Genotype × environment interaction for morphological and quality traits of wheat varieties under different nitrogen regimes in the foothills of Shivalik range of Himalayas

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Received: January 22, 2016; Revised received: July 12, 2016; Accepted: October 6, 2016

Abstract: Variation among twelve winter wheat varieties with respect to N efficiency (NE) were assessed in field trial planned as per factorial experimental design (two years × three nitrogen doses × twelve genotypes) in which treatments were randomized in three replications under three nitrogen levels (control, 150, 250 kg/ha) for two successive years at N. E. Borlaug Crop Research Center, Pantnagar. Stability analysis of nitrogen efficiency contributing traits was performed using mean performance, linear regression and the deviation from regression. No single genotype performed well enough for all the traits under study. QLD 33, HD 2967 and QLD 39 were stable for root length showing good performance for nitrogen uptake. HD 3112 was most stable variety for most of the characters whereas, QLD 33 was found to perform best under higher levels of nitrogen fertilisation, thus, not efficient enough. But, QLD 33 showed delayed maturity which could be linked with an increase in grain yield thus, it could be said that functional stay green phenotypes should increase the grain filling period and boost yield.

Keywords: G × E interaction, Morphology, Nitrogen use efficiency, Quality, Wheat genotypes

INTRODUCTION

The prime objective of a breeder for any crop improvement programme has always been stable grain yield. Its quiet evident from the past researches that in order to improve abiotic stress tolerance, direct selection for yield should be adopted and thereby subjecting the genotypes to stress environments for further research. And one of the major concerns is related to nitrogen use efficiency (NUE). Revolution holding grounds in India, breeding of modern wheat varieties has been mainly done by optimal input management system for cultivation which includes application of high levels of N (Nitrogen) fertilizer (Hirel et al., 2007). But, with the time this excessive use of nitrogen fertilisers has adversely affected the environment. Wheat plants utilize nearly 30–40% of the applied N (Raun et al., 2002) and rest i.e. > 60% is lost in form of or in combination through denitrification, surface runoff, leaching, etc. With these negative impacts on environment it has necessitated use of less N fertilizer and selecting plants which must be positively responsive to N with maintaining good levels of both yield and grain protein content (Witcombe et al., 2008).

In wheat production, nitrogen contributes as a major prerequisite affecting protein content and baking quality thus, ultimately affecting the commercial value of the produce. According to Moll et al. (1982), grain nitrogen uptake and nitrogen availability to the crop during the growth period are the two components of NUE. Whereas, Raun et al. (2002) explained NUE to be the N recovered in yield as a proportion of N applied, allowing for initial soil N conditions, i.e. NUE= (N crop – N from soil) / (N fertilizer). Le Gouis et al. (1996) first showed the genetic variability in wheat for efficiency in wheat with respect to nitrogen. In order to improve the wheat quality either of the two ways can be adopted, first, improve the protein quality of the cultivar; second, improve the nitrogen efficiency of the cultivar which would ultimately affect the gain protein content. With this, it has also been observed that for a specific cultivar, its maximum protein and maximum yield are generally not obtained by application of same strategy of fertilization (Lopez-Bellido and Lopez-Bellido, 2001). Thus, differences in climate along with cultivars and also management practices may account here for efficient nitrogen use (Bellidoa et al., 2005). This makes phenotyping an important tool for selecting the traits contributing to NUE by evaluating their performance under different environmental conditions. Ortiz-Monasterio (1997) gave light upon the contribution of root related traits in nitrogen uptake efficiency by reporting that at low soil N levels there was better expression of uptake while at high N levels utilization is better expressed. In order to improve NuPE (Nitrogen Uptake Efficiency), optimizing the rooting system will be an important consideration. A recently developed model indicated that the deeper the relative distribution of the roots, the greater the N capture as a proportion of that available to the plant (King et al., 2003). It has also been
The analysis of variance for stability using Eberhart and Russell’s model.

**Results and Discussion**

The analysis of variance for stability using Eberhart and Russell’s model.
Table 2. Stability parameters for differential characters in wheat.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Genotype</th>
<th>DTH</th>
<th>RL</th>
<th>GP</th>
<th>GNY</th>
<th>WG</th>
<th>TKW</th>
<th>HI</th>
<th>BY</th>
<th>FY</th>
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<td></td>
<td>X1</td>
<td>b1</td>
<td>S2d1</td>
<td>X1</td>
<td>b1</td>
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<td>S2d1</td>
<td>X1</td>
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<td>1.236</td>
<td>0.921</td>
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<td>1.236</td>
<td>0.921</td>
<td>0.001</td>
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<td>1.236</td>
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DTH: days to 50% heading; NT: number of tillers; SL: spike length; SN: number of spikelets/spike; PH: plant height.
and Russell’s model has been depicted in table 1 in which the mean squares due to genotypes was found significant for all traits except wet gluten and grain protein content, whereas for environment all traits showed significant mean sum of squares except for harvest index and grain yield. The mean sum of squares due to G × E interaction were significant for number of tillers, root length, grain protein, wet gluten and grain nitrogen content of wheat varieties, while for other traits the values of interaction estimate were non-significant. None of the wheat genotypes had stable performance for all the characters over all six environments as were advocated as been depicted in table 2. QLD 11 showed $b_i$, and $S^2d_i$, values significant which clearly shows this genotype showed varying performance across all environments. For days to 50% heading, only HD 3112 exhibited stable performance with mean less than the general mean, linear regression coefficient value near unity and negligible deviation from regression. UP 2825, HD 2932 and HD 2967 showed $b_i$ value significantly different from unity whereas the remaining of the genotypes exhibited non-significant deviation. Significant genotypes indicated their fluctuation in performance for this trait across the environments. Whilst talking about spike length, GW 445, HD 3112, HD 3104 and DBW 97 were recognized as the stable genotypes over all environments because of their higher mean, $b_i ≠ 1$ and $S^2d_i ≠ 0$ across the environments. QLD 33 showed specific adaptability for rich environment due to its higher mean, linear regression coefficient value higher than unity and high deviation from regression. Jena et al. (2005) in his experiment revealed that both linear and non-linear components were predominant in plant height, spike length and number of grains per spike, whereas non-linear components were observed in all characters except spike length. For plant height there most desirable and stable genotype was HD 2967 due to high mean (>88.22), $b_i ≠ 1$ and $S^2d_i ≠ 0$ exhibiting higher plant height. QLD 33, HD 2967 and QLD 39 were considered to be stable for root length, had regression coefficient value nearly about unity ($b_i ≠ 1$) and $S^2d_i ≠ 0$ indicating their stable response over environments with high mean value. Similar results were shown by Patel et al (2014) in which they showed both linear and non-linear components significant and ones with higher general mean, regression coefficient around unity and least deviation from regression were more stable. DBW 97 was found suitable for rich environment and HD 3104 was found suitable for poor environment because of its high genotypic mean for root length, low $b_i$ value and sufficient deviation from regression ($S^2d_i ≠ 0$) which was found similar to the results obtained by Sial et al. (2003) who in their study showed environments (E), genotypes (G), G × E interactions and genotypes × year interactions were highly significant which suggested perceptible seasonal effects. For grain protein, HD 3112 and DBW 97 were found to be stable over the environments because of their high mean, $b_i ≠ 1$ and $S^2d_i ≠ 0$ across the environments whereas, UP 2825 was found suitable for rich environment and none of the genotypes was found to be suitable for poor environment. El Ameen (2012) showed similar results in which he showed the genotypes performed differently for different yield contributing traits. No single genotype showed stable performance across all environments in case of grain nitrogen yield and wet gluten. GW 445 was recognized as the stable genotype over environments for thousand kernel weight. Harvest index was one such trait in which, all the twelve genotypes exhibited non-significant estimates of linear regression coefficient ($b_i$) values showing their average stable performance for harvest index across the environments. Najeeb et al. (2004) in their similar study showed G × E interaction was significant for number of days of heading and effective tillers per plant. Environment (linear) component was significant except for number of effective tillers per plant and grain yield per plant, whereas G × E (linear) was significant for days to heading and effective tillers per plant. Pooled deviation was significant for most of the traits except 1000-seed weight. Similarly, Banerjee et al. (2006) produced their results by conducting stability analysis for 16 genotypes in which they showed ten genotypes with higher mean values and regression coefficient higher than unity indicated stability under favourable condition. Shah et al. (2009) studied variety-environment interaction, stability and adaptability of various characters and effect of different environments, relationship of characters with grain yield and grain protein percentage for three years. Variety-location, variety-year and variety-location year interactions were highly significant for all characters. Similarly in a study conducted by Banica et al. (2008), lower yield variation at a higher average yield level in the cultivars can be explained by their superior drought resistance which is related to a higher level of osmotic adjustment. In the present study good variability was found for biological yield by genotypes and most stable genotypes across the environments were UP 2825, HD 3112, QLD 39, HD 2932 and DPW 621-50 and good performers under rich environment were HD 2967 and HD 3104. The results were in accordance with the findings of Praveen et al. (2010) who selected grain weight per tiller and yield contributing traits of wheat showing that only few genotypes showed stability for the characters.

**Conclusion**

Our results showed different genotypes showed differential performance with respect to stability for different traits and it was seen that the traits and their stability are not mutually
exclusive. QLD 11 showed varying performance with respect to stability. HD 3112 exhibited stable performance for spike length, biological yield and grain protein. DBW 97 was found to be stable over the environments for grain protein and spike length. GW 445 was recognized as the stable genotype over environments for spike length and thousand kernel weight. QLD 39 was found to be stable for root length which could be beneficial with respect to nitrogen uptake efficiency. None of the test genotypes showed stability across all environments for grain yield.

ACKNOWLEDGEMENTS

The experiment was supported by Director Experiment Station, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar.

REFERENCES