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Study the relationships between yield and yield-related traits for rice under rainfed condition

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Abstract
Twenty-eight genotypes of rice including hybrids were grown over a three locations namely (I) Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, UP, (II) Mujhadih, Mirzapur, UP and (III) Dagmagpur, Mirzapur, UP. The hybrids Pusa 6A x HUR 105 recorded high *parse* performance for grain yield per plant. Apart from its high grain yield, Pusa 6A x Pant Dhan 12 also showed high proline content and reduced height. The genotypes such as Danteshwari, NDR 97, BPT 5204, Pusa6B, Pant Dhan-12 and IR79156B showed lowest plant height. Similarly, considering panicle length, the genotypes *viz*., US 312 and hybrids like IR79156A x Akshaydhan and Pusa 6A x IET 222 registered high mean values. The genotype Pusa 6A x Pant Dhan 12, followed by NDR 97 and Pusa6A x URG 30 recorded highest number of effective tillers per plant. The hybrids IR79156A x BPT 5204PRR-78, Pusa6A x Pant Dhan 12 with higher 1000 grain weight. The genotype MTU 7029 followed by BPT 5204, P-27-63 and Sarju 52 were the earliest to flower as well as to mature.

Keywords: Hybrids, mean value, yield, yield component.

Introduction

Rice (*Oryza sativa* L.) crop is a monocotyledonous angiosperm belongs to the genus *Oryza* of family Poaceae (Graminae). The genus *Oryza* is known to consist of two cultivated species i.e. Asian rice (*Oryza sativa*, 2n=24=AA) and African rice (*Oryza* glaberrima, 2n=24=AA) and 22 wild species (2n=24, 48). Wild species (2n = 24, 48) representing 10 genomic types namely, AA, BB, CC, BBCC, CCDD, EE, FF, GG, HHJJ and HHKK. Further, the Asian rice has undergone differentiation into three distinct eco-geographical subspecies, *viz*., India, japonica and javanica (Vaughan *et al*. 2003) [15]. South East Asia is supposed to be the original home of *Oryza sativa*. It is the staple food for one-third of the world's population and occupies almost one-fifth of the total land area covered under cereals (Ren *et al*., 2006) [8] and rich in diversity regarding structure, functions and properties (Vandeputte and Delcor, 2004; Zhou, Robards, Helliwell, & Blanchard, 2002) [14, 17]. It is cultivated in 114 countries across the globe, but 90 percent of world's rice is grown in Asia. Rice production, consumption and trade are mostly concentrated in Asia. One-third of Asia's rice production is consumed in China and one-fifth in India. Among the rice-growing countries in the world, India has the largest area under rice crops (about 45 million ha.) and ranks second in production next to China. (IRRI 2016, standard evaluation system for rice.) [2] Rice is grown in almost all the states of India, but major rice-producing states fall in the regions of middle and lower Gangetic plains, as well as the coastal lowlands of peninsular India, Uttar Pradesh has total rice production of around 12.5 mt (DAE 3rd adv. estimate) which is second largest rice producer in India following West Bengal (14.6 mt). Rice is a short-day self-pollinated crop, needs a hot humid climate with average temperature of 21 to 370 ºC throughout the life cycle of crop. It is grown under many different conditions and production systems. It is the only cereal crop that can grow for long periods of time in standing water. Most of the Asian countries have been able to keep pace between rice production growth rate and that of population during the last four decades. This has been mainly possible due to the contributions made by the green revolution technologies. However, it is of great concern to note that the rate of growth in rice production has started declining during 90s and there has been a plateauing effect.

After a brief review of rice research in India and considering the gains obtained through green revolution technologies, the possibilities and prospects of utilizing the gene revolution technologies are considered for further enhancing the production and productivity of rice for ensuring food security. To feed the ever-growing population, the targeted rice production of the world, China and India for the year 2030 is conceptualized as 771.02, 168.90 and 130.02 million tonnes respectively (United State Department of Agriculture 2014) [13]. To get success in achieving the target, the increase in rice productivity is the only option left.

Therefore, it is imperative to focus on the efforts needed to further improve its competitiveness in the international market to meet the ever-growing domestic needs of food and enhance exports and to achieve sustainability and stability of rice production the research in varietal improvement, evaluation, modification of plant architecture, development of hybrid rice technology, wide-hybridization, soil and nutrient management and integrated pest management would receive priority.

Materials and Methods

The present investigation "Stability analysis of CMS based experimental hybrids and genotypes for yield and yield traits in rice (*Oryza sativa* L.)" was taken up in accordance with the objectives. Twenty-eight genotypes of rice including hybrids were grown over a three locations namely(I)Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, UP, (II) Mujhadih, Mirzapur, UP and (III) Dagmagpur, Mirzapur, UP.

The materials developed and maintained under the hybrid rice project funded by the UP Council of agricultural research (UPCAR), Lucknow in leadership of the supervisor (Prof. S.K. Singh) during Kharif 2014 were used for conducting the study during Kharif 2016.

The weather conditions during the evaluation period from June 2016 to November 2016 were almost normal and favourable for the crop growth. However, the experiment was conducted under rainfed conditions. Twenty-eight genotypes were tested at three locations during Kharif 2016. The experiments layout were randomized complete block design (RCBD) with three replications for all trials under study. Trials were planted according to the practices followed under different growing locations. Net Plot size was 1.8m x 1.8m for each location under study. Inter and intra-row spacing was 20cm and 15 cm, respectively in each location. At Agricultural Research Farm BHU, nursery sowing was done on 11th June 2016 for all three locations. Fertilizers were applied as: 120 kg N, 60 kg $P_2O_5$and 60 kg K_2O per hectare. Normal cultural practices and plant protection measures were followed in each trial.

Results and Discussions

One of the main objectives of any breeding program is to produce high-yielding and better-quality lines for release as cultivars to farmers. The prerequisite to achieve this goal the presence of sufficient amount of variability, in which desired lines are to be selected for further manipulation to achieve the target. Introduction of new populations can be made from one region to the other easily and may be used for further manipulation to develop breeding lines. The present study was conducted to evaluate the performance of twenty-eight exotic lines in order to assess the presence of variability for desired traits and a significant amount of variation for different parameters was conducted.

Days to 50 per cent flowering

Days to 50 per cent flowering ranged from 75.77 to 121.33 days with a mean of 92.18 days. Among all the genotypes, IET 22202 comes to flowering very early (75.77), whereas BPT 5204 flowered very lately (121.33 days). Twelve genotypes were earlier in flowering when compared to the general mean (92.18 days) of the days to 50 per cent flowering. Similar results have been reported by Tahir *et al.* (2002) [12] in rice. This type of variability might be due to the genetic makeup of the exotic lines and genotypic environmental interaction. The better performance of the tested genotypes over the check might be the genotypic novelty and adaptability to the present environment or the overexploitation of the local cultivars.

Days to maturity

The number of days to maturity ranged from 103.33 days to 146.88 days with a mean maturity of 118.84 days. The genotype IET 22202 came to maturity early (103.33 days), while MTU 7029 was found late in maturity (146.88 days) followed by BPT 5204 (146.33 days). Fourteen genotypes were earlier in maturity when compared to mean (118.84 days) maturity of the genotypes for this trait. Karim *et al.* (2007) [3] studied 41 aromatic rice genotypes for variability and genetic parameter analysis and found highly significant mean sum of squares due to genotypes for Days to maturity. He reported that variation for days to maturity was attributed by genetic constituents rather than environment. Short-duration lines can a good source for breeders to use as parents.

Number of tillers per plant

The number of tillers per plant ranged from 7.11 to 11.00 with a mean of 8.77. The highest number of tillers per plant was recorded by the hybrid Pusa6AxPant Dhan 1 (11), whereas the lowest value was registered by Sarju 52 (7.11). Twelve genotypes showed more number of tillers per plant than the general mean (8.77) for this character. Zahid *et al.* (2005) [16], who studied twelve genotypes of coarse rice to check their yield performance in Kallartr Act and reported highly significant variation for different traits including the no of tillers per plant.

Plant height (cm)

The mean values of genotypes for plant height ranged from 90.89 to 138.52 cm with a general mean height of 112.29 cm. Among all the genotypes Danteshwari was the shortest (90.89 cm), whereas P-27-63 was the tallest (138.52 cm). Fourteen genotypes were shorter in height compared to the general mean (112.29 cm) height.

Panicle length (cm)

The trait panicle length ranged from 21.63 to 34.51 cm with a general mean of 27.50 cm. The longest panicle was recorded by US 312 (34.51 cm), whereas the shortest panicle was recorded in BPT 5204 (21.63 cm). Fifteen genotypes had highest panicle length when compared to general mean (27.50 cm) of this character. Hussain *et al.* (2005) [1] reported that transplantation time, water and soil condition, planting and sowing methods affect plant height in rice.

Number of spikelets per panicle

A broad range of 104.33 to 357.11 spikelets per panicle was observed with a general mean of 201.53 spikelets per panicle. The maximum number of spikelets per panicle was recorded in hybrid IR79156AxBPT5204 (357.11), whereas the minimum in URG 30 (104.33). Thirteen genotypes showed more number of spikelets per panicle when compared to the general mean (201.53) of this character. This is supported by Tahir *et al.* (2000) [12].

Number of grains per panicle

A broad range of 93.33 to 278.66 grains per panicle was observed with a general mean of 160.92 grains per panicle. The hybrid IR79156AxBPT5204 (278.66), whereas the minimum in URG 30 (104.33). Fifteen genotypes showed more number of grains per panicle when compared to the general mean (160.92) of this character. Mirza *et al.* (1992) [6], who studied 25 early maturing genotypes for interrelationship and found that number of grains panicle is positively correlated with panicle length, 1000-grainsweight and grain yield.

Spikelets fertility percent

The trait spikelets fertility percent ranged from 68.45 to 91.58 with a general mean of 80.27 The highest spikelets fertility percent was recorded in BPT 5204 (91.58), whereas the lowest spikelets fertility percent was recorded in MTU 7029 (68.45). Fourteen genotypes had highest spikelets fertility percent when compared to general mean (80.27) of this character. The similar results were also reported in the earlier findings of Shadadshari *et al.* (2001) [11], Raja *et al.* (2004).

Grain weight per panicle (g)

This character ranged from 1.95 to 5.57g. The hybrid IR79156AxBPT5204 recorded the highest grain weight per panicle (5.57 g), whereas URG 30 registered the lowest grain weight per panicle (1.95 g). Out of twenty-eight genotypes, fifteen genotypes showed above the general mean (3.65 g) for this trait.

Grain yield per plant (g)

This character ranged from 12.94 to 33.66 g. The hybrid Pusa6AxHUR 105 recorded the highest grain yield (33.66 g), whereas URG30 registered the lowest grain yield per plant (12.94 g). Out of twenty-eight genotypes, twelve genotypes showed above the general mean (22.85 g) for this trait.

1000-grain weight (g)

The trait 1000-grain weight ranged from 15.10 to 25.83 g with a mean of 22.62 g. The genotype P-27-63 recorded maximum 1000-grain weight (25.83 g), whereas BPT5204 recorded minimum 1000-grain weight (15.10 g). Fifteen genotypes exceeded the general mean grain weight (22.62 g). This in contrast with Tahir *et al.* (2002) [12], who reported highly significant variation among different traits and observe that these traits are under the control of genotypic differences among the genotypes.

Grain yield per plot (g)

This trait ranged from 624.39 to 1722.03 g with a mean of 1170.43 g. The hybrid Pusa 6AxHUR 105 registered maximum grain yield per plant (624.39 g), while URG 30 showed minimum weight (624.39 g). Eleven genotypes exceeded the general mean grain weight (1170.43 g). The same result were reported by Zahid *et al.* (2005) [16], who studied twelve genotypes of coarse rice to check their yield performance in Kallartract and reported highly significant variation for different traits. This variation in the grains yield might be due to the environment

Yield per hactare (kg)

The yield per hectare was varied from 3143.48 to 8628.99 kg with the mean of 5870.12 kg. The hybrid Pusa6AxHUR 105 registered maximum grain yield per plant (8628.99 kg), while URG 30 showed minimum weight 3143.48kg). Eleven genotypes exceeded the general mean grain weight (5870.12 kg).). Similar kinds of reports were also reported by Mahapatra (1993) [5].

Proline content (µmol/g fresh weight)

Proline content ranged from 7.57 to 17.72. The highest proline content was registered in genotypes IE 22202 (17.72) and lowest proline content was found in hybrid IR79156AxBPT 5204 (7.57). The average mean for this trait was 12.39. Twelve genotypes exceeded the general mean (12.39).

Canopy temperature depression (CTD)

CTD value varied from 30.49 to 33.34 ^{o}C with a mean of 31.95 ^{o}C. The highest CTD value was recorded in genotype Pusa 6B (33.34 ^{o}C) while lowest in genotype Sahabhagi dhan (30.49 ^{o}C). Twelve genotypes exceeded the general mean (31.95 ^{o}C). The positive heterosis for Canopy temperature depression (CTD) is desirable from yield point of view under rainfed conditions. In the field, genotypes with a cooler canopy temperature under drought stress, or a higher CTD, use more of the available water in the soil to avoid excessive dehydration (Blum, 1988; Ludlow and Muchow, 1990; Reynolds *et al.*, 2007, 2009) [4, 9].

Conclusions and Recommendations

The overall result indicated that there is scope for the selection of promising genotypes from the present set of genotypes for yield improvement. The hybridsPusa6A x HUR 105, recorded high *per se* performance high yield followed by Arise 6444, Pusa6A x URG 30and Pusa6A x Akshaydhan suggesting that these genotypes could be used as donors for yield improvement. Apart from its high grain yield, Pusa6A x HUR 105 also showed reduced plant height. Similarly, Arise 6444 had a high grain yield, with tall plant height. Thus these genotypes could be used as potential donors for yield improvement. The genotypes such as Danteshwari, NDR 97, BPT 5204, and Pusa6B.Vandana and IR79156B showed lowest plant height. Hence, these genotypes could also be utilized for reducing the plant height to enhance the productivity. The genotype IET 22202, Pusa6B, NDR 97, Vandana, Danteshwari and URG 30 were the earliest to flower as well as to mature. For evolving early types in rice, these genotypes can be used as donor parents in hybridization programmes.

Table 1: Mean performance of 28 rice genotypes for 12 characters over three different environments.

No	Character	Days to 50 % Flowering	Days to Maturity	Tillers Per Plant	Plant Height (cm)	Panicle Length (cm)	Spikelets Per Panicle	Grains Per Panicle	Spikelets Fertility %	Grain Weight Per Panicle (g)	Grain Yield Per Plant (g)	1000-grain Weight (g)	Grain Yield Per Plot (g)	Yield/ha Rainfed (kg)	Proline Content (µmol/g Fresh Weight)	Canopy Temp. °C
1	Pusa6A x Akshaydhan	101.67	127.67	8.44	128.28	30.06	242.78	205.33	84.58	4.80	27.90	23.10	1422.01	7135.17	11.46	32.36
2	Pusa6A x Danteshwari	84.56	112.33	8.56	103.12	27.42	224.22	169.33	75.51	4.05	23.07	24.12	1219.17	6116.49	12.24	31.73
3	Pusa6A x IET 22202	93.33	119.67	8.11	128.18	31.64	241.89	195.56	80.83	4.87	27.82	25.03	1450.11	7252.35	10.88	31.37
4	Pusa6A x URG 30	86.00	112.56	10.44	122.43	28.14	206.22	172.78	83.77	4.14	32.67	23.67	1681.79	8433.91	12.29	30.59
5	Pusa6A x HUR 105	94.11	120.78	10.22	111.26	30.88	245.67	184.22	74.99	4.27	33.66	23.42	1722.04	8628.99	10.70	33.23
6	Pusa6A x Pant Dhan-12	89.56	116.33	11.00	104.56	29.31	191.11	156.89	81.84	3.77	32.92	23.76	1694.97	8497.27	15.66	32.60
7	IR79156A x Akshaydhan	93.89	121.33	8.89	116.03	33.27	234.00	198.11	85.74	4.53	30.68	23.00	1637.76	8187.85	10.61	32.66
8	IR79156A x Danteshwari	84.67	112.89	9.44	101.04	27.23	240.33	187.11	77.84	4.11	21.60	22.62	1101.77	5531.73	14.85	32.62
9	IR79156A x BPT 5204	93.00	120.00	8.00	117.73	29.87	357.11	278.67	78.03	5.57	26.83	21.02	1375.98	6900.65	7.57	30.79
10	Pusa6B	79.22	103.33	8.11	98.12	26.21	200.22	135.33	69.27	2.63	21.46	19.83	1094.04	5478.42	9.53	33.34
11	IR79156B	79.33	105.00	9.22	99.95	28.59	175.22	131.89	75.25	2.76	20.42	22.74	1039.78	5217.40	17.10	32.96
12	IET 22202	75.78	103.00	7.22	106.47	28.09	193.33	135.11	69.87	3.32	20.77	25.39	1074.30	5372.40	17.72	32.31
13	Pant Dhan-12	88.56	110.00	8.44	98.15	28.69	136.44	97.00	71.12	2.41	17.35	24.83	832.46	4185.68	10.80	33.25
14	NDR 97	77.78	104.89	10.78	93.83	23.61	119.00	105.33	88.53	2.31	17.95	22.11	910.41	4568.98	13.43	32.54
15	Vandana	82.33	106.78	9.11	126.06	23.62	120.89	99.19	81.99	2.76	17.84	24.80	918.21	4593.71	12.43	31.50
16	HUR 3022	94.22	118.56	8.33	113.65	27.54	171.89	147.85	86.03	3.39	19.55	20.50	1051.01	5252.78	11.37	31.69
17	Akshaydhan	96.56	123.78	7.67	126.85	28.50	190.33	172.78	90.80	4.57	24.41	25.15	1121.35	5647.22	10.14	32.63
18	Danteshwari	83.00	109.33	7.56	90.90	27.31	157.56	135.44	85.97	3.26	16.89	24.73	854.88	4279.05	12.22	33.13
19	URG 30	80.56	108.89	10.33	110.04	22.63	104.33	93.33	89.53	1.95	12.95	20.41	624.39	3143.49	9.98	31.81
20	BPT 5204	121.33	146.33	9.56	97.88	21.64	219.00	200.56	91.58	2.95	19.59	15.10	996.40	5005.92	13.64	31.74
21	MTU 7029	119.78	146.89	8.78	102.90	23.79	204.00	139.70	68.45	3.23	20.52	21.22	1060.50	5355.37	12.51	31.02
22	NDR 359	96.22	126.44	8.33	113.40	27.67	216.44	170.00	78.53	4.33	24.20	24.62	1257.16	6283.61	16.23	31.76
23	Sarju 52	100.44	128.44	7.11	115.86	26.56	222.67	176.22	79.09	3.70	22.23	21.10	1152.02	5757.14	11.19	30.95
24	HUR 105	102.44	127.44	8.44	104.19	23.49	194.33	147.67	75.97	3.22	18.78	21.52	914.04	4655.03	14.98	31.78
25	Subhagidhan	89.56	117.33	7.89	122.12	27.42	179.44	137.78	76.74	3.23	18.47	22.08	986.93	4963.58	13.27	30.50
26	Arise 6444	96.89	124.44	9.89	115.63	27.72	211.22	180.89	85.66	3.92	22.53	21.79	1150.84	5783.31	9.26	31.90
27	US 312	92.56	120.44	8.56	137.00	34.51	194.00	166.85	86.02	3.68	23.29	20.13	1208.57	6042.18	11.40	30.76
28	P-27-63	103.89	132.78	7.33	138.53	24.85	249.33	185.00	74.18	4.53	23.49	25.84	1219.27	6093.64	13.46	31.31
29.	Mean	92.19	118.85	8.78	112.29	27.51	201.54	160.93	80.28	3.65	22.85	22.63	1170.44	5870.12	12.39	31.96
30.	C.V.	1.70	1.73	10.63	3.54	3.01	5.38	4.38	4.16	8.65	5.12	1.90	6.31	6.52	4.02	1.83
31.	F Ratio	460.58	277.62	12.22	94.84	126.12	191.12	285.93	35.90	69.12	179.46	258.25	128.27	118.69	216.20	19.32
32.	F Prob.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
33.	S.E.	0.52	0.69	0.31	1.33	0.28	3.61	2.35	1.11	0.11	0.39	0.14	24.60	127.59	0.17	0.20
34.	C.D. 5%	1.45	1.91	0.87	3.70	0.77	10.07	6.55	3.10	0.29	1.09	0.40	68.57	355.65	0.46	0.54
35.	C.D. 1%	1.92	2.52	1.14	4.87	1.01	13.28	8.64	4.09	0.39	1.43	0.53	90.41	468.93	0.61	0.72
36.	Range Lowest	75.78	103.00	7.11	90.90	21.64	104.33	93.33	68.45	1.95	12.95	15.10	624.39	3143.49	7.57	30.50
37.	Range Highest	121.33	146.89	11.00	138.53	34.51	357.11	278.67	91.58	5.57	33.66	25.84	1722.04	8628.99	17.72	33.34

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