Oilseed rape leaves falling off depends on both leaf nitrogen content and transmitted radiation

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Abstract

Compared to other crops, oilseed rape is known to absorb nitrate in large amount when available. However, absorbed nitrogen is not optimised by oilseed rape in terms of yield and seed quality ; the latter remains weak in relation to nitrogen potentially remobilised towards the seeds, especially because of abscission of leaves with variable nitrogen content. Acquisition of knowledge on the processes involved in leaf falling off would then contribute to reduce nitrate leaching and to improve yield and seed quality.

The general objective of our work was to evaluate the behaviour of different oilseed rape genotypes in response to nitrogen fertilisation, and to provide a grid for selection of genotypes with respect to a better remobilisation of absorbed nitrogen and a reduction of leaf abscission. In this aim, our experimental design consisted in analysing the different kinetics of green leaf area components of three genotypes, contrasted according to their size (dwarf and semi-dwarf) and architecture, grown in different conditions of nitrogen supply during two cycles.

Experimental results concerning leaves falling off in different conditions (genotype, nitrogen availability, position on main stem), indicate a great variability in nitrogen content. Moreover large differences of transmitted radiation at the bottom of the canopy were observed. The objective of this paper is, concerning rapeseed bottom leaves, i) to test if the different couples of values of both bottom leaf nitrogen content and transmitted Photosynthetic Active Radiation (PARt) observed just before leaf falling off, are consistent with the hypothesis of leaf falling off linked to a single low net photosynthesis level, ii) to analyse the genotypic variation on this process.

Key words : oilseed rape, genotype x nitrogen interactions, transmitted photosynthetically active radiation, Leaf Area Index, leaf falling off, leaf nitrogen content

Introduction

Compared to other crops, oilseed rape is known to absorb nitrate in large amount when available. However, absorbed nitrogen is not optimised by oilseed rape in terms of yield and seed quality ; the latter remains weak in relation to nitrogen potentially remobilised towards the seeds, especially because of abscission of leaves with variable nitrogen content. Acquisition of knowledge on the processes involved in leaf falling off would then contribute to reduce nitrate leaching and to improve yield and seed quality (Jullien *et al.,* 2007).

Material and Methods

Experimental design :

Field experiments were carried out in Thiverval-Grignon, France (48.9° N, 1.9° E) on a sandy-loamy soil, on a plot sown at a density of 60-70 plants/m^2 in September 2004. Three contrasted aerial structures have been obtained, resulting from i) the choice of 2 cultivars differing by their final size : Capitol (final height : 1,80 m) and Saturnin (semi-dwarf, final height : 1,30m) ii) Two levels of soil nitrogen availability (0 and 200 kg Nitrogen / ha). The 3 contrasted structures have been named : C0 for Capitol with 0 kg N /ha, C2 for Capitol with 200 kg N /ha and S2 for Saturnin with 200 kg N /ha.

During the whole oilseed rape life, we measured weekly leaf apparition and falling off, and leaves lengthes of 6 plants for each treatment ; just after falling off, nitrogen content of leaves was analysed.

Using leaf area meter LI3100, Li-Cor Inc, NE, USA and gravimetric technics, we determined for each treatment Leaf Area Index, Pod Area index and Flower Area Index, in order to calculate transmitted radiation at the bottom of the canopy (Chartier *et al.,* 1983, Justes *et al.,* 2000, Allirand *et al.,* 2007).

Results

The time course of Leaf Area Index during oilseed rape cycle highly depends on nitrogen availability and little on genotype (fig 1). During winter cold monthes, and during the reproductive period, Leaf Area Index decreases, indicating that it results from two morphogenetic processes, leaf generation and leaf falling off.

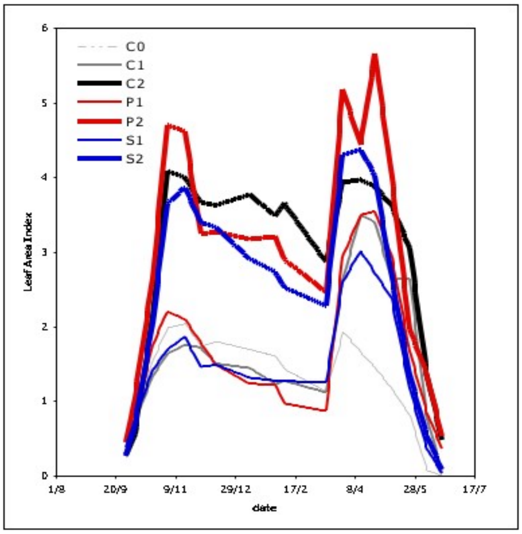

Figure 1 : Time course of Leaf Area Index of 7 plots, differing by genotype and N availability

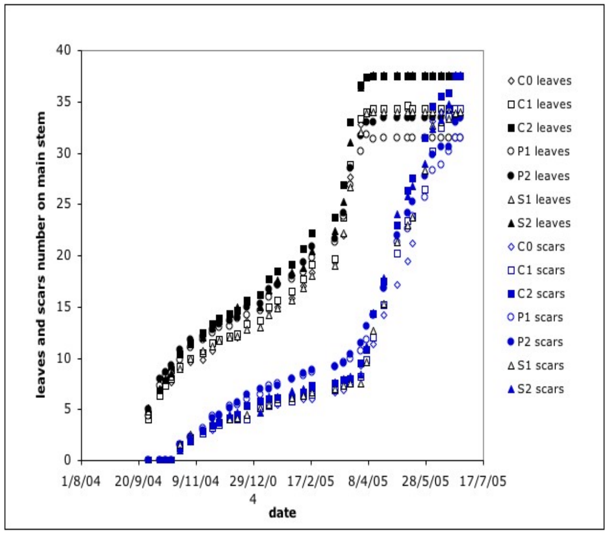

Figure 2 : Time course of leaf number and leaf scar number (indicating leaf falling off)

Leaf generation follows the same pattern for the 7 treatments, but under high nitrogen fertilization, leaf apparition is faster, and total leaf number on the main stem higher (fig 2). On the other hand, leaf falling off, quantified by leaf scar number, is also faster under high nitrogen fertilization.

The span of life of each main stem leaf can then be calculated (fig 3) : it appears that leaf life span is highly dependant on leaf rank on the main stem, within a range from 200 to 800 degree-days ; moreover, leaf life span also depends on genotype and nitrogen availability.

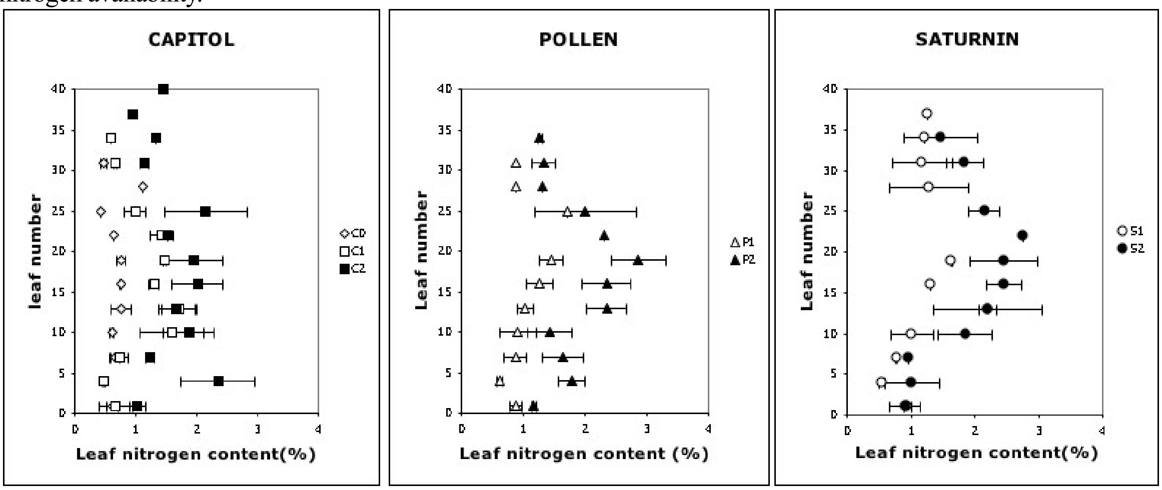

Figure 3 : leaf life-span profile (main stem) in degree days, for different genotypes and N availabilty

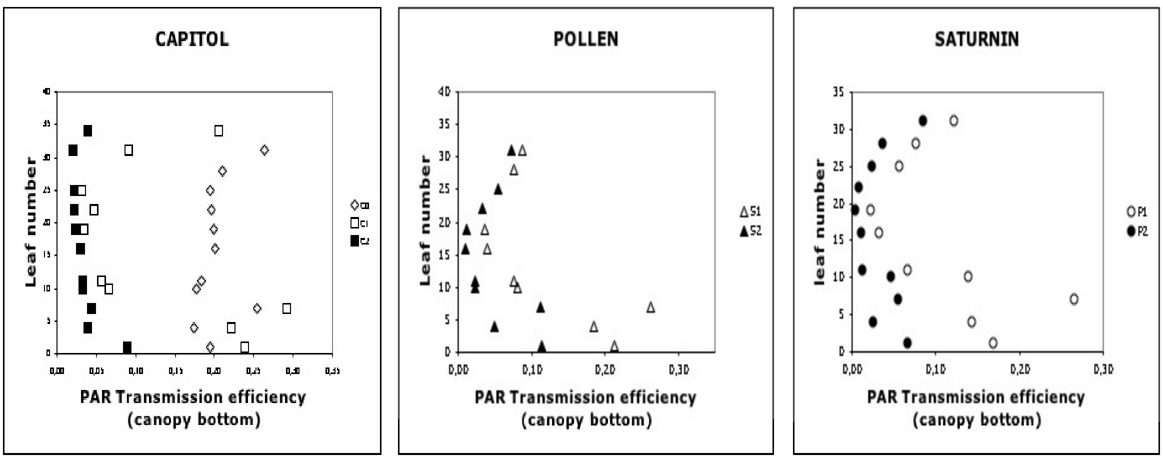

Figure 4 : Leaf nitrogen content (%) profile for different genotypes and N availabilty

The nitrogen status of leaves when they fall off is also dependant of their rank on main stem, but highly depends on N availability for different genotypes (fig 4) : high nitrogen availability induces higher nitrogen content at falling off. Conversely, the PAR available on bottom leaves is higher at low N availabilty, due to smaller aerial structures above (fig5).

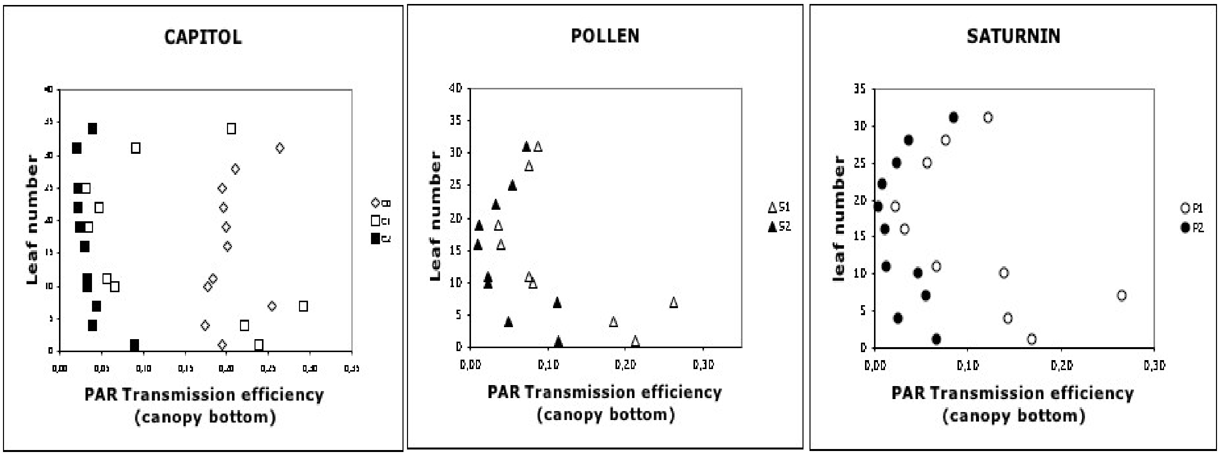

Figure 5 : Percentage of incident PAR radiation transmitted by the canopy to bottom leaves when they fall off, for differnt leaves on the main stem.

It is then possible to calculate the PAR received by leaves, multiplying PAR transmission efficiency by incident PAR radiation (meteorological data). A relationship (fig 6) between individual leaf nitrogen content at falling off, and (averaged on 5 days) daily PAR received at this stade indicates no visible effect of genotype and N availability.

Discussion

The hyperbolic pattern of the relationship obtained (fig 6), suggests that **transmitted PAR x Leaf Nitrogen content** is constant whatever the treatment. If we consider that bottom leaves photosynthesis can be written as :

Pn = (a PAR) x (b%N), in the range of low CO2 exchanges level, we can then hypothesize that bottom leaves falling off is linked to a single low photosynthesis level, may be similar to leaf respiratory losses.

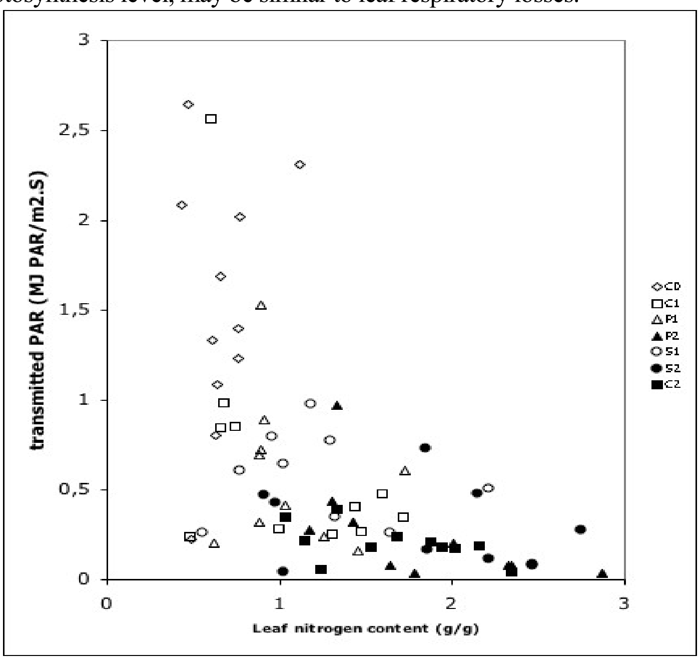

Figure 6 : relationship between individual leaf nitrogen content at falling off, and average on 5 days daily PAR received at this stade.

Conclusions

It would be of great interest to compare the results obtained, to simulations of a oilseed rape leaf photosynthesis model, taking into account both PAR and leaf N status (Mûller *et al.,* 2006), in order to test our hypothesis of falling off linked to low photosynthesis level similar to respiratory losses. Parameterizing such a model for different genotypes could be a way to optimize N management, if genetic variability is real on this point ; otherwise, N management improvement would have to be based on aerial structure optimization.

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