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Research Article

Comparative study on different nonparametric stability measures in soybean

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Abstract
The assessment of stable genotypes to a wide range of environments is important for recommending cultivars in plant breeding programme. Therefore, twenty four genotypes of soybean were tested over three environments in Tamil Nadu. The stability analysis of GxE interaction observed data is mostly handled by parametric methods. If any assumptions of parametric methods are violated, the result of these methods may be questionable. The nonparametric measures are easy to analyse and simple to interpret which have more advantages than parametric methods. In this paper, nine nonparametric methods were used for identification of stable genotype and association among these measures were checked by correlation. According to Principle component analysis, nonparametric measures were divided into three groups Group 1 included Kang ranksum, $NP_i^{(1)}$, $NP_i^{(2)}$, $NP_i^{(3)}$ and $NP_i^{(4)}$, Group 2 included $S_i^{(3)}$ and $S_i^{(6)}$. Group 3 included $S_i^{(1)}$ and $S_i^{(2)}$. According to nonparametric measures, G17 is the stable one.

Keywords
Soybean, Non parametric measures, Stability, GE interaction

Introduction

Soybean (*Glycine max (L.) Merill*) is a pulses crop. It is also known for its highly valued protein and oil which is used in food, feed and industrial application. The development of genotypes which can be adapted to wide range of different environments, is the final objective of plant breeder in crop improvement program. The soybean genotypes are evaluated in multi-environment trials to test their performance across different environments. In most cases, GxE interaction is significant in MET data; Identification of stable genotype is the complicating procedure for breeders and agronomists.

There are parametric and nonparametric methods used to measure crop yield stability. Parametric methods for assessing genotype-environment interactions and phenotypic stability are widely used in plant breeding Lin *et al*.(1986); Becker and Leon (1988). Parametric methods should follow some statistical assumptions and the estimates are highly affected by outliers Huehn(1990). Nonparametric measures for stability based on ranks provide a better alternative of parametric method. Nonparametric stability measures are less sensitive to outliers. In addition, addition or deletion of few observations does not make great variation in the estimates as would be the case for parametric method Nassar and Huhn(1987). When sample size is very small, non parametric methods are the obvious choice. Therefore, the objective of the study is (i) to evaluate the stable genotypes using nonparametric measures and (ii) to study the association among nonparametric methods.

Materials and Methods

This study utilizes the evaluated data on 24 genotypes of soybean yield over three environments during 2016-17. This multi environment data was collected from Department of plant Breeding and Genetics, Agricultural College and Research Institute, Madurai. The experiment was laid out in randomized complete block design with three replications for all the environments and standard agronomic practices were followed.

Multi environment data was converted to two way dataset with k genotypes and n environments. Each cell was denoted by X_{ij}, where i=1,2,...,k, and j=1,2,...,n. Ranks were allotted in descending order of mean yield of the genotype in each environment and r_{ij} was the rank of the i^{th} genotype in the j^{th} environment. The mean of each genotype across environments was $\bar{r}_{i.}$. Kang (1988) developed a method for selecting high yield as well as stable genotypes. Ranks were assigned for the stability

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variance of Shukla (1972), with the lowest estimated value receiving the rank of 1. The sum of the ranks by yield and by stability variance was calculated. The genotype with the lowest rank-sum is the most desirable one.

Huehn (1979) and Nasser and Huehn (1987) proposed four following nonparametric methods for stability analysis. $S_i^{(1)}$ is equal to mean absolute rank differences of a genotype i over the n environments (Eq 1). $S_i^{(2)}$ measures variance among the ranks over the n environments (Eq 2). $S_i^{(3)}$ (Eq 3) and $S_i^{(6)}$ (Eq 4) are, respectively the sum of square of the deviations and the sum of absolute deviations of the $r_{ij's}$ from maximum stability expressed in $\bar{r}_{i.}$ units.

$$S_i^{(1)} = \frac{2\sum_j^{n-1}\sum_{j'+1}^{n}|r_{ij} - r_{ij'}|}{n(n-1)} \quad (1)$$

$$S_i^{(2)} = \frac{\sum_{j=1}^{n}(r_{ij} - \bar{r}_{i.})^2}{n-1} \quad (2)$$

$$S_i^{(3)} = \frac{\sum_{j=1}^{n}(r_{ij} - \bar{r}_{i})^2}{\bar{r}_{i.}} \quad (3)$$

$$S_i^{(6)} = \frac{\sum_{j=1}^{n}|r_{ij} - \bar{r}_{i.}|}{\bar{r}_{i.}} \quad (4)$$

The selection of stable genotype is based on $S_i^{(1)} = S_i^{(2)} = S_i^{(3)} = S_i^{(6)} = 0$.

Thennarasu (1995) proposed another set of nonparametric measures ($NP_i^{(1)}$, $NP_i^{(2)}$, $NP_i^{(3)}$ and $NP_i^{(4)}$), based on ranks of adjusted means of the genotypes in each environment. These were calculated as formula of equation of 5,6,7 and 8.

$$NP_i^{(1)} = \frac{1}{n}\sum_{j=1}^{n}|r_{ij}^* - M_{di}^*| \quad (5)$$

$$NP_i^{(2)} = \frac{1}{n}\sum_{j=1}^{n}\frac{|r_{ij}^* - M_{di}^*|}{M_{di}^*} \quad (6)$$

$$NP_i^{(3)} = \frac{\sqrt{\sum(r_{ij}^* - \bar{r}_{i.}^*)^2/n}}{\bar{r}_{i.}} \quad (7)$$

$$NP_i^{(4)} = \frac{2}{n(n-1)}\sum_{j=1}^{n-1}\sum_{j'=j+1}^{n}\frac{|r_{ij}^* - r_{ij'}^*|}{\bar{r}_{i.}} \quad (8)$$

The adjusted rank r_{ij}^*, is determined on the basis of the adjusted phenotype values $(X_{ij}^* = X_{ij} - \overline{X_{I.}})$, Where $\overline{X_{I.}}$ is the performance of the i[th] genotype. The ranks obtained from these adjusted values (X_{ij}^*), depend only on GxE interaction and error effects. In the above formula, r_{ij}^* is the rank of X_{ij}^*. $\bar{r}_{i.}^*$ and M_{di}^* are the mean and median ranks for adjusted values. R-based packages (phenability) of Leonardo (2015) employed to calculate nonparametric measures.

Spearman's rank correlation was used to understand the relationship among nonparametric measures. This is given by

$$r_s = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)}$$

The significance of rank correlation coefficient between any two stability measures was tested by t test with n-2 degrees of freedom

$$t = \frac{r_s\sqrt{n-2}}{\sqrt{1-r_s^2}}$$

Principal component analysis was used as graphical representative for understanding better relationships among stability measures. For statistical analysis, R (Phenability, Factoextra) was used.

Results and discussion

The results of all nonparametric methods were shown in Table 2. According to mean yields, G14 was the genotype with highest yield followed by genotypes, G20 and G19. Kangrank sum measure used rank of yield and stability variances. According to rank sum statistic, the genotype, G6 (9) had the lowest values for Kang measures and therefore was stable genotype with high yield, followed by the genotypes, G10 (10) and G19 (16).

According to Huehn's, the stable one had minimum value of this statistics. The genotypes G17, G11 and G21 had the lowest value of $S_i^{(1)}$ and ranked 22[nd], 21[th] and 11[th] for seed yield, respectively. The result revealed that $S_i^{(1)}$ measure was negatively related with grain yield. The variance of rank $S_i^{(2)}$ showed that genotypes G17, G13 and G21 had more stability among three environments. This results was similar to $S_i^{(1)}$ measure. The genotypes G17, G10 and G19 were stable genotypes according to $S_i^{(3)}$ and $S_i^{(4)}$ measures.

All four nonparametric measures of phenotypic stability ($NP_i^{(1)}$, $NP_i^{(2)}$, $NP_i^{(3)}$and $NP_i^{(4)}$) proposed by Thennarasu were calculated based on original datasets. The results indicated that G17 was the stable genotype except $NP_i^{(1)}$ measure. According to Table 2, G1 and G24 were the unstable genotypes.

`Each one of the nonparametric methods produced different ranks for genotypes. Spearman rank correlation was used for finding relationship among measures. Spearman's rank coefficients between mean yield and all of the non parametric stability measures were presented in Table 3. Mean yield

was statistically significant (p<0.01) and positively correlated with Kang Ranksum, $S_i^{(6)}$, $NP_i^{(1)}$, $NP_i^{(2)}$, $NP_i^{(3)}$ and $NP_i^{(4)}$. The significant correlation between yield and the stability measures was expected. Genotype G17 is considered as stable one, according to above mentioned methods.

To better understand the relationships between the nonparametric methods, a principal component analysis (PCA) based on the rank correlation matrix was performed. The first two PCs explained 85.47% out of total variance of original variables. Association among different stability measures was graphically displayed by biplot of PC1 and PC2 (Fig. 1). Biplot clustered the nine stability measures in to 3 groups. According to biplot, Group 1 consisted of Kang ranksum, $NPi^{(1)}$, $NPi^{(2)}$, $NPi^{(3)}$ and $NPi^{(4)}$ and associated with Yield. Group 2 included $Si^{(3)}$ and $Si^{(6)}$. Group 3 had $Si^{(1)}$ and $Si^{(2)}$. Simultaneous selection for both yield and stability was an important criterion in plant breeding. It can be achieved by Group1 stability measures.

In this present study, the stability of genotypes was employed using nine nonparametric measures of stability viz. Kang rank sum, $S_i^{(1)}$, $S_i^{(2)}$, $S_i^{(3)}$, $S_i^{(6)}$, $NP_i^{(1)}$, $NP_i^{(2)}$, $NP_i^{(3)}$ and $NP_i^{(4)}$. Group1 stability measures can be considered as the best measures for selecting superior measures. These measures are simple and easy to calculate. The minimum deviation of ranks of genotypes over environment is the stable genotype. According to results, G17 is the stable genotype as well as superior variety. These statistics can be used by breeders who need to make selection based upon GxE interactions.

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References

Awoke, S. and Sharma, M.K., 2016. Parametric and Non-Parametric Methods to Describe Genotype by Environment Interaction and Grain Yield Stability of Bread Wheat. Statistics and applications, **14**(1-2): 9-29.

Bhardwaj, R.K., Bhardwaj, V., Singh, D.P., Gautam, S.S., Jatav, G., Saxena, R.R. and Saxena, R.R., 2017.

Huhn, M., 1990. Nonparametric measures of phenotypic stability. Part 1: theory. Euphytica, **47**: 89-194.

Huhn, M. and Nassar, R., 1989. On tests of significance for nonparametric measures of phenotypic stability. Biometrics, **45**: 997- 1000.

Huhn, M. and Nassar, R., 1991. Phenotypic stability of genotypes over environments: on tests of significance for two nonparametric measures. Biometrics, **47**: 1196-1197.

Nassar, R. and Huhn, M., 1987. Studies on estimation of phenotypic stability: tests of significance for nonparametric measures of phenotypic stability. Biometrics, **43**: 45-53.

Nassar, R., Leon, J. and Huhn, M., 1994. Tests of significance for combined measures of plant-stability and performance. Biometrical Journal, **36**: 109-123.

Sabaghnia, N., Dehghani, H. and Sabaghpour, S.H., 2006. Nonparametric methods for interpreting genotype x environment interaction of Lentil genotypes. Crop Science, **46**: 1100-1106.

Study of Stability Analysis of Rice Varieties through Non-Parametric Approaches in Chhattisgarh, India. International Journal of Current Microbiology and Applied Sciences, **6**(7): 1087-1095.

Shukla, G., 1972. Some statistical aspects of partitioning genotype-environmental components of variability. Heredity, **29**: 237-245.

Truberg, B. and Huhn, M., 2000. Contributions to the analysis of genotype x environments interactions: Comparison of different parametric and non-parametric tests for interactions with emphasis on crossover interaction. Journal of Agronomy and Crop Science, **185:** 267-274.

Thennarasu, K., 1995. On certain non-parametric procedures for studying genotype- environment interactions and yield stability, Ph. D. Thesis, P. J. School, IARI, New Delhi.

Table 1. The names and code of genotypes in soybean multi-environmental trial

Genotype	Code	Genotype	Code	Genotype	Code
AVRDC 508	G1	EC 50082	G9	JS 335	G17
AVRDC 576	G2	EC 62376	G10	JS 9305	G18
Co (soy) 3	G3	EC 799	G11	JS 98-21	G19
DS 2402	G4	IC 109544	G12	JS 99-72	G20
EC 36961	G5	IC 13051	G13	MACS 1184	G21
EC 39498	G6	IC 16009	G14	NRC 77	G22
EC 39536	G7	JS (SH) 99-02	G15	RKS 18	G23
EC 4290	G8	JS 20-09	G16	RSC 14	G24

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Table 2. Values of nonparametric measures of soybean genotypes

	Yield	Rank of yield	Rank sum	Rank of Rank sum	$NP_i^{(1)}$	Rank of $NP_i^{(1)}$	$NP_i^{(2)}$	Rank of $NP_i^{(2)}$	$NP_i^{(3)}$	Rank of $NP_i^{(3)}$	$NP_i^{(4)}$	Rank of $NP_i^{(4)}$	$S_i^{(1)}$	Rank of $S_i^{(1)}$	$S_i^{(2)}$	Ran k of $S_i^{(2)}$	$S_i^{(3)}$	Rank of $S_i^{(3)}$	$S_i^{(6)}$	Rank of $S_i^{(6)}$
G1	23.93	5	28.00	14	7.33	20	1.22	19	1.44	19	0.42	15	2.67	10	124.00	20	1.32	4	0.39	4
G2	15.50	16	26.00	11	3.00	5	0.19	6	0.24	5	0.11	4	1.67	5	20.33	5	5.10	16	1.05	16
G3	15.84	14	19.00	5	4.33	9	0.25	10	0.36	11	0.29	13	4.33	14	43.00	8	5.60	18	1.20	18
G4	15.55	15	17.00	4	5.00	12	0.28	11	0.42	13	0.28	12	4.33	14	66.33	13	9.93	23	1.64	21
G5	20.12	9	20.00	6	6.67	18	1.11	17	0.99	16	0.48	17	4.00	12	101.33	18	4.12	13	0.80	11
G6	20.24	8	9.00	1	7.33	20	0.92	16	1.12	18	0.85	21	7.33	23	142.33	22	6.04	19	0.90	12
G7	21.51	7	29.00	16	5.67	15	1.13	18	0.99	17	0.65	19	5.00	18	86.33	16	2.46	10	0.62	8
G8	14.93	19	39.00	23	4.33	9	0.33	14	0.36	10	0.23	10	3.83	11	50.58	11	7.69	22	1.54	20
G9	16.09	12	31.00	21	4.00	6	0.29	12	0.38	12	0.18	8	2.33	8	36.33	6	5.17	17	1.00	14
G10	25.61	4	10.00	2	7.00	19	1.75	22	2.21	23	0.50	18	2.00	7	117.00	19	0.38	2	0.19	2
G11	14.67	21	39.00	23	4.00	6	0.24	8	0.31	8	0.08	3	1.33	2	37.33	7	6.89	20	1.33	19
G12	17.83	10	27.00	13	5.33	14	0.38	15	0.61	15	0.46	16	5.33	20	76.00	14	2.45	9	0.70	10
G13	16.05	13	29.00	16	1.67	1	0.14	2	0.18	2	0.13	6	1.67	5	8.33	2	1.77	6	0.63	9
G14	30.30	1	22.00	9	7.33	24	7.33	24	2.77	24	2.00	24	7.33	23	154.33	24	2.00	8	0.50	5
G15	14.80	20	29.00	16	4.00	6	0.25	9	0.33	9	0.24	11	4.00	12	44.33	9	4.69	15	1.08	17
G16	15.20	17	32.00	22	2.50	4	0.14	2	0.19	3	0.15	7	2.50	9	14.58	4	3.31	12	1.00	14
G17	10.98	22	30.00	19	1.67	2	0.08	1	0.09	1	0.03	1	0.67	1	6.33	1	0.00	1	0.00	1
G18	10.40	23	30.00	19	5.00	12	0.21	7	0.28	7	0.06	2	1.33	2	60.33	12	4.57	14	2.29	24
G19	25.98	3	16.00	3	6.00	16	1.50	21	1.57	21	1.00	22	5.00	18	93.00	17	0.70	3	0.30	3
G20	26.29	2	26.00	11	7.33	20	3.67	23	1.58	22	1.03	23	6.33	22	142.33	22	6.96	21	0.99	13
G21	16.20	11	23.00	10	2.00	3	0.18	4	0.21	4	0.11	5	1.33	2	9.33	3	1.40	5	0.50	5
G22	15.05	18	21.00	8	6.00	16	0.32	13	0.45	14	0.37	14	6.00	21	81.33	15	16.00	24	2.15	23
G23	10.07	24	28.00	14	4.33	9	0.19	5	0.25	6	0.19	9	4.33	14	46.33	10	3.25	11	1.75	22
G24	22.45	6	20.00	6	7.33	20	1.47	20	1.44	19	0.74	20	4.67	17	124.00	20	1.86	7	0.50	5

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Table 3. Spearman's correlation coefficient among nonparametric measures

	Yield	Rank sum	$S_i^{(1)}$	$S_i^{(2)}$	$S_i^{(3)}$	$S_i^{(6)}$	$NP_i^{(1)}$	$NP_i^{(2)}$	$NP_i^{(3)}$	$NP_i^{(4)}$
Yield	1.000									
Rank sum	.563**	1.000								
$S_i^{(1)}$	-.514*	-.514*	1.000							
$S_i^{(2)}$	-.700**	-.558**	.735**	1.000						
$S_i^{(3)}$	.330	.083	.261	.028	1.000					
$S_i^{(6)}$	.668**	.265	.016	-.214	.833**	1.000				
$NP_i^{(1)}$	.691**	.573**	-.718**	-.991**	-.017	.215	1.000			
$NP_i^{(2)}$	.819**	.501*	-.669**	-.918**	.039	.352	.911**	1.000		
$NP_i^{(3)}$	.821**	.583**	-.695**	-.934**	.046	.348	.933**	.986**	1.000	
$NP_i^{(4)}$	.826**	.637**	-.859**	-.889**	.048	.356	.869**	.908**	.922**	1.000

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

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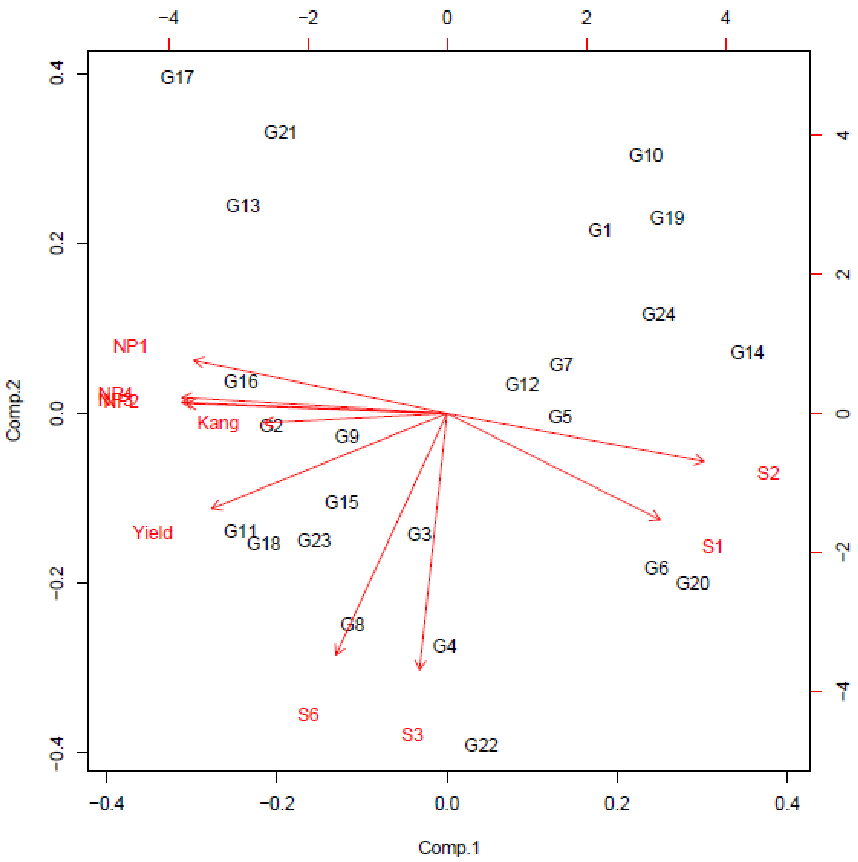

Fig. 1. Biplot analysis of nonparametric stability method