VERY EARLY SOWING OF WINTER OILSEED-RAPE IMPROVES ITS ENVIRONMENTAL BALANCE WITHOUT NEGATIVE CONSEQUENCES ON PRODUCTION

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Our research program aims at demonstrating that changing the sowing date could be a powerful means to improve the environmental balance sheet of a winter rape crop. The hypothesis is that earlier sowing dates could enable rape to absorb more nitrogen in autumn and decrease soil N mineral before leaching. We compared the effects of very early (end of July) and normal sowing dates (beginning of September) on N uptake and N leaching risk. This was assumed on experimental plots and under farm conditions.

Potential N uptake before winter was increased by 150 kg N ha-1 with earlier sowing compared to normal sowing, and it may reach up to 300-350 kg N ha-1 for a standard year. This absorption was strongly correlated with leaf area index. In farm field-trials network, there were no major limitations to sow under dry conditions and absorption was dependent on N availability. Consequently, very early sowing decreased systematically soil N mineral content before leaching to a level of less than 30 kg N ha -1 for 90 cm depth, whereas it was very variable with normal sowing dates : 20 to 280 kg N ha-1. Very early sowing may be of great interest to reduce N leaching, especially when N availability is high in autumn, like after sludge or slurry spreading.

KEY-WORDS : sowing dates, nitrogen, potential N uptake, senescence, leaf fall.

Introduction

Winter oilseed rape is currently sown in France from 20 August to 10 September depending on region and it is known that the earliest sowings are of most interest for high N absorption in autumn (Pouzet *et al* ., 1983). The preceding crop is almost always a cereal crop, harvested in July, 4 to 10 weeks before rape sowing. Very early sowing, one month before the current date, could be of interest to improve economical, energetic and environmental balancesheet of the crop. With a longer duration of growth from sowing to winter, a higher potential of growth and N uptake may be expected. Thus, very early sowing may be used with more efficiency than normal sowing as a N catch-crop before winter and this could reduce soil mineral N before winter drainage and so the risk of N leaching. Moreover, N accumulated in plants after winter has to be deduced from the N fertilizer rate in spring according to *Reau et al.* (1996). Therefore, very early sowing may be interesting to spare N fertilizer as they absorb more N in autumn.

We conducted a field experiment in controlled conditions to measure the potential N uptake in autumn of winter oilseed rape. We also conducted experiments under farmer field conditions in order to verify the interests of very early sowing for N uptake and reduction of N leaching risk in farmers fields, and to make a diagnosis of limiting factors of very early sowing technique in order to define situations and regions of most interest.

Materials ans methods

A **field experiment** was conducted in Grignon (France) with the cultivar Goëland (*Brassica napus*). We present results only from 1996/97, the second of a 2 year experiment. We compared 3 sowing dates, named Sowing 1 (S1: 15 July), Sowing 2 (S2: 03 August) and Sowing 3 (S3: 03 September), in a randomized block lay-out with 3 replicates. Sowing 1 and 2 are very early sowing dates wheras sowing 3 is a normal sowing date. The crop was given 300 kg N ha-1 at sowing. We verified N was not limiting for N uptake in autumn, according to the critical and maximum N content curves, determined for rape by Colnenne *et al.* (1998). The crop was fully protected against pests and diseases, and irrigated from sowing and early autumn to ensure rapid and homogeneous emergence and no water limitations. Each week, we gathered the dead leaves which have fallen on a plastic wire netting. We regularly measured the dry matter and N content of root, shoot and gathered dead leaves, and the green leaf area index (GLAI).

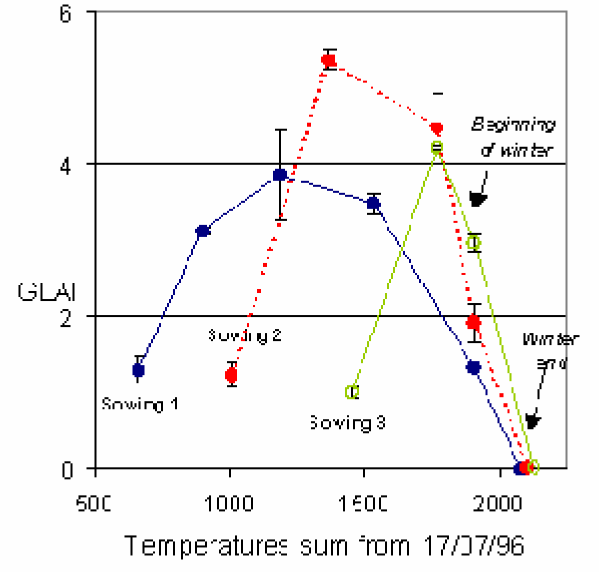
During 2 years we also conducted 28 experiments in a **farmer field network** with the same cultivar Goëland. We compared 2 different crop managements based on very early sowing and normal sowing dates respectively, in large plots (1000 m^2) without repetition. Normal sowing were conducted according to regional recommandations. The goal with the very early sowing treatment was to sow 1 month before the normal one. Spring N fertilization rates were adjusted for each treatment to N accumulated in plants after winter (Reau *et al*., 1996). Experiments were made in 4 french regions with contrasting climate and with different crop rotations, soil types and depth. In this paper, we present more results on experiments receiving slurry or sludge at the end of July, just before the very early sowing ; because they have high risk of N leaching in winter. We measured soil mineral N, accumulated plant N and plant density before winter, after winter, and just before harvest, and yield.

Results and discussion

Leaf production and losses and autumn N uptake in experimental plots

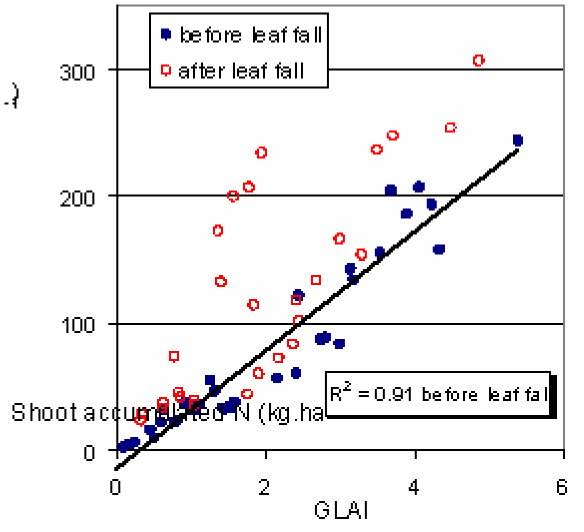
We measured very high values of GLAI during autumn, which reached 4 for sowing 1 and 3 and more than 5 for sowing 2 (**Figure 1**). For each sowing date, values above 3 were reached very quickly after sowing and they remained high for very early sowing during autumn. At the end of autumn and especially in winter, which was very cold (minimum temperature of -13.3°C), GLAI strongly decreased and was almost nil after winter for all of the 3 sowing dates.

Fig 1.. Evolution of GLAI in autumn, before the beginning of winter



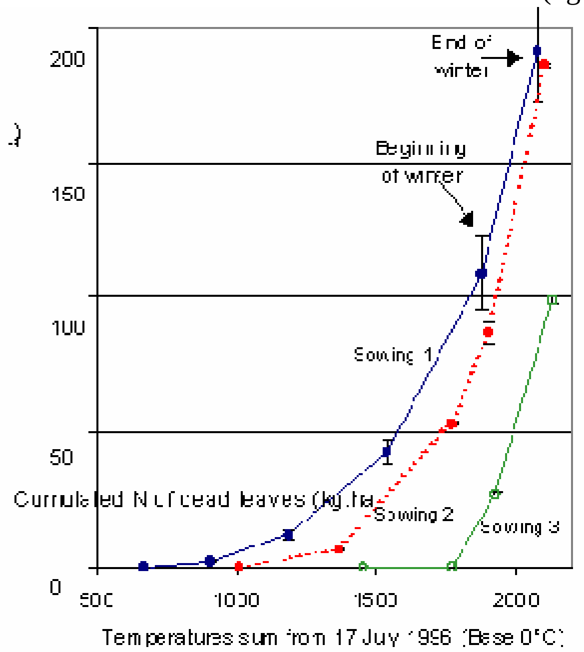
Accumulated shoot N reached very high levels before winter, more than 200 kg ha-1. It was strongly correlated with GLAI before leaves began to fall (**Figure 2**). This relation has often been observed for initial vegetative growth because leaves, and especially limb, is the major constituant of plants and there are few roots, stems and petioles. After leaves began to fall, there was no more relation between GLAI and accumulated shoot N because as plants became bigger, they accumulated more N in stems and petioles and their leaves became thicker, leading to lower values of GLAI with larger amounts of N in the rest of the plant.

Fig. 2. *Relation between shoot accumulated N and GLAI from sowing to the beginning of winter.*
All treatments and sampling dates are represented.



In this study, leaf fall appeared to be an important characteristic of rape functioning in autumn and winter, as shown by the GLAI decrease (**Figure 1**), therefore we studied precisely the quantity of N lost by dead leaves (**Figure 3**). The first losses were very early after sowing (800 °day). Before the beginning of winter, losses were important only for the 2 early sowings as they reached around 100 kg ha-1 against 25 kg ha-1 for sowing 3. During winter, losses were high for all sowing dates, ranging from 75 to 100 kg ha-1. In fact, leaves fallen in autumn were senescent and had low N content whereas leaves fallen in winter were frozen and still green, their N content was therefore higher since they could not remobilize N to the rest of the plant before falling.

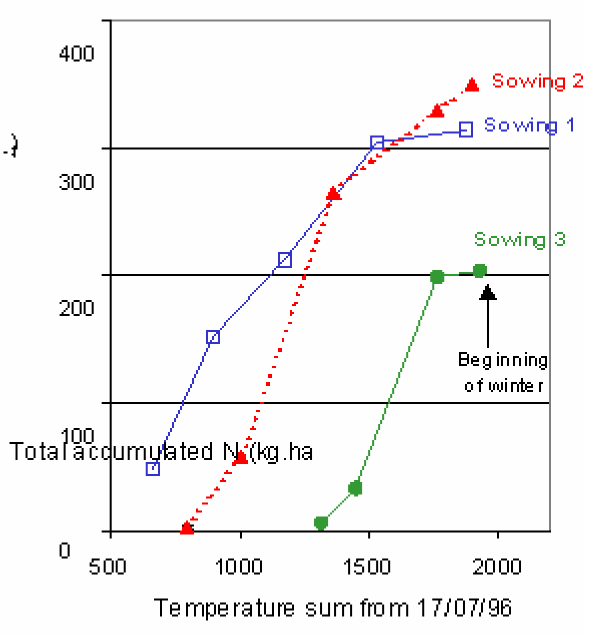
Figure 3. *Cumulated N of dead leaves, gathering as they were falling, from sowing to late winter* Cumulated N of dead leaves (kg/ha)



When estimating the total N uptake it is therefore needed to take into account not only root and shoot N but also the cumulated N of dead leaves (**Figure 4**). Sowings 1 and 2 reached as high values of 260 kg ha-1 when the sowing 3 was still emerging. As N uptake curves of sowing 2 and 3 were almost parallel, the delay of N uptake of sowing 3 was not make up. In the beginning of winter , sowing 3 could absorb 200 kg ha-1, which 120 to 150 kg less than the very early sowing. In conclusion, we have demonstrated the ability to absorb very high quantity of N in autumn, and the interest of earlier sowings to strongly increase this ability. This rapeseed characteristic may be explained by its ability to produce large amount of leaves in early autumn (Vos et van der Putten, 1997). We have also analyzed if the interest of very early sowing could be of value under farmer field conditions in various climates in the second experimental lay-out.

Figure 4. *Total cumulated N: shoot, root and cumulated N of dead leaves, from sowing to the beginning of winter*

Total cumulated N (kg/ha)



Farmer field-trials: diagnosis for implantation and pests in autumn

Planned sowing dates were generally respected, in very early sowing particularly. But in Poitou, most of the normal sowing dates were delayed for sowing. The lack of rain in the late summer in both experimental years, followed by abundant rainfalls in September 1995 caused these delays of the sowing dates and in 5 experiments, '*normal sowing*' were made in the end of September. The very early sowings were always made under dry conditions and germination never started before a rain. In some of the experiments, seeds remained a long time in dry soil, but without reduction in emergence rates. The duration from sowing to emergence and the emergence rates were very variable within experiments, equally variable in both very early sowing and in normal sowing. In very early sowing, plants rapidly reached a stage of 2/3 leaves after emergence and they were able to survive even 3 or 4 weeks of high temperatures and without rains after emergence, probably thanks to a rapid deep rooting. Thus, plant density was never limiting for growth in autumn.

In the first year, there was a high slug pressure. Climatic conditions were very favorable to the slug activity during all September ; therefore normal sowings was very sensitive to slugs because rape was only emerging and plants had less than 2 leaves, whereas rape was not sensitive anymore in very early sowings, because plants had more than 4 to 6 leaves. Consequently, normal sowing dates received more treatments against slugs, for preventive and curative applications (**Table 1**). Despite these applications, 2 fields were strongly damaged by slugs in normal sowings and it was therefore necessary to sow them again.

***Table 1**. Number of fields which received treatments against slugs in the first experimental year*
(The total field number N = 11)

	Normal Sowing	**Very early sowing**
Preventive	3	0
Curative	7	2
Re-sowing of the field	2	0

On the other hand, it was necessary to apply 20% more insecticides in very early sowing, but there were no insect damages. Last, more weeds emerged in very early sowings, especially summer weeds and cereal volunteers, but it led to increased *post-emergence* herbicide applications in only 5% of the experiments. Moreover, in high available N situations we observed that rape was rapidly covering the soil and was able to limit weeds emergence and to increase weed mortality.

Farmer field-trials: autumn N uptake, soil mineral N and fertilization rate

In the 4 experiments receiving slurry or sludge in summer (**Table 2**), very early sowing (S1) have accumulated large amounts of N and have systematically reduce soil mineral N below 35 kg ha-1. The highest value of N accumulation is consistent with the one measured in experimental plots. On the contrary, N accumulation was much more variable for normal sowing (S2). In West part of France (region Poitou), late sowing or emergence were associated to especially low N accumulation, lower than 30 kg ha-1, leading to large amount of soil mineral N, ranging from 130 to 250 kg ha-1. As demonstrated in experimental plots, measurements of accumulated N in the beginning of winter underestimates N absorbed because of leaf fall, especially in very early sowing.

That may explain why the normal sowing had a higher accumulated N in the South. The lower amount of soil mineral N in very early sowing may prove that it has absorbed the same amount of N or even more than the normal sowing. Simulated N leaching was almost nil for very early sowing whereas it ranged from 20 to 130 kg ha-1 for normal sowing.

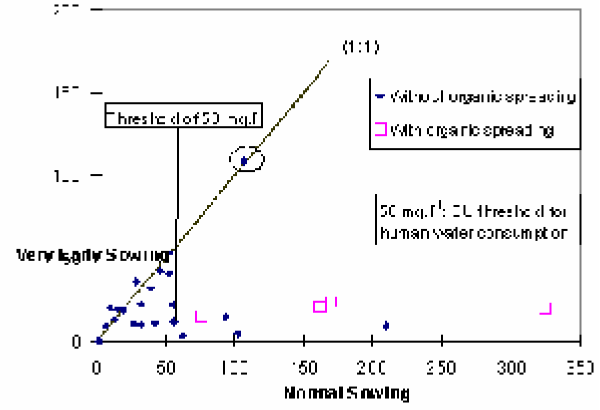
As N accumulated in plants after winter has to be deduced from the N fertilizer rate in spring according to *Reau et al.* (1996), it was possible to spare N fertilizer in 2 very early sowings. However, there were no differences of accumulated N after winter and consequently no fertilization reduction in the others experiments because of winter leaf fall. As fertilization was adjusted, we measured no increase in soil mineral N at harvest nor in residues N content (data not shown). Last, yields were the same or higher with very early sowing.

***Table 2**. Some results for experiments with summer slurry or sludge spreading (S1 = normal sowing; S2 = very early sowing)*

	Winter beginning				*Spring*			
	Shoot and root accumulated N (kg ha-1)		Soil mineral N on 90 cm depth (kg ha-1)		Spring N Fertilization (kg ha-1)		Yield (q ha-1)	
Sowing date	S2	S1	S2	S1	S2	S1	S2	S1
Expt. 1 (West)	30	275	218	18	100	0	21.0	33.0
Expt. 2 (West)	22	117	249	34	170	140	39.7	43.6
Expt. 3 (West)	2	63	130	25	131	131	29.5	36.5
Expt. 4 (South)	259	163	48	22	32	32	24.2	26.3

For the others experiments without organic matter spreading in summer (20 experiments), soil mineral N before winter was always below 30 kg ha-1 in very early sowing, identical or slightly less than normal sowing, except for 5 normal sowings, with values ranging from 40 to 80 kg ha-1. Therefore simulated N leaching was generally low and always lower for very early sowing. As there was no differences in water drainage, its simulated Nitrate content was always lower for very early sowing and below the threshold of human consumption (**Figure 5**). The only exception concerns an experiment where the very early sowing emerged only in September because rainfalls lacked in summer. There were few differences in spring N fertilization rates and yields.

Figure 5. *Simulated Nitrate content of water drained during winter (in mg l-1) Comparison of normal sowing and very early sowing*



Conclusion

Under experimental conditions as in farm fields, very early sowings are very interesting to improve the N absorption capacity of rapeseed. With earlier sowings, it seems possible to strongly reduce risks of winter N leaching and nitrate content of percolated water, which may be particularly interesting for situations with high N availability in summer and autumn, as after summer slurry applications. The South experiment shows that it is possible to get very efficient N catch-crop with normal sowing. But it was sown relatively early and got favorable conditions for emergence and autumn growth, i.e. rain and warmth. Therefore, these results demonstrate that the environmental interest for N is less hazardous with very early sowing. Moreover, our results showed interests for reduction of pesticide use. This has been particularly observed for slug control and it is of major importance as these pesticides are environmentally harmful.

Concerning production aspects, we checked that there was no major limiting factor of implantation, pests or yield elaboration with very early sowing, but some risks have to be more extensively investigated, as risks of frost. Advancing the sowing date had particularly no negative effect on spring growth and yield when weeding was not changed. In some experiments, it has even improved yields, especially when autumn N was highly available or when normal sowing led to late implantation, as mentioned by Mendham *et al.* (1981).

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