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Association among stability measurements in rubber tree traits

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ABSTRACT

The simultaneous use of different methods of stability analysis is becoming more widely used in the selection of genotypes in breeding programs. Knowing how these different methods are associated can contribute to a more efficient selection. The objective of the present study was to assess association among different methods of stability analysis in the rubber tree [*Hevea brasiliensis* (Willd. ex Adr. de Juss.) Muell.-Arg.], using different traits and different groups of genotypes for the same trait. Two open-pollinated progeny populations (POP1 and POP2) and a group of clones (Group 1) were analyzed. POP1 contained 22 progeny, assessed in the municipalities of Pindorama, Votuporanga and Jaú, São Paulo state, Brazil. POP2 included 30 progeny assessed in Selvíria, Mato Grosso do Sul state, Votuporanga and Colina, São Paulo state, Brazil. Group 1 consisted of 25 clones assessed in Votuporanga. The following traits were assessed in POP1: girth, rubber yield, bark thickness and number of latex vessel rings. Rubber yield was assessed in POP2 and Group 1 clones. The following methods of stability analysis were used: Wricke; Eberhart and Russell; Lin and Binns; AMMI (Principal Additive Effect and Multiplicative Interaction) and HMRPGV (Harmonic Mean of the Relative Performance of the Genetic Values) predicted by Blup (Best Linear Unbiased Prediction). The Spearman correlation was used to verify the association between the stability parameters. Three scenarios were observed; in the first, some parameters did not show significant association in any of the analyses: Eberhart and Russell with Lin and Binns; Eberhart and Russell with HMRPGV; Wricke with HMRPGV; AMMI with Lin and Binns and AMMI with HMRPGV. In the second, some parameters showed significant associations in all the analyses such as: Wricke with AMMI, Lin and Binns with HMRPGV. Finally, in the third, the significance of association varied according to the analysis: Eberhart and Russell with Wricke, Eberhart and Russell with AMMI and Wricke with Lin and Binns. Therefore, the association among some stability parameters varies according to the trait and/or the group of genotypes analyzed. The association observed in one analysis cannot be applied to another analysis. In this data analysis is possible to observe that the AMMI method can be used with HMRPGV or Lin and Binns. In addition, Eberhart and Russell can be used with HMRPGV or Lin and Binns, since they offer differentiation and provide additional approaches to the study of stability.

1. Introduction

In breeding programs, when assessing genotypes in different environments, there is often significant effect of the genotype x environment interaction. Environments are sometimes different locations and sometimes different assessment periods. When there is significant effect, the stability and adaptability analyses are complementary.

Several studies have been conducted on stability in the rubber tree in the last decade. In some studies, the stability between location was assessed (Gonçalves et al., 2009; Gouvêa et al., 2013; Verardi et al., 2009) and in other studies, stability in time (Gonçalves et al., 2008; Vinod et al., 2010; Priyadarshan et al., 2008; Gouvêa et al., 2013, 2012, 2011; Silva et al., 2014). In some of these studies the genotypes assessed were progeny (Gonçalves et al., 2009; Gouvêa et al., 2013 Verardi et al., 2009) and in others they were

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clones (Gonçalves et al., 2008; Vinod et al., 2010; Priyadarshan et al., 2008; Gouvêa et al., 2012, 2011; Silva et al., 2014). A single method of stability analysis was used in most of the studies, but the simultaneous use of different methods has become more frequent, for example, as in those by Priyadarshan et al. (2008), Gouvêa et al. (2012) (e 2011) and Silva et al. (2014).

The simultaneous use of different stability methods with the assessment of correlation between the parameters estimated from these methods has been observed in several studies, such as those by Gouvêa et al. (2012), Sahin et al. (2011), Segherloo et al. (2008), Mohammadi and Amri (2008) and Mohebodini et al. (2006). In these studies assessments were made on a single group of genotypes and a single trait.

Several characters contribute to the production of rubber. According to Henon and Nicolas (1989), the number of latex vessels is the character that most influences latex production. Genetic and phenotypic correlations between yield and number of latex vessel rings were verified by Gonçalves et al. (2005). Silva et al. (2012) observed genetic correlations between bark thickness and girth growth. According to Gonçalves and Fontes (2012), girth growth is also associated with various aspects in the genetic improvement of rubber. The early opening of the panel and good production are only possible in trees that grow vigorously in the juvenile phase. Good stem growth, during the tapping period, will maintain constant production and at the same time will reduce breakage by the wind. Therefore, the importance of identifying progeny with stability for these traits.

An assessment that considers the correlation between stability parameters by analyzing different traits and different groups of genotypes may supply complimentary information to the studies already carried out. Thus the objective of the present study was to assess the correlation between different methods of stability analysis in the rubber tree using different traits and different groups of genotypes for the same trait.

2. Material and methods

2.1. Plant material and experimental information

POP1 consisted of 22 open-pollinated progeny, obtained from 22 parental clones selected phenotypically in a H. brasiliensis clone population from Asia and Africa, established in the Campinas Experimental Center (CEC), Agronomic Institute (IAC). The three progeny tests were set up in Experimental Stations of Pindorama, 21°13'S, 48°56'W and 560 m altitude, in Jaú latitude 22°17′S, 48°34′W and 580 m altitude and in Votuporanga, latitude 20°25′S, 49°50′W and 480 m altitude. A randomized block design was used with six replications and ten plant-linear plots with 2 × 2 m spacing. POP2 consisted of 30 open-pollinated progeny from Asian clones, IACs and other genotypes selected previously. The three progeny tests were set up in Selvíria, experimental field that belongs to Paulista State University at Unesp, Ilha Solteira-SP, latitude de 20°20′S, 51°23′W and 370 altitude and in Experimental Stations of Colina-SP latitude 20°43′S, 48°32′W and 569 m altitude and Votuporanga-SP. A randomized block design was used with three replications and 10 plants per plot with 3.0 × 3.0 m spacing in Selvíria-MS, and 2.0 × 2.0 m spacing in Colina and Votuporanga. Group 1 of clones consisted of 25 clones, one Malayan, eight Amazon (IAN, Fx, RO) and 16 local clones (IAC). The experiment was assessed in Votuporanga in a randomized block design with three replications, using eight plants per linear plot in 7.0 m × 3.0 m spacing.

2.2. Traits assessed

2.2.1. Rubber yield

The data for the progeny rubber yield were obtained by the modified Hamaker Morris-Mann (HMMm) precocious test for three-year-old seedlings (Tan and Subramaniam, 1976). The panel was opened 15 cm above ground level, using the S/2 system (half spiral cut) and d/3 (interval between tapping, that is, one every three days) discarding the first five tapping samples that corresponded to the panel running-in phase. Three tests were carried out of 10 descending tappings on the individuals of each progeny. The results were expressed in grams of dry rubber per tapping per tree ($g\,s^{-1}\,a^{-1}$). In POP2 there was stimulation with ethefon at 2.5% concentration. The clone group (Group 1) yield data were registered starting in the seventh year, for the trees that presented trunk girth greater than 45 cm, measured 1.2 m above the rootstock. The data were recorded by means of latex from one tapping, randomly collected twice a month, dried under normal shade and ventilation conditions throughout the evaluation period, fastened by a wire on each tree. The total annual weight of rubber per tree was divided by the number of coagulates. The system used was that of tapping ½S d/4 6 d/7.11 m/y.ET 2,5% Pa La 8/y–half spirals tapping (½S), carried out at four-day intervals (d/4), with rest on Sundays (6d/7), tapping 11 months per year (11 m/y), stimulated with 2.5% ethephon (ET 2.5%) applied to the panel (Pa) on the gutter with coagulates (La), eight times a year (8/y). The assessment period for girth was once a year in six years

2.2.2. Girth

Girth was measured at, 50 cm above ground level, using a tape measure. The data from the third year were assessed because early selection is made in the third year.

2.2.3. Bark thickness

To measure the bark thickness, three barks samples were collected from each plant, using a gouge, measured with a digital packymeter and the mean expressed in millimeters. The measurements were made in the third year.

2.2.4. Number of latex vessel rings

The number of latex vessel rings was assessed from bark samples that were blocked in histological paraffin sections and stained. The radial longitudinal type of histological cut was used. To obtain this cut the cambium rings were placed in parallel position in relation to the workbench at the time of inclusion in paraffin. The samples were sectioned in a microtome (Leitz mod. 1512) 125 micras thick, dehydrated in 90% ethylic alcohol and stained with Sudan III. The number of latex vessel rings was counted under an optical microscope (Olympus CBA) with 10x magnification.

2.3. Statistical analysis

2.3.1. Between locations joint analysis

Before carrying out the between location joint analyses of variance, homogeneity was verified the residual variances, using the analysis of individual variance. The criteria used were described by Pimentel-Gomes (2000) where homogeneous variances present a ratio between the greatest and smallest residual mean square lower than seven. Joint analyses of variance and joint deviation analysis were carried out

The model used in the between location joint analysis of variance of POP1 and POP2 is expressed by the equation:

$$\mathbf{Y}_{ijk} = \mu + (\mathbf{B}/\mathbf{A})_{jk} + \mathbf{G}_i + \mathbf{A}_j + \mathbf{GA}_{ij} + \mathbf{E}_{ijk}, \text{where :}$$

$\mathbf{Y}_{ijk}$ = $\boldsymbol{\mu}$ = general mean of the experiment; $(\mathbf{B/A})_{jk}$ = effect of block **k** within environment **j**; observation in the **k**-th block, assessed on the **i**-th genotype and **j**-th environment; $\mathbf{G}_i$ = effect of genotype **i** (i = 1, 2, . . . n); $\mathbf{A}_j$ = effect of environment **j** (**j** = 1,2. . .n); $\mathbf{GA}_{ij}$ = effect