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CARBON ECONOMY OF A YOUNG WALNUT TREE

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Abstract

The carbon economy of young walnut grafted trees in their second growing year, was investigated through carbohydrate analysis and 14C-labelling experiments.

In October, 3 weeks before leaf-fall, starch and soluble sugars represented up to 25% of the total dry matter, with starch highly predominant among them. Sucrose was more abundant in the bark than in the wood, while the starch content was similar in both compartments.The reserves were located in the wood and in the innermost pith.

Between October and January, the minor roots (ø < 15mm) underwent a significant depletion of their August-labelled reserves, whereas the tap-root was the main organ depleted between January and May (early growth resumption).

Both labelling experiments, and root respiration monitoring, provided some information about the timing of translocation processes and the early metabolism of the translocation compounds.

1. Introduction

Modelling of growth and carbon movements in trees currently available - most of them for apple - are generally valid only for short periods characterized by constant growth patterns (Frossard & Lacointe, 1988). In order to build models valid for a long period - 1 year or more -, an improvement of the understanding and quantitation of the carbon balance in the annual cycle is needed. To this end, the first results of a current program on young walnut trees carried out in Clermont-Ferrand were presented here. Particularly, the formation of reserves and their subsequent utilization, both in winter during the so-called 'rest-period', and in spring at growth resumption, were investigated.

2. Material and methods

Walnut (*Juglans regia* L.) cv. Lara scions were planted in late April 1988 (or 1989 for the respiration experiment), in 200 liter containers.

The culture was carried out in natural conditions with irrigation.

The carbon reserves and their dynamics were investigated through :
* carbohydrate analysis in mid-October,
* 14C movements after labelling in August, as derived from 3 harvests:
  * mid-October (Autumn): shoot growth over
  * mid-January (Winter): rest-period
  * mid-May (Spring) (2 full-grown new leaves per shoot)

2.1. Carbohydrate analysis

This part concern only the Autumn harvest. Different carbohydrates (fructose, sucrose, glucose and starch) were extracted in methanol/chloroform/water 12/5/3 and assayed by enzymatic and spectrometric methods.

2.2. 14C-experiments

In mid-August, each tree was fed with 2 mCi (74 MBq) $^{14}CO_2$, with an individual chamber used either as 14C labelling, or as a gaz exchange monitoring system allowing independent measurement for shoots and roots.

For each harvest, 2 trees were sampled and divided in 14 organs (Fig 1) which were freeze-dried and ground.

The radioactivity of each organ was measured after harvest with an argon-methane flow counter.

Autoradiographs were also performed for the localization of ^{14}C within organs.

The evolution of $^{14}CO_2$ from root respiration was monitored continuously for 15 days after labelling (Fig 2).
* the total CO_2 evolution was assessed with a gas-exchange measurement system including an IR gas-analyser.
* the specific radioactivity of the CO_2 was assessed by titrimetry and liquid scintillation after trapping in NaOH.

3. Results and discussion

3.1. Fate of carbon assimilated in August:

As derived from root respiration monitoring due to the duration of the translocation processes, the $^{14}CO_2$ specific radioactivity (SR) reached a maximum 1 day after labelling.
After 6 days, the export was over, the labelled compounds were incorporated in metabolic pools with long time constants : the SR had decreased to a much lower value, still decreasing very slowly.

3.2. Biochemistry, location and amount of carbohydrate reserves in October

Only starch and soluble sugars were investigated, but they represented up to 25% of the total dry matter weight (Fig. 3) : they were certainly the main class of reserve substances. Among them, starch was predominant in all perennial organs. Generally, there was only little difference in the concentrations of starch between wood and bark. Sucrose, the main translocation form of assimilates, was more concentrated in the bark than in the wood. However, there was some sucrose in the wood. This most probably reflected the lateral transport of sucrose in the rays towards the reserve storage areas, where it would be converted into starch.
The reserves were mostly located in the lower part of the plant, including the root-stock part of the stem, Even the smallest roots contained a significant fraction of the total reserves (Bachelard & Wightman 1973, in Jourdan, 1980).

As for the location of reserves within the organs, the wood formed from current assimilates was intensely labelled (periphery). Labelled reserves were localized in the rays and in the central pith (Fig4) : even the oldest tissues took part in reserve storage. Similar results were obtained by Glerum, (1980) and Kandiah, (1979) on apple trees.

3.3. carbon movements from October to May

The total radioactivity of the perennial parts decreased between October and January (Fig 5), due mainly to the maintenance respiratory losses : the plant was not totally "inactive" during the so-called "rest-period". These losses concerned mainly, if not only, the minor roots of all sizes (ø < 15 mm). The leaves remained the most radioactive organs per mass unit until leaf-fall (Lacointe, 1988) on walnut.

Between January and May, the decrease went on in the smallest roots (ø < 3mm), whereas an increase was noticed in the medium roots (ø 3-7 mm). This could be due to a redistribution of nutrients from the former to the latter, as mentioned in literature (Priestley, 1981) concerning stone-fruit trees.

A decrease was also observed in the twigs, both upper and lower, which were the most labelled organs per mass unit together with the smallest roots.

However, the organ which was most depleted of its reserves at growth resumption was the tap-root (Hansen, 1967) on apple.

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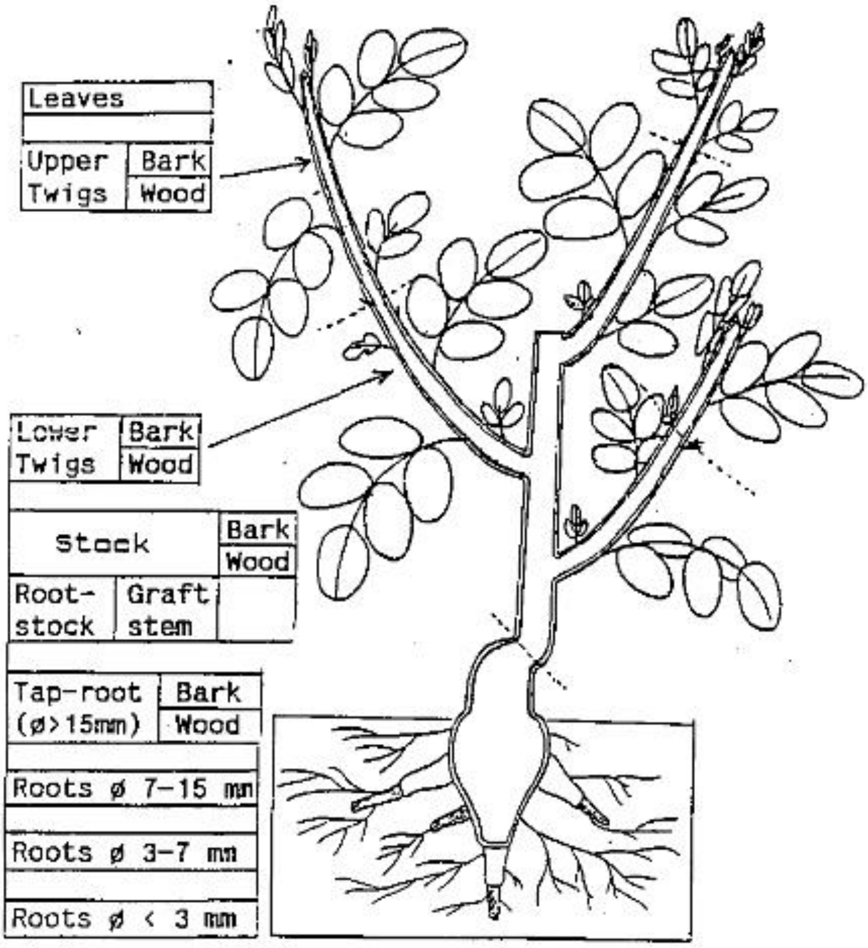


Fig. 1 -Schematic representation of a young walnut grafted tree, showing the different parts analysed for radioactivity and carbohydrates content.

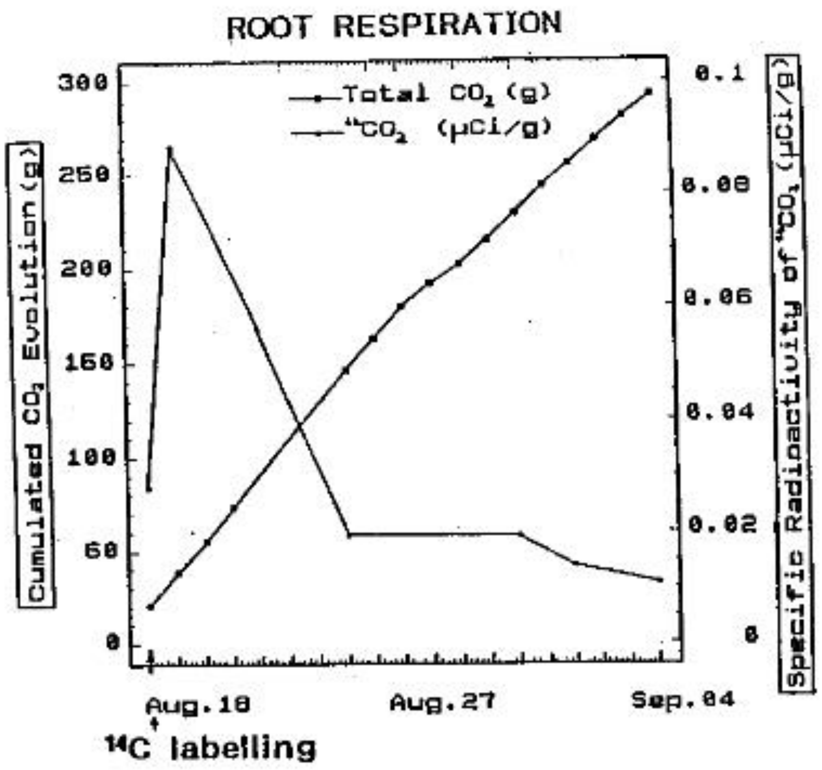


Fig. 2 -Cumulated CO2 evolution and specific activity of root respiration of a young walnut grafted tree for 15 days after labelling.

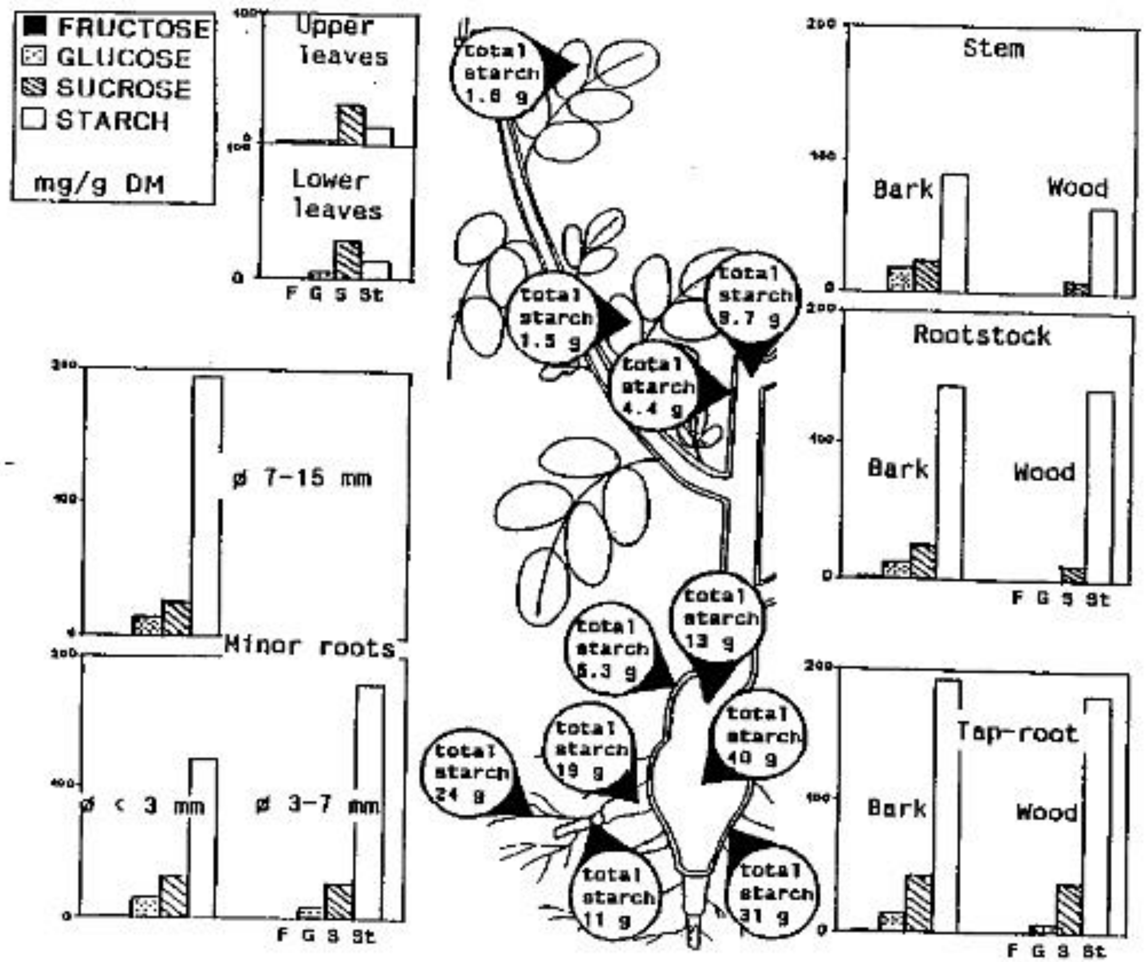
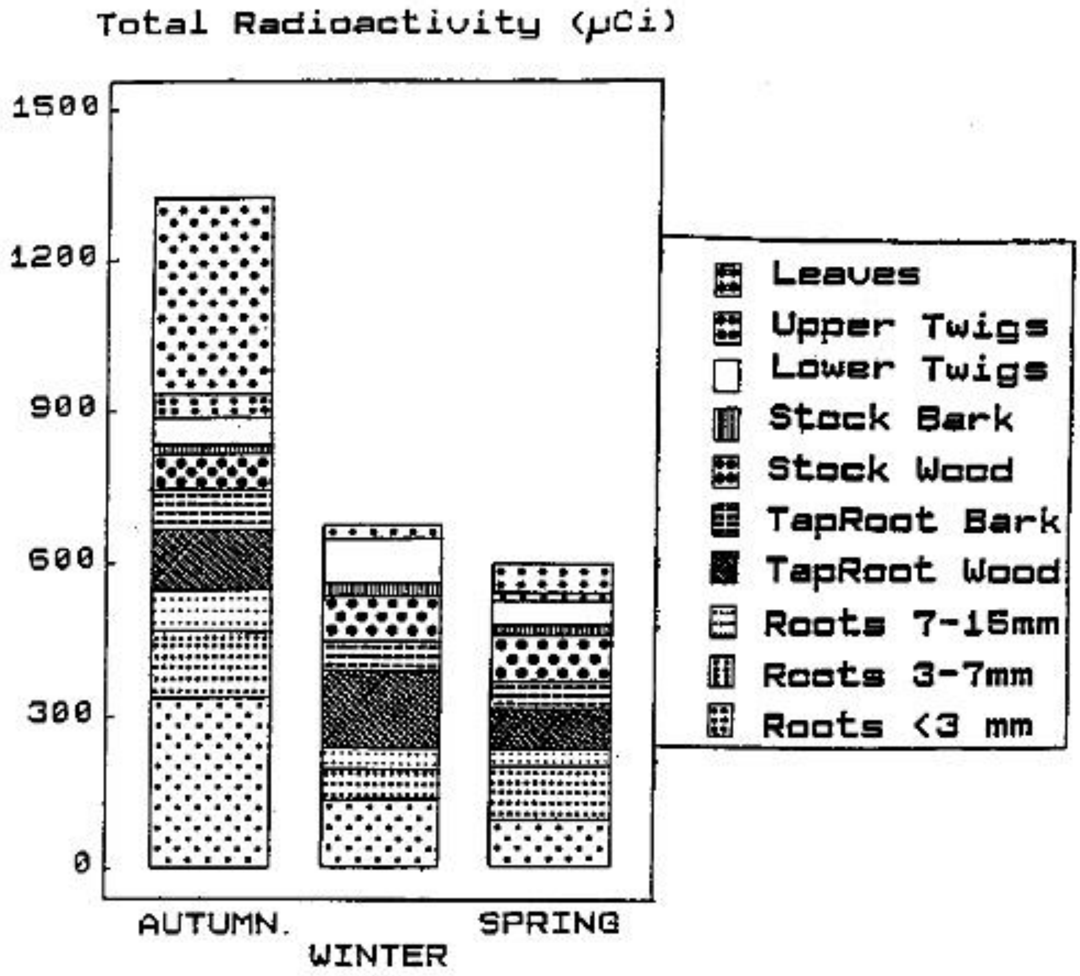


Fig. 3 -Carbohydrates content at Autumn harvest in different parts of a young walnut grafted tree.



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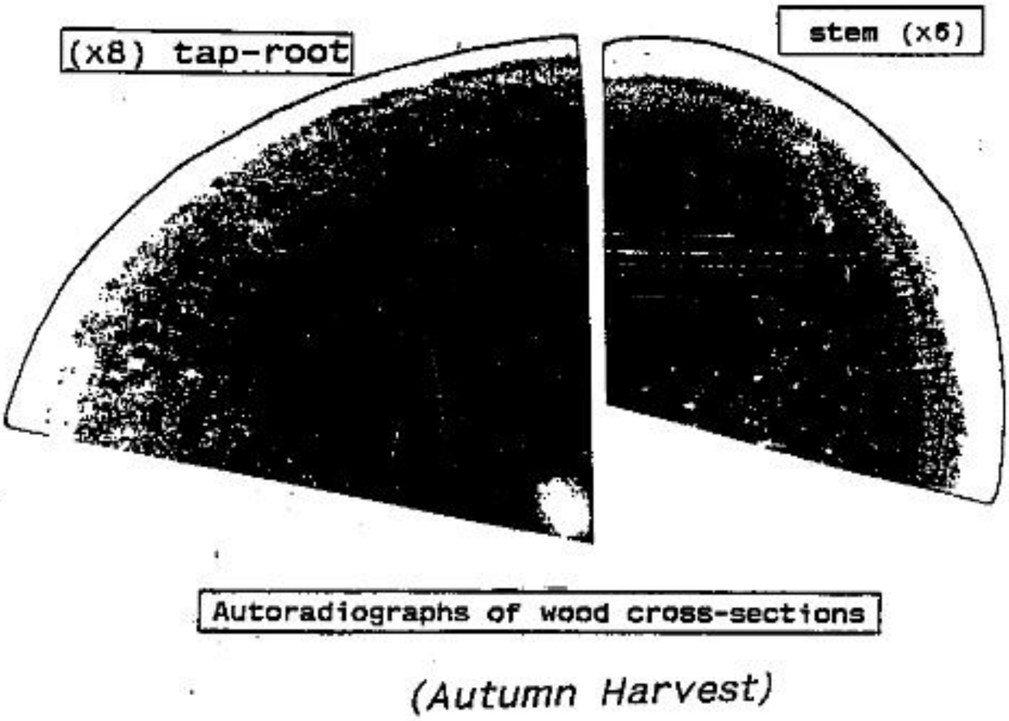


Fig. 4-Autoradiographs of the tap-root and the stem of a young walnut grafted tree, showing tissular repartition of reserves.

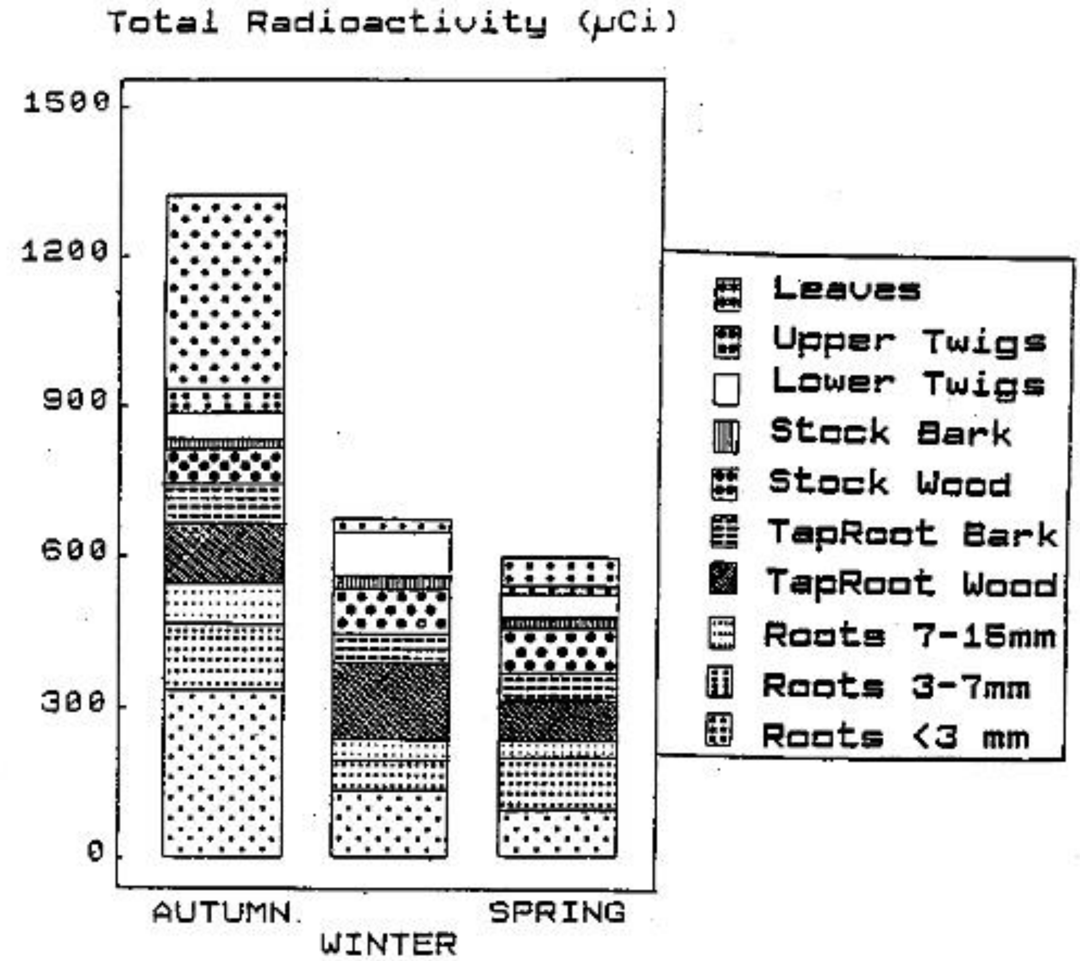
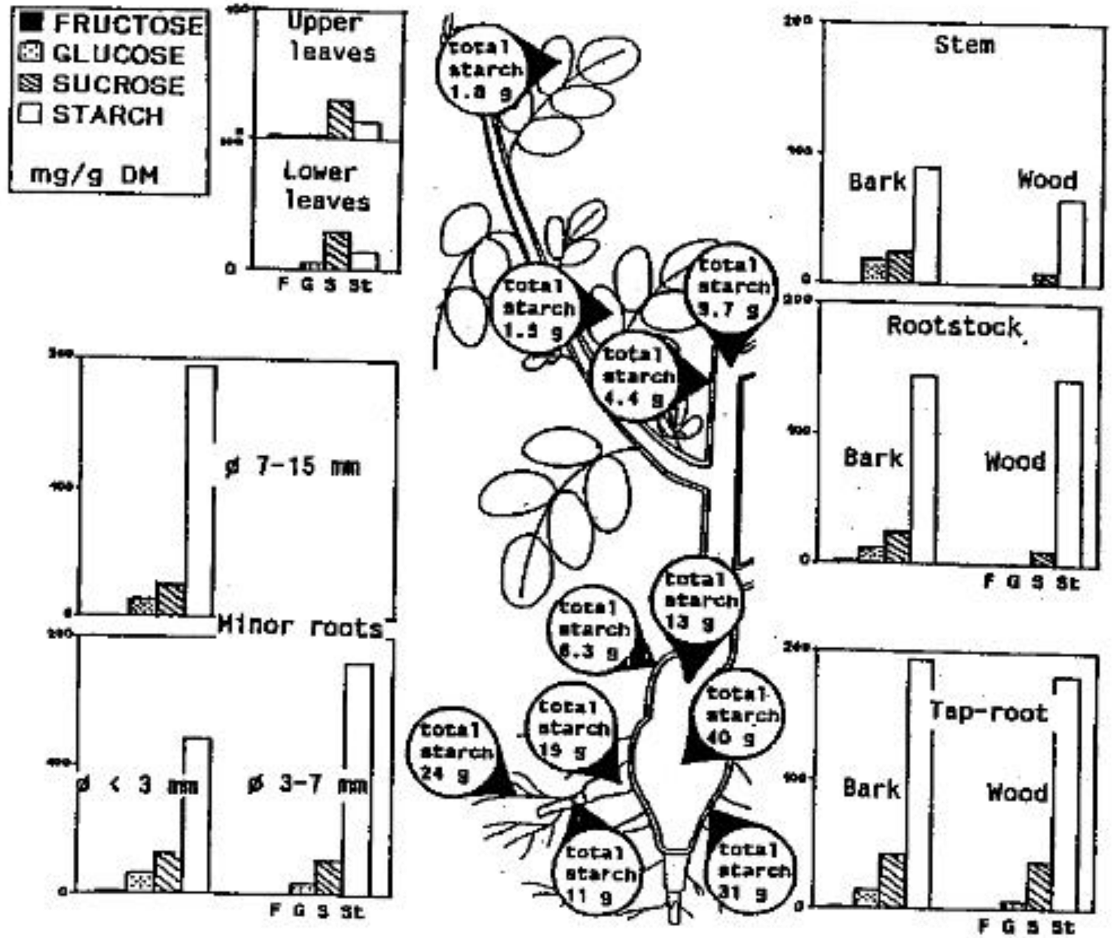


Fig. 5-Seasonal variations of the total radioactivity in the different parts of a young walnut grafted tree.



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