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Adaptability and stability of 34 peach genotypes for leafing under Brazilian subtropical conditions

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ABSTRACT

This study aimed to evaluate adaptability and stability for leafing of peach genotypes in a subtropical climate. The design was completely randomized with three replicates (trees) and five branches per replicate in a factorial arrangement of 34 × 4 for genotypes and years, respectively. The beginning of budburst (5%), final budburst (75%) and fruit-bearing shoots formed at 45 days after the end of the budburst were evaluated for four years (2007–2010). The number of hours of temperature below 7.2 °C or 12 °C or above 20 °C from May to August was recorded. Adaptability and stability analyses were performed using GGE biplot methodology. 'Cascata 1063', 'Cascata 1303', 'Conserva 1187', 'Conserva 1223', 'Conserva 1396', 'Kampai', 'Libra' and 'Santa Áurea' were the peach tree genotypes with the greatest adaptability and stability for budburst trait. For fruit-bearing shoots formed, the genotypes 'Conserva 1127', 'Conserva 1216' and 'Conserva 681' had the greatest adaptability and stability. A high percentage of budburst does not necessarily lead to a high percentage of fruit-bearing shoots development. 'Âmbar', 'Bonão', 'Conserva 655', 'Kampai', 'Libra', 'Rubimel' and 'Santa Áurea', showed a good percentage of budburst and development of fruit-bearing shoots, remained stable for both traits and are considered the best adapted.

1. Introduction

The spread of commercial growing of temperate fruit crops to subtropical and tropical regions has increased rapidly in recent years. This increase is especially noticeable with peaches in Brazil, where the climatic conditions are highly variable. Subtropical humid zones, located in Southern Brazil, have hot, humid, rainy summers that favor disease development. Furthermore, inconsistent winter dormancy conditions, caused by conflicting air masses of tropical and polar origins, result in both insufficient chill accumulation in some years or sites and late frost danger during bloom. Temperatures above 20 °C during the endodormancy period, considered undesirable (Erez et al., 1979), are also frequent. The cultivars better adapted to Brazil have low chilling requirements (0–400 chilling hours below 7.2 °C) (Byrne et al., 2000; Topp et al., 2008). The Brazilian peach breeding programs have developed germplasms by combining local cultivars with breeding materials from the USA. These programs have been working to improve the production, yield consistency, quality, and disease resistance (Raseira et al., 2003; Medeiros et al., 2011).

A high level of budburst is needed, but not enough, to obtain a high yield and good foliage cover. Even if a bud is breaking and a vegetative growth is emerging, normal development is not secured. With a vegetative bud, a typical rosette formation testifies to an incomplete dormancy release (Erez, 2000). Fuchigami and Nee (1987) suggested that the breaking of rest involves two distinct processes: bud release and stem elongation. This phenomenon indicates two stages that can be easily separated, *i.e.*, the actual budburst and the second stage of elongation of the axis and further development of new fruit-bearing shoots.

Thus, the aim of this work was to evaluate the adaptability and stability of leafing based on budburst and new fruit-bearing shoot formation of peach tree genotypes developed for subtropical conditions.

2. Materials and methods

The evaluations were conducted from 2007 to 2010 in Pato Branco, Paraná State, Brazil (26°10′ S; 52°41′ W, 764 m a.s.l.). The local climate is classified as subtropical humid (Cfa – by Köeppen Classification).

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Table 1
Chilling hours (CH) below 12 °C accumulated until the date of budburst (BB) and range of budburst (RB). Average (2007–2010).

Genotypes	CH	BB (5% green tip)	RB (days)
Ambar	336	29-June ± 9[a]	13 ± 2[a]
Atenas	310	24-June ± 7	15 ± 4
Bonão	260	17-June ± 10	9 ± 3
Cascata 587	652	13-August ± 8	9 ± 4
Cascata 962	435	13-July ± 10	12 ± 3
Cascata 967	488	18-July ± 13	14 ± 5
Cascata 1055	596	2-August ± 7	16 ± 5
Cascata 1063	357	4-July ± 10	16 ± 7
Cascata 1065	596	2-August ± 9	13 ± 8
Cascata 1070	580	3-August ± 4	11 ± 3
Cascata 1303	369	8-July ± 6	11 ± 7
Conserva 655	361	6-July ± 5	20 ± 2
Conserva 681	521	30-July ± 10	12 ± 5
Conserva 688	407	11-July ± 10	12 ± 2
Conserva 844	353	5-July ± 11	21 ± 10
Conserva 871	568	4-August ± 18	7 ± 2
Conserva 977	375	7-July ± 8	17 ± 4
Conserva 985	353	6-July ± 11	19 ± 8
Conserva 1127	311	25-June ± 6	9 ± 3
Conserva 1129	571	1-August ± 4	12 ± 9
Conserva 1153	291	24-June ± 9	12 ± 4
Conserva 1186	421	14-July ± 8	14 ± 7
Conserva 1187	357	4-July ± 10	12 ± 2
Conserva 1205	357	6-July ± 11	18 ± 9
Conserva 1216	265	10-June ± 4	11 ± 7
Conserva 1223	330	30-June ± 6	19 ± 6
Conserva 1396	304	25-June ± 7	8 ± 5
Kampai	322	26-June ± 10	12 ± 5
Libra	238	14-June ± 11	9 ± 3
Olímpia	441	13-July ± 9	13 ± 1
Rubimel	315	26-June ± 6	11 ± 4
Santa Áurea	581	2-August ± 16	15 ± 10
T. Beauty	240	12-June ± 12	14 ± 5
T. Snow	355	7-July ± 11	18 ± 8

[a] Standard deviation.

Thirty-four peach genotypes were evaluated from 2007 to 2010 (Table 1). Each genotype was represented by three plants. Five one-year-old shoots, 25–30 cm long, per plant were randomly selected around the canopy for budburst analysis and fruit-bearing shoot formation. The trees were four and seven years old in 2007 and 2010, respectively. The orchard received standard fungicide and insecticide sprays, pruning and fertilization, similar to the treatments used in commercial orchards. No chemical means were used to break dormancy.

The experiment used a completely randomized design with three replicates, each represented by five twigs, and two factors, genotypes (34) and years (4).

2.1. Chilling and heat accumulation during the dormancy period

The number of hours with temperatures below 12 °C or 7.2 °C or above 20 °C was recorded from May to August (Fig. 1). Temperatures below 7.2 °C are traditionally used to determine chilling accumulation (Weinberger, 1950). Nowadays, temperatures below 12 °C are also considered effective for chilling accumulation (Erez and Couvillon, 1987; Fishman et al., 1987a,b; Citadin et al., 2002; Chavarria et al., 2009), especially for low chilling genotypes. Temperatures above 20 °C are undesirable during the dormant period, as they deny the accumulation of chilling (Erez et al., 1979).

The chilling accumulation for budburst of each genotype was calculated by the sum of hours of temperatures below 12 °C from May until 5% of vegetative budburst. Measures were made for four years.

2.2. Phenology of budburst

Five one-year-old shoots per plant were sampled. Their lengths were recorded and the total number of vegetative buds, on each, was counted. Twice a week, the number of buds that reached the green tip stage was recorded. The beginning, full, and end of budburst were considered to have occurred when green tip stage rise 5%, 50%, and 75%, respectively.

Range of budburst was calculated as the number of days elapsed from 5% to 75% of total of budburst.

2.3. Percentage of budburst and percentage of fruit-bearing shoot formation

To calculate the percentage of budburst, the following equation was used: PBB TNVBGT * 100/TNVB, where PBB is the percentage of budburst, TNVBGT is the total number of vegetative buds that reach the green tip stage, and TNVB is the total number of vegetative buds.

The percentage of buds, that gave rise to fruit-bearing shoots, was recorded 45 days after the final date of budburst.

2.4. Adaptability and stability of budburst and fruit-bearing shoot formation

To analyze the adaptability and stability of budburst and fruit-bearing shoot formation, the GGE (genotype main effect plus genotype by environment interaction effect) biplot methodology was used, based on the following model:

$$\gamma_{ij} - \ddot{y}_j = \gamma_1 \varepsilon_{i1} \rho_{j1} + \gamma_2 \varepsilon_{i2} \rho_{j2} + \varepsilon_{ij}$$

where y_{ij} represents the average of genotype i in the year j; $\ddot{y}_j$ is the mean of all genotypes in the environment j; $y_1\varepsilon_{i1}\ \rho_{j1}$ is the first principal component (PC1); $y_2\varepsilon_{i2}\ \rho_{j2}$ is the second principal component (PC2); y_1 and y_2 are the self values associated with PC1 and PC2, respectively; ε_{i1} and ε_{i2} are the scores of PC1 and PC2, respectively, for genotype i; ρ_{j1} and ρ_{j2} are the self values associated with PC1 and PC2, respectively, for the year j; and ε_{ij} is the error ij associated with the model (Yan and Kang, 2003). In the GGE biplot method, only the genetic effect and the genotype × environment interaction are considered to be relevant, and both must be considered simultaneously in the evaluation of the cultivars. The two main axes represent most of the variation in the data, considering the environment effect as fixed, *i.e.*, the variation in budburst or fruit-bearing shoot formation would be only due to genotype and the genotype × environment interaction (Yan and Rajcan, 2002).

In each graphic, a polygon was constructed to join the points that represent the most distant genotypes in relation to the origin of the axes in each quadrant. Later perpendicular lines were designed for each polygon edge passing through the origin, separating it into sections. The genotypes in each sector showed the best performance in environments/years included in that sector (Yan and Kang, 2003).

A PC1 value near the origin indicates that the genotypes have means close to the general mean (represented by the origin of the lines). As the value becomes more distant and to the right of the origin, the greater the value of the variable can be considered and more adapted are the genotypes (in this case, for percentage of budburst or fruit-bearing shoots formed). A PC2 value near the zero indicates the more stable genotypes. The graphical biplot may also identify the ideal environment (year), indicated by the year that has a high value for PC1 and a value near zero for PC2 (Yan and Kang, 2003).