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Genetic Variability and Association Studies on Bpt-5204 Based Rice Mutants under Saline Stress Soil

C. Prashanth[1*], K. Mahantashivayogayya[1], J. R. Diwan[2], P. H. Kuchanur[3] and J. Vishwanath[1]

[1]*Agricultural Research Station, Gangavati, University of Agricultural Sciences, Raichur - 584104, India.*
[2]*Department of Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, Raichur- 584104, India*
[3]*Department of Genetics and Plant Breeding, College of Agriculture, Bheemarayangudi, University of Agricultural Sciences, Raichur - 584104, India*

**Corresponding author*

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Present investigation was carried out with 12 advanced (M_7) mutants developed using gamma rays on two varieties i.e., BPT-5204 and RP Bio-226 along with checks (Gangavati Sona and CSR-22) at Agricultural Research Station Gangavati, Karnataka state, India during *kharif* 2018. Analysis of variance revealed highly significant differences among the mutant lines for all morpho-physiological characters under study *viz*., Days to 50 *per cent* flowering, Plant height, Panicle length, Number of grains per panicle, Panicle weight, Productive tillers per hill, Length of flag leaf and Grain yield per plant. Higher magnitude of heritability (broad sense) and genetic advance as percentage of mean were observed for number of grains per panicle, productive tillers per hill, spikelet sterility, test weight, grain yield per plant, grain yield per ha and Na^+/K^+ ratio indicating presence of additive gene action and fixation of genes. Correlation study revealed that grain yield per plant exhibited significant positive association with plant height, panicle length, number of grains per panicle and panicle weight at phenotypic level under saline stress condition. However, significant negative association was observed in case of days to fifty per cent flowering. Path analysis revealed that plant height, panicle length, panicle weight and length of flag leaf exhibited direct positive effect on grain yield per plant. Hence, it would be rewarding to lay stress on these characters in selection programme for increasing the yield and to screen for salinity tolerance.

Introduction

Rice (*Oryza sativa* L.) is the most important staple food crop for more than 60 per cent of the global population and forms the cheapest source of food, energy and protein. By origin, the crop is native to South East Asia with two cultivated (*Oryza sativa* and *Oryza glaberrima*) and 22 wild species. It belongs to the genus *Oryza* and grass family *Poaceae*.

The crop is cultivated under a wide range of agro-ecological situations. Globally, it is grown in an area of 162.71 mha with an annual production of 741.47 mt and productivity of 4556 kg ha^{-1}. It is the most important food crop of India with world ranking first in area (43.85 mha) and second to China in production (FAO, 2014). In India, rice is cultivated in an area of 43.49 mha with an annual production of 104.40 mt and average productivity of 2400 kg ha^{-1}.

In Karnataka, it covers an area of 0.93 mha with a production of 3.01 mt and average productivity of 2649 kg ha^{-1} (Anonymous, 2017). The slogan- "Rice is life "is due to its overwhelming importance as staple food and also a source of livelihood for about 120-150 million rural households of the country. Rice is central to the lives of billions of people around the world. With the growth of world's population towards 10 billion by 2050, the demand for rice will grow faster than for other crops.

A large number of factors such as drought, lodging, weeds, soil salinity, poor soil fertility, insect-pests, diseases, rodents *etc*., are responsible for the reduced quality and quantity of rice, among these salt-sensitivity being the major one. Millions of hectares in the humid regions of South and South-east Asia are technically suited for rice production but are left uncultivated or grown with low yields because of saline and problematic soils.

The extent of salt affected soils currently in India is 6.73 mha in different agro-ecological regions, which is expected to increase to 16.2 million ha by 2050 (Anonymous, 2017). Tungabhadra Project (TBP) area is the major rice growing region in northern Karnataka with 3.5 lakh ha area under rice. Water logging and soil salinity in this command area is increasing over the years. Every year, salinity adds approximately 1000 ha to the salinity affected area and leads to drastic reduction in the paddy yields. Already one lakh hectare area is converted into saline stress soil. The popular cultivar in the area is BPT-5204 locally called Sambha Masuri/ Sona Masuri is a long duration variety, matures at around 140-150 days. This variety is excellent in grain quality and is better than other varieties in quality. BPT-5204 is suitable for growing in *kharif* season in TBP area under normal soils which occupied 90 per cent of the area. But its yield levels are lower in salt affected soils to the tune of 50 per cent. Therefore, there is an urgent need to develop salinity stress tolerant rice varieties having grain quality like BPT-5204 but with short duration. Accordingly, the mutation breeding programme was initiated and several early maturing and high yielding salt tolerant mutants of BPT-5204 and RP Bio-226 have been identified.

Genetic variability is of greatest interest to the plant breeder as it plays a vital role in framing successful breeding programme. Heritability of a metric character is a parameter of particular significance to the breeder as it measures the degree of resemblance between the parents and the offsprings and its magnitude indicates the heritability with which a genotype can be identified by its phenotypic expression, while genetic advance aids in exercising the necessary selection pressure.

Materials and Methods

The material for the study consisted of 12 rice mutants evaluated along with four checks under saline soil. The present investigation was conducted to study the variability and association among traits in the rice mutants under saline soil. The experiment was conducted at Agricultural Research Station (ARS), Gangavati during *kharif* 2018 in a Randomized Block Design (RBD) with three replications. Ten rows of each 4 m length were assigned to each genotype with plants having 20×15 cm spacing.

All cultural practices were followed as per the package of practices adopted for irrigated rice, recommended by the University of Agricultural Sciences, Raichur. Soil samples from all the three replications were collected and they were analyzed for parameters such as pH and electrical conductivity (EC) using standard procedures.

Observations were recorded on five randomly selected plants in each replication for days to 50 per cent flowering, plant height, panicle length, number of grains per panicle, panicle weight, productive tillers per hill, length of flag leaf, spikelet sterility, test weight, grain yield per plant, grain yield per ha, length to breadth (L/B) ratio, Na^+/K^+ ratio and amylose content.

Data for the above traits were subjected to statistical analysis *viz*., Analysis of variance (ANOVA), mean, range, genetic variability components such as phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance as percent of mean (GAM). Correlation analysis was computed as per Karl Pearson (1932) and path coefficient analysis was carried out as suggested by Wright (1921).

Results and Discussion

Genetic variability in any crop is a pre-requisite for selection of superior genotypes over the existing cultivars. Variance analysis for all the characters revealed significant variation among the genotypes studied and are represented in Table 1. The variation in panicle length is depicted in Plate 1. The phenotypic coefficient of variation (PCV) in general was higher than genotypic coefficient of variation (GCV) for all the characters studied indicated the influence of environment on the manifestation of these characters. However, the difference between PCV and GCV was less which indicated low environmental influence and predominance of genetic factors controlling variability in these traits.

The rice mutants exhibited high variability for two characters namely spikelet sterility (%) and Na^+/K^+ ratio. The estimates of PCV and GCV for spikelet sterility (%) were 22.58 and 22.56 respectively. Na^+/K^+ ratio exhibited PCV and GCV of 59.52 and 59.51 respectively.

Low amount of variability was also observed in some other traits. The PCV and GCV estimates for days to days to fifty per cent flowering were 7.73 and 7.63, 9.75 and 6.50 for plant height, 6.07 and 4.76 for panicle length, 7.38 and 4.91 for length of flag leaf, 8.93 and 6.86 for L/B ratio, 5.83 and 4.84 for amylose content.

The amount of genetic variation considered alone will not be of much use to the breeder unless supplemented with the information on heritability estimate, which gives a measure of the heritable portion of the total variation. It has been suggested by Burton and Devane (1953) that the GCV along with heritability estimate could provide a better picture of the amount of advance to be expected by phenotypic selection.

Since genetic advance is dependent on phenotypic variability and heritability in addition to selection intensity, the heritability estimates in conjunction with genetic advance will be more effective and reliable in predicting the response to selection (Johnson *et al*., 1955). Heritability in broad sense includes both additive and non-additive gene effects (Hanson *et al*., 1953). While, narrow sense heritability includes only additive components (Johnson *et al*., 1955). In the present study, heritability in broad sense was estimated. Heritability along with genetic advance is useful for selection. The estimates of heritability (%) and genetic advance as per cent of mean (%) were 98.29 and 45.85 for the trait number of grains per panicle, 95.14 and 20.58 for productive tillers per hill, 99.86 and 46.46 for spikelet sterility, 97.50 and 28.43 for test weight, 81.69 and 23.54 for grain yield per plant and 99.96 and 122.58 for Na^+/K^+ ratio respectively.

These traits recorded high heritability (%) coupled with high genetic advance over mean (%) indicating the presence of additive gene action. The study clearly showed that there is ample scope to improve these traits through direct selection.

Correlation between characters

Selection for a specific character is known to result in correlated response in certain other characters (Falconer, 1964). Generally, plant breeders make selection for one or two attributes at a time, and then it becomes important to know the effect on other characters. Simple phenotypic correlation indicated broadly the type of association that exists between various attributes. The inter character correlation at phenotypic level among thirteen characters studied are presented in Table 2.

Under saline soil, grain yield per plant showed strong positive and highly significant phenotypic association with plant height (0.6193), panicle length (0.6143), number of grains per panicle (0.3592) and panicle weight (0.4364). Similar findings were reported earlier by Krishnamurthy and Kumar (2012) for plant height, Gopikannan and Ganesh (2013) for panicle length, Rajamadhan *et al.*, 2011 for number of grains per panicle and Seetharaman (2009) for panicle weight. Whereas days to fifty per cent flowering (-0.8414) showed strong negative and highly significant association with grain yield per plant. Similar result was also obtained by Pillai *et al.*, (2011).

Path coefficient analysis

Path analysis furnishes information of influence of each contributing trait to yield under saline soil directly as well as indirectly and also enables the breeders to rank the genetic attributes according to their contribution. The direct and indirect effects of different yield components which were not revealed by correlation studies are partitioned by path analysis were given in Table 3.

Four out of eight characters had positive and direct effect on grain yield per plant at phenotypic level. Length of flag leaf (0.0651) showed positive negligible effect. Plant height (0.2143) and panicle length (0.2972) showed moderate and positive effect. Panicle weight (1.3084) showed very high and positive effect on grain yield per plant. Similar results were obtained by Sivakumar and Kannan (2005) and Rita *et al.*, (2006).

This indicates that, if other factors are held constant, an increase in panicle length and weight individually will reflect in increased yield, whereas character like days to days to fifty per cent flowering (-0.8020) showed high and negative effect.

Number of grains per panicle (-1.8538) and test weight (-1.3210) showed very high and negative effect. Productive tillers per hill (-0.0537) shows negligible and negative effect on grain yield per plant. The residual effect was found to be 0.4144 in path analysis. This indicated that other attributing characters were also important and may play a critical role in rice yield improvement.

Table.1 Estimation of range, mean and different genetic parameters for yield and yield attributing characters of rice mutants

Character	Range			Co-efficient of variation (%)		h^2 (bs) (%)	GA @ 5%	GAM (%)
	Min	Max	Mean	PCV	GCV			
DFF	94.66	118.66	109.64	7.73	7.63	98.75	17.03	15.53
PH	66.70	95.23	83.85	9.75	6.50	44.43	7.48	8.93
PL	18.86	23.01	21.63	6.07	4.76	61.43	1.66	7.68
NGP	98.51	184.46	154.82	14.63	14.50	98.29	45.85	29.62
PW	1.85	2.77	2.37	10.88	10.06	85.53	0.45	19.17
PTH	13.52	18.91	16.06	10.50	10.24	95.14	3.30	20.58
LF	23.67	29.15	26.41	7.38	4.91	44.40	1.78	6.75
SS	7.47	21.81	14.07	22.58	22.56	99.86	6.45	46.46
TW	14.20	23.45	15.55	13.99	12.64	97.50	4.42	28.43
GYP	9.09	25.83	13.14	14.15	13.97	81.69	3.09	23.54
YLD	3030.66	5277	4381.66	13.99	12.65	81.68	1032	23.55
LBR	2.66	3.66	2.91	8.93	6.86	59.01	0.316	10.86
SPR	0.102	0.596	0.260	59.52	59.51	99.96	0.319	122.58
AC	21.45	24.82	23.00	5.83	4.84	68.97	1.908	8.29

DFF: Days to 50% flowering
PH: Plant height (cm)
PL: Panicle length (cm)
NGP: No. of grains per panicle
PW: Panicle weight (g)
PTH: Productive tillers per hill
LF: Length of flag leaf (cm)
SS: Spikelet sterility
TW: Test weight (g)
GYP: Grain yield per plant (g)
YLD: Yield per ha
LBR: Length to breadth ratio
SPR: Na^+ to K^+ ratio

Table.2 Association (phenotypic correlation) among different quantitative traits in rice under saline soil

	DFF	PH	PL	NGP	PW	PTH	LF	TW	GYP
DFF	**1.000**								
PH	-0.5346	**1.000**							
PL	-0.4230**	0.4123**	**1.000**						
NGP	-0.3287*	0.1311	0.2210	**1.000**					
PW	-0.3742**	0.3603*	0.4109**	0.7294**	**1.000**				
PTH	-0.0407	0.1437	-0.0609	-0.2889*	-0.0414	**1.000**			
LF	0.0055	-0.0922	-0.1880	0.0455	-0.1567	0.0511	**1.000**		
TW	-0.0595	0.2732	0.1737	-0.6683**	0.0086	0.4051**	-0.2084	**1.000**	
GYP	-0.8414**	0.6193**	0.6143**	0.3592*	0.4364**	-0.0587	-0.0317	0.0516	**1.000**

DFF: Days to 50% flowering
PH: Plant height (cm)
PL: Panicle length (cm)
NGP: No. of grains per panicle
PW: Panicle weight (g)
PTH: Productive tillers per hill
LF: Length of flag leaf (cm)
TW: Test weight (g)
GYP: Grain yield per plant (g)

Table.3 Phenotypic path analysis for direct and indirect effects on grain yield per plant in rice genotypes

	DFF	PH	PL	NGP	PW	PTH	LF	TW
DFF	**-0.8020**	0.4288	0.3393	0.2636	0.3001	0.0326	-0.0044	0.0477
PH	-0.1145	**0.2143**	0.0883	0.0281	0.0772	0.0308	-0.0198	0.0585
PL	-0.1257	0.1225	**0.2972**	0.0657	0.1221	-0.0181	-0.0559	0.0516
NGP	0.6093	-0.2430	-0.4097	**-1.8538**	-1.3521	0.5356	-0.0844	1.2388
PW	-0.4896	0.4714	0.5376	0.9543	**1.3084**	-0.0541	-0.2050	0.0112
PTH	0.0022	-0.0077	0.0033	0.0155	0.0022	**-0.0537**	-0.0027	-0.0217
LF	0.0004	-0.0060	-0.0122	0.0030	-0.0102	0.0033	**0.0651**	-0.0136
TW	0.0786	-0.3609	-0.2294	0.8828	-0.0113	-0.5351	0.2753	**-1.3210**
GYP	-0.8414	0.6193	0.6143	0.3592	0.4364	-0.0587	-0.0317	0.0516

Residual effect: 0.4144
R SQUARE: 0.8282

DFF: Days to 50% flowering
PH: Plant height (cm)
PL: Panicle length (cm)
NGP: No. of grains per panicle
PW: Panicle weight (g)
PTH: Productive tillers per hill
LF: Length of flag leaf (cm)
TW: Test weight (g)
GYP: Grain yield per plant (g)

Plate.1 Variation in panicle length

A: CSR-22	B: Gangavati Sona
C: RP Bio-226	D: BPT-5204
1: BPT-5204 Mutant 601	2: BPT-5204 603
3: BPT-5204 Mutant 609	4: RP Bio-226 Mutant 614
5: RP Bio-226 Mutant 615	6: RP Bio-226 Mutant 618
7: BPT-5204 Mutant 626	8: BPT-5204 Mutant 633
9: BPT-5204 Mutant 638	10: BPT-5204 Mutant 619
11: BPT-5204 Mutant 653	12: BPT-5204 Mutant 1807

Direct yield improvement under saline condition is difficult. Hence, yield improvement in salt stress environments could be achieved by identifying secondary traits contributing to salt tolerance and selecting those traits in a breeding programme.

Commencing the experimental findings it could be accomplished that most of the characters were governed by additive gene action such as number of grains per panicle, productive tillers per hill, spikelet sterility, test weight, grain yield per plant and Na^{+}/K^{+} ratio indicates that these traits are least influenced by environment hence selection may be effective through these characters.

Grain yield per plant exhibited a very strong positive association with plant height, panicle length, number of grains per panicle and panicle weight at phenotypic level which indicated that these traits were the strongest associates of grain yield per plant. Path analysis identified that plant height, panicle length, panicle weight and length of flag leaf as major direct contributors.

Thus a genotype with higher magnitude of these traits could be either selected from existing genotypes or evolved by breeding program for genetic improvement of yield in rice. Further the occurrence of negative as well as positive indirect effects by yield components on grain yield via one or the other character simultaneously, presents a complex situation where a compromise is required to attain proper balance of different yield components in determining ideotype for high grain yield for salt affected soils in rice.

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