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# SIMULTANEOUS SELECTION OF MOST STABLE AND HIGH YIELDING GENOTYPES IN BREEDING PROGRAMS BY NONPARAMETRIC METHODS

Naser SABAGHNIA*, Hamid HATAMI-MALEKI, Mohsen JANMOHAMMADI

Department of Agronomy and Plant Breeding, Faculty of Agriculture, University of Maragheh, Iran
*Corresponding author: sabaghnia@maragheh.ac.ir

## ABSTRACT

Explaining genotype by environment (GE) interaction is important in breeding programs because environmental effects are very often greater than genotypic effects in multi-environment trials. Statistical methods that select for high yield and stability have been proposed, but have not been compared for their usefulness especially for nonparametric methods. We compared fourteen nonparametric methods used for analyzing GE interaction at a set of experimental lentil data (11 genotypes at 20 environments). Nonparametric methods consist of six Huehn's statistics (S1, S2, S3, S4, S5 and S6), four Thennarasu's statistics (NP1, NP2, NP3 and NP4), tow Sabaghnia's statistics (NS1 and NS2), Kang's RS and nonparametric method of Fox et al. (1990). Considering mean yield versus nonparametric stability values via their plotting in a plot, indicated four different sections as A, B, C and D. The genotype fall in the section D were the most favorable genotypes due to high mean yield as well as high stability performance. Plot of the most nonparametric methods showed that genotypes G1 (1.21 t $ha^{-1}$), G2 (1.34 t $ha^{-1}$) and G5 (1.38 t $ha^{-1}$) were the most favorable genotypes and so these genotypes considered both yield and stability simultaneously. Although, most of the nonparametric methods have static (biological) concept of stability and measure the real concept of stability but plotting them versus mean yield and selecting the genotypes of section D, could identify relatively the high mean yield genotypes as the most stable ones.

**Keywords:** *GE interaction, static stability, plotting, mean yield.*

## INTRODUCTION

Multi-environment trials (MET) are important in plant breeding for investigating yield stability of genotypes across environments. There are nonparametric statistics versus the parametric methods as an alternative strategy which are unaffected by data distribution and they are based on ranks and a special genotype is considered stable if its ranking is constant across test environments. Several nonparametric stability statistics have been developed to explain the GE interaction in multi-environment yield trials (Huehn, 1979; Thennarasu, 1995; Sabaghnia, 2015). The nonparametric strategy is based on ranks of genotypes across test environments and provides an alternative to the parametric strategies. These methods separate genotypes based on their similarity of response to a range of test environments and has some advantages over the parametric strategies such as: reduction of the bias caused by outliers, no need for assumptions about the data distribution, easy to use, and not influencing by additions or deletions of few genotypes or environments (Huehn, 1996), Furthermore, for many applications such as selection, the rank order of genotypes is the most essential information. The good ability of the nonparametric methods for detecting the most stable genotypes as well as the GE interaction investigation have been reported in different crops such as lentil (Sabaghnia et al. 2006), chickpea (Ebadi-segherloo et al. 2008) and durum wheat (Sabaghnia et al. 2012b). The objective of this investigation was an estimation of yield stability performance of genotypes in environments via two new nonparametric stability statistics and their comparison with the existent methods.

## MATERIALS AD METHODS

The lentil multi-environmental trials dataset of Sabaghnia et al. (2006) was used in this research and its two-way layout of yield performance for 11 autumn lentil cultivars at 20 different environments. Several nonparametric stability statistics were computed for each of lentil genotypes. The six statistics were based on yield ranks of genotypes in each environment and calculated as (Huehn, 1979). Kang's (1988) rank-sum (RS) was another nonparametric statistics where and computed via mean yield and stability variance. Nonparametric stability indices as Top, Mid and Low were calculated as Fox et al. (1990) using stratified ranking of the genotypes at each environment separately and the number of environment at which the genotype occurred in the top, middle, and lower third of the ranks was computed. Four nonparametric statistics of Thennarasu (1995) were based on the corrected ranks. The two nonparametric stability statistics as $NS_i^{(1)}$ and $NS_i^{(2)}$ which are proposed by Sabaghnia (2015) computed as:

$$NS_i^{(1)} = (Q_3 - Q_1) / M_{di}$$

$$NS_i^{(2)} = (D_9 - D_1) / M_{di}$$

where, $Q_3 - Q_1$ was the inter-quartile range which is a nonparametric index of statistical dispersion. $M_{di}$ is the median of the genotypes' ranks in the test environments, $D_9 - D_1$ was the inter-decile range which is another nonparametric index of statistical dispersion of the values in a set of data. For simultaneous selection of most favorable genotypes (stable and high yielding), the calculated values of each of above mentioned nonparametric methods were plotted against mean yield performance separately. Each generated plot can be divided into four distinct sections as section A: low stability and low mean yield; section B: low stability and high mean yield; section C: high stability and low mean yield and section D: high stability and high mean yield. Therefore, the genotypes which were in the section D could be regarded as most favorable genotypes (stable and high yielding). All of mentioned stability statistics were computed via Microsoft EXCEL program and plots were generated via STATISTICA version 10.0.

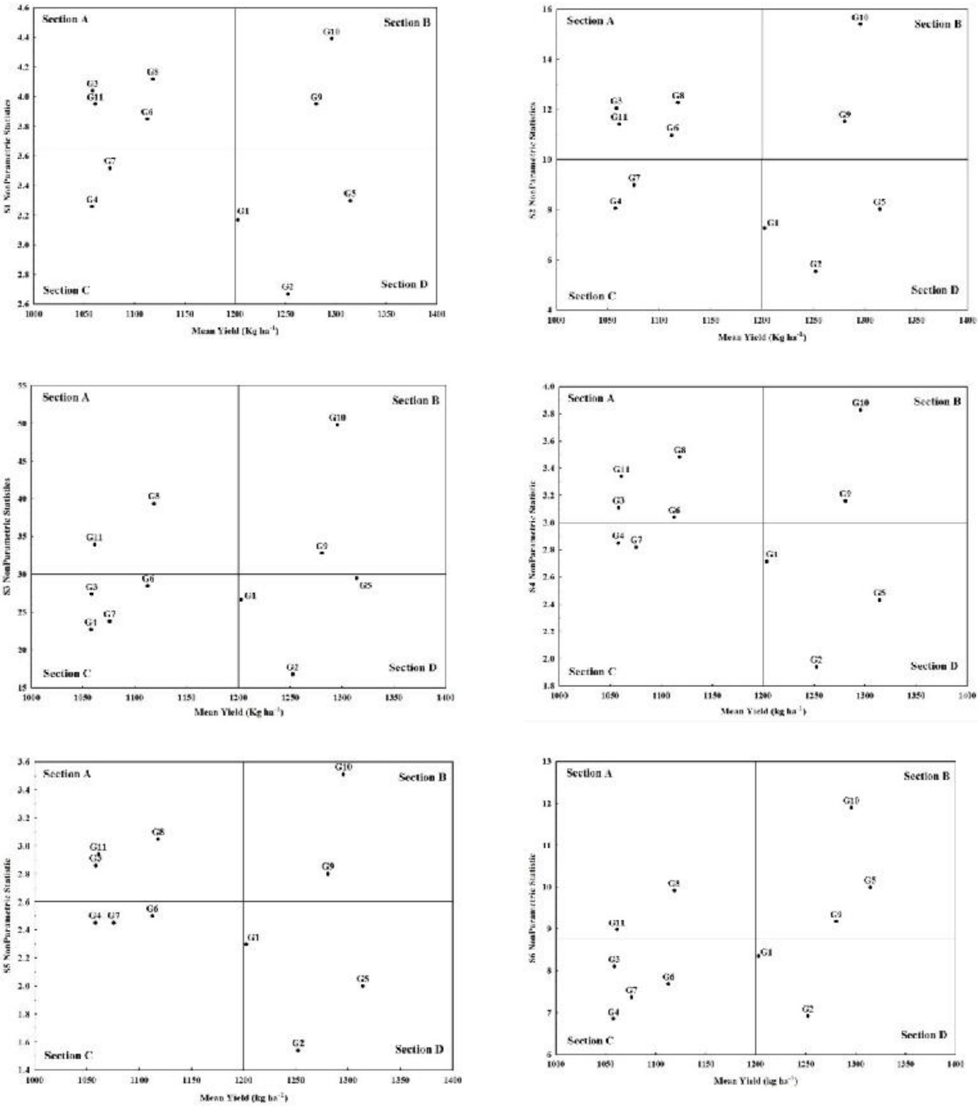


Figure 1. Plot of S1, S2, S3, S4, S5 and S6 stability statistic versus mean yield using yield data from 11 lentil genotypes grown in 20 environments.

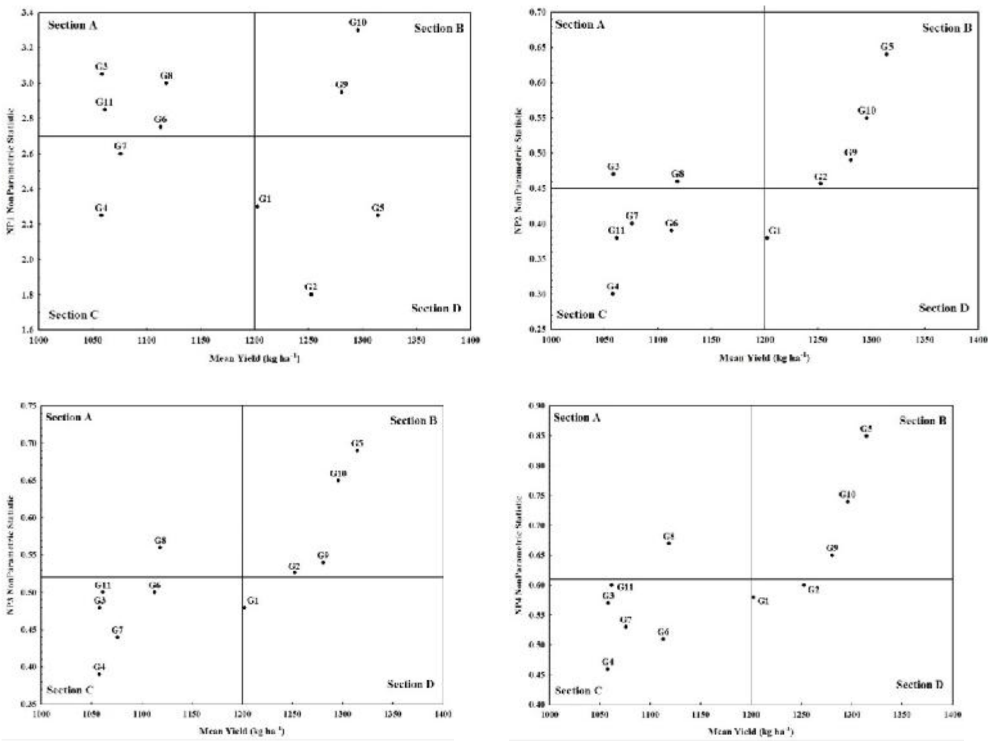


Figure 2. Plot of NP1, NP2, NP3 and NP3 stability statistic versus mean yield using yield data from 11 lentil genotypes grown in 20 environments.

## RESULTS AND DISCUSSION

According to Fig. 1, genotypes G1, G2 and G5 were in the section D of related plots to five nonparametric statistics of Huehn (1979) as S1, S2, S3, S4 and S5. In the sixth statistics of Huehn (1979) as S6, only genotypes G1 and G2 fall into section D and could be regarded as the most favorable genotypes. Based on Fig. 2, genotypes G1, G2 and G5 were in the section D of NP1 while only genotype G1 was in the section D of NP2 and NP3. Also, genotypes G1 and G2 were in the section D of NP4. Plots of NS1 and NS2 (Sabaghnia, 2015) revealed that genotypes G1 in NS1 and genotypes G1, G2 and G5 in NS2 were the most favorable genotypes due to high mean yield and high stability performance (Fig. 3). Kang’s (1988) rank-sum (RS) indicated that genotypes G1, G2 and G5 were in the section D while based on three nonparametric stability indices of Fox et al. (1990), genotypes G1, G2, G5 and G9 were in the section D (Fig. 3).Crop breeders have used the yield stability to characterize a genotype which acts a constant yield, ignoring of environmental changes, and so they have explored for genotypes with a less variation for yield performance over different environmental conditions. This idea of yield stability is similar to the homeostasis in quantitative genetics and is regarded as a biological or static concept of stability (Becker, 1981), which a genotype having a constant performance in all environments does not necessarily respond to changes of conditions. The above type of yield stability, thus, is not suitable to most farmers, who would prefer an agronomic or dynamic concept of stability (Becker and Leon, 1988). For each test environment, the performance of a stable genotype based on static concept corresponds to the estimated level but in the dynamic stability, it is not required that the genotypic response to environmental changes should be equal for all studied genotypes.

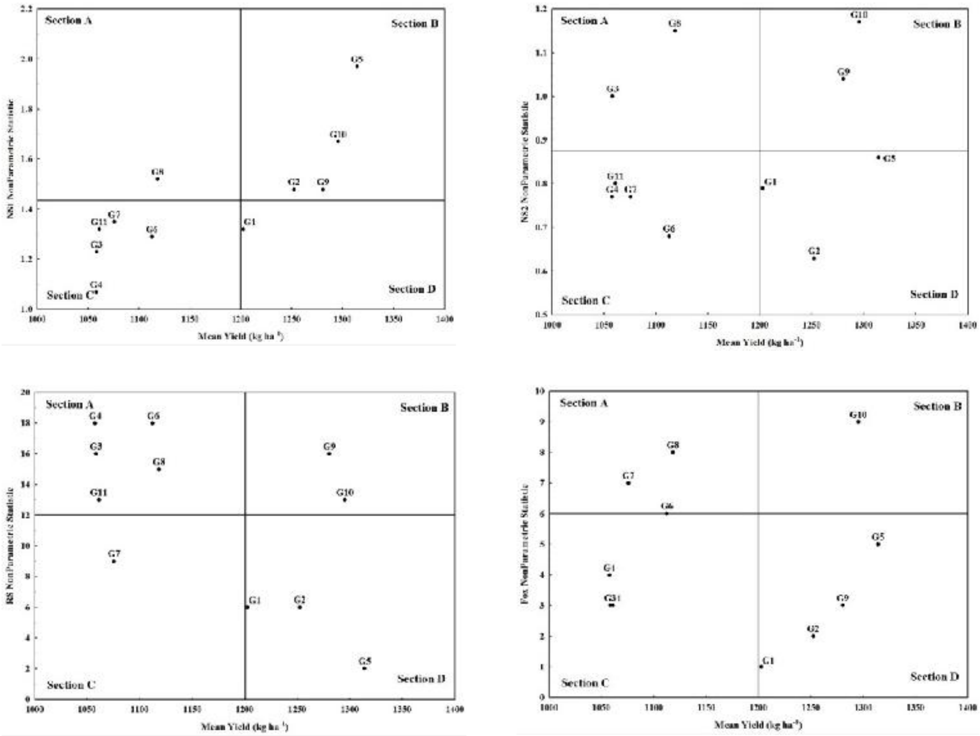


Figure 3. Plot of NS1, NS2, RS and Fox stability statistic versus mean yield using yield data from 11 lentil genotypes grown in 20 environments.

Flores et al. (1998) pointed out that the nonparametric statistics of S1 and S2 are associated with the static or biological concept of stability. Sabaghnia et al. (2006) noted that the nonparametric measures of stability, S1, S2, S3 and S6 are similar in concept to genotypes by environment interaction measures as they define stability in the sense of homeostasis. Sabaghnia et al. (2012) pointed out that the nonparametric statistics of NP1, NP2, NP3 and NP4 and are associated with the static or biological concept of stability. Sabaghnia et al. (2015) noted that the nonparametric measures of stability, S1, S2, S3, S4, S5 and S6 are similar in concept to yield stability measures as they define stability in the sense of static concept. Thus, the nonparametric statistics corresponding to the biological concept of stability. The fact that stability is of economic importance for a genotype was recognized as the variance across environments and such stability parameters follow a static concept meaning that a stable genotype is defined as one having an unchanged performance regardless of any variation in the environmental conditions.

It is desirable that target traits such as yield performance should be maintained through all environments but the yield performance of a genotype usually reacts like other quantitative characters to favorable or unfavorable environmental conditions thus, varies in its performance. It is unrealistic to expect the same level of performance in all environments and yield performance thus follow an agronomic or dynamic concept of stability, meaning that the performance may change from environment to environment, but in a predictable way. A genotype is therefore regarded to be economically stable if its contribution to the genotype by environment variance is low. Although, a wide range of stability parameters resulting from univariate, parametric and nonparametric, and multivariate methods have been described and advantages and disadvantages as well as the relationships between them have been reviewed by several authors (Lin et al. 1986; Flores et al. 1998; Sabaghnia et al. 2006).

Though several statistical strategies for yield stability analysis have been proposed, they each reflect different aspects of stability nature and maybe no single method can adequately explain genotype performance across test environments but we found that using plot of a stability statistic versus mean yield performance can detect the most favorable genotype (high mean yield and high stability) even this stability statistic had a static concept. This a simple method for selecting the best genotypes via traditional methods like S1 or environmental variance. The nonparametric stability statistics seem to be useful alternatives to parametric methods (Huehn, 1990), because they do not supply information about genotype adaptability and for several reasons, the use of nonparametric stability statistics is preferred. For making practical recommendations, it is necessary to study the effectiveness of the other statistics (univariate, parametric and multivariate method) and compare their powers for detection of the most favorable genotypes.

## CONCLUSION

The NS1 and NS2 nonparametric statistics which used are similar to the nature and concept of environmental coefficient of variation (Francis and Kannenberg, 1978), because they use the central tendency of ranks is the median and its related measures of dispersion are inter-quartile or inter-decile range. It seems that there are good poetical in the introduced strategy in distinction of favorable genotypes in plant breeding programs because it provides some flexibility in the hands of plant breeders for simultaneous selection for yield and stability.

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