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ORIGINAL ARTICLE

Stability Analysis of Quality Traits in Wheat (*Triticum aestivum* L.)

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ABSTRACT
Assessment of stability of a genotype to different environments is useful for recommending cultivars for known conditions of cultivation. Stability was evaluated in terms of protein and gluten content of wheat in ten genotypes planted at three different locations. Both protein and gluten content were significantly affected by the wheat varieties under various locations. The highest protein content (pooled) was exhibited by SKW-489 and SW-1 whereas the lowest protein content was observed in SKW-848. Similarly, highest gluten content (pooled) was observed in SKW-517 and SW-355, while lowest percentage was exhibited by SKW-489. All the genotypes (with IPCA 1 "+") except G1 were categorized under favourable environments with above-average means for protein content, whereas genotype G1 which lies on the origin of biplot contributed lowest to the GE interaction. All the genotypes were tightly grouped with E2 with regard to gluten content.
Key words: *Variability, stability, AMMI, protein content, gluten content, wheat*

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INTRODUCTION

The quality of wheat will mean different thing to a breeder, a miller or a baker. Generally, wheat quality refers to its suitability for a particular end-use. Botanical, subjective and objective criteria are used to assess the quality. Objective criteria are based on physical, chemical and nutritional properties of wheat grain and are more reliable in evaluation of wheat quality, hardness. Protein content and gluten strength are the basic quality attributes. Protein content is a key quality factor [17], that determine the suitability of wheat for a particular type of product as it affects other factors including mixing tolerance, loaf volume and water absorption capacity. Wheat is unique among cereals and other protienaceous plants in that its milled product, flour, alone is capable of forming dough due to its gluten content. The dough retains the gas evolved during fermentation [7] and on baking will yield a light, well aerated loaf of bread. This unique characteristic of wheat is derived from its proteins that are gliadin and gluten and upon hydration results in gluten, the actual substance that imparts the property of gas retention to dough. Bread (or hard wheat) flour has high gluten content and is therefore good for yeast raised bread, which require an elastic framework. On the other hand, weak wheat flour is best suited for cakes and for biscuit making [18].

Stability analysis which provides an idea about consistent performance of a genotype under varied environmental conditions is a prerequisite for wide, commercial cultivation of the common bean. G x E interactions are of major importance to the plant breeder in developing improved genotypes [10]. When genotypes are compared over a series of environments, the rankings usually differ and this may cause difficulty in demonstrating the superiority of any genotype across environments. Stratification of environments has been used effectively to reduce such type of interaction. Stability performance of genotypes will be of special importance in Jammu and Kashmir where environmental conditions vary considerably and the means of modifying the environment are inadequate. The major problem of wheat improvement program in this state has been the lack of genotypes that consistently perform well across different wheat growing environments. Hence, the development of high yielding genotypes and information on multi location performance are of paramount importance in Jammu and Kashmir where environments vary greatly within short distances. In view of the above, the present investigation was undertaken to evaluate the protein and gluten content of wheat genotypes in different environments and to determine their stabilities using AMMI model.

MATERIAL AND METHODS

The present investigation was carried out during *rabi* season of 2012-13 and 2013-14 at three locations namely Experimental Farm of the Division of Plant Breeding and Genetics, SKUAST-K, Shalimar, Mountain Field Crop Research Centre, Khudwani and Experimental Farm of the Regional Research Station, Wadura, Sopore. The basic material for the present investigation comprised of 10 genotypes viz; SKW-848, SKW-489, SKW-490, SKW-514, SKW-515, SKW-517, SKW-519, SKW-527, SKW-530 and SKW-531 of wheat (*Triticum aestivum* L.) selected from the germplasm resources maintained at Division of Plant Breeding and Genetics, SKUAST-K, Shalimar. The experiment was laid out in a completely randomized block design with 3 replications at each location. The experimental plot comprised 3 rows each of 1 meter length. Row to row and plant to plant spacing was maintained at 25 cm and 10 cm, respectively. Recommended agronomic practices were followed to raise a good crop at all the three locations. Observations were recorded on protein and gluten content fron five randomly selected competitive plants of each genotype from very replication. For protein content the grains were dried in oven and ground to the fine powder to pass through, 40 mesh sieve in a 'Micro Willey Mill.' From each treatment, 0.5 gram sample was weighed for chemical analysis to determine the contents of nitrogen. The total content of nitrogen was estimated by Kjeldahl method and was expressed in %. Protein content (%) in grain was determined by multiplying the nitrogen % in grain with the conversion factor 6.25.

Gluten in sample of flour was estimated by washing the dough free of starch, sugars, water soluble proteins and other minor components. The wet cohesive mass obtained is referred to as wet gluten while the dry product obtained from it is referred to as dry gluten. 25 g flour was kneaded with about 15 ml of water to get a dough ball. The dough ball was allowed to remain immersed in water for one hour to ensure proper hydration after which the starch is washed out by kneading gently in a gentle steam of water over a fine sieve or silk till the washed liquid is clear.

The gluten which is cohesive was pressed as dry as possible and weighed. The gluten so obtained was dried at 100^{O}C for 24 hours and weighed again to get the value for dry gluten.

$$\text{Wet gluten (\%)} = \frac{A}{C} \times 100, \qquad \text{Dry gluten (\%)} = \frac{B}{C} \times 100$$

Where,

A = Weight of wet gluten, B = Weight of dry gluten, C = Weight of flour

Based on the performance of the genotypes in three random environments, phenotypic stability was worked out by the AMMI model of Gauch and Zobel [6]. The analysis of variance by Panse and Sukhatme [14], mean, coefficient of variability, heritability by Shakoor *et al*., [16] and genetic advance as per cent of mean by Johnson *et al.,* [9].

RESULTS AND DISCUSSION

It is evident from Table 1 that both protein and gluten content were significantly affected by the wheat varieties under various locations. The highest protein content (pooled) was exhibited by SKW-489 (13.54%) and SW-1 (13.23%) whereas the lowest protein content was observed in SKW-848 (10.31%). Similarly, highest gluten content (pooled) was observed in SKW-517 (29.65 %) and SW-355 (29.14%), while lowest percentage was exhibited by SKW-489 (22.22%). The data further revealed that genotypes with high gluten content were also good in bread/chappati making quality. Phenotypic coefficient of variability was higher than genotypic coefficient of variability for both the traits, however, the differences between them was very narrow indicating the lesser role of environment. As the coefficient of variation indicates only the extent of variability, it doesn't reflect on heritable proportion of variation. Hence, estimation of heritability coupled with genetic advance as per cent of mean permits greater effectiveness for selection by separating out the environmental influence from the total variability and thereby allowing accurate selection of a potential phenotype. The results indicated high heritability coupled with high genetic advance for both the traits, thus indicates the predominance of additive genetic variance for these traits. Hence, these characters are amenable for simple selection of superior segregants. High heritability with high genetic advance was also reported for protein content by Pasha *et al*. [15], Noorka *et al*. [13] and Mueen-ud-Din [12]. Anjum and Walker [1] observed that dry and wet gluten contents of Pakistani wheat were significantly influenced by cultivars but not by crop years or growth locations. Mueen-ud-Din [12] has been investigated the gluten content of flour of various wheat varieties which is in conformity with the present findings.

The high protein percentage of SKW-489 and SKW-1 indicates their stability for hard wheat products like yeast-leavened bread. The dough made from these type of varieties results in increased loaf volume after baking [8]. High protein levels are related to undesirable cookie textured. Protein content of rest of the genotypes were low to medium in range and characterized as semi hard wheats. Dough from these varieties will be strong, stretchable, elastic and non-sticky i.e. suitable for un-leavened bread like chapati. All varieties used in this study were found to have medium to high gluten content. High gluten content leads to strong gluten matrix which may during baking increases the viscosity of cookie dough, which in un-desirable because cookie spread is restricted [7] but it is good for bread making.

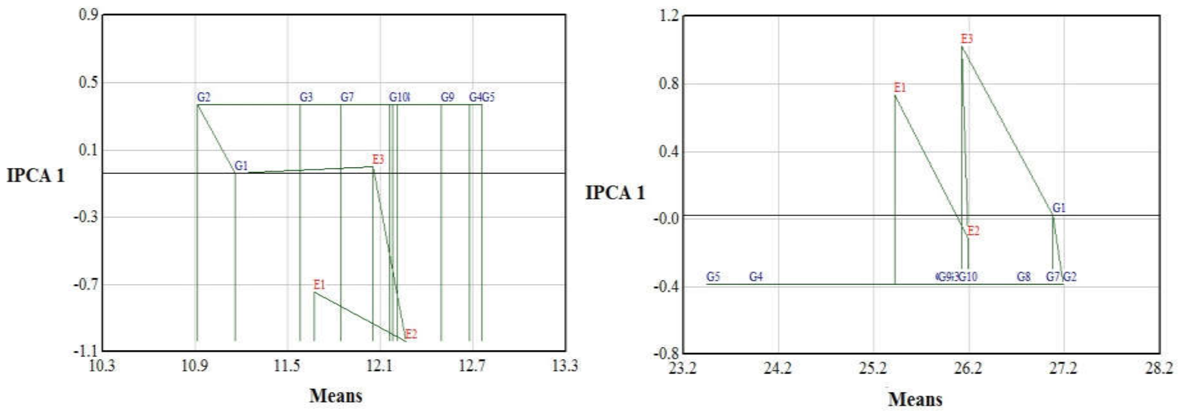
Table 1 Protein and gluten content (%) in 10 wheat genotypes under three environments

Genotypes	Environment I		Environment II		Environment III		Pooled Environments	
	Protein Content	Gluten Content	Protein Content	Gluten Content	Protein Content	Gluten Content	Protein Content	Gluten Content
SKW-848	9.90	26.95	10.64	29.12	10.40	28.62	10.31	28.23
SKW-489	13.13	22.72	13.87	19.55	13.63	24.39	13.54	22.22
SKW-490	12.01	26.49	12.75	28.66	12.26	21.82	12.34	25.65
SKW-514	10.57	24.88	11.31	27.05	11.12	26.55	11.00	26.16
SKW-515	13.56	21.37	12.82	23.54	13.06	23.04	13.14	22.65
SKW-517	11.13	30.93	11.87	28.76	11.63	29.26	11.54	29.65
SKW-519	12.26	25.70	13.00	27.87	12.76	27.37	12.67	26.98
SKW-527	10.81	27.32	11.55	25.15	11.31	28.99	11.22	27.15
SKW-530	11.14	24.31	11.88	26.48	11.64	25.98	11.55	25.59
SKW-531	12.19	23.83	12.93	26.00	12.69	25.50	12.60	25.11
GCV	8.981	9.965	7.490	10.088	7.578	9.784	7.922	8.476
PCV	8.996	9.981	7.502	10.104	8.125	9.799	8.004	8.489
H^2 (BS)	94.669	98.688	95.689	97.684	86.979	98.691	97.956	98.682
GA % Mean	18.470	20.496	15.406	20.748	14.558	20.124	16.152	17.432

Table 2 AMMI Analysis of variance for protein and gluten content in wheat (*Triticum aestivum* L.)

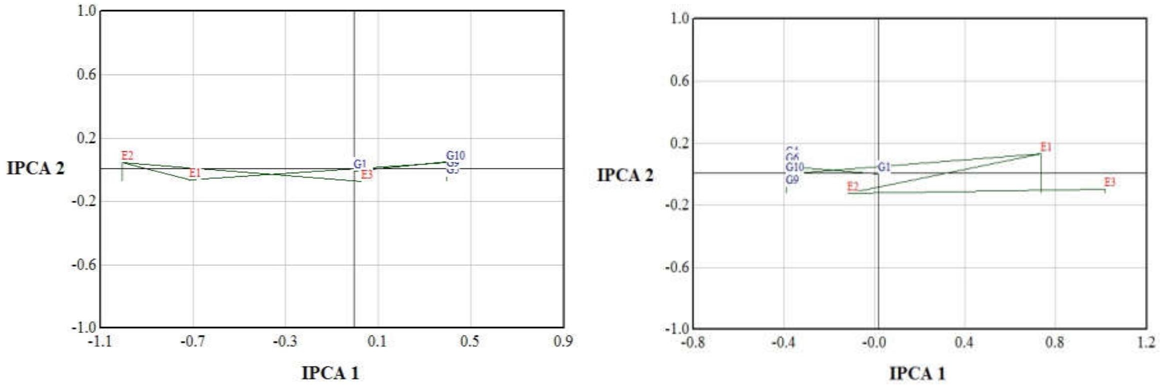
Source of variation	df	Mean sum of squares	
		Protein content (%)	Gluten content (%)
Genotypes	9	3.46**	15.00**
Environments	2	2.69**	5.43**
Replications within environments	6	0.49*	4.38*
Genotype x Environment	18	0.08*	3.36*
Error	54	1.51	9.37
Total	89	1.38	8.29

*, ** Significant at 5 and 1 per cent levels, respectively



1a 1b

Fig. 1 Biplot of the first AMMI interaction (IPCA 1) score (Y-axis) plotted against mean protein (1a) and gluten (1b) content (%) (X-axis) for 10 wheat genotypes



2a 2b

Fig. 2 Biplot of the first AMMI interaction (IPCA 2) score (Y-axis) plotted against AMMI interaction (IPCA 1) score (X-axis) for protein (2a) and gluten (2b) content for 10 wheat genotypes and 3 environments Where,

G1 (SKW-848), G2 (SKW-489), G3 (SKW-490), G4 (SKW-514), G5 (SKW-515), G6 (SKW-517), G7 (SKW-519), G8 (SKW-527), G9 (SKW-530), and G10 (SKW-531), and E1 (Experimental Farm of the Division of Plant Breeding & Genetics, SKUAST-K, Shalimar, Srinagar), E2 (Mountain Field Crop Research Centre, Khudwani) and E3 (Regional Research Station, Wadura, Sopore).

The results of AMMI analysis for maturity, morphological, yield, yield attributing and quality traits in wheat (*Triticum aestivum* L.) for the 10 genotypes and 3 environments are presented in Table 2. The AMMI analysis of data revealed that the environment, genotype, and GE interaction were highly significant (P< 0.01). The large MS of environments indicated that the environments were diverse. The large differences among environmental means caused most of the variation in studied traits.

To characterize GE interaction, an AMMI 1 biplot was plotted using the genotype and environment mean protein content and their IPCA 1 scores (Fig. 1a). All the genotypes (with IPCA 1 "+") except G1 exhibited highest contribution to GE interaction as indicated by their distance from the origin of the biplot i.e. zero. On the other hand the genotype G1 lies on the origin of the biplot i.e with zero distance and therefore showed least contribution to GE interaction. Regarding the environments E3 exhibited minimum IPCA 1 score and led to zero interaction, whereas E2 followed by E1 (with IPCA 1 "-") contributed maximum to GE interaction.

To understand the relationships between particular genotypes and environments for protein content, AMMI 2 biplot analysis was performed, where IPCA 1 scores were plotted against IPCA 2 scores of the AMMI analysis (Fig. 2a). The results of this biplot showed the genotype G1 was tightly grouped with environment E3 but contributed least to GE interaction because both lies very close to the origin of the biplot. On the other hand the environments E1 and E2 and rest of the genotypes had maximum GE interaction as indicated by the distances from the origin of biplot. From the figure (2a) it is clear that all the genotypes (with IPCA 1"-") except G1 contributed maximum to GE interaction. Among them the highest contribution was exhibited by G5 and G4. The environment E2 showed minimum IPCA score and led to zero interaction, whereas the environment E3 followed by E1 contributed maximum to GE interaction as indicated by their distance from the origin of biplot. The AMMI 2 biplot (Fig. 2b) for gluten content revealed all the genotypes were tightly grouped with E2 and were highly stable to that particular environment. The environments E1 and E3 were separated and showed maximum effect on GE interaction.

Quality is a complex characteristic and the degree of influence of each component determining its expression is affected by the genotype's behavior to a specific environment. Diverse studies point out that climatic conditions during the growing season, especially during the wheat's reproductive period, are very important since they are closely related to the formation and accumulation of protein reserves [5] that have an impact on genotype quality [4]. Borghi *et al*. [2] point out that in a Mediterranean-type climate, such as the one found in Chile, the G×E interaction has a strong influence and causes important variety response variability for both yield and quality in each season and each planting site. In general, cultivars exhibited wide response variability to the G×E effect on quality. However, 'G1' stood out because it exhibited a higher yield than the others in all environments and also maintained the quality-related parameters close to the mean without any important variations from one locality to the other. A fundamental aspect in cereal genetic improvement is to understand and integrate the effect of G and G×E in selecting genotypes with enhanced behavior [3, 11, 19].

CONCLUSION

Based on the findings of the present study, the parental material did not indicate much variation for protein and gluten content. However, the genotypes viz., SKW-489 and SKW-515 exhibited high protein content and desirable gluten content. All genotypes except G1 showed stable performance were fit for better environment. The genotype G1 was stable for average environment for the studied traits. The material needs to be studied and evaluated further for identification of superior genotypes for future breeding programme.

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