*Ann. Sci. For.* (1989) 46 suppl., 297s-300s
*Forest Tree Physiology*, E.Dreyer *et al.*, eds.



# Growth relationships between root and shoot in walnut seedlings (*Juglans regia* L.)

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## Introduction

It is well known that the periodicity of root growth throughout the year may be the same as or different from that of shoot growth (Riedacker, 1976; Kramer and Koslowski, 1979; Frossard and Lacointe, 1988), depending upon the species. It is difficult to interpret the published results because they were obtained on trees of different ages under different climatic conditions.

It is particularly difficult to give precise answers to the following questions: 1) is the relative position within the annual cycle of root and shoot growth a general characteristic of a given species? In other words, is there any evolution between years, in the relative periodicity of root and shoot growth? 2) are the relationships between variables describing growth equivalent throughout the year? Answers to these questions are of particular interest when working on seedling growth and when investigating the carbon allocation to different organs (Lacointe, 1989).

## Materials and Methods

For 3 yr (1985, 1986, 1987), walnuts were sown in early June, in clay soil, and grown in a glasshouse. After 1 mo, 10 seedlings per yr were transplanted into minirhizotrons and grown outdoors, under natural conditions (continental climate). Root and shoot growths were measured weekly, during 2 yr for the 1985 and 1986 seedlings, and during 1 yr for the 1987 seedlings.

From September to March, bud dormancy was studied using the MTB test (Bailly and Mauget, 1989).

## Results

There was a high variability between plants during both the 1st and the 2nd yr. An example of between yr variability is given in Figs. 1 (1985–1986) and 2 (1986–1987).

However, the relative growth patterns of the different organs were the same. There were '1st yr' and '2nd yr' patterns. During the 1st growing season (sowing yr), root and shoot growth occurred simultaneously; during the 2nd season (2nd yr), leaf growth began first, followed by shoot elongation and root growth came last.

In autumn, there was no relationship between dynamics of bud dormancy and root growth (data not shown). No root growth was observed in winter.

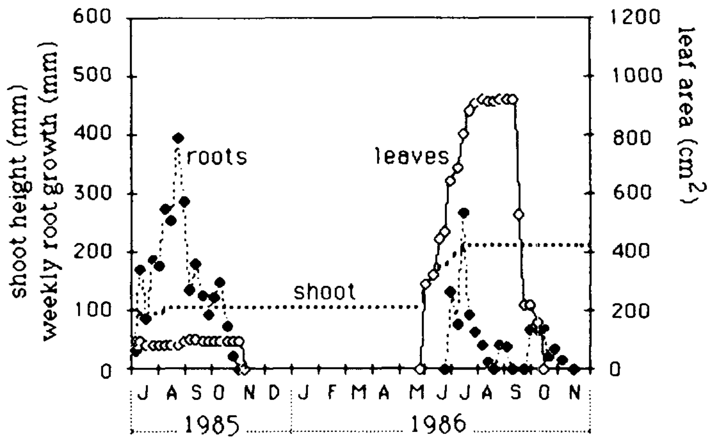


**Fig. 1.** Time variations of root growth, shoot height and leaf area during 2 yr. A representative individual (sowing yr 1985).

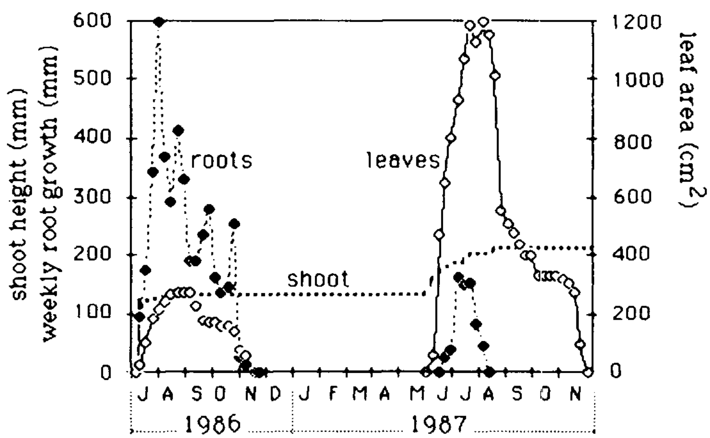


**Fig. 2.** Time variations of root growth, shoot height and leaf area during 2 yr. A representative individual (sowing yr 1986).

In order to specify the dynamics of relationships among growth variables, 5 French principal components analyses were performed, one for each of the 3 sowing yr and one for each of the 2nd yr studied: on the average values for the 10 plants; taking as 'individuals' the measurement dates.

The sowing yr analyses provided 3 very similar figures, and the same was true for both 2nd yr analyses. The results for the 1985 sowing are presented in Figs. 3 (sowing yr) and 4 (2nd yr).

Comparison of component weights (variables) *vs* principal components (measurement dates), for both years, enabled

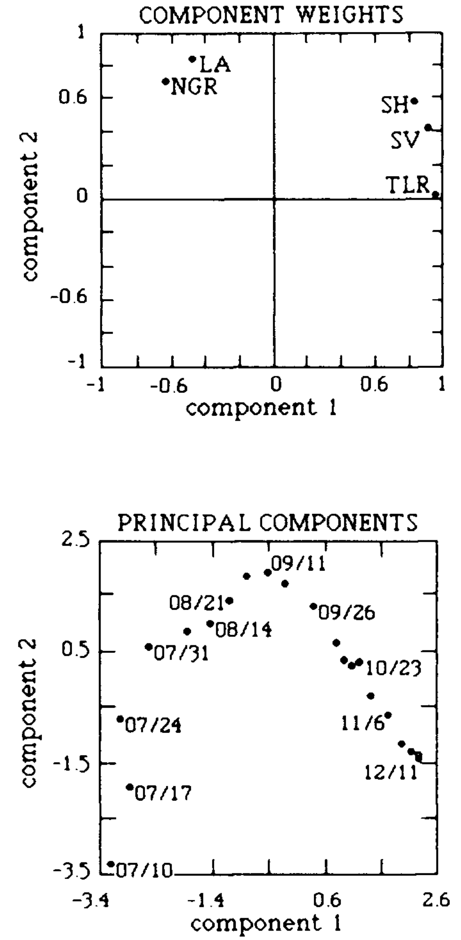


**Fig. 3.** Component weights (growth variables) and principal components (measuring dates) for the sowing yr 1985. *LA* = leaf area; *NGR* = number of growing roots; *SV* = shoot volume; *SH* = shoot height; *TLR* = total length of roots; for principal components, each point stands for a day.

us to interpret the geometrical relationships among variables as time relationships. As an example, for the sowing yr, the number of growing roots *(NGR)* was maximal near August 10, the leaf area *(LA)* in late August, the shoot height *(SH)* and the shoot volume *(SV)* in late October and the total length or roots *(TLR)* in early November.

For some of them, such as *LA* or *TLR*, this synthetic overview of the growth dynamics was consistent with that which could be derived from the plots of the considered variables *vs* time (Figs. 1 and 2). For *SH*, however, there was a large discrepancy: it was probably related to the biphasic growth pattern of the shoot, with a high rate in July/August, followed by much

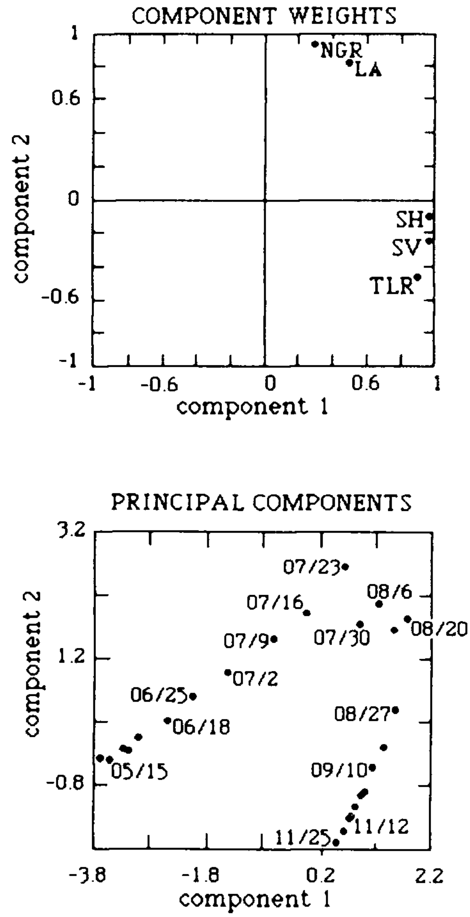


**Fig. 4.** Component weights and principal components for the 2nd yr (sowing yr 1985). *LA* = leaf area; *NGR* = number of growing roots; *SV* = shoot volume; *SH* = shoot height; *TLR* = total length of roots; for principal components, each point stands for a day.

slower growth in late summer and autumn, which could not be detected from the individual curves. Similarly, the discrepancy between the root growth variables, *NGR* and *TLR*, probably reflected the root growth pattern: an early multiplication of white tipped roots, followed by an active elongation.

## Discussion and Conclusion

The results show that there was an evolution between years in the relative periodicity of root and shoot growth of walnut seedlings. Since there was no relationship between bud dormancy and root growth, the reasons for the cessation of root growth might be related to carbon allocation or to climatic factors, such as soil or temperature (or both).

The specific relationships observed between the growth variables during the 2 growing seasons were characteristic of the walnut seedling and relatively independent of climatic hazards because they were obtained in different years (with different patterns of temperature and radiation in this continental climate, for each year).

Thus, it might be possible to study under controlled conditions particular relationships between a climatic factor (for example, temperature) and growth, conserving the same ranges as those observed under natural conditions.

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