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Inter Generation Trait Association and Regression Analysis in F_2 and F_3 Generations of Rice

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A B S T R A C T

A research work was undertaken at Agricultural College and Research Institute during late rabi, 2016 (Nov-Feb), and rabi, 2017 (Nov-Feb) to determine the response of selection for grain yield and yield related components and to estimate the amount of genetic potential transferred from one generation to next generation using different segregating generations of rice. In the present study, segregating generations *viz*., F_2, F_3 and generations of four crosses *viz.*, ADT 45 x NLR 34449, CO 51 x NLR 34449, ADT 45 x WGL 365 and CO51 x WGL 365 were evaluated for yield and its related traits using descriptive statistics and parent progeny regression analysis. The mean, median and mode were dissimilar for all the traits in almost all the generations of all the crosses indicated that the distribution was asymmetrical. The coefficient of variation was high in F_2 whereas in forwarding generations of F_3 it was low, indicating that the settle down of homozygosity. The mean was high compared to the median and mode for grain yield indicating that the distribution was positively skewed. Hence, selection for grain yield may be practiced among the progenies. The kurtosis value was less than three in almost both crosses, indicated that the progenies were not bunched around the mode in all generations. In respect of days to 50 per cent flowering (DFF) and plant height, F_2 generation showed high mean performance than in F_3 generation. This indicates that there was a reduction in mean value for days to 50 per cent flowering and plant height over advancement of generations. The results revealed that significant positive inter-generation correlation and regression was observed for character like plant height in all four crosses ADT 45 x NLR 34449, CO 51 x NLR 34449, ADT 45 x WGL 365 and CO51 x WGL 365 and grain yield per plant was found significant in crosses CO 51 x NLR 34449 and CO51 x WGL 365. The results indicated that F_2 is good indicator of F_3 performance for all the traits. It indicates the chances of selecting high yielding genotypes at early generations. In all the crosses, the identified superior genotypes were fixed as homozygous lines in F_4 generation. These lines will be evaluated in yield trials *viz.*, Initial Yield Trial (IYT), Preliminary Yield Trial (PYT) and Advance Yield Trial (AYT) along with the check varieties. Hence, selection of high yielding genotypes at early generation based on these characters is valuable for identification of promising cultures.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops, which supplies food for more than half of the world's population. Asia is the biggest rice producer and consumer, accounting for 90 per cent of the world's production and consumption of rice (Sala *et al.,* 2015). Rice is the backbone of India's economy providing direct employment to about 70 per cent working people in the country.

Crop improvement for grain yield has been achieved in rice through effective use of F2 and F3 segregating populations and fixing desirable character combinations. However, there are still possibilities to increase the yield output through proper breeding technologies in rice (Jayaprakash *et al*., 2017). Among the segregating populations F2 generation is the most crucial, where selection has to be done more critically. Segregating populations would allow the gene expression for particular traits. Effectiveness of early generation selection was studied by many researchers in wheat through correlations between F2 and F3 (Pawar *et al.*, 1989) and between F2 and F3 and F3 and F4 (Saini and Gautam, 1990). Estimates of realized heritability of the particular trait is important in determining its response to yield and its components has been reported by earlier workers in rice (Govintharaj *et al*., 2017). Grain yield is a complex trait and is the result of interaction of many variables. Parent progeny regression is a method commonly used for estimating the amount of genetic potential transferred from parent to progeny. The parent progeny correlation and regression between two generations shows lesser susceptible to environmental effect and is very useful for selection in segregating population for the development of new improved genotypes (Suwarto *et al.,* 2015). Inter-generation correlation studied by using parent offspring regression which helps in estimating the extent of transferring the genetic potentials of the character from one generation to other generation.

Selection pressure in rice based on grain yield, total tillers and grain per panicle could be advantageous (Talwar, 1976). Effectiveness of early generation selection could be reduced by genotype and environment interaction (Rahman and Bahl, 1986). Direct selection may not be effective in segregating population for improvement of grain yield (Bartley and Weber, 1952; JOHNSON *et al.*, 1955). The present investigation was aimed at studying the response of selection for yield and its component characters through parent progeny correlation and regression method between F2 and F3 generations. Regression analysis is the better way to make crop yield prediction (Singh *et al.,* 2017). The degree of dependence of one variate on the other is measured by regression coefficient. Regression coefficient was estimated on the basis of parent-offspring regression.

Correlation and regression analysis are related in the sense that both deal with relationships among variables. The correlation coefficient is a measure of linear association between two variables. Regression analysis involves identifying the relationship between a dependent variable and one or more independent variables (Banumathy *et al.*, 2017). The present investigation was aimed at studying the descriptive statistics response of selection for yield and its component characters through parent progeny correlation and regression method between F2 and F3 generations.

Materials and Methods

The F_1 progenies of four crosses ADT 45 x NLR 34449 (cross 1), CO 51 x NLR 34449 (cross 2), ADT 45 x WGL 365 (cross 3) and CO51 x WGL 365 (cross 4) were raised along with the parental lines during late rabi, 2015 (Nov-Feb) at Central Farm, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai Tamil Nadu. The harvested seeds of these crosses were used to raise the F_2 generation.

The F_2 progenies of four crosses were raised during late rabi, 2016 (Nov-Feb). Single seeds per hill were planted at a spacing of 20 × 20 cm. An average of 200 population size was maintained for each cross along with two rows of parental lines. Observations *viz.,* days to 50 per cent flowering (DFF), plant height, number of productive tillers per plant, panicle length and single plant yield were recorded on the selected seventy plants in each cross. Mean values were utilized for statistical analysis. Seventy five plants were selected from each of the two crosses and forwarded to generate F_3 families.

Evaluation of F_3 families

Seventy five F_3 families in each cross were raised during late rabi, 2017 (Nov-Feb September-December). One hundred plants in each cross were evaluated for traits *viz.,* DFF, plant height, number of productive tillers per plant, panicle length and single plant yield. Progeny mean and range of selected individuals for each cross were estimated. Mean values were used to estimate the parent offspring correlation and regression between F_2 and F_3 generation.

Statistical analysis

The quantitative traits observed in $F_{2,}$ and F_3 generation were subjected for statistical analysis. The average of the traits was estimated for descriptive statistics of each population. Mean, range, coefficient of variation, skewness and curtosis were estimated as per Snedecor and Cochran (1974). The parent progeny regression analysis between F_2 and F_3 was carried out by regressing the mean values of a character in the progeny (F_3) upon the value of a character in the parent (F_2). The regression coefficient b was calculated by using the formula suggested by Lush (1940).

Results and Discussion

The yield performance and other contributing characters of F_3 families raised from the selected F_2 populations on the basis of phenotypic performance of the crosses showed hopeful results (Tables 1 to 5).

The results revealed that there was strong association between the yield of individual F_2 selection and the mean yield of corresponding F_3 families. Similarly improvement was observed in other yield contributing traits *viz*., productive tillers per plant and panicle length.

In respect to days to 50 per cent flowering and plant height, F_2 generation showed high mean performance than in F_3 generation in all the crosses. This indicates that there is a reduction in mean value for days to 50 per cent flowering and plant height over advancement of generations. These progenies are worthy of exploitation for obtaining early maturing lines. The mean of F_2s was lower than the mean of F_1s and its parent, indicating the occurrence of transgressive segregation in the negative direction in all the cross combinations. Transgressive segregation may arise due to the dominance and dominance interaction in addition to additive x additive interaction which is fixable. Similar findings also reported by Thirugnanakumar *et al.*, 2011 and Banumathy *et al.*, 2017. This could be due to recombination of additive alleles. The coefficient of variation was higher in F_2s than in F_3. It may be due to settle down of the homozygosity.

The distribution was asymmetrical since, the mean, median and mode were dissimilar in almost all the generations for all the crosses studied. If the mean is lesser than the mode indicating the distribution is negatively skewed, whereas the reverse indicating that the distribution is positively skewed. Hence, selection for earliness can be practiced well in all the generations of all the four crosses and similarly selection for reduction in height can be practiced in F_3 of all the crosses. Kurtosis will occur if either a few genes are controlling the phenotypic distribution or there are inequalities in the additive genetic effects at different loci. Traits for which data is showing leptokurtic distribution are usually those under control of relatively few segregating genes, whereas data showing a platykurtic distribution usually represent characters that are controlled by many genes. The positive values of kurtosis indicate leptokurtic curve while negative kurtosis indicate platykurtic curve and if values are not significant or zero, it indicates mesokurtic i.e. normal distribution. The kurtosis value was in between with zero value in all the generation of crosses suggested that the curve was platykurtic. Negative kurtosis was observed in single plant yield. This indicates platykurtic curve which means characters are controlled by many genes. If selection for these characters were made intensively, the gain will be faster (Sruthy Menon *et al.*, 2016).

The F_1s of all the crosses exhibited higher number of productive tillers and lengthier panicles when compared to F_2 and F_3 generation. In all the crosses the coefficient of variation was lesser in F_3 and observed as high in F_2. The coefficient of variation was lesser F_3 and observed as high in F_2. It showed that the settle down of homozygosity. The mean was higher than the median and mode in F_3 of all crosses for the trait number of tillers per plant. It indicated that the distribution was positively skewed. Hence, selection for number of productive tillers may be practiced among these progenies. The mean was low compared to the median and mode for panicle length for all generations of the four crosses studied, indicated that the distribution was negatively skewed. The kurtosis value was less than three in all the generations of all crosses indicating that the distribution was platykurtic, which means characters are controlled by many genes. If selection for these characters were made intensively, the gain will be faster. The findings were consistent with the findings of Thirugnanakumar *et al.,* 2011 and (Sruthy Menon *et al.,* 2016).

The improvement in grain yield was high in F_1s and low in F_2s and F_3s generation of the four crosses. In all the crosses the coefficient of variation was lesser in F_3 and observed as high in F_2. The coefficient of variation was high in F_2 whereas in forwarding generations of F_3 and F_4 in all crosses, it was low. It indicated that the settle down of homozygosity. The mean, median and mode were dissimilar for all crosses and in all the generations. It indicated that the distribution was asymmetrical. The mean was high compared to the median and mode. Hence, selection for grain yield may be practiced among the progenies. Negative kurtosis was observed in most of the character in all the crosses exhibited platykurtic curve which means the characters are controlled by many genes. If selection for these characters were made intensively, the gain will be faster.

Inter generation correlation studies by using parent offspring regression helps in estimating the extent of transferring the genetic potentials of the character from one generation to other generation. The parent progeny correlation and regression between two generations shows lesser sensitivity to environmental effect and is very useful for selection in segregating population for the production of new and improved genotypes.

Table.1 Descriptive statistics for days to first flowering

CROSS 1 (**ADT 45 x NLR 34449**)	ADT45	NLR 34449	F_1	F_2	F_3
Max				110	99
Min				75	76
Range				35	23
Mean	93.60	89.20	93.40	89.01	86.50
Median				89.50	86.00
Mode				90.00	90.00
Skewness				0.18	0.03
Kurtosis				-0.67	-0.99
CV	1.24	0.96	1.63	9.11	6.76
CROSS 2 (**CO 51 x NLR 34449**)	CO 51	NLR 34449	$\mathbf{F_1}$	$\mathbf{F_2}$	$\mathbf{F_3}$
Max				128	96
Min				74	77
Range				54	24
Mean	93.60	94.60	93.80	78.58	85.07
Median				89.00	85.00
Mode				88.00	90.00
Skewness				1.15	0.18
Kurtosis				2.26	-1.11
CV	1.91	1.22	1.60	12.20	7.38
CROSS 3 (**ADT 45 X WGL 365**)	ADT 45	WGL 365	$\mathbf{F_1}$	$\mathbf{F_2}$	$\mathbf{F_3}$
Max				108	95
Min				74	75
Range				34	20
Mean	93.60	89.20	93.40	88.26	85.48
Median				89.50	85.00
Mode				90.00	95.00
Skewness				0.18	0.05
Kurtosis				-0.67	-1.22
CV	1.22	0.94	1.62	9.52	7.18
CROSS 4 (**CO 51 x WGL 365**)	CO 51	WGL 365	$\mathbf{F_1}$	$\mathbf{F_2}$	$\mathbf{F_3}$
Max				128	98
Min				74	77
Range				54	22
Mean	95.10	94.20	94.65	78.58	88.07
Median				89.00	85.00
Mode				91.00	90.00
Skewness				1.15	0.18
Kurtosis				2.26	-1.11
CV	1.91	1.22	1.60	12.20	7.48

Table.2 Descriptive statistics for plant height

CROSS 1 (ADT 45 x NLR 34449)	ADT45	NLR 34449	F1	F2	F3
Max				112.00	106.00
Min				76.00	80.00
Range				36.00	26.00
Mean	90.48	101.38	92.26	91.42	82.30
Median				90.50	90.10
Mode				89.20	89.12
Skewness				0.52	0.34
Kurtosis				0.32	0.59
CV	3.52	2.09	3.17	8.86	5.57
CROSS 2 (CO 51 x NLR 34449)	**CO 51**	**NLR 34449**	**F1**	**F2**	**F3**
Max				111	100.05
Min				73.2	80.20
Range				37.8	19.80
Mean	89.48	100.28	90.82	89.98	82.76
Median				89.30	89.25
Mode				88.00	89.30
Skewness				0.36	0.06
Kurtosis				0.11	-0.58
CV	2.20	3.12	2.66	9.37	5.42
CROSS 3 (ADT 45 X WGL 365)	**ADT 45**	**WGL 365**	**F1**	**F2**	**F3**
Max				112.00	97.30
Min				76.00	80.20
Range				36.00	17.10
Mean	89.98	103.38	90.26	91.42	88.94
Median				90.50	90.10
Mode				89.20	90.30
Skewness				0.52	-0.49
Kurtosis				0.32	-0.12
CV	3.52	2.09	3.17	8.86	4.48
CROSS 4 (CO 51 x WGL 365)	**CO 51**	**WGL 365**	**F1**	**F2**	**F3**
Max				111	95.30
Min				73.2	80.20
Range				37.8	15.10
Mean	89.48	100.28	90.82	89.98	88.58
Median				89.30	89.45
Mode				88.00	90.30
Skewness				0.36	-0.64
Kurtosis				0.11	-0.32
CV	2.20	3.12	2.66	9.37	4.52

Table.3 Descriptive statistics for number of productive tillers per plant

CROSS 1 (ADT 45 x NLR 34449)	ADT45	NLR 34449	F1	F2	F3
Max				27.00	27.00
Min				12.00	14.00
Range				15.00	13.00
Mean	25.50	21.80	26.20	19.87	21.09
Median				20.00	20.75
Mode				20.00	20.00
Skewness				-0.002	-0.16
Kurtosis				-0.589	-0.87
CV	4.38	6.80	5.66	18.01	16.83
CROSS 2 (CO 51 x NLR 34449)	**CO 51**	**NLR 34449**	**F1**	**F2**	**F3**
Max				27.00	26.80
Min				12.00	16.00
Range				15.00	10.80
Mean	22.08	18.54	26.84	19.80	22.97
Median				19.65	22.25
Mode				19.00	23.00
Skewness				0.02	-0.38
Kurtosis				-0.74	-0.57
CV	6.77	7.63	4.81	18.79	13.03
CROSS 3 (ADT 45 X WGL 365)	**ADT 45**	**WGL 365**	**F1**	**F2**	**F3**
Max				27.00	27.00
Min				12.00	15.00
Range				15.00	12.00
Mean	25.50	21.80	26.20	19.87	20.92
Median				20.00	20.15
Mode				20.00	19.00
Skewness				-0.002	0.14
Kurtosis				-0.589	-1.04
CV	4.38	6.80	5.66	19.01	15.62
CROSS 4 (CO 51 x WGL 365)	**CO 51**	**WGL 365**	**F1**	**F2**	**F3**
Max				27.00	26.80
Min				12.00	16.00
Range				15.00	10.80
Mean	22.08	18.54	26.84	19.80	21.78
Median				19.65	21.70
Mode				19.00	20.00
Skewness				0.02	-0.13
Kurtosis				-0.74	-0.64
CV	6.77	7.63	4.81	19.79	11.59

Table.4 Descriptive statistics for panicle length

CROSS 1 (**ADT 45 x NLR 34449**)	ADT45	NLR 34449	F_1	F_2	F_3
Max				28.50	28.60
Min				20.10	21.00
Range				8.40	7.60
Mean	25.16	26.90	26.90	23.54	25.78
Median				26.10	26.00
Mode				26.50	27.00
Skewness				-0.76	-0.91
Kurtosis				0.28	0.76
CV	2.38	3.14	2.07	6.92	5.93
CROSS 2 (**CO 51 x NLR 34449**)	CO 51	NLR 34449	$\mathbf{F_1}$	$\mathbf{F_2}$	$\mathbf{F_3}$
Max				28.50	28.60
Min				22.10	23
Range				6.4	5.6
Mean				24.56	25.99
Median	24.56	23.54	27.14	25.60	26.05
Mode				26.50	27.00
Skewness				-0.25	-0.39
Kurtosis				-0.99	-0.38
CV	5.45	7.05	2.84	6.25	4.65
CROSS 3 (**ADT 45 X WGL 365**)	ADT 45	WGL 365	$\mathbf{F_1}$	$\mathbf{F_2}$	$\mathbf{F_3}$
Max				28.50	28.60
Min				20.10	20.30
Range				8.40	8.30
Mean	25.16	26.90	26.90	25.54	26.22
Median				26.10	26.50
Mode				26.50	27.00
Skewness				-0.76	-1.62
Kurtosis				0.28	4.63
CV	2.38	3.14	2.07	6.92	5.27
CROSS 4 (**CO 51 x WGL 365**)	CO 51	WGL 365	$\mathbf{F_1}$	$\mathbf{F_2}$	$\mathbf{F_3}$
Max				28.50	28.60
Min				22.10	23.20
Range				6.4	5.40
Mean				25.56	26.39
Median	24.56	23.54	27.14	25.60	26.50
Mode				26.50	27.00
Skewness				-0.25	-0.60
Kurtosis				-0.99	0.33
CV	5.45	7.05	2.84	6.25	4.03

Table.5 Descriptive statistics for grain yield

CROSS 1 (ADT 45 x NLR 34449)	ADT45	NLR 34449	F1	F2	F3
Max				53.60	55.70
Min				40.70	42.30
Range				12.90	13.40
Mean	48.66	53.26	53.10	**47.06**	**48.53**
Median				46.50	48.00
Mode				46.00	46.00
Skewness				-0.06	0.74
Kurtosis				0.41	-0.23
CV				5.65	5.90
CROSS 2 (CO 51 x NLR 34449)	**CO 51**	**NLR 34449**	**F1**	**F2**	**F3**
Max				52.50	56.30
Min				42.50	42.00
Range				10.00	14.30
Mean	**51.90**	**50.20**	**51.90**	**47.13**	**49.57**
Median				46.50	48.70
Mode				46.00	48.00
Skewness				0.58	0.38
Kurtosis				0.17	-0.41
CV				4.28	6.47
CROSS 3 (ADT 45 X WGL 365)	**ADT 45**	**WGL 365**	**F1**	**F2**	**F3**
Max				53.60	56.30
Min				40.70	45.00
Range				12.90	11.30
Mean	48.66	53.26	53.10	**47.06**	**48.63**
Median				46.50	48.70
Mode				46.00	48.00
Skewness				-0.06	0.612
Kurtosis				0.41	-0.71
CV				5.65	6.23
CROSS 4 (CO 51 x WGL 365)	**CO 51**	**WGL 365**	**F1**	**F2**	**F3**
Max				52.50	55.60
Min				42.50	44.50
Range				10.00	11.10
Mean	**51.90**	**50.20**	**51.90**	**47.13**	**49.31**
Median				46.50	48.00
Mode				46.00	46.00
Skewness				0.58	0.86
Kurtosis				0.17	-0.49
CV				4.28	5.92

Table.6 Parent offspring correlation in F_2 and F_3 and regression of the crosses over segregating generation for different characters in cross (ADT 45 x NLR 34449) and (CO 51 x NLR 34449)

	ADT 45 x NLR 34449		CO 51 x NLR 34449	
Characters	**Correlation**	**Regression**	**Correlation**	**Regression**
	F_2 - F_3	**F_2 - F_3**	**F_2 - F_3**	**F_2 - F_3**
Days to 50 per cent flowering	0. 329	0.385	0.465	0.801
Plant height	0.259	0.528	0.361	0.632
Number of productive tillers per plant	0.513	0.604	0.717	0.872
Panicle length	0.390	0.451	0.498	0.658
Single plant yield	0.604	0.551	0.610	0.428

Table.7 Parent offspring correlation in F_2 and F_3 and regression of the crosses over segregating generation for different characters in cross (ADT 45 X WGL 365) and (CO 51 x WGL 365)

	ADT 45 X WGL 365		CO 51 x WGL 365	
Characters	**Correlation**	**Regression**	**Correlation**	**Regression**
	F_2 - F_3	**F_2 - F_3**	**F_2 - F_3**	**F_2 - F_3**
Days to 50 per cent flowering	0.719	0.937	0.663	0.918
Plant height	0.561	0.812	0.712	1.022
Number of productive tillers per plant	0.705	0.900	0.890	1.15
Panicle length	0.552	0.809	0.609	0.919
Single plant yield	0.776	0.896	0.696	0.836

The intergeneration correlation and regression for yield component characters are presented in Tables 6 and 7. It was calculated for selected F3 over F2 plants in four crosses for all different characters. The selection of the plants is effective only when the performance of progeny is more dependable on the performance of the parent. Lush (1940) suggested that selection of best genotypes based on its genetic potentiality can be ascertained by regression of the progeny mean over the value of corresponding parent. All the characters showed strong correlation and regression between F_2 and F_3 generation.

The F_2 generation showed significant positive correlation and regression with F_3 generation for all the traits. The highest correlation in F_2 and F_3 in the cross AD T45 X NLR 34449 Nwas observed in grain yield per plant (0.60) followed by productive tillers per plant (0.51) and lowest is plant height (0.26).

The highest correlation in F_2 and F_3 in the cross CO 51 X NLR 34449 was also observed in single plant yield (0.78) and lowest is panicle length (0.32). The highest correlation in F_2 and F_3 in the cross ADT 45 X WGL 365 was observed in single plant yield (0.78) and lowest is panicle length (0.55) and The highest correlation in F_2 and F_3 in the cross CO 51 X WGL 365 was observed in number of productive tillers per plant (0.90) and lowest is panicle length (0.61) The positive significant regression and correlation coefficient estimate in F2-F3 generation was reported by Kavithamani *et al.,* (2013), Kahani and Hittalmani (2016) and Sigh *et al.,* (2017). This indicated the effectiveness of selection for these characters. These results were also consistent with the mean performance of the F_2 selection and F_3 progeny mean performance. The worth of the early generation selection can be known by intergeneration correlation. Selection is generally practiced in segregating F2 generation based on high mean and high heritability. However, the elimination of environmental variance and estimating the genetic variance that is being inherited from F2 to F3 generation by parent offspring regression helps in knowing the nature of inheritance and possible selection. Similar conclusions were drawn by Singh *et al.,* (2017).

Present study confirmed that thus usefulness of selection in early generation and it may have greater impact on breeding program of rice with respect to number of productive tillers per plant and single plant yield. Parent-offspring correlation showed strong association for number of productive tillers, single plant yield and panicle length in F2 and F2:3 generation indicates that selection was effective at this stage. The results indicated that F_2 is good indicator of F_3 performance for all the traits in all the crosses, Hence, selection of high yielding genotypes at early generation based on these characters is valuable for identification of promising cultures.

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