Eco. Env. & Cons. 28 (November Suppl. Issue) : 2022; pp. (S16-S20)
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ISSN 0971–765X

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

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(Received 10 February, 2022; Accepted 5 April, 2022)

ABSTRACT

Significant variations due to environments 38.3%, GxE 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 GxE 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 × 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 accuracy 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, $NP_i^{(1)}$, $NP_i^{(2)}$, $NP^{(3)}$, $NP_i^{(4)}$ have been also utilized to interpret the response of genotypes to environmental conditions (Pour-Aboughadareh *et al.,* 2019). GxE 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-

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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).

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 un anonymously pointed for G5, G4 as desirable genotypes (Table 3). Composite measures $NP_i^{(s)}$ 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 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				

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).

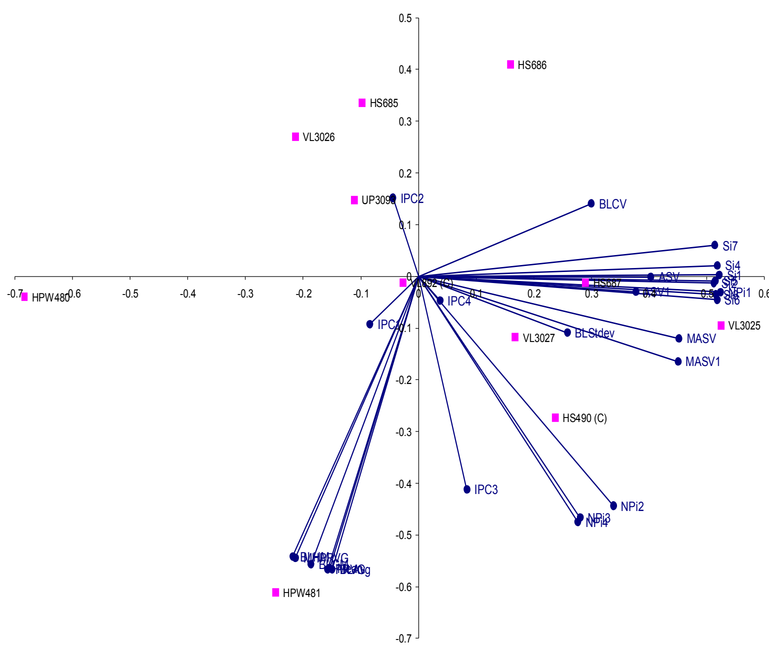

Fig. 1. Biplot analysis of AMMI, BLUP and non parametric measures

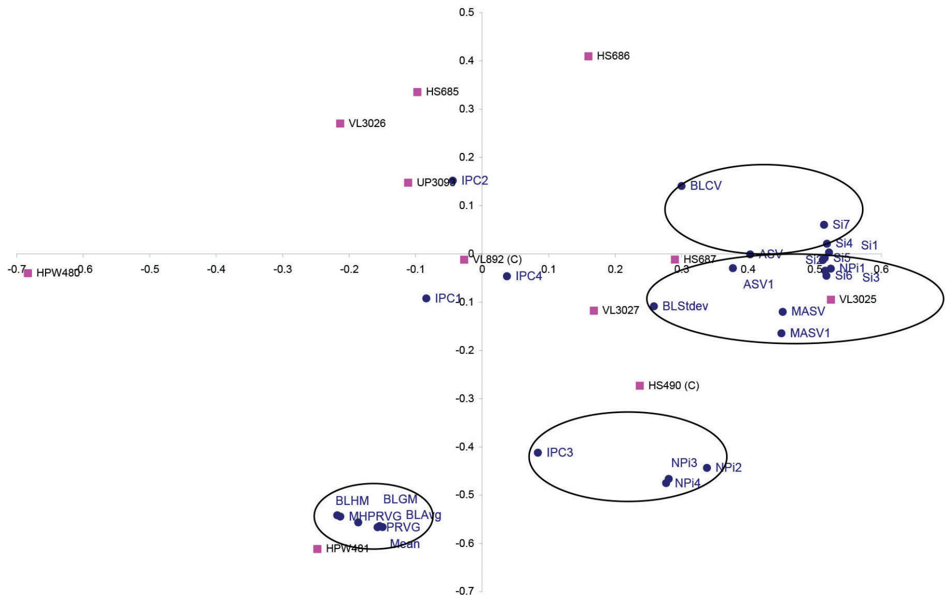

Fig. 2. Clustering pattern of AMMI, BLUP and non parametric measur

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

Acknowledgements

The training by Dr. J. Crossa and financial support by Dr. A.K. Joshi and Dr. R.P. Singh CIMMYT, Mexico sincerely acknowledged along with hard work of the staff to carry out the field evaluation of genotypes at coordinating centers.

Conflict of Interests

No conflict of interests reported by the authors

References

Ahakpaz, F., Abdi, H., Neyestani, E., Hesami, A., Mohammadi, B., Nader Mahmoudi, K., Abedi-Asl, G., Jazayeri Noshabadi, M.R., Ahakpaz, F. and Alipour, H. 2021. Genotype-by-environment interaction analysis for grain yield of barley genotypes under dry land conditions and the role of monthly rainfall. *Agric Water Manag*. 245 : 10665.

Anuradha, N., Patro, T.S.S.K., Singamsetti, A., Sandhya Rani, Y., Triveni, U., Nirmala Kumari, A., Govanakoppa, N., Lakshmi Pathy, T. and Tonapi, V.A. 2022. Comparative Study of AMMI- and BLUP-Based Simultaneous Selection for Grain Yield and Stability of Finger Millet [*Eleusine coracana* (L.) Gaertn.] Genotypes. *Front. Plant Sci.* 12 : 786839. doi: 10.3389/fpls.2021.786839

Gonçalves, G. de M. C. , Gomes, R. L. F., Lopes, Â. C. de A. and Vieira, P. Fe. de M. J. 2020. Adaptability and yield stability of soybean genotypes by REML/ BLUP and GGE Biplot. *Crop Breeding and Applied Biotechnology.* 20(2): e282920217.

Pour Aboughadareh, A., Ali, B., Ali, K. S., Mehdi, J., Akbar M., Ahmad, G., Kamal, S.H., Hassan, Z., Poodineh, Omid and Masoome, K. 2022. Dissection of genotypebyenvironment interaction and yield stability analysis in barley using AMMI model and stability statistics. *Bulletin of the National Research Centre.* 46 : 19.

Pour-Aboughadareh, A., Yousefian, M., Moradkhani, H., Poczai, P. and Siddique, K.H. 2019. STABILITYSOFT: A new online program to calculate parametric and non- parametric stability statistics for crop traits. *Applications in Plant Sciences.* 7(1): e1211

Mehraban, R. A., Hossein-Pour, T., Koohkan, E., Ghasemi, S., Moradkhani, H. and Siddique, K.H. 2019. Integrating different stability models to investigate genotype × environment interactions and identify stable and high-yielding barley genotypes. *Euphytica.* 215: 63.

Silva, E. M. da, Nunes, E. W. L. P., Costa, J. M. da, Ricarte A. de O., Nunes, G. H. de S. and Aragão Fernando Antonio Souza, de 2019. Genotype x environment interaction, adaptability and stability of 'Piel de Sapo' melon hybrids through mixed models. *Crop Breeding and Applied Biotechnology*. 19(4): 402-411.

Sousa, A.M.C.B., Silva, V.B., Lopes, A.C.A., Ferreira-Gomes R.L. and Carvalho, L.C.B. 2020. Prediction of grain yield, adaptability, and stability in landrace varieties of lima bean (*Phaseolus lunatus* L.). *Crop Breeding and Applied Biotechnology.* 20: e295120115

Vaezi, B., Pour-Aboughadareh, A., Mehraban, A., Hossein-Pour, T., Mohammadi, R., Armion, M. and Dorri, M. 2018. The use of parametric and non- parametric measures for selecting stable and adapted barley lines. *Archives of Agronomy and Soil Science*. 64 : 597–611.