Grafting Compatibility among Eleven Chestnut Cultivars and Hybrids

CATI - Coordenadoria de Assistência Técnica Integral
12490-000 São Bento do Sapucaí, SP
Brazil

E.L. Coutinho
CATI - Coordenadoria de Assistência Técnica Integral
13073-001 Campinas, SP
Brazil

A.H. Maiá
Embrapa Meio Ambiente
Rod. SP 340 - Km 127, 5
13820-000 Jaguariúna, SP
Brazil

O.K. Yamanishi
Universidade de Brasília (UnB)
Faculdade de Agronomia e Medicina Veterinária
Campus Universitário Darcy Ribeiro
Caixa Postal 04508, 70910-970 Brasilia-DF
Brazil

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Abstract
Among the four commercial chestnut species the C. dentata (Marsh.) Boskh. and C. sativa P. Mill. has excellent quality but more susceptible to diseases when compared to C. mollissima Blume and C. crenata Siebold & Zucc. which has inferior quality but can be used as rootstocks. This work aimed to evaluate the behavior of chestnut varieties grafted in different rootstocks under São Bento do Sapucaí, São Paulo, Brazil condition. In 1986, eleven chestnut cultivars and hybrids - Ibuki (IB), Izumo (IZ), Kinchu (KI), KM1 (KM2), KM(2) KM(2), Moriowase (MO), Okuni (OK), Taishowase (TAI), Tamatsukuri (TAM), Tiodowase (TIO) and Senri (SEN) (only graft) – were grafted each other resulting in hundred ten combinations. Fifteen-year later grafted trees with minimum of three plants were evaluated for tree height, trunk diameter above and below graft union and graft compatibility. Randomized blocks with three replications were submitted to analysis of variance for tree height and trunk diameter. Grouping analysis using the PROC CLUSTER – SAS system was used to describe the pattern of variance among different combinations. Seventy eight combinations in hundred ten showed perfect grafting compatibility 6 months after grafting. Forty seven combinations showed incompatibility after transplanting and the dieback rate in each combination ranged from 25 to 100%. Among seventy eight combinations established in the field twenty six had enough plants for evaluation fifteen-year later. Tree height and trunk diameter showed highly significant difference among the combinations. The highest plant (6 m) was grafted on Moriowase and Tamatsukuri which showed the highest compatibility as rootstock. The harvesting season is from November to May where MOR, IB, TAM, OK and TAI behave as early-season-cultivar and SEN the latest one.

INTRODUCTION
Chestnut trees produce delicious nuts and are natives of the northern hemisphere, especially China, Korea, Japan and South Europe (Janick and Moore, 1975). The nut can be eaten cooked, roasted, in the form of a paste, pudding or as the famous marron glacé, which is said to have the most delicate and fine flavor in the world. In Brazil it is traditional to eat them cooked for dinner parties at New Year’s, where it is popularly

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a npmsb@cati.sp.gov.br
b edson@cati.sp.gov.br
c ahmaia@cnpma.embrapa.br
d kiyoshi@unb.br

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127
known as “Portuguese Chestnut”.

The chestnut belongs to the Fagaceae family, Castanea genus, with four commercial species: C. dentata (Marsh.) Boskh. (North American); C. mollissima Blume (China); C. sativa P. Mill. (Europe), and C. crenata Siebold & Zucc. (Japan) and its hybrids (Little, 1979). C. crenata can grow to between 12 to 18 m in height and is resistant to many diseases, however the flavor of its chestnuts is inferior compared to the others. C. mollisima is between 8 to 15 m tall and has nuts with a good flavor and is resistant to chestnut blight; they produce at a young age and are used as rootstocks. C. sativa and C. dentate produce excellent flavored fruits in trees up to 30 m in height and are most susceptible to diseases (Vossen, 2000).

Various varieties have been created through cross-breeding of species. Some require cross pollination to produce fruits. Plants that originate from seed are not uniform in terms of their size, type and vigor, which is not acceptable in commercial production. The production of fruits is also variable, in terms of their size, color and flavor. Commercially, chestnut trees are produced through cleft-grafting, using stocks that are a year old, sourced from plantlets of the same variety, since different varieties can be incompatible. Grafting between different cultivars can result in increased incompatibility and, eventually, in death of the plants after 1 to 10 years. Other forms of propagation such as tissue culture and cutting are difficult. To minimize incompatibility problems, it is advisable to use rootstocks of the same variety (Vossen, 2000).

Anagnostakis (1997) reported on cultivars that are only used as stocks, or as pollinators. Craddock and Bassi (1999) reported that some traditional cultivars of the European chestnut tree (Castanea sativa) are susceptible to Phytophthora cambivora and P. cinnamomi, which cause damage or death and that resistance to Phytophthora occurs in C. crenata and C. mollissima. However, grafting can be incompatible between these species.

Farmers are currently interested in chestnut cultivation, because of the high value of their products and their good adaptability to the culture in some regions of Brazil, where the harvest takes place between November and May, and enables the sale of uncooked chestnuts for end-of-year parties, and the processing of the product during the rest of the harvest season. However, it is important to analyze various factors regarding this crop, in order to create suitable technology for each condition. Therefore, the aim of this study is to begin the evaluation of one of the key aspects that results in the production of good quality nursery plants, or rather, the adequate combinations of scions and rootstocks, for each condition.

MATERIAL AND METHOD

The experiment is based in São Bento do Sapucaí, Sao Paulo state at Fruit Tree Nursery Center, Extension Service, São Paulo Agricultural Station (CATI–SAA/SP-NPM-SBS), where the climate is Cwb. The treatments consisted of 11 hybrids of chestnut tree (Castanea crenata × Castanea sp.), whip-grafted onto 10 hybrids of the same species, making a total of 110 combinations. The rootstocks were produced from seeds, which were harvested from the NPM-SBS collection of chestnut trees and sowed in November 1985. The hybrids that were used were: Ibuki (IB), Isumo (IZ), Kinchu (KI), KM1 (KM1), KM2 (KM2), Moriowase (MO), Okuni (OK), Taishowase (TAI), Tamatsukuri (TAM), and Tiodowase (TIO).

The whip graft was carried out in July 1986, when the rootstocks measured approximately 1cm in diameter at their graft-position, and scions were taken from mother plants that were at the end of their dormant period. The scions used were the same as those mentioned above with the addition of the Senri hybrid (SEN). Only nursery trees with apparent comparability between rootstock and scion were transplanted and the number of replication per combination varied from 2 to 5. The grafted trees were transplanted in December 1986, in previously amended soil accordingly to soil analysis and fertilization done in the holes that were dug when the planting took place.

The planting spacing was 6 m between plants and 7 m between lines. Only
combinations that had a minimum of three living plants after 15 years were analyzed. The experiment design used was entirely random with three replications, with each valid parcel consisting of one plant. The parameters observed were: number of combinations per rootstock line that had perfect apparent compatibility 6 months after grafting; number of combinations that showed incompatibility after transplanting; phenological status of the plants in December (15 years after transplanting); height of the plants and their diameter 10 cm above and 10 cm below the graft-union (15 years after transplanting). ANOVA was applied to the measurement data of the height and diameter of the trunk above the graft-union. With these parameters, combinations were initially classified based on each of the following characteristics, with each characteristic considered separately:

a) Tree height: group I, group II, and group III;
b) Diameter above graft-union: group I, group II, and group III.

The SAS System’s PROC CLUSTER module was used to analyze the groups and to classify the combinations in terms of their similarity. At the same time, the three aforementioned characteristics were considered.

According to the group analysis, a graph of tree height was plot. A negative exponential model was adjusted to describe the variation pattern between the combinations.

RESULTS AND DISCUSSION

The studied hybrids have been producing fruits from November to May each year. The earliest ones to harvest are: MOR, IB, TAM, OK and TAI and the latest is the SEN.

Table 1 shows that of the 110 combinations, 78 had apparently perfect grafting compatibility, 6 months after grafting. Out of these, 47 combinations proved incompatible after transplanting and the mortality rate within each combination type, varied from 25 to 100%. Out of the 78 combinations planted in the field, 26 produced enough number of plants to carry out the measurements of height, diameter and phenological status on 15-year-old trees.

ANOVA of the 26 combinations revealed a highly significant difference for the plant height and the trunk diameter and the variation coefficients were 17.67 and 6.17%, respectively.

Table 2 and Figure 1 shows the 26 combinations with the best compatibility rates over 15 years and that the highest plants were the ones grafted onto Moriowase and Tamatsukuri. When it was a Moriowase scion, plants were low in height. The highest number of possible combinations was achieved when the stocks were MOR and TAM.

CONCLUSIONS

For the studied hybrids, the tree height and trunk diameter are not completely correlated, however the compatibility, the plant height and trunk diameter are influenced by the type of rootstock and scion, so one must choose compatible combinations that have a good productivity and resistance to pests and diseases, as the choice of adequate rootstocks is all-important for achieving good results for tall and vigorous plants or dwarf plants that are easier to handle and allow high-density planting.

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Literature Cited


Tables

Table 1. Number of combinations per type of rootstock with apparently perfect compatibility at time of transplanting, combinations that were incompatible after planting and mortality rate during 15 years.

<table>
<thead>
<tr>
<th>Compatible up to 6 months</th>
<th>Incompatibility after transplanting</th>
<th>Mortality in 15 years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/MOR</td>
<td>6/MOR</td>
<td>25-67</td>
</tr>
<tr>
<td>11/KM2</td>
<td>8/KM2</td>
<td>25-67</td>
</tr>
<tr>
<td>11/KM1</td>
<td>6/KM1</td>
<td>50</td>
</tr>
<tr>
<td>9/TAI</td>
<td>6/TAI</td>
<td>25-67</td>
</tr>
<tr>
<td>8/IZ</td>
<td>5/IZ</td>
<td>25-67</td>
</tr>
<tr>
<td>7/TIO</td>
<td>3/TIO</td>
<td>50-67</td>
</tr>
<tr>
<td>6/TAM</td>
<td>4/TAM</td>
<td>25-75</td>
</tr>
<tr>
<td>6/KIN</td>
<td>2/KIN</td>
<td>25-67</td>
</tr>
<tr>
<td>5/IB</td>
<td>4/IB</td>
<td>33-75</td>
</tr>
<tr>
<td>4/OK</td>
<td>4/OK</td>
<td>25-100</td>
</tr>
</tbody>
</table>

Table 2. Classification of 26 combinations according to trunk diameter 10 cm above the graft-union, in 15-year-old trees.

<table>
<thead>
<tr>
<th>Group</th>
<th>Diameter (cm)</th>
<th>Combinations</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>35-25</td>
<td>TAI/TAM; KIN/KIN; KIN/MOR; IZ/MOR</td>
</tr>
<tr>
<td>II</td>
<td>24-15</td>
<td>IZ/TAM; OK/MOR; IZ/IZ; IZ/TAI; IZ/KM1; OK/KM2; IB/MOR; KM2/KIN; SEM/KM2</td>
</tr>
<tr>
<td>III</td>
<td>15</td>
<td>KM2/OK; MOR/MOR; TAM/MOR; TAM/TAM; TIO/TAI; SEN/KM1; TIO/IZ; MOR/TAM; TIO/TAM; TAM/TIO; MOR/KIN; TAM/OK; MOR/TIO</td>
</tr>
</tbody>
</table>
Fig. 1. Classification of 26 combinations according to height (m), in 15-year-old plants.

The equation for the graph is:

\[ y = 6.6167e^{-0.0328x} \]

\[ R^2 = 0.9788 \]