Evaluation of Phenotypic Stability of Seven Plum Cultivars by Means of Nonparametric Analysis

Viorel MITRE, Marin ARDELEAN, L. LUKÁCS, Ioana MITRE, Mirela CORDEA

University of Agricultural Sciences and Veterinary Medicine, Mănăştur st., no. 3 – 5, 400372 Cluj-Napoca, Romania
(e-mail: mitreviorel@yahoo.com)

Abstract

Phenotypic stability of fruit yield, fruit weight, height and diameter was evaluated in seven plum cultivars across five environments in Transylvania, Romania, in 2006. Friedman's test resulted in values of χ^2 for the analyzed characters comprised between 21.4–28.8, much higher than χ^2=12.6, for DF=6 suggesting significant differences among the tested cultivars. For fruit yield the highest phenotypic stability was noted in Anna Späth (P_i=0.1) while for fruit weight the lowest P_i values were found in Stanley (1.3), Tuleu Gras (3.2) and Tuleu Timpuriu (7.8). Fruit height and fruit diameter exhibited the same low levels of stability indices (P_i=0.1–2.5) in Stanley and Gras Ameliorat.

Key words: plum, phenotypic stability, nonparametric analysis

Introduction

Nonparametric analysis of phenotypic stability, based on ranks, proves to be a most attractive and viable alternative to the existing parametric analysis. It can be based both on actual data and on ranking results, providing valuable indices for breeding and extension programs. Huhn and Nassar (1989) have presented statistical proprieties and significance for nonparametric measures of phenotypic stability while Lin and Binns (1988) and Eberhart and Russell (1966) have obtained high similarities in accuracy by comparing parametric and nonparametric analyses of stability.

Since nonparametric analysis is easy to use and less affected by errors of measurement, in the present paper the phenotypic stability of seven plum cultivars, widely grown in Transylvania, has been evaluated.

Material and method

Seven plum cultivars (TuleuGras Ct; TuleuTimpuriu, Silvia, Gras Ameliorat; Stanley; Vinete Romanest; Anna Späth were evaluated in 2006 concerning their phenotypic stability across five environments (locations) (Cluj-Napoca, Calacea (Sj), Bistrita, Mihaesti (BN), Reghin (Ms)), for fruit yield and three fruit characters (mean weight, mean height and mean diameter). Randomized complete blocks with three replications represented the experimental layout, in each environment. Friedman's test for nonparametric analysis of variance was used to reveal the existence of significant/ nonsignificant differences among the five cultivars as far as the studied characters were concerned. Simple indices of superiority (P_i) were computed according to Lin and Binns (1988), using both actual data

$$\left[P_i = \sum_{j=1}^{n} (X_{ij} - M_j)^2 / 2n \right]$$ and the ranking results $$\left[P_i = \sum_{j=1}^{n} (R_{ij} - RM)^2 / 2n \right]$$

of cultivars in each environment, where X_{ij} = actual value of a character of i-th cultivar in the j-th environment, M_j = maximum response noted among all cultivars in the j-th environment, n = number of

Proceedings. 43rd Croatian and 3rd International Symposium on Agriculture. Opatija. Croatia (877-880)

environments, R_{ij} = rank value of i-th cultivar in the j-th environment and RM = maximum rank value. According to the above mentioned formulas, the superior genotype would be that with the lowest P_i value which means that the respective genotype shows the highest actual/ranking values for the studied character in the set of environments taken into consideration.

Results and discussion

The actual date of fruit yield and fruit characters obtained with the seven plum cultivars evaluated in five environments are presented in table 1.

Table 1. Fruit yield (t/ha), weight (g), height (mm) and diameter (mm) in seven plum cultivars evaluated in five environments

Character	Environment (Location)	Tuleu Gras, Ct	Tuleu Timpuriu	Silvia	Gras Ameliorat	Stanley	Vinete Romanest	Anna Späth
Fruit yield	Cluj-Napoca	18.07	15.3^{ooo}	8.57^{000}	6.33^{ooo}	21.13***	5.63^{ooo}	19.50*
	Calacea (Sj)	26.60	18.80^{ooo}	7.70^{ooo}	4.57^{ooo}	28.73***	6.23^{ooo}	28.83***
	Bistrita	18.50	12.6^{ooo}	11.83^{ooo}	7.77^{ooo}	18.33	11.63^{ooo}	22.33***
	Mihaesti (BN)	15.40	12.30^{ooo}	12.63^{ooo}	6.83^{ooo}	15.67	10.23^{ooo}	22.63***
	Reghin (Ms)	15.10	11.83^{ooo}	11.97^{ooo}	6.83^{ooo}	16.23	12.50^{ooo}	21.83***
DL 5 %= 1.3 t/ha; DL 1 %= 1.7 t/ha; DL 0.1 %= 1.9 t/ha								
Fruit weight	Cluj-Napoca	34.3	41.7***	42.3***	38.0**	38.0**	23.7^{ooo}	37.7**
	Calacea (Sj)	31.7	42.7***	42.3***	36.3***	38.3***	24.0^{ooo}	35.7***
	Bistrita	35.7	40.0***	40.7***	37.3	39.7	25.7^{ooo}	35.0
	Mihaesti (BN)	38.0	40.7*	41.0**	39.3	39.0	28.3^{ooo}	35.0^{oo}
	Reghin (Ms)	37.3	40.7**	40.0*	39.7*	39.3	27.0^{ooo}	36.0
DL 5 %= 2.2 g; DL 1 %= 2.9 g; DL 0.1 %= 3.9 g								
Fruit height	Cluj-Napoca	47.3	47.7	48.3	48.0	53.7^{ooo}	39.7^{ooo}	49.7
	Calacea (Sj)	44.7	48.7*	48.0*	50.0***	49.7**	39.7^{oo}	45.7
	Bistrita	46.7	45.7	46.0	46.3	50.3*	33.7^{ooo}	47.7
	Mihaesti (BN)	48.0	46.7	45.7	47.7	54.0***	35.0^{ooo}	47.7
	Reghin (Ms)	48.3	46.7	46.3	48.3	54.3***	33.7^{ooo}	48.0
DL 5 %= 3.3 mm; DL 1 %= 4.9 mm; DL 0.1 %= 5.3 mm								
Fruit diameter	Cluj-Napoca	38.3	39.7	38.3	44.0***	41.0	34.7^{o}	44.7***
	Calacea (Sj)	36.3	41.7***	39.0	46.0***	39.3*	34.7	42.7***
	Bistrita	37.7	38.7	37.0	43.3***	40.3	30.0^{ooo}	43.3***
	Mihaesti (BN)	38.0	37.7	35.3	46.3***	41.0*	30.7^{ooo}	43.7***
	Reghin (Ms)	38.3	37.7	36.3	44.3***	41.0	30.7^{ooo}	43.7***
DL 5 %= 2.9 mm; DL 1 %= 4.2 mm DL 0.1 %= 4.9 mm								

It is obvious, from the above data, that a parametric analysis of variance, though it provides a lot of useful information, is not able to perform an accurate classification of cultivars on the basis of their performances in all environments. Friedman's test of nonparametric analysis of variance completed with the computation of P_i based on ranking of cultivars seems to be a much more appropriate approach.

The values of χ^2 obtained in Friedman's test applied to fruit yield and fruit weight, height and diameter are presented in table 2.

There should be noted that, for all characters, the values of χ^2 obtained by using Friedman's test of nonparametric analysis of variance are all significant, either for $P_{5\%}$ or $P_{1\%}$. These data confirm the existence of significant differences among the five apple cultivars for all characters under study.

A classification of the tested apple cultivars, on the basis of their P_i (index of superiority) values is presented in table 3. Values in parentheses were computed using actual data of the studied characters while the other P_i values were computed using the ranking data of each cultivar in the five environments.

Table 2 Values of χ^2 produced by Friedman's test applied to fruit yield in seven plum cultivars evaluated in five environments (locations) in 2006

Character	χ^2	Significance
Fruit yield (t/ha)	26.3	***
Fruit mean weight (g)	28.4	***
Fruit men height (mm)	21.4	**
Fruit mean diameter (mm)	27.8	***

For DF=6; $\chi^2_{P5\%}$=12.6; $\chi^2_{P1\%}$=16.8; $\chi^2_{P0.1\%}$=22.5

Table 3 Superiority indices (P_i) of seven plum cultivars grown in five different environments (locations)

Cultivar	P_i values for:							
	Fruit yield		Mean weight of fruit		Mean height of fruit		Mean diameter of fruit	
Tuleu Gras, Ct.	(59.3)	1.7	(4.7)	3.2	(25.7)	6.1	(37.0)	7.9
Tuleu Timpuriu	(110.5)	6.8	(6.2)	7.8	(24.6)	7.7	(27.3)	5.4
Silvia	(168.7)	7.3	(10.5)	23.1	(26.0)	7.9	(42.3)	11.1
Gras Ameliorat	(249.9)	16.9	(9.5)	15.1	(18.3)	2.5	(1.8)	0.1
Stanley	(49.9)	0.7	(3.0)	1.3	(3.2)	0.1	(16.8)	2.5
Vinete Românesti	(195.1)	13.1	(9.2)	14.9	(159.9)	18.0	(102.5)	18.0
Anna Späth	(21.5)	0.1	(23.0)	18.4	(266.8)	3.1	(3.9)	0.3

As it can be noted from data in table 3, for fruit yield the highest phenotypic stability was noted in Anna Späth ($P_{i=}$0.1) closely followed by Stanley and Tuleu Gras. This is not a surprising result since one of the three cultivars mentioned above (Tuleu Gras) is a domestic variety and the other two (Anna Späth and Stanley) have been for rather a long time grown in Transylvania, all three of them being well adapted to a variety of Romanian environments. On the contrary, for fruit weight, the highest phenotypic stability was found in Stanley and the lowest in Silvia. These results might be considered a sound proof of the fact that old plum cultivars might show high phenotypic stability of fruit yield and fruit characters due to their long term adaptation to certain environments.

Fruit height and fruit diameter exhibited nearly the same low levels of stability indices (P_i = 0.1 – 2.5) in Gras Ameliorat and Stanley nominating these two cultivars as most stabile for the respective characters. It is worth mentioning the fact that stability of cultivars computed on the basis of their performances in the four analyzed characters was practically identical both when using actual data and when using ranking data. The second method, based on ranking results of cultivars, is preferable since is simpler and less affected by measurement errors.

Conclusions

For all studied characters, the χ^2 values obtained by using Friedman's test of nonparametric analysis of variance were significant suggesting the existence of true differences among the seven plum cultivars.

The highest phenotypic stability of fruit yield was found in Anna Späth cultivar while for fruit weight the highest stability was noted in Stanley.

These results might be considered a sound proof that old plum cultivars might show high phenotypic stability of fruit yield and fruit characters due to their long term adaptation to certain environments.

Friedman's test of analysis of variance completed with the computation of P_i (superiority index) based on ranking of cultivars in each environment seems to be a rather appropriate approach to achieving an accurate classification of genotypes on the basis of their phenotypic stability.

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sa2008_0902