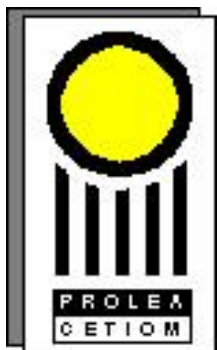


The critical nitrogen curve for winter oilseed rape



A tool in order to estimate the nitrogen
status of the crop

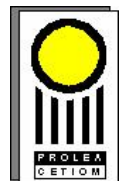
Luc Champolivier (CETIOM), Caroline Colnenne (INRA)



Workshop « N fertilization of WOSR – Berlin – 23-24 march 2009

Introduction

- Tools to determine the nitrogen status of the crops are needed for several uses:
 - Diagnosis of the crop status:
 - During the growing period : ajustement of the nitrogen fertilization...
 - After the harvest : explanation of the result of the crop (yield, oil content...)
 - Use in dynamic models to take into account the effect of nitrogen on growth and yield
- Concept of critical N concentration in aerial biomass developed in many crops in France (Lemaire and Salette, 1984)
- The objective of the study was to determine the critical N curve for winter oilseed rape

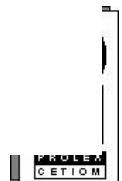


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods

- Ranges of N fertilizer rates were studied in field experiments and in experiments with controlled environment
 - Some of them supposed to be insufficient for growth
 - The others supposed to be non-limiting for growth
 - Several sampling periods with determination of shoot dry matter and total N content
- Experiments with controlled environnement
 - From sowing to 6-leaves stage
 - Plants grown with very low N contents to obtain early deficiencies
 - Experiment carried out twice
 - 3 or 4 N treatments
 - 2 sampling stages : 13 and 16 (stages according to Lancashire et al., 1991)



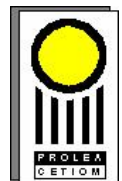
The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods

- Field experiments

- 2 growing seasons: 1994 and 1995
- 3 autumn and 6 spring experiments distributed in the french production area
- Autumn N deficiencies:
 - Early sowing, following an underfertilized crop on shallow soils
 - 6 N fertilizer levels applied at emergence (0 to 100 kgN ha⁻¹ ; step : 20 kgN ha⁻¹)
 - 3 or 4 sampling stages during autumn (st. 16 to 19)
- Spring N deficiencies
 - Various plant dry matters after winter among trials
 - Various fertilizer rates applied at recovery growth (according to the exp. : min. : 0 kgN ha⁻¹ ; max : 175 to 272 kgN ha⁻¹ ; step : 30 to 40 kgN ha⁻¹)
 - 3 or 4 sampling stages during spring (st. 18 to st. 61-63)

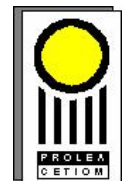


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods

- Data processing
 - Analysis of variance on shoot biomass and N content at each measurement date and for each experiment + test of Newman and Keuls ($P < 0.05$)

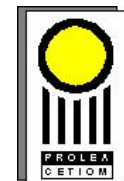
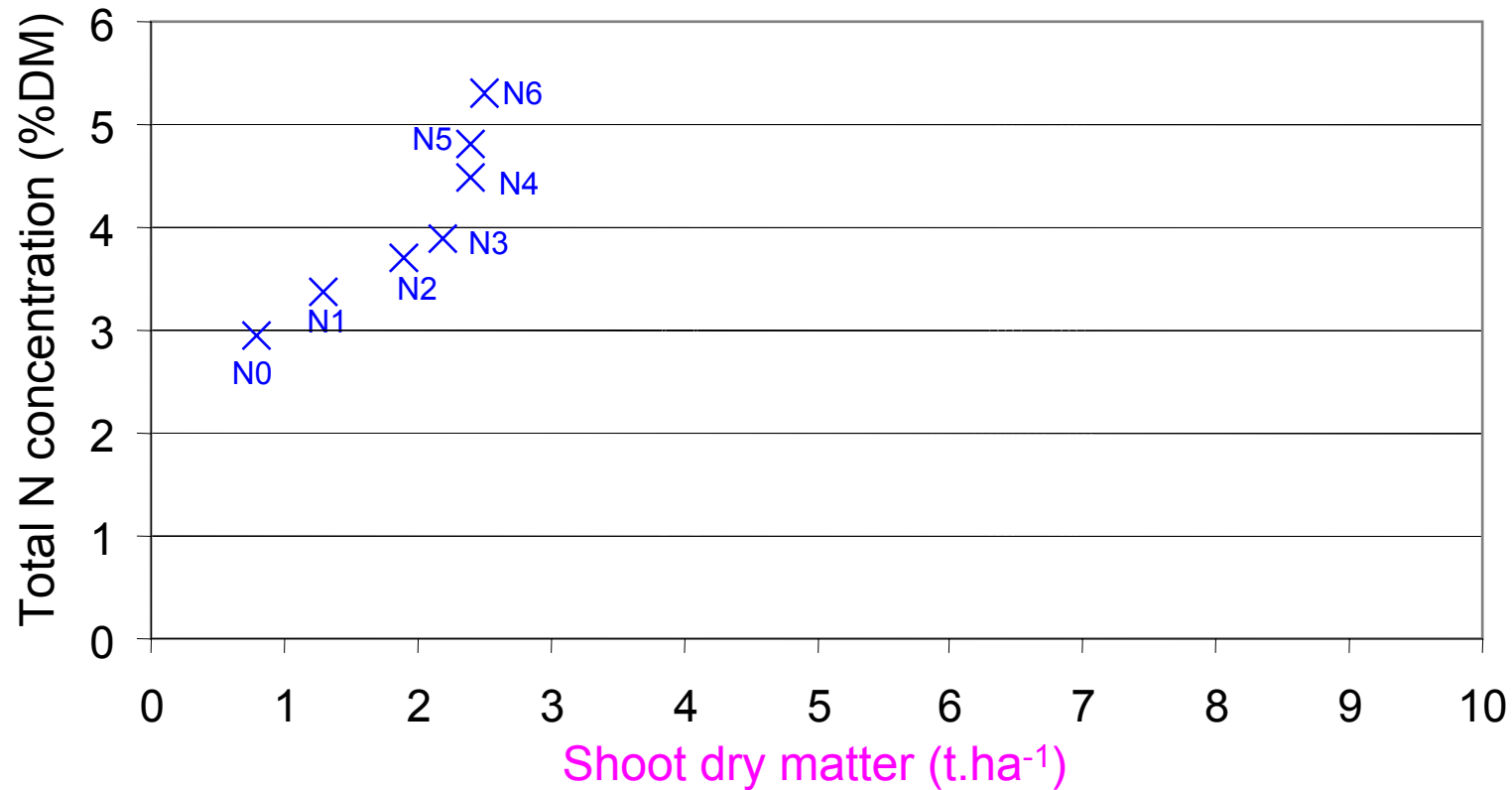


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods (data processing)

- Theoretical critical points
 - 1) Determination of N-limiting and non-N-limiting treatments



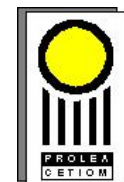
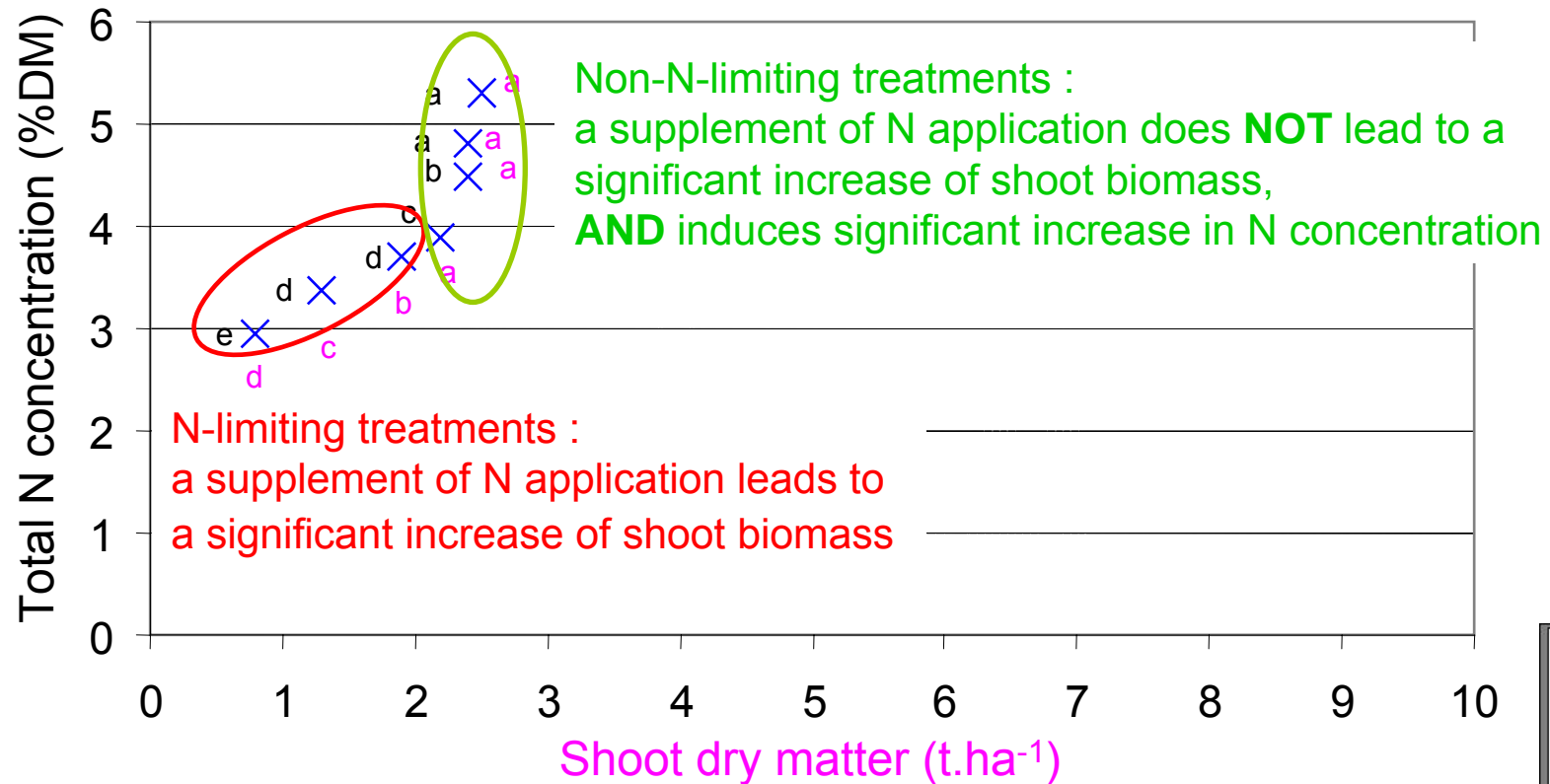
The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods (data processing)

- Theoretical critical points

- Determination of N-limiting and non-N-limiting treatments

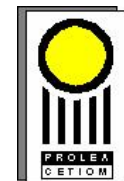
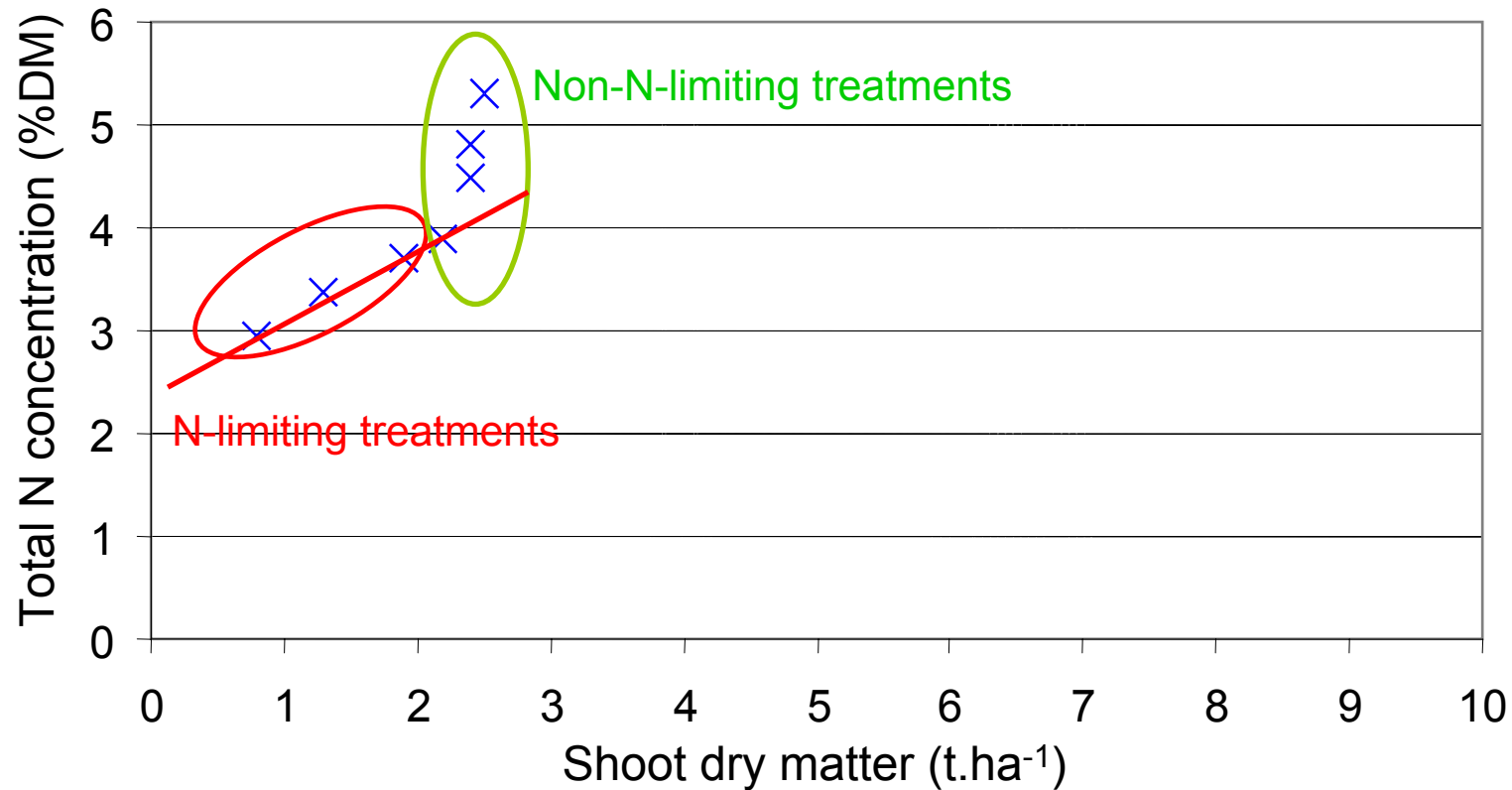


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods (data processing)

- Theoretical critical points (Justes et al. 1994)
 - 2) Data of limiting N growth conditions fitted by a simple linear regression

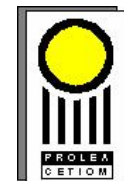
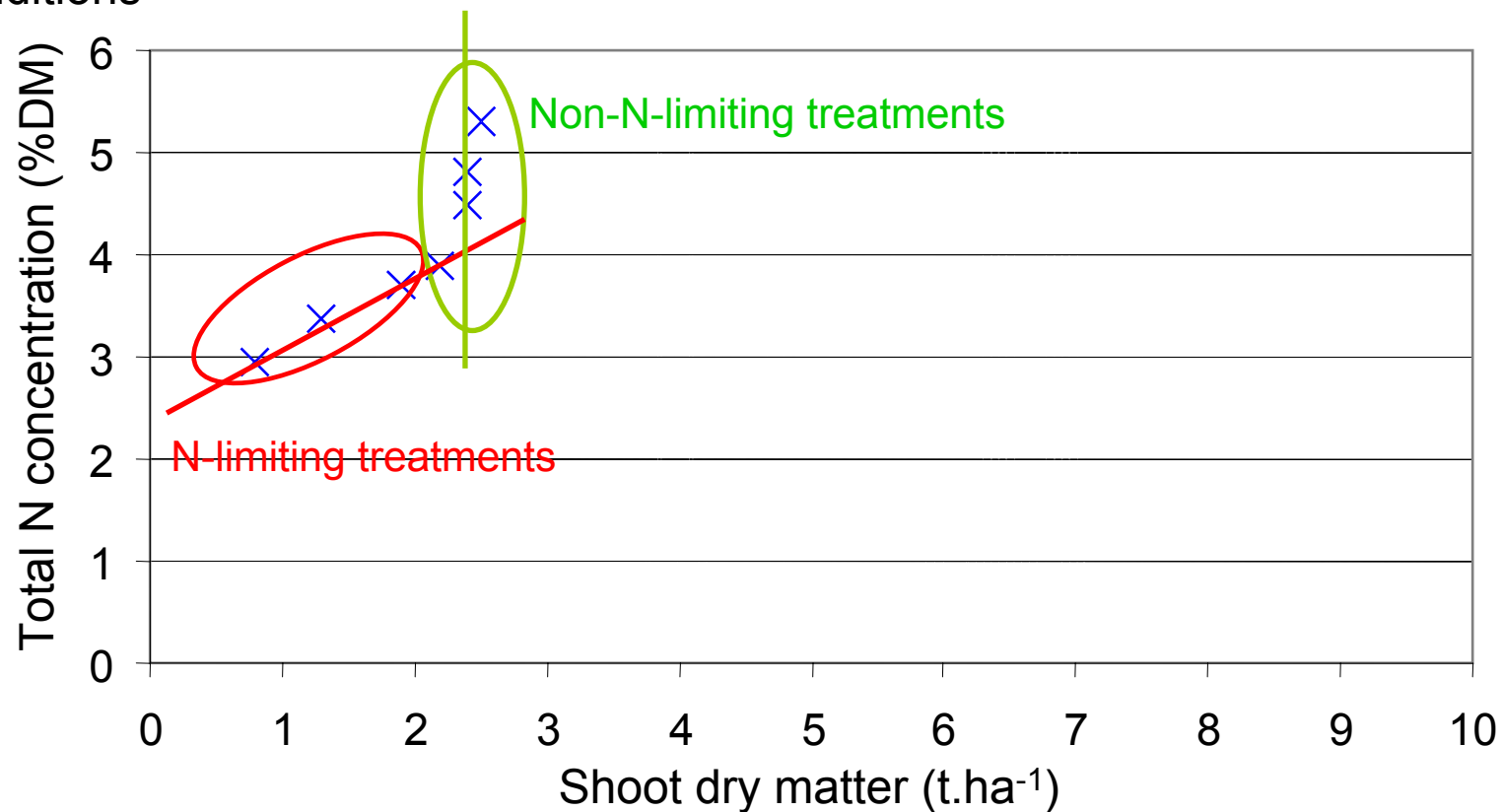


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods (data processing)

- Theoretical critical points (Justes et al. 1994)
 - 3) Maximum shoot biomass = average of observed data of non-limiting N growth conditions

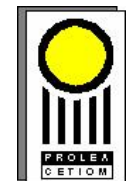
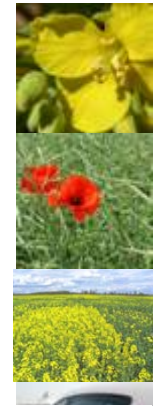
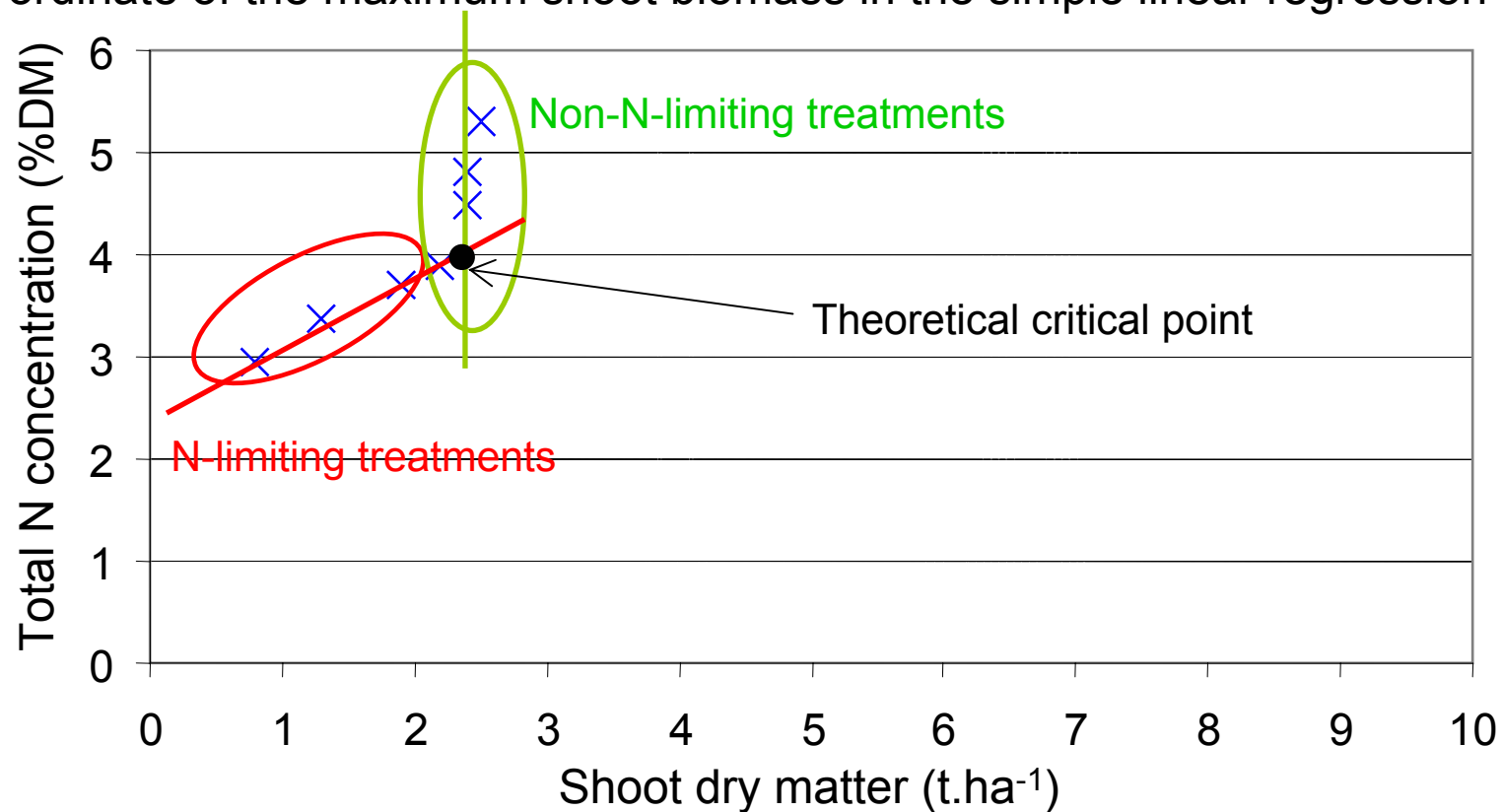


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods (data processing)

- Theoretical critical points (Justes et al. 1994)
 - 4) Theoretical critical point = maximum shoot biomass and its total N concentration as the ordinate of the maximum shoot biomass in the simple linear regression



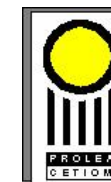
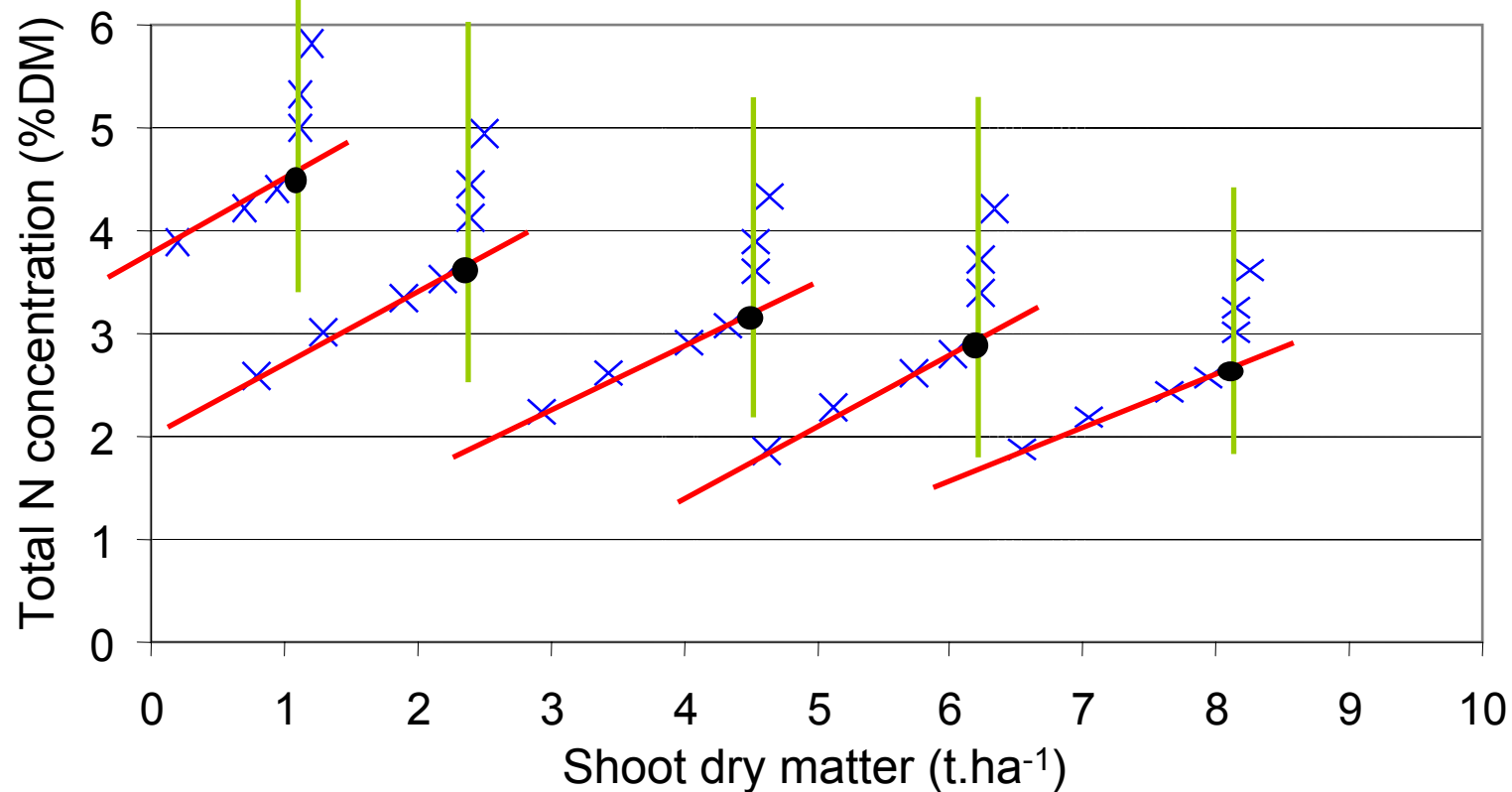
The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods (data processing)

- Theoretical critical points

5) Idem for all the series of data selected to define the critical N curve



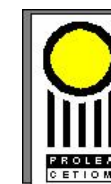
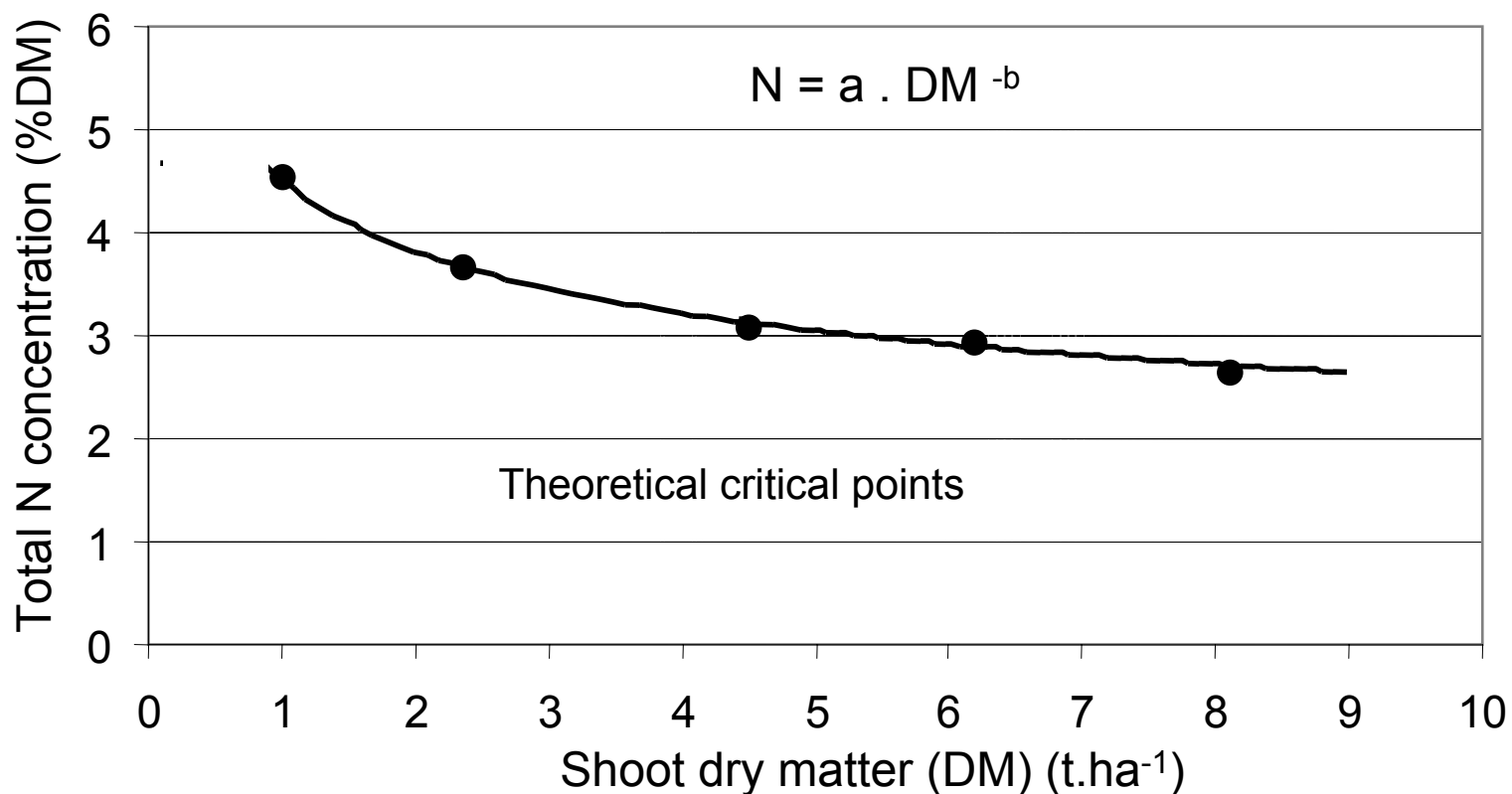
The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Materials and methods

- Critical N curve

6) power regression equation fitted to the theoretical critical points

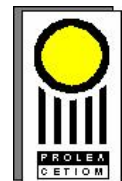
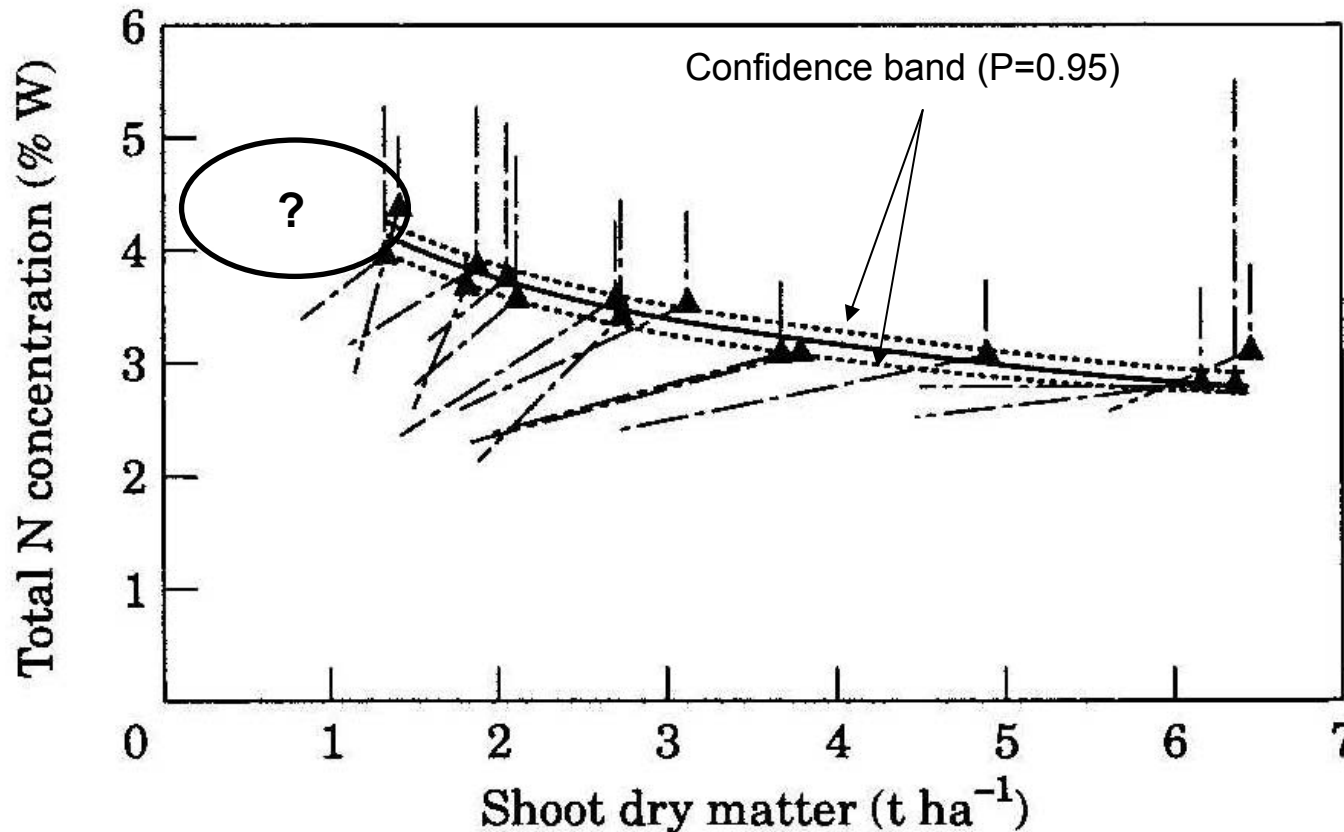


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Results

- Critical N curve for oilseed rape : $N = 4.48 \text{ DM}^{-0.25}$
 - 15 series of data used

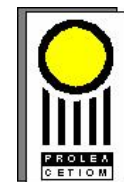
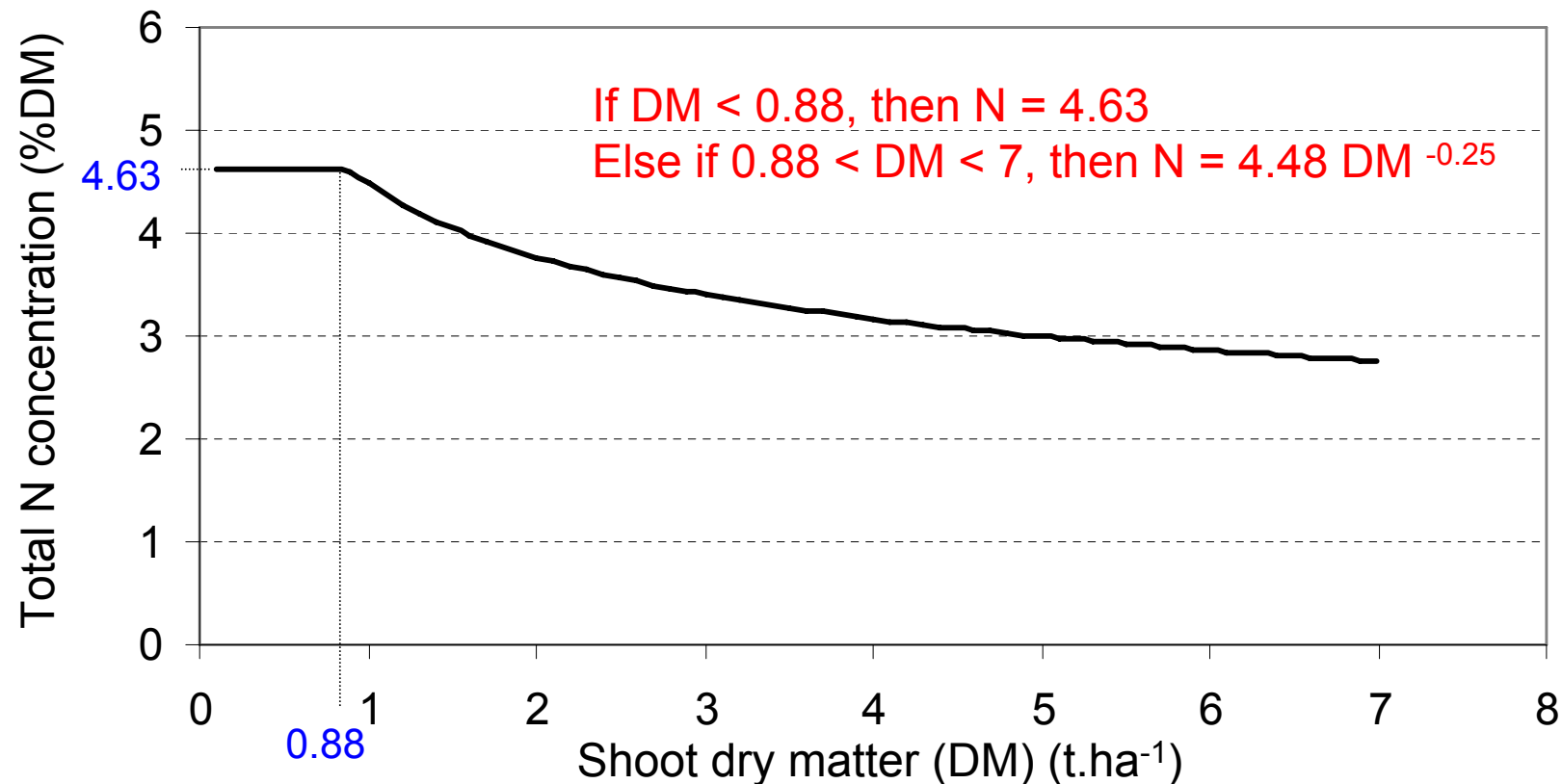


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Results

- Critical N constant value: mean value of:
 - the minimum N concentration of the non-N-limiting situations (4.71 %)
 - And the maximum N concentration of the N-limiting situations (4.55 %)
 - For situations where plants can be considered as isolated ($DM < 1.18 \text{ t.ha}^{-1}$)

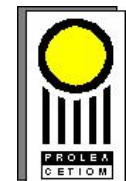
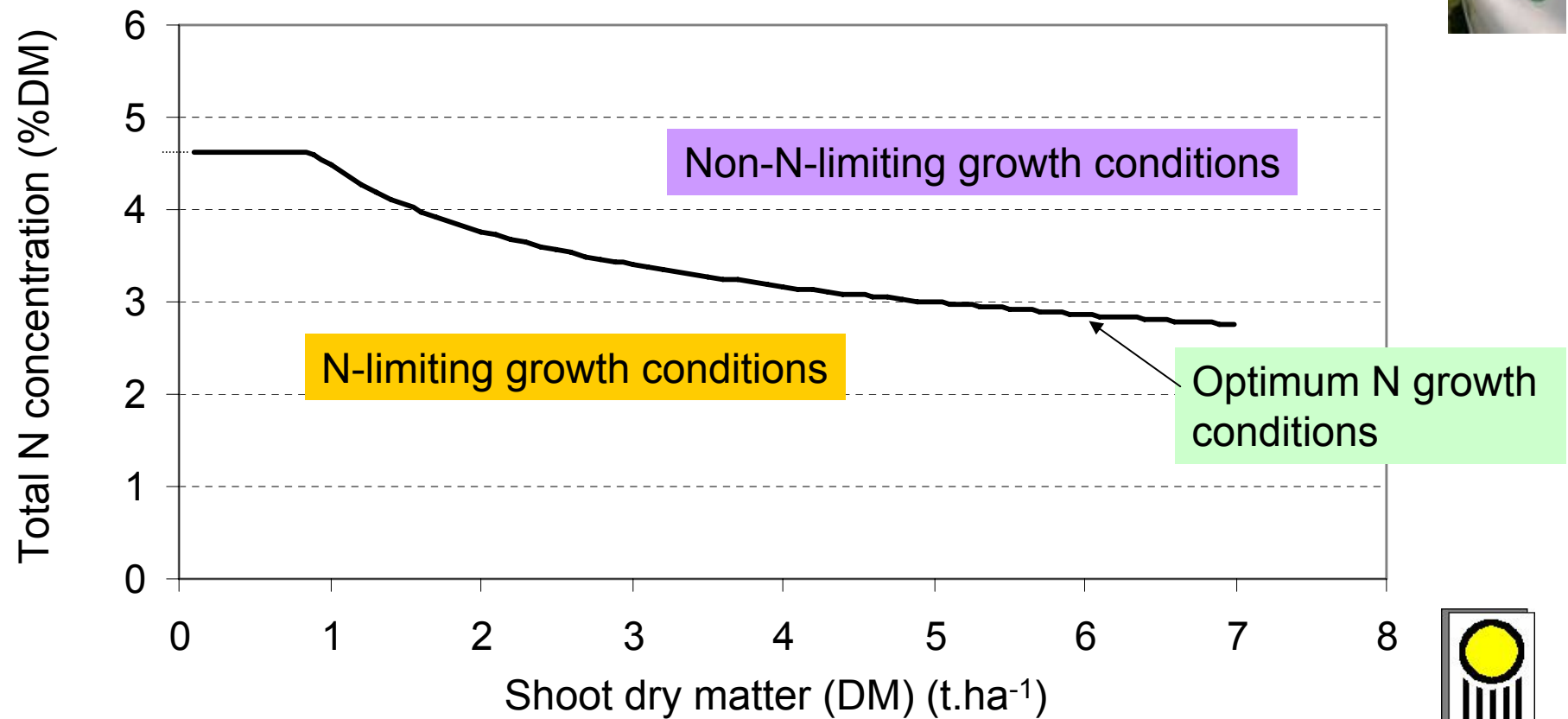


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Results

- Meaning of the critical N curve

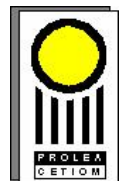
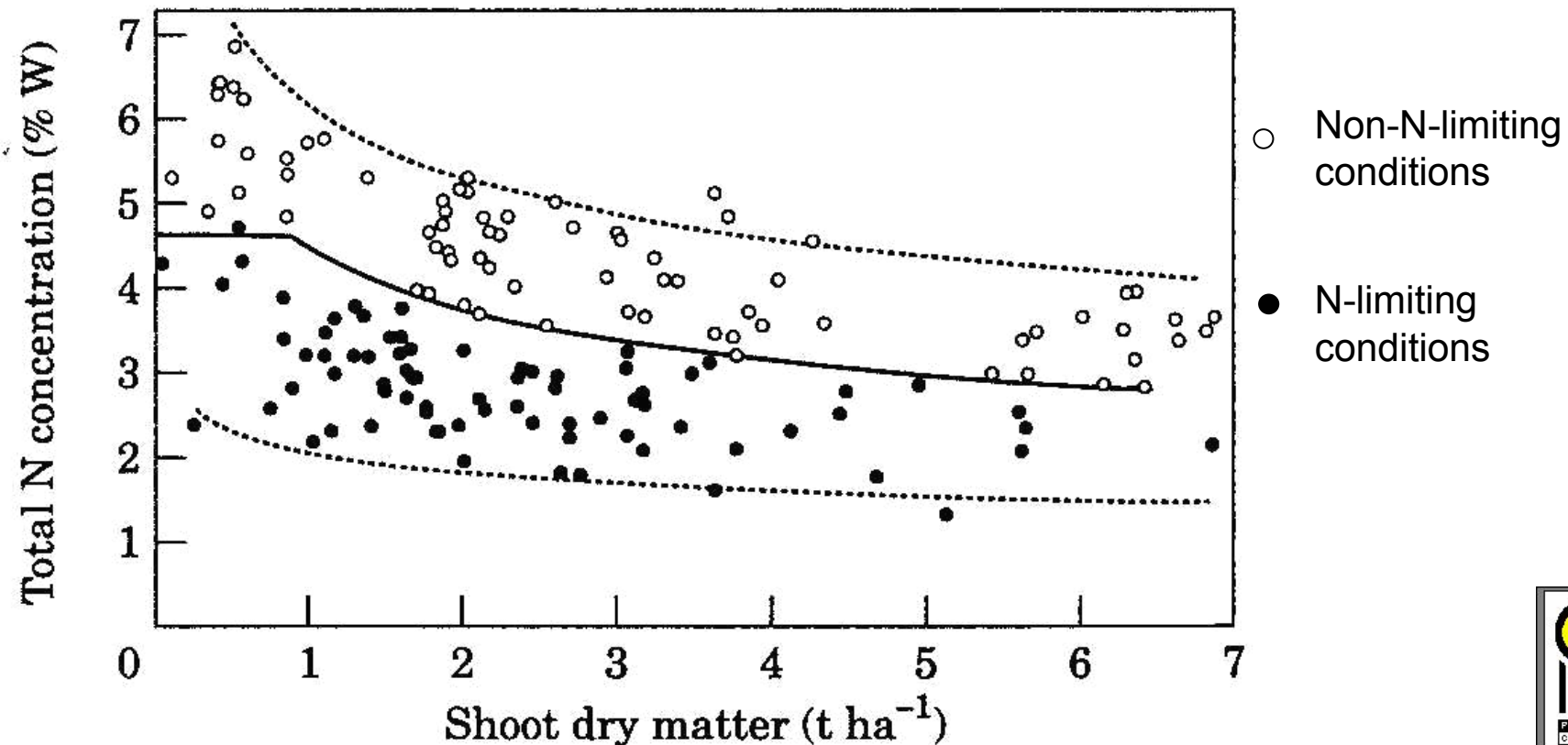


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Results

- Experimental validation of the critical N curve
 - With data coming from situations not selected for its definition

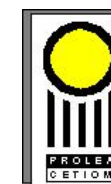
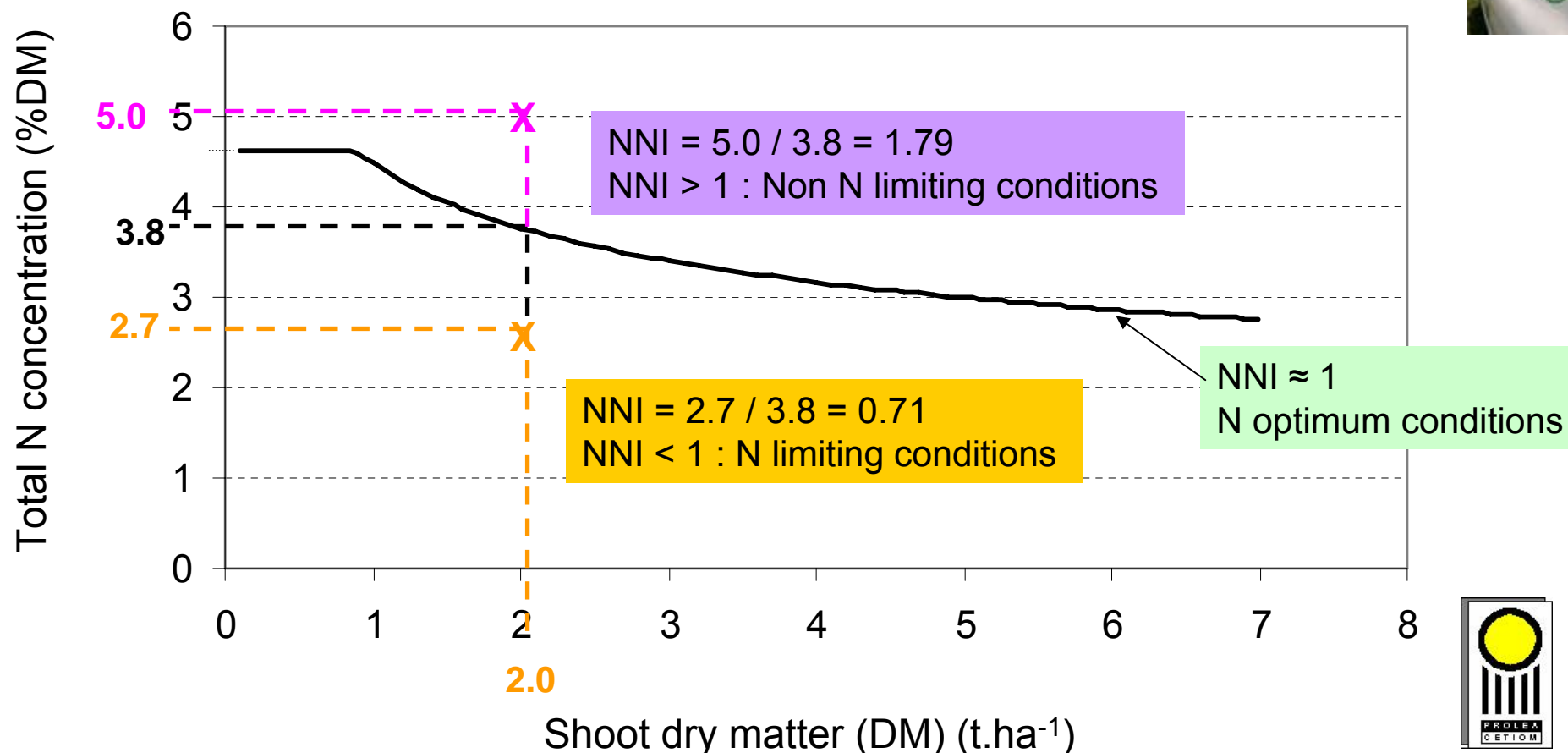


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

Discussion

- Calculation of an indicator of the nitrogen status of the crop : the nitrogen nutrition index : NNI

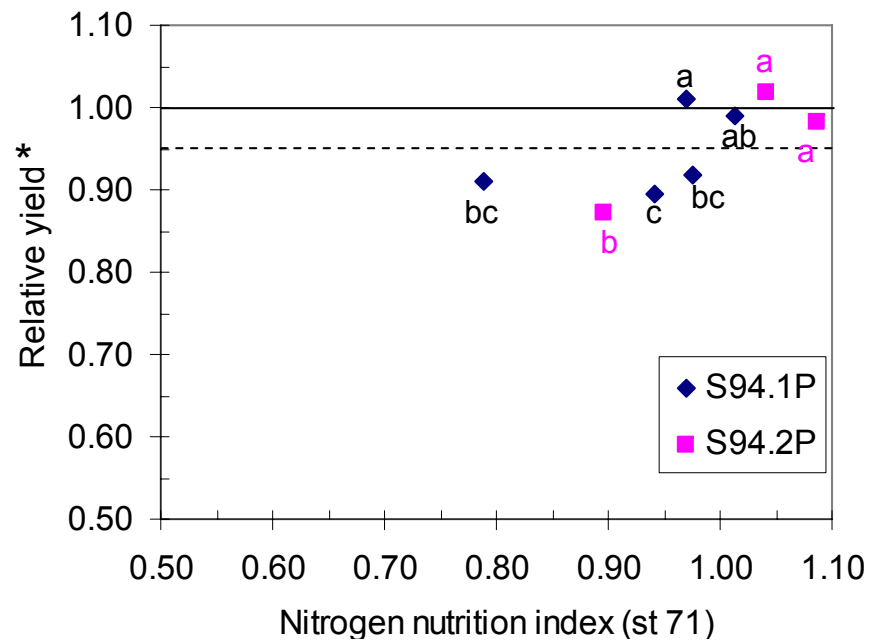


The winter oilseed rape critical N curve

(Colnenne et al., 1997)

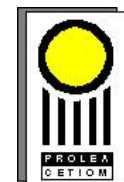
Discussion

- Relationship between NNI and seed yield
 - Situations without N stress until flowering



* : $\frac{\text{yield of a given treatment}}{\text{maximum yield in the same experiment.}}$

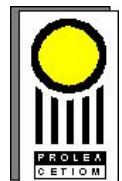
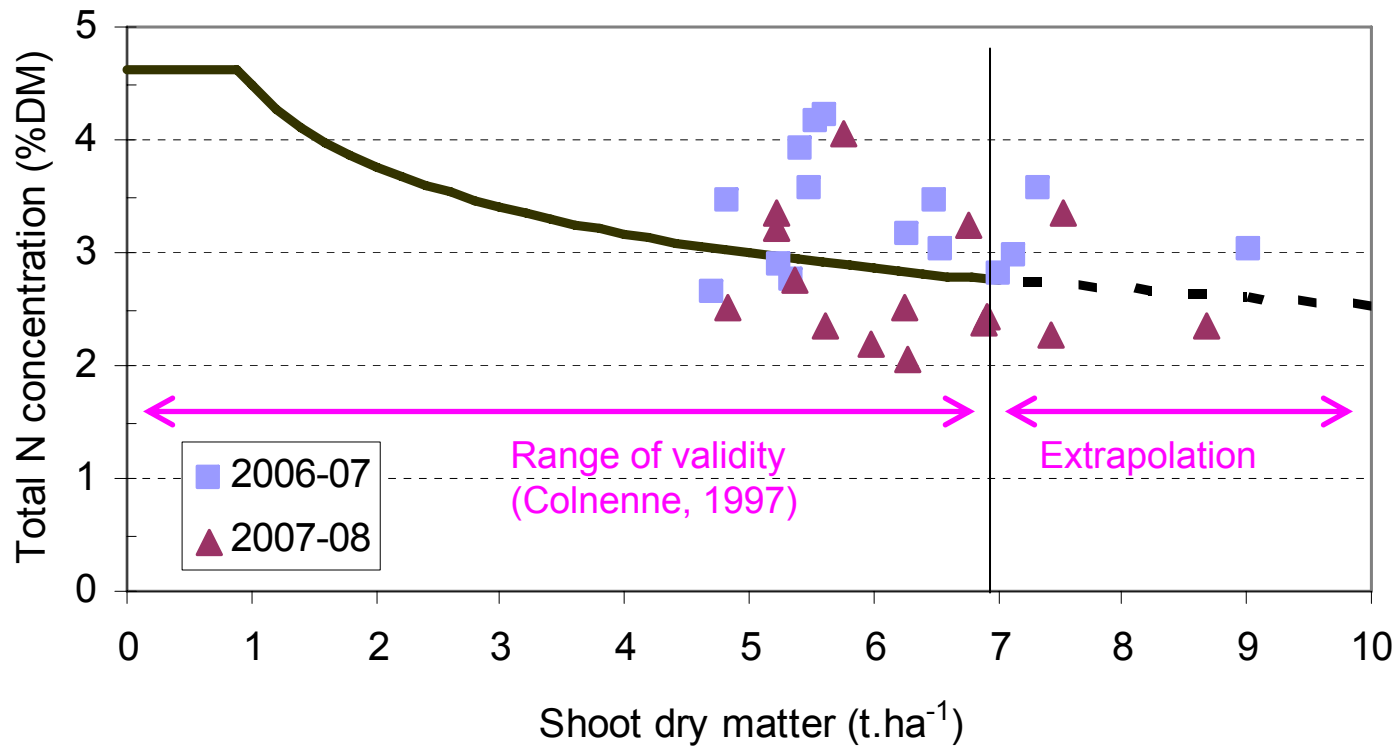
NNI : a good indicator of the N nutrition status for yield elaboration



The winter oilseed rape critical N curve

Discussion

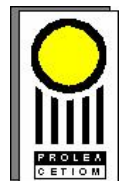
- Use of NNI to diagnose N deficiencies: DIACOL
 - Diagnose in farmers' fields, Burgundy, 2007 and 2008
 - Measurement at stage 60 (beginning of flowering)



The winter oilseed rape critical N curve

Conclusion

- NNI is an indicator widely used in France, in various crops, to estimate the N status of the crop
- The critical N curve is established with data during vegetative growth
- Nevertheless, NNI is a good indicator of the N nutrition status with regard to the yield elaboration
- It is mainly valid from the emergence of the crop to the beginning of flowering
- But we consider that it can be used until the end of flowering



The winter oilseed rape critical N curve



- References

- LEMAIRE G., SALETTE J. (1984): - Relation entre dynamique de croissance et dynamique de prélèvement d'azote pour un peuplement de graminées fourragères. I. – Etude de l'effet du milieu. *Agronomie*, **4** (5), 423-430.
- JUSTES E., MARY B., MEYNARD J.-M., MACHET J.-M., THELIER-HUCHE (1994): - Determination of a critical nitrogen dilution curve for winter wheat crops. *Annals of Botany*, **74**, 397-407.
- COLNENNE C., MEYNARD J.-M., REAU R., JUSTES E., MERRIEN A. (1998) : - Determination of a critical nitrogen dilution curve for winter oilseed rape. *Annals of Botany*, **81**, 311-317.

