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Review

Phenological evaluation for determination of pruning strategies on pear trees in the tropics

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ABSTRACT

Pear production in the tropics is limited not only by the reduced number of cultivars more adapted to places with higher temperatures, but also due to the lack of strategies for correct culture management. The intensity and the way of pruning the branches and the vegetative and reproductive structures are external factors that most influence the production and quality of pears. Thus, the aim was to evaluate the structure type that is related with the yield levels of pear trees and to establish strategies for the pruning of cultivars with greater adaptability and reproductive stability in the tropics. The experimental design was complete randomized blocks in the factorial design of split-plot in time, being six pear tree cultivars and two crop years. The duration of the phenophases in days, the percentage of vegetative spurs, reproductive spurs, reproductive brindles, vegetative brindles, bourses, yield per plant, and the number of fruits per plant were evaluated. Moreover, the adaptability and reproductive stability of species were verified. The pruning should be guided in order to maintain the reproductive spurs, the pear tree's main developed reproductive structure in the tropics and related to the greater yield of pears. Pruning in the tropics should be mild due to the evolution of vegetative brindles. There is no difference in the total length of the cultivar's phenological cycle regarding the reproductive spurs and reproductive brindles. 'Seleta' and 'Shinseiki' cultivars show greatest adaptability and reproductive stability to be cultivated in the tropics.

RESUMO

A produção de peras nos trópicos é limitada não somente pelo número reduzido de cultivares mais adaptadas a locais com temperaturas mais elevadas, mas também, devido à falta de estratégias para o manejo cultural correto. A intensidade e a forma de como se podar os ramos e as estruturas vegetativas e reprodutivas são um dos fatores externos à planta que mais influenciam a produção e qualidade das peras. Sendo assim, o objetivo foi avaliar o tipo de estrutura que possui correlação com os níveis de produtividade das pereiras e estabelecer estratégias para a poda de cultivares que apresentam maior adaptabilidade e estabilidade reprodutiva nos trópicos. O delineamento experimental utilizado foi o de blocos inteiramente casualizados, no esquema fatorial de parcelas subdivididas no tempo, sendo seis cultivares de pereira e duas safras agrícolas. Foram avaliadas a duração das fenofases em dias, a porcentagem de dardos, lamburdas, brindilas floríferas, brindilas vegetativas, bolsas, a produção por planta e o número de frutos por planta. Além disso, foi verificada a adaptabilidade e estabilidade reprodutiva das espécies. A poda deve ser orientada para se manter as lamburdas, principal estrutura reprodutiva desenvolvida nas pereiras nos trópicos e que está relacionada à maior produção de peras. A poda nos trópicos deve ser branda devido à evolução das brindilas vegetativas. Não há diferença na duração total do ciclo fenológico das cultivares para as lamburdas e brindilas floríferas. 'Seleta' e 'Shinseiki' são as cultivares que apresentam maior adaptabilidade e estabilidade reprodutiva para serem cultivadas nos trópicos.

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1. Introduction

The common pear (*Pyrus communis* L.) is a pomaceous fruit belonging to the genus *Pyrus* produced mainly in the temperate regions. However, the volume produced is insufficient to supply the world market. This situation indicates the need for the implementation of structured genetic improvement programs in order to obtain new cultivars and rootstocks better adapted to the edaphoclimatic conditions of the tropics and that guarantees high fruit yield and quality (Bettiol Neto, 2014; Nogueira et al., 2016).

Although being a temperate fruit, there are hybrid pear cultivars resulting from crosses between *Pyrus communis* L. and *Pyrus pyrifolia* (Burn). Nak. adapted to subtropical climate in regions with mild winters (Tecchio et al., 2011). These cultivars were obtained through hybridization between European pears (high cold requirement in winter and excellent fruit quality) and eastern pears (low cold and lower fruit quality requirement) (Curi et al., 2017). The hybrid cultivars harvested in the tropics in South America are 'Tenra', 'Centenária', 'Cascatence', 'Primorosa' and 'Seleta', developed by the Agronomic Institute (IAC), Campinas/SP, Brazil (Bettiol Neto et al., 2014).

The wetlands from the tropics, such as southeastern Brazil, show hot and humid summer and cold and dry winter. Furthermore, thermal fluctuations in winter caused by conflicting air masses from tropics and polar regions result in insufficient chill accumulation. Thus, pear trees do not reach good vegetative and productive development because it does not reach the proper number of cold hours at temperatures equal to or lower than 7.2 °C. There are cultivars with chilling requirement lower than 500 h and over 700 h, and it is essential that Brazilian producers choose low-chilling cultivars (Nakasu et al., 2003). Another important factor to consider is the flowering and ripening season that can vary according to the year and the site of cultivation (Hummer et al., 2007).

The pear tree shows specific fruiting structures, arising from buds located on the branches. These buds evolve differently according to their importance and environmental conditions, being able to give rise to structures as spurs (vegetative or reproductive), brindles (vegetative or reproductive) and bourses. The habit differences among cultivars may indicate a specific management related to the pruning operations that must guarantee the structures correlated with good yield levels (Oliveira et al., 2015).

Thereby, the phenology study is important to relate local edaphoclimatic conditions to the plant cycle in its different stages during its development (Martínez-Nicolás et al., 2016). Thus, the aim was to determine whether the structure type is related with the yield levels of pear trees and to establish strategies for the pruning of cultivars with greater adaptability and reproductive stability in the tropics.

2. Material and methods

2.1. Climatic characterization and plant material

The experiment was performed in a typical subtropical climate located in the municipality of Lavras, Minas Gerais, Brazil, the years 2015 and 2016. The Köppen classification for this region is Cwa - subtropical climate (21°14′S, 45°00′W and 918 m average altitude), i.e., high altitude tropical climate characterized by dry winter and hot and humid summer (Alvares et al., 2013).

Six pear cultivars, with their respective genealogy and origin, were used: the Asian cultivar 'Shinseiki' ('Nijisseiki' x 'Chojuro') from Japan, the European cultivar 'Packham's Thiumph' ('Uvedale St. German' x 'William's') from Australia, and the Brazilian hybrid cultivars (*Pyrus communis* L. x *Pyrus pyrifolia* (Burn). Nak.,] 'Cascatense' ('Packham's Thiumph' x 'Le Conte'), 'Primorosa' ('Hood' x 'Packham's Triumph'), 'Seleta' ('Hood' x 'Packham's Triumph') e 'Tenra' ('Madame Sieboldt' x 'Packham's Triumph'). Pear cultivars were grafted on the *Pyrus calleryana* L. rootstock and planted five years before the beginning of the experiment, spaced 3.0 m between rows and 4 m of row distance (density of 833 plants ha^{-1}). Pears were conducted in "central leader" system.

2.2. Chill and heat accumulation during dormancy period

To calculate the number of hours with temperatures below 7.2 °C and 12 °C, in the period from the end of April to the end of September, air temperature data were collected hourly from the main weather station at the Federal University of Lavras. Currently, temperatures below 12 °C are also considered effective for the chill accumulation (Chavarria et al., 2009), especially for cultivars with chilling requirement lower than 500 h.

2.3. Fruiting habit

The fruiting habit was evaluated through the methodology described by Pasa et al. (2011). In the dormancy period of plants, the yield structures from all the replicates per cultivar were counted, according to adapted Grisvard, 1979 Grisvard's classification (1979): Vegetative spur - structure from 0.5 to 10 cm, with vegetative bud in the apical region; Reproductive spur - structure from 0.5 to 10 cm, showing a flower bud in apical region; Bourses - globose structure formed due to the accumulation of carbohydrates in apical region from a productive structure in the previous cycle; Reproductive brindle – growth structure originated in the last vegetative cycle, from 10 to 30 cm, showing a flower bud in apical region; and Vegetative brindles – growth structure originated in the last vegetative cycle, from 10 to 30 cm, showing a leaf bud in apical region. After counting the total of structures per plant, the percentage of each structure was calculated and the number of buds potentially reproductive was counted. At the end of each productive cycle, the total fruit yield ($kg.plant^{-1}$) was measured.

2.4. Flowering phenology

In the both years of the study a general phenological study was performed in all plants by monitoring every day right after the dormancy period the dates of the opening of the first flower (FF) until the end of full bloom (EFB) in the plant as a whole, regardless of the type of reproductive structure.

A specific phenological development of flowering was performed according to methodology adapted from Francescatto et al. (2015). During the dormancy period, 20 structures from two different types were selected: ten reproductive spurs (0.5–10 cm length) and ten reproductive brindles (10 to 30 cm length) located in the middle third and distributed in the four quadrants of each plant. After identification, the structures were marked with ribbons, adopting a color for each structure type. The flowering phenology of all the structures was monitored every two days through the adapted classification of Fleckinger (1971). Based on the obtained data, the total time and the average time of every phenological phase were evaluated in each type of fruiting structure, being marked the onset of bud break (C3), the onset of fruit growth when they reach 10 mm diameter (*J*) and the harvest starting. At the end, the sum of time since the onset of bud break (C3) to the average date of flowering (C3-*J*) and harvesting (C3-Harvest) was evaluated for each year and each structure.

2.5. Adaptability and stability of sprouting and fruiting

The interrelationship between the years and the cultivars was done through the GGE biplot (*Genotype and Genotypes by Environments Interaction*) method named by Yan et al. (2000) based on the following model:

$$\overline{Y}_{ij} - \mu_j = \lambda_1 \gamma_{i1} \alpha_{j1} + \lambda_2 \gamma_{i2} \alpha_{j2} + \rho_{ij} + \overline{\varepsilon}_{ij}$$