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Decipher interactions effects of wheat genotypes evaluated in Northern Hills Zone by AMMI, BLUP and Non Parametric measures

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ABSTRACT

Significant variations due to environments 38.3%, Gx E interactions 32.1%, and genotypes 10.9% were observed by AMMI analysis. ASV1 and ASV measures recommended G13, G2, G11 genotypes. Based on 97.8% of Gx E interactions sum of squares MASV1 identified G13, G3, G7 whereas MASV settled for G13, G1, and G7 genotypes. BLUP-based measures HMGV, RPGV, HMRPGV identified G9, G6, G13 genotypes. Non parametric composite measure $NP_i^{(1)}$ observed suitability of G3, G13, G12 whereas $NP_i^{(2)}$, $NP_i^{(3)}$, $NP_i^{(4)}$ identified G3, G10, G12 genotypes. Biplot analysis observed 65.4% of the total variation in the considered measures accounted by PC1 and PC2. Cluster of IPC2, $NP_i^{(2)}$, $NP_i^{(3)}$, $NP_i^{(4)}$ placed adjacent to BLUP based measures in the same quadrant. ASV, ASV1, MASV, MASV1, clustered with $S_i^1, S_i^2, S_i^3, S_i^4, S_i^5, S_i^6, S_i^7$ BL Std and $NP_i^{(1)}$, BLCV, IPC7 observed in different quadrant of biplot analysis.

Key words: AMMI, BLUP, Biplot analysis, Non parametric composite measures

Introduction

Multi-environment trials have been advocated for the selection of better performing stable yield across various environments before the wide scale cultivation (Ahakpaz *et al.*, 2021). A use of recent analytic approaches in analyzing the genotype \times environment precisely has been advocated in recent studies to (PourAboughadareh *et al.*, 2022 Anuradha *et al.*, 2022). Accumulation of main effects of genotypes, environments with their multiplicative interactions in Additive main effect and multiplicative interaction based measures (AMMI stability value (ASV), ASV1, Modified AMMI stability value (MASV) & MASV1) have also gained visibility (Pour-Aboughadareh *et al.*, 2019 Sousa *et al.*, 2020). Best linear unbiased prediction (BLUP) based measures offers the potential to improve the predictive accu-

racy of random effects, harmonic mean of genotypic values (HMGV), relative performance of genotypic values (RPGV), and harmonic mean of relative performance of genotypic values (HMRPGV), were also highlighted for the stability and adaptability of genotypes (Gonçalves *et al.*, 2020). Nonparametric measures $S_i^1, S_i^2, S_i^3, S_i^4, S_i^5, S_i^6, S_i^7, NP_i^{(1)}, NP_i^{(2)}, NP_i^{(3)}, NP_i^{(4)}$ have been also utilized to interpret the response of genotypes to environmental conditions (Pour-Aboughadareh *et al.*, 2019). Gx E interactions effects have been deciphered for the wheat genotypes evaluated in northern hills zone of the country under restricted irrigated timely sown conditions.

Materials and Methods

Eleven promising wheat genotypes were evaluated in research field trials at 06 centers of All India Co-

ordinated Research Project on Wheat across northern hills zone of the country during 2020-21 cropping season in field trials under restricted irrigation timely sown conditions.. Field trials were laid out in Randomized block designs with four replications. Recommended practices of packages had followed in total to harvest the good yield. Pour-Aboughadareh *et al.*, 2019 recommended various non parametric and parametric measures for assessing GxE interaction and stability analysis. Non parametric composite measures $NP_i^{(1)}$, $NP_i^{(2)}$, $NP_i^{(3)}$ and $NP_i^{(4)}$ based on the ranks of genotypes as per yield and corrected yield of genotypes. AMMI based stability measures ASV, ASV1, MASV, MASV1 along with BLUP based measures HMGV, RPGV, HMRPGV, GAI were also calculated for evaluated genotypes to put forward a more or less complete picture of associations among the measures. AMMISOFT and SAS software version 9.3 utilized for analysis.

Results and Discussion

AMMI analysis

Highly significant variations due to environments, GxE interactions, and genotypes were observed by AMMI analysis (Table 1). This analysis also revealed about 59.1% of the total sum square of variation for yield was due to environments followed by 19.7% of GxE interactions, whereas genotypes accounted only 7.5%. First two AMMI components in total shared 68.1% of the total variation while total contribution of four were up to 97.2 % of interaction effects would be useful (PourAboughadareh *et al.*, 2022).

Table 1. AMMI analysis of wheat genotypes evaluated under restricted irrigation late sown conditions

Source	Degree of freedom	Mean Sum of Squares	Significance level	% share of factors	GxE interaction Sum of Squares (%)	Cumulative Sum of Squares(%) by IPCA's
Treatments	65	192.27	***	86.29		
Genotype (G)	10	109.00	***	7.53		
Environment (E)	5	1712.45	***	59.12		
GxE interaction	50	56.91	***	19.65		
IPC1	14	91.84	***		45.19	45.19
IPC2	12	54.38	***		22.93	68.12
IPC3	10	56.27	***		19.77	87.90
IPC4	8	32.99	***		9.27	97.17
Residual	6	13.41				
Error	198	10.03				
Total	263	55.07				

Ranking of genotypes as per measures

Mean yield of genotypes selected G4, G5 with lowest yield of G6 (Table 2). This measure is simple, but not fully exploiting all information contained in the dataset. Absolute lower IPCA-1 scores pointed for G7, G9 their general adaptations as per IPCA-2, G5, G2 genotypes would be of choice. Values of IPCA-3 favored G3, G8 genotypes. As per IPCA-4, G5, G7 genotypes would be of stable performance. ASV1 measures recommended (G7, G5) and ASV pointed towards (G5, G7) as of stable performance. Measures MASV and MASV1 used 97.2% of GxE interactions sum of squares (Gerrano *et al.*, 2020). MASV1 identified G5, G2 genotypes whereas genotypes G5, G2 be of stable yield performance by MASV. Consistent yield of G 8, G5 pointed out by least values of standard deviation and CV values. BLUP-based simultaneous selections settled for G4, G5 genotypes. The estimates of HMGV, RPGV, and HMRPGV had the same genotype ranking that was reported Anuradha *et al.*, 2022.

Non parametric measures

S_i^s measures consider the ranks of genotypes and anonymously pointed for G5, G4 as desirable genotypes (Table 3). Composite measures $NP_i^{(6)}$ based on the ranks of genotypes as per yield and corrected yield across environments simultaneously. $NP_i^{(1)}$ measure found suitability of G5, G4 while as per values of $NP_i^{(2)}$, $NP_i^{(3)}$ $NP_i^{(4)}$ genotypes G5, G3 would be choice for this zone.

Biplot analysis

The first two significant PC's has explained about

Table 2. AMMI along with BLUP based measures of yield for wheat genotypes

Code	Mean	IPC1	IPC2	IPC3	IPC4	MASV1	MASV	ASV1	ASV	BLStdev	BLCV	BLGM	BLHM	PRVG	MHPRVG
G 1	24.16	0.482	1.163	-1.203	0.910	3.60	2.96	1.50	1.35	6.67	27.37	23.66	22.98	0.919	0.910
G 2	25.91	-0.751	0.115	-0.520	0.499	1.99	1.50	1.48	1.06	7.38	28.48	25.07	24.24	0.973	0.965
G 3	24.75	-1.229	-0.437	-0.135	-0.403	2.56	1.90	2.46	1.78	6.68	26.61	24.39	23.73	0.947	0.939
G 4	31.05	0.929	0.518	1.506	0.686	4.13	3.14	1.90	1.40	7.63	25.20	29.58	29.00	1.147	1.139
G 5	28.44	0.222	-0.023	-0.614	-0.076	1.51	1.13	0.44	0.31	5.80	20.61	27.68	27.25	1.070	1.069
G 6	23.28	1.444	1.710	-0.858	-0.439	4.39	3.59	3.32	2.65	7.12	30.22	22.65	21.75	0.889	0.860
G 7	26.64	0.097	-0.373	2.272	0.121	5.38	4.06	0.42	0.40	7.65	28.70	25.92	25.35	1.006	0.997
G 8	26.16	-0.777	-0.471	-0.329	-2.147	2.84	2.57	1.60	1.19	5.38	20.40	25.92	25.50	1.008	0.996
G 9	25.85	0.142	-2.523	-1.028	1.038	4.69	4.26	2.54	2.53	5.99	22.92	25.45	24.68	0.995	0.972
G 10	26.89	-2.712	0.949	0.471	0.404	5.66	4.16	5.43	3.92	9.31	34.70	25.52	24.28	1.002	0.970
G 11	27.53	2.153	-0.629	0.440	-0.593	4.51	3.31	4.29	3.09	6.57	24.02	26.70	26.09	1.044	1.020

74% of the total variation in the AMMI, BLUP and non parametric measures considered for this study in biplot analysis (Table 4) with respective contributions of 45.3% & 28.7% by first and second principal components respectively (Ahakpaz *et al.*, 2021). Measures $S_i^1, S_i^2, S_i^3, S_i^4, S_i^5, S_i^6, S_i^7, NP_i^{(1)}, MASV, MASV1$ accounted more of share in first principal component whereas $RPGV, HMRPGV, BLGM, HMGV, NP_i^{(3)}, BLAVg, NP_i^{(4)}$ were major contributors in PC2. Very tight positive relationships observed for $IPC3, IPC4, NP_i^{(2)}, NP_i^{(3)}, NP_i^{(4)}$. AMMI based measures $MASV, MASV1$ closely associated with $BLstdev, S_i^2, S_i^3, S_i^5, S_i^6, ASV, ASV1$ values. $BLCV$ observed with S_i^1, S_i^4, S_i^7 . BLUP based measures observed in separate quadrant along with mean yield. This group of measures expressed no relationship with group consisted of $BLCV, S_i^1, S_i^4, S_i^7$. $BLCV$ also expressed no relationships $IPC3, NP_i^{(3)}, NP_i^{(4)}$. Group $MASV, MASV1$ also expressed right angles with BLUP based measures (Fig. 1). Measures $IPC3, NP_i^{(2)}, NP_i^{(3)}, NP_i^{(4)}$ formed a cluster observed adjacent to cluster of $ASV, ASV1, MASV, MASV1, BLstdev, NP_i^{(1)}, S_i^2, S_i^5, S_i^6$ in same quadrant. Moreover $BLCV, S_i^1, S_i^4, S_i^7$ formed a cluster in different quadrant. BLUP based measures constructed a cluster placed in different quadrant. Four clusters had accommodated studied measures (Fig. 2).

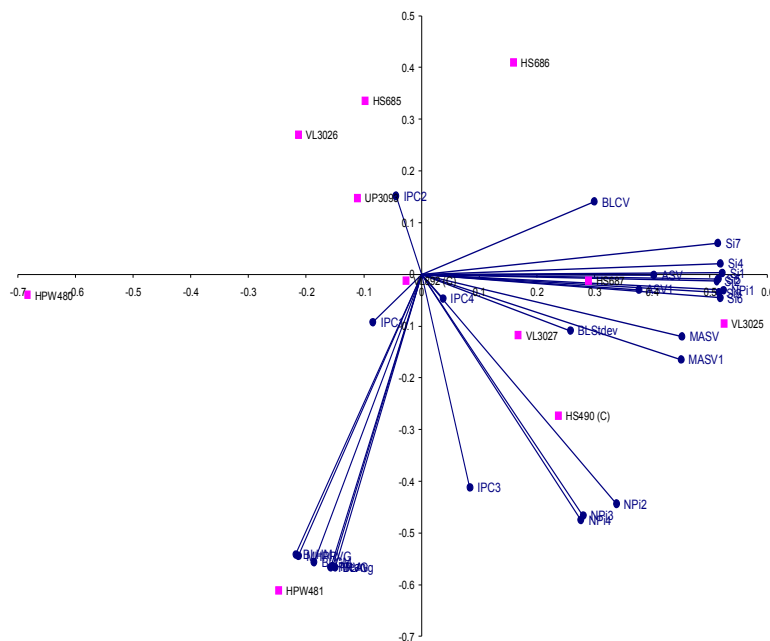


Fig. 1. Biplot analysis of AMMI, BLUP and non parametric measures

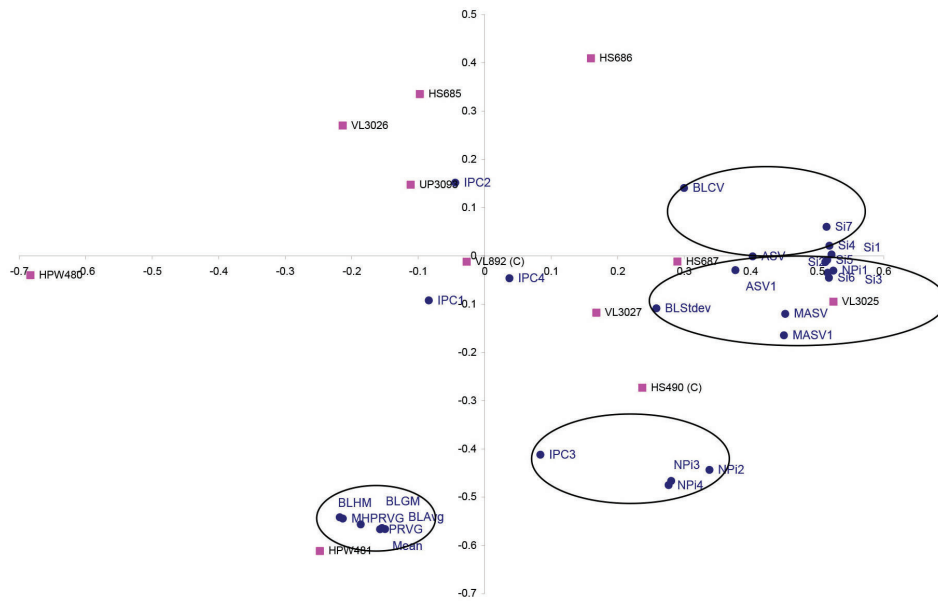


Fig. 2. Clustering pattern of AMMI, BLUP and non parametric measur

Table 3. Non parametric measures of yield for wheat genotypes

Code	S _i ¹	S _i ²	S _i ³	S _i ⁴	S _i ⁵	S _i ⁶	S _i ⁷	NP _i ⁽¹⁾	NP _i ⁽²⁾	NP _i ⁽³⁾	NP _i ⁽⁴⁾
G 1	3.333	8.667	1.368	2.944	1.667	2.105	3.250	2.000	0.286	0.421	0.476
G 2	3.600	10.000	1.667	3.162	2.000	2.667	3.125	2.333	0.359	0.487	0.554
G 3	3.000	6.167	1.000	2.483	1.375	1.784	2.803	1.833	0.244	0.331	0.400
G 4	2.667	4.667	0.824	2.160	1.250	1.765	2.333	1.667	0.714	0.926	1.143
G 5	1.200	1.067	0.188	1.033	0.583	0.824	1.143	0.667	0.160	0.248	0.288
G 6	4.333	12.567	2.154	3.545	2.125	2.914	3.696	2.833	0.347	0.434	0.531
G 7	4.933	16.000	2.667	4.000	2.500	3.333	4.000	3.333	0.500	0.600	0.740
G 8	4.267	13.867	2.080	3.724	2.333	2.800	3.714	2.667	0.471	0.657	0.753
G 9	5.400	19.767	3.205	4.446	2.875	3.730	4.297	3.833	0.535	0.620	0.753
G 10	5.533	21.767	3.530	4.665	3.125	4.054	4.353	4.167	0.676	0.757	0.897
G 11	4.800	15.867	2.975	3.983	2.500	3.750	3.967	3.333	0.741	0.885	1.067

Table 4. Loadings of AMMI, BLUP and non parametric measures

Measure	Principal Component 1	Principal Component 2	Measure	Principal Component 1	Principal Component 2
Mean	-0.083	-0.338	PRVG	-0.084	-0.339
IPC1	-0.045	-0.055	MHPRVG	-0.114	-0.326
IPC2	-0.024	0.091	S _i ¹	0.279	0.002
IPC3	0.045	-0.247	S _i ²	0.274	-0.008
IPC4	0.020	-0.028	S _i ³	0.276	-0.021
MASV1	0.241	-0.099	S _i ⁴	0.277	0.013
MASV	0.242	-0.072	S _i ⁵	0.275	-0.005
ASV1	0.202	-0.018	S _i ⁶	0.277	-0.027
ASV	0.216	-0.001	S _i ⁷	0.275	0.036
BLAVg	-0.080	-0.339	NP _i ⁽¹⁾	0.280	-0.018
BLStdev	0.138	-0.065	NP _i ⁽²⁾	0.181	-0.266
BLCV	0.160	0.084	NP _i ⁽³⁾	0.150	-0.279
BLGM	-0.100	-0.333	NP _i ⁽⁴⁾	0.148	-0.285
BLHM	-0.117	-0.325	74.00	45.26	28.74

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Conflict of Interests

No conflict of interests reported by the authors

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