Is there a need for N fertilizer in autumn in winter oilseed rape (WOSR) ?

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Introduction

- **N fertilizer in WOSR is crucial**
  - Effects on production and economy
    - Seed yield and quality
    - Energy balance = Energy in the seeds – Energy cost of inputs
    - Gross margin (€) = Price of seeds (€) – Cost of inputs (€)
  - Effects on environment
    - Nitrate leakage
    - Greenhouse gases (N_2O and CO_2 from fossil energy)
    - Other gases (NH_3 and NO_x)

Introduction

- **WOSR can uptake great amounts of N in autumn and winter :**
  - Earlier sowing dates result in increased N uptake (Dejoux, 1999)
  - N uptake until the end of winter may be greater than 200 kg N ha^{-1} (Van Paemel and Reau, 1998)
- **N fertilizer may be applied in autumn only if a N deficiency at this period would result in a decrease in the seed yield potential**
  - The efficiency of N fertilizer is lower in autumn than in spring (Van Paemel and Reau, 1998)
  - Nitrate leakage may increase due to the application of N fertilizer, despite the great hability of WOSR to uptake N

Introduction

- **Is there a need for N fertilizer in autumn in WOSR in order to preserve the seed yield potential ?**
  - N deficiency in autumn : is it observed very often ?
  - The relationship between seed yield and N deficiency in autumn :
    - If there is a N deficiency in autumn, does N fertilizer increase seed yield ?
    - Is there a relationship btw N uptake or NNI in autumn and the yield increase due to N fertilizer in autumn?
- **The objective was to answer these questions**

Material and methods

Experiments were conducted in order to study the effect of N fertilizer in autumn when N nutrition in spring was not limitant

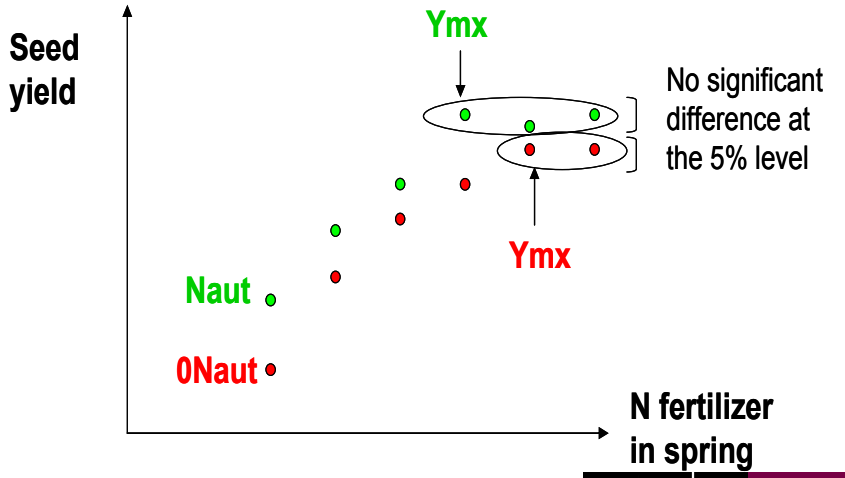
Exp. n°1 (Colnenne et al., 2002) : accurate measurements of the evolution of N status, to make sure that there was no N deficiency in spring

- **Number of experiments : 1 in France in 1993/94 (exp. n°1.1) and 2 in France in 1994/95 (exp. n°1.2 and 1.3)**
- **N fertilizer :**
  - In autumn : 0, 20, 40, 60, 80 or 100 kg N ha^{-1}
  - In spring : in order to avoid N deficiency
- **N status of plants was observed during the whole growth period**
  - Plant biomass and N% during autumn, winter and spring
  - Calculation of the NNI according to Colnenne et al. (1998) : NNI < 1 indicates than growth is N limited
- **Measurement of seed yield**

Material and methods

Exp. n°2 (Unpub. data and Henke et al., 2008) : the lack of N deficiency in spring was estimated from the response of seed yield to N in spring

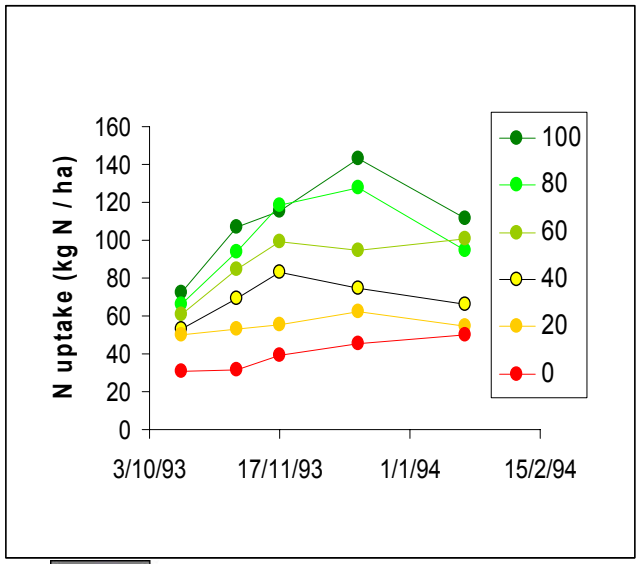
- **Number of experiments :**
  - In France : 11 in 1994/95 (n°2.1), 4 exp. in 1995/96 (n°2.2) and 7 exp. in 1996/97 (n°2.3)
  - In Germany : 11 exp. in 2005/06 (n°2.4), 10 exp. in 2006/07 (n°2.5) and 14 exp. in 2007/08 (n°2.6)
- **Effect of a range of N in spring, with or without N fertilizer in autumn**
- **N status of plants was observed at least once, at the end of winter**
- **N treatments in spring resulting in higher seed yields were supposed to be without N deficiency**
  - Max. yield was calculated : mean of higher yields (5 %)
  - Two experiments were not used, because higher yields could not be determined (no plateau)



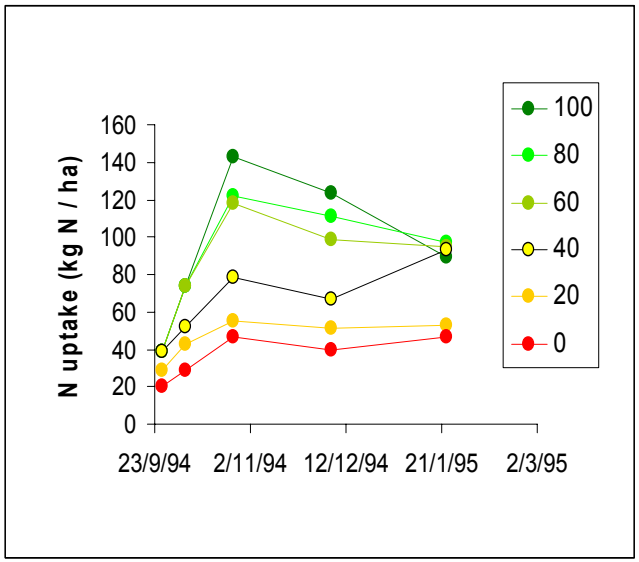
Experiments n°1 – Results

- **A wide range of N uptake in autumn and winter was obtained**

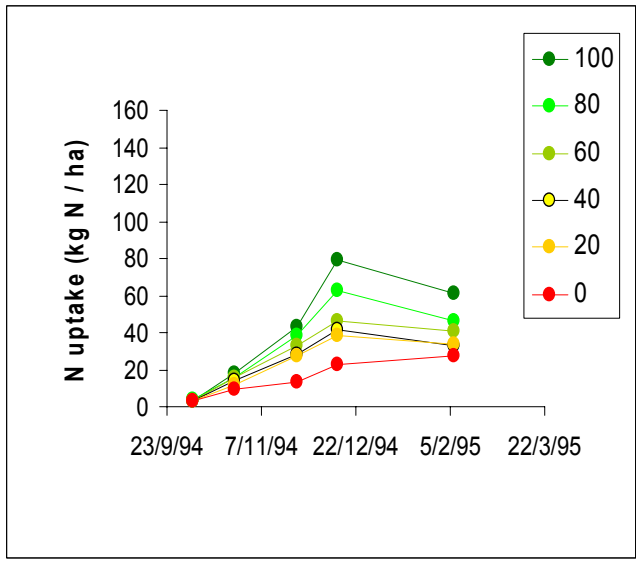
Experiment n°1.1



Experiment n°1.2



Experiment n°1.3



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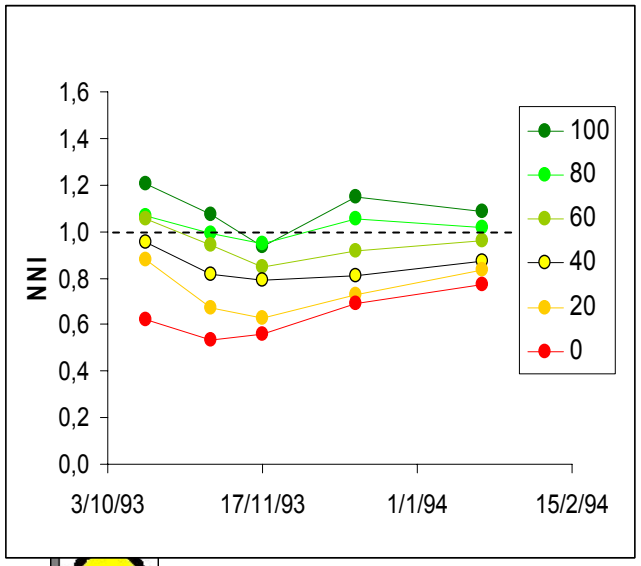
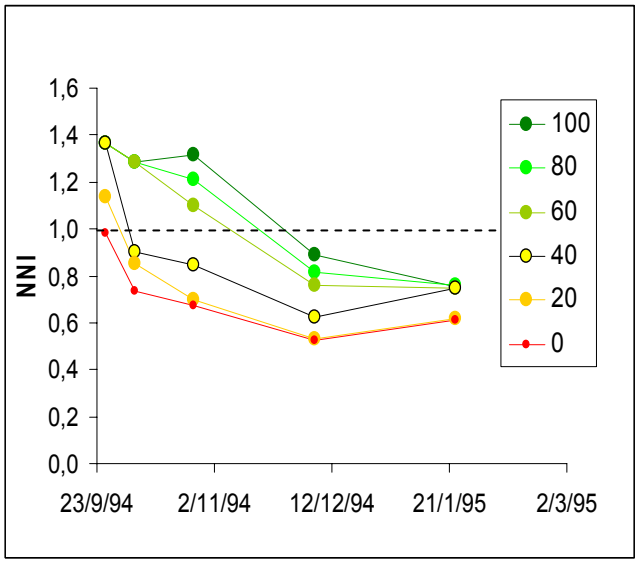
Experiments n°1 – Results

- **In spring, NNI ≥ 1 in all treatments (data not shown)**
- **In autumn and winter :**
  - A wide range of NNI was obtained
  - When no N fertilizer was applied in autumn, NNI ≤ 1
  - NNI ≥ 1 during autumn and winter in only 2 treatments (100N and 80N) in one experiment (n°1.1)

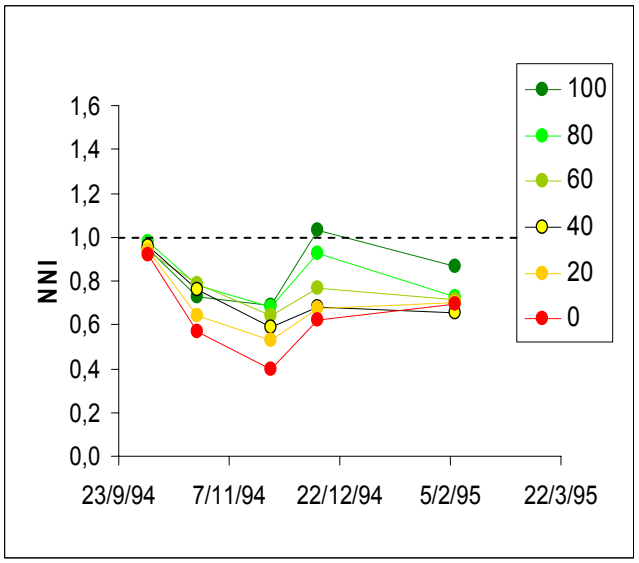
Experiment n°1.1



Experiment n°1.2



Experiment n°1.3



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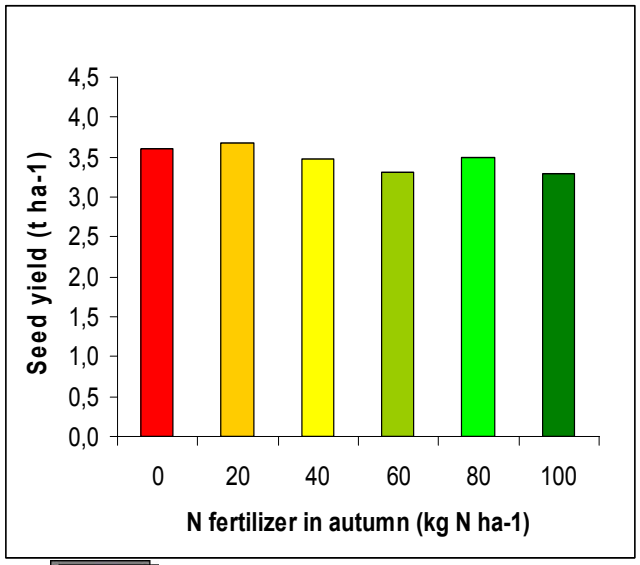
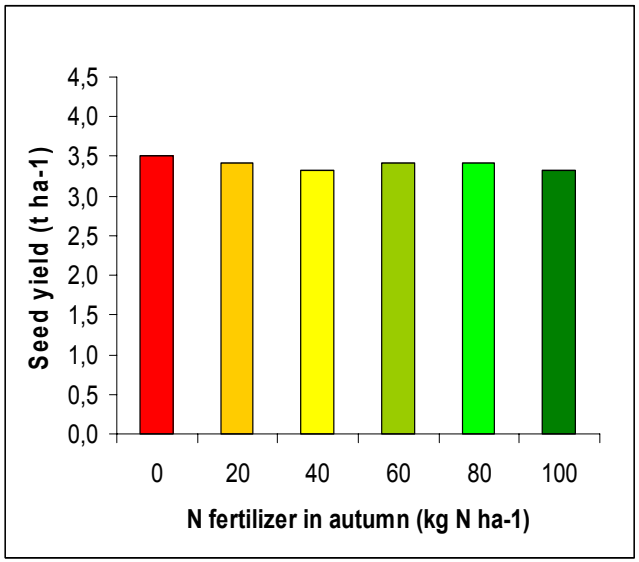
Experiments n°1 – Results

- **The N status of plants in autumn had no significant effect (5%) on seed yield**

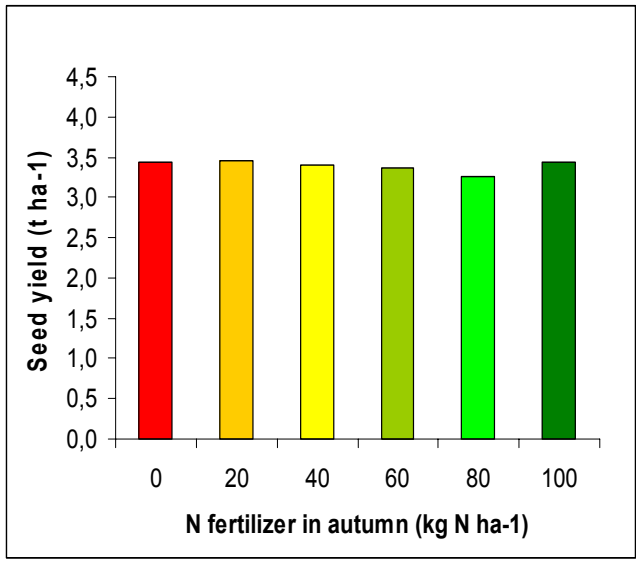
Experiment n°1.1



Experiment n°1.2



Experiment n°1.3



Experiments n°1 – Discussion

- **Answer to the questions, in the conditions of the three experiments**
  - **N deficiency in autumn : is it observed very often ?**

    In the 3 exp., without N fertilizer NNI ≤ 1 during autumn and winter
  - **The relationship between seed yield and N deficiency in autumn :**
    - **If there is a N deficiency in autumn, does N ferti. increase seed yield ?**

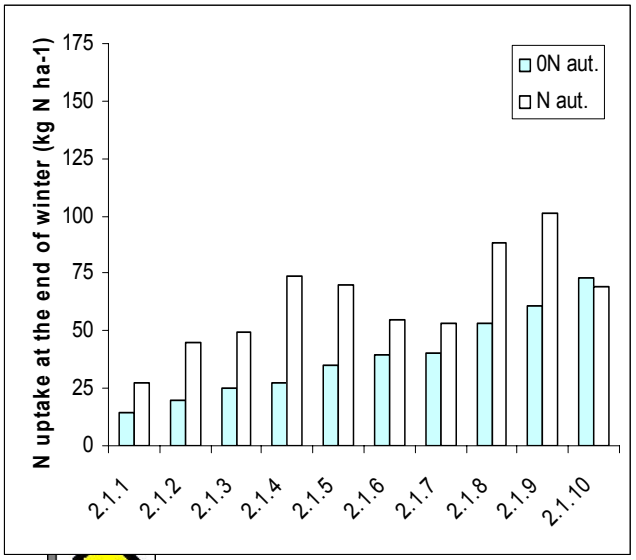
      No yield increase, despite the N deficiency during autumn and winter
    - **Is there a relationship btw N uptake or NNI in autumn and the yield increase due to N fertilizer in autumn ?**

      No relationship, because no effect was observed
- **More results are needed to generalize the conclusions**

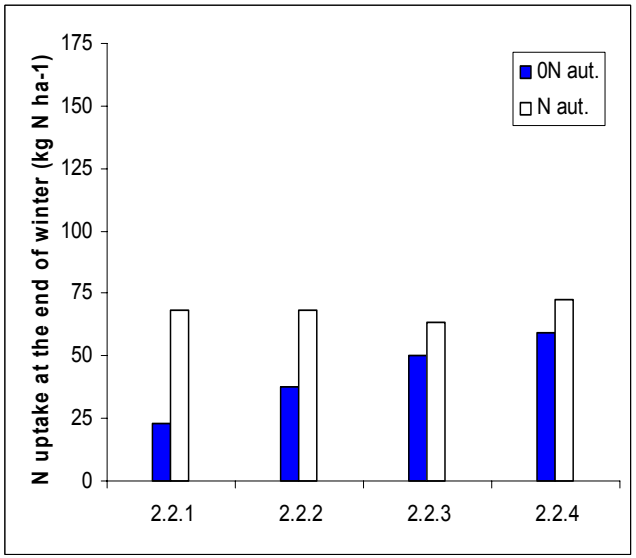
Experiments n°2 – Results

- **N uptake at the end of winter in the experiments in France :**
  - A wide range of values when no N was applied in autumn : 14 – 82 kg N ha^{-1} *
    ** 27 – 50 kg N ha^{-1} in experiments 1.1 to 1.3*
  - N fertilizer in autumn resulted in 0 – 47 kg N ha^{-1} * increase in N uptake
    ** 34 – 62 kg N ha^{-1} in experiments 1.1 to 1.3*

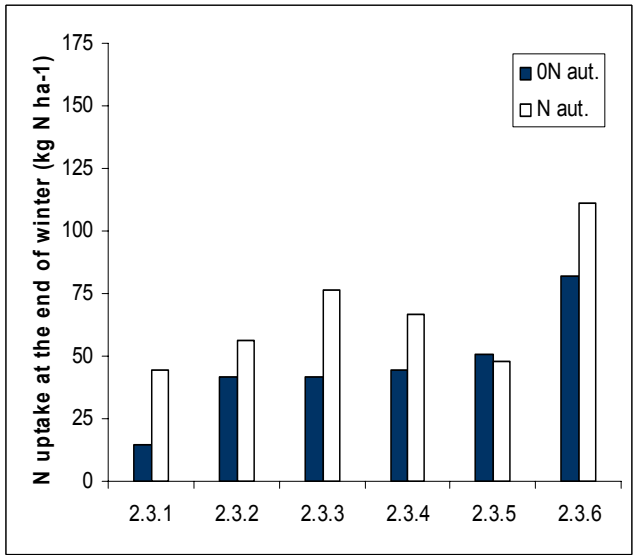
Experiments n°2.1 (94/95)



Experiments n°2.2 (95/96)



Experiments n°2.3 (96/97)



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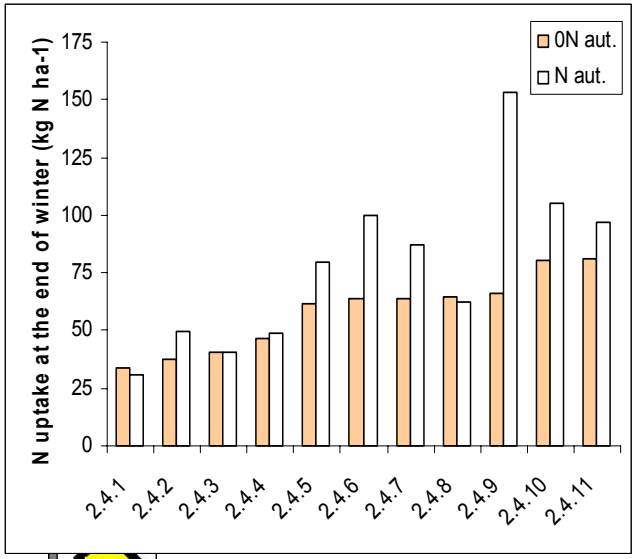
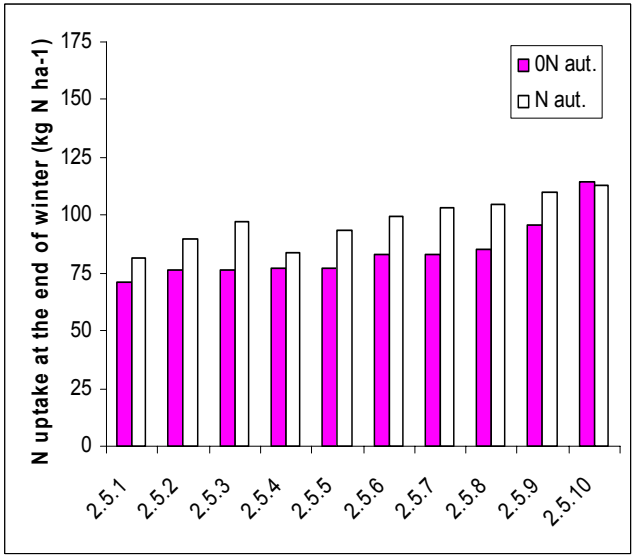
Experiments n°2 – Results

- **N uptake at the end of winter in the exp. in Germany :**
  - A wide range of values when no N was applied in autumn : 5 – 115 kg N ha^{-1} *
    ** 27 – 50 kg N ha^{-1} in experiments 1.1 to 1.3*
  - N fertilizer in autumn resulted in 0 – 88 kg N ha^{-1} * increase in N uptake
    ** 34 – 62 kg N ha^{-1} in experiments 1.1 to 1.3*

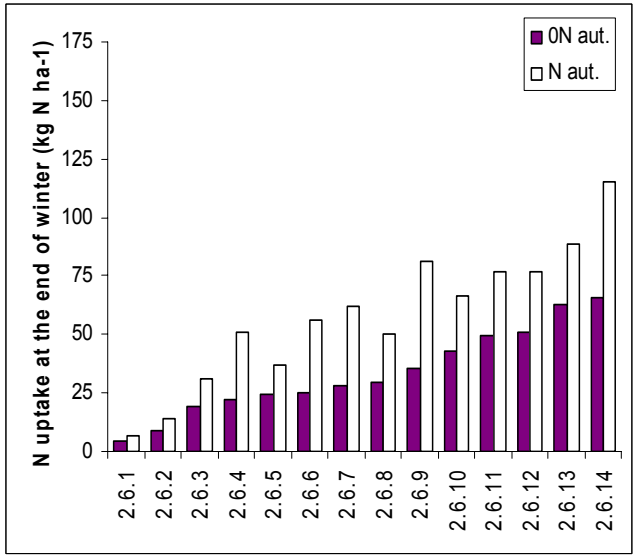
Experiments n°2.4 (05/06)



Experiments n°2.5 (06/07)



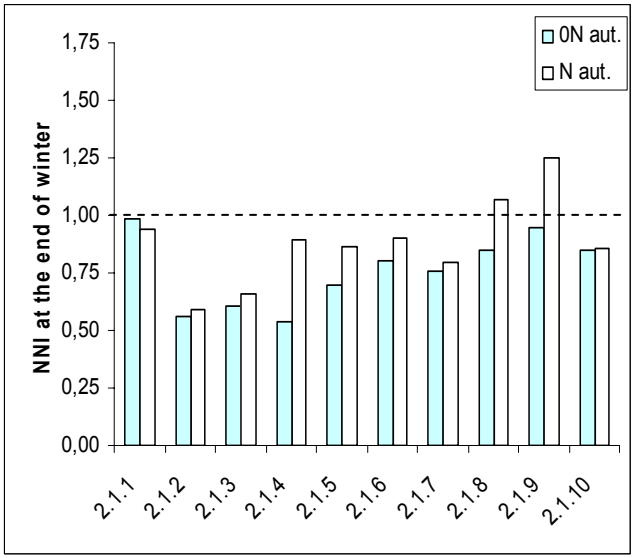
Experiments n°2.6 (07/08)



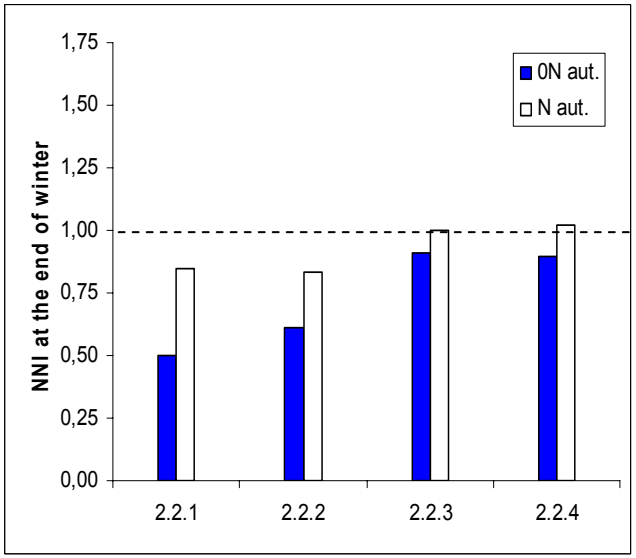
Experiments n°2 – Results

- **Nitrogen Nutrition Index (NNI) at the end of winter in the experiments in France :**
  - A wide range of values when no N was applied in autumn : 0,35 – 0,99 *
    ** 0,61 – 0,77 in experiments 1.1 to 1.3*

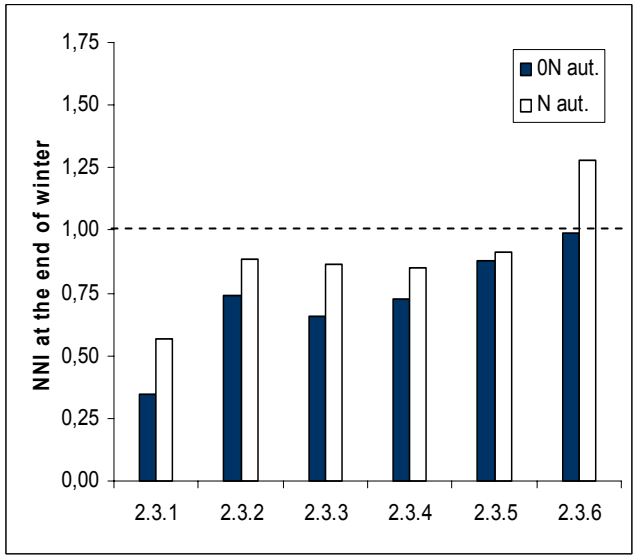
Experiments n°2.1 (94/95)



Experiments n°2.2 (95/96)



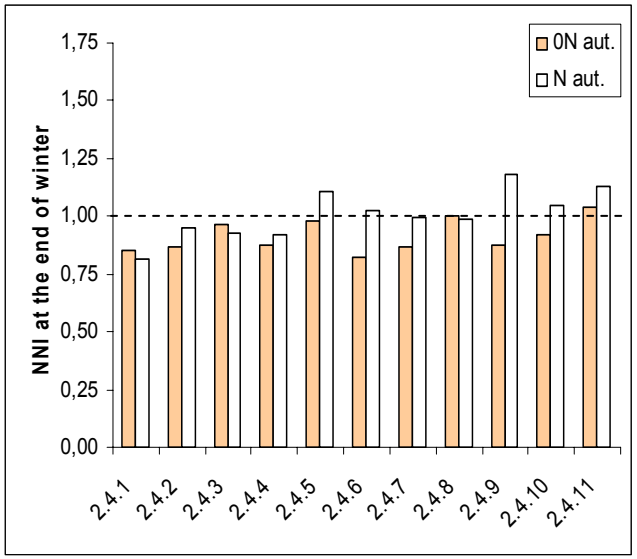
Experiments n°2.3 (96/97)



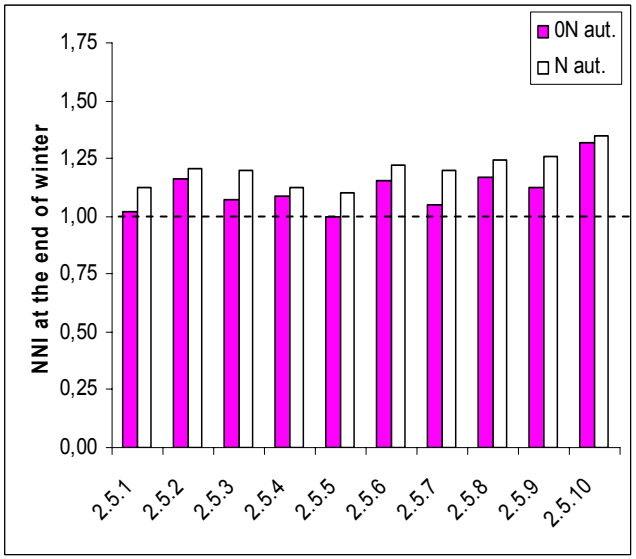
Experiments n°2 – Results

- **Nitrogen Nutrition Index (NNI) at the end of winter in the experiments in Germany :**
  - A wide range of values when no N was applied in autumn : 0,82 – 1,32 *
    ** 0,61 – 0,77 in experiments 1.1 to 1.3*

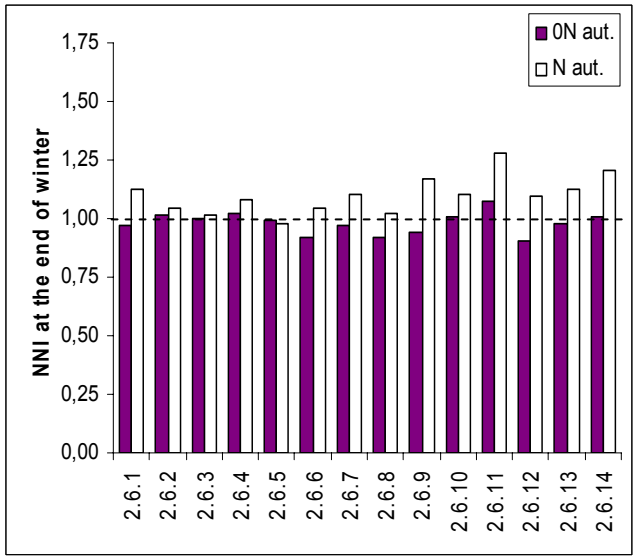
Experiments n°2.4 (05/06)



Experiments n°2.5 (06/07)



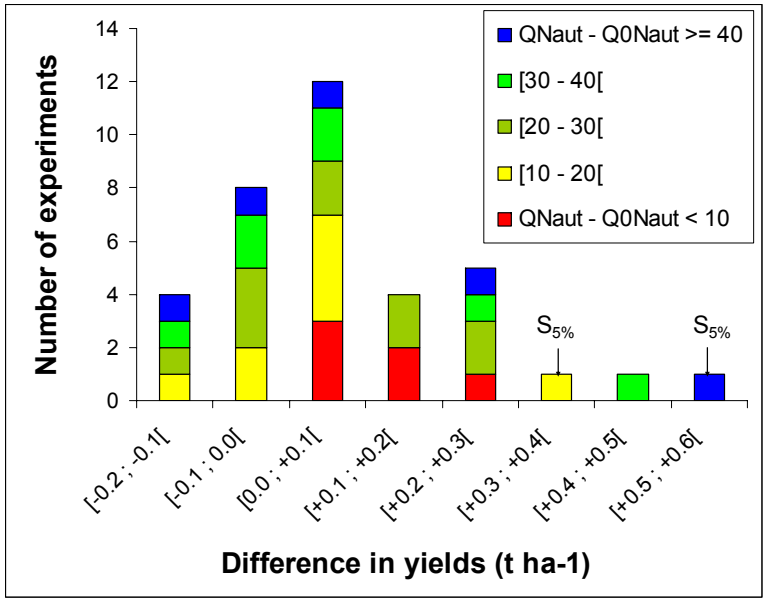
Experiments n°2.6 (07/08)



Experiments n°2 – Results

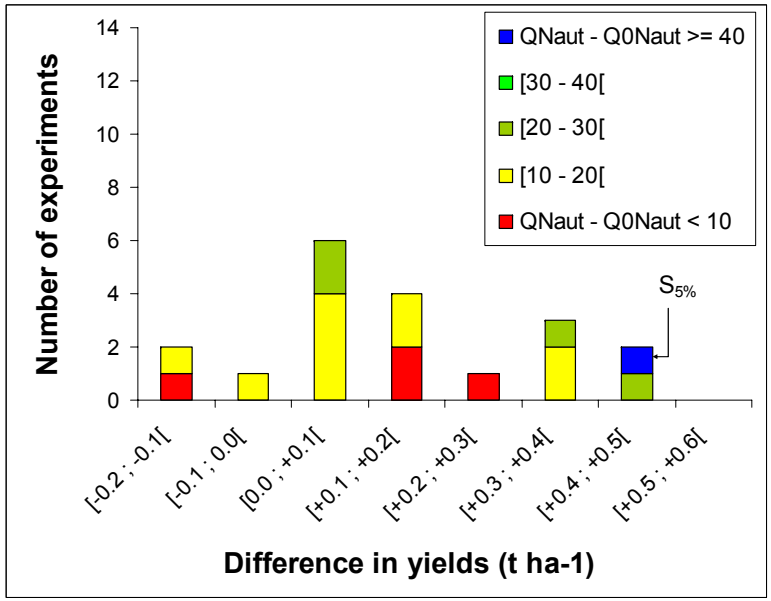
- **Little increase in maximum yield due to N fertilizer in autumn :**
  - The yield increase was statistically significant in only 3 exp.
  - The average difference in yield ranged from 0.08 to 0.15 t ha^{-1}
- **This small effect could not be only explained by the lack of increase in N uptake (< 10 kgha^{-1}) nor by the high NNI in some experiments**

Difference in yields when NNI_0Naut < 1



Average difference = 0.08 t ha^{-1*}

Difference in yields when NNI_0Naut ≥ 1



Average difference = 0.15 t ha^{-1*}

* With QNaut – Q0aut ≥ 10

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Experiments n°2 – Results

- **The effect of N fertilizer in autumn tended to be greater when N uptake at the end of winter < 50 kg N ha^{-1}**
- **No consistent tendency with NNI (data not shown)**

Difference in yield between Naut and 0Naut

Experiments with increased Nutptake due to N fertilizer in autumn ≥ 10 kg N ha^{-1}

		N uptake at the end of winter in 0Naut (kg N ha^{-1})			
		[0 – 25[	[25 – 50[	[50 – 75[	[75 – 100[
Number of experiments		7	16	12	10
Increase in N uptake due Naut (kg N ha^{-1})	**Mean**	**23.9**	**26.8**	**31.6**	**19.0**
	Std	12.5	10.8	21.3	5.1
Increase in yield due Naut (t ha^{-1})	**Mean**	**0.18**	**0.15**	**0.03**	**0.05**
	Std	0.11	0.22	0.18	0.15

Experiments n°2 – Discussion

- **Answer to the questions, in the conditions of the experiments**
  - **N deficiency in autumn : is it observed very often ?**

    In France, at the end of winter NNI < 1 in 20 exp. / 20 exp.

    In Germany, NNI < 1 in 16 exp. / 35 exp., but N deficiency may have occured before the end of winter

  - **The relationship between seed yield and N deficiency in autumn :**
    - **If there is a N deficiency in autumn, does N fertilizer increase seed yield ?**

      On average the increase in yield was only 0.08 t ha^{-1}, when NNI_0Naut < 1 and increases in N utpake ≥ 10 kg N ha^{-1}
    - **Is there a relationship btw N uptake or NNI in autumn and the yield increase due to N fertilizer in autumn ?**

      The yield increase tended to be greater when N uptake at the end of winter < 50

Conclusion

- The effect of N fertilizer in autumn on seed yield :
  - On average the effect was low, because of either little increase in N uptake in autumn and winter, or little effect of the increased N uptake
  - It was greater when N uptake at the end of winter < 50 kg N ha^{-1}, but with a great variability
- Moreover, the efficiency of N fertilizer in autumn is lower than in spring (Van Paemel and Reau, 1998), and there is a risk of increased nitrate leakage
- Hence, N fertilizer in autumn should not be recommended
- Further studies are needed to better understand why there is sometimes an effect on yield of N fertilizer in autumn

- **References** :

  - Colnenne C., Meynard J.M., Roche R., and Reau R. 2002. Effects of nitrogen deficiencies on autumnal growth of oilseed rape. European Journal of Agronomy, 17 : 11-28.
  - Dejoux J.F., Meynard J.M., Reau R., Roche R., and Saulas P. 2003. Evaluation of environmentally-friendly crop management systems based on very early sowing dates for winter oilseed rape in France. Agronomie, 23 : 725-736.
  - Henke J., Sieling K., Sauermann W., and Kage H. 2009. Analysing soil and canopy factors affecting optimum nitrogen fertilization rates of oilseed rape (Brassica napus). Journal of Agricultural Science, 147 : 1-8.
  - Van Paemel H., and Reau R. 1998. Fertilisation azotée du colza : Prendre en compte l'absorption automnale. Perspectives agricoles, 233 : 75-79.