1. Introduction

Carbohydrate partitioning and storage, have been studied taking into account the same cultivar on different rootstocks, which widely differ in growth vigor, such as in European prune (Gaudillière et al., 1992), sweet cherry (Olmstead et al., 2010), and peach trees (Caruso et al., 1997), as well as considering the effect of training systems in peach (Caruso et al., 1999), or training systems-rootstock combination in apple (Stutte et al., 1994).

The partitioning of carbon implicates the transport of assimilates from source organs to various sinks, and their distribution, therefore the knowledge of the role of branch architecture (training system) acquire a great importance in order to understand the process of distribution of assimilates in fruit trees (Fanowa et al., 2014).

In the European pear orchards, the selection of new quince rootstocks, such as dwarfing clones like MM® and Adams as well as those more vigorous like Sydo® and BA29 (Sansavini et al., 2008), and the development of new training systems like Bi-axis (Musacchi, 2008) allowed to improve the high density planting (HDP) management.

The research goals were 1) to analyze the relationship between starch concentrations on different bearing woods in pear trees, trained at Spindle and Bi-axis, and grafted on the same rootstocks, Sydo®; 2) to compare three quince rootstocks with increasing level of vigor: Adams, MM®, and Sydo®, trained as Spindle, on the storage of nonstructural carbohydrates (NSC), on different bearing woods at dormancy release; and 3) to evaluate the effect of bearing wood position on the tree, in the bottom and upper part of the canopy, related to storage concentration of NSC.

2. Material and methods

Location:
Experimental orchard located in Ferrara, Italy (Marborghetto di Boara, 44°51′24″N; 11°39′09″E). Three growing seasons (2011-2012-2013) on 6-year-old pear trees (Pyrus communis L.) cv. 'Abbe Fétel' (planted in 2005).

Four combination between two training systems and three rootstocks were studied (Table 1).

Evaluations:
I. At harvest time:
   a) position in the canopy
II. Dormancy:
   a) type of bearing wood

Determination of starch and soluble carbohydrates is based on a protocol published by Roe (1955) with appropriate modifications, that uses a colorimetric method with Anthrone reagent for the quantification of starch by spectrophotometry.

3. Results

Among the three evaluations years for each combination registered statistical differences for Bi-axis/Sydo® and Spindle/Sydo® combinations. Trees in 2012 cropped the lowest yield/tree, whereas between the seasons 2011 and 2013, no significant differences were found (Fig.1).

The type of organ, regardless the training system and rootstock, had a strong effect on the starch concentration at dormancy period, unlike to the non-significance observed for soluble carbohydrate (Tab.2).

The woody tissues presented a concentration two-fold higher than the flower buds. However, the starch concentration in the organs was unaffected by the year of assessment.

Regardless of the training system-rootstock combinations and evaluation year, at dormancy period the starch concentration were higher than soluble carbohydrates on woody organs (Fig.2). However, an opposite result was obtained for flower buds (Fig.3), being more significant the concentrations range of soluble carbohydrates.

In general, brindle-type shoots were characterized by the highest amount of starch in all combination (Fig.2). Whereas for the soluble carbohydrates, highest amounts have been determined in both, brindle-type shoots and short-old spurs.

A similar trend was observed in the flower buds, although there were no statistical differences for all combinations (exception in 2012 for Spindle/Sydo®), numerically brindle-type shoots showed a higher amount of NSC (Fig.3).

4. Conclusions

Factors as type of bearing wood, position in the canopy, training systems and rootstock had a different effect on the starch and soluble carbohydrates concentrations.

Type of bearing wood: as far as the age of woody organs increases, lower concentrations of STARCH were obtained.

The bottom canopy of the tree showed the highest NSC concentrations, however this could be also related to the training system.