Biomass Production Chain and Growth Simulation Model for Kenaf

University of Thessaly *(UTH)*

Department of Agriculture,

Crop Production & Agricultural Environment

Project: BIOKENAF

(QLK5-CT-2002-01729)

5rth technical meeting, Catania 5-6/7/05

Experimental year 2004

WP2 (tasks 2.2 and 2.3)

Adaptability and Productivity field experiments

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11.07.2004 16:53

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11.07.2004 16:59

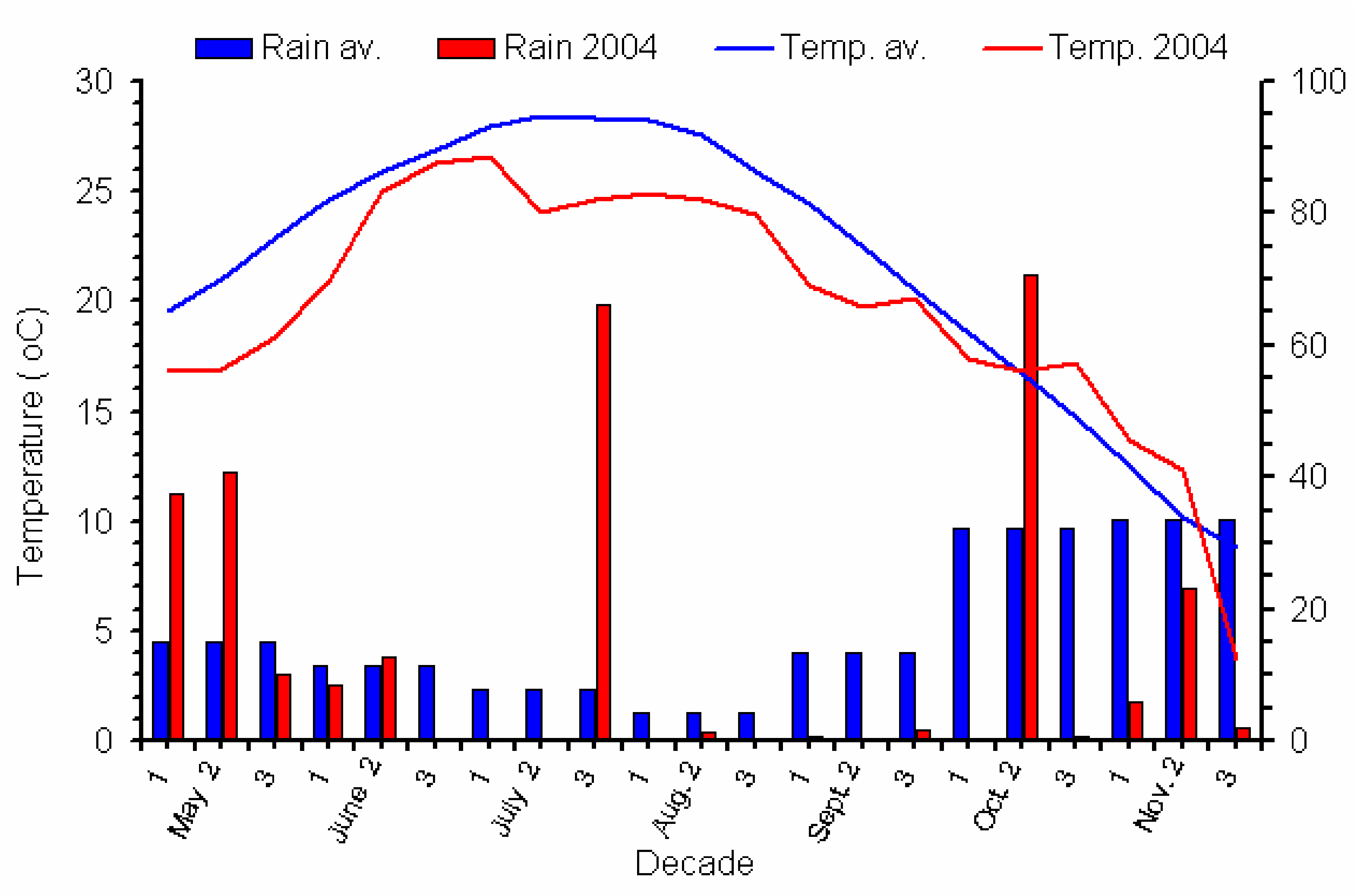
Area

Experiments established exactly at the same plots as the experimental year 2003

The field experiment was carried out on a deep, fertile, loamy soil located in Palamas (Karditsa, western Thessaly, Greece, 3 km south east of the village of Palamas, coordinates: $39^o 25'43.4''$ N, $22^o 05'09.7''$ E, altitude 107.5 m) in 2004

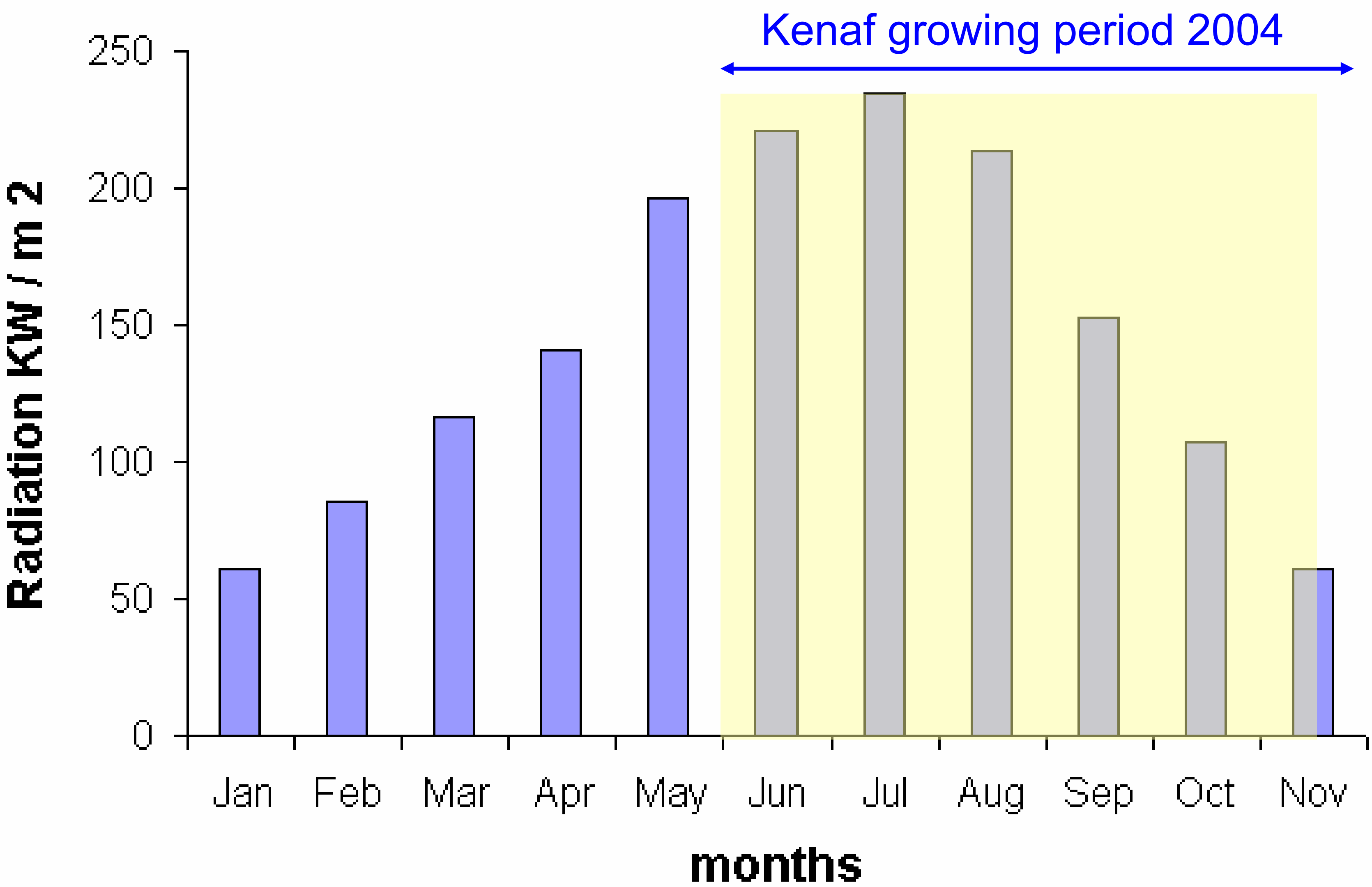
The soil is classified as Aquic Xerofluvent, having groundwater table fluctuating from some 150-200 cm below the surface in May (180 cm on June 1^{st})

Climate data: Temperature / precipitation [1]



Effective rainfall: 176 mm (Start June – End October)

Climate data, Cumulative Irradiance [2]



Task 2.2 [1]

A 2x2x2 factorial completely randomized block design in 3 blocks

Factors:

Variety:	V_1 = Tainnung 2 V_2 = Everglades 41
Sowing date:	S_1 = 01/06/04 S_2 = 01/07/04
Plant density:	D_1 = 20 plants m^{-2} D_2 = 40 plants m^{-2}

(in reality for the D_2 plantation achieved 30 pl m^{-2})

Task 2.2 [2]

<ins>Basal dressing</ins> of 50 kg P and 100 kg K ha^{-1} (29/5/2004)

<ins>Top dressing</ins> of 100 kg N ha^{-1} (plant height 50 cm)

Crop received <ins>drip irrigation</ins> (total 500 mm) until 07/10/2004

<ins>Measurements</ins>: plant height, stem diameter, number of nodes per plant, LAI, SLA, fresh and dry biomass productivity (leaves, stems, storage organs) of the crop

<ins>Dates of harvests</ins>: 4/7, 21/7, 4/8, 19/8, 8/9, 2/10, 30/10 and 19/11/2004.

<ins>Soil</ins>: water content (g g^{-1}) in 3 depths and 3 Irrigation intervals

Task 2.2 [3]

Photosynthesis data:

Radiation (0-1000 W m^{-2}) x Temperature (5-40 ^{o}C) x Development stage (July-August-September) x variety (Tainnung 2, Everglades 41)

Flowering:

		0%	10%	50%
S_1:	Tainnung	270	282	290
	Everglades	282	289	297
S_2:	Tainnung	288	296	303
	Everglades	291	298	308

at Joulean days

Task 2.2 [4]

Results:

Plant height (cm)

Stem diameter (cm)

Number of main nodes (stem) per plant

Dry / fresh ratio

Specific leaf area (kg m^{-2})

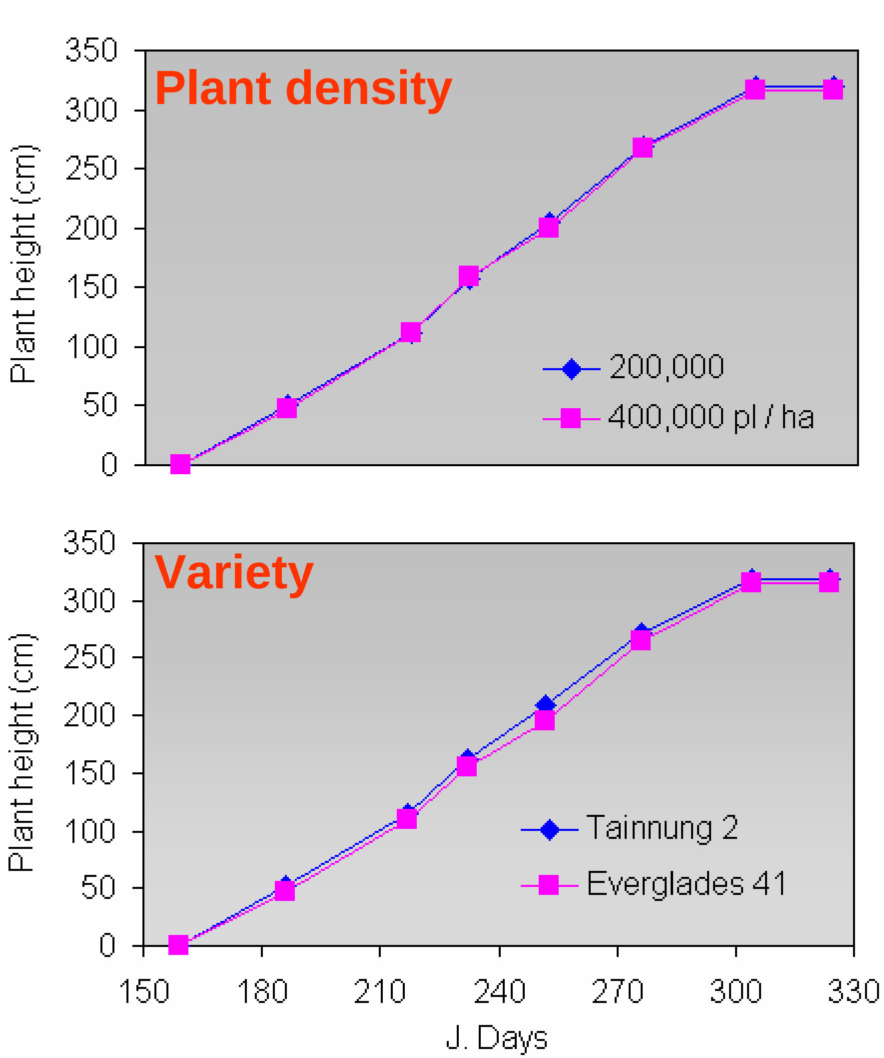
Leaf area index (m^2 leaf / m^2 ground)

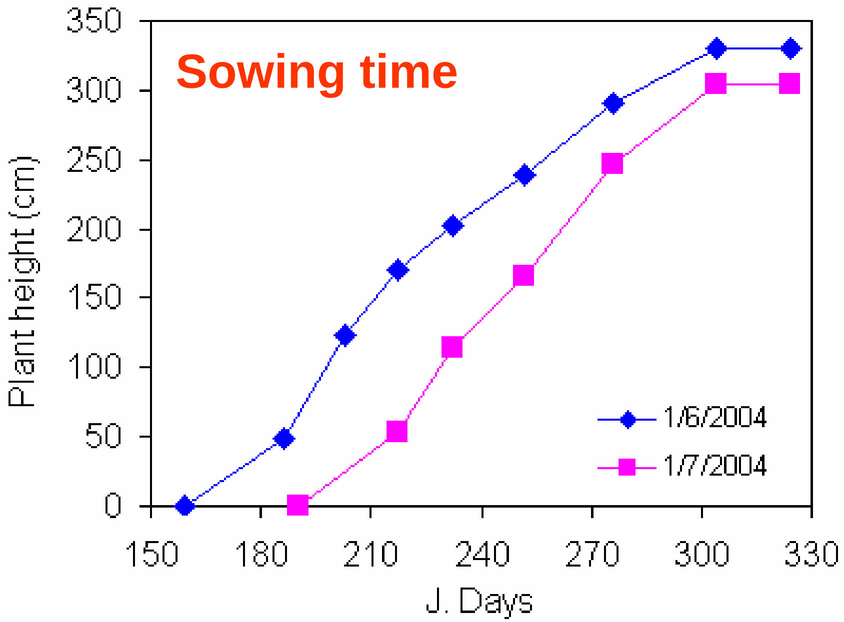
Dry stem biomass (t ha^{-1})

Total dry biomass (t ha^{-1})

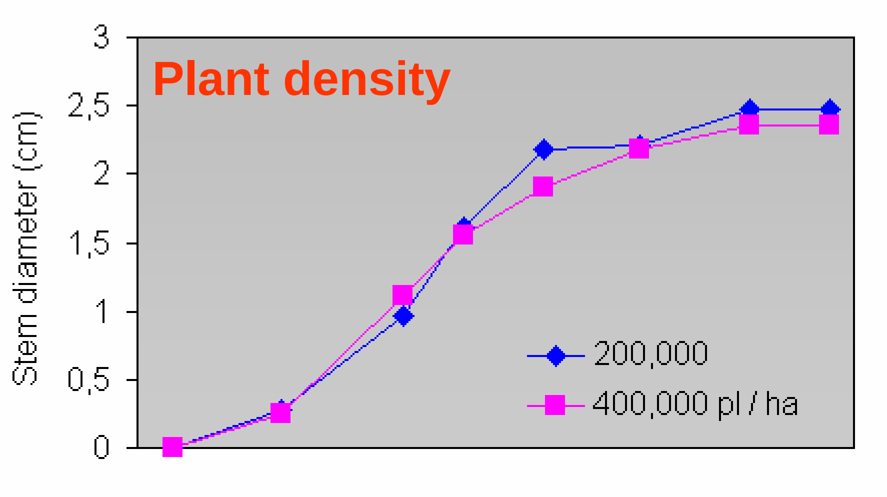
Photosynthesis (light- and temperature- response curve)

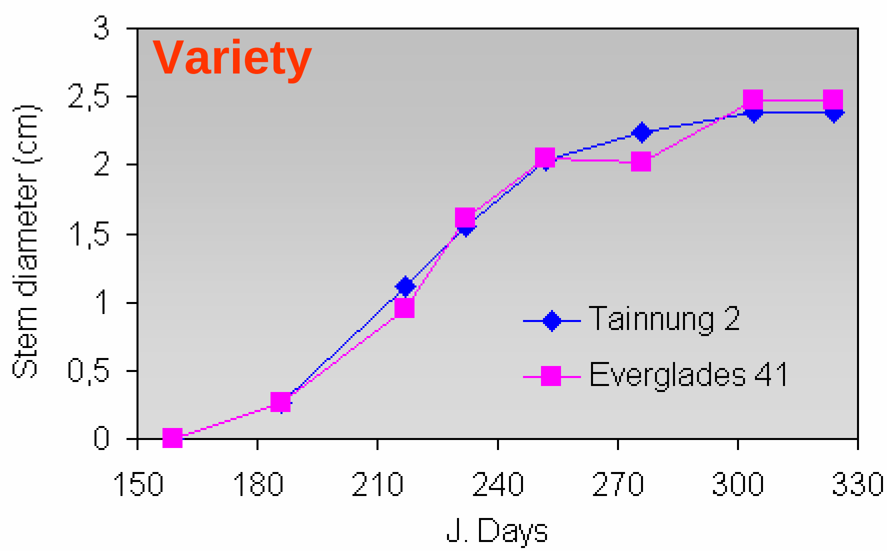
Task 2.2, Plant height (cm)

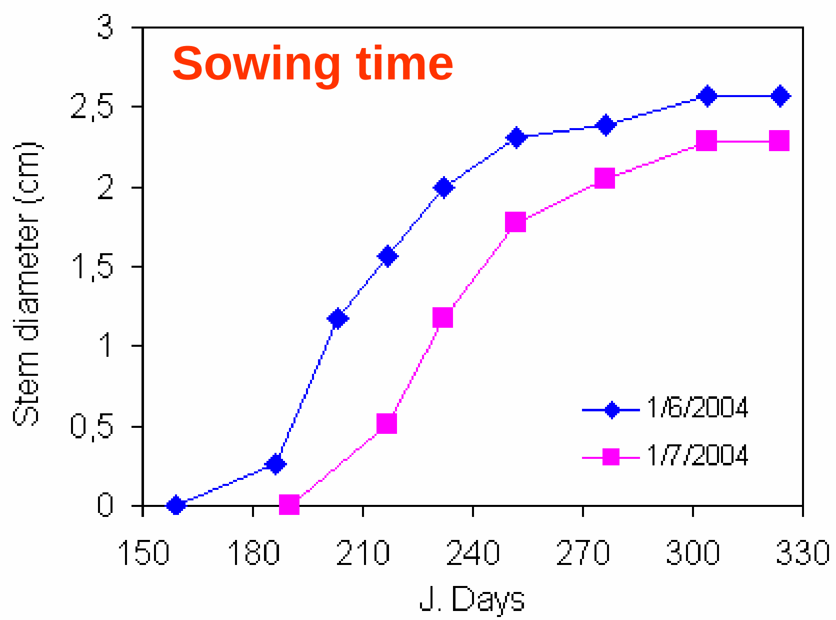




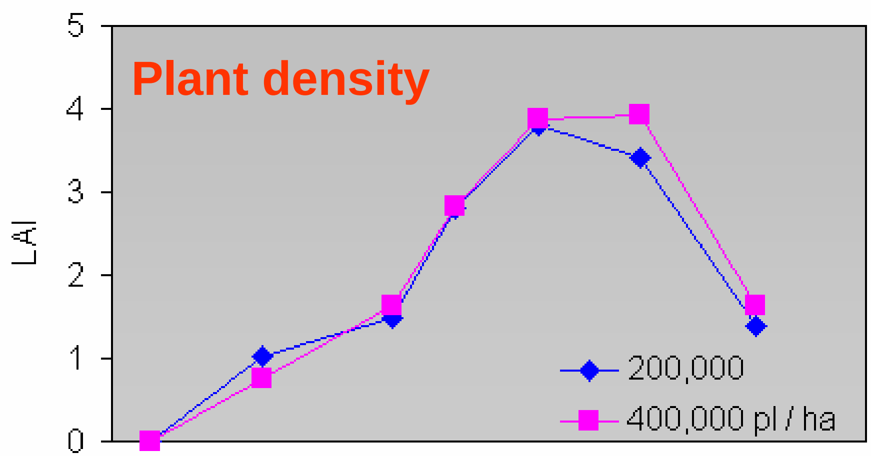
Task 2.2, Stem diameter (cm)

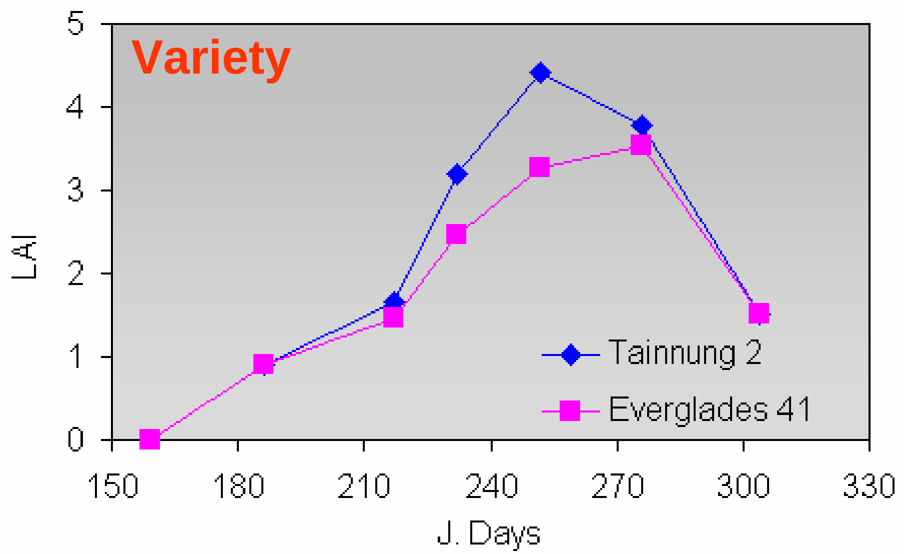


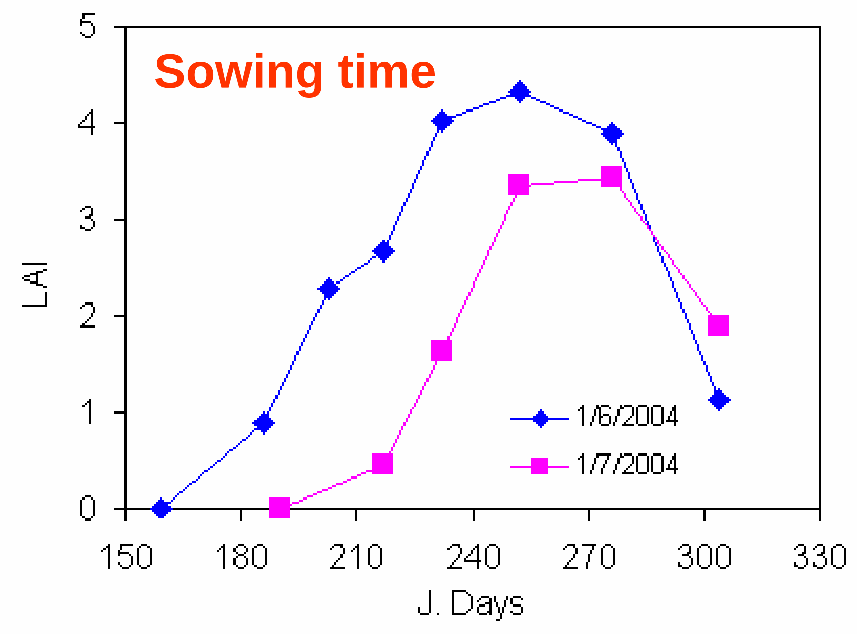




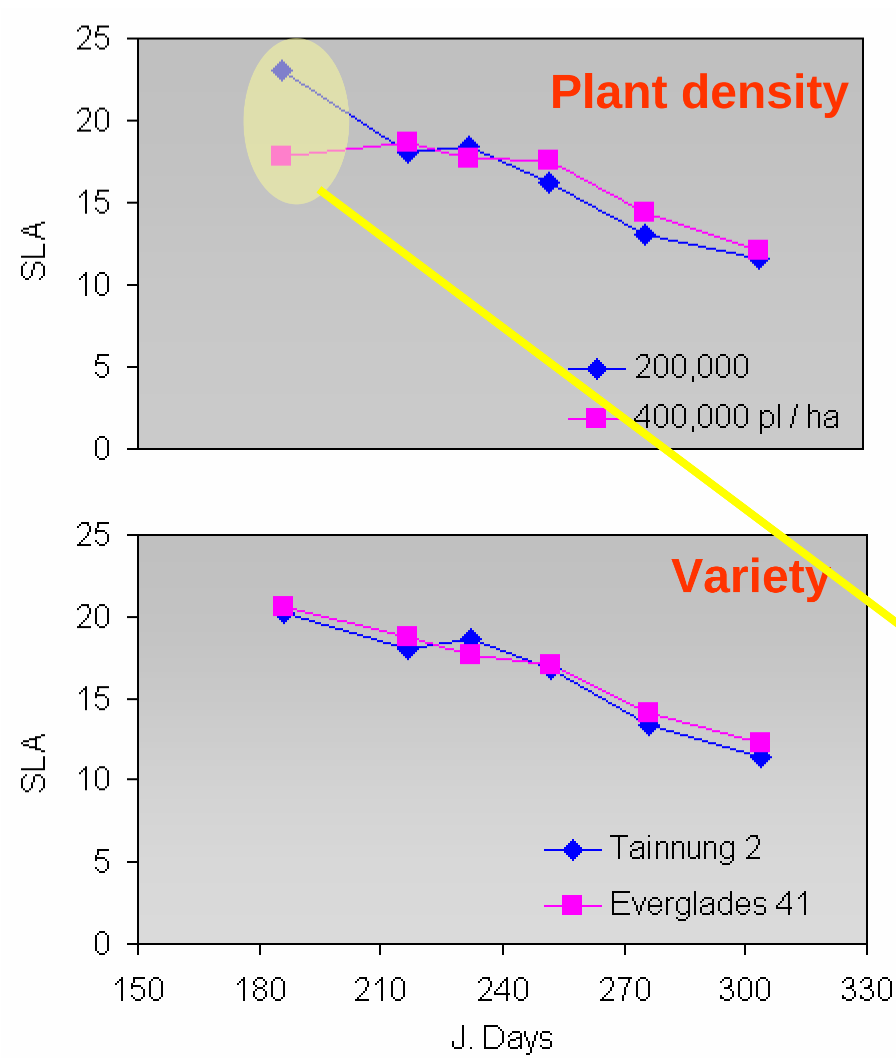
Task 2.2, Leaf area index ($m^2\ m^{-2}$)

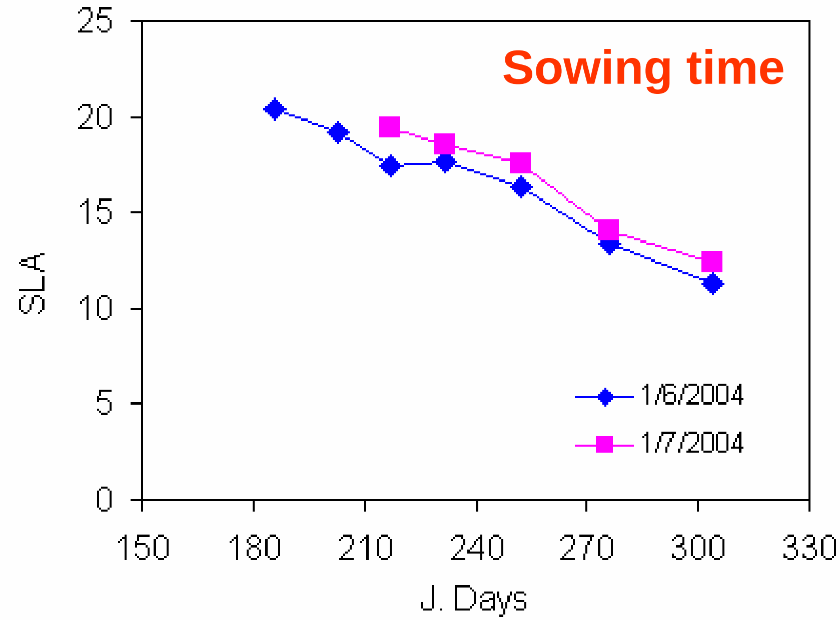






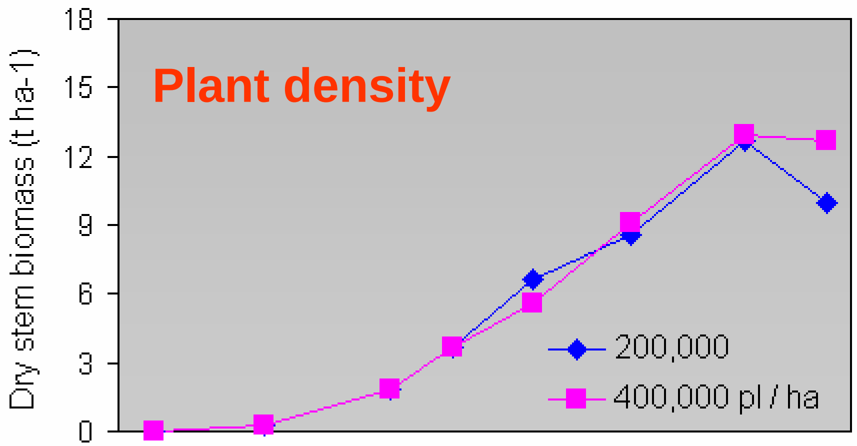
Task 2.2, Specific Leaf area (kg m^{-2})

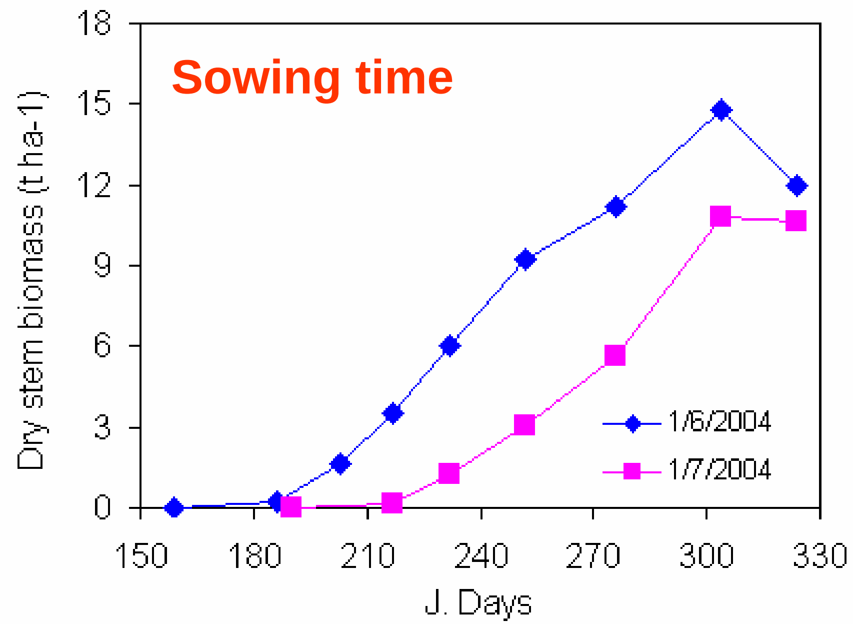


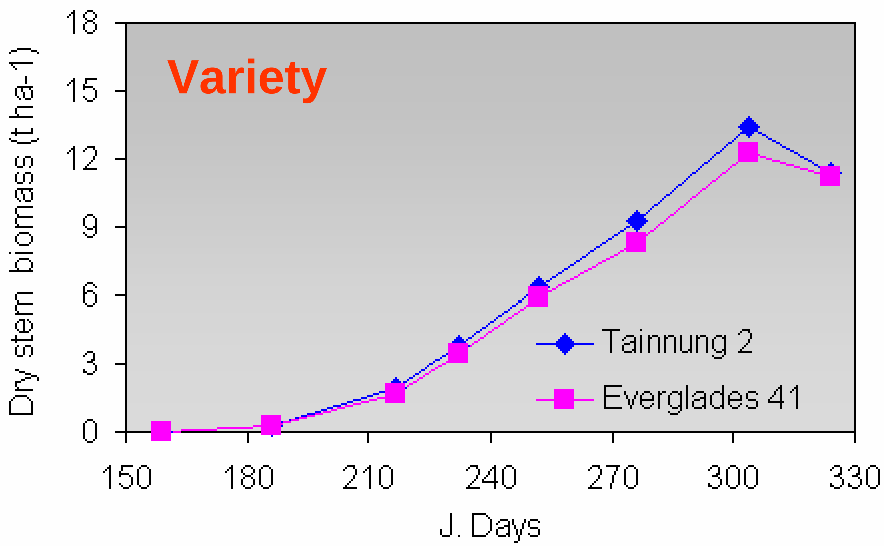


Probably
measurement error

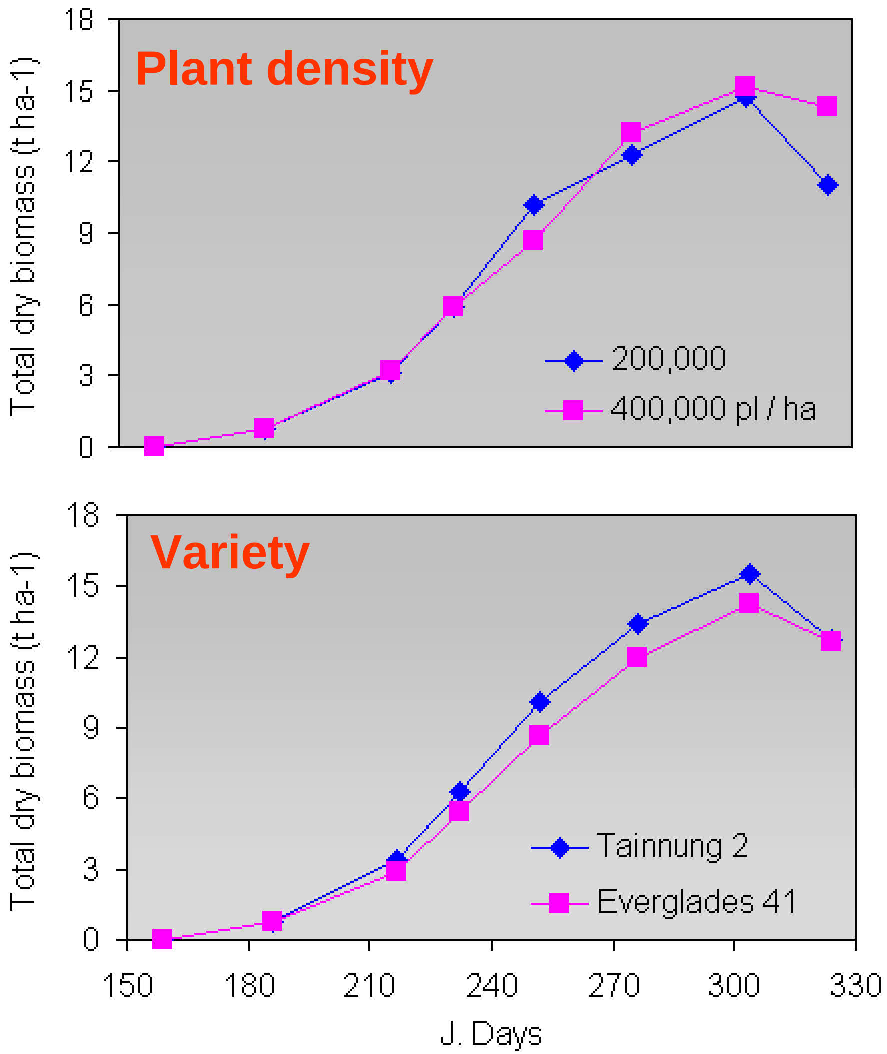
Task 2.2, Dry stem Biomass (t ha^{-1})

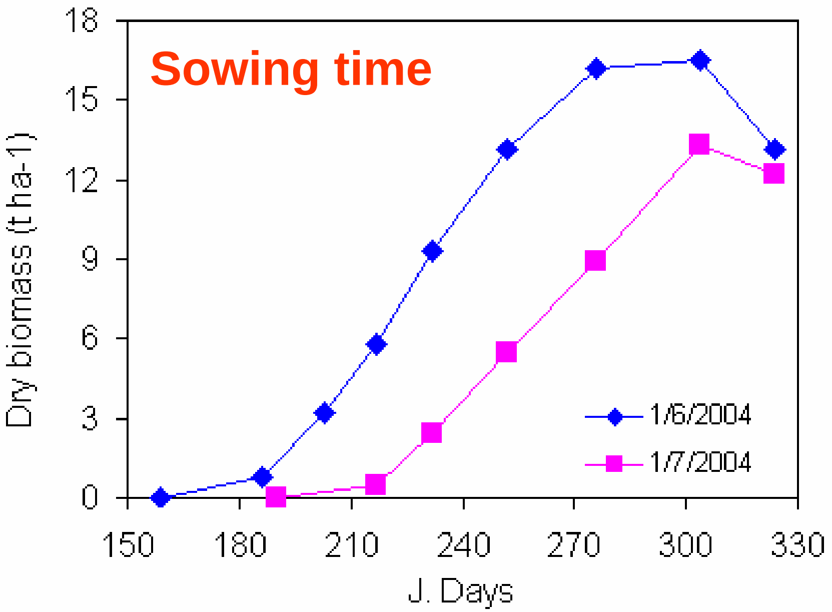




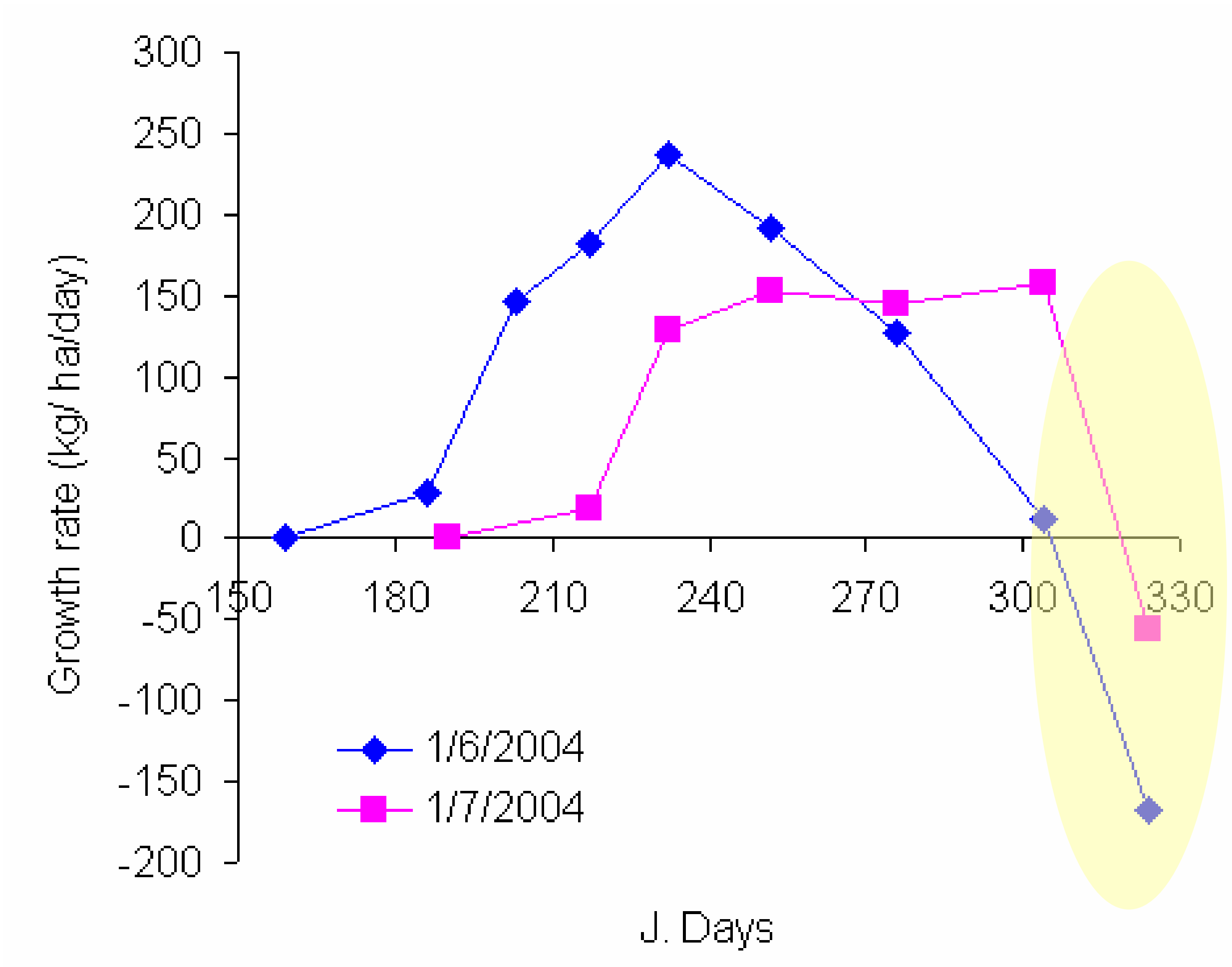


Task 2.2, Total dry Biomass (t ha^{-1})





Task 2.2, Growth rate (kg ha^{-1} d^{-1})



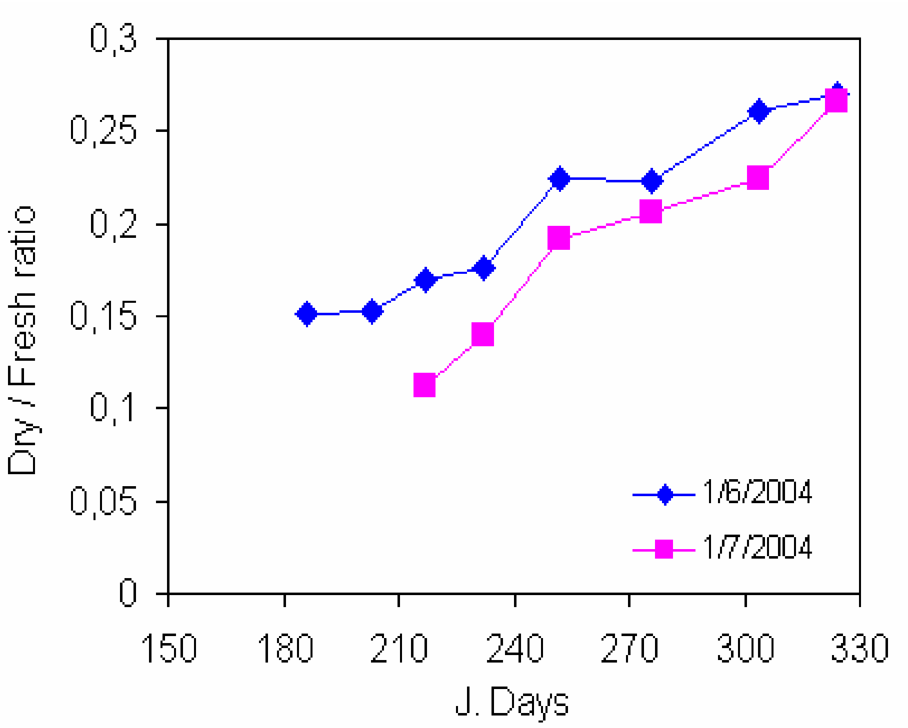
After 30/10/04

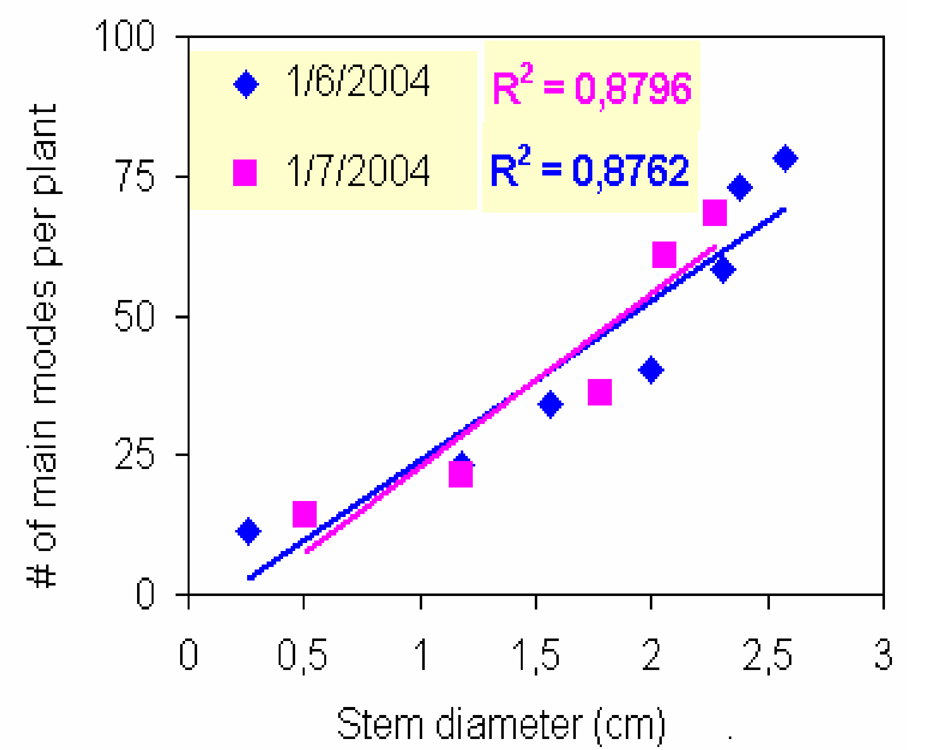
Drop off leaves

dry / fresh

ratio > 26%

Task 2.2, dry / fresh; nodes per plant





Moisture of plant increase with growing period. The same value during the last harvest

Strong linear increase of node number with basal stem diameter

Task 2.2, Light response curve [1]

$$Agross = Amax * (1 - e^{-Ia * \varepsilon / Amax})$$

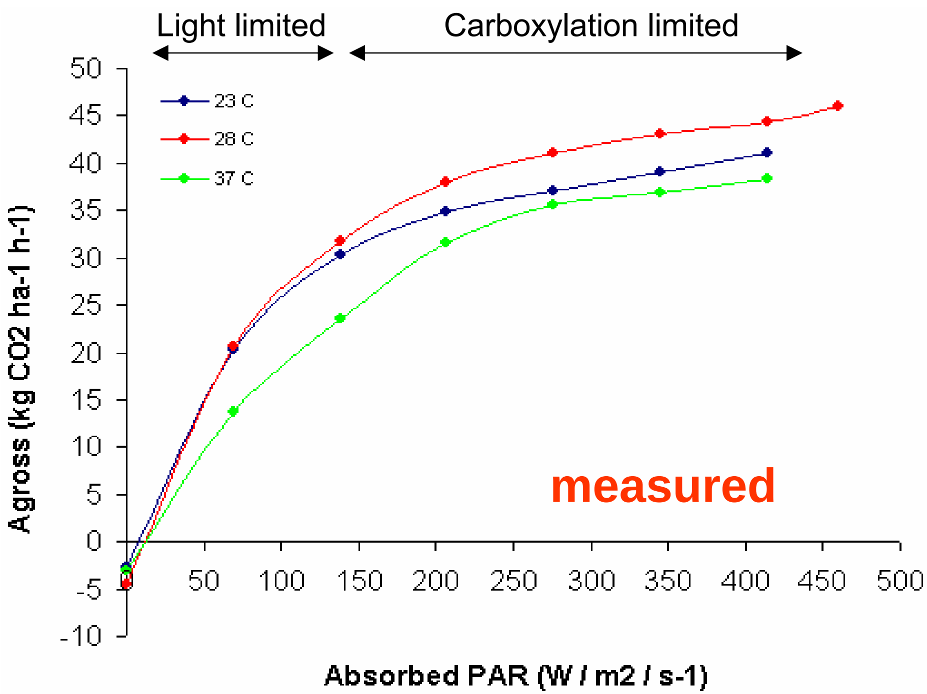
Agross	: gross assimilation rate	[$kgCO_2ha^{-1}h^{-1}$],
Amax	: maximum gross assimilation rate	[$kgCO_2ha^{-1}h^{-1}$],
Ia	: absorbed PAR, 46% of the (measured) global	[$W\ m^{-2}$],
ε	: initial light use efficiency	[$kgCO_2ha^{-1}h^{-1}W^{-1}m^2$]

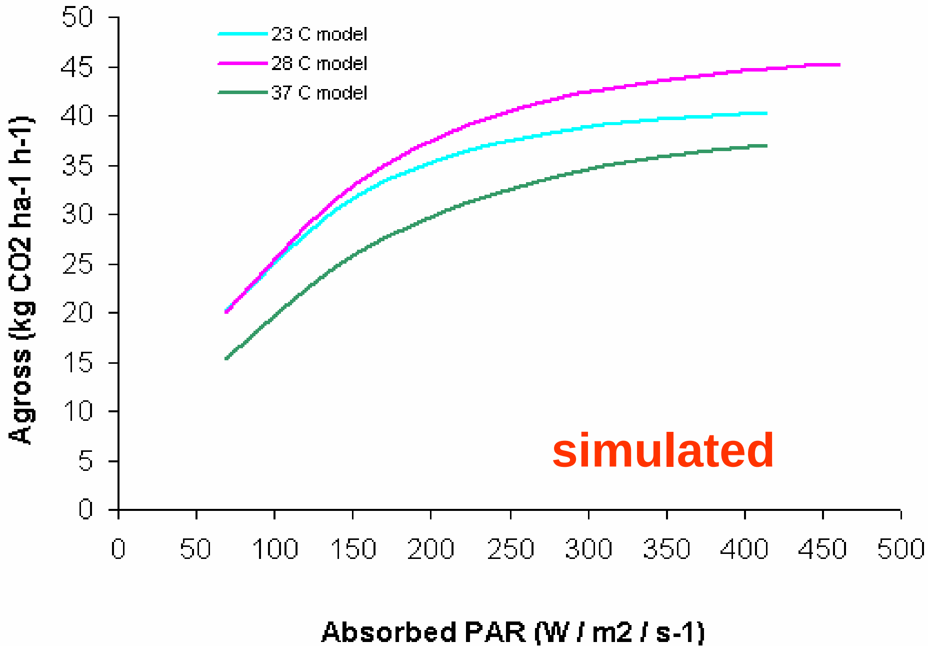
Example:

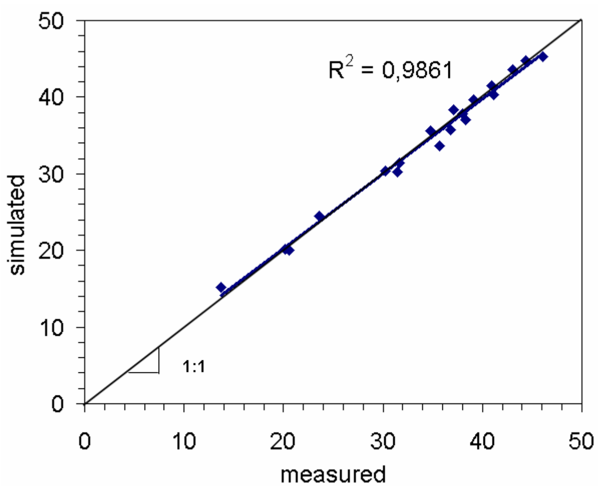
variety “Everglades 41”; day “11/8/04”

Gross assimilation rate versus absorbed photosynthetic active radiation for 3 temperatures regimes (23, 28, 33 ^oC)

Task 2.2, Light response curve [2]





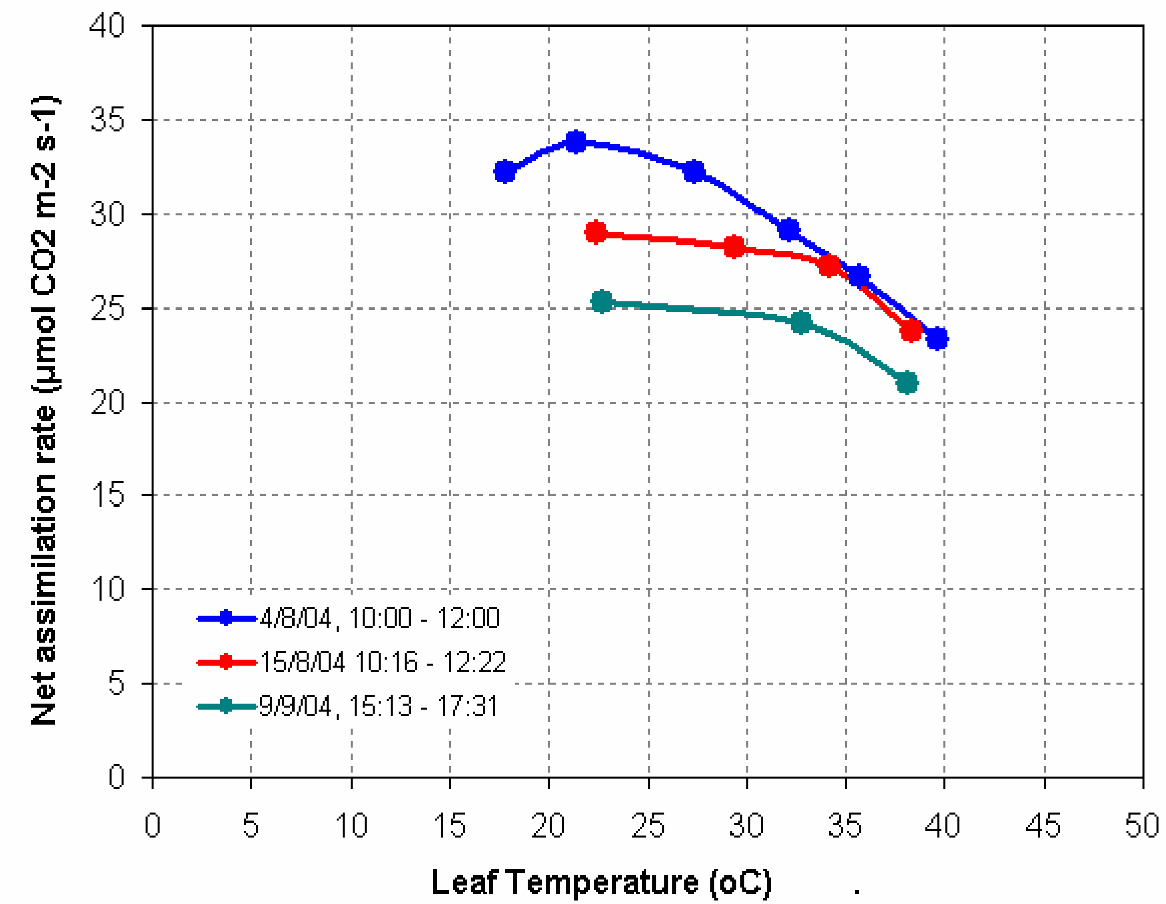


temp	23 C	temp	28 C	temp	37 C
Amax	41,1	Amax	46,3	Amax	39
ε	0,4	ε	0,38	ε	0,28

Increasing temperature → decrease quantum efficiency

High temperature → photoinhibition

Task 2.2, Photosynthesis vs. develop. stage

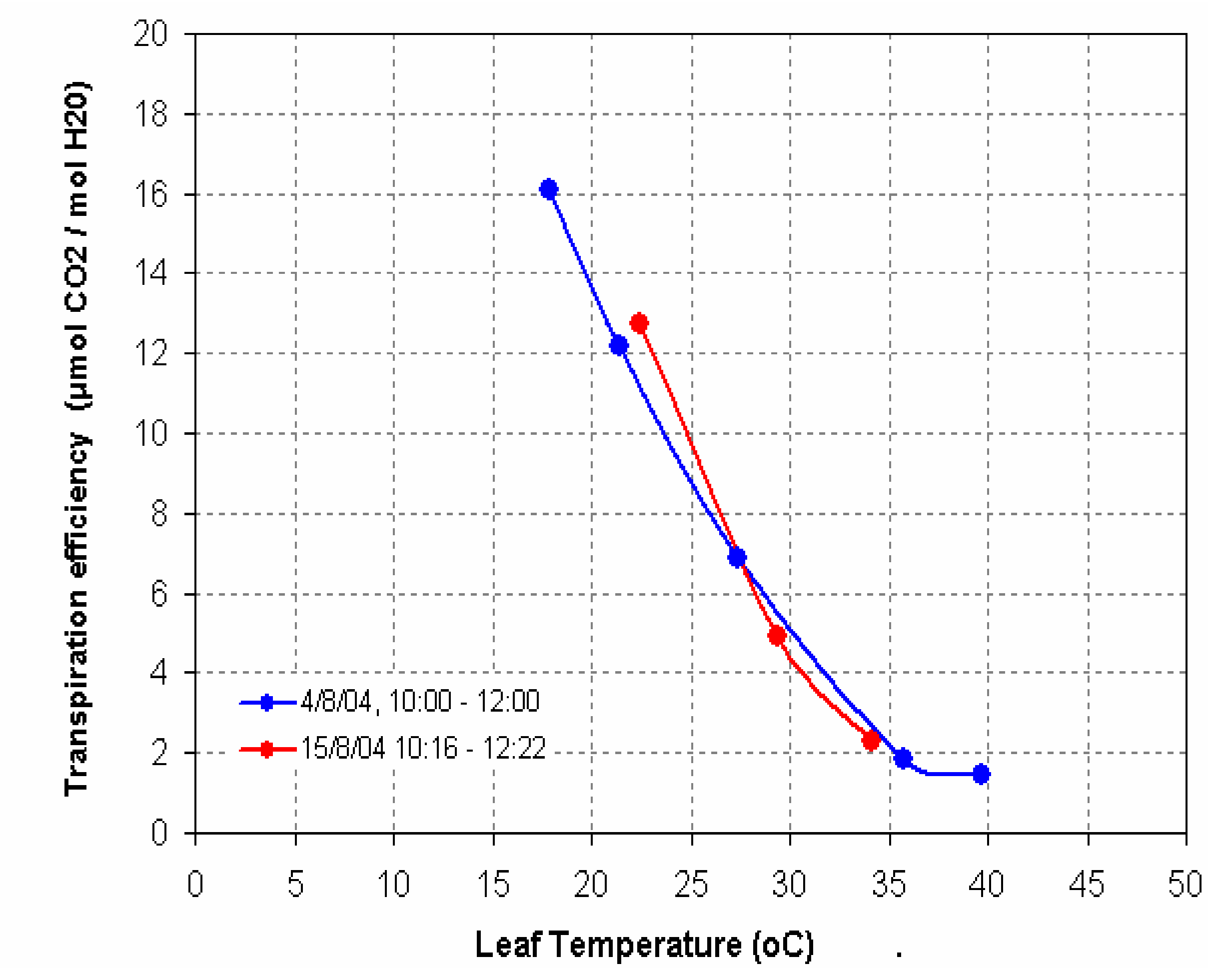


The effect of three growth stages on net assimilation rate of Tainnung 2 under different temperature regimes.

Data collected under saturated light condition (global 2000 µ mol m^{-2} s^{-1}). Each value is an average value

During cropping period… biomass increase → increase respiration (growth + maintenance) → decrease net assimilation rate

Task 2.2, Transpiration efficiency

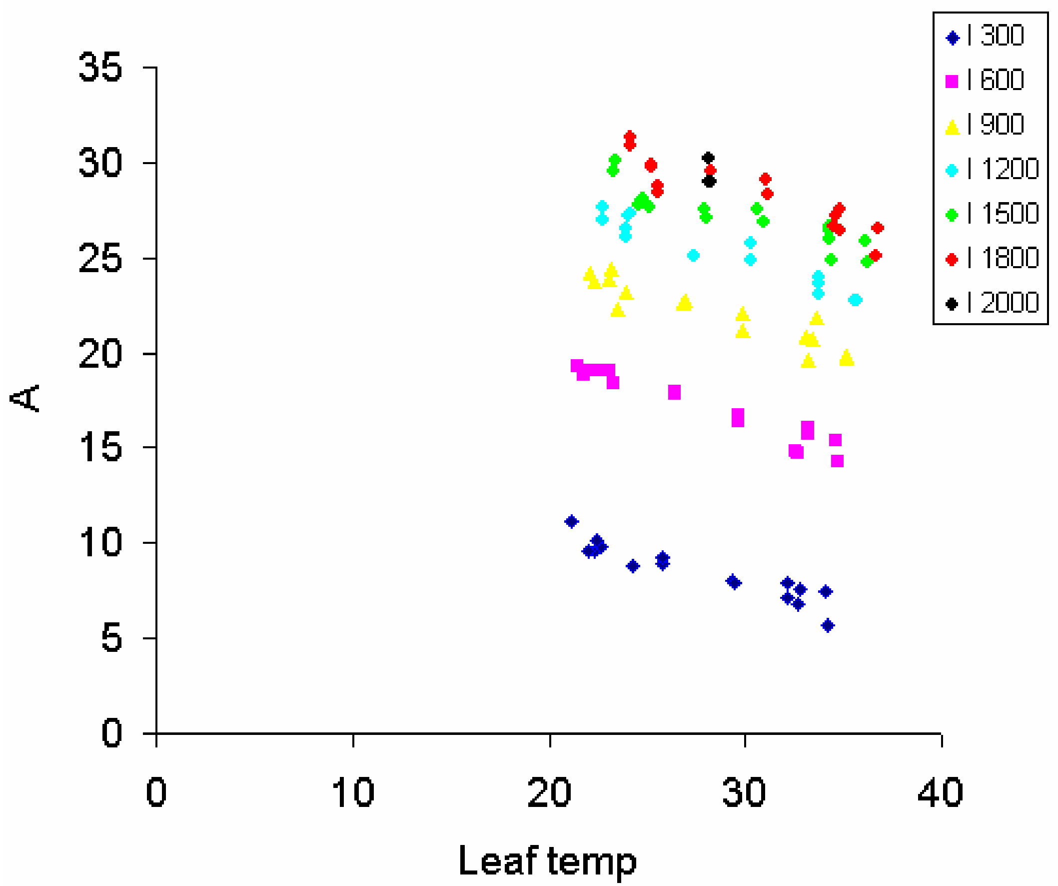


Transpiration efficiency of Tainnung 2 under different temperature regimes and for 3 growth stage.

Data collected under saturated light condition (global 2000 µ mol m^{-2} s^{-1}). Each value is an average value

Under stress condition → stomata close → decrease efficiency

Task 2.2, Temperature response curve [1]



Temperature response curve of Everglades 41 under different light intensities (μmol $m^{-2}s^{-1}$)

Data recorded on 11/7/2004

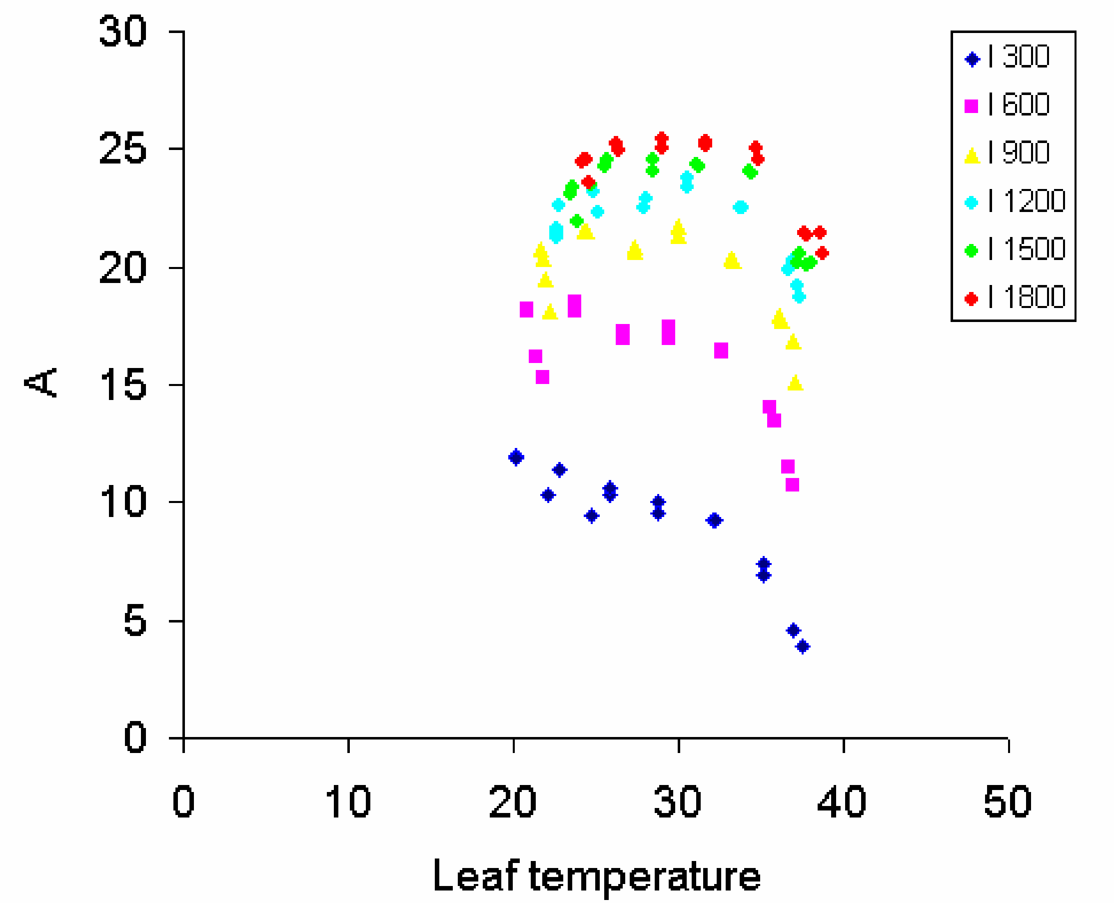
A: net assimilation rate (μ mol m^{-2} s^{-1})

Leaf Temperature ^{o}C

High temperature assimilation inhibit (damage PSI, PSII; electron transport)

Data on low temperature not presented

Task 2.2, Temperature response curve [2]



Temperature response curve of Everglades 41 under different light intensities (μmol $m^{-2}s^{-1}$)

Data recorded on 11/8/2004

A: net assimilation rate (μ mol m^{-2} s^{-1})

Leaf temperature °C

And one month later…

Most of data recorded under constant-free condition

Task 2.3 [1]

A 3x4 factorial completely randomized spit-plot design was used in 3 blocks

Factors: I = Irrigation N = Fertilization

I_1=25% (125 mm)
I_2=50% (250 mm)
I_3=100% (500 mm)

N_0 = control
N_1 = 50
N_2 = 100
N_3 = 150 kg N ha^{-1}




Task 2.3 [2]

Sowing time: 1/6/04 (distance 0.50 m x 0.10 m)

Emergence 50%: 6/6/04

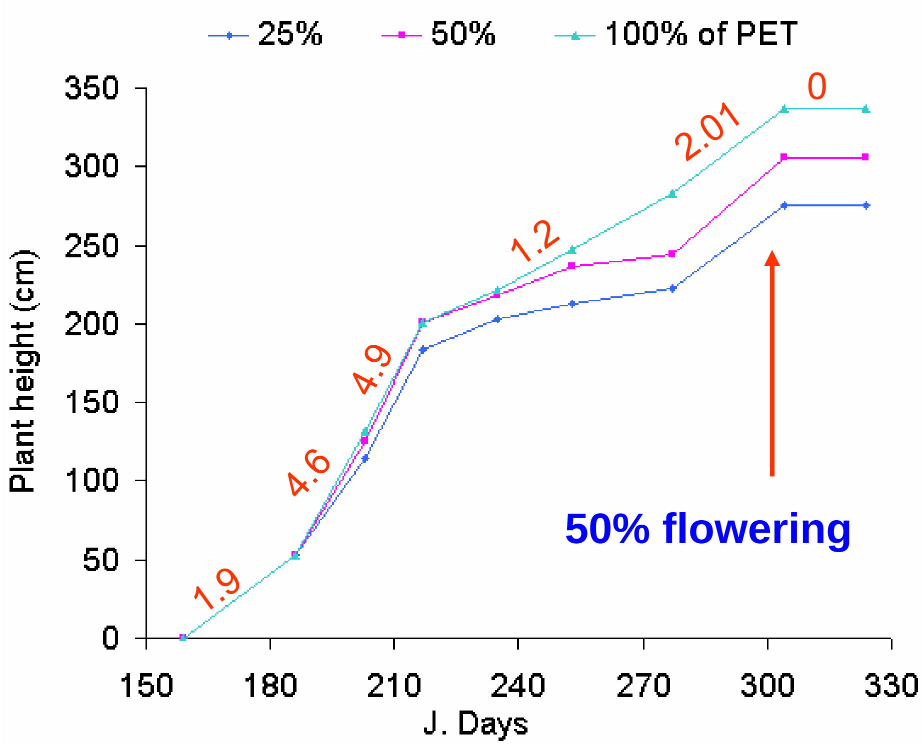
Flowering 50%: 15/10/04

Basal dressing of 50 kg P ha^{-1} and 100 kg K ha^{-1} at 29/5/2004

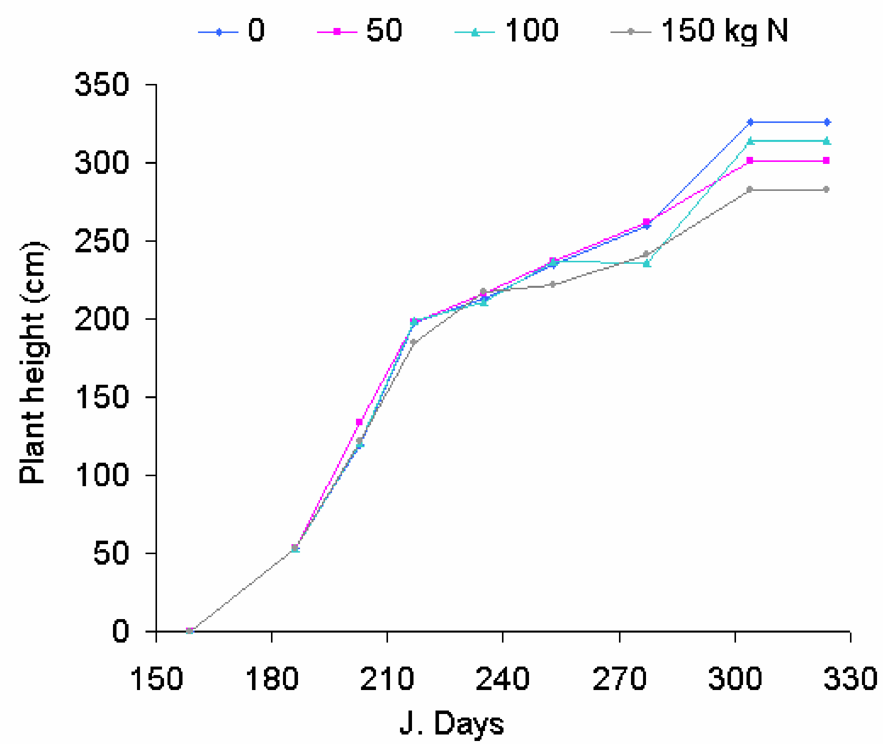
Top dressing when plant reached 50 cm height

Sub-harvests: 4/7, 21/7, 4/8, 22/8, 9/9, 3/10, 30/10, and 19/11

Task 2.3, Plant height (cm)



Irrigation

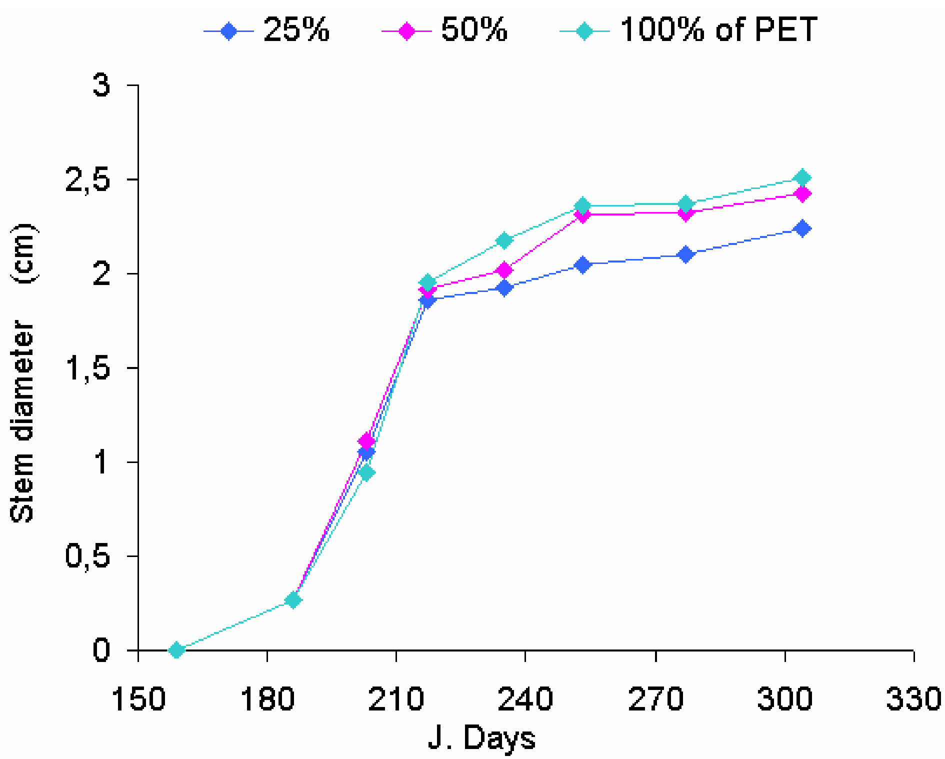


Fertilization

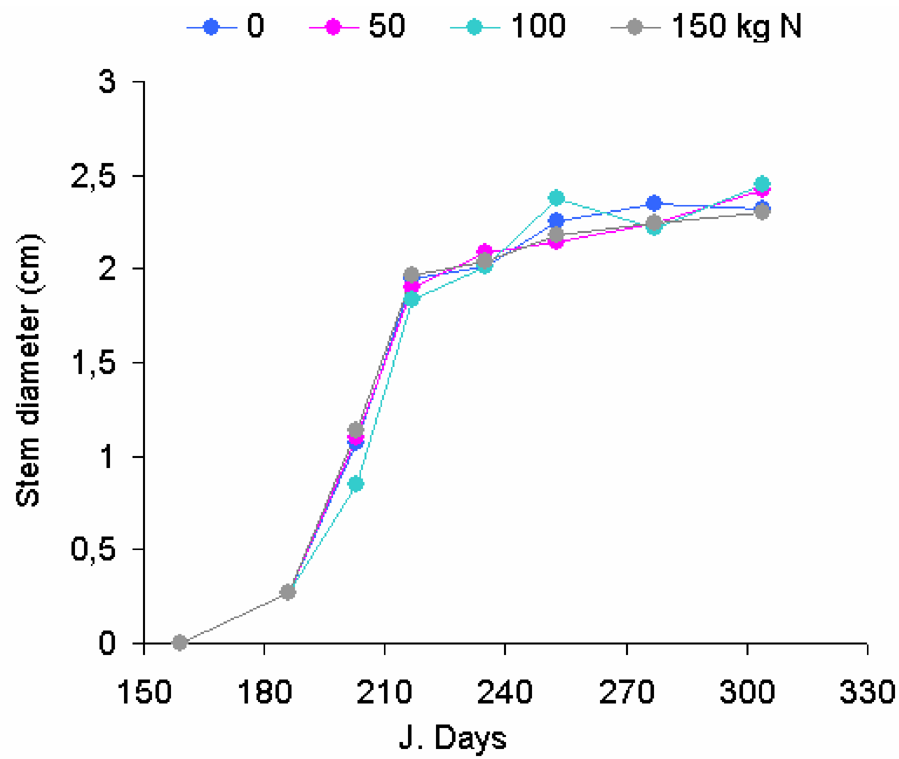
Rate of increase ?

Max 4.9 cm / day. See values (in cm d^{-1}) on the left graphic

Task 2.3, Stem diameter (cm)

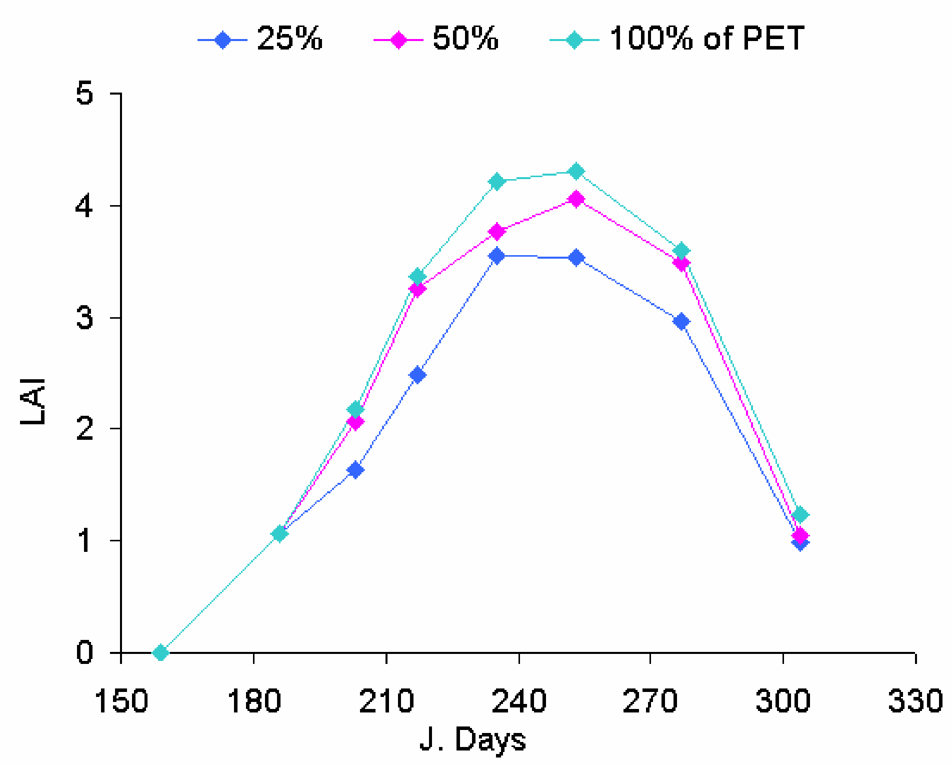


Irrigation

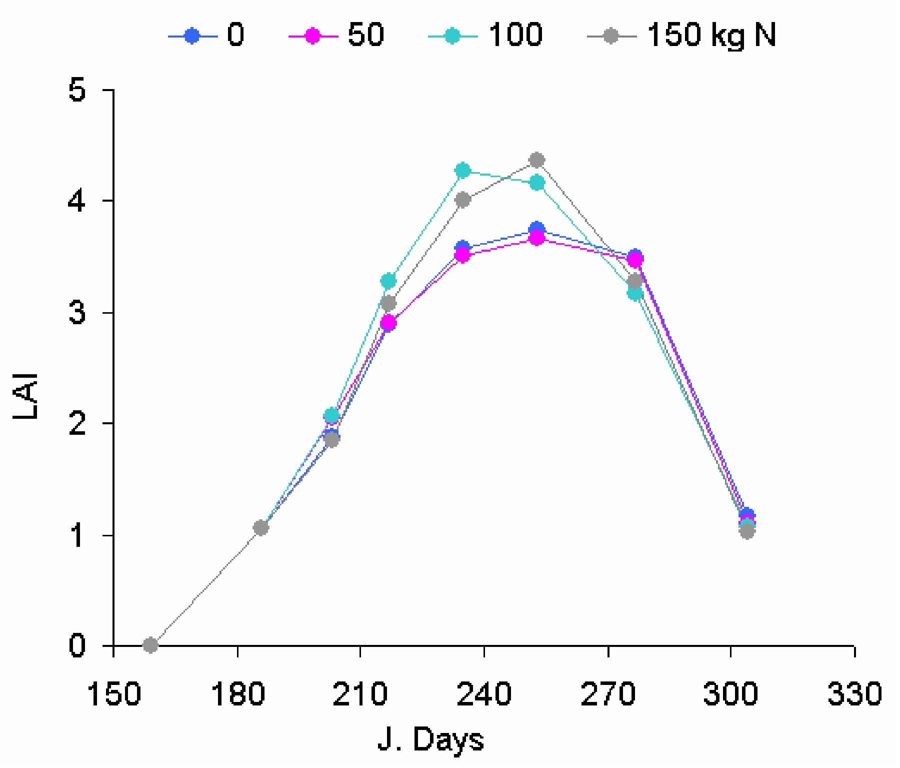


Fertilization

Task 2.3, Leaf area index ($m^2\ m^{-2}$)

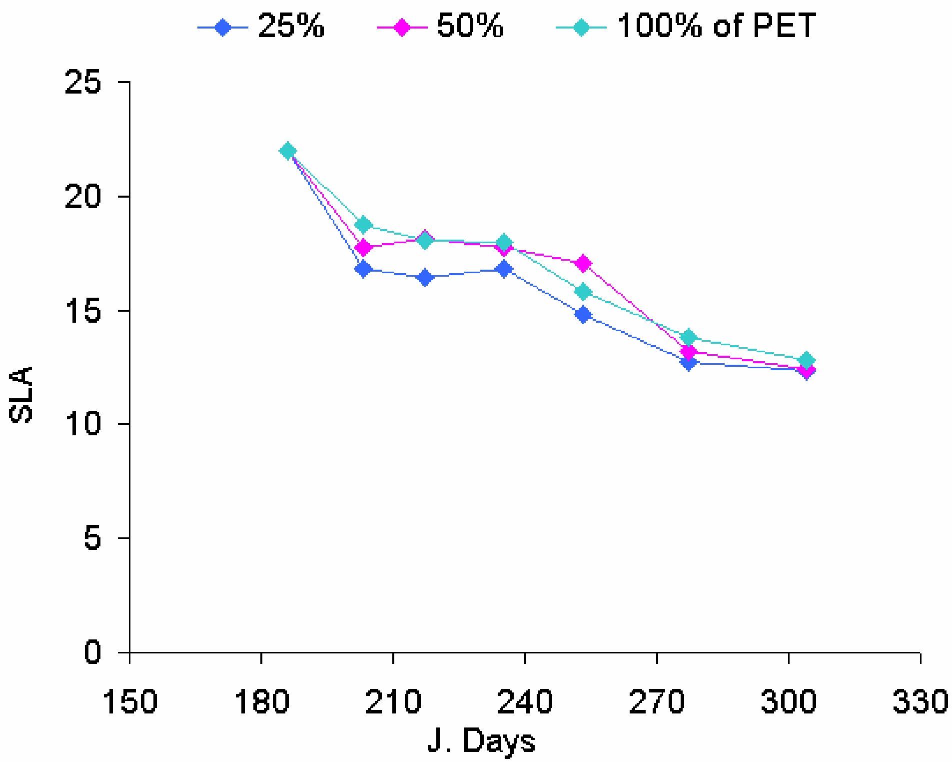


Irrigation

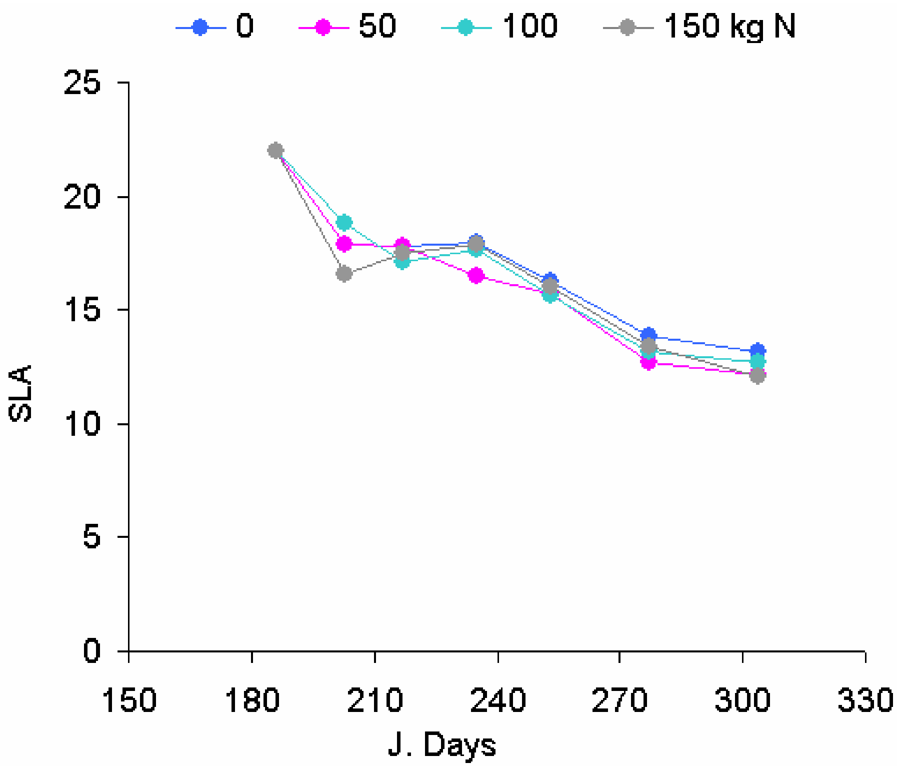


Fertilization

Task 2.3, Specific Leaf area (kg m^{-2})

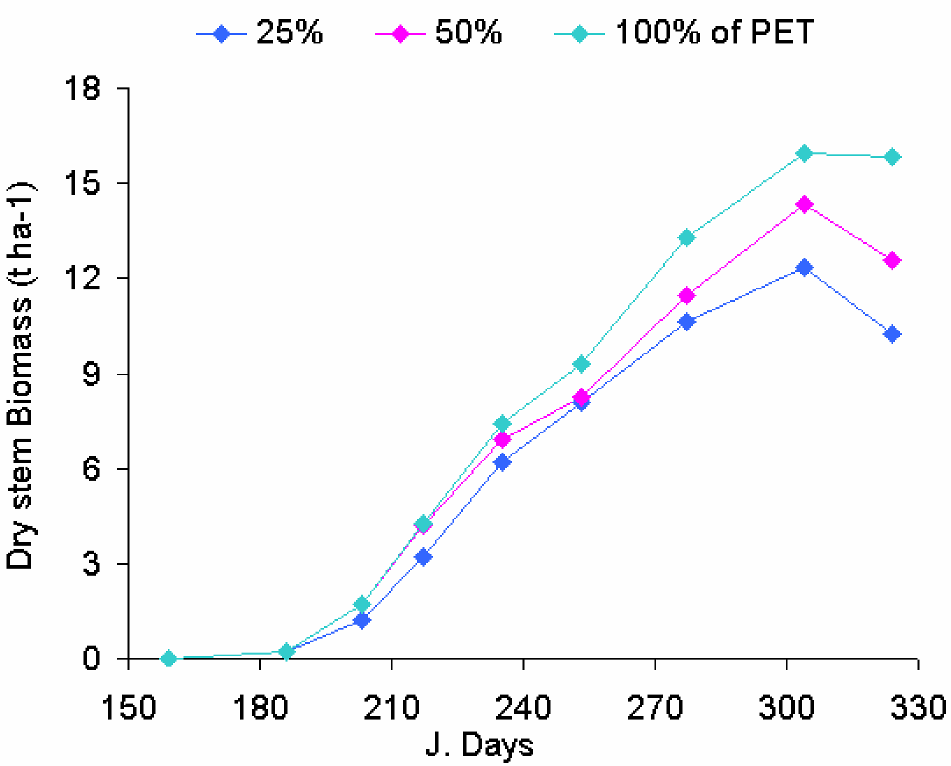


Irrigation

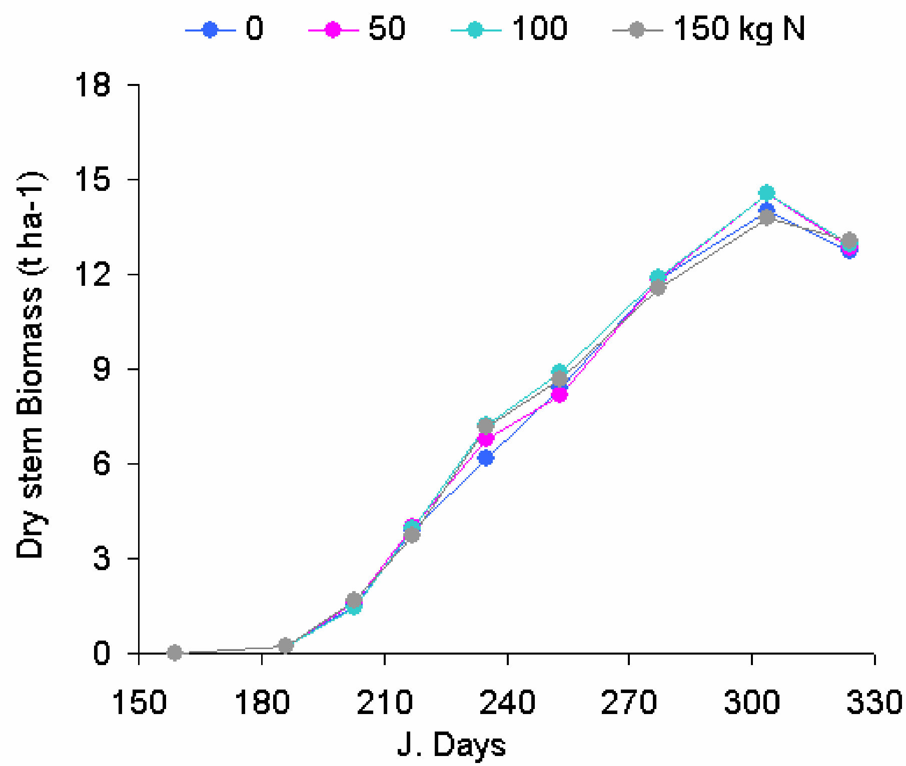


Fertilization

Task 2.3, Dry stem Biomass (t ha^{-1})

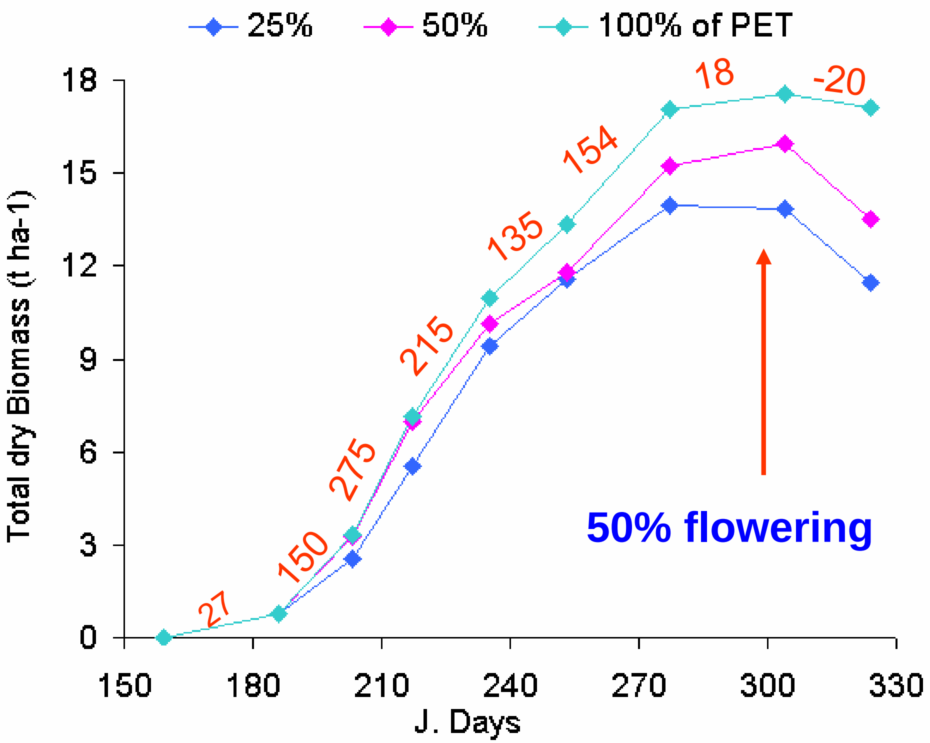


Irrigation

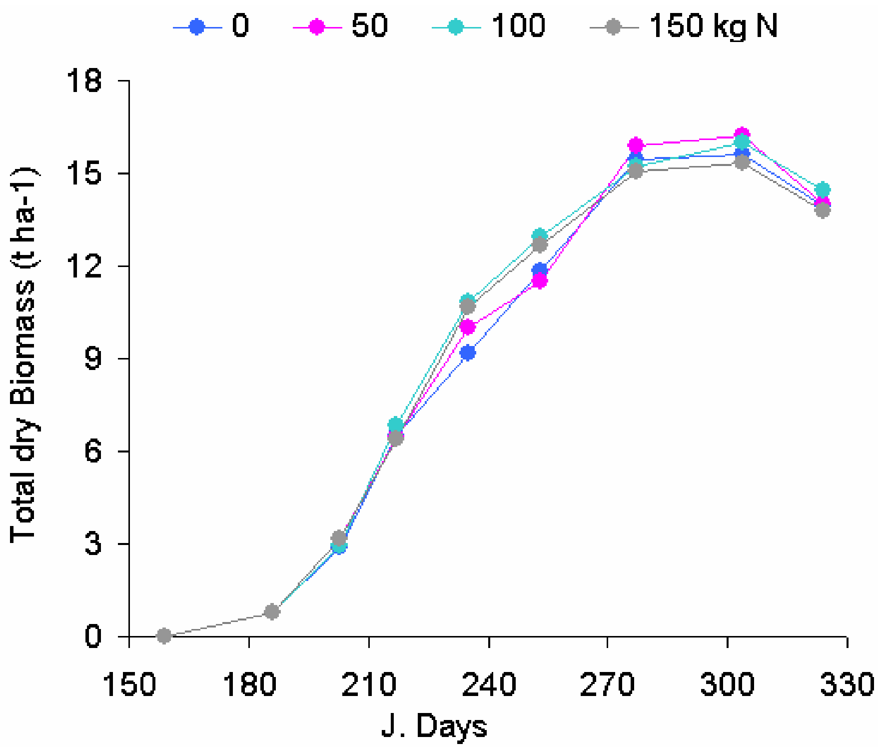


Fertilization

Task 2.3, Total dry Biomass (t ha^{-1})



Irrigation

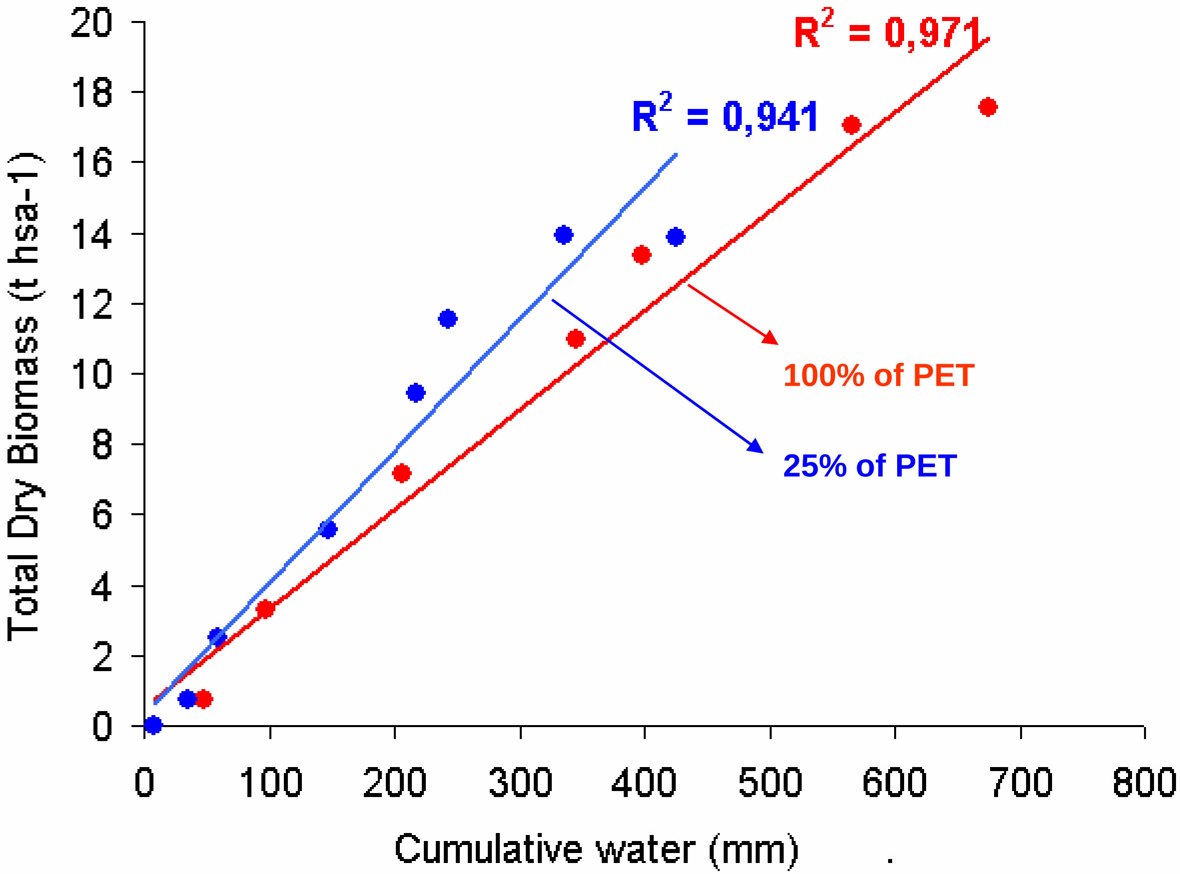


Fertilization

Growth Rate ?

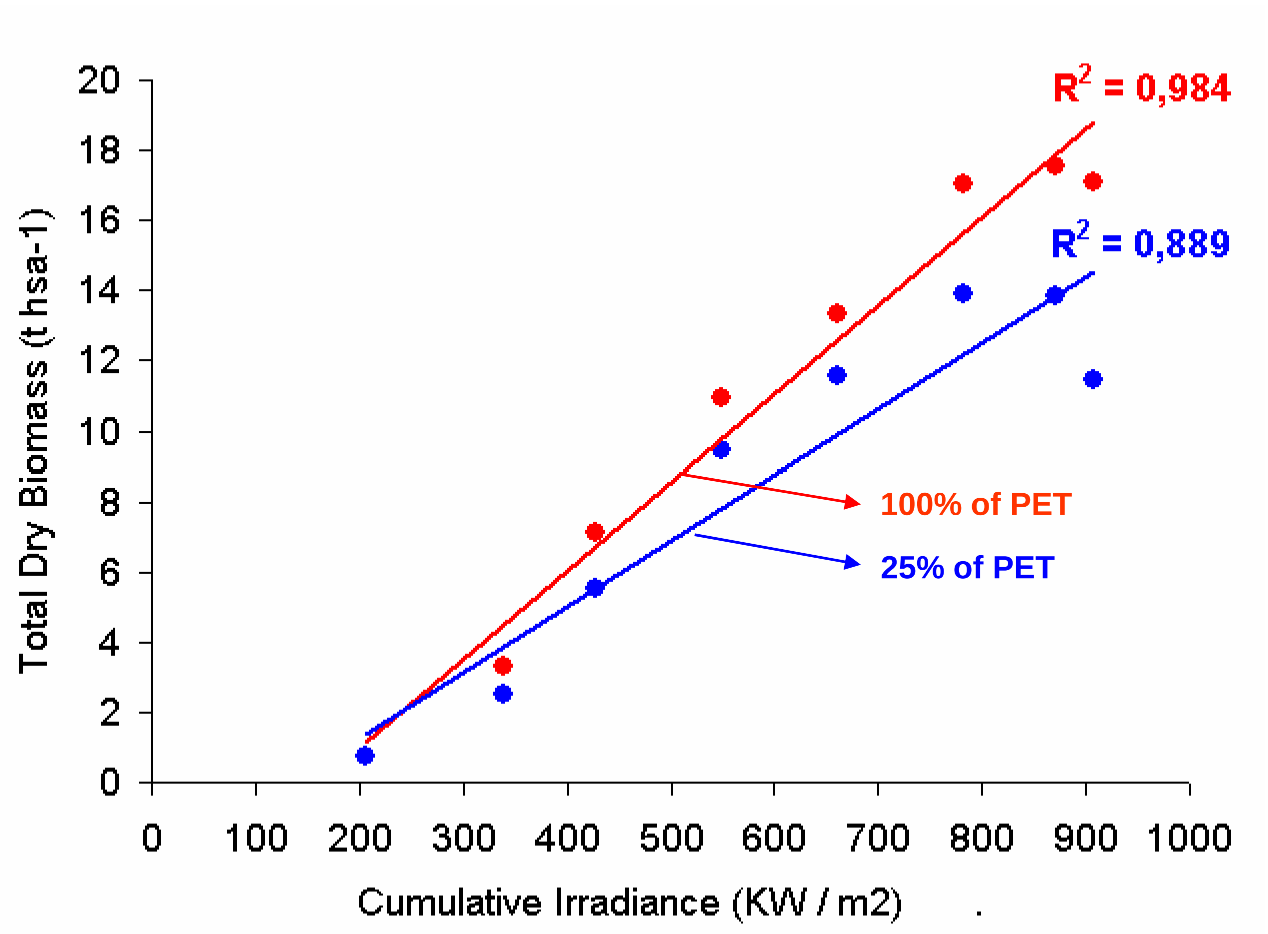
Max 275 kg / ha / day at 100% of PET interval, see left graphic

Task 2.3, Water Use Efficiency [WUE]



Cumulative water = Irrigation + Rainfall (June 1st – October 30th)

Task 2.3, Light Use Efficiency [LUE]



How efficiency the light convert into Biomass ?

Comparison 1st and 2nd year

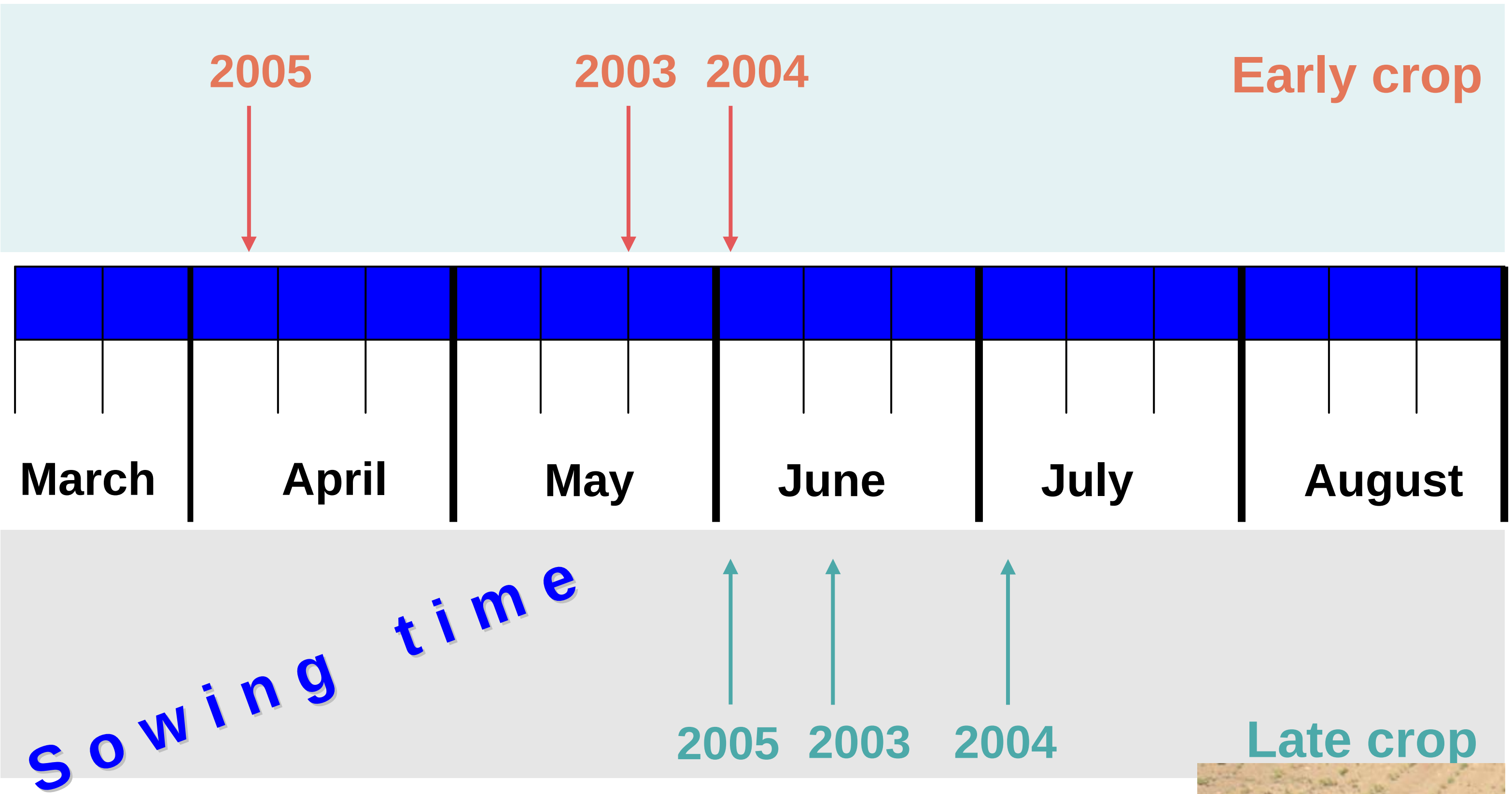
2003	2004
Planting earlier	Planting later
Higher production	Lower production
Higher plant height	Lower plant height
LAI, SLA, the same	LAI, SLA, the same
Ratio Dry Stem / Total Dry Biomass the same	Ratio Dry Stem / Total Dry Biomass the same
Less water as irrigation	More water as irrigation

According to previous experimental results we conclude:

The earlier the panting date the higher the biomass production

What about 2005 ?

Experimental year 2005



Day 3/7/05: Kenaf height = 1.2 m !!!

Kenaf crop on 4/5/05

Papers come up…

Danalatos, N.G. and S.V. Archontoulis, 2005. Sowing time and plant density effects on growth and biomass productivity of two Kenaf varieties in central Greece. International Conference on Industrial Crops and Rural Development to be held in Murcia, Spain, 17-21 September 2005. **(paper accepted)**

Danalatos, N.G. and S.V. Archontoulis, 2005. Irrigation and N-fertilization effects on Kenaf growth and biomass productivity in central Greece. International Conference on Industrial Crops and Rural Development to be held in Murcia, Spain, 17-21 September 2005. **(paper accepted)**

Danalatos, N.G. and S.V. Archontoulis, 2005. Growth and biomass productivity of Kenaf as biomass crop in Greece. 14th European Biomass Conference and Exhibition: Biomass for Energy, Industry and Climate Protection. Palais des Conges, Paris, France, 17-21 October 2005. **(abstract submitted)**

Danalatos, N.G. and S.V. Archontoulis, 2005. Leaf photosynthesis of kenaf (variety Everglades 41) as affected by different light intensity and temperature regimes. 14th European Biomass Conference and Exhibition: Biomass for Energy, Industry and Climate Protection. Palais des Conges, Paris, France, 17-21 October 2005. **(abstract submitted)**

Thanks for your attention !!!

Questions will be answered by email

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