



## Genetic divergence and AMMI analysis of hybrid rice (*Oryza sativa*) in Himalayan foothill regions of Jammu

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Received: 03 October 2020; Accepted: 08 February 2021

### ABSTRACT

The present experiment was undertaken during *kharif* 2017 and 2018 at two locations (Jammu and Kathua) and consisted of nine hybrid rice (*Oryza sativa* L.) genotypes of diverse origin. The highest grain yield per ha was observed for PAC 807 followed by Sava 200 and PHB 71 based on pooled mean data over the environments. The highest genetic advance were observed for panicle per m<sup>2</sup> (9.35), whereas the highest genetic advance as percent of mean was observed for days to flowering (6.15). Genetic divergence study revealed that all the nine hybrid rice genotypes were grouped into three clusters. Cluster II had the largest number of genotypes (5), although they were originated from different sources. Cluster I had three genotypes, whereas cluster III was a single genotype cluster. There was good amount of diversity present in hybrid genotypes with maximum diverse genotypes of PHB 71, BS 008 and BS 1294. Environment III and IV were highly interactive and showed higher mean grain yield for favourable and unfavourable conditions. Environment I (Jammu-2017) showed very less interaction and can be considered as ideal for cultivation of hybrid rice genotypes under study. The hybrid BS 008 and Sava 200 found as a genetically diverse hybrid with stable below average mean performance for grain yield and can be identified as stable genotype under varying conditions of these north western Himalayan foot hill regions of Jammu and Kashmir.

**Keywords:** AMMI, Genetic divergence, GE, Hybrid rice, Stability

Rice (*Oryza sativa* L.) is very important staple food crop for world's population. The world rice production has increased continuously since 1961, but at varying rates. The annual growth rate of yields declined from 2.5% in the 1960s to about 1.1% in the 1990s, owing to the difficulty of sustaining rice productivity growth as yields increase (FAO 1998). At present, hybrid rice technology for large-scale production has a yield advantage of 15–30% or more than 1 tonne of paddy per ha, over the best bred varieties (Julfiqar 2009). Rice production in J&K showed low productivity due to lack of appropriate HYVs of rice. With the passage of time rice production has shown a declining trend as the area under rice is being used for other commercial purposes which has caused the food deficiency in J&K and has already touched to 40%. To overcome the present yield ceiling of existing high yielding varieties (HYVs) of rice, hybrid rice seems to be highly attractive and available alternative. Private sector hybrid rice seed companies are playing very important role in spreading the hybrid rice technology in Jammu regions. A large quantity of hybrid rice seeds have been procured and supplied to rice growers every year as per government demand from private seed companies.

The sustainability and to understand the production constraints of hybrid seed technology, it was found necessary to validate this technology under diverse environments. The genetical and agronomical potential of hybrid rice need to be tested before commercialization of hybrid rice in Jammu which has begun by interested private seed companies introducing and testing hybrids. The thorough understanding of factors that affect these hybrids in varying environments is important and may serve as a basis for their rational utilization. Thus diversity of such hybrids may either complement or highlight new features of the variation in hybrid rice (Anand and Murthy 1968, Maurya and Singh 1977). On the other hand the performance of every hybrid may or may not be similar in the different environments and they do interact with the environment as such the knowledge of G×E interaction and stability analysis help in selecting the stable genotypes. In this paper the results of these efforts are discussed along with salient features of this technology.

### MATERIALS AND METHODS

The present investigation was undertaken during *kharif* 2017 and 2018 at two locations (districts), i.e. Research Farm, SKUAST-J, Chatha, Jammu and Krishi Vigyan Kendra, Kathua situated at north-western Himalayan foothill regions of Jammu and Kashmir. The experimental materials consisted of nine hybrid rice genotypes of diverse origin

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developed by four different private sector hybrid rice seed companies (Table 1). The research experiments were carried out in Randomised block design with three replications at four environments i.e two years and two locations. Other agronomical standard recommended practices followed to raise a good hybrid rice crop. The yield and yield attributing observations were recorded from each replication under the four environments for all the hybrid rice genotypes during the investigation. However, five important observations were taken for divergence study in this paper and grain yield observation for stability analysis. The genetic divergence among the genotypes used in the present investigation and to know the fluctuation in clustering pattern of those genotypes, the D2 values were calculated by using Mahalanobis (1936). The stability analysis was carried out through Additive Main effect and Multiplicative Interaction (AMMI) analysis for evaluating the similarities among test environments based on experimental main effect and genotype-environment interaction effects. All the statistical analysis were carried out through computer statistical package WINDOSTAT.

RESULTS AND DISCUSSION

The analysis indicated that genotypes showed significant variation among themselves-irrespective of the effect of environments on the characters (Table 2). The highest grain yield per ha was observed for PAC 807 followed by Sava 200 and PHB 71 based on pooled mean data over the environments (Table 1). The range of grain yield over the environments varied from 50.86 to 61.11 q/ha. The highest plant height observed for BS 049 followed by PAC 8744 and PHB 71 with range of 95.50 to 114.60 cm over the environments. The range of panicles per m<sup>2</sup> varied from highest in Sava 200 (309.95) to lowest in BS 1294 (261.22). The hybrid BS 1294 was also observed earliest

for days to flowering and days to maturity.

The environmental, genotypic and phenotypic variances were 35.11, 7.47 and 42.59 for grain yield; 49.36, 24.99 and 74.36 for plant height; 1666.8, 196.09 and 1862.9 for panicles per m<sup>2</sup>; 44.52, 13.26 and 57.28 for days to maturity and 37.43, 11.71 and 49.15 for days to flowering were observed with 17%, 34%, 11%, 23% and 24% heritability for respective characters (Table 2). The highest genetic advance were observed for panicles per m<sup>2</sup> (9.35), whereas

Table 2 AMMI ANOVA for grain yield (kg/ha)

Source of variation	Df	Mean squares			
Trials	35	51.20			
Genotypes	8	59.35*			
Environments	3	130.65**			
G*E interaction	24	42.93			
PCA I	10	73.38**			
PCA II	8	19.72**			
Residual	6	23.13**			
Pooled residual	6	23.13			
Error	72	1.11			
Total	107	18.47			
		Variance	Variance %	Cum. variance%	Residual variance
PCA I		733.83	71.22	71.22	296.60
PCA II		157.80	15.31	86.53	138.69
Residual		138.78	13.47	100.00	
Comparison		S.E.D.	CD 5%	CD 1%	
Genotype Gi-Gj		0.74	1.53	2.08	
Environment Ei-Ej		0.49	0.99	1.31	

Table 1 Pooled mean performance of rice hybrids over the environments and PCA values of AMMI analysis

Hybrid name	Origin	Pooled mean performance and PCA scores (for grain yield)						
		Grain yield (q/ha)			Plant height (cm)	Panicles per m <sup>2</sup>	Days to maturity	Days to flowering
		Mean	PCA I	PCA II				
Sava 127	Savanah Seeds Pvt Ltd.	54.86	-0.96	-1.20	99.45	273.91	94.23	53.60
Sava 200	Savanah Seeds Pvt Ltd.	59.74	0.34	2.17	102.34	309.95	90.31	59.74
PAC 807	UPL Advanta Seeds	61.11	-1.86	0.95	98.65	288.57	90.31	61.11
PAC 8744	UPL Advanta Seeds	58.17	1.84	0.11	104.86	270.49	85.82	60.74
BS 1294	Bayer BioSeeds	50.86	0.33	-1.52	95.50	261.22	82.72	49.99
BS 140	Bayer BioSeeds	55.55	0.85	1.06	103.54	266.15	93.16	52.75
BS 008	Bayer BioSeeds	53.30	0.50	0.27	100.45	261.33	86.70	54.18
BS 049	Bayer BioSeeds	56.19	3.12	1.10	114.60	266.98	92.50	56.19
PHB 71	Pioneer Overseas	58.24	2.90	0.75	104.17	303.55	94.49	55.50
Percentage contribution towards genetic divergence			16.67		27.78	11.11	13.89	30.56
Environmental variance		35.11			49.36	1666.8	44.52	37.43
Genotypic variance		7.47			24.99	196.09	13.26	11.71
Phenotypic variance		42.59			74.36	1862.9	57.78	49.15
h <sup>2</sup> (Broad sense)		0.17			0.34	0.11	0.23	0.24
Genetic advance		2.35			5.97	9.35	3.59	3.44
Gen. Ad. as % of mean		4.18			5.81	3.36	3.95	6.15

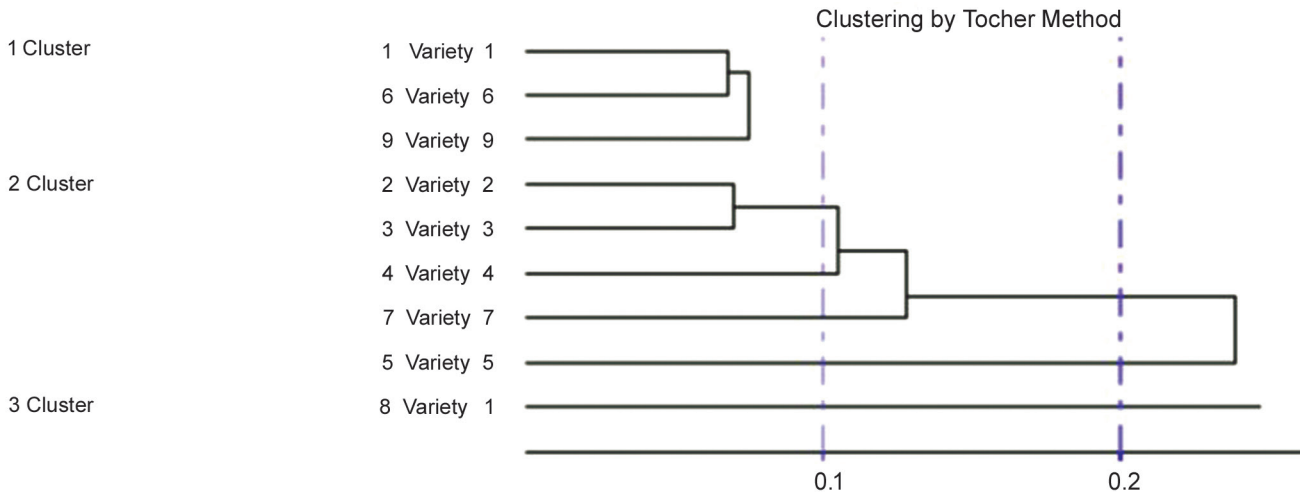


Fig 1 Clustering by tocher methods and 3D representation showing divergence by canonical vector method.

the highest genetic advance as percent of mean was observed for days to flowering (6.15).

High performance is essential for any hybrid technology for their better adaptation. Mean performance over environments of each genotype was studied and it was found that PAC 807, Sava 200 and PHB 71 were the highest yielder for most of the characters under study over the environments. The higher phenotypic variances observed for all the characters then their genotypic variances indicating importance of non-genetic factors. The heritability measures the transmission of characters and separates the portion of environment variability from phenotypic expression. The low heritability observed for most of the characters under study conveyed the quantitative nature of characters. The genetic advance provides information of expected genetic gain resulting from selection of superior genotype. The selection of genotype on the basis of panicles per m<sup>2</sup> (9.35) in the present study will be effective as it showed highest value of genetic advance.

The distribution (clustering pattern) of hybrid rice genotypes based on genetic divergence D<sub>2</sub> values were presented in Fig 1. All the nine hybrid rice genotypes were grouped into three clusters. Cluster II had the largest number of genotypes (5), although they were originated from different sources. Cluster I had three genotypes, whereas cluster III was a single genotype cluster. Similar study was also carried out by Tiwari *et al.* (2011). The pattern of distribution of genotypes within various clusters was random and independent of their origin (Nayak *et al.* 2004). On the basis of results obtained from the present study, high degree of genetic divergence was observed. It is evident as more number of clusters (three) formed by the merely nine hybrid rice genotypes. The more diversity of hybrids, the greater is the chance of obtaining high heterotic hybrids, this study help in selection of hybrids based on their genetic divergence. The hybrids showing less genetical diversity are almost at par for characters under study. Thus, genetic divergence study is important for better selection and adaptation of superior hybrids.

Canonical vector and roots representing different axes of differentiation and the amount of variation accounted for by each such axes, respectively were derived for all five quantitative characters in all nine hybrid rice genotypes were calculated. The two effective axes of differentiation vector 1 and vector 2 absorbed more than fifty percentage variation (54.99%). Character contribution towards divergence was calculated for each of the characters (Table 1). Days to maturity (30.56%), plant height (27.78%) and grain yield (16.67%) exhibited comparatively higher percent contribution towards genetic divergence. The study exhibited great extent of genetic diversity and reflected highest diversity between PHB 71, BS 1294 and BS 008 while minimum genetic diversity between Sava 127 and BS 140. The similar study was also reported by Anand and Murthy (1968) and Maurya and Singh (1977).

This paper was confined to additive main effect and multiplicative interaction analysis only for one important qualitative character, i.e. grain yield in hybrid rice genotypes under study (Freeman 1985). The significant sources of variations indicate the presence of substantial variation in the mean performance of rice hybrid genotypes over all four environments (Table 1). The significant GE interaction variation for grain yield allowed to proceed further for estimating GE interaction using AMMI analysis, which provide the comprehensive understanding of pattern of the data (McLaren and Chaudhary 1994). The analysis of GE interaction variation by AMMI analysis showed that maximum significant variation was carried out by first PC axis, i.e. 71.22% of total GE interaction (Table 2). The biplot AMMI 1 showed the more productive environment III (2<sup>nd</sup> year Jammu location) followed by environment IV (2<sup>nd</sup> year Kathua location), whereas Environment I and II were below average productive environment with negative and positive PCA scores, respectively (Fig 2a). The smallest GE interaction was observed with variety BS 1294(5), BS 008(7) and Sava 200(2) showing stability over the environments. However, the genotype BS 1294 and BS 008 were below average performer for grain yield, while

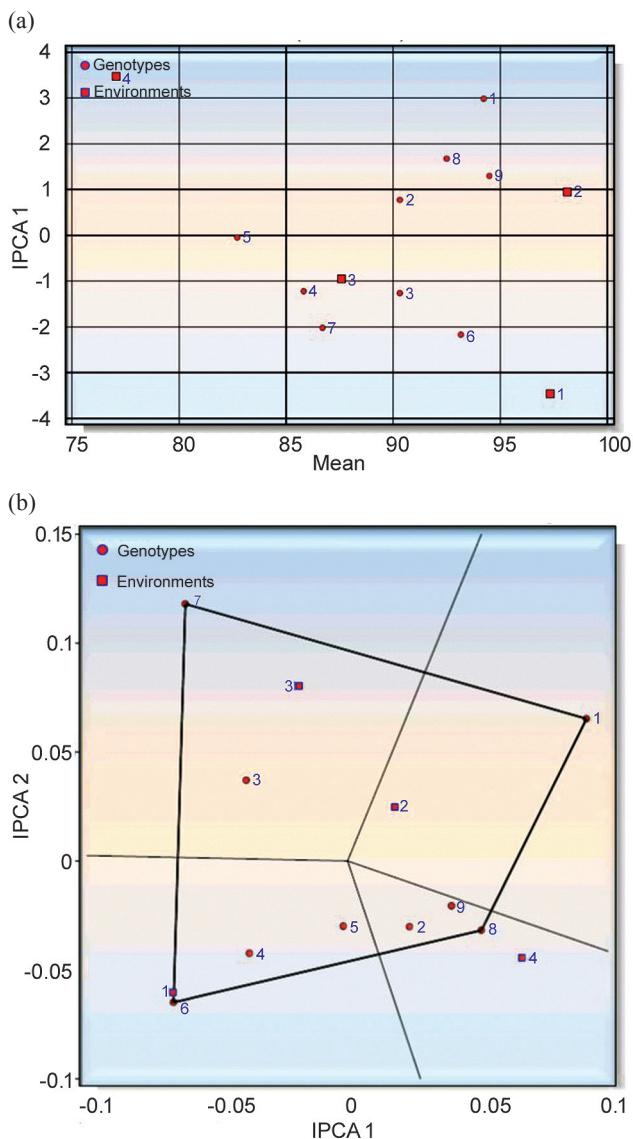


Fig 2 Biploting of (a) AMMI 1 and (b) AMMI 2 for hybrid genotypes based on PCA scores.

Sava 200 had highest mean grain yield and also showed stability. These findings were in general agreement with findings of Nadeem and Islam (2007). BS 049 and PHB 71 were highly interactive genotypes with environment IV in favourable conditions. While the hybrids PAC 8744 and PAC 807 also holding their higher grain yield but showed their best in unfavourable environment III with negative PCA scores. The similar types of findings were also reported by Das *et al.* (2010).

Another important PC axis (PCA2) also played very significant role by contributing 15.31% variation to the total GE interaction variation (Table 2). So, the PCA1 scores were plotted against PCA2 scores in AMMI 2 to further explore the adaptability of hybrids over environments (Fig 2b). The analysis revealed that all the hybrids were most interactive or unstable except BS 008 (7) which showed very less interaction and thus adaptable over environments.

Environment II and IV were highly interactive while, environment I showed less interaction with near to both PC axis. The similar findings were also reported by Gauch and Zobel (1996). The environment I represented the Jammu location had well irrigation facility with good amount of annual rainfall showed less interaction than Environment II and IV which represented the Kathua (district) location for the year 2017 and 2018, respectively.

Study on genetic parameters revealed panicles per m<sup>2</sup> and days to flower as selection indicators for superior rice hybrid genotypes. Genetic divergence analysis evidenced the good amount of diversity present in hybrid genotypes with maximum diverse genotypes of PHB 71, BS 008 and BS 1294. The AMMI analysis revealed the effects of years and locations constituting four environments to GE interaction. Environment III and IV were highly interactive and showed higher mean grain yield for favourable and unfavourable conditions. Environment I (Jammu-2017) showed very less interaction and can be considered as ideal for cultivation of hybrid rice genotypes under study. Among all the nine rice hybrids, Sava 200 and BS 008 showed stability over the environments. The hybrid BS 008 also found as a genetically diverse hybrid with stable below average mean performance for grain yield and can be identified as stable genotype under varying conditions of this north western Himalayan foot hill regions of Jammu and Kashmir.

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