

Biokenaf

Contract n°QLK5-CT2002-01729

2nd technical meeting
Athens, 23-24 October 2003

INRA CONTRIBUTION

Marie-Pierre Boutin

Samuel Quinton

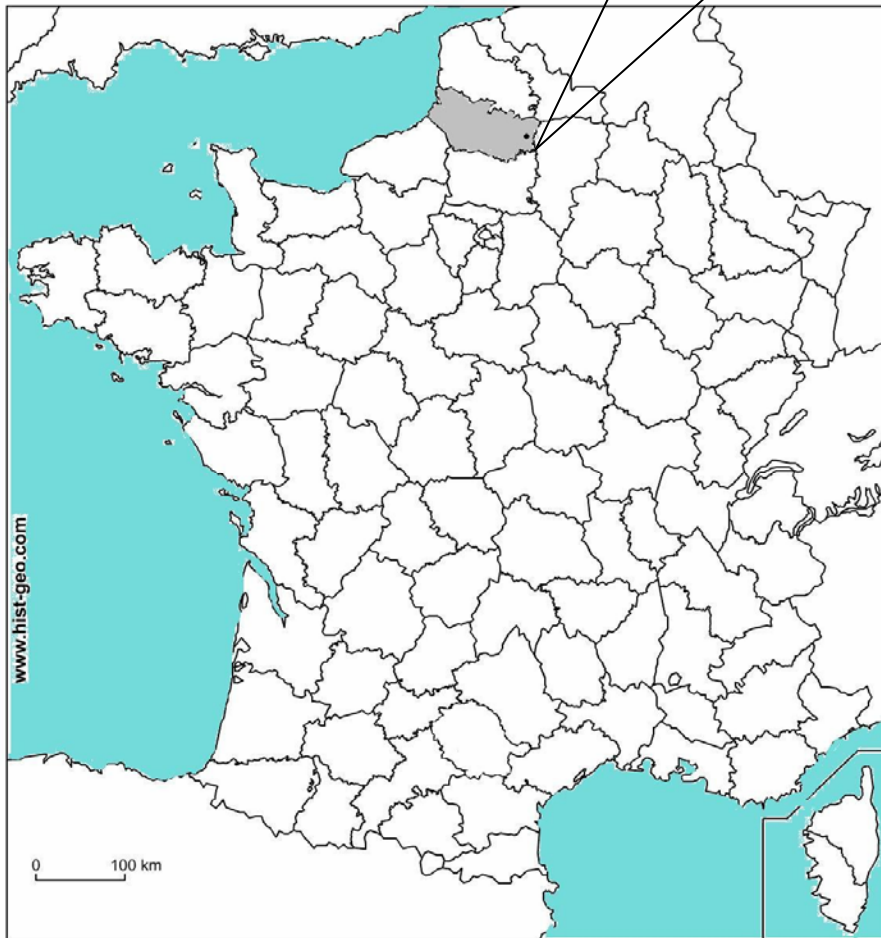
Supervisor : Ghislain Gosse

INRA main involvement

- ***WP2 : Adaptability and productivity field trials***
 - Task 2.2 : Effect of different sowing dates and plant populations on biomass yields.
 - Task 2.3 : Effect of irrigation and nitrogen fertilization on biomass yields.
- ***WP3 : Development of the crop growth simulation model***
 - Task 3.1 : Development, calibration and validation of the crop production simulation model.
- ***WP6 : Environmental impact assessment and life cycle analysis of kenaf production and use***

Trials localisation

Estrées-Mons
INRA centre



- **Lat.** 49°52'44'' ; **Long.** 03°00'27''
Alt. 85m
- **oceanic temperate climate**
- **Temperature** $T_m = 10.7^{\circ}\text{C}$
Spring : 13°C ; Summer : 17°C
Autumn : 7.5°C ; Winter : 5.5°C
- **Average rainfall** 703.5 mm/yr
Spring : 147 mm; Summer : 184 mm
Autumn : 243 mm; Winter : 133 mm
- **Average PET_0** 695.55 mm/yr
- **Soil type** organic clayey silt

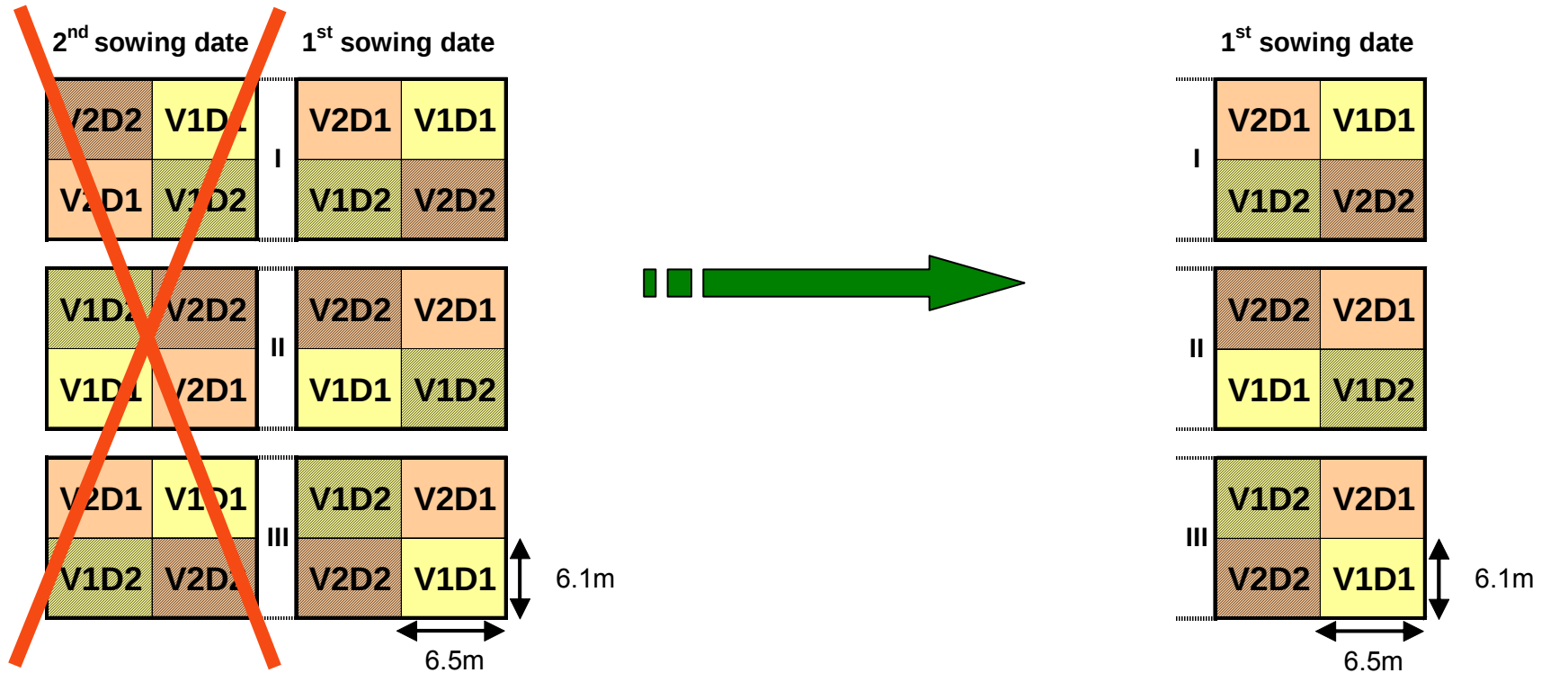
Data already collected

- **Meteorological data**
 - Temperature (min & max)
 - Global radiation
 - Precipitation
 - Air humidity
 - Wind speed
 - PET
- **Phenological data**
 - Date of emergence (50-100%)
- **Growth data (every 2 weeks)**
 - Plant height (5 plants per plot)
 - Stem diameter (5 plants per plot)
 - Number of leaves on primary axis
- **Productivity data (every 3 weeks)**
 - Fresh and dry matter (harvest row=2 m):
 - ✓ On leaf blades, stems and leaf stalks
 - ✓ Total
 - Leaf Area Meter

WP2 Task 2.2

Effect of different sowing dates and plant populations on biomass yields

Experimental design



Sowing dates

1st sowing date : 28/05/2003
2nd sowing date : 20/06/2003

Varieties

V1 = Everglades 41
V2 = Tainung 2

Densities

D1 = 200 000 plants/ha
D2 = 400 000 plants/ha

basic N Fertilization

N = 150 kg/ha

Crop management sequence

Previous crop

None

Harrowing (28/05)

Sowing (28/05)

Manual sowing machine

N fertilization (28/05)

150 kg/ha

Weed control (28/05)

alachlor : 2.4 kg a.i/ha

Pest management

Myzus persicae

1) Lambda-Cyhalothrine (27/06)

↪ 6.5 g a.i/ha

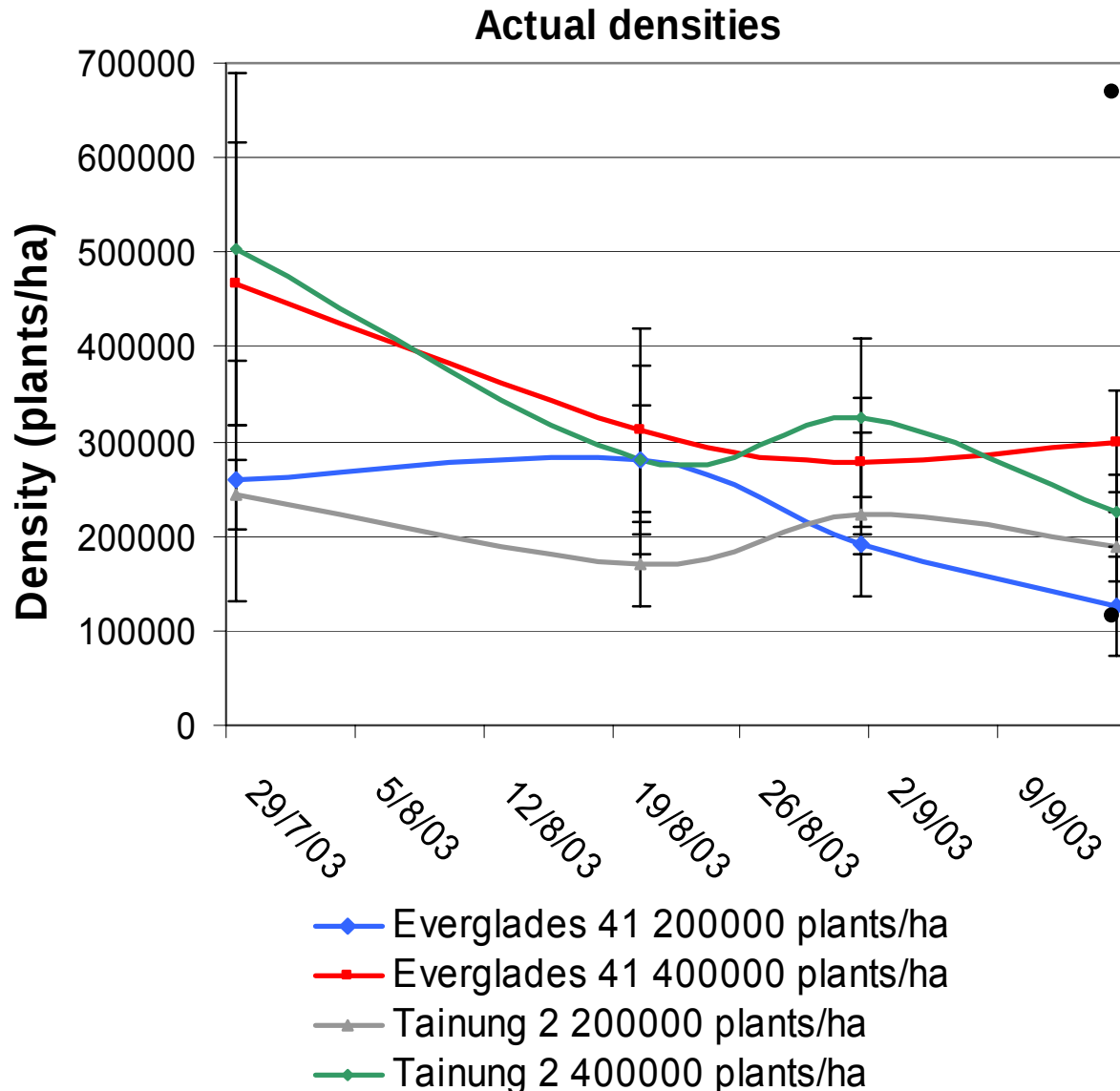
2) Lambda-Cyhalothrine (04/07)

↪ 7.5 g a.i/h

3) Lambda-Cyhalothrine + Pyrimicarbe (15/07)

↪ 7.5 g a.i /ha + ↪ 150 g a.i/ha

Actual densities



Sowing densities higher than those planned

↪ Strong standard deviation

↪ Proportion respected anyway

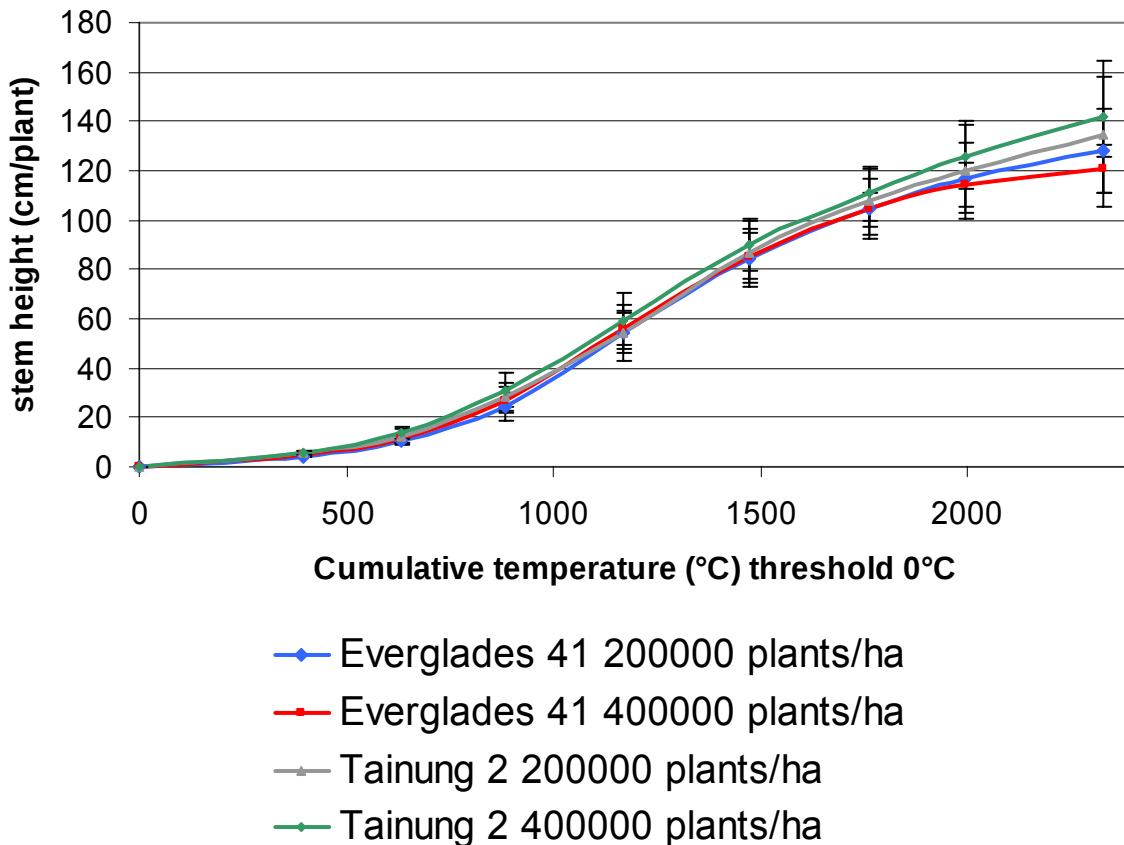
Self thinning for higher densities

↪ Equilibrium (between 155000 plants/ha and 260000 plants/ha)

Results / discussion

Stem height

Stem height evolution function of variety and density

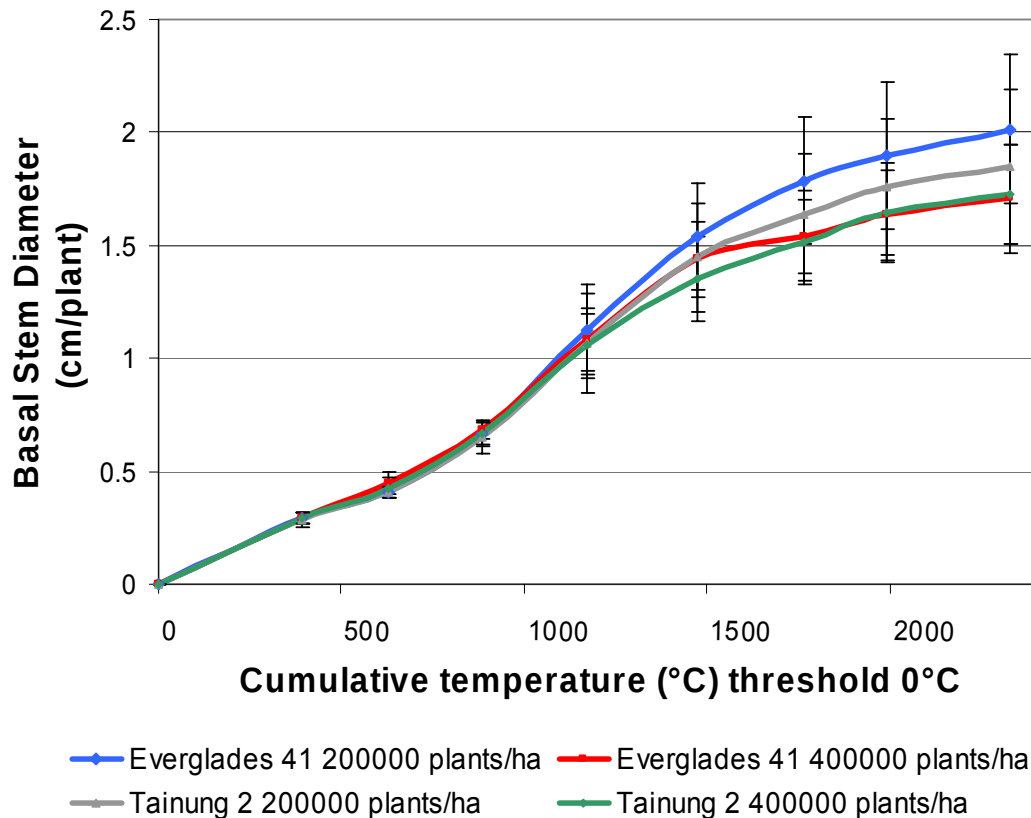


- Hypothesis :
 - ↳ Temperature threshold of growth = 0°C (No reference found)
- Variety effect :
 - ↳ Tainung 2 > Everglades 41
- Density effect :
 - ↳ Not obvious
- Stem heights in September :
 - ↳ Everglades 41 : 127 cm
 - ↳ Tainung 2 : 140 cm

Results / discussion

Stem diameter

Evolution of stem diameter fonction of variety and density

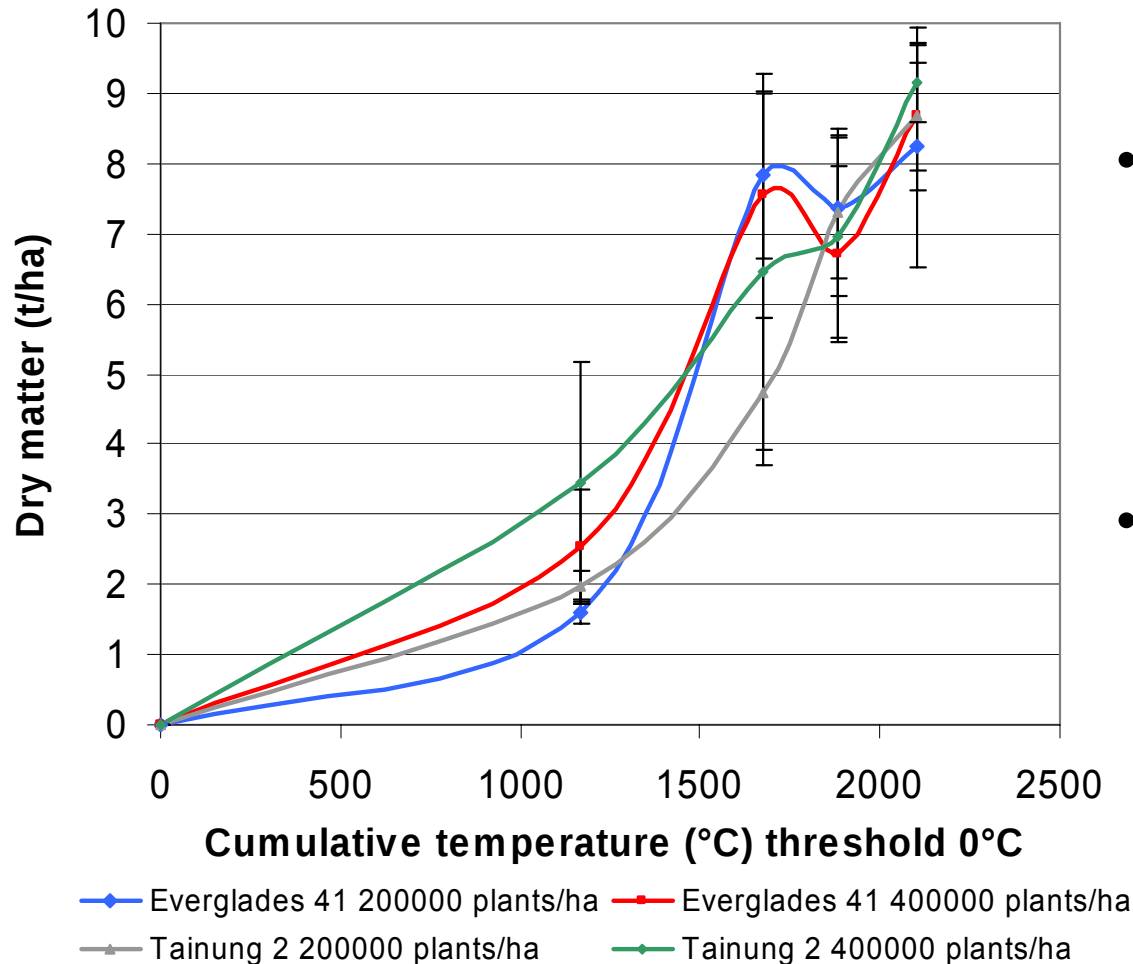


- Density effect :
 - ↳ Stem diameter thicker at lowest density
- Variety effect :
 - ↳ Not obvious
- Diameter in September :
 - ↳ 17-20 mm

Results / discussion

Dry matter yield

Evolution of dry matter function variety and density

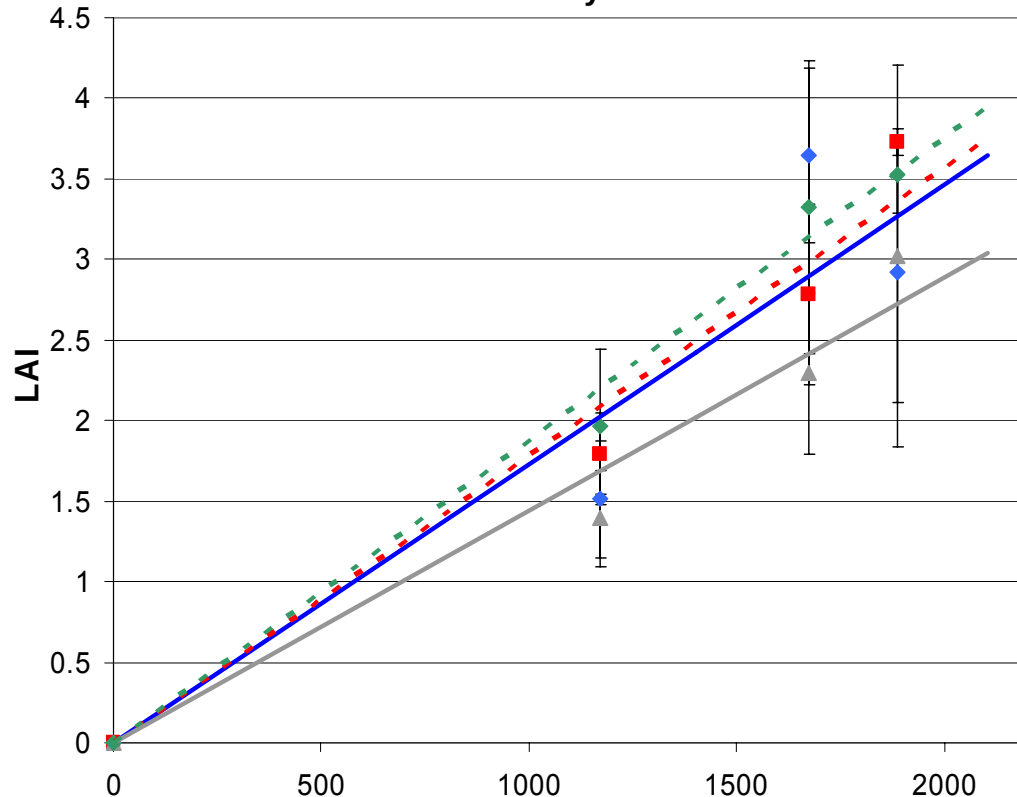


- Density and variety effects
 - ↳ Not obvious
- Best dry matter yields in September
 - ↳ 8-9 t/ha

Results / discussion

Leaf Area Index

Evolution of Leaf Area Index function of variety and density



- ◆ Everglades 41 200000 plants/ha
- ▲ Tainung 2 200000 plants/ha
- Linéaire (Everglades 41 200000 plants/ha)
- Linéaire (Tainung 2 200000 plants/ha)
- Everglades 41 400000 plants/ha
- ◆ Tainung 2 400000 plants/ha
- - Linéaire (Everglades 41 400000 plants/ha)
- - Linéaire (Tainung 2 400000 plants/ha)

- Strong standard deviation
- Slight effect of density (?)
- No variety effect

Task 2.2

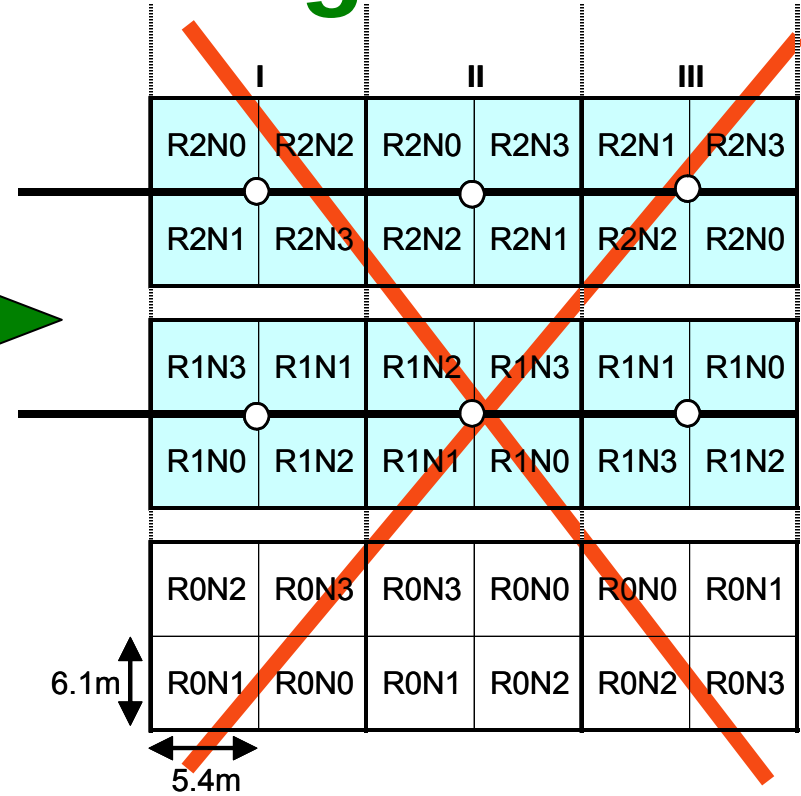
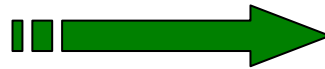
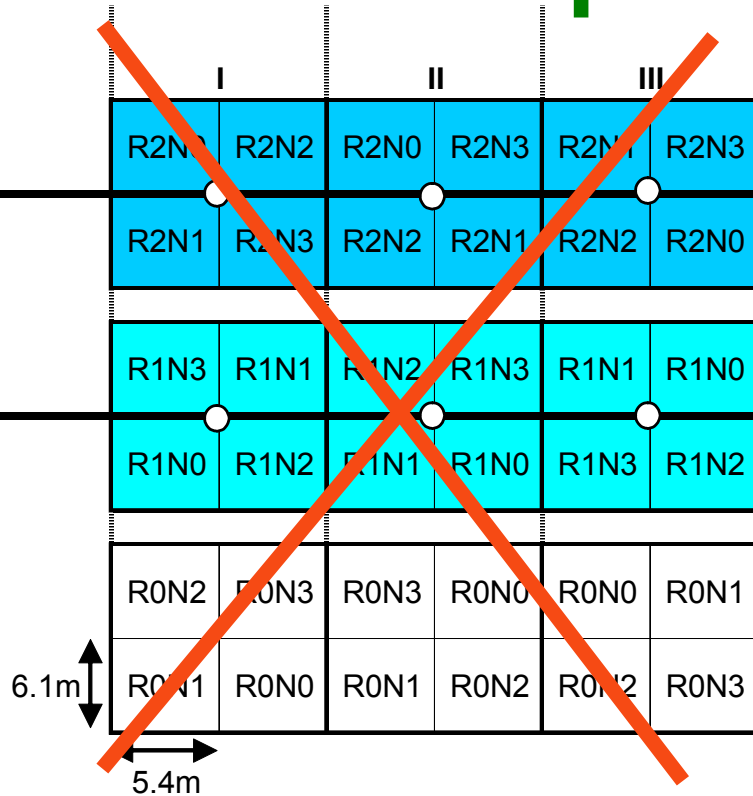
Conclusion

- Effects of density :
 - ↳ Higher stem diameter at lower density
 - ↳ Kenaf is thinning itself at higher density
 - ⇒ New densities could be tested in North France : 100000 plants/ha and 200000 plants/ha
- Effects of variety
 - ↳ No major difference between varieties except the height (Tainung 2 > Everglades 41)

WP2 Task 2.3

Effect of irrigation and nitrogen fertilization on biomass yields

Experimental design



Variety Gregg

Irrigation

R0 = no irrigation

R1 = 60% of PET

R2 = 100% of PET

Density 200 000 plants/ha

N Fertilization

N0 = no fertilization

N1 = 50 kg N/ha

N2 = 100 kg N/ha

N3 = 150 kg N/ha

Total Irrigation

40mm

Crop management sequence

Previous crop

None

Harrowing (28/05)

Sowing (28/05)

Pneumatic sowing machine

N fertilization (28/05)

Weed control (28/05)

alachlor : 2.4 kg a.i/ha

Pest management

Myzus persicae

1) Lambda-Cyhalothrine (27/06)

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3) Lambda-Cyhalothrine + Pyrimicarbe (15/07)

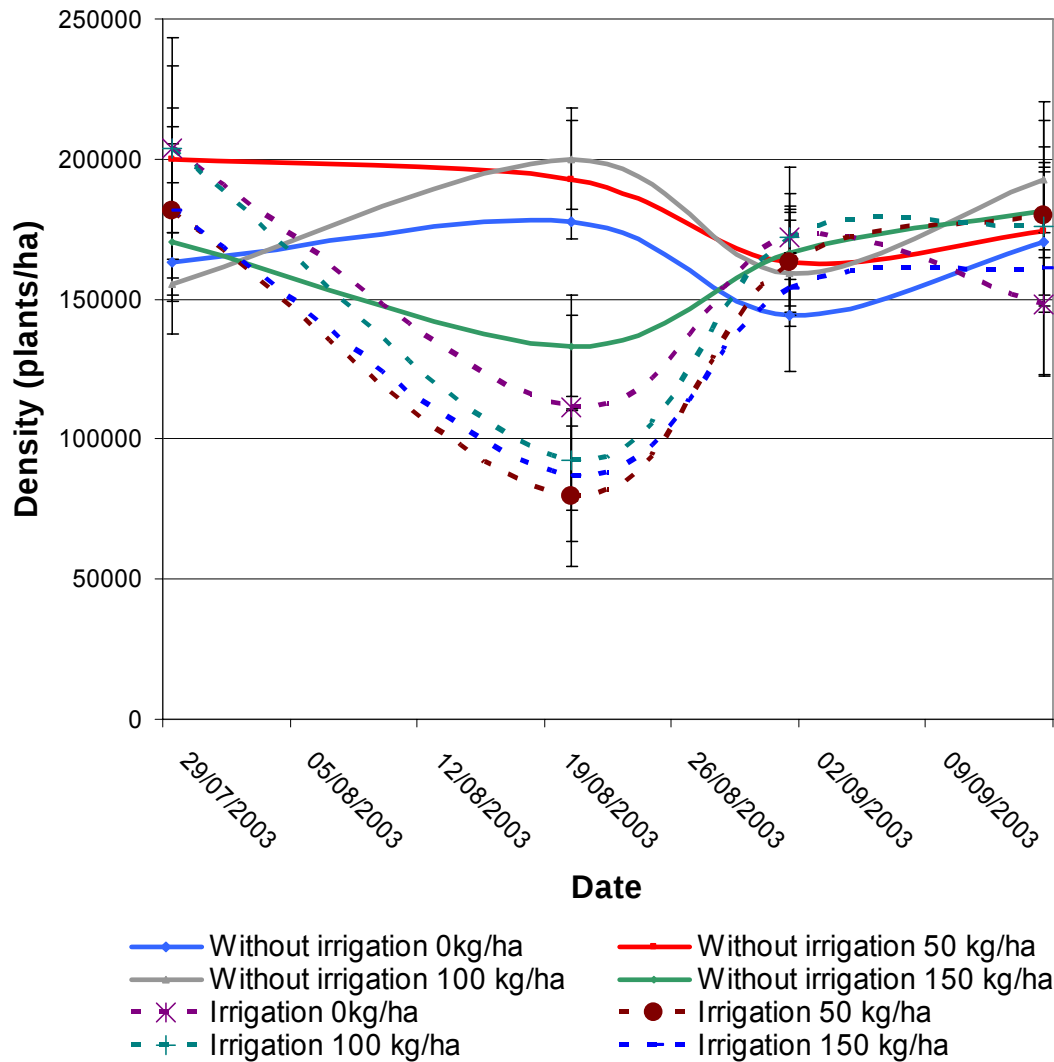
↪ 7.5g a.i /ha + ↪ 150g a.i/ha

Irrigation (12-13/08)

Sprinklers : 40 mm

Actual densities

Densities

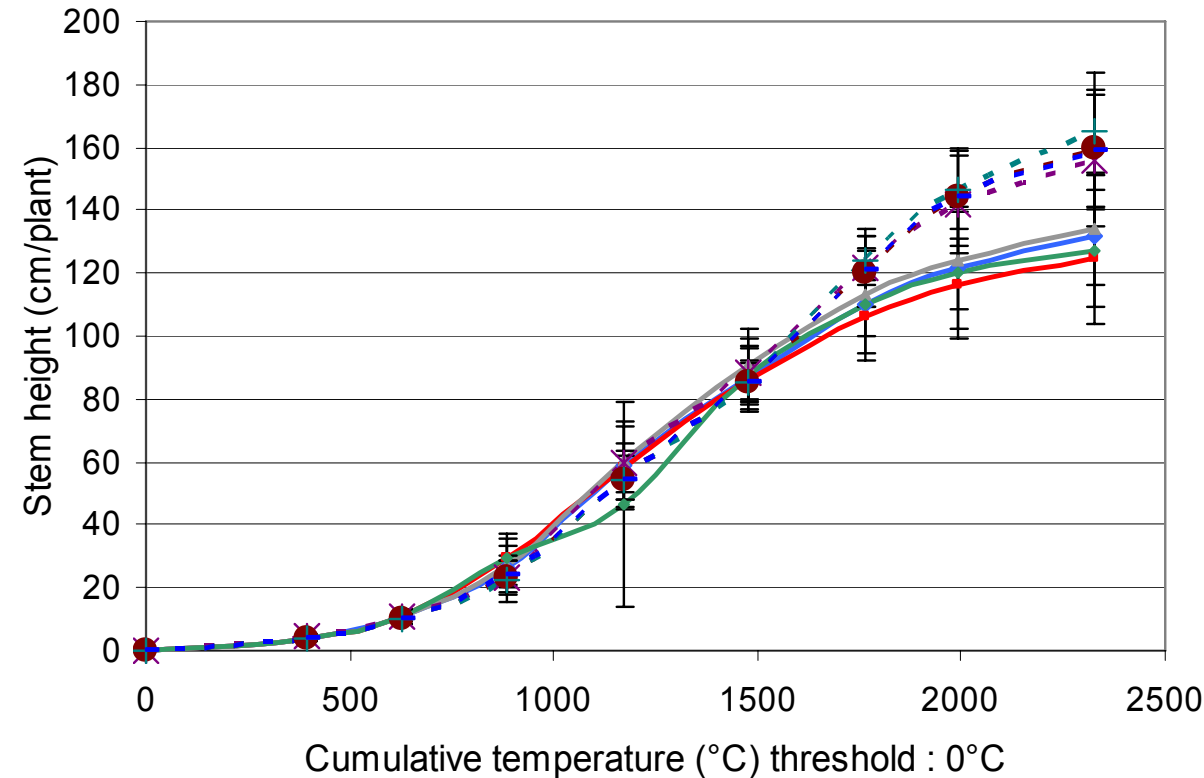


- Constant density during the growing period

Results / discussion

Stem height

Evolution of stem height function of fertilization and irrigation



- N fertilization effect :
 ↪ No effect observed
 (Initial N soil residue: 28.5 kg/ha)
- Irrigation effect :
 ↪ Plants higher with irrigation

—◆— 0 kg N/ha without irrigation —●— 50 kg N/ha without irrigation
 —▲— 100 kg N/ha without irrigation —◆— 150 kg N/ha without irrigation
 - - * - - 0 kg N/ha irrigation - - ● - - 50 kg N/ha irrigation
 - - + - - 100 kg N/ha irrigation - - - - - 150 kg N/ha irrigation

Stem diameter

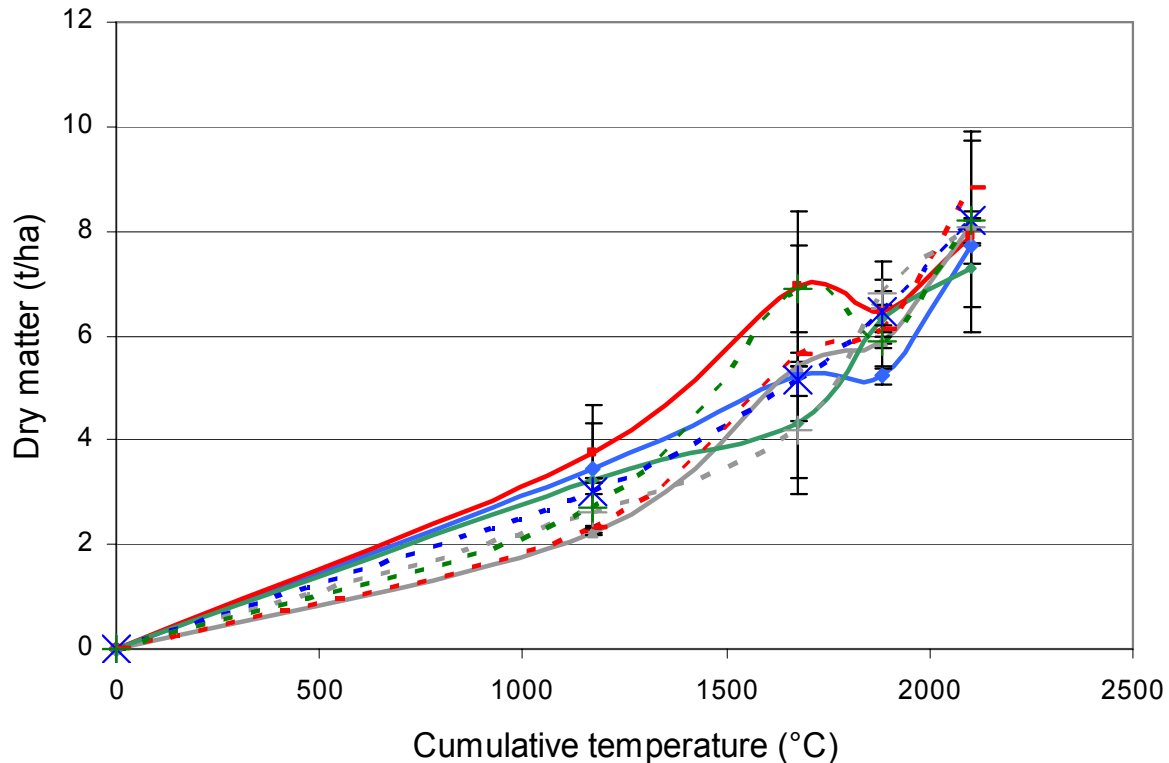
Figure 1 is a line graph showing the relationship between cumulative temperature threshold (°C) and stem diameter (cm/plant) for six different plant species. The x-axis represents the cumulative temperature threshold in °C, ranging from 0 to 2500. The y-axis represents the stem diameter in cm/plant, ranging from 0 to 2.5. The data points for each species are connected by lines, and error bars are included for each measurement. The species are: 1) Green circles (solid line), 2) Blue squares (dashed line), 3) Red triangles (dotted line), 4) Purple diamonds (dash-dot line), 5) Orange crosses (long-dashed line), and 6) Grey triangles (solid line). All species show a positive correlation, with diameter increasing as cumulative temperature increases. The species with the highest diameter at a given temperature threshold are the blue squares and red triangles, while the species with the lowest diameter are the orange crosses and grey triangles.

- Slight effect of irrigation
- No effect of fertilization



Dry matter yield

Evolution of dry matter function of fertilization and irrigation



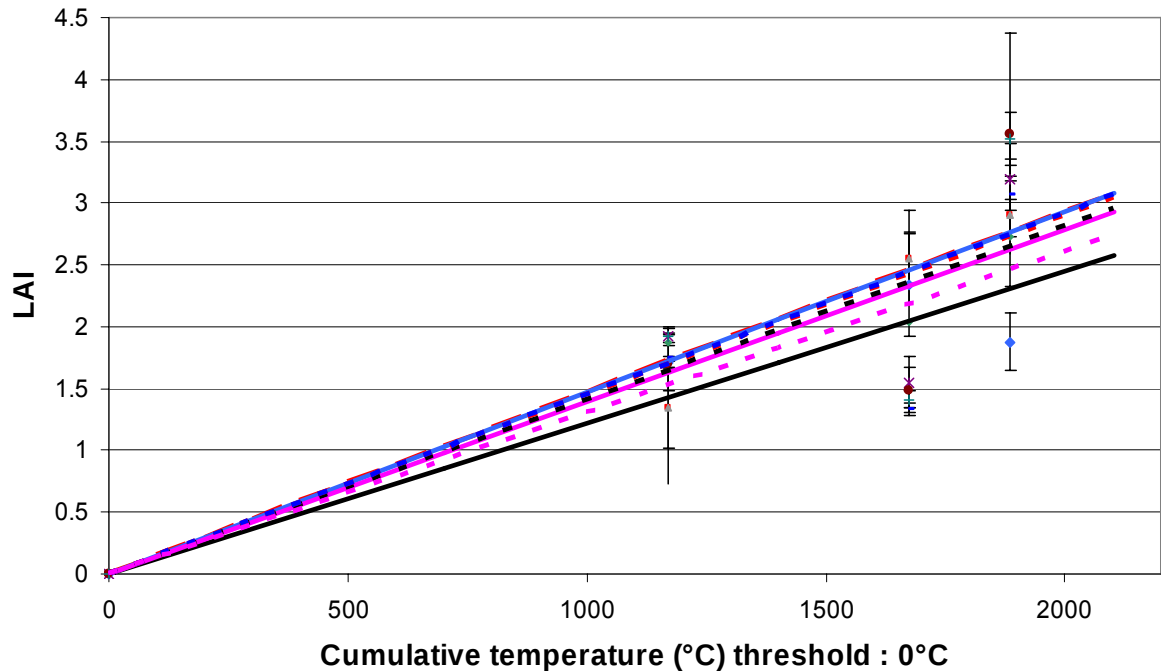
- No N-fertilization effect
- No irrigation effect



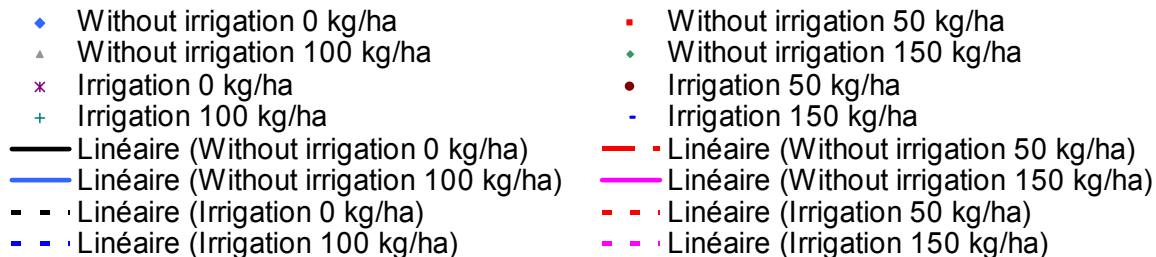
Results / discussion

Leaf Area Index

Evolution of Leaf Area Index function of fertilization and irrigation



- No obvious effect of irrigation or N- fertilization



Task 2.3

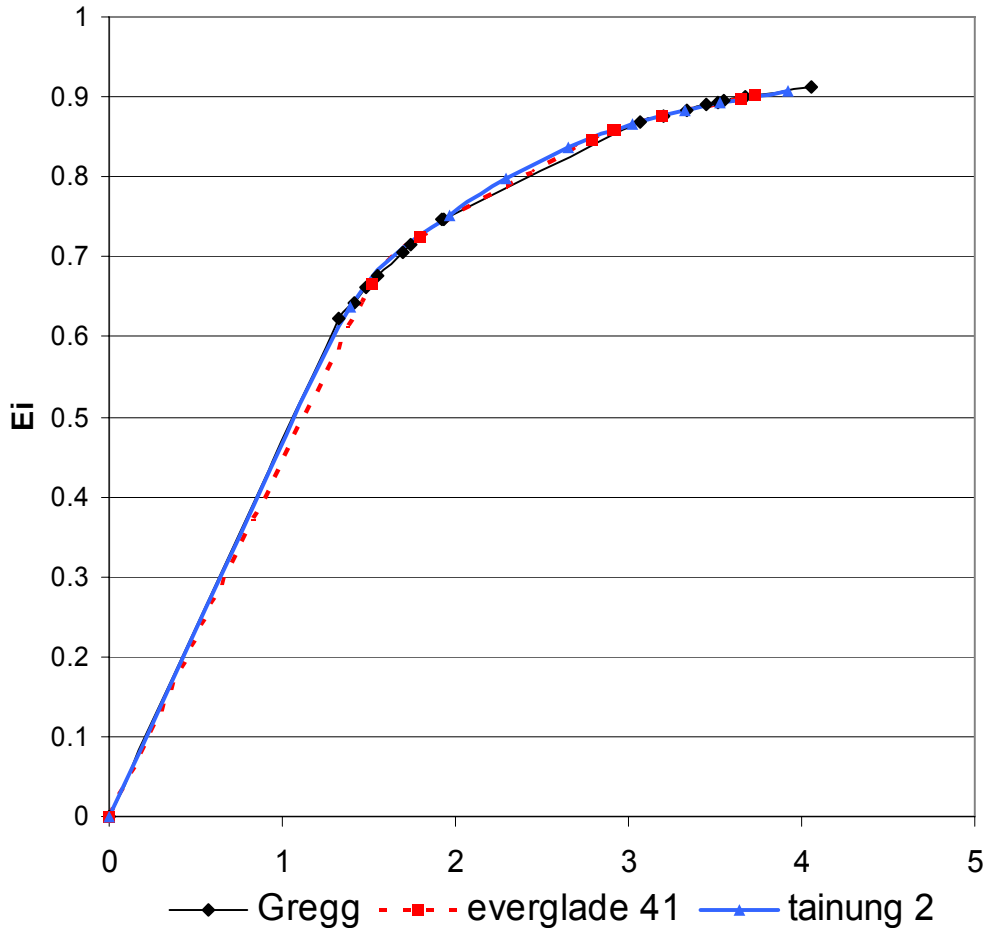
Conclusion

- N fertilization effect
 - ↳ No particular effects of N-fertilization at the tested levels
 - ⇒ 3 new levels (0, 150 and 300kg/ha) to test in north of France
 - Irrigation effect
 - ↳ Obvious effect of irrigation on stem height but not on dry matter yield
- ⇒ Potential Yield in North of France in 2003 without irrigation or N-fertilization : 8 t/ha

Modelling

Determination of Radiation Interception Efficiency

Relationship between radiation interception efficiency and Leaf Area Index

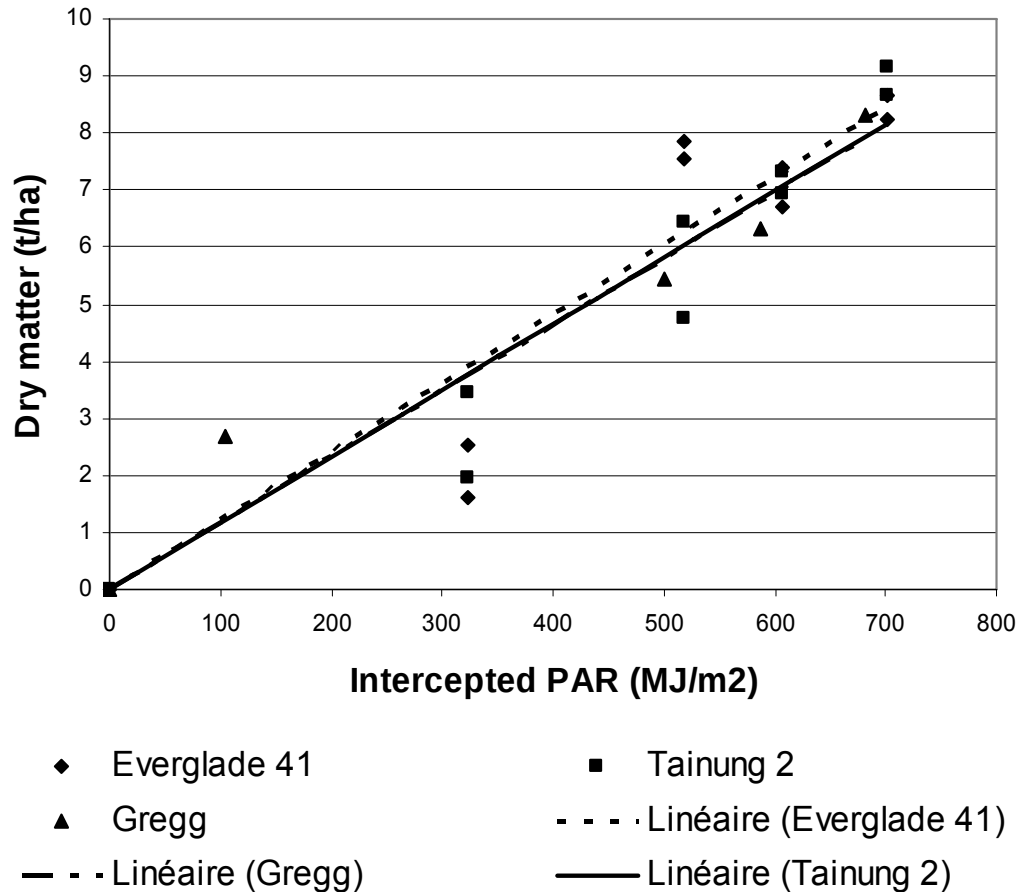


- $\epsilon_i = 0.95 \times (1 - \exp(-k \times LAI))$
- Hypothesis $k=0.8$ for kenaf
 - Zea Mays :
 - $k=0.5$
 - Helianthus annuum
 - $k=1$

Modelling

Determination of Radiation Use Efficiency

Determination of Radiation Use efficiency
of Tainung 2

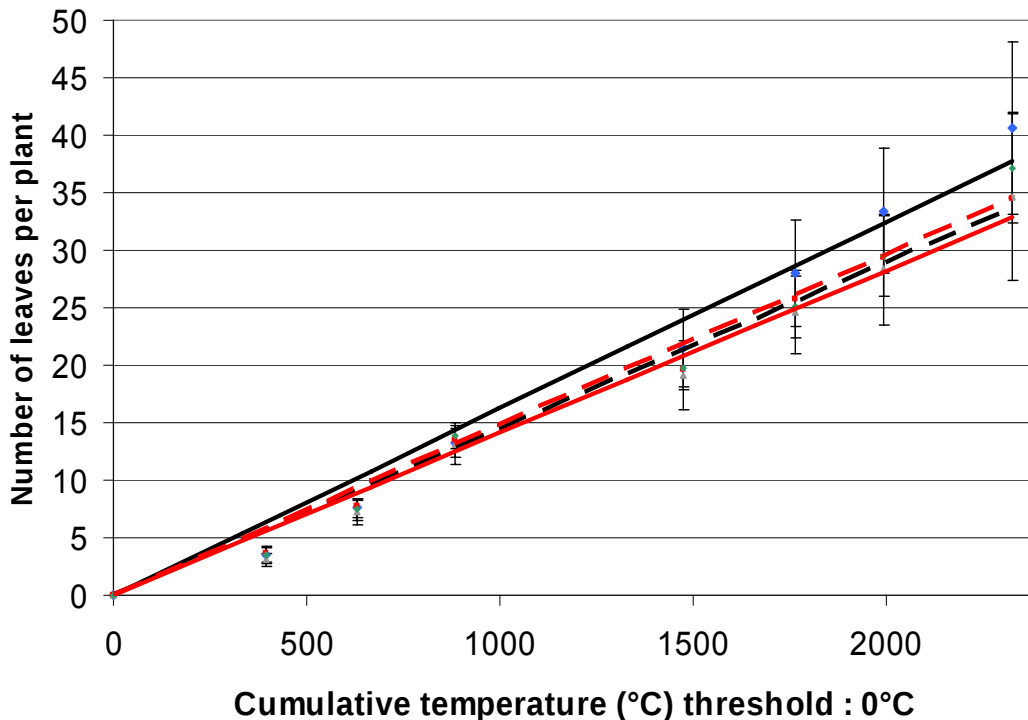


- Slight difference between varieties
 - ↳ Everglades 41: 1.21 g/MJ
 - ↳ Tainung 2 : 1.16 g/MJ
 - ↳ Gregg : 1.16 g/MJ
- Low value compared to other C3 species
 - ↳ *Triticum spp.* : 2 g/MJ
 - ↳ *Festuca spp.* : 1.89 g/MJ

Modelling

Determination of Phyllochron (task 2.2)

Evolution of number of leaves on primary axis fonction
of variety and density



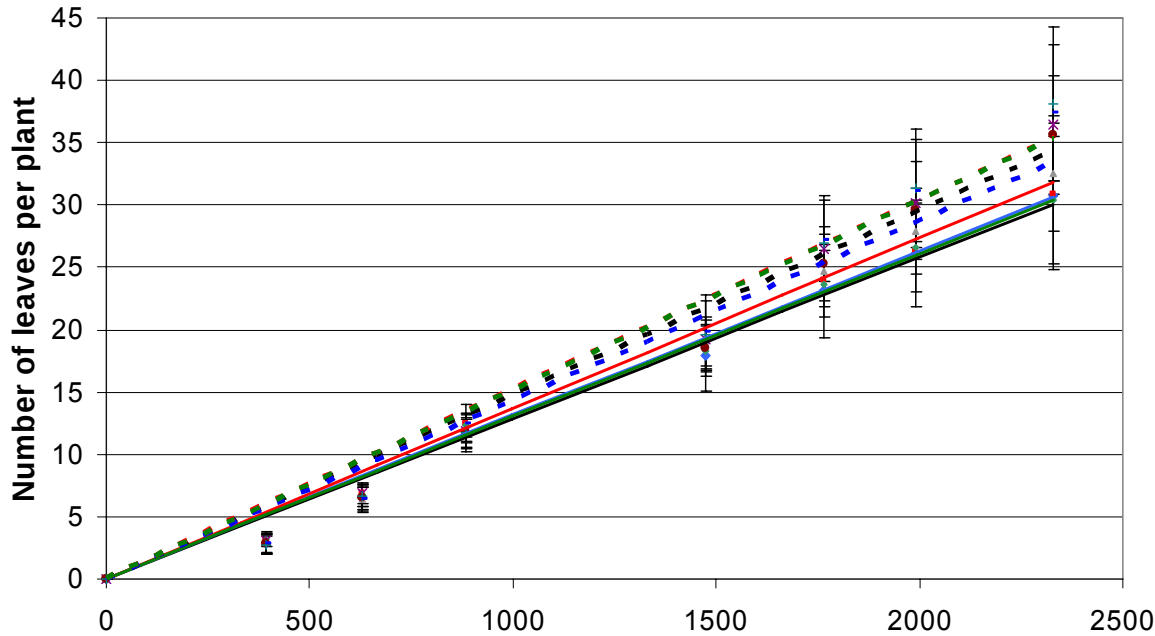
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- Everglade 41 400000 plants/ha
- Tainung 2 400000 plants/ha
- Linéaire (Everglade 41 400000 plants/ha)
- Linéaire (Tainung 2 400000 plants/ha)

- Phyllochron
 - ↳ Everglades 41 :
0.015 leaf/°C
($\pm 8.5 \times 10^{-4}$)
 - ↳ Tainung 2 :
0.014 leaf/°C
($\pm 3.5 \times 10^{-4}$)
- Effect of density :
not obvious
- Slight difference
between varieties

Modelling

Determination of phyllochron (task 2.3)

Evolution of number of leaves on primary axis fonction of fertilization and irrigation



- ◆ 0 kg N/ha without irrigation
- ▲ 100 kg N/ha without irrigation
- ✕ 0 kg N/ha irrigation
- + 100 kg N/ha irrigation
- Linéaire (0 kg N/ha without irrigation)
- Linéaire (100 kg N/ha without irrigation)
- - Linéaire (0 kg N/ha irrigation)
- - Linéaire (100 kg N/ha irrigation)
- 50 kg N/ha without irrigation
- ◆ 150 kg N/ha without irrigation
- 50 kg N/ha irrigation
- 150 kg N/ha irrigation
- Linéaire (50 kg N/ha without irrigation)
- Linéaire (150 kg N/ha without irrigation)
- - Linéaire (50 kg N/ha irrigation)
- - Linéaire (150 kg N/ha irrigation)

- Effect of irrigation on phyllochron
 - with irrigation : 0.015 leaf/°C ($\pm 3.5 \cdot 10^{-4}$)
 - without irrigation : 0.013 leaf/°C ($\pm 3 \cdot 10^{-4}$)
- No effect of fertilization

Work to do in WP 2

- **Until the end of 2003**

- Dates of flowering (50% and 100%)
- Harvest : October and December
- Analysis N,P,K of plants
 - for stems, leaves and leaf stalks
- Statistical Analysis of our data

- **In 2004**

- Densities, varieties and sowing dates in Estrées-Mons (North France)
- N fertilization and irrigation trials in Toulouse (South France)

Questions

- Differences expected between Tainung 2 and Everglades 41 ?
- Effect of N-fertilization expected ?
- Densities : how to increase homogeneity in trials ?
- Natural enemies of kenaf ?
- Value of Temperature threshold of growth ?
- Value of K ?

Kenaf flower





- Losses of plantlets on the 2nd sowing date trial (unknown causes).



- Heterogeneity of sowing density
- Sowing date : 28/05/03
- Date of emergence :
 - 50% : 02/06/03
 - 100% : 09/06/03

Manual sowing machine



Pneumatic sowing machine



Difference in stem heights between varieties

Everglades 41

Tainung 2



Morphological difference between leaf blades

Everglades
41



Tainung 2

