Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(4): 2476-2481
Received: 15-05-2018
Accepted: 20-06-2018

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Genetic variability, heritability and genetic advance in medium mature rice (*Oryza sativa* L.) hybrids in eastern plain zone of Uttar Pradesh

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Abstract
Data were recorded for 13 quantitative and 7 quality characters to study genetic variability, heritability and genetic advance. Analysis of variance among 31 rice hybrids showed highly significant differences for all the characters indicated the presence of substantial amount of genetic variability. On the basis of mean performance highest grain yield per hill observed in hybrid IHRT-M 3311 (32.67 g), followed by IHRT-M 3312 (30.67 g), IHRT-M 3314 (29.67 g). The hybrid IHRT-M 3311 was considered to be best hybrid having high grain yield, early maturity, more no of tillers per plant coupled with desirable hulling %, long kernel length and less width. Highest GCV and PCV was observed for grain yield per hill (27.14, 27.55), followed by spikelets per panicle (22.67, 22.76) indicating that these characters could be used as selection for crop improvement. High estimates of heritability were observed for plant height, spikelets per panicle and biological yield (99.00%) followed by days to 50% flowering (98.3%) and days to maturity (97.34%). High heritability coupled with high genetic advance was observed for spikelets per panicle (99.24% and 110.69), indicating predominance of additive gene effects and the possibilities of effective selection for the improvement of these characters.

Keywords: hybrid rice, yield, genotypic variance, phenotypic variance, genetic variability, heritability and genetic advance

Introduction
Rice is life' was the theme of International year of rice 2004 denoting its overwhelming importance as an item of food and commerce (Pandey *et al.*, 2010). Rice is inseparable from our day-to-day life since time immemorial as evident from its use in almost all rituals of our culture. The crop is grown in a diverse geographical and climatic conditions ranging from below sea level in Kuttanad (Kerala) to high altitude in Kashmir valley. Rice is cultivated in a hydrology range of moisture stress upland condition to waterlogged ecology.

India stands first in area and second in production. India is a major rice growing country in world with an area of 43.97 million hectares, having production 106.2 million tones and productivity of 2.372 t/ha. It is estimated that the demand for rice will be 129.6 million tons by 2040 and 137.3 million tons by 2050 for internal consumption. Directorate of Rice Research Annual Report (2014-15).

The yield level of modern rice varieties obtained from green revolution technologies has reached a plateau especially in irrigated ecosystem. Without an immediate shift in the yield frontier for rice and increased rice production, future rice supplies will not keep up with demand. Generally hybrid rice offers 30% yield advantage over conventional pure line varieties. Recent breakthrough in tropical hybrid rice technology provide some hope and indication for sustaining future rice production in India

At present, the hybrid entries imported and developed by different seed agencies and research stations are being tested every year in on-station and on-farm trials, but no specific selection criteria have yet been reported for the recommendation of hybrid varieties in eastern plain zone of Uttar Pradesh. The present investigation was, therefore, undertaken to study the genetic variability, heritability and genetic advance for important economic characters, so that appropriate strategies for recommending the suitable hybrid varieties in eastern plain zone of Uttar Pradesh condition could be worked out with the following objectives.

1. To evaluate rice hybrids for yield, yield attributing traits
2. To assess genetic variability among the rice hybrids.
3. To evaluate heritability and genetic advance.

Materials and Methods

The experimental materials comprised of 31 pre released medium duration rice hybrids including two checks received from (DRR-ICAR)), Hyderabad (T.S) during *Kharif*-2017, planted in the Field Experimentation Centre of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, located on the banks of River Yamuna, Allahabad, U.P during Kharif 2017.

The observations recorded on randomly selected from each genotype in each replication leaving the first two border rows from all the four sides, in order to avoid sampling error. Readings recorded from five plants were averaged replication-wise and the mean data was used for statistical analysis for 13 quantitative characters namely plant height (cm), flag leaf length (cm), flag leaf width (cm), number of tillers per hill, number of panicles per hill, panicle length (cm), number of spikelets per panicle, biological yield per plant (g), harvest Index, test weight (1000 grain weight), grain yield per plant except days to 50% flowering and days to maturity. The data for these two traits were considered on plot basis.

Results and Discussion

Mean performance

According to the mean performance (table 1.1) a wide range of variation was found for most of the characters. The variability exploited in breeding programme is desired from the naturally occurring variants and wild relatives of main crop species as well as from strains and genetic stocks artificially developed by human efforts. Through this study an attempt was made to assess the mean performance of 31 genotypes for 13 quantitative characters as the mean serve as the basis for eliminating the undesirable genotypes (Subbaiah *et al.* 2011 and Babu *et al.* 2013).

Days to 50% flowering

The estimates of days to 50% flowering ranged from 85 to 117 days with a mean of 102.9 days. Minimum days to 50% flowering is a desirable character, the hybrid IHRT-M 3327 (85 days) showed the earliest days to 50% flowering which was significant and considered as the best genotype for 50% flowering followed by IHRT-M 3329 (89 Days), IHRT-M 3315 (90 Days), IHRT-M 3328 (91 Days), IHRT-M 3311 (97 Days), IHRT-M3310, IHRT-M 3321, IHRT-M 3324, IHRT-M (99 Days), IHRT-M 3309 and IHRT-M 3319 (100 Days) while delayed days to 50% flowering was observed for genotypes IHRT-M 3318 (117 Days) followed by IHRT-M 3306 (113 Days), IHRT-M 3302, IHRT-M 3320 (111 Days), IHRT-M 3301, IHRT-M 3303, IHRT-M 3314, IHRT-M 3326, IHRT-M 3331(109 Days) IHRT-M 3313, IHRT-M 3317, IHRT-M 3325 (108 Days) and IHRT-M 3312 (106 Days).

Plant height (cm)

The estimates of Plant height among the genotypes ranged from 83.9 cm to 164.39 cm with a general mean of 107.08 cm. Both hybrids IHRT-M 3328 (83.9 cm) & IHRT-M 3321 (83.94 cm) were the shortest in stature followed by IHRT-M 3331 (88.44 cm), IHRT-M 3315 (94.5 cm), IHRT-M 3313 (94.68 cm) while the tallest plants by stature were IHRT-M 3306 (164.39 cm), followed by IHRT-M 3310 (132.82 cm), IHRT-M 3316 (118.6 cm) & IHRT-M 3304 (118.18 cm).

Flag leaf length (cm)

Flag leaf length varied from 24.09 cm to 47.15 cm with a mean of 36.17 cm. Maximum flag leaf length was observed in hybrid IHRT-M 3316 (47.15 cm) among all the genotypes which was significant, followed by IHRT-M 3306 (44.47 cm), IHRT-M 3325 (43.73 cm), IHRT-M 3319 (42.87 cm) & IHRT-M 3303 (42.07 cm). While the lowest value of flag leaf length was recorded in IHRT-M 3315 (24.09 cm) followed by IHRT-M 3331 (28.45 cm), NDR-359 (NVC) (28.72 cm), IHRT-M 3312 (29.2 cm) & IHRT-M 3328 (29.39 cm).

Flag leaf width (cm)

Flag leaf width varied from 1.06 cm to 1.83 cm with a mean of 1.45 cm. Maximum flag leaf width was in IHRT-M 3306 (1.83 cm). However IHRT-M 3301 (1.82 cm), IHRT-M 3316 (1.79 cm), IHRT-M 3304 (1.72 cm) were statistically at par, while the hybrid IHRT-M 3321 (1.06 cm) and IHRT-M 3331 (1.09 cm) had lowest value, followed by IHRT-M 3305 (1.24 cm), IHRT-M 3328 (1.25 cm) and IHRT-M 3310 (1.29 cm).

Number of tillers per hill

Number of tillers per hill varied from 11.23 to 23.4 with a mean value of 16.91. The hybrid IHRT-M 3303 (23.4) had highest number of tillers per hill followed by IHRT-M 3320 (22.53), IHRT-M 3327 (20.47), IHRT-M 3312, IHRT-M 3319 (19.67), IHRT-M 3302 (19) and IHRT-M 3306 (18.67). While the minimum number of tillers per hill was in the hybrid PHB-71 (NHC) 11.23 followed by NDR-359 (NVC) (12.03), IHRT-M 3311 (12.2), IHRT-M 3323 (12.67) and IHRT-M 3331 (14.47).

Number of panicles per hill

Number of panicle bearing tillers were counted per plant and varied from 11.17 to 18.93 with a mean value of 15.77. The hybrid IHRT-M 3303 (18.93) was the best genotype for number of panicles per hill followed by IHRT-M 3312 (18.8), IHRT-M 3318 (18.07), and IHRT-M 3302 (17.93) while the minimum number of panicles was observed for the local check NDR-359 (11.17) followed by PHB-71 (NHC) (11.23), IHRT-M 3311 (12.2), and IHRT-M 3323 (12.67).

Panicle length (cm)

The estimates of panicle length was measured and varied from 22.63 cm to 31.5 cm with a mean of 26.35 cm. The longest panicle was observed in hybrid IHRT-M 3311 (31.5 cm) which was highly significant followed by IHRT-M 3301 (29.47 cm), IHRT-M 2209, IHRT-M 3322 (28.73 cm) and IHRT-M 3319 (28.05 cm). While the hybrid IHRT-M 3323 (22.63 cm) showed lowest panicle length, followed by IHRT-M 3328 (23.9 cm), IHRT-M 3303 (24.08 cm) and IHRT-M 3316 (24.23 cm).

Number of spikelets per panicle

The mean value for the number of grains/panicle is an important yield contributing trait which has direct effect on grain yield. The number of spikelets per panicle were counted and varied from 103 to 283.6 with a mean of 185.65. The hybrid IHRT-M 3304 (283.6) had the highest number of spikelets per panicle, followed by IHRT-M 3316 (268.2), IHRT-M 3326 (238.6), IHRT-M 3327 (236.8) and IHRT-M 3308 (229.6). The minimum number of spikelets per panicle was observed in the hybrid IHRT-M 3331 (103), followed by IHRT-M 3315 (112), IHRT-M 3311 (142), IHRT-M (184.07), IHRT-M 3318, IHRT-M 3325 (148.4) and IHRT-M 3317 (149).

Days to maturity
The estimates of Days to maturity varied from 115 days to 141 days with mean of 131.03 days. Minimum days to maturity is a desirable character that's why the hybrid IHRT-M 3327 (115 Days) can be taken as best early duration hybrid for days to maturity followed by, IHRT-M 3329 (119 Days), IHRT-M 3315, NDR-359 (NVC) (120 Days), IHRT-M 3328 (121 Days) and IHRT-M 3311 (125 Days), while hybrid IHRT-M 3306 (1141 Days) showed late days to maturity followed by IHRT-M 3302 (139 Days), IHRT-M 3318, IHRT-M 3326 (138 Days), IHRT-M 3303, IHRT-M 3314 and IHRT-M 3331 (137 Days).

Biological yield per hill (g)
The Biological yield per hill ranged from 47.3 g to 94.36 g with mean of 73.85 g, The hybrid IHRT-M 3304 (94.36) exhibited highest biological yield which was highly significant followed by IHRT-M 3316 (90.48), IHRT-M 3326 (87.28), IHRT-M 3301 (86.36), IHRT-M 3308 (83.76), IHRT-M 3315 (83.64) and IHRT-M 3302 (83.26). The minimum value was observed in the hybrid IHRT-M 3329 (47.3) followed by NDR-359 (NVC) (53.48), IHRT-M 3331 (59.22), IHRT-M 3327 (59.92), PHB-71 (NHC) (60.1), IHRT-M 3322 (66.9) and IHRT-M 3309 (67.62).

Harvest Index (%)
The harvest index varied from 21.8 to 43.51 with the mean of 31.96. While the hybrid PHB-71 (43.51) had highest harvest index which was highly significant followed by IHRT-M 3312 (42.3), NDR-357 (NVC) (39.78), IHRT-M 3303 (39.02), IHRT-M 3313 (39.1) and IHRT-M 3309 (38). The minimum value was observed in the hybrid IHRT-M 3326 (21.8), followed by IHRT-M 3316 (22.22), IHRT-M 3304 (22.34) and IHRT-M 3305 (23.73), IHRT-M 3306 (23.83) and IHRT-M 3324 (24.3).

Test weight (g)
The test weight (g) was recorded and varied from 18.9 g to 25 g with mean of 21.71 g. The hybrid PHB-71 (NHC) (25 g) had highest test weight which was significantly and followed by IHRT-M 3311 (24.37 g), IHRT-M 3312 (24.35 g), IHRT-M 3303 (24.02 g), IHRT-M 3315 (23.33 g), IHRT-M 3321 (23.16 g), IHRT-M 3317 (23.12 g) and IHRT-M 3305 (23.02 g). The least test weight observed in IHRT-M 3309 (18.9), followed by IHRT-M 3301 (19.06), IHRT-M 3324 (19.6 g), IHRT-M 3316 (20 g), IHRT-M 3328 (20.06) and IHRT-M 3306 (20.08 g).

Grain yield per hill (g)
Grain yield per hill varied from 12.67 g to 32.67 g with mean of 21.78 g. The maximum grain yield was observed in IHRT-M 3311 (32.67 g), followed by IHRT-M 3314 & IHRT-M 3315 (29.67 g), IHRT-M 3313 (29.33 g), IHRT-M 3301 (29 g), IHRT-M 3302 (28.33 g) and IHRT-M 3303 (28 g). The minimum grain yield was observed in both hybrids IHRT-M 3310 & IHRT-M 3326 (12.67), followed by IHRT-M 3327 (13.67 g), IHRT-M 3328 (14 g), IHRT-M 3316 (16.33 g) and IHRT-M 3329 (16.67 g).

Variability parameters
Variability plays an important role in crop breeding. The development of an effective plant breeding programme depends on the existence of genetic variability. The efficiency of selection largely depends on the magnitude of genetic variability present in the plant population.

Estimation of genotypic variance and phenotypic variance
Estimation of genotypic variance (σ^2g) and phenotypic variance (σ^2p) were obtained for different characters and wide range of variance was observed for all the characters. The highest variance (σ^2g and σ^2p) was recorded for spikelets per panicle (1771.52 and 1785.05) followed by plant height (248.20 and 249.32), biological yield per plant (112.95 and 114.01), days to 50% flowering (59.40 and 60.43) and Days to maturity (44.21 and 45.28). Whereas, tillers per hill (6.44 and 11.08), panicles per hill (3.34 and 4.95), panicle length (3.16 and 4.27), showed low variance. The least genotypic and phenotypic variance was observed in flag leaf width (0.03 and 0.04).
Phenotypic variance was higher than genotypic variance for all the yield and yield attributing characters indicates that the influence of environmental factors on these traits. Similar findings were reported by Singh *et al.* (2011) [42], Prajapati *et al.* (2011) [36], Rather *et al.* (1981), Kumar and Senapati (2013) [27], Vinoth *et al.* (2016) [47], for grain yield per plant, plant height, number of spikelets per panicle and biological yield.

Coefficient of variation
Coefficient of variation is the per cent ratio of standard deviation of sample to its mean value. Analysis of variance provides estimate of phenotypic and genotypic variance used for the estimation of respective coefficient of variation.

Estimation of genotypic and phenotypic coefficient of variation
The estimation of phenotypic coefficient of variation and genotypic coefficient variation for all the characters were presented in (table 1.2).
The genetic coefficient of variability provide a mean to compare the genetic variability for the quantitative traits. The studies on GCV and PCV indicated that the presence of high amount of variation and role of the environment on the expression of these traits. The magnitude of PCV was higher than GCV for all the characters which may due to higher degree of interaction of genotypes with the environment (Senapati and Kumar, 2015) [41],
The difference between PCV and GCV were less for most of the characters indicating lesser contribution of environment towards of these characters. A wide range of phenotypic coefficient of variation (PCV) was observed for the character ranging from (5.07) for days to maturity to (27.14) for grain yield per hill. Higher magnitude of phenotypic coefficient of variation was recorded for grain yield per hill (27.55), followed by spikelets per panicle (22.76). Lowest magnitude of PCV was recorded for days to maturity (5.14), followed by days to 50% flowering (7.55), panicle length (7.84) and test weight (8.71). This finding were in accordance with the findings of Selvaraj *et al.* (2011) [40], Ketan *et al.* (2014) [26], Islam *et al*. (2015) [20] and Vinoth *et al.* (2016) [47].
Genotypic coefficient of variation (GCV) ranged from (5.07) for days to maturity to (27.14) for grain yield per hill. Higher magnitude of genotypic coefficient of variation was recorded for grain yield per hill (27.14), followed by spikelets per panicle (22.67). Lowest magnitude of GCV was recorded for panicle length (6.74), test weight (7.29) and days to 50% flowering (7.49). Selvaraj *et al.* (2011) [40], Singh *et al.* (2012) [43] and Roy *et al.* (2015) [39].
Relatively low magnitudinal differences were observed between phenotypic coefficient of variation and genotypic coefficient of variation for Days to 50% flowering, plant

height, biological yield, days to maturity, spikelets per panicle, grain yield per hill and harvest index.

Relatively high differences between phenotypic coefficient of variation and genotypic coefficient of variation observed for tillers per hill. These findings suggest that greater influence of the environment in the expression of these traits. Similar results were also reported by Mohammad *et al* (2002) [33] that the high magnitudinal difference between phenotypic coefficient of variation and genotypic coefficient of variation for flag leaf width and number of panicles per hill, where as environmental coefficient of variation contributed more in the expression of these characters. These PCV, GCV values are not helpful in determining the heritable portion of variation (Falconer, 1960).

Heritability and Genetic advance

The proportion of genetic variability which is transmitted from parents to offspring is reflected by heritability. The estimates of heritability are more advantageous when expressed in terms of genetic advance, knowledge of heritability of a character is important as it indicate the possibility and extend to which improvement is possible through selection.

The estimates of heritability in the present study are presented in (table 1.2). Biological yield per plant, days to 50% flowering, harvest index, spikelets per panicle, days to maturity, grain yield per hill, plant height showed high heritability estimates indicating the less influence of environment on these characters. Bhati *et al.* (2015) [6] also reported high heritability values for number of spikelets per panicle and plant height.

The heritability estimates were high (>0.60) for plant height, spikelets per panicle and biological yield per plant (99.00%) followed by days to 50% flowering (98.00%), days to maturity (97.63%), harvest index (97.34%), grain yield per hill (97.00%), flag leaf width (81.6), flag leaf length (74.9%), panicle length (74.00%), test weight (70%), Moderate heritability (>0.30 to <0.60) for panicles per hill (67.6%) and tillers per hill (58.11%), low heritability (<0.30) was not found in any character. Kumar and Senapati (2013) [27] recorded high heritability estimates for most of the character. According to such characters governed predominantly by additive gene action and can be improved through individual plant selection.

High heritability alone is not enough to make sufficient improvement through selection in advance generation unless accompanied by substantial amount of genetic advance.

High heritability coupled with high genetic advance (>30) in the present set of hybrids was recorded for spikelets per panicle (99.24% and 110.69), plant height (99.5% and 41.49) indicating predominance of additive gene effects and the possibilities of effective selection for the improvement of these characters. Similar findings were reported by Bhati *et al.* (2015) [6].

Genetic advance as per cent of mean was highest for grain yield per hill (70.59%) followed by spikelet per panicle (59.62%), harvest index (51.31%), plant height (38.75%), biological yield (37.81%), flag leaf length (32.74), tillers per hill (30.19%), flag leaf width (28.88) and panicles per hill (25.16). Similar findings were reported by Roy *et al.* (2015) [39].

Moderate genetic advance as per cent of mean was recorded for and Low genetic advance as per cent of mean was recorded for days to 50% flowering (19.60%),test weight (16.10), panicle length (15.31%) and days to maturity (13.23%) (Table 1.2).

The present investigation concluded that presence of adequate amounts of variability for yield and its associated traits among the 31 rice hybrids on the basis of mean performances IHRT-M 3311 (9.8 t/ha) was found to be superior in grain yield followed by IHRT-M 3312 (9.2 t/ha) and IHRT-M 3314 (8.9 t/ha). Among the medium duration rice hybrids IHRT-M 3311 was best because it showed high grain yield, early maturity over check it showed nearly 1.2 ton/ha. High heritability coupled with high genetic advance in the present set of hybrids was recorded for spikelets per panicle. Genetic advance as per cent of mean was highest for grain yield per hill followed by spikelet per panicle, harvest index, plant height, biological yield per plant and flag leaf length. Hence, utmost importance should be given to these characters during selection for single plant yield improvement. Since one year data is not sufficient to conclude results. So, further experimentation is required to corroborate the results.

Table 4.1: Analysis of variance for 13 quantitative characters in 31 rice hybrids.

S. No	Characters	Mean sum of squares		
		Replications (df=2)	Treatments (df=30)	Error (df=60)
1.	Days to 50% Flowering	0.032	179.23**	1.02
2.	Plant Height	0.032	745.71**	1.11
3.	Flag Leaf Length	3.36	89.64**	9.00
4.	Flag Leaf Width	0.043	0.09**	0.0069
5.	Tillers per hill	3.382	10.58**	1.10
6.	Panicles per hill	1.611	23.95**	4.64
7.	Panicle Length	4.639	11.63**	1.60
8.	Spikelets per Panicle	9.969	5328.08**	13.53
9.	Days to Maturity	0.033	133.69**	1.07
10.	Biological Yield	0.090	339.91**	1.06
11.	Harvest index	0.0002	120.01**	1.08
12.	Test Weight	0.038	8.58**	1.07
13.	Grain Yield per hill	0.035	105.83**	1.05

Table 4.2: Genetic parameters for 13 quantitative characters in 31 rice hybrids**.**

S. No	Characters	σ^2g	σ^2p	Coefficient of variation		h^2% (B.S)	GA	GA as % of mean
				GCV	PCV			
1	Days to 50% Flowering	59.40	60.43	7.49	7.55	98.3	20.17	19.60
2	Plant Height	248.2	249.32	14.71	14.75	99.5	41.49	38.75
3	Flag Leaf Length	26.88	35.88	14.33	16.56	74.9	5.10	30.19
4	Flag Leaf Width	0.03	0.04	12.11	13.40	81.6	3.96	25.16
5	Tillers per hill	6.44	11.08	15.00	19.68	58.11	4.03	15.31
6	Panicles per hill	3.34	4.95	11.59	14.10	67.6	11.84	32.74
7	Panicle Length	3.16	4.27	6.74	7.84	74.00	0.41	28.88
8	Spikelets per Panicle	1771.5	1785.05	22.67	22.76	99.24	110.69	59.62
9	Days to Maturity	44.21	45.28	5.07	5.14	97.63	17.34	13.23
10	Biological Yield	112.95	114.01	14.39	14.46	99.00	27.92	37.81

11	Harvest index	39.64	40.73	19.70	19.97	97.34	16.40	51.3
12	Test Weight	2.51	3.58	7.29	8.71	70.00	3.49	16.10
13	Grain Yield per hill	34.93	35.98	27.14	27.55	97.00	15.37	70.59

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