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## ADAPTABILITY PERFORMANCE OF FEED BARLEY GENOTYPES EVALUATED UNDER NWPZ OF THE COUNTRY

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### ABSTRACT

Highly significant effects of the environment (E), genotypes (G), and GxE interaction had been observed by AMMI analysis. Environment explained 63.4% whereas GxE interaction accounted for 23.4% of treatment variations in yield during first year. Harmonic Mean of Genotypic Values (HMGV) expressed higher values for PL906, KB1707, UPB1080 genotypes. Ranking of genotype as per IPCA-1 were NDB1723, NDB1709, HUB266. While IPCA-2, selected BH1023, BH1024, NDB1723 genotypes. Values of Measures ASV1 selected NDB1723, NDB1709, HUB266 and ASV identified NDB1723, NDB1709, BH1023 barley genotypes. Adaptability measures Harmonic Mean of Relative Performance of Genotypic Values (HMPRVG) pointed towards PL906, KB1707, UPB1080 and Relative Performance of Genotypic Values (RPGV) identified KB1707, PL906, RD2994 as the genotypes of performance among the locations. Biplot graphical analysis observed clustering of adaptability measures PRVG, HMPRVG, along with GM, HM in a group. During 2019-20 cropping season Environment effects accounted 61.4% whereas GxE interaction contributed for 26.9% of treatment variations in yield. HMGV expressed higher values for DWRB137, PL906. IPCA-1 scores, desired ranking of genotypes was UPB1080, PL906. While IPCA-2 pointed towards PL906, RD2994, as genotypes of choice. Analytic measures ASV and ASV1 selected PL906, UPB1080 barley genotypes. HMPRVG selected DWRB137, PL906 whereas PRVG settled for DWRB137, KB1707. Biplot analysis seen cluster of ASV, ASV1 IPC1, Mean, GM, HM along with adaptability measures PRVG, HMPRVG observed in adjacent quadrant.

**Keywords :** AMMI, ASV, ASV1, HMGV, GAI, HMPRVG, Biplots

**Introduction**

Barley (*Hordeum vulgare L.*) is frequently being described as the most cosmopolitan of the crops as it is grown over the wide environmental range than any other cereal (Kharub et al 2017; Bocianowsk et al 2019). Also known, as “poor man’s crop” due to low input requirements and better adaptability to harsh conditions (Kendel et al 2019). Traditionally the crop cultivated and used as a grain crop for human consumption as well feed for animals (Karkee et al 2020). Barley is particularly cultivated in the high-altitude areas of Himalaya as consumed by tribal people as food in the hilly areas (Kendel et al 2019). Grains consist of ample quantity of β-glucan beneficial in decreasing the glucose level of diabetic patients and to reduce the cholesterol of heart patients (Shimizu et al. 2008). GxE interaction analysis under multi location trials carried out by AMMI analytic tools (Agahi et al 2020). Researchers gave more emphasis to identification of genotypes would express stable yield along with broad or narrow adaptation of the genotypes to environments (Bocianowsk et al 2019). Quite large number of measures for stability and adaptability of genotypes based on AMMI had observed in literature ( Tekdal & Kendal 2018). Analytic measure of adaptability as the harmonic means of the relative

performance of the predicted genotypic values (MHPRVG) utilized productivity, stability, and adaptability simultaneously of genotypes (Resende & Durate 2007). Comparative performance of AMMI based measures had been studied with relatively new adaptability measures for feed barley genotypes evaluated under North Western Plains Zone of the country.

**Material and methods**

Parts of sub-humid Sutlej-Ganga Alluvial Plains and arid western plains, which comprises Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions), Western Uttar Pradesh (except Jhansi division and hilly areas), parts of Jammu and Kashmir (Jammu and Kathua districts) and parts of Himachal Pradesh (Paonta Valley and Una districts) categorized as the North Western Plain Zone of India. During cropping seasons of 2018-19 and 2019-20 twenty one genotypes in advanced trials evaluated at six major locations of the zone and eight genotypes at eight locations respectively. Field trials were conducted at research centers in randomized complete block designs with three replications. Recommended agronomic practices were followed to harvest good yield. Details of locations and genotype parentage were reflected in tables 1 & 2 for ready reference.

Mohamadi & Amri 2008 Geometric Mean as Adaptability Index

$$GAI = \sqrt[n]{\prod_{k=1}^n \bar{X}_k}$$

Purchase1997 AMMI stability value

$$ASV = [(\frac{SSIPC 1}{SSIPC 2} PCI)^2 + (PC2)^2]^{1/2}$$

Zali et al2012 AMMI stability value

$$ASV1 = [\frac{SSIPC 1}{SSIPC 2} (PCI)^2 + (PC2)^2]^{1/2}$$

Resende 2004 Harmonic mean of Genetic

$$MHVG_i = \text{Number of environments} / \sum_{i=1}^k \frac{1}{X_i}$$

Values

Resende & Durate 2007 Relative performance of genotypic values across environments  $PRVG_{ij} = VG_{ij} / VG_i$

Resende & Durate 2007 Harmonic mean of Relative performance of genotypic values  $MHPRVG_i = \text{Number of environments} / \sum_{j=1}^k \frac{1}{PRVG_{ij}}$

AMMI analysis was performed using AMMISOFT version 1.0, available at <https://scs.cals.cornell.edu/people/hugh-gauch/> and SAS software version 9.3. Simple and effective measure for adaptability is calculated as the relative performance of genetic values (PRVG) across environments and MHVG (Harmonic mean of Genetic Values), based on the harmonic mean of the genotypic values across in different environments. Lower the standard deviation of genotypic performance across environments, the greater is the harmonic mean of its genotypic values.

**Results and discussion**

**AMMI analysis of barley genotypes**

**First year of study 2018-19**

Adaptability performance of barley genotypes studied by AMMI based measures. These measures evaluate the performance after reduction of the noise from the GxE interaction effects (Gauch 2013). Highly significant effects of the environment (E), genotypes (G), and GxE interaction had been observed by AMMI analysis (Table 3). Analysis observed the greater contribution of environments, GxE interactions, and genotypes to the total sum of squares (SS) as compared to the residual effects. Environment explained about significantly 63.4% of the total sum of squares due to treatments indicating that diverse environments caused most of the variations in genotypes yield. Genotypes explained only 9.1% of a total sum of squares, whereas GxE interaction accounted to the tune of 23.4% of treatment variations in yield. Further bifurcation of GxE interaction observed the significant four multiplicative terms most of the interaction sum of squares as compared to residual / noise (Oyekunle et al 2017).

**Second year 2019-20**

Analysis observed the greater contribution of environments, GxE interactions, and genotypes to the total

sum of squares (SS) as compared to the residual effects. Environment explained about significantly 61.4%, GxE interaction accounted for 26.9% whereas Genotypes explained only 3.6% % of the total sum of squares due to treatments. Partitioning of GxE interaction two highly significant multiplicative terms out of six explained more of the interaction sum of squares.

**Ranking of genotypes as per descriptive measures**

**First year of study 2018-19**

An average yield of genotypes over the studied locations selected KB1707, PL906, RD2994 as higher productive genotypes (Table 4). Though this measure is simple to calculate, but failed to exploit full information contained in dataset as per the field performance. Geometric mean is used to evaluate the adaptability of genotypes. Geometric mean observed PL906, KB1707, UPB1080 were top-ranked genotypes. Harmonic Mean of Genotypic Values of yield expressed higher values for PL906, KB1707, UPB1080 genotypes. Consistent yield performance of genotypes judged by lower values of Coefficient of Variation and genotypes KB1713, DWRB205, BH1023 would be suitable for considered locations of this zone of the country. Minimum values of standard deviation of yield values

selected KB1713, DWRB205, HUB266 barley genotypes.

### **Second year 2019-20**

Average yield selected DWRB137, PL906 genotypes for higher values (Table 8). Geometric mean observed DWRB137, PL906 were with top-rank. Harmonic mean of genetic values (HMGV) expressed higher values for DWRB137, PL906 genotypes.

Consistent yield performance of UPB1080, DWRB137 judged by lower values of Coefficient of Variation. Minimum values of standard deviation of yield values selected UPB1080, DWRB137 barley genotypes. Analytic measures PRVG, MHVG, and MHPRVG, had showed consensus for classification of genotypes as per raking of genotypes vis-à-vis analytic measures (Table 6). Presence of significant cross over interactions has been validated by differences among ranks of genotypes vis-à-vis locations of the zone.

### **Adaptability behaviour of genotypes**

#### **First year of study 2018-19**

The IPCA scores of a genotype in AMMI analysis indicate the stability or adaptation over environments. The greater the IPCA scores, either negative or positive (as it is a relative value), the more specifically adapted is the genotype to certain environments. The more the IPCA scores approximate zero, the more stable or adapted the genotypes. Adaptability of genotypes over locations indicated by the IPCA scores in the AMMI analysis. Ranking of genotype as per absolute IPCA-1 scores were NDB1723, NDB1709, HUB266 (Table 5). While for IPCA-2, genotypes BH1023, BH1024, NDB1723 would be of choice. Values of IPCA-3 favored NDB1709,

KB1707, RD2552 barley genotypes. Lower Values of IPCA-4 settled for UPB1080, KB1707, RD2991 barley genotypes.

Analytic measures of adaptability ASV and ASV1 consider two significant IPCAs of the AMMI analysis for adaptability behaviour (Tekdal & Kendal 2018). Values of ASV1 selected NDB1723, NDB1709, HUB266 and ASV identified NDB1723, NDB1709, BH1023 barley genotypes. Harmonic Mean of Relative Performance of Genotypic Values (HMRPGV) method, the genotypes can be simultaneously sorted by genotypic values (yield) and stability using the harmonic means of the yield so that the smaller the standard deviation of genotypic performance among the locations. Values of HMRPGV ranked PL906, KB1707, UPB1080 as the performance of the genotypes among the locations. When considering the yield and adaptability simultaneously, the recommended approach is the relative performance of genetic values (RPGV) over crop years. Relative Performance of Genotypic Values had settled for KB1707, PL906, RD2994 genotypes. Analytic measures PRVG, MHVG, and MHPRVG, had showed consensus for classification of genotypes as per raking of genotypes vis-à-vis analytic measures. Presence of significant cross over interactions has been validated by differences among ranks of genotypes vis-à-vis locations of the zone.

#### **Second year 2019-20**

UPB1080, PL906 were the top ranked genotype as per absolute IPCA-1 scores (Table 8). While for IPCA-2 identified PL906, RD2994 genotypes would be of choice. Values of IPCA-3 favoured KB1707, PL906 barley genotypes. As per IPCA-4, KB1707, DWRB137 genotypes would be of stable performance.

Minimum values of IPCA-5 settled for KB1707, RD2552 barley genotypes. Genotypes DWRB137, PL906 identified by as per IPCA-6 measure. Two significant IPCAs of the AMMI analysis considered by ASV and ASV1 for adaptability behaviour of genotypes. Both measures selected same set of PL906, UPB1080 barley genotypes. Harmonic Mean of Relative Performance of Genotypic Values (HMRPGV) values ranked DWRB137, PL906 as of stable performance among the locations. Relative Performance of Genotypic Values (RPGV) had settled for DWRB137, KB1707 genotypes.

### **Biplot analysis**

#### **First year of study 2018-19**

Graphical analysis to understand the association if any among adaptability measures utilized the first two highly significant Interaction Principal Components of analysis. First two significant interaction principal components contribute to the tune of 39.6% & 21.8% to the total for 61.5 % of total GxE interaction sum of squares (Figure 1). Loadings of adaptability measures based on significant two interaction principal components had mentioned in table 6. Biplot observed cluster of CVs with IPC3 whereas Sdev grouped with mean, IPC1 IPC2. Cluster of ASV and ASV1 observed with IPC4 measures in one quadrant and adaptability measures PRVG, HMPRVG, along with GM, HM grouped in a separate cluster.

#### **Second year 2019-20**

First two significant interaction principal components accounted total for 52.8 % with respective share of 32.5% & 20.3% of total GxE interaction sum of squares

(Figure 2). Loadings of adaptability measures based on two interaction principal components had mentioned in table 10. Measure CV clustered with Sdev, IPC4 in one quadrant of biplot analysis. ASV, ASV1 IPC1, Mean, GM, HM along with adaptability measures PRVG, HMPRVG observed in adjacent quadrant. IPC2 and IPC5 joined hands in one quadrant while IPC3 & IPC6 were grouped together in next quadrant.

### **Conclusions**

Researchers concentrates on genotypes with high productive potential that respond to favorable environments. Often the occurrence of complex type GxE interaction leads to uncertainty in the identification of promising genotype; in this case, techniques exploit adaptability and stability can provide precise information about genotypes performance. The identification of stable and highly productive genotypes between different environments remains a constant challenge for breeders of various crop species around the world. Selection of barley genotypes by the harmonic mean of genotypic values allow to identify the stable and productive genotypes.

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### **Conflict of interest**

No conflict of interest

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Table 1: Parentage details of barley genotypes and environmental conditions (2018-19)

Code	Genotype	Parentage	Code	Location	Latitude	Longitude	Altitude
G1	RD2991	RD2592 /RD2503//RD 2715	E1	Karnal	29° 43' N	70° 58'E	245
G2	KB1707	Manjula/DWRUB52	E2	Hisar	29° 10' N	75° 46'E	229
G3	RD2994	RD2624 / NDB1173	E3	Durgapura	26°51'N	75° 47'E	390
G4	RD2992	RD2660 /13thEMBGSN-4	E4	Ludhiana	30° 54' N	75° 48 'E	247
G5	KB1713	IBON-19 (2011-12)/RD2885	E5	Pantnagar	29° 02'N	79° 48'E	243.8
G6	UPB1077	AHOR1489.58//GLORIA-BAR/COPAL/3/PRO- /4/CAPUL/TOCTE/5/ICARO	E6	Tabji	26° 35'N	74° 61'E	508
G7	UPB1080	AHOR1489.58//GLORIA-BAR/COPAL/3/PRO- /4/CAPUL/TOCTE/5/ICARO					
G8	HUB266	DL 70 / 25TH IBYT-22-1					
G9	PL906	RD2503/WSA353 ( <i>H.spontaneum</i> )					
G10	DWRB205	CDC MANLEY/BCU2881					
G11	NDB1709	INBYT-HI-2 (2016)					
G12	PL909	RD2740/BL194					
G13	BH 946	BHMS22A/BH549//RD2552					
G14	NDB1723	3rd GSBSN-35 (2016)					
G15	DWRB203	P.STO/3/LBIRAN/UNA80//LIGNEE640/4/BLLU/5/PETUNIA 1/6/M111					
G16	RD2552	RD2035/DL472					
G17	BH1023	NBGSN-4 (2011-12)/RD 2552					
G18	RD2786	RD2634/NDB1020//K425					
G19	DWRB137	DWR28/DWRUB64					
G20	BH1024	NBGSN-12 (2011-12)/BH 393					
G21	RD2899	RD2592/RD2035//RD2715					

Table 2: Parentage details of barley genotypes and environmental conditions (2019-20)

Code	Genotype	Parentage	Code	Location	Latitude	Longitude	Altitude
G1	BH946	BHMS22A/BH549//RD2552	E1	Durgapura	26°51'N	75° 47'E	390
G2	RD2994	RD2624 / NDB1173	E2	Hisar	29° 10' N	75° 46'E	229
G3	DWRB137	DWR28/DWRUB64	E3	Karnal	29° 43' N	70° 58'E	245
G4	PL906	RD2503/WSA353 ( <i>H.spontaneum</i> )	E4	Ludhiana	30° 54' N	75° 48 'E	247
G5	BH902	BH495/RD2552	E5	Modipuram	29° 05' N	77° 70'E	226
G6	RD2552	RD2035/DL472	E6	Pantnagar	29° 02'N	79° 48'E	243.8
G7	UPB1080	AHOR1489.58//GLORIA-BAR/COPAL/3/PRO- /4/CAPUL/TOCTE/5/ICARO	E7	Tabiji	26° 35'N	74° 61'E	508
G8	KB1707	Manjula/DWRUB52	E8	Udaipur	24° 34' N	73° 41' E	585



Table 3: Multi environment trails analysis by AMMI of barley genotypes (2018-19)

Source	Degree of freedom	Mean Sum of Squares	Significance level	% contributions of factors
Treatments	125	638.79	.0000000 ***	95.94
Genotypes (G)	20	378.02	.0000000 ***	9.08
Environments (E)	5	10555.55	.0000000 ***	63.42
Interactions (GxE)	100	195.11	.0000000 ***	23.44
IPC1	24	305.44	.0000000 ***	
IPC2	22	228.62	.0000000 ***	
IPC3	20	186.59	.0000000 ***	
IPC4	18	116.28	.0000000 ***	
Residual	16	82.85	.0000000 ***	
Error	252	13.40		
Total	377	220.75		

Table 4: Ranking of barley genotypes as per descriptive measures (2018-19)

Genotype	Karnal	Hisar	Durgapura	Ludhiana	Pantnagar	Tabji	MEAN	R <sub>k</sub>	GM	R <sub>k</sub>	HM	R <sub>k</sub>	CV	R <sub>k</sub>	Sdev	R <sub>k</sub>
RD2991	40.74	39.45	71.01	19.86	36.78	39.45	41.22	20	38.56	20	35.96	20	0.4016	20	16.55	14
KB1707	89.78	47.99	76.81	51.26	39.81	34.22	56.65	1	53.37	2	50.49	2	0.3863	19	21.88	21
RD2994	78.75	34.38	66.43	52.34	39.85	52.74	54.08	3	52.01	4	50.00	4	0.3045	11	16.47	13
RD2992	62.24	30.28	53.86	17.17	29.55	39.45	38.76	21	35.59	21	32.42	21	0.4321	21	16.75	16
KB1713	44.77	43.72	62.56	44.69	41.97	44.28	47.00	14	46.55	12	46.16	10	0.1637	1	7.69	1
UPB1077	53.62	39.05	70.29	29.79	48.49	38.24	46.58	17	44.84	17	43.22	16	0.3071	14	14.31	10
UPB1080	79.79	43.08	66.18	41.87	37.12	56.36	54.07	4	52.07	3	50.24	3	0.3062	13	16.56	15
HUB266	56.52	41.14	67.39	45.89	39.29	36.63	47.81	12	46.69	11	45.67	12	0.2483	4	11.87	3
PL906	75.76	44.36	78.26	49.38	32.76	55.15	55.95	2	53.51	1	51.10	1	0.3203	16	17.92	19
DWRB205	49.60	39.85	55.79	40.26	33.11	61.59	46.70	16	45.65	14	44.63	14	0.2318	2	10.83	2
NDB1709	61.35	33.57	64.73	37.57	39.60	44.69	46.92	15	45.49	16	44.19	15	0.2778	7	13.04	7
PL909	74.40	44.12	64.73	39.18	34.23	52.74	51.57	7	49.68	7	47.90	7	0.3011	10	15.53	12
BH 946	69.56	51.45	71.02	25.76	37.29	37.04	48.69	11	45.64	15	42.70	17	0.3824	18	18.62	20
NDB1723	57.89	39.13	60.63	36.23	29.95	42.27	44.35	19	42.98	19	41.68	18	0.2767	6	12.27	5
DWRB203	65.14	38.41	67.15	48.04	44.07	32.21	49.17	10	47.48	10	45.86	11	0.2889	9	14.21	9
RD2552	58.70	43.24	70.53	38.49	32.21	55.96	49.85	8	48.12	9	46.42	9	0.2875	8	14.33	11
BH1023	60.47	41.55	66.67	33.55	48.09	47.50	49.64	9	48.39	8	47.15	8	0.2449	3	12.15	4
RD2786	76.73	52.98	67.87	47.23	32.98	37.04	52.47	6	50.16	6	47.95	6	0.3269	17	17.16	18
DWRB137	62.32	36.47	79.95	45.62	36.50	56.76	52.94	5	50.80	5	48.82	5	0.3192	15	16.90	17
BH1024	52.50	44.20	66.91	29.52	32.22	43.88	44.87	18	43.18	18	41.58	19	0.3057	12	13.72	8
RD2899	50.81	52.01	66.91	50.46	32.46	33.82	47.74	13	46.25	13	44.76	13	0.2698	5	12.88	6

Table 5: Adaptability measures of barley genotypes evaluated under MET (2018-19)

Genotype	IPC1	IPC2	IPC3	IPC4	ASV1	R <sub>ASV1</sub>	ASV	R <sub>ASV</sub>	PRVG	R <sub>PRVG</sub>	HMPRVG	R <sub>HMPRVG</sub>
RD2991	-2.715	-1.048	1.823	-0.336	4.09	20	3.44	19	0.8366	20	0.7815	20
KB1707	3.630	-1.478	0.196	0.189	5.49	21	4.62	21	1.1423	1	1.0990	2

Genotype	IPC1	IPC2	IPC3	IPC4	ASV1	R <sub>ASV1</sub>	ASV	R <sub>ASV</sub>	PRVG	R <sub>PRVG</sub>	HMPRVG	R <sub>HMPRVG</sub>
RD2994	1.721	1.634	-1.214	1.752	2.99	16	2.64	16	1.1069	3	1.0784	4
RD2992	0.549	1.261	2.211	0.363	1.49	5	1.42	4	0.7707	21	0.7208	21
KB1713	-2.133	-0.959	-1.670	0.392	3.25	17	2.75	17	0.9901	12	0.9652	12
UPB1077	-1.399	-1.434	1.485	1.691	2.49	13	2.22	13	0.9577	17	0.9287	17
UPB1080	1.359	1.965	0.433	-0.087	2.79	15	2.56	15	1.1003	4	1.0885	3
HUB266	-0.204	-1.450	-1.220	0.627	1.48	3	1.47	7	0.9876	13	0.9747	11
PL906	1.063	1.193	-0.613	-0.861	1.96	9	1.75	9	1.1325	2	1.1160	1
DWRB205	-2.100	2.366	-1.506	-0.534	3.87	19	3.47	20	0.9764	15	0.9447	15
NDB1709	-0.111	0.427	0.016	1.466	0.46	2	0.45	2	0.9597	16	0.9524	14
PL909	1.011	1.498	0.406	-0.656	2.10	11	1.93	11	1.0487	7	1.0394	7
BH 946	0.685	-1.187	2.692	-1.399	1.55	6	1.45	5	0.9790	14	0.9379	16
NDB1723	-0.021	0.299	-0.415	-0.562	0.30	1	0.30	1	0.9044	19	0.9020	18
DWRB203	0.964	-1.801	-0.942	1.873	2.28	12	2.14	12	1.0130	10	0.9816	10
RD2552	-1.037	1.298	-0.199	-1.137	1.99	10	1.80	10	1.0179	9	1.0051	9
BH1023	-1.021	-0.091	1.159	1.337	1.49	4	1.24	3	1.0253	8	1.0091	8
RD2786	2.209	-1.139	-0.403	-1.588	3.41	18	2.90	18	1.0682	6	1.0398	6
DWRB137	-0.732	1.227	-0.681	0.430	1.63	7	1.51	8	1.0765	5	1.0585	5
BH1024	-1.204	-0.185	0.728	-1.274	1.76	8	1.47	6	0.9135	18	0.9013	19
RD2899	-0.514	-2.396	-2.286	-1.687	2.51	14	2.48	14	0.9926	11	0.9526	13

Table 6: Loadings of adaptability measures as per Principal Components (2018-19)

Component	PC1	PC2
IPC1	0.2245	-0.1821
IPC2	0.0289	-0.1778
IPC3	-0.1527	-0.0527
IPC4	0.0263	0.3791
ASV1	0.0878	0.4457
ASV	0.0878	0.4457
PRVG	0.3623	-0.0057
MHPRVG	0.3589	-0.0009
Karnal	0.2649	-0.1735
Hisar	0.1338	-0.1404
Durgapura	0.2135	-0.0113
Ludhiana	0.3031	0.0291
Pantnagar	0.0878	0.4457
Tabji	0.0924	-0.0994
MEAN	0.3607	-0.0470
CV	-0.0694	-0.2535
Sdev	0.1270	-0.2530
GM	0.3617	-0.0041
HM	0.3544	0.0379
% variation	39.65	21.83

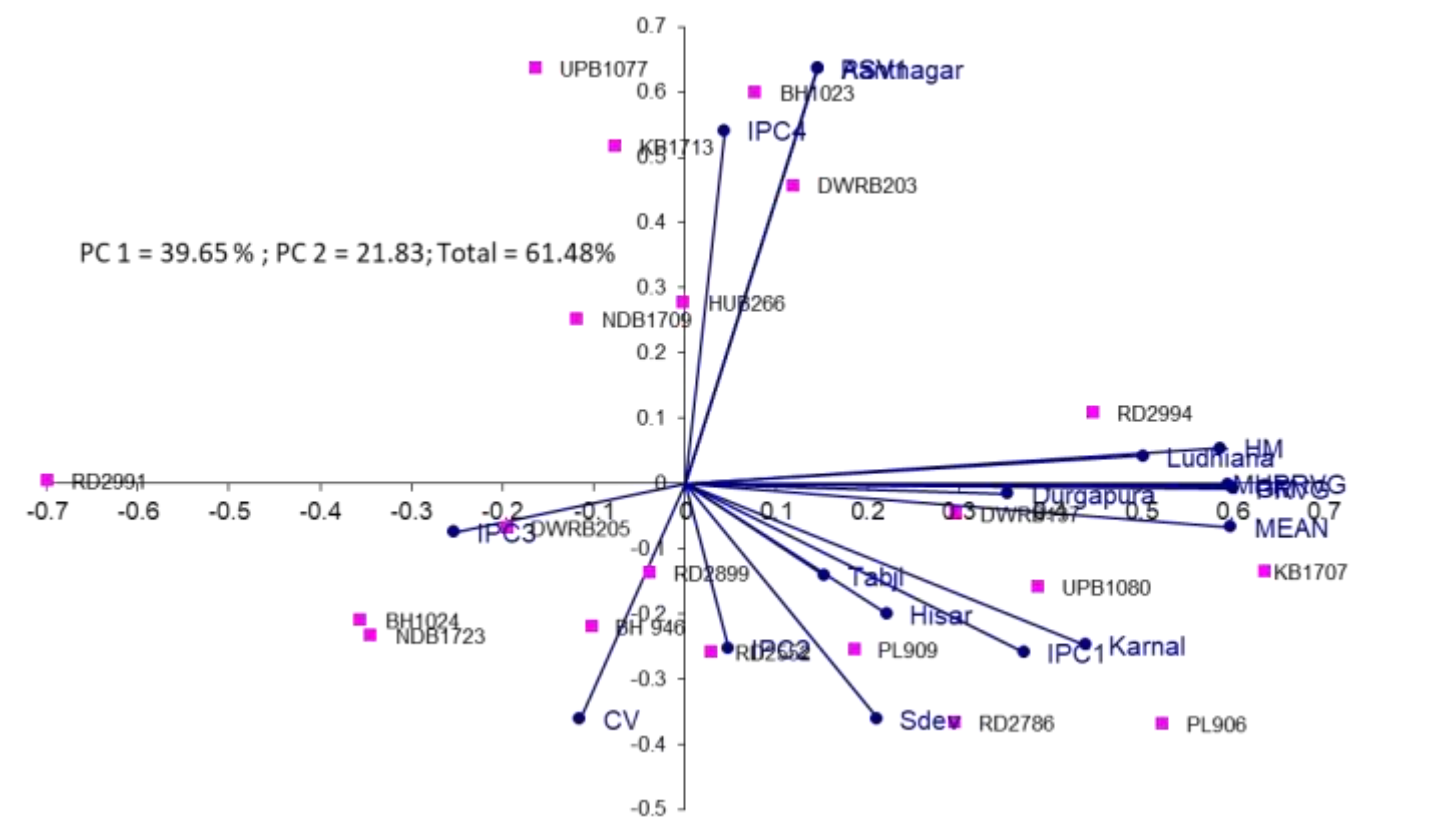


Figure 1: Biplot analysis of adaptability measures for barley genotypes (2018-19)

Table 7: Multi environment trails analysis by AMMI of barley genotypes (2019-20)

Source	Degree of Freedom	Mean Sum of Squares	Significance level	% contributions of factors
Treatments	63	425.98	***	91.93
Genotypes (G)	7	150.36	***	3.61
Environments (E)	7	2559.33	***	61.37
Interactions (GxE)	49	160.59	***	26.95
IPC1	13	237.81	***	
IPC2	11	198.94	**	
IPC3	9	126.06		
IPC4	7	130.13		
IPC5	5	68.54		
IPC6	3	63.48		
Residual	1	10.58		
Error	128	18.42		
Total	191	152.85		

Table 8: Ranking of barley genotypes as per descriptive measures (2019-20)

Genotype	Durgapura	Hisar	Karnal	Ludhiana	Modipuram	Pantnagar	Tabiji	Udaipur	MEAN	R <sub>k</sub>	GM	R <sub>k</sub>	HM	R <sub>k</sub>	CV	R <sub>k</sub>	Sdev	R <sub>k</sub>
BH946	50.48	53.49	38.09	48.31	60.14	28.82	60.03	57.41	49.60	3	49.11	3	46.82	5	0.2238	3	11.10	3
RD2994	65.30	40.74	43.07	50.72	48.71	33.38	72.46	42.75	48.54	5	47.55	4	46.93	4	0.2700	6	13.11	6
DWRB137	48.16	47.47	45.41	46.38	64.21	36.24	69.42	53.95	50.95	1	49.64	1	49.53	1	0.2114	2	10.77	2
PL906	50.31	54.3	33.96	51.45	57.37	36.40	72.22	44.12	50.38	2	49.31	2	47.45	2	0.2426	4	12.22	4
BH902	49.80	46.21	29.51	50.24	52.90	31.05	77.07	34.1	48.78	4	47.54	5	42.35	7	0.3177	8	15.50	8
RD2552	54.86	35.14	21.08	43.12	48.19	39.20	72.14	44.2	46.89	7	45.28	7	39.99	8	0.3174	7	14.88	7
UPB1080	50.40	46.02	37.59	49.76	50.64	42.56	54.92	35.43	45.57	8	44.31	8	44.96	6	0.1504	1	6.85	1
KB1707	39.47	52.05	26.60	55.68	50.60	54.63	67.28	60.03	47.45	6	46.30	6	47.14	3	0.2655	5	12.60	5

Table 9 : Adaptability measures of barley genotypes evaluated under MET (2019-20)

Genotype	IPC1	IPC2	IPC3	IPC4	IPC5	IPC6	ASV1	R <sub>ASV1</sub>	ASV	R <sub>ASV</sub>	PRVG	R <sub>PRVG</sub>	HMPRVG	R <sub>HMPRVG</sub>
BH946	0.829	3.135	-0.977	0.639	-1.867	0.452	3.35	6	3.29	6	1.025	3	1.0034	4
RD2994	-3.041	-0.291	0.781	1.734	-0.516	-1.639	4.31	7	3.63	7	1.024	5	1.0025	5
DWRB137	0.194	2.298	-0.954	0.507	2.561	-0.121	2.31	3	2.31	3	1.067	1	1.0522	1
PL906	-0.111	0.109	-0.550	-1.921	-0.538	0.251	0.19	1	0.17	1	1.025	4	1.0212	2
BH902	-1.673	-1.236	-1.096	-2.524	0.098	-0.363	2.67	4	2.34	4	0.937	7	0.9216	7
RD2552	-0.515	-2.700	-1.185	1.831	0.088	1.625	2.80	5	2.77	5	0.905	8	0.8762	8
UPB1080	-0.047	0.371	3.743	-0.524	0.256	0.948	0.38	2	0.37	2	0.962	6	0.9464	6
KB1707	4.365	-1.686	0.238	0.258	-0.082	-1.153	6.39	6	5.45	6	1.055	2	1.0092	3

Table 10: Loadings of adaptability measures as per Principal Components (2019-20)

Component	PC1	PC2
IPC1	0.1254	-0.2042
IPC2	0.2938	0.1883
IPC3	-0.0183	0.2418
IPC4	-0.0369	-0.0909
IPC5	0.0459	0.0505
IPC6	-0.1364	0.2567
ASV1	0.0086	-0.4061
ASV	0.0103	-0.4005
Durgapura	-0.1177	0.1340
Hisar	0.2828	-0.0319
Karnal	0.2558	0.1946
Ludhiana	0.1265	-0.1820
Modipuram	0.2913	0.0837
Pantnagar	-0.0185	-0.1742
Tabiji	-0.1020	-0.2308
Udaipur	0.2205	-0.2598
Average	0.2442	-0.0626
GM	0.2623	-0.0604
HM	0.3491	-0.0132
CV	-0.2054	-0.3063
Sdev	-0.1671	-0.3057
PRVG	0.3370	-0.1278
HMPRVG	0.3492	-0.0554
% variation	32.52	20.31

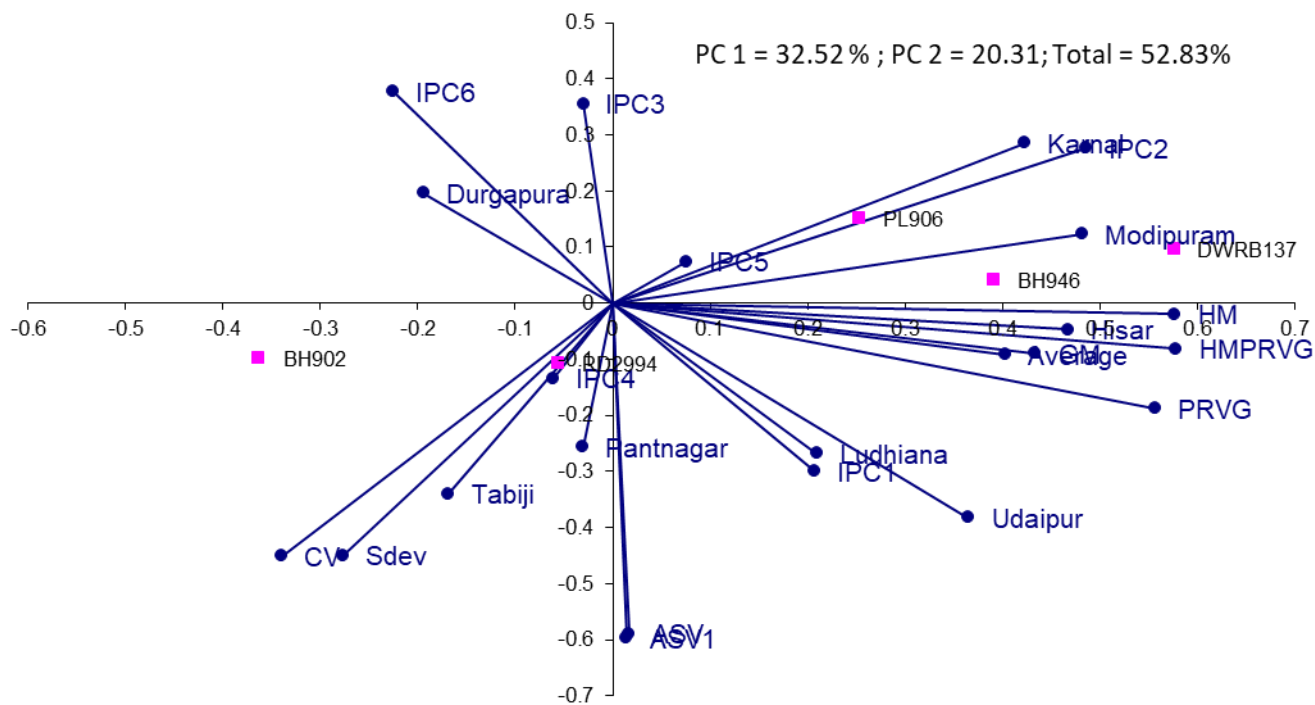


Figure 2: Biplot analysis of adaptability measures for barley genotypes (2019-20)