Nitrogen use Efficiency in Cereal Production Under Mediterranean Conditions

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Climatic Constrains

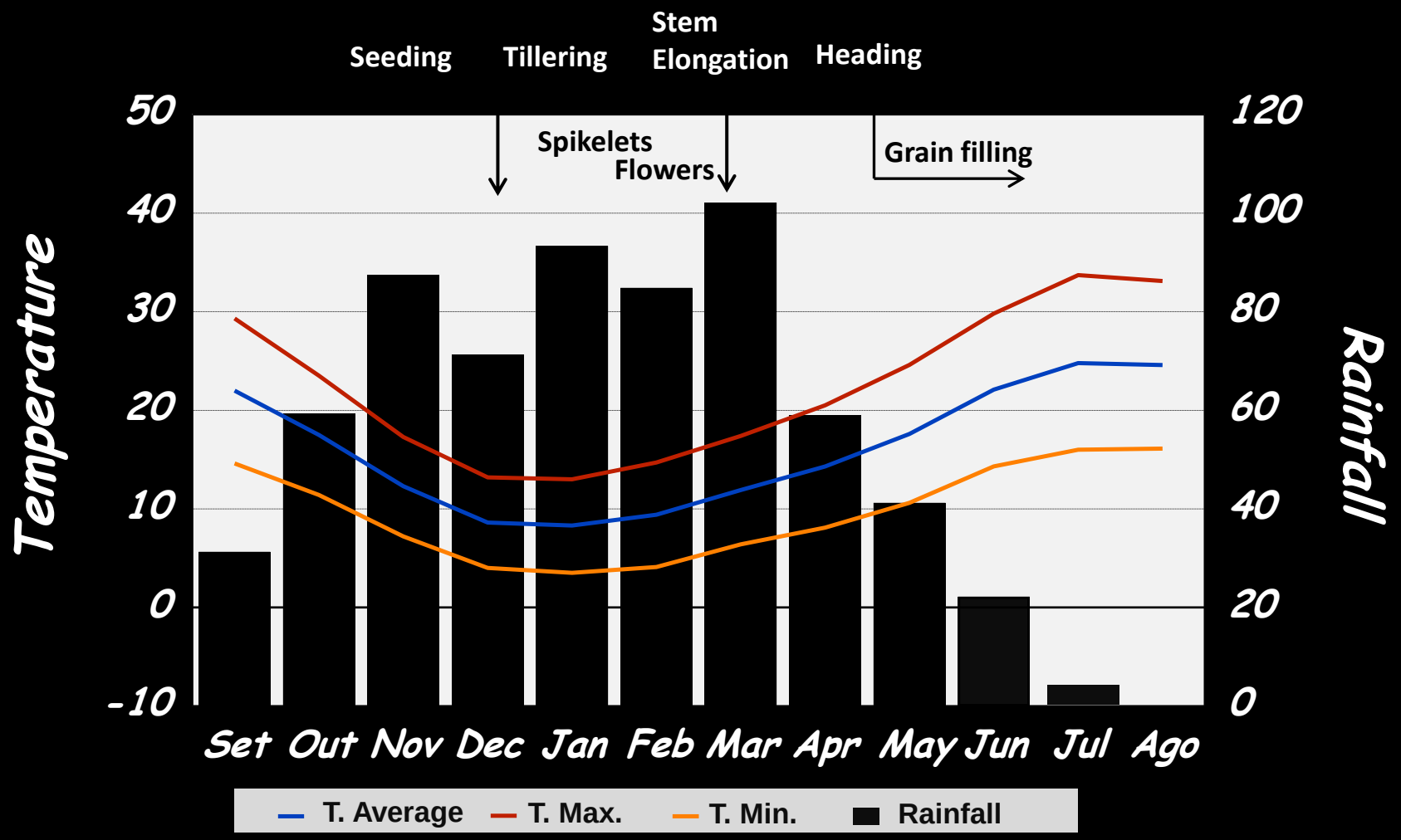
Edaphic Constrains

Crop Phenology

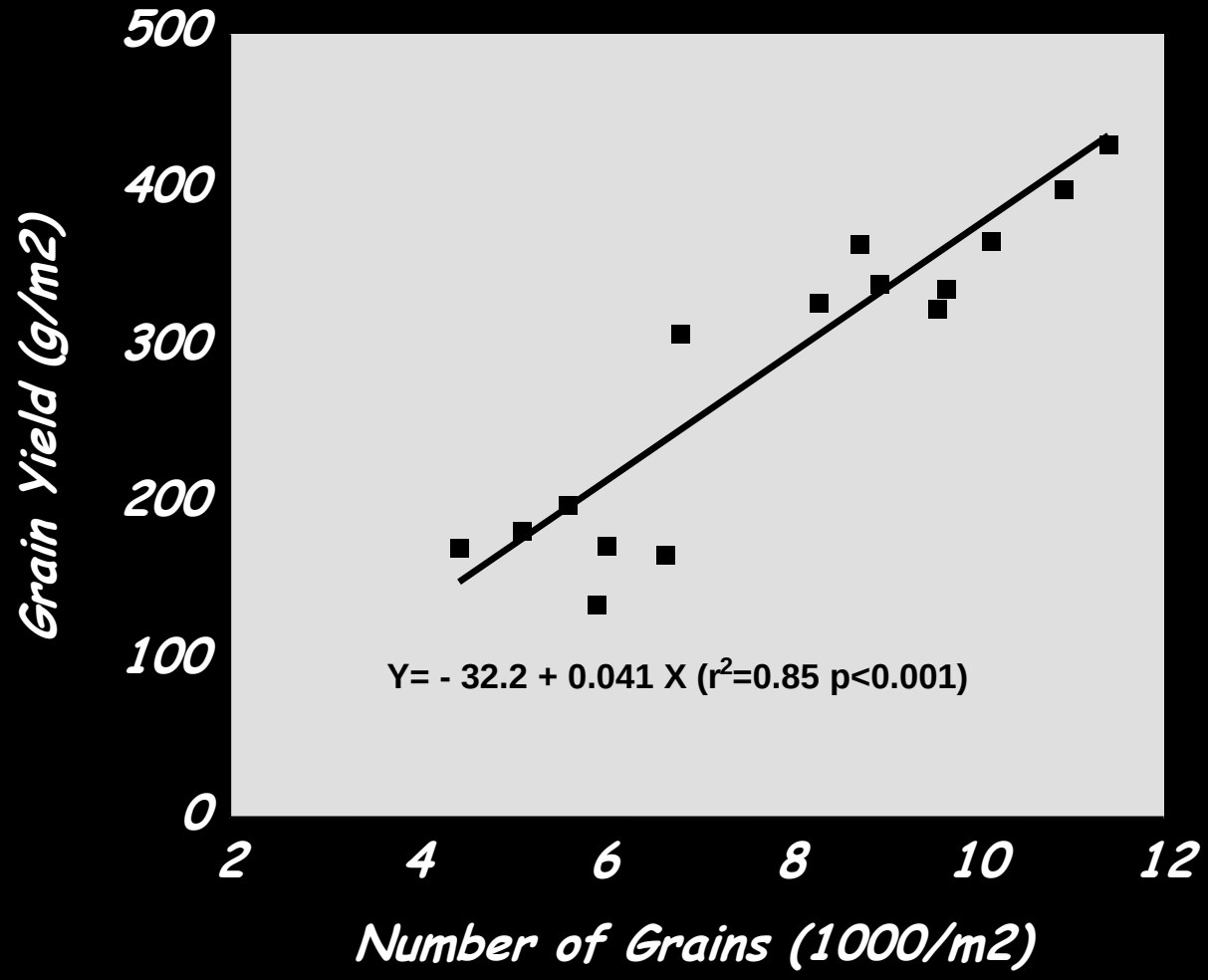
Crop Technology

First Climatic Constrain

Temperature and Rainfall –Elvas Meteorological Station (1941/70)

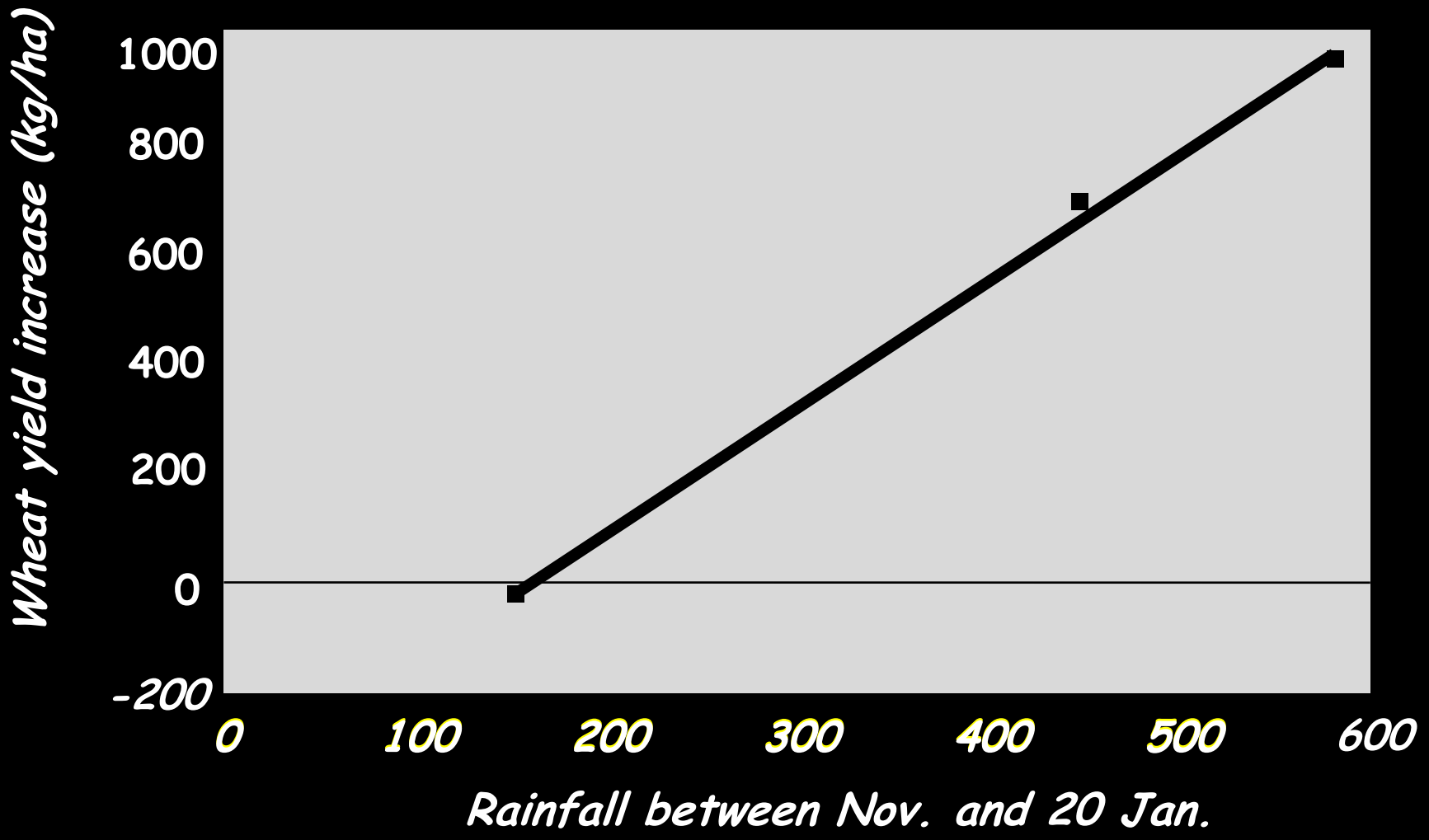


Relationship between the number of grains and wheat yield
Vertic Clay Soil – South of Portugal



Adapted from Carvalho (1987)

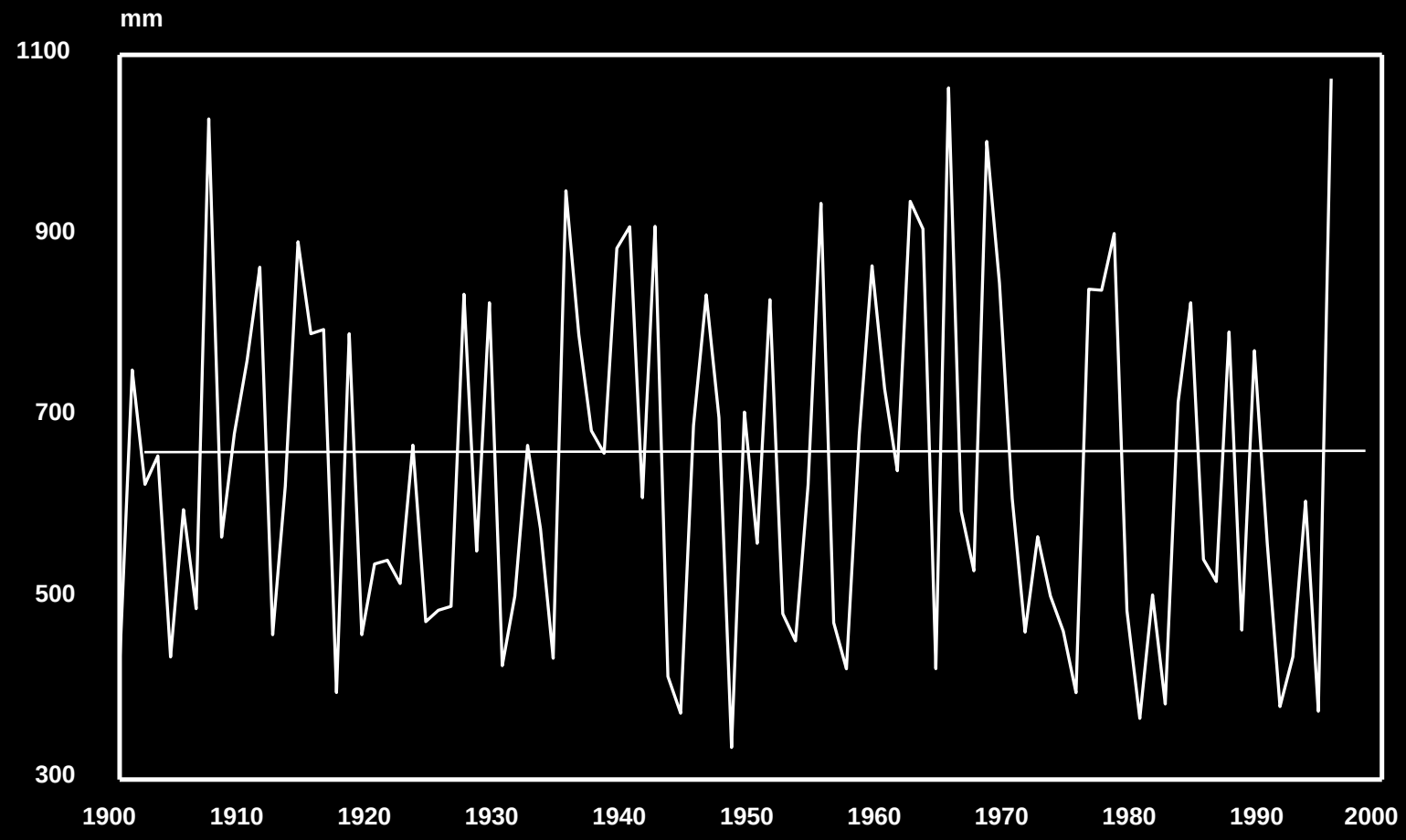
Effect of rainfall on the wheat response to 60 kg N/ha applied at 20th of Jan.
120 kg N/ha were applied at 28th of Feb.



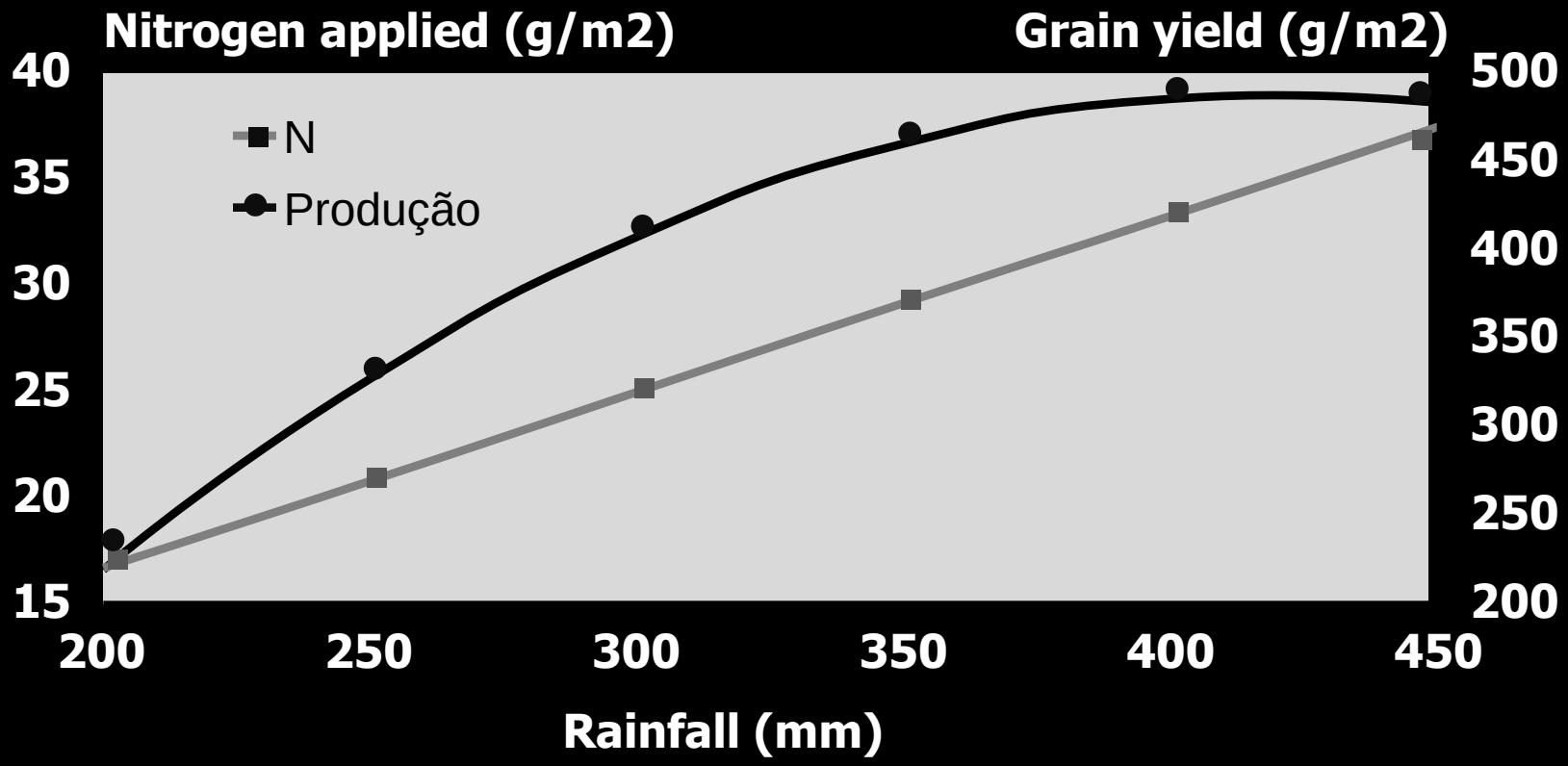
Carvalho et al (2005)

Second Climatic Constrain

Variation of Annual Rainfall (Évora)



Relationship between rainfall (Nov to Feb.), applied nitrogen and wheat yield. Vertic Clay Soil - Beja – South of Portugal



Which yield? Which NUE?

Carvalho et al (1996)

Major Soil Constrains

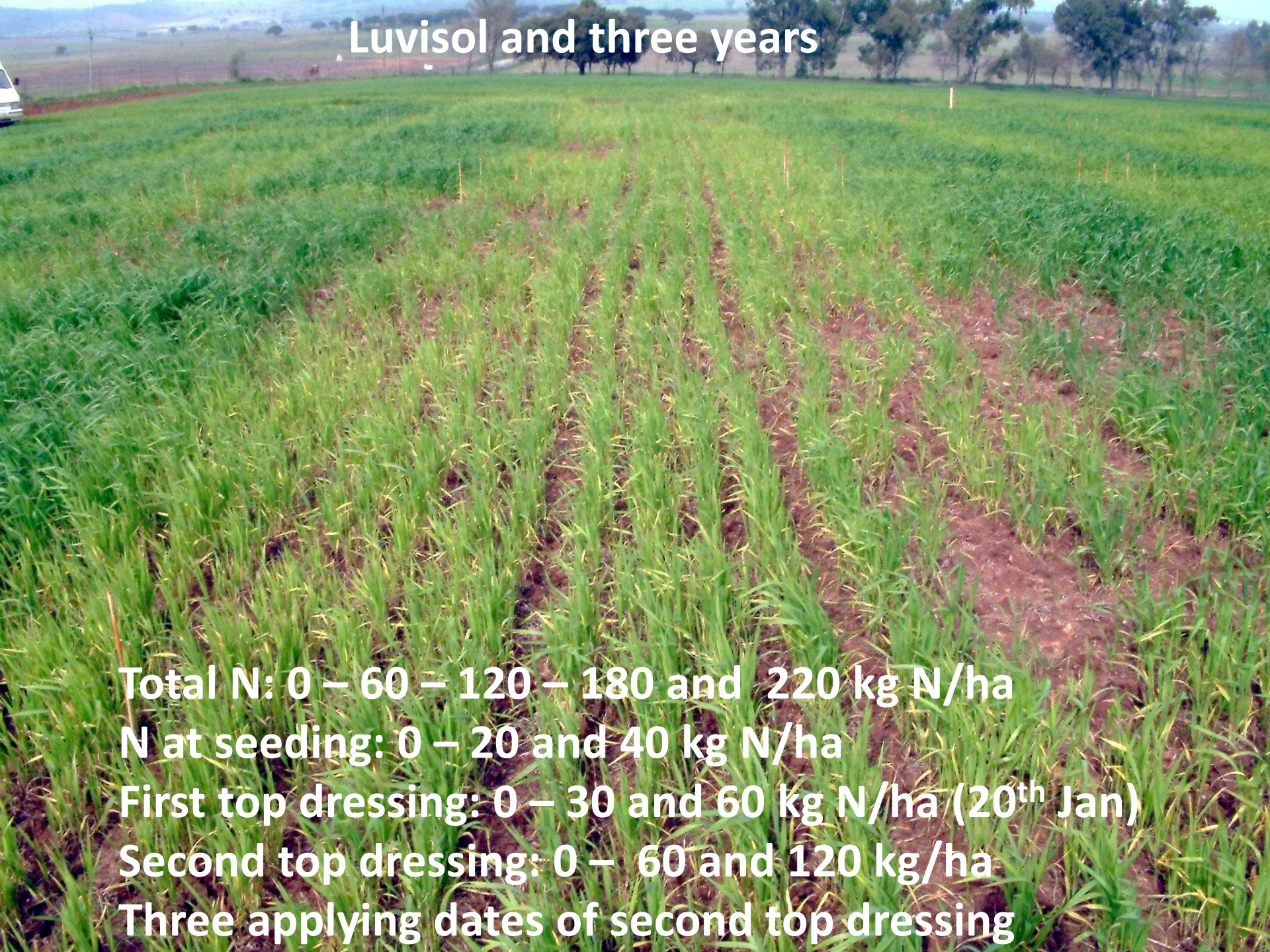
Soil organic matter content
(70% of Portuguese soils has less than 1% SOM)

Poor drainage (Luvisol and Vertic Clay Soils)
(how to ensure soil trafficability)

Two major difficulties for a high efficiency in the use of nitrogen

How to match “year requirements” with N applied
(the traditional approach of expected yield does not work)
(How to avoid mistakes)

N losses due to leaching/volatilization in wet winters
(N deficiency during tillering and spikelets differentiation)
(Splitting; Type of fertilizer; Crop rotation; Soil contribution)


Luvisol and three years
Total N: 0 – 60 – 120 – 180 and 220 kg N/ha
N at seeding: 0 – 20 and 40 kg N/ha
First top dressing: 0 – 30 and 60 kg N/ha (20th Jan)
Second top dressing: 0 – 60 and 120 kg/ha
Three applying dates of second top dressing

Model developed N fertilizer application according rainfall for wheat production (Luvisol and Vertic Clay Soils)

$$Y = 574 + 10.25\,N - 0.04\,N^2 - 1.76\,R_1 + 0.001\,R_1N + 19.6\,R_2 + 0.09\,R_2N$$

$$F_{[6,74]} = 106.81 \quad p<2.15\,E^{-34} \quad r^2=0.90$$

Optimal Economic N Level

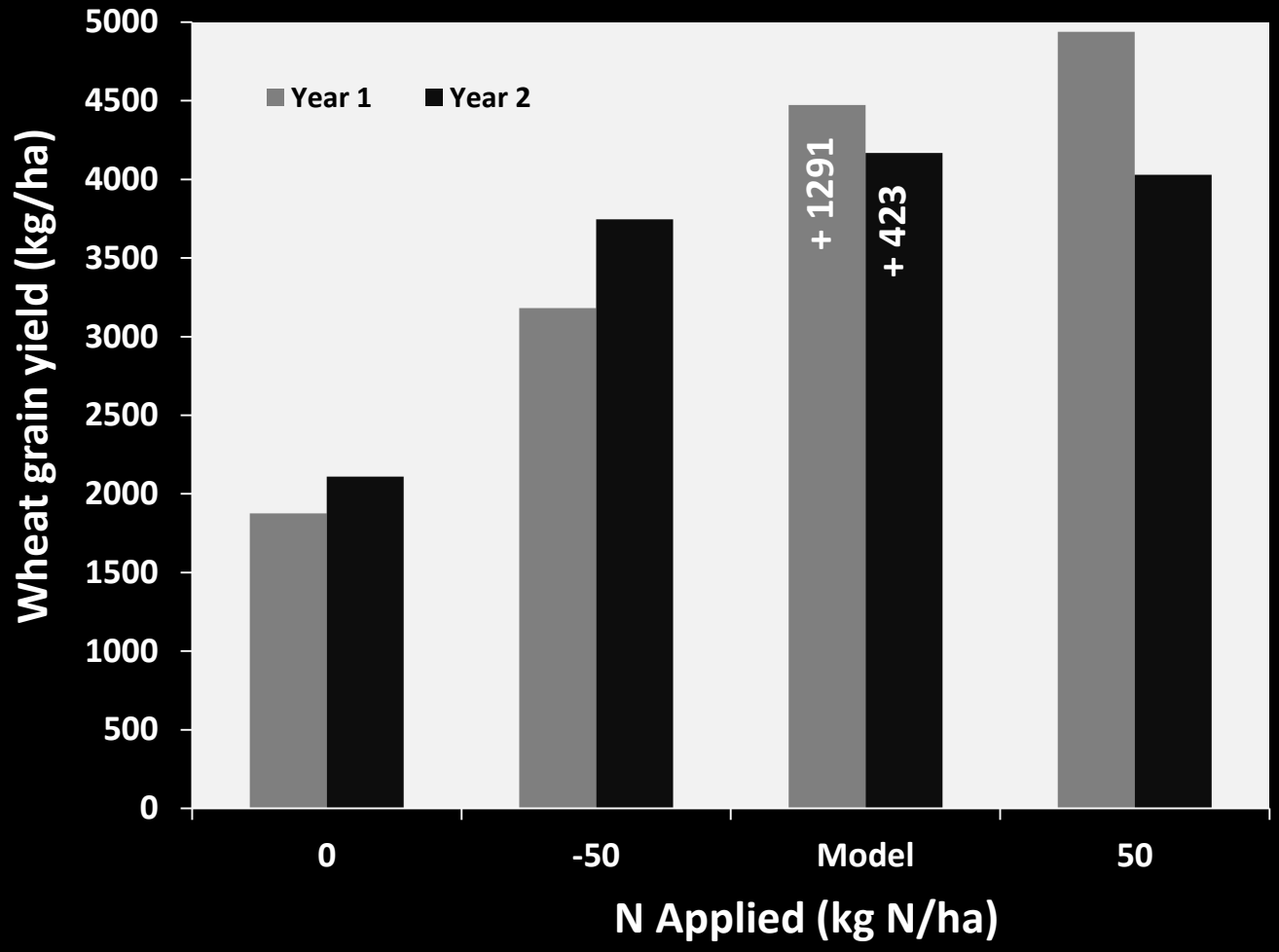
$$N = 78.1 + 0.01\,R_1 + 1.1\,R_2$$

Carvalho et al (2005)

Independent validation of the N management model
Two years and two different soils (Luvisol and Vertic Clay)

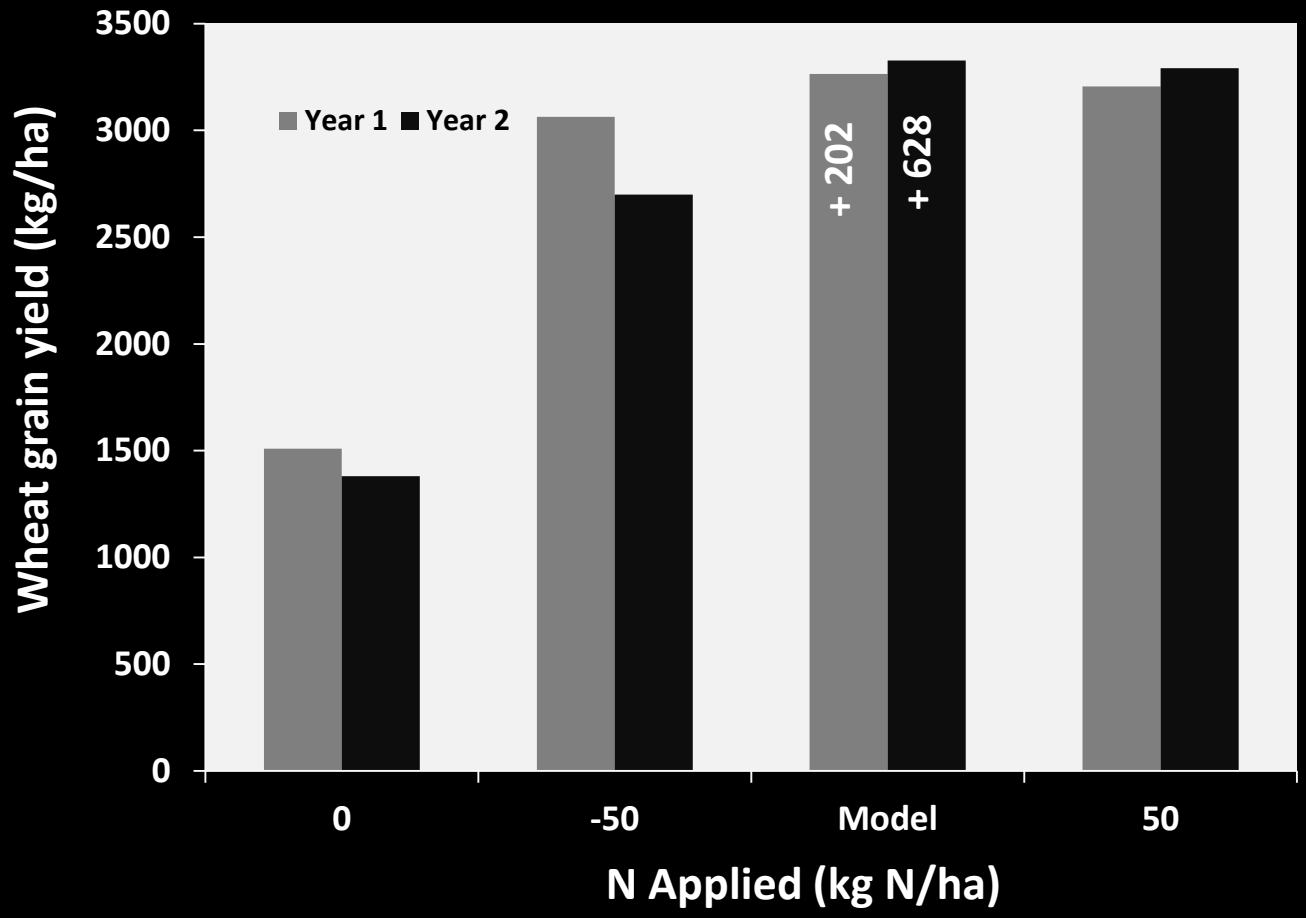
	Seeding (kg N/ha)	1rst Top Dressing (%)	2nd Top Dressing (%)
T0	0	0	0
T111	20	50	50
T112	20	50	100
T113	20	50	150
T121	20	100	50
T122 (MODEL)	20	100	100
T123	20	100	150
T131	20	150	50
T132	20	150	100
T133	20	150	150

Validation of the Model - Luvisol



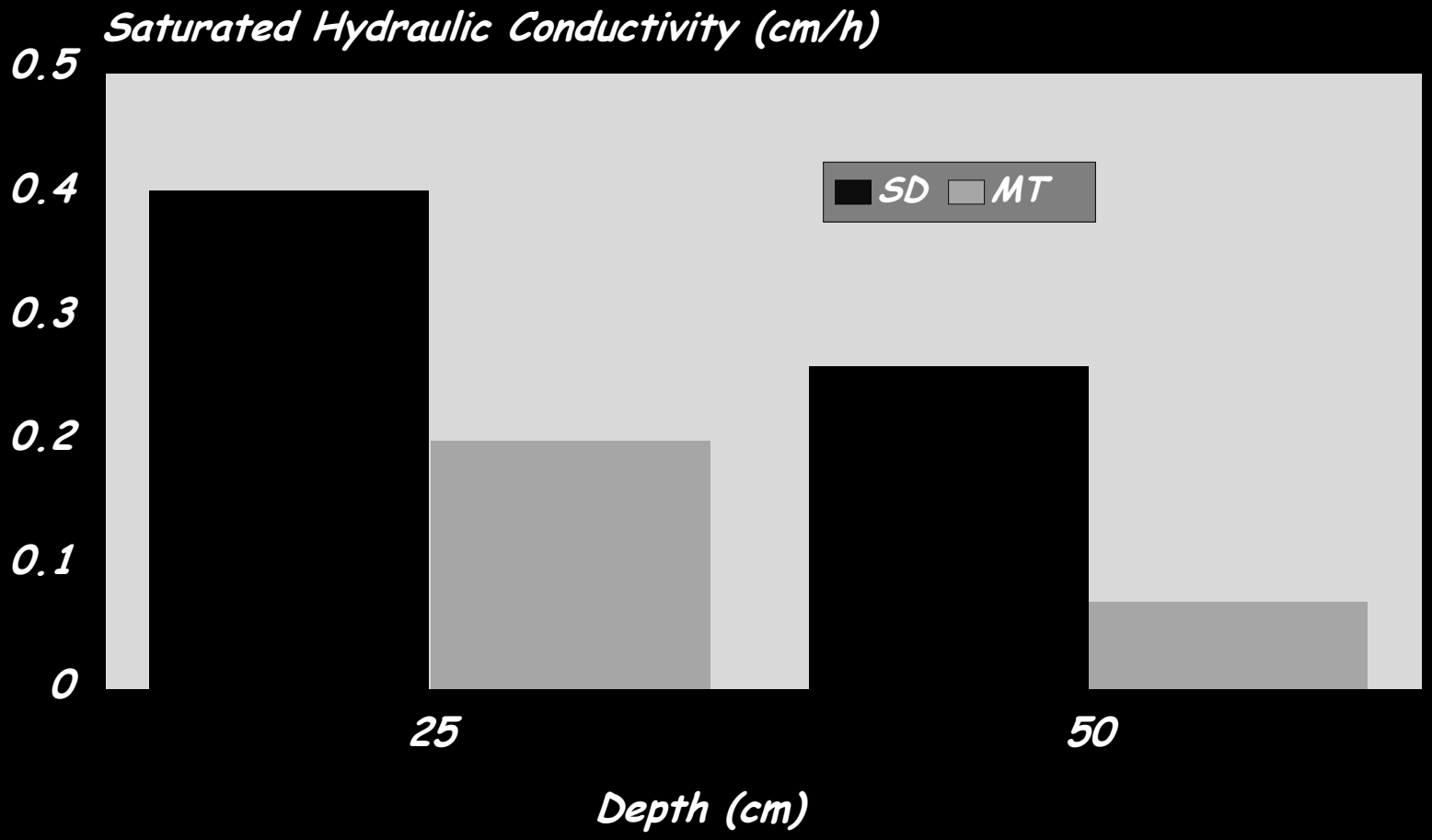
Carvalho et al (2005)

Validation of the Model – Vertic Clay Soil



Carvalho et al (2005)

Effect of tillage on the saturated hydraulic conductivity
Vertic Clay Soil– 6th Year

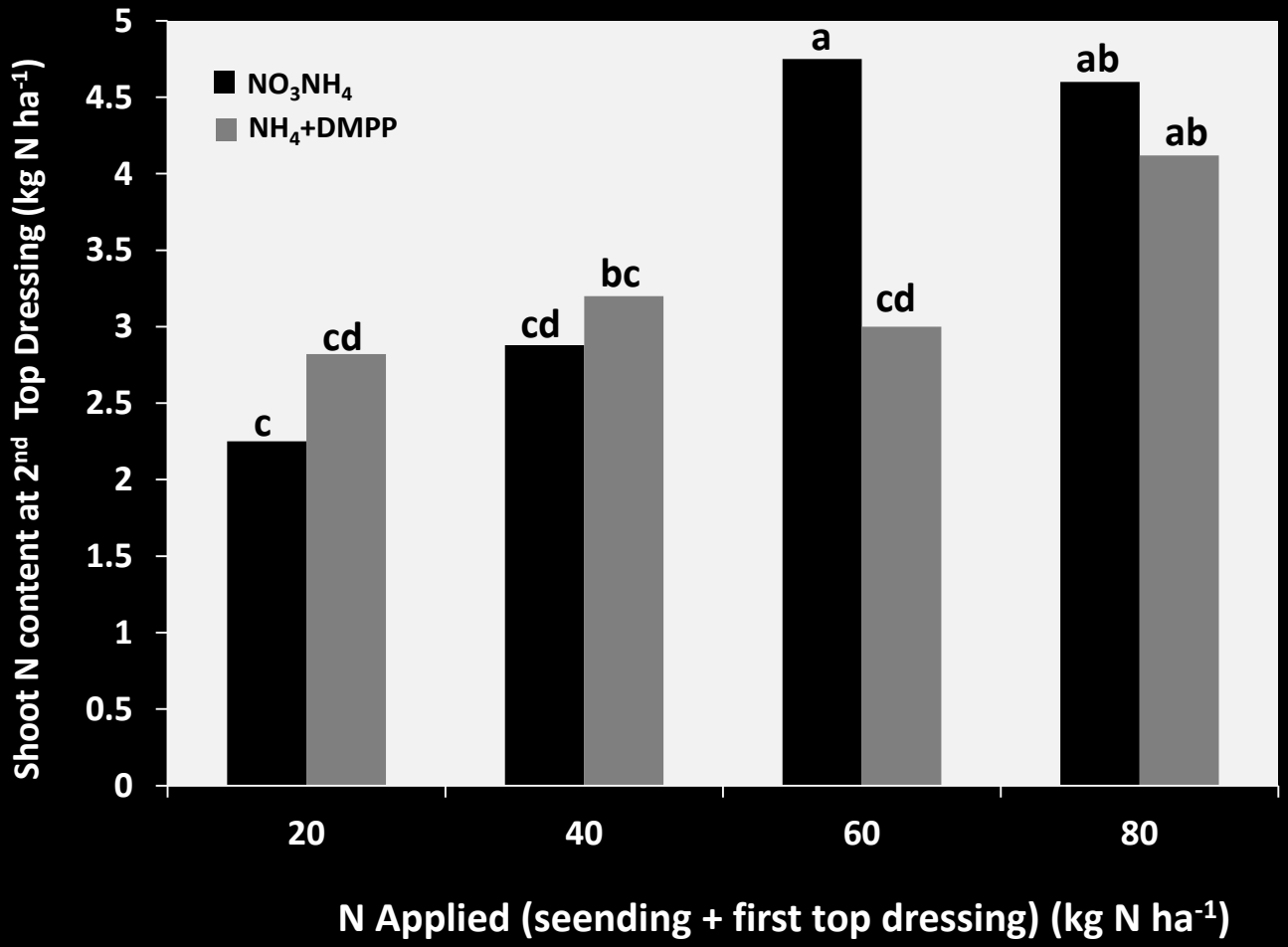


Adapted from Carvalho and Basch (1995)

Drainage + Soil Cohesion = Better soil trafficability

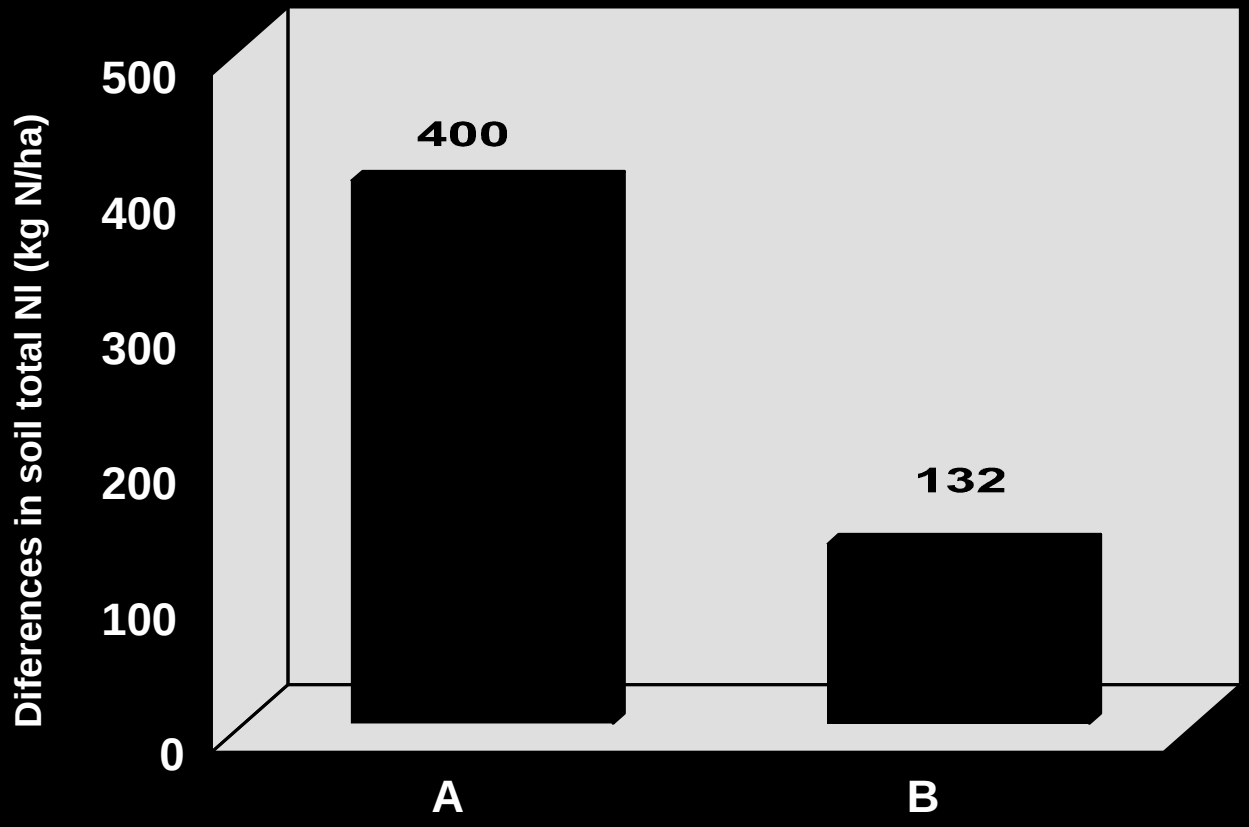
Effect of nitrification inhibitor on N use efficiency by wheat during the winter

NO_3NH_4 – 20 kg N/ha at seeding and the rest at 20th Jan.
NH_4+DMPP (3,4-dimethyl pyrazole phosphate) – ENTEC BASF single application at seeding



Carvalho et al (2005)

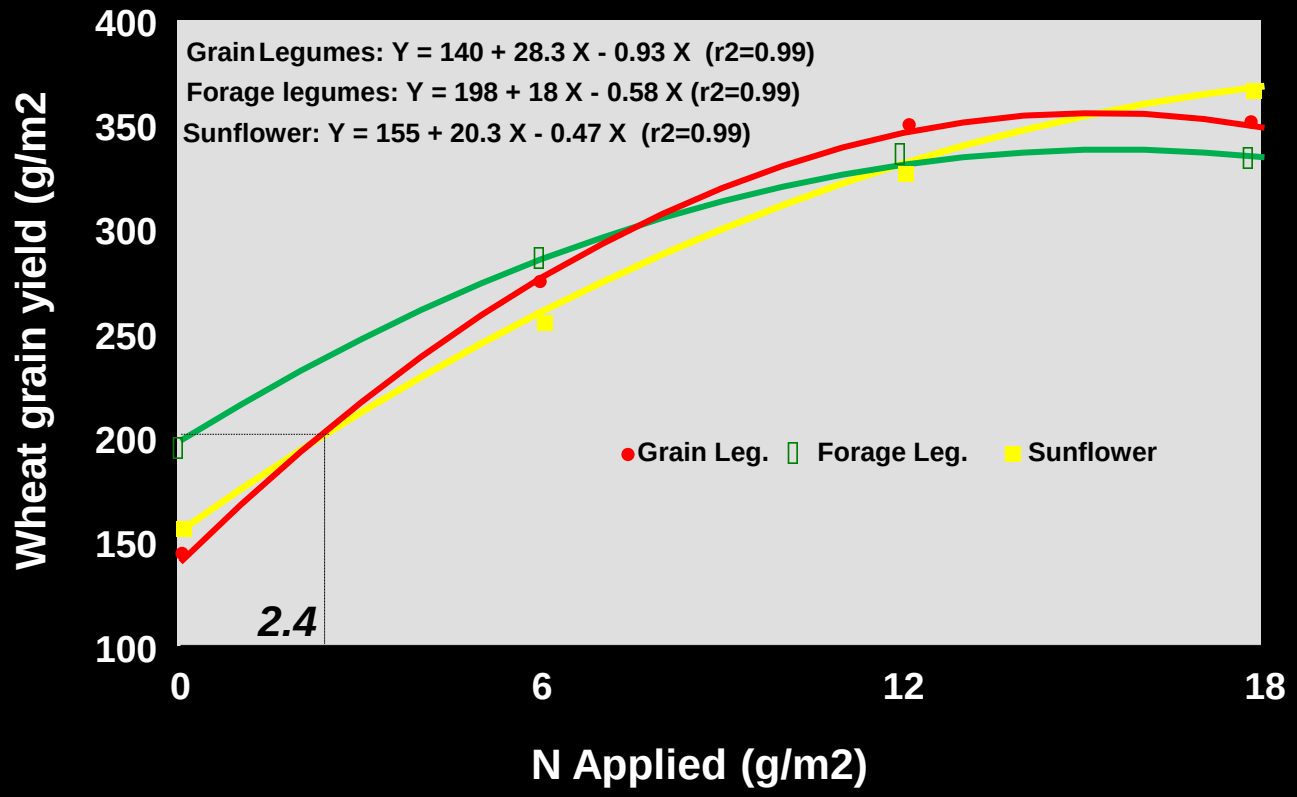
Effect of the crop rotation on total N in the soil before the seeding of the wheat – Vertic Clay Soil – Average of four years



A -Between forrage legumes and sunflower
B -Between grain leguems and sunflower

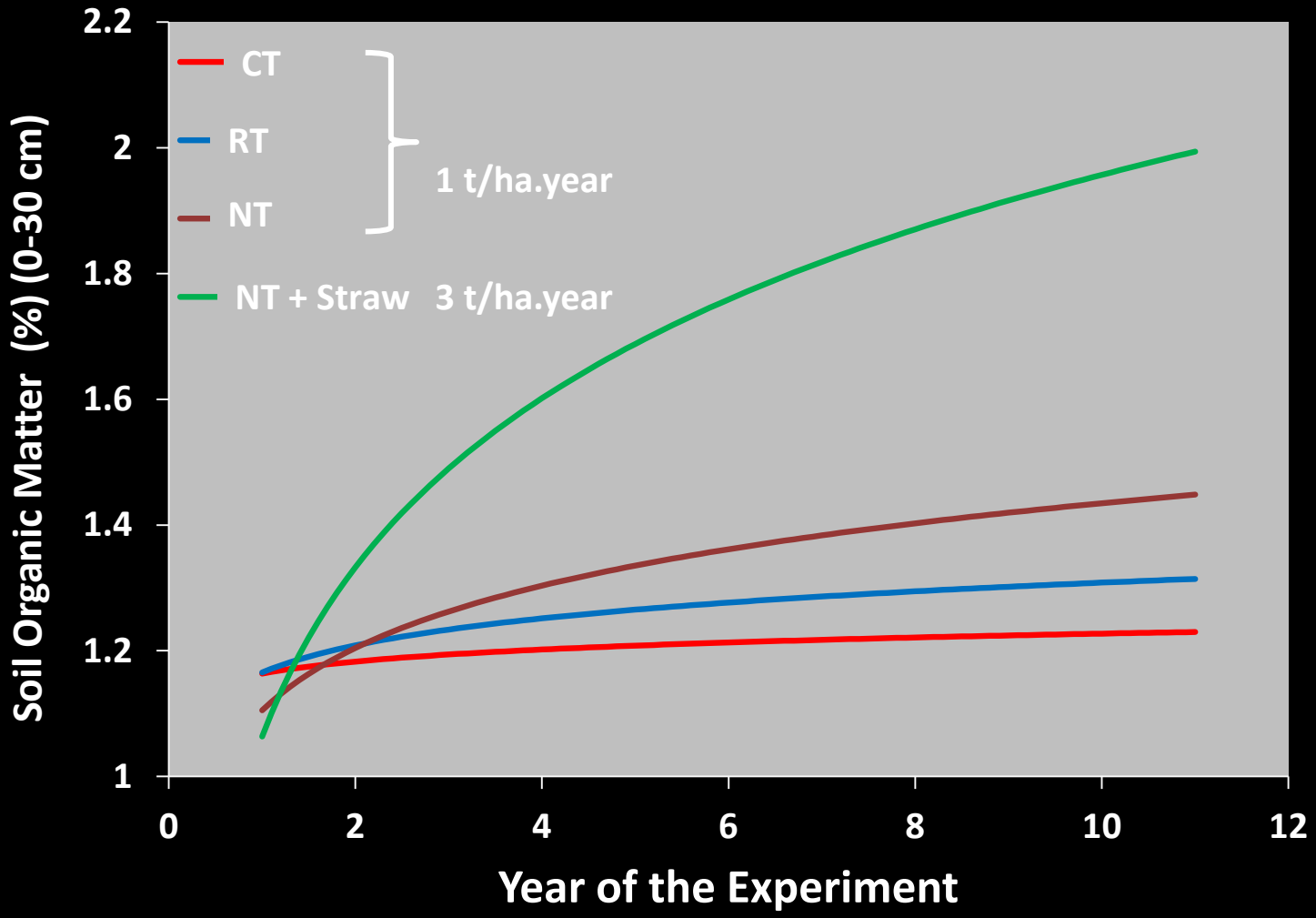
Carvalho et al. (1998)

Wheat response to N after different preceding crops
Vertic Clay Soil – Average of four years



Carvalho et al. (1998)

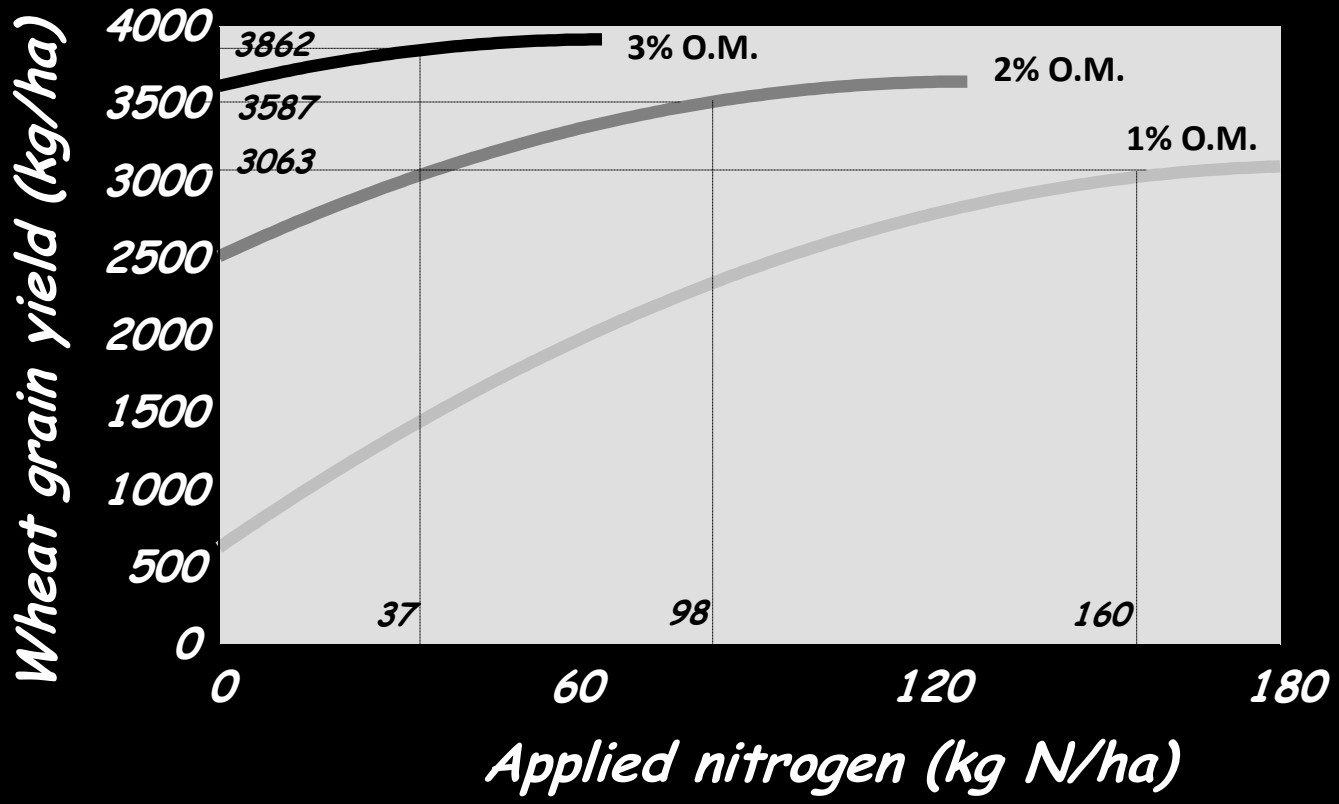
Soil Organic Matter Evolution under Different Tillage Systems
Revilheira Experimental Farm- Luvisol



Lupines -> Wheat -> Oat for Hey -> Barley

Carvalho et al (2012)

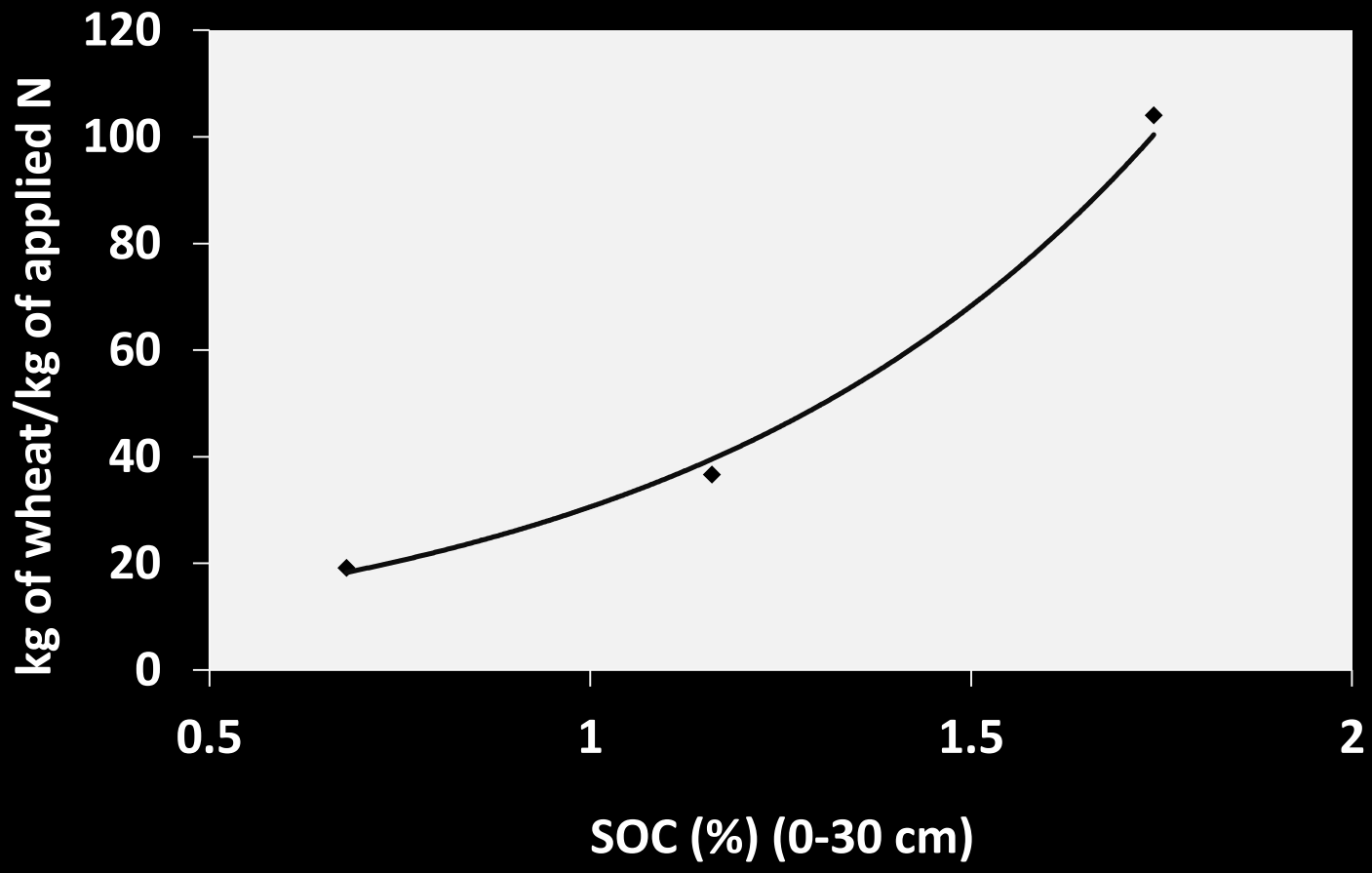
Effect of soil organic matter (O.M.) on the wheat response to nitrogen fertilization



$Y = 631 + 35\ N - 0.07\ N^2 + 2718\ \ln(O.M.) - 8.6N\ (O.M.)$ $(r^2=0.80\ \ p<0.001)$

Carvalho et al. (2005)

Effect of Soil Organic Carbon (SOC) (0-30 cm) on the Efficiency of Applied Nitrogen



Nitrogen Fertilization Experiment
26th March 2003/2004

Field under NT+Straw
1,2% C (0-30cm)

Field under CT
0.6% C (0-30 cm)

CONCLUSIONS

Use efficiency of applied nitrogen for cereal production under Mediterranean conditions:

- **Can be improved by Managing N fertilizer (amount and time) according "winter" rainfall in order to avoid mistakes (management model and soil transitability)**

- **But the benefits of using nitrification inhibitors or legumes do not seem to improve NUE significantly**

HOWERVER

- **Significant increases of applied NUE can only be achieved by *Increasing soil organic matter content***