Effect of the soil water potential on the growth of the root system of young oak trees

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EFFECT OF THE SOIL WATER POTENTIAL ON THE GROWTH OF THE ROOT SYSTEM OF YOUNG OAK TREES

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INTRODUCTION

Three important factors for the growth of the root systems in the soil are mechanical impedance, poor aeration, and restricted water availability. Effects attributed to one of these factors are either exagerated or underestimated because accompanying effects due to other limiting factors are not detected. So it is very difficult to obtain precise references on the effect of one single factor such as the soil water potential on the growth and the development of the root system, whose different members may also have different and not independant responses (see Pagès *et al.*, in the same Symposium).

In this paper, we present the first results of a work in which we chose to study only the effects of the soil water potential on the root system (taproot and lateral roots) of young oak seedlings.

MATERIAL AND METHODS

In order to study specifically the effects of the soil water potential we used an original device in which young oak seedlings (*Quercus robur* L.) were grown in root observation boxes under controlled conditions.

Acorns were rather genetically homogeneous as they were all collected on the same tree. Their teguments were taken off, and the acorns were rinsed in running tap water during 24 hours. They were subsequently pre-germinated on moist filter paper at 20 °C for about 4 days.

They were placed in root boxes (Riedacker, 1974) when their taproot was 1 to 3 cm long. These root observation boxes (40 cm long, 12 cm wide, and 2 cm thick) were filled with calibrated soil agregates.

The silt-clayed soil was screened through a 3-5 mm screen (in order to obtain in the soil medium holes according to the taproot diameter). The agregates were saturated under vacuum and then maintained at a constant known pressure (on a pressure plate). The bulk density was about 1.2 and the whole porosity about 54 %.

The plants were grown during 6 weeks in darkness at a temperature of 20 ± 1 °C.

Two water potential levels have been tested : - 0.07 ± 0.03 MPa (replicated 4 times) and - 0.2 ± 0.05 MPa (replicated 5 times).

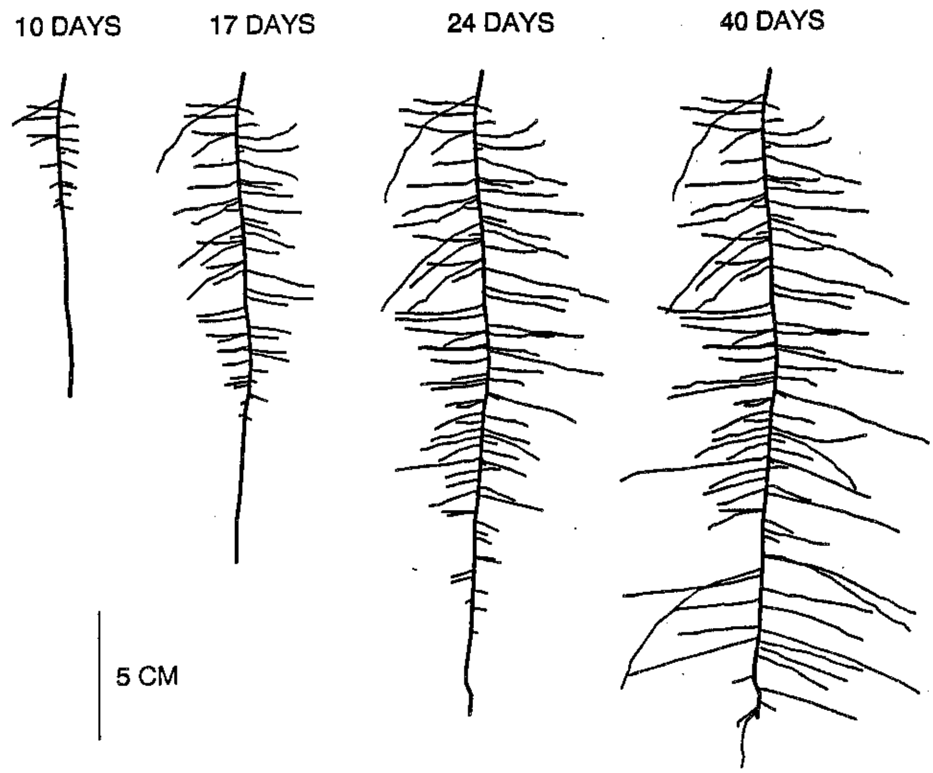
The growth and development of the root systems were followed by tracing every day the new root increments on a plastic transparent sheet fixed on the transparent side of the root box. Different colours were used to differentiate the observation dates. The obtained pictures were subsequently digitized on a digitizing table, with a specific software described precisely by Colin-Belgrand *et al.* (1989).

Congrès de la Société Internationale de Recherche sur les Racines, Vienne, (AUT) août 1991

RESULTS

Morphology of the root systems. The figure 1 presents the drawings of different stages of a root system.

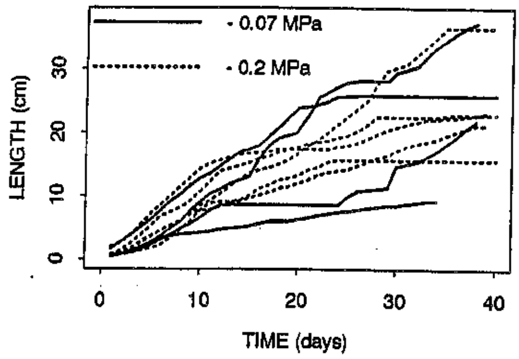
FIG. 1 : Morphology of a root system



Important variations were observed in the morphology of the root systems, either between the treatments or within each treatment. Nevertheless, the main morphological traits were similar to those reported by Riedacker *et al.* (1982) on the same species grown in peat. The hierarchy of the root systems (see Pagès *et al.*, same Symposium) was more or less important according to the growth pattern of the taproot. The branching density along the taproot also presented great variations.

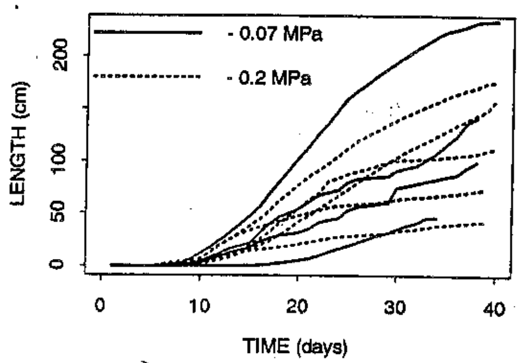
Growth of the taproots. An important variability appears in the growth of the taproots (figure 2). During a first phase (about 3 days) the growth rate generally increases. Then, the increasing and decreasing growth rate is related to local mechanical obstacles (agregates clumps). These curves show that the growth of the taproot can stop and start again after several days. The mean growth rate varies from 0.3 to 1 cm/day.
The growth curves from the two potential levels cannot be separated.

FIG. 2 : Growth of the taproots



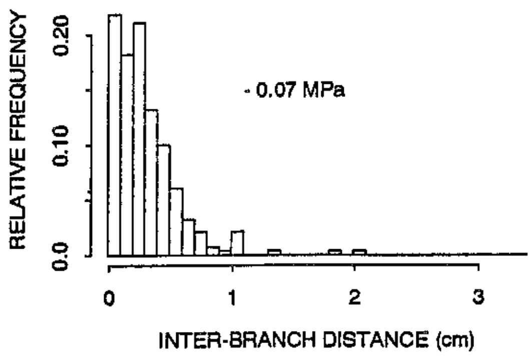
Cumulated growth of the lateral roots. The cumulated growth curves of the lateral roots are presented on figure 3. These curves show a sigmoidal growth pattern. The lateral root growth begins 5 to 9 days after the installation of the root system in the root box. The growth rate increases as the number of elongating lateral roots also increases, during about 5 days more. Then, the growth rate is quite constant, or slowly decreasing. This slow decrease may be related to the appearance of branches on the lateral roots. During the period of active growth, the cumulated growth rate of the lateral roots varies from 2 to 8 cm/day.
There are no visible differences between the two potential levels.

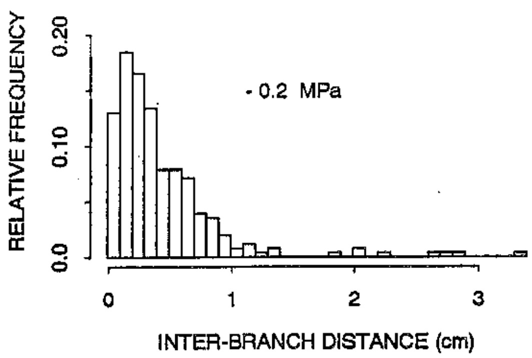
FIG. 3 : Total length of the lateral roots



Inter-branch distances. The histograms are presented on figure 4. They were obtained from all the root systems of each treatment. The low classes of inter-branch distances are more frequent in the wetter treatment (- 0.07 MPa), whereas the high classes are more frequent in the dryer treatment (- 0.2 MPa). This tendency has been confirmed by a Kolmogorov-Smirnov test and a Chi-square test. The distributions are significantly different (signification level 0.002 for the Kolmogorov-Smirnov test, and 0.09 for the chi-square test).

FIG. 4 : Distribution of inter-branch distances

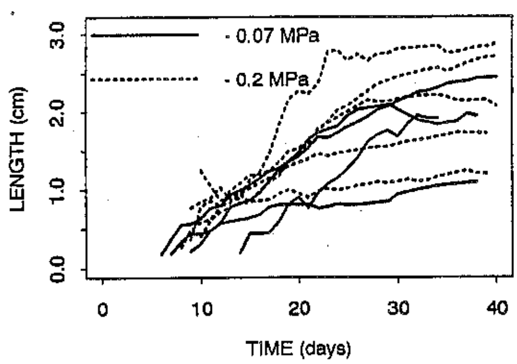




Mean lateral root increment. As we know at each date the total lateral root length, and the total number of lateral roots, we can compute at each date the mean lateral root length. These data are presented on figure 5. The mean lateral root length seems increasing rather sharply at the beginning, and reaching a maximum value. This result is the consequence of the continuous emergence of new lateral roots (which are short when young), and of the definite growth of most of the laterals.

Furthermore, the curves related to the dryer treatment (- 0.2 MPa) seem to be higher than the curves of the wetter treatment (- 0.07 MPa).

FIG. 5 : Mean length of the lateral roots



DISCUSSION, CONCLUSION

In these experiments, the growth of the root systems : taproots, lateral roots and branching densities along the taproots, exhibited an important variability. The variations can be partly related to mechanical impedance encountered by the roots at the interface between the plastic window and the agregates (see the growth curves of the taproots). They prevent to test powerfully the differences (if any) between the growth curves from the two potential levels.

Nevertheless, the branching densities (distribution of inter-branch distances) along the taproot are significantly different in the two treatments. The taproots from the wetter treatment seem to be more densely branched than those from the dryer treatment. It would be interesting to know if the density of primordia is already different, or not, according to the soil water potential level.

We also noticed a difference between the mean lateral root increment, which seems to be higher in the dryer treatment. This effect, which has to be confirmed, may be indirect. It can be interpreted as a consequence of the lower competition level that exists in the dryer treatment because of the lower density of sinks. This phenomenon emphasizes the importance of growth correlations in the response of a root system to the environment, even in an homogeneous medium (see Pagès *et al.*, same Symposium).

These preliminary results, which must be confirmed, have shown that the response of the root systems to these potential levels is weak and may be partly hidden by the variations related to other factors. In consequence, experiments in more drastic conditions (water potentials lower than - 0.2 MPa) would be made. Moreover, the preparation of soil medium would be modified to prevent local mechanical obstacles.

REFERENCES

COLIN-BELGRAND, M., JOANNES, H., DREYER, E., et PAGES, L. 1989. A new data processing system for root growth and ramification analysis : description of methods. *Ann. Sci. For.* 46 suppl., 305-309. Forest Tree Physiology, E. Dreyer *et al.* (Eds). Elsevier/INRA

RIEDACKER, A. 1974. Un nouvel outil pour l'étude des racines et de la rhizosphère : le minirhizotron. *Ann. Sci. for.* 31, 129-134

RIEDACKER, A., DEXHEIMER, J., TAVAKOL, R., et ALAOUI, H. 1982. Modifications expérimentales de la morphogénèse et des géotropismes dans le système racinaire de jeunes chênes. *Can. J. Bot.* 60, 765-778