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Studies on genetic variability and heritability for quantitative characters in rice (*Oryza sativa* L.) under sodic soil

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Abstract
A field experiment was conducted during wet season 2015 at the GPB Farm of N.D. University of Agriculture and Technology, Faizabad. The experimental materials of rice for this investigation comprised of 20 genotypes as lines (females) and three testers (males) Narendra 5026, jaya and Sarjoo 52. Each of three testers was crossed with 20 lines during kharif 2014. Thus, total number of 60 hybrids (F_1) were obtained. The total set of eighty five genotypes were grown during kharif in 2015 and evaluated along with their parents and two check varieties (Narendra Usar 3 and IR28) in Randomized complete block design with three replications crosses obtained through crossing in a "line × tester" mating design. Besides these, two checks *viz*; Narendra Usar 3 and IR28 a rice hybrid were also included for standard heterosis. The experiment was conducted at pH = 9.2, EC =2.21 dSm^{-1} and ESP 45%. The analysis variance revealed that all the treatments, parents, parent vs crosses, crosses, lines and testers were highly significant for majority of the yield and its contributing traits indicating wide genetic variability among the materials under study. Results revealed that there was least differences of estimates of the PCV and GCV. The estimates of PCV were higher than GCV for all the traits indicating that they all interacted with the environment to some extent. Besides, high estimates of phenotypic and genotypic coefficient of variation were estimated for grains yield per plant. High estimates of broad sense heritability was recorded for the characters *viz*., days to 50% flowering, plant height, flag leaf area, panicle bearing tillers per plant, spikelets per panicle, grains per panicle, spikelet fertility (%), 1000 - grain weight, biological yield per plant, L:B ratio, grains yield per plant. High heritability (broad sense) coupled with high genetic advance in per cent of mean were observed for the characters like grain yield per plant, biological yield per plant, grains per panicle, panicle bearing tillers per plant, spikelets per panicle, L:B ratio and flag leaf area indicating the involvement additive gene action. The moderate narrow sense heritability with low genetic advance in per cent of mean were observed for spikelet fertility and 1000-grain weight indicating presence of non- additive gene action suggesting heterosis breeding may be useful.

Keywords: Genetic variability, Heritability, Genetic advance, Rice (*Oryza sativa* L.)

Introduction

The major objective of plant breeder is to create maximum extent of genetic variability in the existing genetic stock. Variation is the basis of plant breeding. Thus the success of any improvement programme will largely depend on the magnitude and range of variability in the available genetic stocks (Basavaraja *et al*., 2013) [2]. Rice is the life and the prince among cereals as this unique grain helps to sustain two thirds of the world's population. Uttar Pradesh is an important rice growing state in the country. Agriculture is the most important in the state, because, about 80% of its population resides in rural areas and 75% of the total workers are involved directly or indirectly in cultivation/farming which accounts for 27% of state's GDP (Sindelar *et al*., 2016) [24]. Agriculture is the main source of income for families in the state. It has 11.56 million hectare of cultivated area, constituting 70% of the total geographical area. The irrigated area is over 13.43 million hectare (Sindelar *et al*., 2016) [24]. Rice area with salt problem in state is estimated to be ≤ 2%. In land salinity areas are mainly concentrated in Raibareilly, Azamgarh, Sultanpur, Faizabad, Lucknow, Unnao and Pratapgarh district. The area and production of rice in this state is about 13.84 million hectare and 32.64 million tonnes respectively and productivity of 2358 kg per hectare

Rice, being the staple food for more than 70 per cent of our national population along with the source of livelihood for 120-150 million rural households. It is a backbone to the Indian agriculture. Rice production (according to USDA 2016/2017) is forecast higher at 105 MMT from 43.5 million hectares compared to 2015/16 production of 103.5 million tones in India (Gain report 2016) [24].

The genetic variability and combining ability provides the basis in selecting the suitable genotypes in any breeding programme (Singh *et al*., 1980) [26]. The effectiveness of selection depends on the magnitude of heritability for the traits being selected. The knowledge of heritability enables the breeder to predict the genetic gain under selection which will heritability and genetic advance are two selection parameters which were also estimated during the course of present investigation (Basavaraja *et al*., 2013) [2]. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone (Chaudhary *et al*., 2004) [4]. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance (Johnson *et al*., 1955)] [9]. Heritability is a good index of the transmission of character from parents to their offspring (Falconer *et al*., 1981) [5]. The estimates of heritability help the plant breeder in selection of elite genotypes from diverse genetic populations. Genetic advance is the measure of genetic gain under selection. The success of genetic advance under selection depends on genetic variability, heritability and selection intensity Johnson *et al*., 1955) [9].

Materials and Methods

The experiment was laid out during wet season 2015 at the GPB farm of N.D. University of Agriculture and Technology, Faizabad. The experimental materials of rice for this investigation comprised of 20 genotypes as lines (females) and three testers (males) Narendra 5026, jaya and Sarjoo 52. Each of three testers was crossed with 20 lines during kharif 2014. Thus, total number of 60 hybrids (F_1) were obtained. The total set of eighty five genotypes were grown during kharif in 2015 and evaluated along with their parents and two check varieties (Narendra Usar 3 and IR28) in Randomized complete block design with three replications crosses obtained through crossing in a "line × tester" mating design (Kempthorne 1957) [10]. Besides these, two checks viz; Narendra Usar 3 and IR28 a rice hybrid were also included for standard heterosis. The experiment was conduted at pH = 9.2, EC =2.21 dSm^{-1} and ESP 45%. The fertilizers were applied @ 120 kg nitrogen, 60 kg phosphorus and 60 kg potash per hectare through urea, DAP and murate of potash, respectively. The full dose of phosphorus and potash and half dose of nitrogen were applied as basal and rest of nitrogen was applied in two split doses as top dressing at tillering and panicle initiation stage of crop growth. The observations *viz*., Days to 50% flowering, plant height (cm), Flag leaf area (cm^2), panicle bearing tillers per plant, panicle length (cm), spikelets per panicle, Grains per panicle, spikelet fertility (%), 1000-grain weight (g), biological yield per plant (g), harvest-index (%), L/B ratio, grain yield per plant (g), blast, BLB, brown spot, leaf folder, stem borer were recorded on the basis of five randomly selected competitive plants in each plot. The mean data of different traits were subjected to analyze by standard statistical and biometrical method for Line x Tester analysis.

Results and Discussion

The analysis of variance for eighty three genotypes of line × tester set comprising of sixty crosses and twenty three parents is presented in table-2 under sodic soil. The analysis of variance revealed that mean sum of squares due to treatments, parents, parents *vs*. crosses, crosses, lines and line × tester were highly significant for all the characters indicating the existence of sufficient variability in the materials (Panwar *et al*., 2007) [18]. The variances due to testers were non-significant for all the characters except days to 50% flowering (16.00) showed highly significant, while 1000- grains weight (1.89) and L:B (0.27) ratio which were found significant (Kumar and Verma, 2016) [11]. The mean sum of squares due to lines were highly significant for all the characters. The mean squares due to replications were non-significant for all the characters while panicle bearing tillers per plant(3.72), spikelets per panicle (206.13) and grains per panicle (131.49) exhibited significant variances due to replications (Mall *et al*., 2005) [15]. The high estimates of phenotypic and genotypic coefficient of variation (> 20%) were estimated for grains yield per plant (23.08, 22.28) but high PCV and moderate GCV only for panicle bearing tillers per plant (21.21, 18.73) and biological yield per plant (20.73, 19.65). The moderate estimates (10-20%) of PCV and GCV were recorded for grains per panicle (18.79, 17.98), L:B ratio (18.20, 16.15), spikelets per panicle (16.20, 15.31) and flag leaf (13.06, 11.69) and it was low for 1000- grains weight (7.93,7.34), panicle length (cm) (7.66, 6.38), days to 50% flowering (6.21, 6.11), plant height (5.75, 5.15), spikelet fertility (5.82, 5.27) and harvest-index (5.47, 4.32) (Kumar and Verma, 2016; Panvar *et al.,* 2007) [11]: indicating little opportunity of selection for these characters under sodic soil (Table 1) (Bhattacharya *et al*., 1978). High coefficient of variability indicated that there is a scope of selection and improvement of these traits (Pandey *et al*., 2010 and Tiwari *et al*., 2011) [28]. Low values indicated the need for creation of variability either by hybridization or mutation followed by selection. Similar findings were also reported by Pandey *et al* (2010) and Tiwari *et al* (2011) [28]. The proportion of genetic variability which is transmitted from parents to offspring is reflected by heritability (Harlan *et al*., 1956 and Lush *et al*., 1949). Robinson *et al* (1949) viewed that the knowledge of heritability of a character is important to the breeder, as it indicates the possibility and extent to which improvement is possible through selection. In the present study, high estimates of broad sense heritability (>75%) was recorded for the characters *viz*., days to 50% flowering (97.00), grains yield per plant (93.00), grain per panicle (92.00), biological yield per plant (90.00), spikelets per panicle (89.00), 1000-grain weight (86.00), spikelet fertility (82.00), plant height (80.00), flag leaf area (80.00), L:B ratio (79.00), panicle bearing tillers per plant (78.00)[7,28]. panicle length (69.00), harvest-index (62.00) which exhibited moderate estimate of heritability (50-75%). The genetic advance in per cent of mean in sodic soil was found to be high (>20-50%) for grains yield per plant (44.29), biological yield per plant (38.31), grains per panicle (35.44), panicle bearing tillers per plant (34.07), spikelets per panicle (29.82), L:B ratio (29.57) and flag leaf area (21.55) (Tiwari *et al*., 2015). On the other hand, moderate genetic advance in per cent of mean (10-20%) were noted for 1000-grain weight (13.99), days to 50% flowering (12.39) and panicle length (10.95) while low (<10%) for spikelet fertility (9.84), plant height(9.51) and harvest-index (7.02) (Table 1) (Kumar and Verma 2016) [11]. The broad sense heritability of these characters are in accordance with those of Bhattacharya (1978) [3] for grain yield per plant; Kumar and Verma (2016) [11] for days to 50% flowering, Plant hight, spikelets per panicle, 1000 grain weight and grain yield per plant.

Further, results revealed that high heritability coupled with high genetic advance in per cent of mean were observed for the characters *viz*., grain yield per plant, biological yield per plant, grains per panicle, panicle bearing tillers per plant, spikelets per panicle, L:B ratio and flag leaf area indicated the involvement of additive gene action (Chaudhary *et al*., 2004; Sathya *et al*., 2013) [4, 22]. High heritability in broad sense coupled with moderate genetic advance in per cent of mean were observed for the characters *viz*., 1000- grain weight and days to 50% flowering under sodic soil. High heritability coupled with high genetic advance have additive gene action and may be directly utilized for rice improvement. On the other hand the character having low heritability and high genetic advance in percent of mean and high heritability and low genetic advance in percent of mean have non-additive gene action. The high to very high estimates of direct selection parameters for above mentioned characters indicated that these would be ideal traits for improvement through selection in context of materials evaluated due to existence of high genetic variability represented by high coefficients of variation and high transmissibility denoted by high heritability for them. (Shukla *et al*., 2004; Mall *et al*., 2005; Panwar *et al*., 2007; Babar *et al*., 2009; Basavaraja *et al*. 2013; Kaini, 2013; Sathya and Jebaraj, 2013; Kumar and Verma, 2016 and Hefena *et al.,* 2016) [21, 15, 18, 1, 2, 12, 22, 4, 11, 31, 7]. The moderate narrow sense heritability with low genetic advance in per cent of mean was noticed for spikelet fertility (12.084) and 1000-grain weight (11.543) indicated that these traits are unlikely to provide reasonable selection response. Majority of the characters showed low narrow sense heritability and variable range genetic advance in per cent of mean indicated the preponderance of non-additive gene action reflecting heterosis breeding may be rewarding (Table 1) (Hefena *et al*., 2016) [7]. Above findings were also confirmed from the estimates of variance due to additive and dominance genetic components in the present study. These findings were similar to those of Verma and Srivastava (2004): Singh *et al*. (1980) [31, 26].

The estimates of dominance variance were higher than the corresponding estimates of additive variance for all the traits indicated the predominance of non-additive gene effects represented by dominance variances. The values of average degree of dominance were more than unity (>1) revealing over dominance for all the characters. The importance of additive as well as non-additive gene effects with predominance of non-additive gene effects in inheritance of grain yield and yield components of rice has also been reported earlier Pradhan *et al*., 2007 [18]; Saidaiah *et al.* 2010 [23]; Gopikannana and Ganesh 2013 [6]; Talapati *et al.,* 2014 [30]; Seesang *et al.,* 2014 [25]; Prasad *et al.,* 2015 [17] and Kannan and Ganesh 2016 [13]. The predominance of non-additive gene effects representing non-fixable dominance and epistatic components of genetic variance indicated that maintenance of heterozygosity, would be highly fruitful for improving the yield under sodic soil.

Table 1: Estimates of coefficient of variation, heritability, genetic components of variance, degree of dominance and genetic advance for 18 traits in rice under sodicity.

Characters	Coefficient of variation (%)		Heritability (%)		Genetic component		Degree of dominance	Genetic advance in (%) of mean	Genetic advance
	Phenotypic	Genotypic	Broad sense	Narrow sense	Additive variance	Dominance variance			
Days to 50% flowering	6.21	6.11	97.00	7.441	1.178	27.841	4.861	12.39	0.431
Plant height (cm)	5.75	5.15	80.00	3.258	0.902	45.888	7.132	9.51	0.249
Flag leaf area (cm^2)	13.06	11.69	80.00	5.163	0.462	14.316	5.565	21.55	0.225
Panicle bearing tillers per plant	21.21	18.73	78.00	1.236	0.056	7.824	11.764	34.07	0.038
Panicle length (cm)	7.66	6.38	69.00	2.688	0.082	4.614	7.498	10.95	0.068
Spikelets per panicle	16.20	15.31	89.00	6.570	23.777	601.695	5.030	29.82	1.820
Grains per panicle	18.79	17.98	92.00	7.462	21.604	478.415	4.705	35.44	1.849
Spikelet fertility (%)	5.82	5.27	82.00	12.084	0.853	6.563	2.772	9.84	0.467
1000- grains weight (g)	7.93	7.34	86.00	11.543	0.234	2.890	3.512	13.99	0.239
Biological yield per plant (g)	20.75	19.65	90.00	9.017	3.814	68.267	4.230	38.31	0.854
Harvest-index (%)	5.47	4.32	62.00	2.019	0.103	7.432	8.490	7.02	0.066
L:B ratio	18.20	16.15	79.00	8.856	0.021	0.343	3.983	29.57	0.063
Grain yield per plant(g)	23.08	22.28	93.00	9.980	0.872	14.489	4.075	44.29	0.429

Table 2: Analysis of variance for 18 characters of line × tester set of crosses and their parents in rice under sodic soil

Characters	Sources of variation								
	Replications	Treatments	Parents	Parents *vs* Crosses	Crosses	Parent (Lines)	Parent (Testers)	Parent (Lines × testers)	Error
d.f.	2	82	22	1	59	19	2	38	164
Days to 50% flowering	1.45	103.68**	135.33**	2427.76**	52.48**	147.57**	16.00**	21.98**	1.10
Plant height (cm)	0.29	73.56**	98.60**	114.19**	63.54**	112.77**	6.44	40.18**	5.76
Flag leaf area (cm^2)	5.11	25.08**	18.39**	194.45**	24.70**	20.01**	3.65	12.73**	2.00
Panicle bearing tillers per plant	3.72*	9.83**	3.64**	239.89**	8.24**	3.65**	2.11	6.78**	0.91
Panicle length (cm)	0.57	7.12**	5.06**	84.04**	6.58**	5.77**	0.67	4.45**	1.00
Spikelets per panicle	206.13*	1423.91**	1351.83**	20774.37**	1122.81**	1462.95**	21.68	507.13**	55.85
Grains per panicle	131.49*	1405.43**	1134.73**	33566.36**	961.27**	1182.86**	8.86	401.84**	43.04
Spikelet fertility (%)	3.25	63.24**	53.21**	2160.39**	31.43**	56.30**	2.72	9.32**	4.40
1000- grains weight (g)	0.14	10.02**	7.80**	132.80**	8.76**	8.75**	1.89*	2.69**	0.53
Biological yield per plant (g)	4.95	172.55**	109.02**	2518.17**	156.49**	105.18**	1.06	57.72**	6.52
Harvest-index (%)	0.47	10.92**	6.72**	146.85**	10.18**	7.48**	2.88	7.51**	1.93
L:B ratio	0.09	0.93**	0.68**	8.40**	0.89**	0.72**	0.27*	0.33**	0.08
Grains yield per plant (g)	0.41	37.59**	18.15**	653.89**	34.39**	17.55**	0.31	11.80**	0.93

*,** Significant at 5% and 1% probability levels, respectively

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