.84). The grain length has positively correlated with decorticated grain length (0.93), decorticated grain length breadth ratio (0.93), grain length after cooking (0.76). So it could be those traits used as selection criteria for the improvement of grain yield as well as grain quality.The genetic correlation revealed that grain yield per plot had strong negative and significant association with grain length followed by decorticated grain length, decorticated length breadth ratio and grain length after cooking at both genotypic and phenotypic levels. The moderate negative correlation between grain length with fertile grain per panicle, spiklets per panicle, yield per plot, yield per plant and decorticated grain breadth; grain yield plant^{-1} with grain length, decorticated grain length and decorticated grain length breadth ratio. The genotypic correlation coefficients showed higher magnitude than phenotypic correlation coefficients which indicated masking or modifying effect of environment. In general quality characters negatively correlated with quantitative characters in rice. These results suggested that selection for one trait would result into negative /adverse correlated response in other trait, which had negative correlation. The overall results indicated that selection favouring higher grain yield plant^{-1}, fertile grains panicle^{-1}, spiklets panicle^{-1}, grain breadth and decorticated grain breadth, days to flowering and days to maturity with a reasonable balance for moderate fertile grains panicle^{-1} would help to achieve higher grain yield in rice genotypes. Therefore, those traits are to be given priority during selection to increase the grain yield.

Keywords: rice, correlation, yield components, quality, *Oryza sativa*

Introduction
Rice {*Oryza sativa*} is an important cereal crop worldwide with increased consumption mainly due to population growth, urbanization and economic growth (Kubo M, Purevdorj M., 2004) [9]. The global rice productivity is rising at a rate of 1% per year instead of the needed 2.4% per year in order to double production by 2050. It is the second most widely consumed food grain after wheat (Rathod R, Pulagam M B, Rao S D, *et al*. 2016) [12] and provides 20% caloric intake worldwide (Donde R, Mohapatra S, Baksh SKY, *et al*., 2020) [3]. Interventions to evaluate, select and disseminate improved high yielding rice varieties, combined with widespread adoption, would lead to increased productivity above the current national average of <2000 kg/ha to, at least, 3000 kg/ha, standing for a 50% rise. Korea Africa Food and Agriculture Cooperation Initiative (KAFACI) through the Rural Development Administration (RDA) is further supporting rice-breeding activities so that more improved high yielding and quality rice varieties are released and made available to farmers (Elias Jeke, *et al*., 2021) [5].

Character associations have been reported to vary with the environmental conditions (Kawano and Tanako, 1988) [8]. Hence, the study of character association under target environment helps the breeder in fixing proper selection criteria for grain yield in germplasm lines under study, such that the selection accomplished will possess the desired combination of characters. Undesirable associations between desired attributes under selection may limit genetic advance.

Therefore, knowledge of association between different characters and their direct and indirect effects on yield is highly essential for planning a sound breeding programme in the target environment.

Materials and Methods

The materials of present investigation comprise 30 genotypes of rice (*Oryza sativa* L.) (Table 1). These genotypes were obtained with kind courtesy from IARI-Regional Station, Karnal, Haryana.

The experimental materials were sown using Randomized Block Design with three replications. The sowing was done under three environments. The environment were created by sowing dates i.e., June 1st (E_1), June 15th (E_2) and June 30th (E_3) at Crop Research Farm of Post Graduate College, Ghazipur, Uttar Pradesh, (India), during the Kharif 2011 and 2012. The plot size is 1.2 x 3 square meter (6rows and 3meters length) and row to row and plant to plant distances were kept 20 cm. Nursery sown in wet raised bed and one month old seedlings uprooted from nursery and planted in main field. Standard agronomic practices were adopted in each experiment to raise a good nursery and crop. Observations were recorded for nineteen characters *viz*., penultimate leaf length, days to 50% flowering, plant height (cm), panicle length (cm), effective tillers plant^{-1}, days to maturity, fertile grains panicle^{-1}, spikelets panicle^{-1}, thousand grains weight (g), grain yield plot^{-1} (kg), grain yield plant^{-1} (g), grain length (mm), grain breadth (mm), decorticated grain length (mm), decorticated grain breadth (mm), decorticated grain length breadth ratio and grain length after cooking (mm), elongation ratio, alkali spreading value. Data were recorded on 5 randomly selected plants from each plot and further analyzed by using statistical as well as biometrical techniques. The following data were recorded and taken observation, as per the guidelines for the conduct of test for DUS on rice, PPV & FRA, Government of India (Plant Variety Journal of India. Vol.1 (1), 2007).

Table 1: Thirty genotypes of rice collected from IARI-Regional

S. No.	Variety	S. No.	Variety	S. No.	Variety	S. No.	Variety
1	ASD17	9	HURPBIS97AK	17	Pusa254	25	CSR13
2	Gurjari	10	Pusa Basmati1	18	Pusa834	26	CSR30
3	Jaya	11	Pusa1401	19	Sarjoo52	27	HMT Sona
4	NLR33358	12	Pusa1460	20	Usar	28	BPT5204
5	Pusa Sugandh4	13	PNR381	21	Basmati370	29	Pusa44
6	PR106	14	WGL32183	22	Heera	30	Pusa Sugandh5
7	PR109	15	IR20	23	Pant Dhan12		
8	PR118	16	IR64	24	KJT3		

Results and Discussions

Phenotypic and genotypic correlation coefficients estimated among nineteen characters under study are presented in Table 3. Generally the estimates of genotypic correlation coefficients were higher than the estimates of phenotypic correlation coefficients, indicating that the environment was also played a role in determining the relative contribution of different traits revealing there by the prominence of additive and additive gene action. Correlation between different traits is generally due to the presence of linked genes and epistatic effect of different genes. Environment plays an important role in correlation. In some cases, environment affects both the traits simultaneously, in same direction or some time in different directions. Genetic and environmental causes of correlation combine together and give phenotypic correlation.

Plant breeders usually select for yield components, which directly increase grain yield. Yield component breeding to enhance grain yield would be most effective, if the component traits (e.g. number of grains per panicle and grain yield) are highly heritable and genetically independent or positively correlated. The degree of correlation between the traits is a key factor especially in complex and economic trait such as yield (Akinwale *et al.*, 2011) [2].

In the present study, the characters which showed negative correlation at genotypic level also showed negative correlation at phenotypic level. And the estimates of genotypic correlation coefficients were higher than the estimates of phenotypic correlation coefficients, its indicating that the environment also play a role in determining the relative contribution of different characters revealing there by the prominence of additive and non additive gene action. Similar result observed by Sowmiya and Venkatesan (2017) [14].

The high and positive significant correlation coefficient found between grain yield plot^{-1} with grain yield plant^{-1} (0.98) followed by days to 50% flowering with days to maturity (0.96); fertile grains panicle^{-1} with spikelets panicle^{-1} (0.93); grain length with decorticated grain length (0.82), decorticated grain length breadth ratio and grain length after cooking (0.76); grain breadth with decorticated grain breadth (0.93); grain length with grain length after cooking (0.76); decorticated grain length with decorticated grain length breadth ratio (0.87); decorticated grain length with grain length after cooking (0.84); length after cooking with elongation ratio (0.70); panicle length with grain length (0.51), decorticated grain length (0.56), decorticated grain length breadth ratio (0.50), grain length after cooking (0.55); yield plant^{-1} with grain breadth (0.53), decorticated grain breadth (0.53). Number of fertile grains panicle^{-1} was positively and significantly associated with grain yield plot^{-1} at both genotypic and phenotypic levels. Similar study by Abdala *et al.* (2016); decorticated grain length with grain length, decorticated grain length breadth ratio, grain length after cooking; decorticated grain length breadth ratio with grain length after cooking; grain length after cooking with grain length, decorticated grain length and elongation ratio. Number of filled spikelets/panicle was positively and significantly associated with grain yield at both genotypic and phenotypic levels. Thi Tu Anh *et al.* (2018) [16] reported the positive association of grain length with grain length breadth ratio; Eidi-kohnaki *et al.* (2013) [4] reported the positive association of grain yield with filled grains/panicle. Similar finding recorded by Rawte and Saxena (2017) for elongation ratio with grain length after cooking, Prasad *et al.* (2017) [10] for days to 50% flowering with days to maturity, Sowmiya and Venkatesan (2017) [14] for panicle length with length breadth ratio.

Grain yield plot^{-1} possessed high and positive correlation coefficient was found with grain yield plant^{-1} (0.98) followed by fertile grains panicle^{-1} (0.45), spiklets panicle^{-1} (0.43), grain breadth (0.51), decorticated grain breadth (0.51), days to 50% flowering (0.34), days to maturity (0.34), thousand grains weight (0.13) and penultimate leaf length (0.13). Similar study was found by Prasad *et al.* (2017) [10] for fertile grains panicle^{-1}, spiklets panicle^{-1}, thousand grains weight; Sowmiya and Venkatesan (2017) [14] for thousand grains weight; Aghaei *et al.* (2017) [1] for fertile grains per panicle; and Islam *et al*. (2015) [6] studied grain yield was found to be positively and significantly correlated with filled grain per panicle, plant height, days to 50% flowering and days to maturity both at genotypic and phenotypic levels, indicating the importance of these traits for yield improvement in rice; Eidi kohnaki *et al.*, (2013) [4] and Akinwale *et al.* (2011) [2] reported the positive association of grain yield with filled grains panicle^{-1}. The traits exhibiting significant positive association with grain yield suggest that such traits may be important for improving the grain yield, and indirect selection for these traits would be effective for increasing grain yield of the rice genotypes under study.

Moderate positive correlation was found between fertile grain per panicle with spikelets panicle^{-1} (0.45), yield plant^{-1} (0.46); spikelets panicle^{-1} with yield plant^{-1} (0.44), yield plot^{-1} (0.43); 1000 grain weight with grain length (0.40), grain breadth (0.42), decorticated grain breadth (0.48); penultimate leaf length with plant height (0.42); days to 50% flowering with fertile grains panicle^{-1} (0.44), spikelets panicle^{-1} (0.47); panicle length with alkali spreading value (0.40); days to maturity with fertile grains panicle^{-1} (0.44) and spikelets panicle^{-1} (0.46); grain length with alkali spreading value (0.46); decorticated grain length with alkali spreading value (0.48) and decorticated grain length breadth ratio with alkali spreading value (0.46).

Moderate positive significant correlation was found between fertile grain panicle^{-1} with spiklets per panicle (0.45), yield plant^{-1} (0.46); spiklets panicle^{-1} with yield plant^{-1} (0.44), yield plot^{-1} (0.43); 1000 grain weight with grain length (0.40), grain breadth (0.42), decorticated grain breadth (0.48); penultimate leaf length with plant height (0.42); days to 50% flowering with fertile grains panicle^{-1}(0.44), spiklets panicle^{-1} (0.47); panicle length with alkali spreading value (0.40); days to maturity with fertile grains panicle^{-1} (0.44) and spikelets panicle^{-1} (0.46); grain length with alkali spreading value (0.46); decorticated grain length with alkali spreading value (0.48); decorticated grain length breadth ratio with alkali spreading value (0.46). Similar findings done of spiklets per panicle by Islam *et al.* (2015) [6] for filled grain per panicle, days to 50% flowering and days to maturity.

The low and positive correlation coefficient was found between penultimate leaf length with days to 50% flowering, panicle length, days to maturity, fertile grain panicle^{-1}, yield plot^{-1}, yield plant^{-1}, grain length after cooking, elongation ratio; days to 50% flowering with yield plot^{-1}, yield plant^{-1}; plant height with panicle length, effective tillers plant^{-1}, thousand grains weight, grain breadth, decorticated grain length, grain length after cooking, elongation ratio; panicle length with thousand grain weight, elongation ratio; effective tillers plant^{-1} with decorticated grain length breadth ratio, elongation ratio; days to maturity with yield plot^{-1}, yield plant^{-1}; fertile grain plant^{-1} with grain breadth, decorticated grain length; thousand grain weight with yield plant^{-1}, grain length after cooking, alkali spreading value; grain length with elongation ratio; decorticated grain length with elongation ratio; decorticated grain length breadth ratio with alkali spreading value and elongation ratio with alkali spreading value.

The low and positive correlation coefficient was found between penultimate leaf length with days to 50% flowering, panicle length, days to maturity, fertile grain panicle^{-1}, yield plot^{-1}, yield plant^{-1}, grain length after cooking, elongation ratio; days to 50% flowering with yield plot^{-1}, yield plant^{-1}; plant height with panicle length, effective tillers plant^{-1}, 1000 grains weight, grain breadth, decorticated grain length, grain length after cooking, elongation ratio; panicle length with thousand grain weight, elongation ratio; effective tillers plant^{-1} with decorticated grain length breadth ratio, elongation ratio; days to maturity with yield plot^{-1}, yield plant^{-1}; fertile grain plant^{-1} with grain breadth, decorticated grain length; thousand grain weight with yield per plant, grain length after cooking, alkali spreading value; grain length with elongation ratio; decorticated grain length with elongation ratio; decorticated grain length breadth ratio with alkali spreading value and elongation ratio with alkali spreading value. Similar finding done by Prasad *et al.* (2017) [10] for plant height with panicle length.

The high and negative correlation coefficient was found between fertile grain per panicle with grain length (-0.57), decorticated grain length breadth ratio (-0.51), decorticated grain length after cooking (-0.56). Similar result observed by Sravan *et al.* (2015) [15] for grain length, decorticated grain length, grain length after cooking. Spikelets per panicle with grain length (-0.54), decorticated grain length (-0.56), grain length after cooking (-0.52). Similar result observed by Sravan *et al.* (2015) [15] for days to 50% flowering, effective tillers per plant, days to maturity, fertile grain per panicle; Rawte and Saxena (2017) for grain length with grain length breadth ratio. In general quality characters negatively correlated with quantitative characters in rice. These results suggested that selection for one trait would result into negative/adverse correlated response in other trait, which had negative correlation.

The negative significant correlation coefficient was observed between grain yield plot^{-1} with decorticated grain length breadth ratio (-0.55), grain length (-0.42), decorticated grain length (-0.42), grain length after cooking (-0.35), panicle length (-0.21), alkali spreading value (-0.20), elongation ratio (-0.13) and effective tillers plant^{-1}(-0.09). Similar result observed by Rawte and Saxena (2017) for grain length; Sravan *et al.* (2015) [15] for grain length, decorticated grain length. Grain yield were significantly positive correlation with number of filled grains panicle^{-1} (Aghaei *et al.*, 2017) [1].

The moderate and negative correlation coefficient was found between days to 50% flowering with thousand grain weight (-0.46); days to maturity with thousand grain weight (-0.42); spiklets panicle^{-1} with decorticated grain length breadth ratio (-0.48); yield plant^{-1} with grain length (-0.44), decorticated grain length (-0.42); grain length with decorticated grain length (-0.43), alkali spreading value (-

0.46); decorticated grain length with decorticated grain breadth (-0.46). Similar finding recorded by Thi Tu Anh *et al.* (2018) [16] reported the positive association of grain length with grain breadth; Prasad *et al.* (2017) [10] for thousand grains weight with days to 50% flowering and days to maturity; Sowmiya and Venkatesan (2017) [14] for yield with grain length breadth ratio and tillers plant^{-1}.

The low and negative correlation coefficient was found between days to 50% flowering with plant height, grain length, grain breadth, decorticated grain length, decorticated grain breadth, grain length after cooking; plant height with days to maturity, spiklets panicle^{-1}, alkali spreading value; panicle length with fertile grain panicle^{-1}, spiklets panicle^{-1}, yield plot^{-1}, yield plant^{-1}, grain breadth, decorticated grain breadth; effective tillers plant^{-1} with fertile grain panicle^{-1}, spiklets panicle^{-1}, thousand grains weight, grain breadth, decorticated grain breadth, alkali spreading value; days to maturity with grain length, grain breadth, decorticated grain length, decorticated grain breadth, decorticated grain length breadth ratio, grain length after cooking; fertile grains panicle^{-1} with thousand grain weight, elongation ratio; yield plant^{-1} with grain length after cooking, elongation ratio, alkali spreading value; grain length with grain breadth; grain breadth with decorticated grain length, grain length after cooking; decorticated grain breadth with elongation ratio, alkali spreading value.

The result is concluded the traits which showed positive significant correlations in the various environments, the selection for the improvement of these characters may be useful for breeding for early flowering, early maturity and fertile grains panicle^{-1} could be considered potential selection criteria for yield.

Table 2: General mean performance of 30 genotypes for 19 yield and quality contributing traits.

Genotype	Penultimate leaf length (cm)	Days to 50% flowering (days)	Plant height (cm)	Panicle length (cm)	Effective tillers plant^{-1}	Days to maturity (days)	Fertile grains panicle^{-1}	Spikelets panicle^{-1}	TGW (gm)	Yield plot^{-1} (kg)
ASD17	48.62	87.14	140.86	26.54	11.63	116.28	186.14	208.55	23.79	2.77
Gujjar	44.68	96.89	102.51	24.24	9.17	124.94	159.64	201.50	29.20	3.04
Jaya	47.56	105.67	96.95	26.43	9.76	134.11	185.81	227.57	25.62	2.75
NLR33358	44.54	91.50	95.55	24.42	10.96	119.17	151.47	190.62	23.03	2.93
PusaSugandh4	48.30	94.78	98.94	28.55	14.40	122.33	84.57	103.66	27.22	2.14
PR106	43.95	108.67	86.34	24.78	9.38	137.44	168.15	217.83	23.22	2.39
PR109	42.02	103.39	91.33	25.47	11.44	131.33	141.40	165.34	24.38	2.71
PR118	47.24	103.39	85.26	25.20	10.92	132.17	163.43	210.77	22.90	2.78
HURPBIS97AK	46.17	103.06	100.27	28.55	12.24	130.50	125.56	184.04	20.14	2.02
PusaBasmati1	43.82	103.61	103.23	29.13	11.94	130.44	129.38	178.52	20.65	2.08
Pusa1401	42.21	99.33	87.74	27.71	13.07	125.83	105.89	143.63	21.28	1.91
Pusa1460	40.40	102.50	89.54	28.33	12.63	129.06	109.98	154.24	20.24	1.58
PNR381	40.28	96.17	93.92	24.25	13.61	122.56	144.84	201.64	23.34	2.89
WGL32183	37.56	81.78	82.52	24.73	11.71	108.06	141.17	192.54	24.14	1.52
IR20	45.09	117.72	88.11	28.19	12.61	145.22	171.87	223.47	18.09	2.78
IR64	36.77	96.22	88.06	25.46	12.97	124.17	124.54	140.59	25.21	2.81
Pusa254	46.46	96.67	105.14	27.68	9.31	124.06	162.47	201.81	27.09	2.35
Pusa834	45.29	96.56	97.31	25.87	11.41	124.56	155.25	222.67	23.19	2.89
Sarjoo52	48.84	102.56	98.04	26.11	10.59	130.61	211.77	244.62	22.22	2.72
Usar	44.65	103.56	123.00	22.21	12.97	131.44	161.46	198.41	22.47	3.00
Basmati370	55.03	101.94	137.64	29.06	12.55	128.61	135.91	157.92	20.73	1.83
Heera	35.26	66.44	91.22	23.88	12.04	99.83	89.39	107.68	23.73	1.33
PantDhan12	41.78	97.39	91.05	25.43	12.34	125.00	136.03	182.54	25.07	2.92
KJT3	43.05	103.94	90.91	23.93	14.06	132.17	162.59	217.53	21.78	3.18
CSR13	45.52	113.89	93.36	24.73	12.91	141.67	170.48	208.28	20.39	2.86
CSR30	44.69	96.78	115.99	25.83	17.97	124.28	73.06	84.17	23.07	1.91
HMT Sona	49.08	106.83	82.74	21.43	14.17	131.50	215.44	247.97	12.97	2.24
BPT5204	40.70	114.83	84.94	22.77	12.91	141.50	251.19	296.28	14.21	2.42
Pusa44	45.58	103.72	84.95	24.85	10.87	131.56	209.25	270.54	21.97	2.93
PusaSugandh5	44.82	96.61	105.57	28.19	8.37	124.00	163.84	200.36	27.64	2.37
Mean	44.33	99.78	97.77	25.80	12.03	127.48	153.07	192.84	22.63	2.47
C.V.	9.31	2.95	6.83	5.05	17.14	2.74	11.23	10.32	3.93	13.01
F ratio	17.21	200.17	86.87	44.93	15.41	124.33	96.66	100.02	276.38	44.73
F Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S.E.	0.97	0.69	1.57	0.31	0.49	0.82	4.05	4.69	0.21	0.08
C.D. 5%	2.70	1.93	4.37	0.85	1.35	2.29	11.25	13.04	0.58	0.21
C.D. 1%	3.56	2.54	5.75	1.12	1.78	3.01	14.81	17.16	0.77	0.28
Low Range	35.26	66.44	82.52	21.43	8.37	99.83	73.06	84.17	12.97	1.33
High Range	55.03	117.72	140.86	29.13	17.97	145.22	251.19	296.28	29.20	3.18

Genotype	Yield plant-1 (gm)	Grain length (mm)	Grain breadth (mm)	Decorticated grain length (mm)	Decorticated grain breadth (mm)	Decorticated length breadth ratio	Grain length after cooking (mm)	Elongation ratio	Alkali spreading value
ASD17	31.53	8.16	3.07	5.59	2.68	2.10	8.87	1.58	3.13
Gurjari	33.46	9.41	2.94	6.89	2.59	2.66	11.32	1.64	3.37
Jaya	31.35	8.78	3.04	6.32	2.63	2.41	11.08	1.75	6.38
NLR33358	32.31	9.41	2.58	6.56	2.24	2.93	10.76	1.64	3.03
PusaSugandh4	24.31	11.83	2.44	9.08	2.03	4.45	19.29	2.14	6.52
PR106	26.43	9.12	2.41	6.91	2.16	3.22	10.92	1.58	6.48
PR109	30.53	9.71	2.56	7.07	2.16	3.29	10.34	1.46	3.72
PR118	30.60	9.09	2.53	6.51	2.18	2.99	10.37	1.58	6.49
HURPBIS97AK	22.67	10.84	2.11	8.27	1.74	4.71	14.62	1.77	6.35
PusaBasmati1	22.98	10.75	2.06	8.21	1.80	4.58	15.06	1.84	6.38
Pusa1401	21.49	10.94	2.16	8.37	1.72	4.85	15.72	1.88	6.36
Pusa1460	17.18	10.72	2.11	7.86	1.72	4.60	13.38	1.70	6.77
PNR381	32.16	9.39	2.57	7.02	2.18	3.23	11.22	1.60	4.89
WGL32183	16.81	9.63	2.48	6.77	2.17	3.13	10.32	1.52	6.31
IR20	31.26	7.93	2.43	5.75	2.14	2.70	8.98	1.55	3.44
IR64	31.34	10.03	2.41	7.19	2.06	3.49	10.26	1.42	2.70
Pusa254	26.96	11.42	2.46	8.77	2.08	4.22	13.41	1.52	6.26
Pusa834	32.01	9.44	2.53	6.97	2.22	3.16	11.63	1.67	5.02
Sarjoo52	30.61	8.54	2.74	6.21	2.35	2.64	10.03	1.61	6.74
Usar	33.24	7.79	2.92	5.46	2.51	2.17	9.33	1.71	3.29
Basmati370	20.59	9.51	2.24	7.29	1.91	3.84	12.71	1.74	3.07
Heera	14.86	9.53	2.42	7.03	2.08	3.37	10.50	1.49	3.21
PantDhan12	32.99	9.24	2.83	6.77	2.49	2.73	10.63	1.58	5.93
KJT3	35.81	8.02	2.68	5.71	2.36	2.41	9.31	1.63	3.12
CSR13	32.18	9.14	2.29	6.66	1.99	3.36	10.03	1.49	3.20
CSR30	21.15	10.67	2.18	8.13	1.83	4.47	13.03	1.61	3.42
HMT Sona	25.42	8.41	1.93	5.76	1.64	3.54	9.26	1.62	3.07
BPT5204	27.54	7.78	2.08	5.31	1.82	2.93	8.87	1.69	2.79
Pusa44	33.12	9.30	2.54	6.70	2.20	3.07	9.96	1.48	6.57
PusaSugandh5	25.57	11.46	2.25	8.84	1.93	4.56	13.98	1.58	6.48
Mean	27.62	9.53	2.47	7.00	2.12	3.39	11.51	1.64	4.82
C.V.	12.78	4.71	4.55	3.10	4.14	4.97	7.15	7.20	10.97
F ratio	47.01	114.37	128.91	418.58	189.09	420.95	153.92	27.32	167.55
F Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S.E.	0.83	0.11	0.03	0.05	0.02	0.04	0.19	0.03	0.12
C.D. 5%	2.31	0.29	0.07	0.14	0.06	0.11	0.54	0.08	0.35
C.D. 1%	3.04	0.39	0.10	0.19	0.08	0.15	0.71	0.10	0.46
Low Range	14.86	7.78	1.93	5.31	1.64	2.10	8.87	1.42	2.70
High Range	35.81	11.83	3.07	9.08	2.68	4.85	19.29	2.14	6.77

Table 3: Correlation coefficients among nineteen yield and quality traits in rice.

Character	Correlation	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Effective tillers plant^{-1}	Days to 50% maturity	Fertile grains panicle^{-1}	Spikelet's panicle^{-1}	Thousand grain weight (gm)	Yield plot^{-1} (kg)	Yield plant^{-1} (gm)	Grain length (mm)	Grain breadth (mm)	Decorticated Grain Length (L) (mm)	Decorticated grain breadth (B) (mm)	Decorticated length breadth Ratio	Grain length after cooking (mm)	Elongation ratio	Alkali spreading value
Penultimate leaf length (cm)	G	0.40	0.54	0.31	-0.1	0.38	0.29	0.22	-0.1	0.18	0.2	-0.07	0.09	-0.01	0.07	-0.02	0.16	0.36	0.07
	P	0.28**	0.42**	0.19**	0	0.26**	0.23**	0.21 ***	-0.07	0.15 ***	0.15**	-0.04	0.04	-0.02	0.03	-0.01	0.12**	0.23**	0.06
Days to 50% flowering	G		-0.17	0.04	0.05	0.99	0.49	0.52	-0.49	0.4	0.41	-0.29	-0.21	-0.24	-0.18	-0.05	-0.13	0.1	0.01
	P		-0.13**	0.04	0.04	0.96**	0.44**	0.47**	-0.46**	0.34**	0.34**	-0.25**	-0.19**	-0.23**	-0.16**	-0.05	-0.11**	0.09*	0
Plant height (cm)	G			0.3	0.05	-0.17	-0.14	-0.24	0.22	-0.02	-0.01	0.02	0.28	0.07	0.24	-0.03	0.12	0.19	-0.25
	P			0.3**	0.12 **	-0.11**	-0.08	-0.16**	0.19**	0.06	0.06	0.02	0.24**	0.05	0.22**	-0.04	0.11**	0.16**	-0.24**
Panicle length (cm)	G				-0.14	0.03	-0.43	-0.38	0.25	-0.36	-0.36	0.65	-0.22	0.69	-0.27	0.6	0.7	0.42	0.49
	P				-0.06	0.04	-0.3**	-0.25**	0.2**	-0.21**	-0.22**	0.51**	-0.18**	0.56**	-0.23**	0.5**	0.55**	0.27**	0.4**
Effective tillers plant^{-1}	G					0.01	-0.41	-0.44	-0.43	-0.22	-0.21	-0.02	-0.36	-0.03	-0.39	0.21	0.1	0.23	-0.4
	P					0.04	-0.23**	-0.28**	-0.29**	-0.09*	-0.08	-0.04	-0.19**	-0.03	-0.22**	0.11*	0.09*	0.18**	-0.25**
Days to maturity	G						0.5	0.52	-0.47	0.43	0.44	-0.33	-0.16	-0.27	-0.13	-0.1	-0.17	0.06	-0.01
	P						0.44**	0.46**	-0.42**	0.35**	0.35**	-0.28**	-0.15**	-0.25**	-0.11**	-0.1*	-0.14**	0.08	-0.02
Fertile grains panicle^{-1}	G							0.96	-0.4	0.51	0.52	-0.67	0.19	-0.67	0.25	-0.57	-0.63	-0.29	-0.1
	P							0.93**	-0.35**	0.45**	0.46**	-0.57**	0.16**	-0.6**	0.22**	-0.51**	-0.56**	-0.23**	-0.09*
Spikelets panicle^{-1}	G								-0.39	0.53	0.53	-0.62	0.17	-0.62	0.24	-0.53	-0.58	-0.25	0.03
	P								-0.34**	0.43**	0.44**	-0.54**	0.14**	-0.56**	0.21**	-0.48**	-0.52**	-0.2**	0.03
1000- grain weight (gm)	G									0.15	0.14	0.44	0.57	0.44	0.53	-0.01	0.31	-0.03	0.28
	P									0.13**	0.12**	0.4**	0.52**	0.42**	0.48**	-0.01	0.29**	-0.01	0.25**
Yield plot^{-1} (kg)	G										1	-0.51	0.61	-0.5	0.65	-0.67	-0.48	-0.25	-0.23
	P										0.98**	-0.42**	0.51**	-0.42**	0.51**	-0.55**	-0.35**	-0.11*	-0.2**
Yield plant^{-1} (gm)	G											-0.52	0.62	-0.51	0.65	-0.68	-0.48	-0.24	-0.24
	P											-0.44**	0.53**	-0.42**	0.53**	-0.57**	-0.36**	-0.11*	-0.21**
Grain length (mm)	G												-0.42	0.99	-0.49	0.88	0.89	0.35	0.51
	P												-0.36**	0.93**	-0.43**	0.82**	0.76**	0.21**	0.46**
Grain breadth (mm)	G													-0.42	0.99	-0.77	-0.37	-0.15	-0.06
	P													-0.37**	0.93**	-0.72**	-0.29**	-0.06	-0.05
Decorticated grain length (L) (mm)	G														-0.48	0.88	0.9	0.37	0.52
	P														-0.45**	0.87**	0.84**	0.24**	0.48**
Decorticated grain breadth (B) (mm)	G															-0.82	-0.45	-0.21	-0.09
	P															-0.81**	-0.4**	-0.15**	-0.1*
Decorticated length breadth ratio	G																0.82	0.39	0.38
	P																0.76**	0.26**	0.37**
Grain length after cooking (mm)	G																	0.73	0.52
	P																	0.7**	0.46**
Elongation ratio	G																		0.31
	P																		0.22**

Note: * & ** Significant at 5% & 1% level of significance, respectively, G=Genotypic, P=Phenotypic

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