UNIVERSITY OF BOLOGNA

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BioKenaf Project

Contract No: QLK5-CT2002-01729

Fifth Technical Meeting

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Second Year Results

(WP2 - Task 2.2 _ 2.3)

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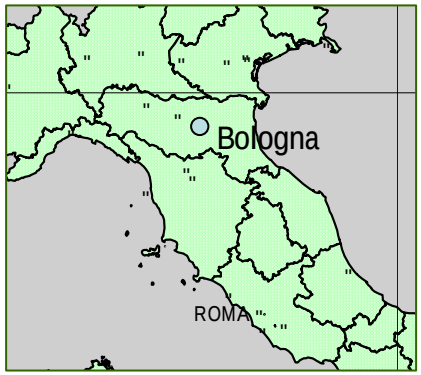
Experimental Farm of Bologna University, Cadriano (Northern Italy)



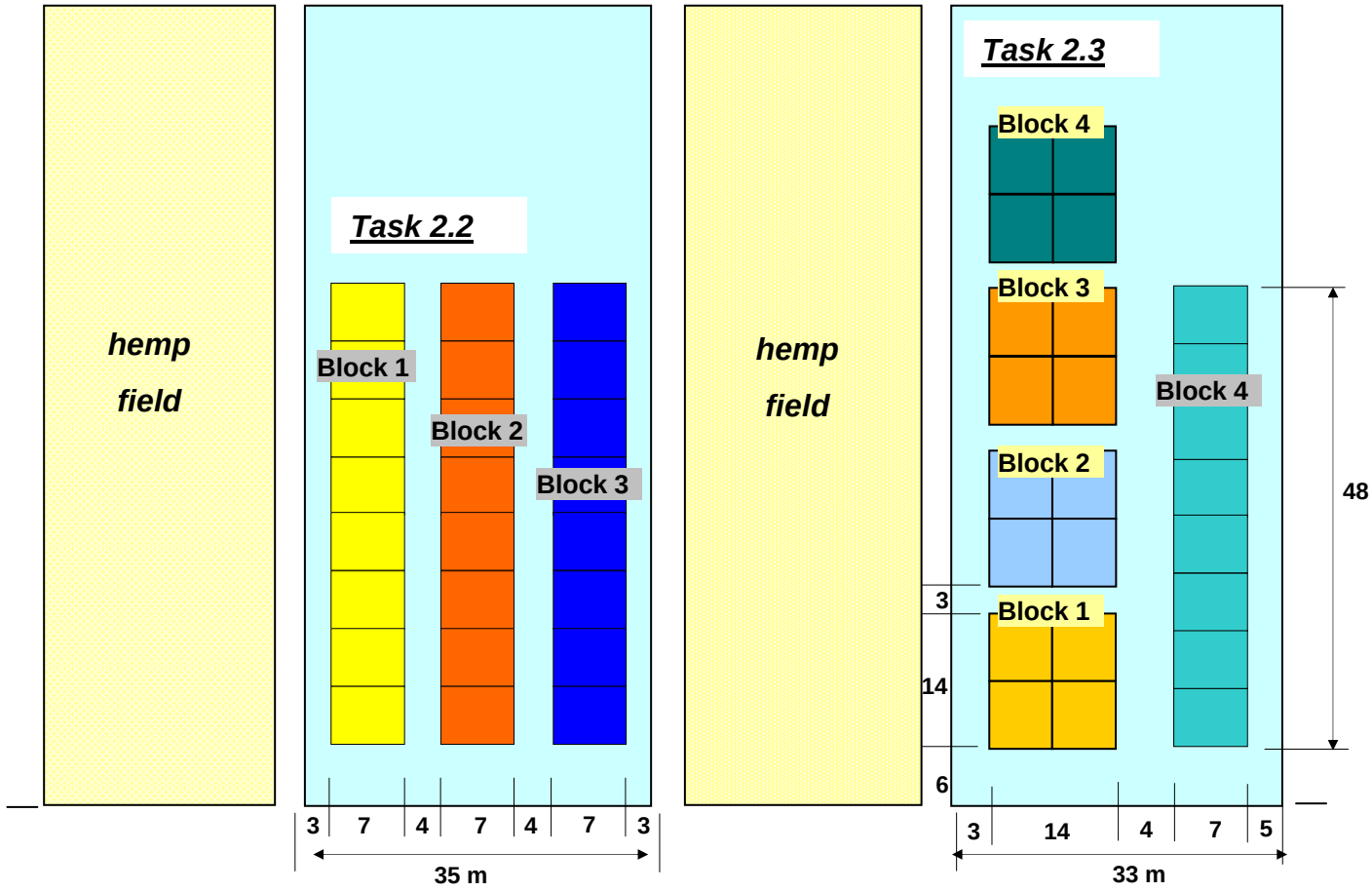
44° 33' N, 11° 21' E

altitude: 32 m a.s.l.
soil slope: 0%
organic matter = 1.9%
pH = 7.14

farm soil typology:
Udic Ustochreps fine silty, mixed mesic

sand = 19%
silt = 53%
clay = 28%

Experimental layout



TESTED TREATMENTS AND EXPERIMENTAL LAYOUT OF Task 2.2 and Task 2.3

Task 2.2

S1	1st sowing time (7th May 2004)
S2	2nd sowing time (9th June 2004)
V1	Tainung2
V2	Everglades41
D1	20 p m^{-2}
D2	40 p m^{-2}

Task 2.3

N0	0 N Kg ha^{-1}
N1	50 N Kg ha^{-1}
N2	100 N Kg ha^{-1}
N3	150 N Kg ha^{-1}

	TASK 2.2				TASK 2.3		
	Block 1	*Block 2*	*Block 3*	*Block 4*			
1	S1 V2 D1	S2 V2 D1	S2 V2 D2	S1 V2 D1	N1	N0	*Block 4*
2	S1 V2 D2	S2 V1 D1	S1 V1 D1	S2 V1 D2	N3	N2	
3	S2 V2 D2	S1 V1 D2	S1 V2 D1	S1 V2 D2	N3	N1	*Block 3*
4	S2 V2 D1	S1 V1 D1	S2 V1 D2	S1 V1 D2	N2	N0	
5	S2 V1 D2	S1 V2 D2	S2 V1 D1	S2 V2 D1	N0	N1	*Block 2*
6	S1 V1 D2	S2 V2 D2	S2 V2 D1	S2 V2 D2	N2	N3	
7	S2 V1 D1	S1 V2 D1	S1 V1 D2	S1 V1 D1	N2	N3	*Block 1*
8	S1 V1 D1	S2 V1 D2	S1 V2 D2	S2 V1 D1	N0	N1	

Complete randomized block design for all tested factors

First sowing date:
7th May 2004
Tot. emergence:
5 days

Second sowing date:
9th June 2004
Tot. emergence:
6 days

sowing date:
21th May 2004
Tot. emergence:
5 days

Fertilization:
4th June 2004

Woven non woven tissue

Irrigation after sowing to help emergence

COLLECTED DATA

Soil typical data before sowing

Meteorological data like …

- Daily maximum/minimum air temperature (°C)
- Rainfall (mm)
- Air humidity (%)
- Evaporation (glass A panel)
- Sunshine hours
- Water table

	Harvest n°	I	II	III	IV	V	VI	VII	VIII	IX	X
TASK 2.2	date	18/6	1/7	15/7	29/7	12/8	2/9	20/9	13/10	17/11	14/12
	DOY	170	183	197	211	225	246	264	287	322	349
S1	DAE	38	51	65	79	93	114	132	155	190	217
	GDD	258	407	563	744	926	1175	1328	1465	1542	1542
S2	DAE	4	17	31	45	59	80	98	121	156	183
	GDD	35	184	341	521	703	959	1111	1248	1325	1325
TASK 2.3	date	18/6	1/7	15/7	29/7	12/8	3/9	21/9	14/10	18/11	15/12
	DOY	170	183	197	211	225	247	265	288	323	350
	DAE	24	37	51	65	79	101	119	142	177	204
	GDD	190	338	495	676	858	1119	1269	1397	1474	1474

Repeated harvests during crop cycle

(rows of 1,5 m)

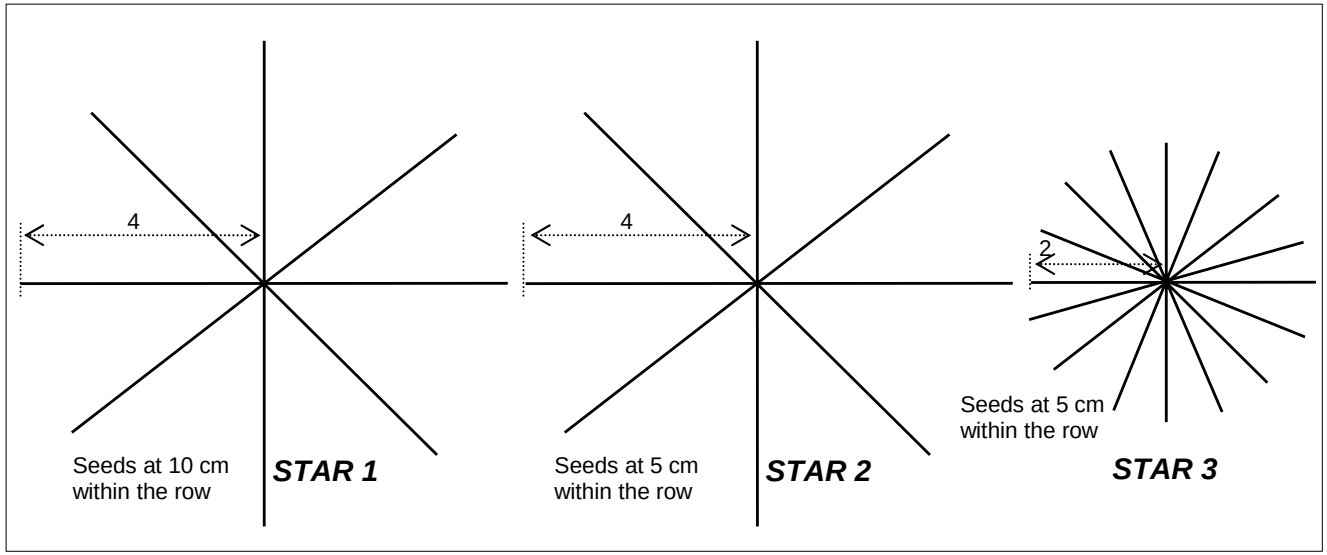
- Fresh / dry weight of harvested row
- Number of plants
- Height (cm) and Base Stem Diameter (mm)
- Fresh / dry weight of stems, leaves and petioles
- Leaf area (cm^2)

Final harvests of 5 m^2 (Harvest A and B)

- Biometric parameters
- Number of branches
- Number of nodes
- Decortication (fresh / dry weight of bark and core)
- C and N% in leaves, stems and soil (Harvest A)
- Ash content (%) in core

The light response curve of leaf photosynthesis (A)

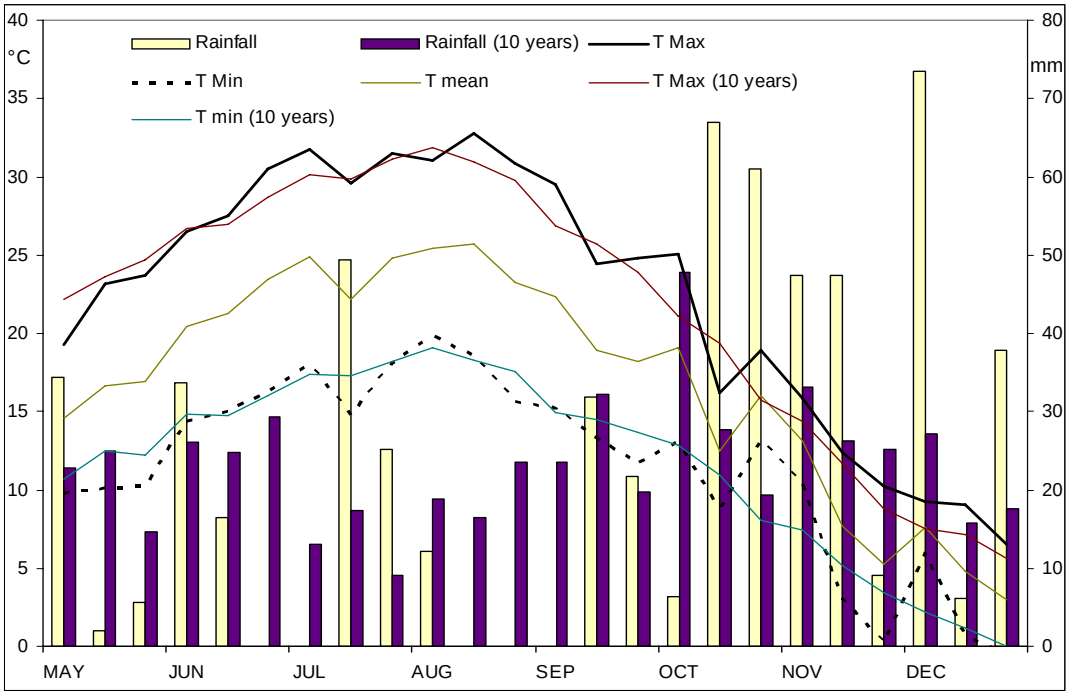
Effect of the distance between the rows on plant biometric parameters and yields



Tainung2
Sowing: 21st May 2004

- **Height (cm) and Base Stem Diameter (mm) for all plants**
- **Fresh / dry weight**
- **Fresh / dry weight of bark at 20, 50, 150 cm from centre**
- **% of fresh bark**

Rainfall, Min and Max temperature during the experimental period.



			Plant Cycle Lenght (Days)	acc. Rainfalls (mm)	acc. GDD from emerg (°C)
TASK 2.2	S1	Harvest A	195	434,4	1541,8
		Harvest B	222	517,4	1541,8
	S2	Harvest A	162	385,8	1325,5
		Harvest B	189	468,8	1325,5
TASK 2.3		Harvest A	182	425,2	1473,8
		Harvest B	209	508,2	1473,8

Air temperature followed the typical trend of the local conditions

Temperatures during the growing period resulted lower than 2003 mainly during August

After the first sowing date few days without GDD increasing was observed.

GDD stopped to increase on the beginning of November, few days before harvest A. In 2003 it happens at the middle of October.

Rainfalls were almost absent from August until 12th September

Rainfalls from the first sowing (7th May 2004) to the final harvest (15th December 2004) were 517 mm, instead of 380 mm of the last year and of 539 mm as a mean of the last 10 years

<u>50 mm in one event with hail</u>

More rainfall in May and June than 2003

Soil analysis results of Task 2.2 and 2.3 fields

	Task 2.2	***Task 2.3***	*units*	*method*
sand	*36*	*44*	%	
silt	*41*	*35*	%	
clay	*23*	*21*	%	
pH (in H_20)	7,74	7,41		M.III. 1 DM 13-9-99
$CaCO_{3\ TOT}$	< 1	< 1	%	(Dietrich-Fruehling)
$CaCO_{3\ ACT}$	< 1	< 1	%	(Drouineau)
Organic Carbon	9,4	8,6	g kg^{-1}	(Walkley & Black)
Organic Matter	1,6	1,5	%	
total N	1,06	1,09	‰	(Dumas)
C.E.C.	16	12	meq/100 g	(M. 27 DM 11-05-92)
P ass.	182	169	g kg^{-1} P_2O_5	(Olsen)
K exc.	197	215	g kg^{-1} K_2O	(M. 13,5 DM 13-9-99)
Ca exc.	2955	2625	g kg^{-1} CaO	(M. 13,5 DM 13-9-99)
Mg exc.	308	380	g kg^{-1} MgO	(M. 13,5 DM 13-9-99)
Na exc.	37	33	g kg^{-1}	(M. 13,5 DM 13-9-99)

Weight 1000 seeds:

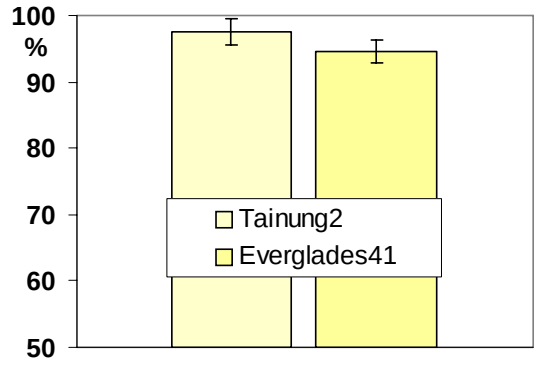
Tainung2: 297.1 g

Everglades41: 292.2 g

50 seeds per 4 replications. Incubation room at 20-30 °C.
Sowing on 14/04/2004. First germination survey on 19/04/2004.
Second germination survey on 26/4/2004.

% of germinated plants after 5 and 10 days of incubation.

5 DAS	A	B	C	D	mean	St. Dev.	St. Err
Tainung2	78	90	74	88	***82,5***	*7,72*	*3,86*
Everglades41	88	90	86	98	***90,5***	*5,26*	*2,63*
10 DAS							
Tainung2	98	92	100	100	***97,5***	*3,79*	*1,89*
Everglades41	94	96	90	98	***94,5***	*3,42*	*1,71*
					96		



Adapted mechanical sowing machine

“Vignoli”

20% of seed damaged by sowing machine

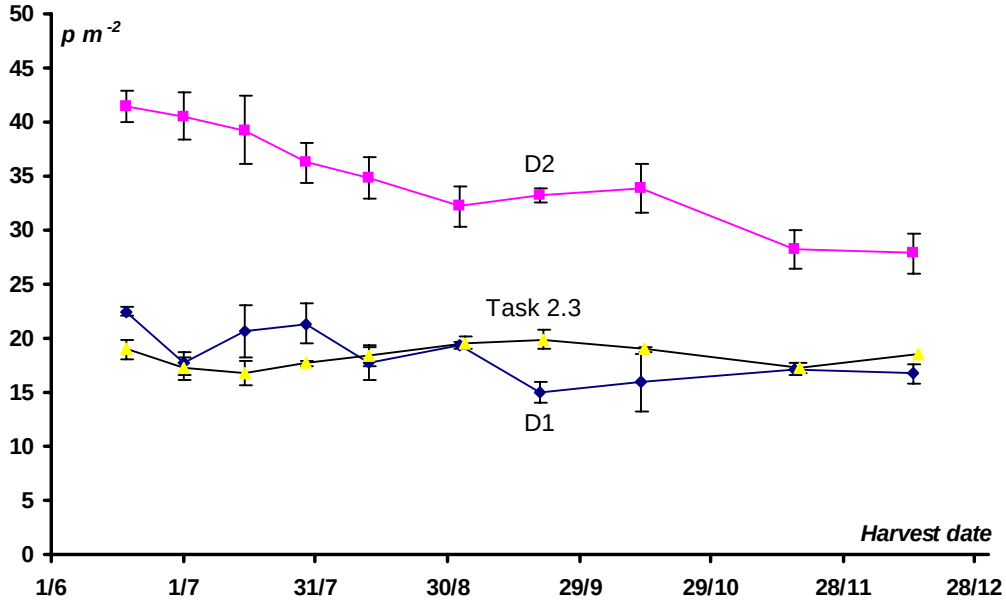
Plant germination and emergence on field

D1 was reasonably reached, 18.4 ± 3.5 plants m^{-2}

D2 was 35 ± 5.7 plants m^{-2}

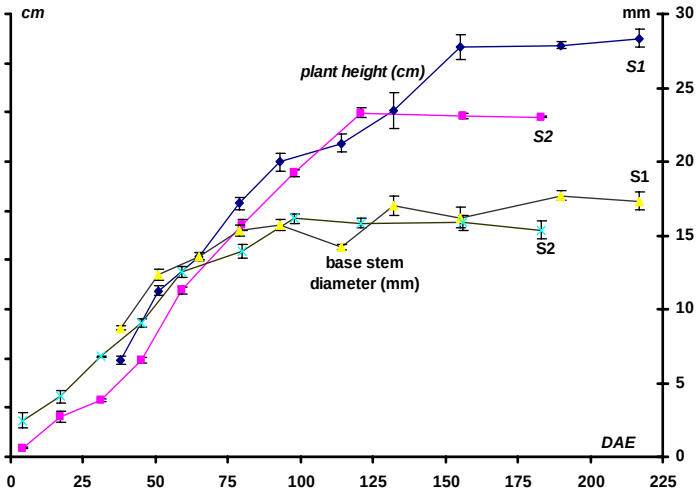
D1 density constant during time

D2 density decreased from 40 p m^{-2} to 30 p m^{-2} at final harvests

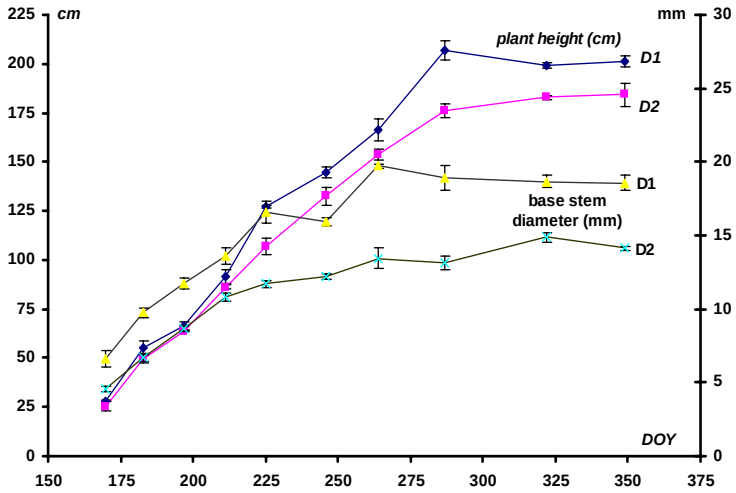


No important influence of the variety on emergence on field.

Height (cm) and Base stem diameter (mm) during time



Effect of sowing time

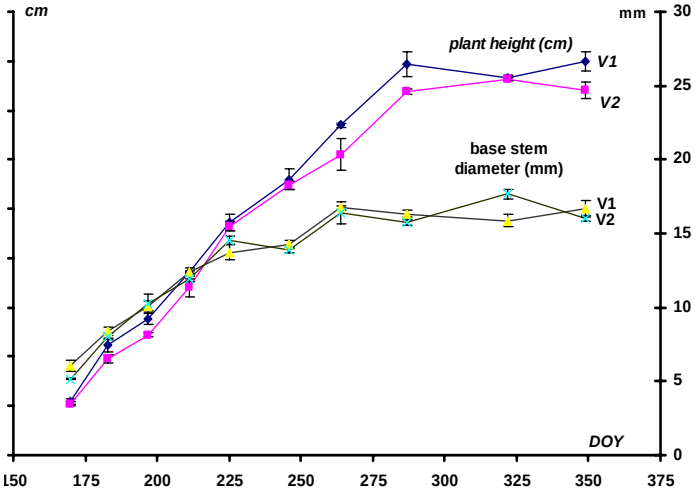


Effect of density

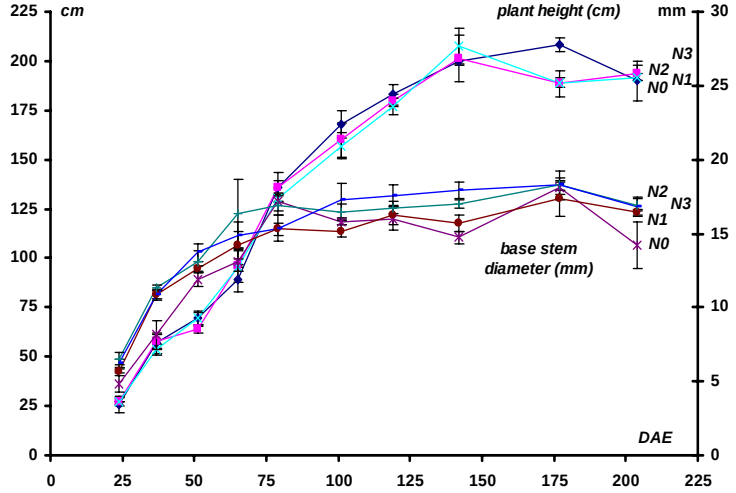
234 cm by S1, D1, Tainung2
164 cm in 2003

D2 density reached the lower heights for both the sowing times.

Task 2.3 similar height for all N levels,
N2: 207 cm
N0: 190 cm



Effect of genotype



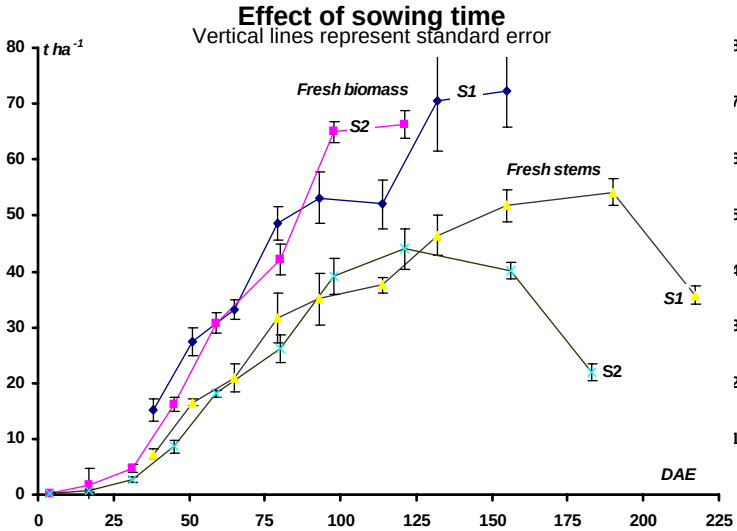
Effect of N level

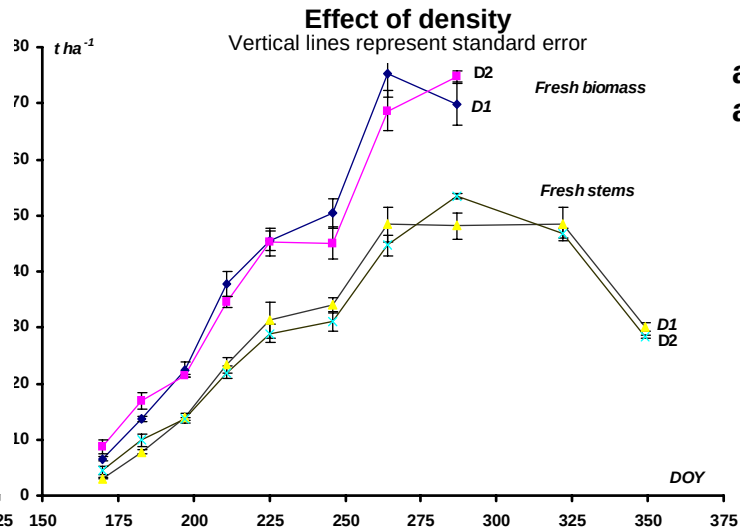
20 mm Ø by S1 D1 Everglades41
very similar values for all N levels: 16 mm
N0: 14 mm

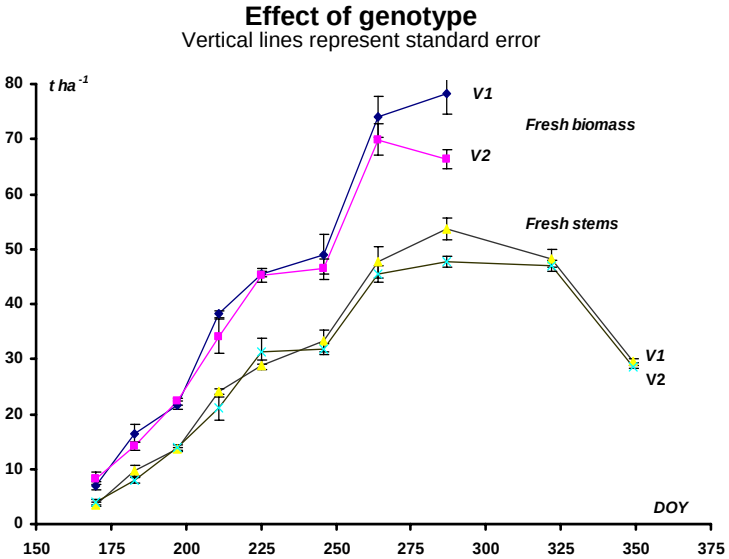
Last two harvests showed a stabilization of plant height,

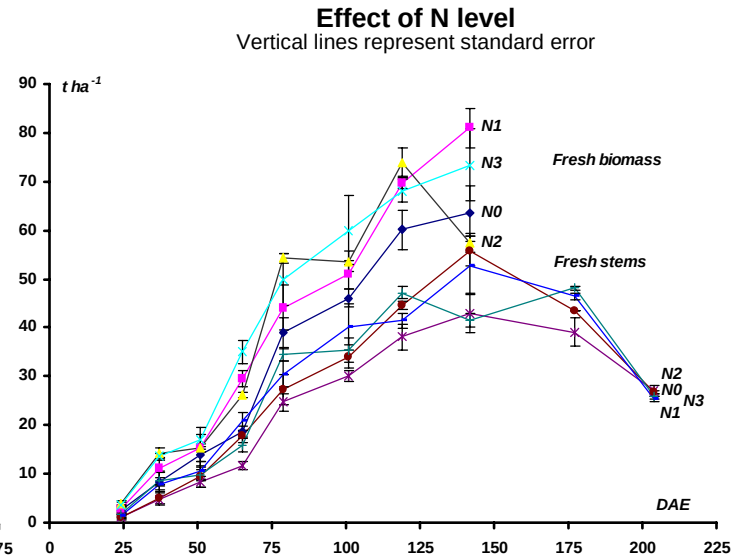
the base stem diameter seems to stop increasing already after 75 DAE,
similar to 2003 trends

Fresh yields (t ha^{-1}) of total biomass and stems during time









Best performance for N1 and for S1 Tainung2, D1 and D2

75 t ha^{-1} Fresh biomass *(52 t ha^{-1} in 2003)* **at harvest VIII (13th October)**

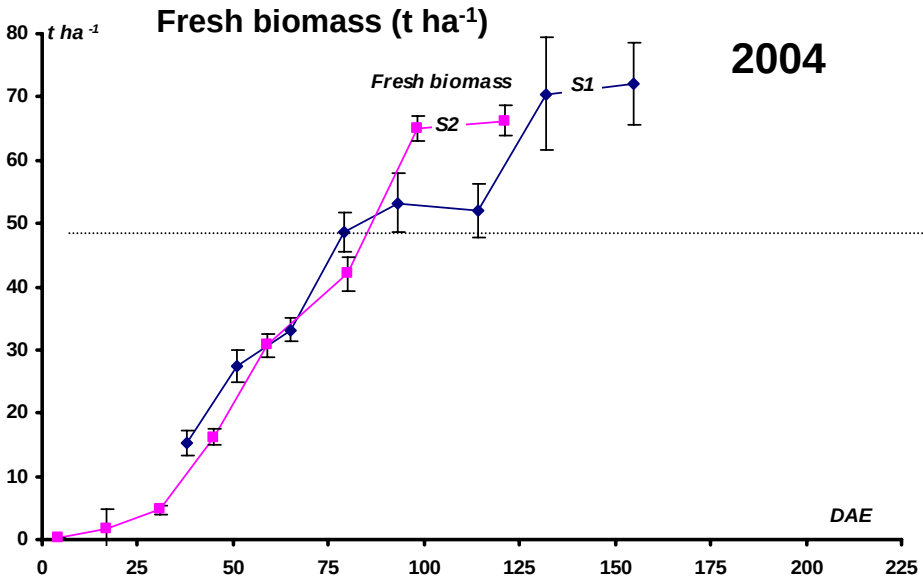
Sowing times affected fresh biomass yield and mainly fresh stem yield, at the final harvest S1 reached up to 30 t ha^{-1} of fresh stem instead of 20 of S2.

The stem growth rate for both sowing times was similar until 125 DAE

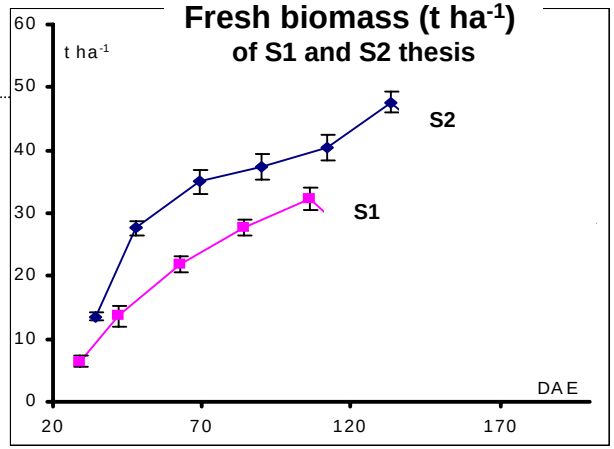
All trends were also very similar, like 2003 year.

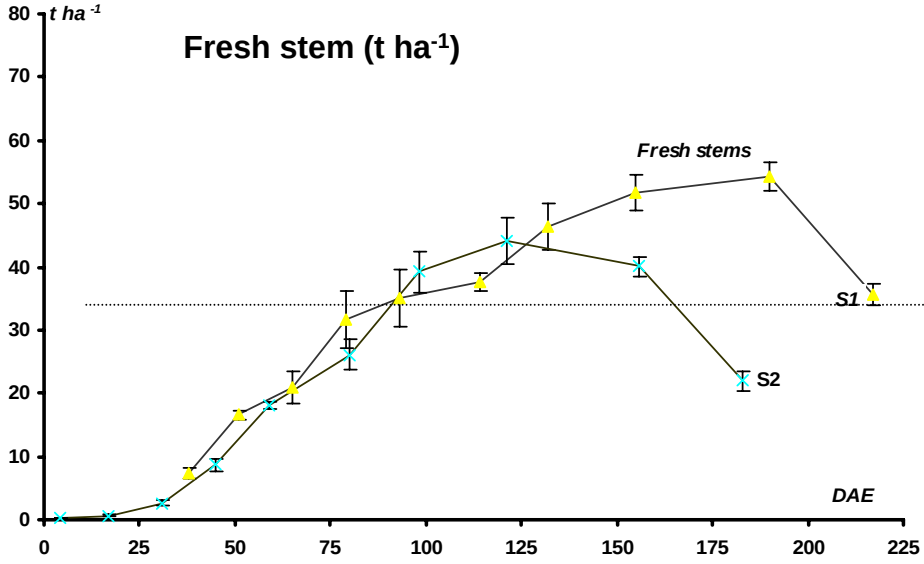
During the last surveys fresh yields decreased significantly, as moisture content on plant decreased too

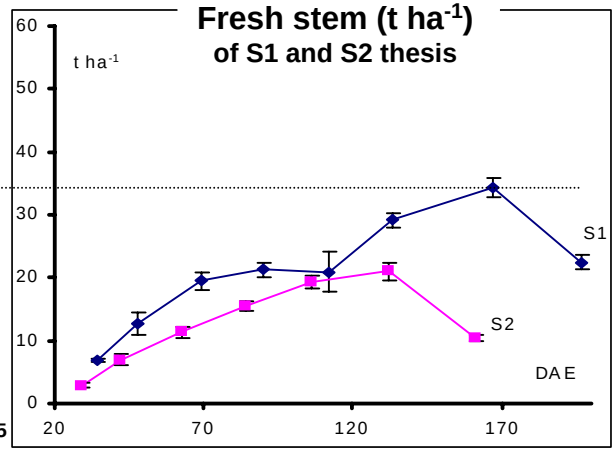
Fresh yields (t ha^{-1}) of total biomass and stems



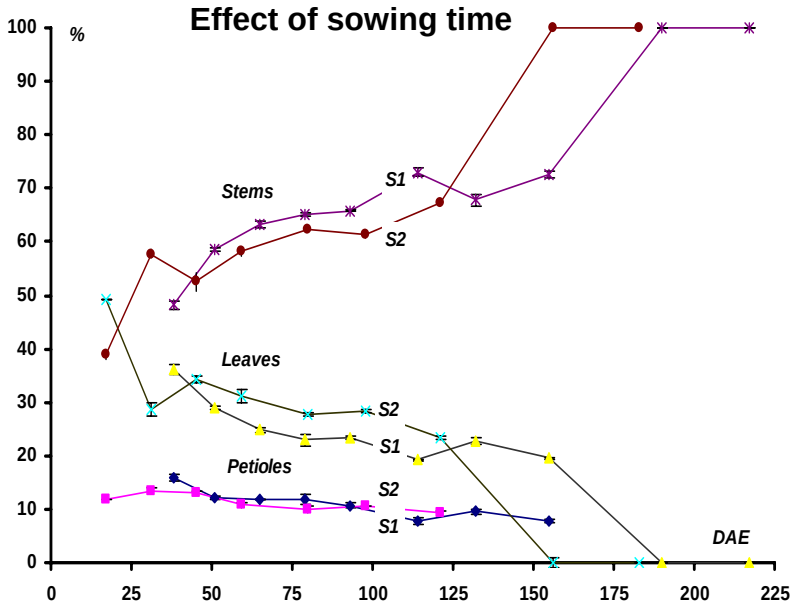
2003

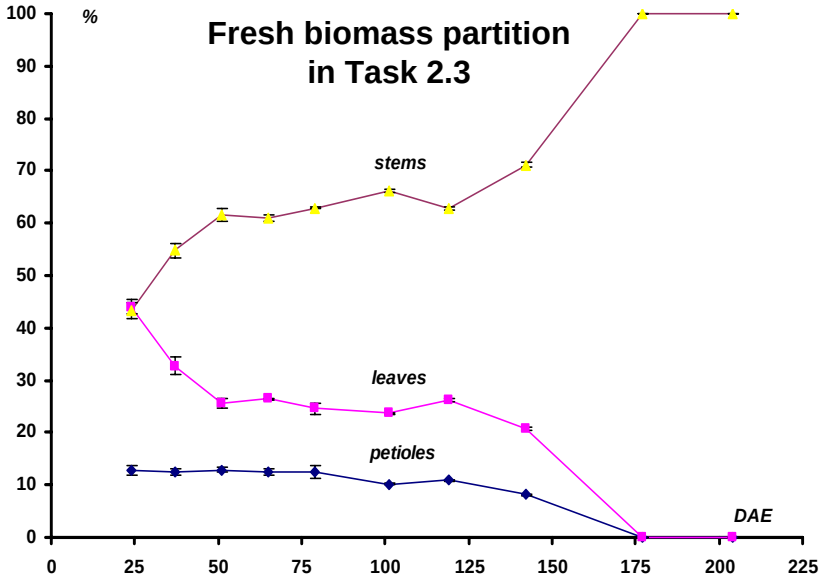






Partition of FB on plant organs during time





Stem % increased during time,
Leaves and petioles decreased until to reach almost 0 at the final harvests.

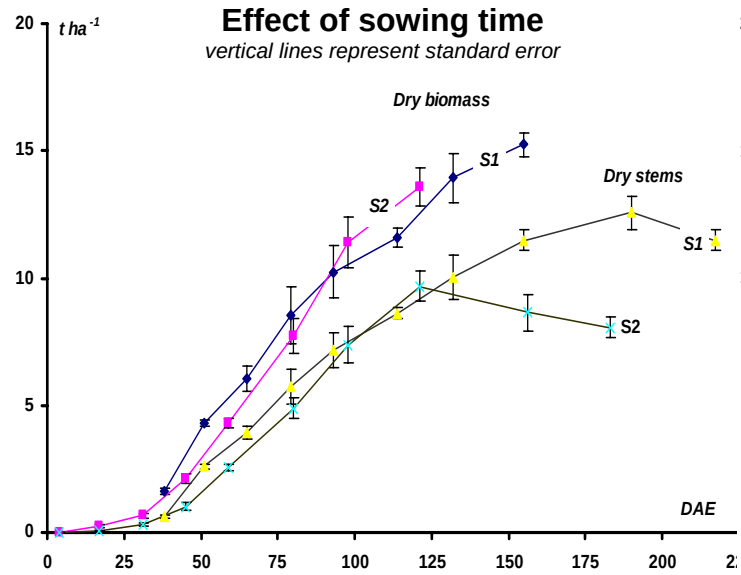
Sowing time seems to have a little effect on partition of biomass in plant organs.

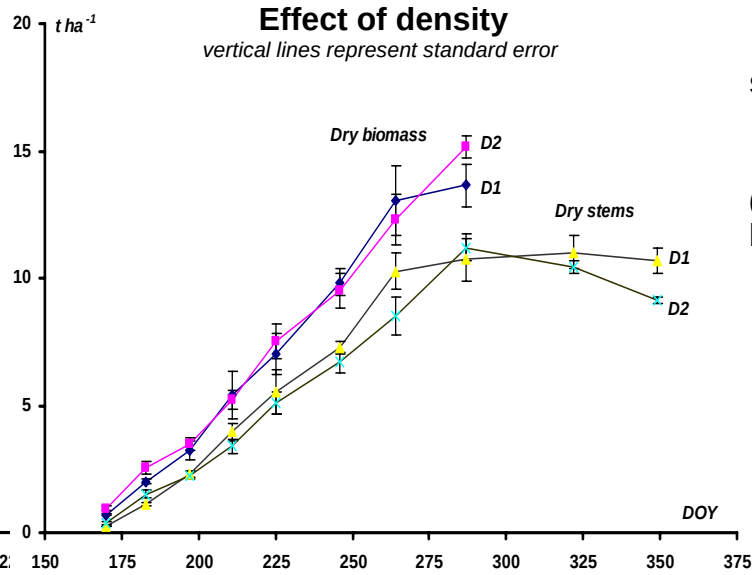
S2 showed higher values of leaves % during time until November.

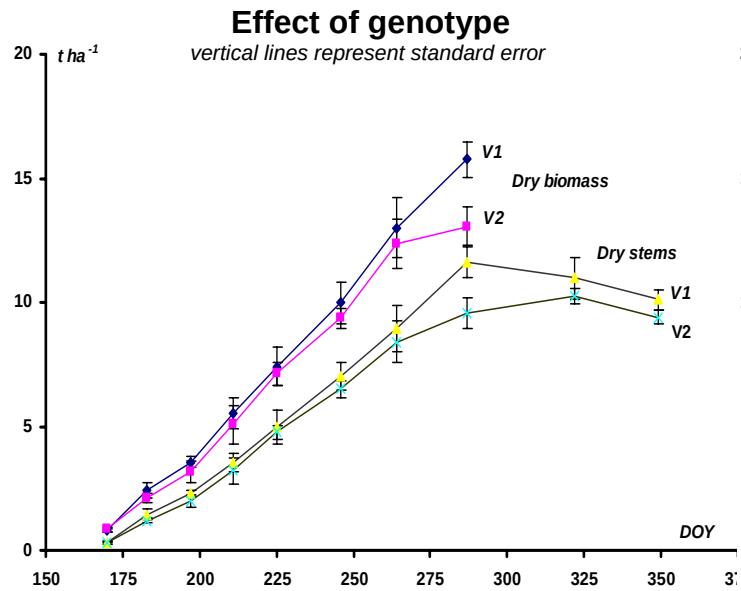
Density and genotype did not affected the partition of biomass on plant organs.

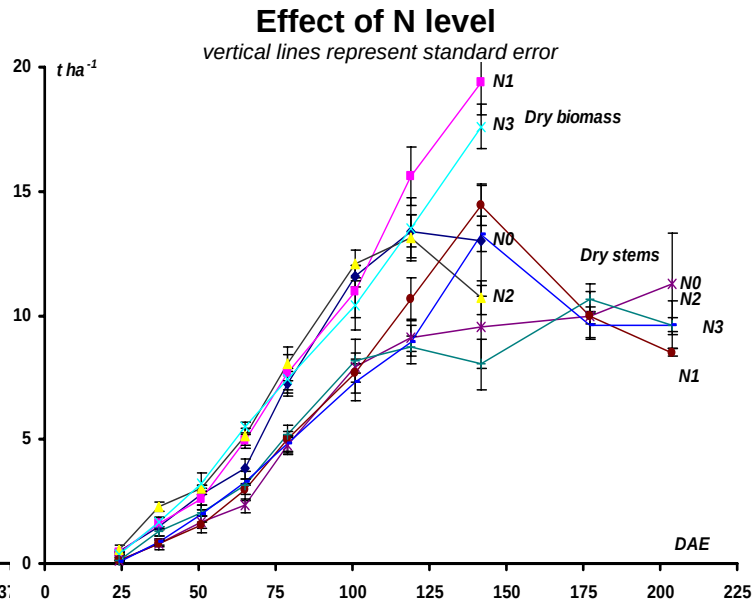
The same consideration can be done for N level

Dry Biomass yields (t ha^{-1})









Dry biomass increased significantly until October

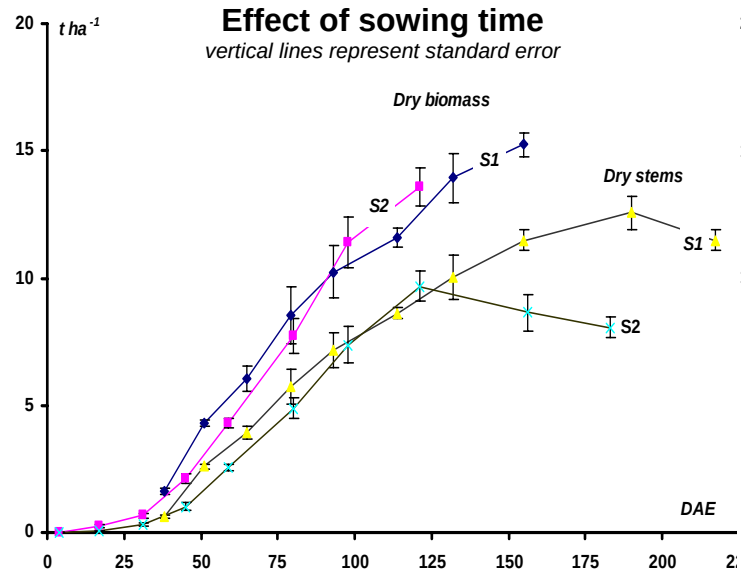
18 t ha^{-1} at 155 DAE
(11 t ha^{-1} at 140 DAE in 2003)
by S1 D1 Tainung2

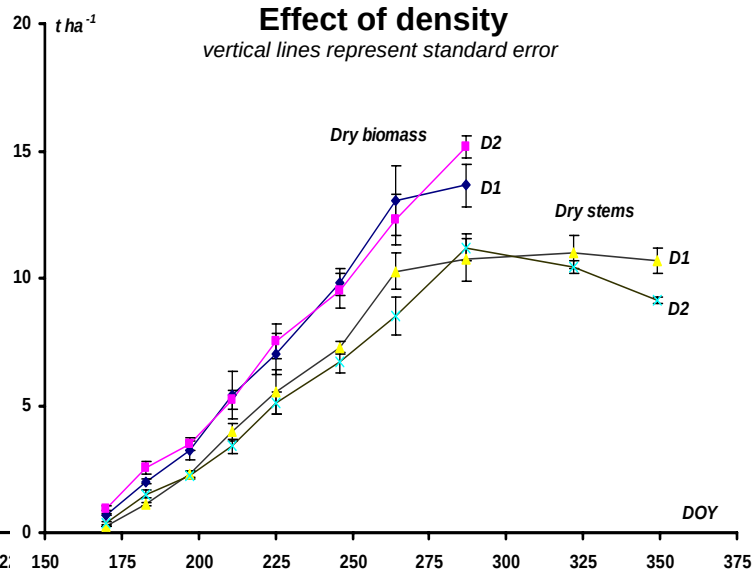
Trends of all treatments were very similar.
S1 produced more than S2, as D2 and Tainung2 produced more than D1 and Everglades41

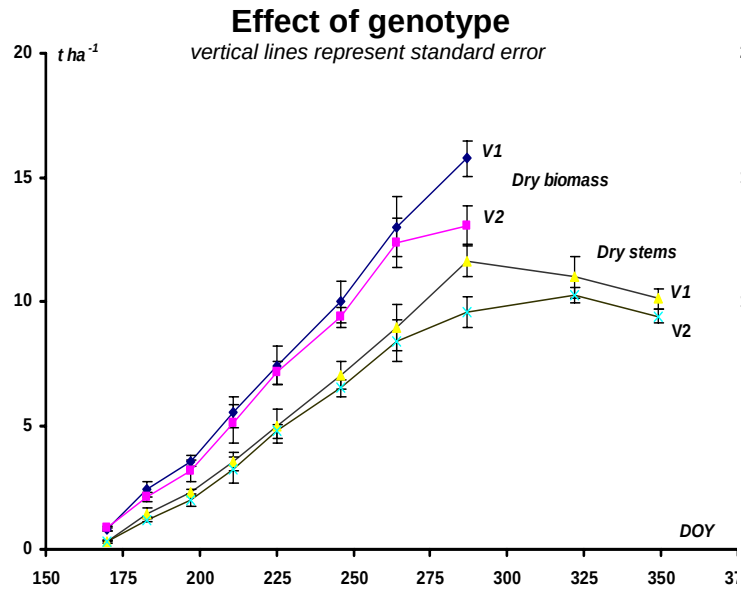
…differences was not so relevant and the growth rates were comparable

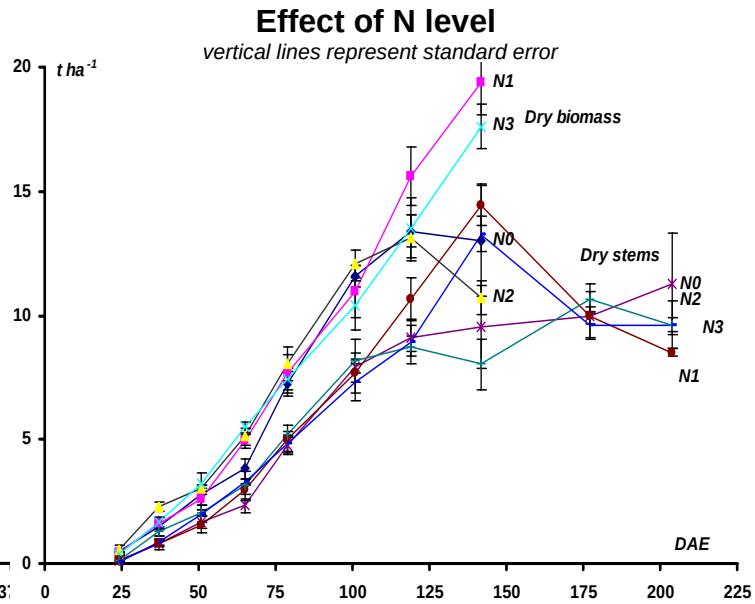
At 150 DAE N1 and N3 treatment showed the best performance (up to 18 t ha^{-1})
…high standard error

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









Trends were quite similar

Best performance was shown by combination S1 D1 Tainung2 (13 t ha^{-1})

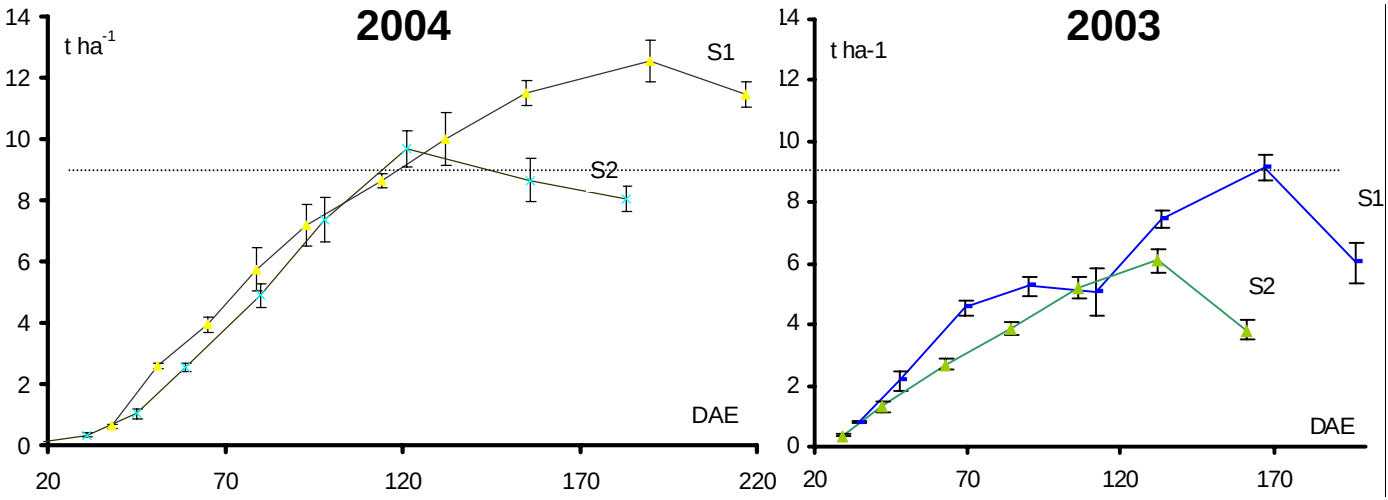
Plants of S1 treatments increased dry stem biomass until around 190 DAE, while S2 (sowed 30 days after S1) stopped to growth around 125 DAE.
This resulted in a quite higher yields of S1 treatments respect to S2

At the last survey in all the cases dry stem yield slightly decreased.

N0 higher values (up to 11 t ha^{-1})
…high standard error

…3 t ha^{-1} of dry leaves can be estimated for N1 and N3 treatment at harvest VIII

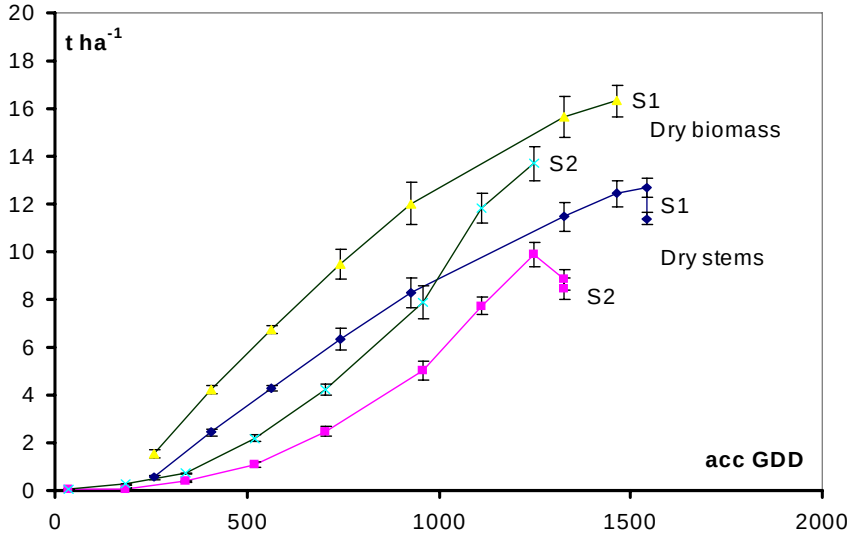
Dry stem yields (t ha^{-1})



The higher value reached by S1 in 2003 at 170 DAE (5th November) was reached by S1 in 2004 at 120 DAE (8th September),

…even if difference in sowing time was only of 10 days

Effect of sowing time on dry biomass yield and stems respect to the accumulation of the GDD (°C)



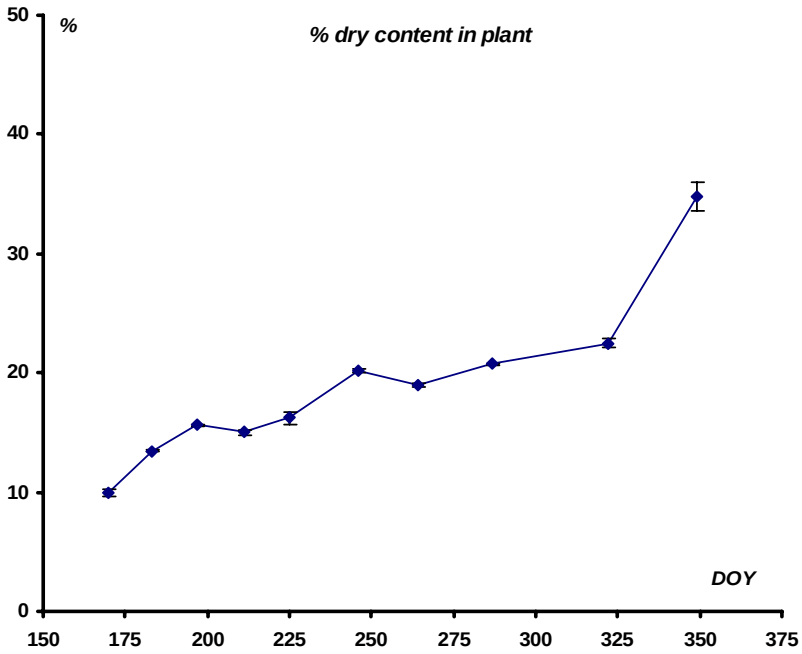
In all cases S1 is up to S2

S2 needed more growing degree days to reach same values of S1 yield

Dry biomass content (%) during time

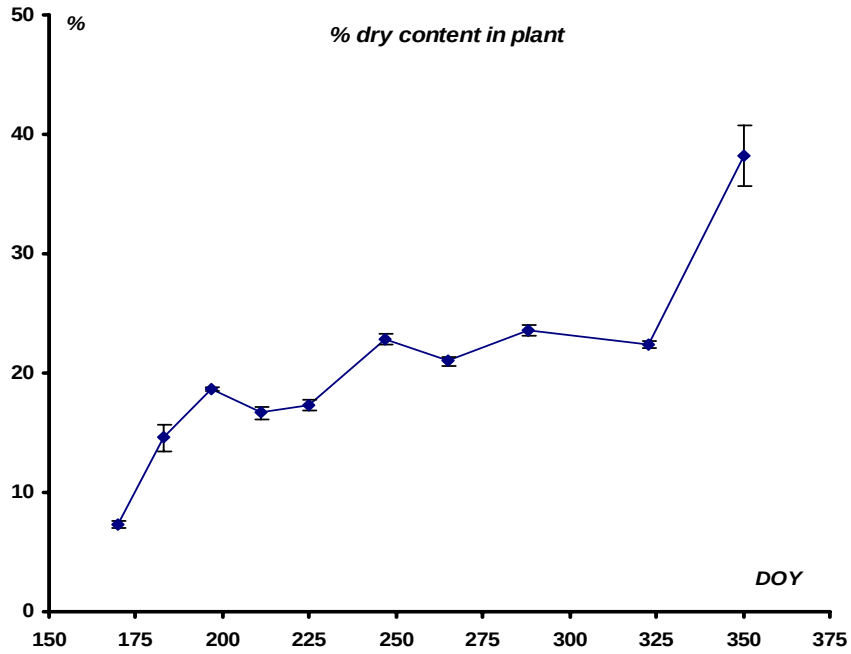
Dry biomass content (%) in plant during time in Task 2.2

vertical lines represent standard error



Dry biomass content (%) in plant during time in Task 2.3

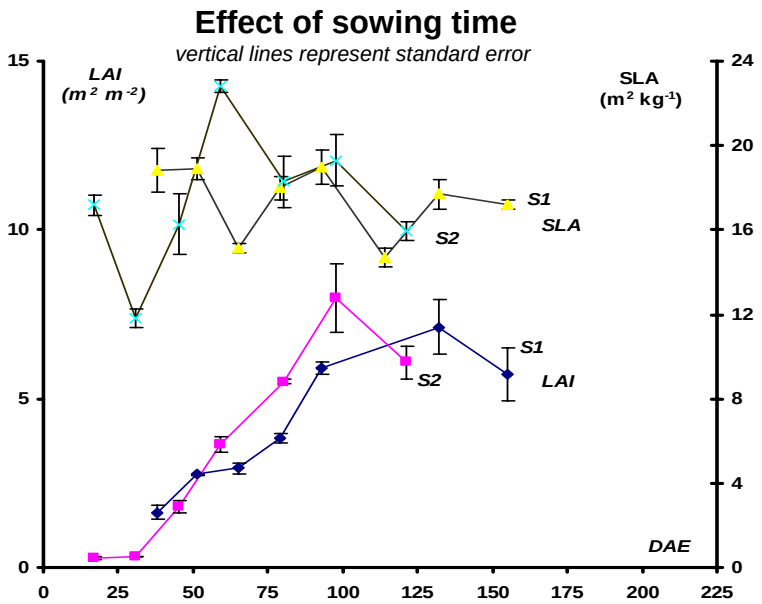
vertical lines represent standard error

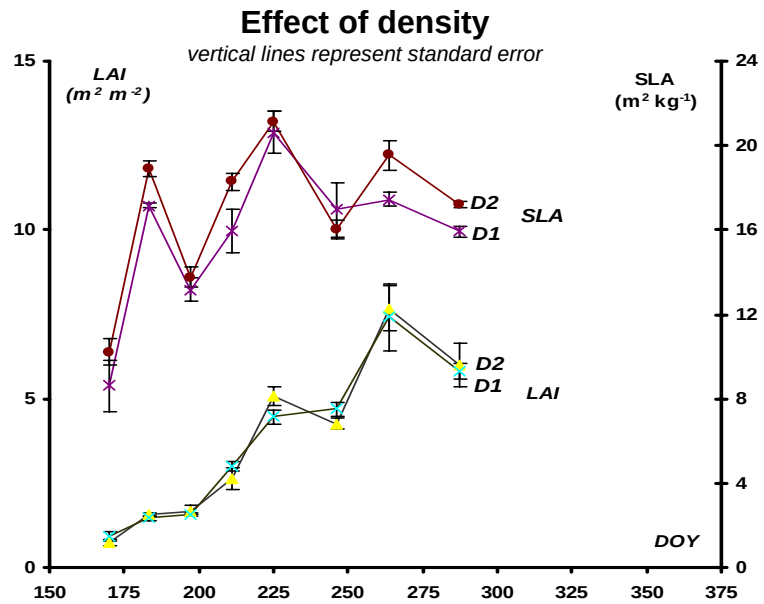


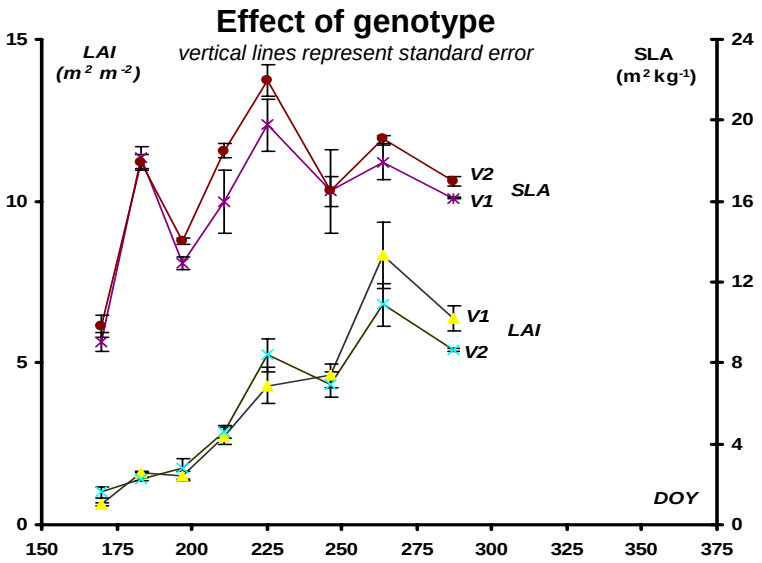
Dry matter content increased during time (from 10 to 40 %)
a big jump was observed at the final harvest carried out on the middle of December

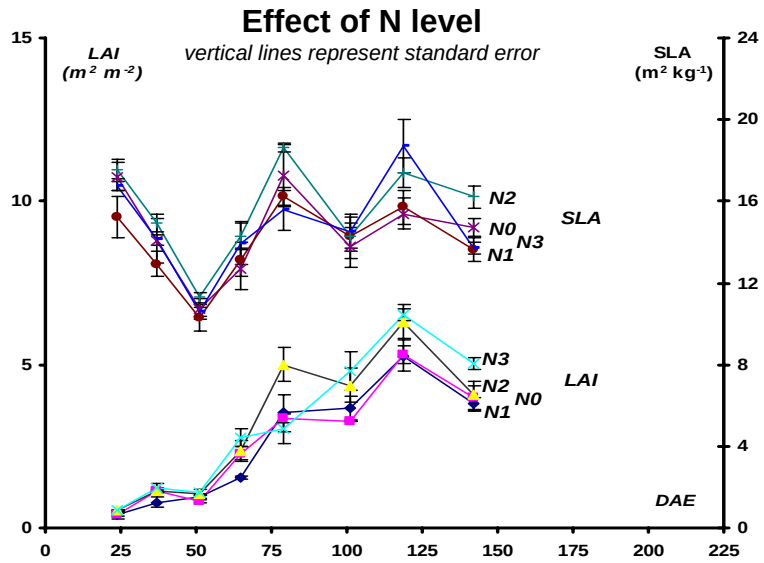
For all treatments trends were very similar

Leaf Area Index and Specific Leaf Area during time









Sowing time did not affected LAI as final value …even though during the crop cycle S2 trend were usually up to S1 curve

D2 and Tainung2 showed higher values of LAI respect to D1 and Everglades41, … differences were not relevant

N3 treatment seems to produce more leaves per m^{-2} during time, but again difference was not so important to consider it.

In terms of SLA, the most relevant difference was showed by D2 density, but in any case trends were very similar.

Final harvests (5 m^2)

At harvest soil moisture was in a range of 40 % to 50 % (V/V)

Crop did not reached complete flowering

Plants lost leaves before the harvests, all yields are referred to stem

Analysis of variance (ANOVA) for all treatments and their interaction:

Task 2.2

4 factors complete randomized block design

- **Variety**
- **Density**
- **Sowing time**
- **Harvest**

(2 levels)

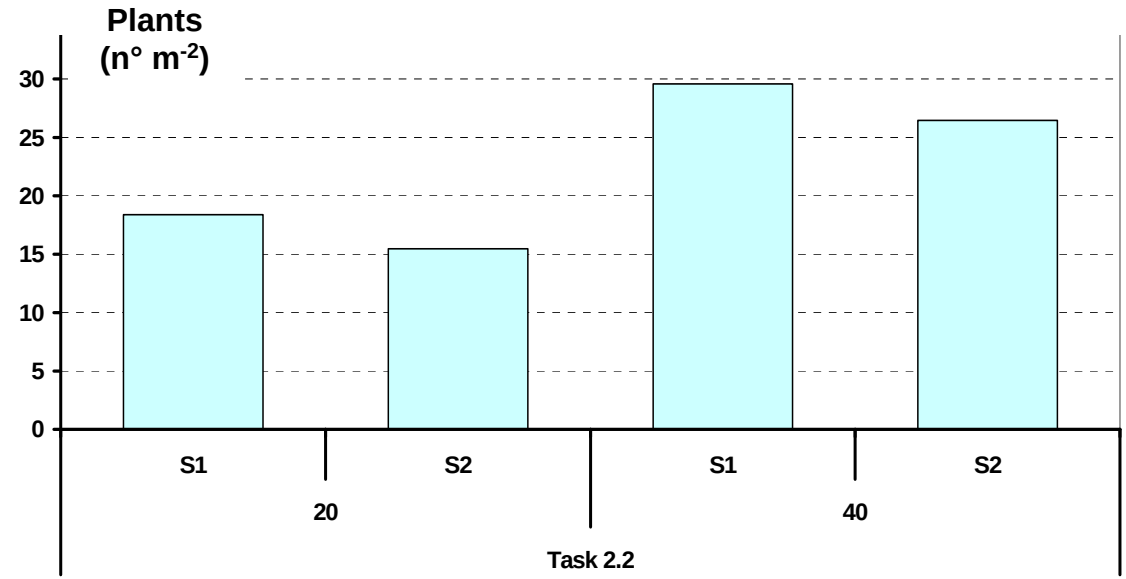
Task 2.3

2 factors complete randomized block design

- **N (4 levels)**
- **Harvest (2 levels)**

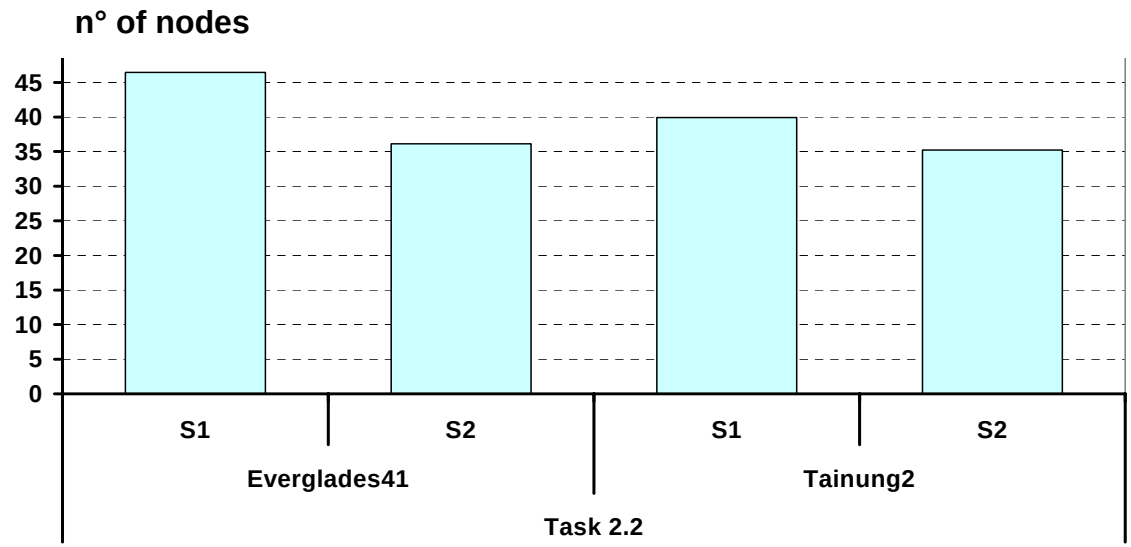
Differences analyzed at P = 0.05 and 0.01

Trends of some interesting parameters related to the factor that significantly affect their value



Reached density on field was significantly different between the two D thesis.

In both the last harvests n° of plants m^{-2} was significantly higher for the S1 treatments than S2 ones (P = 0.01)

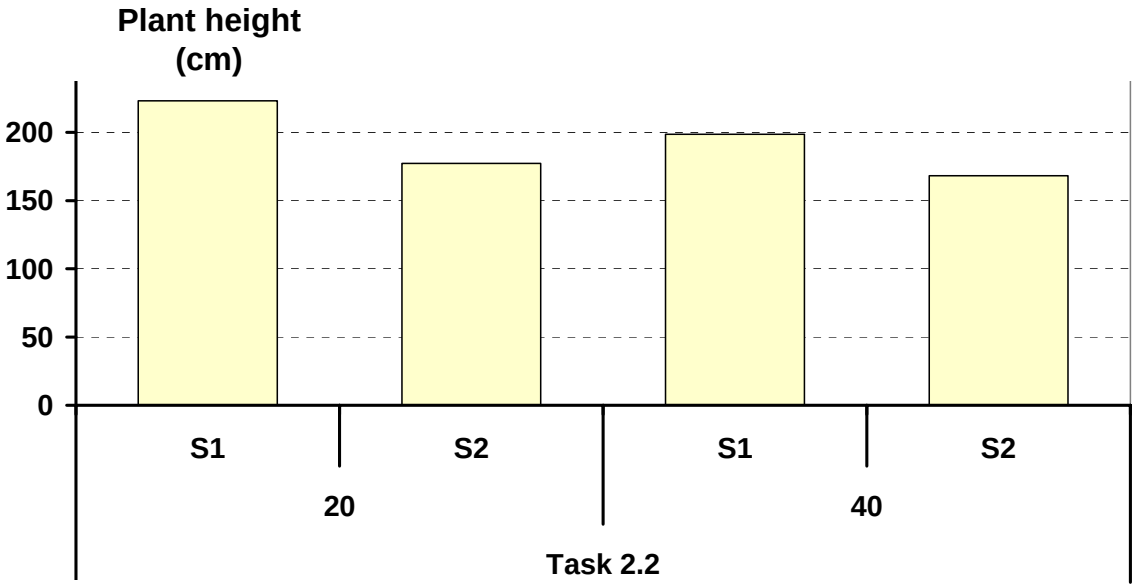


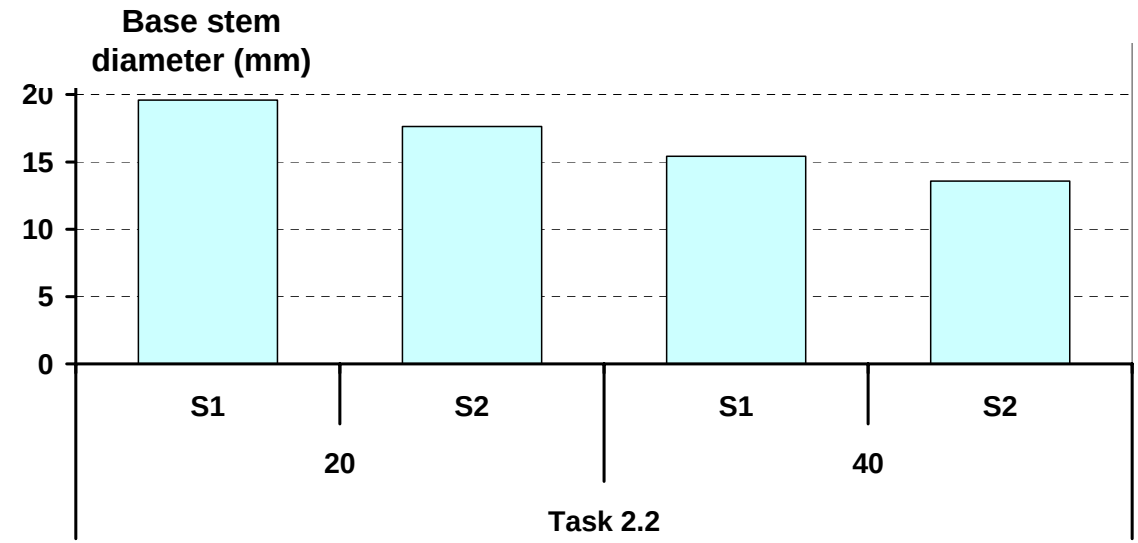
Similar to 2003.
In plants of S1 and D1 were present more nodes, around 40

Sowing time affected significantly the n° of nodes, S1 10 nodes more than S2.

Everglades41 more nodes than Tainung2 (P=0.05)
…little statistical significance also among replications

Trends of some interesting parameters related to the factor that significantly affect their value

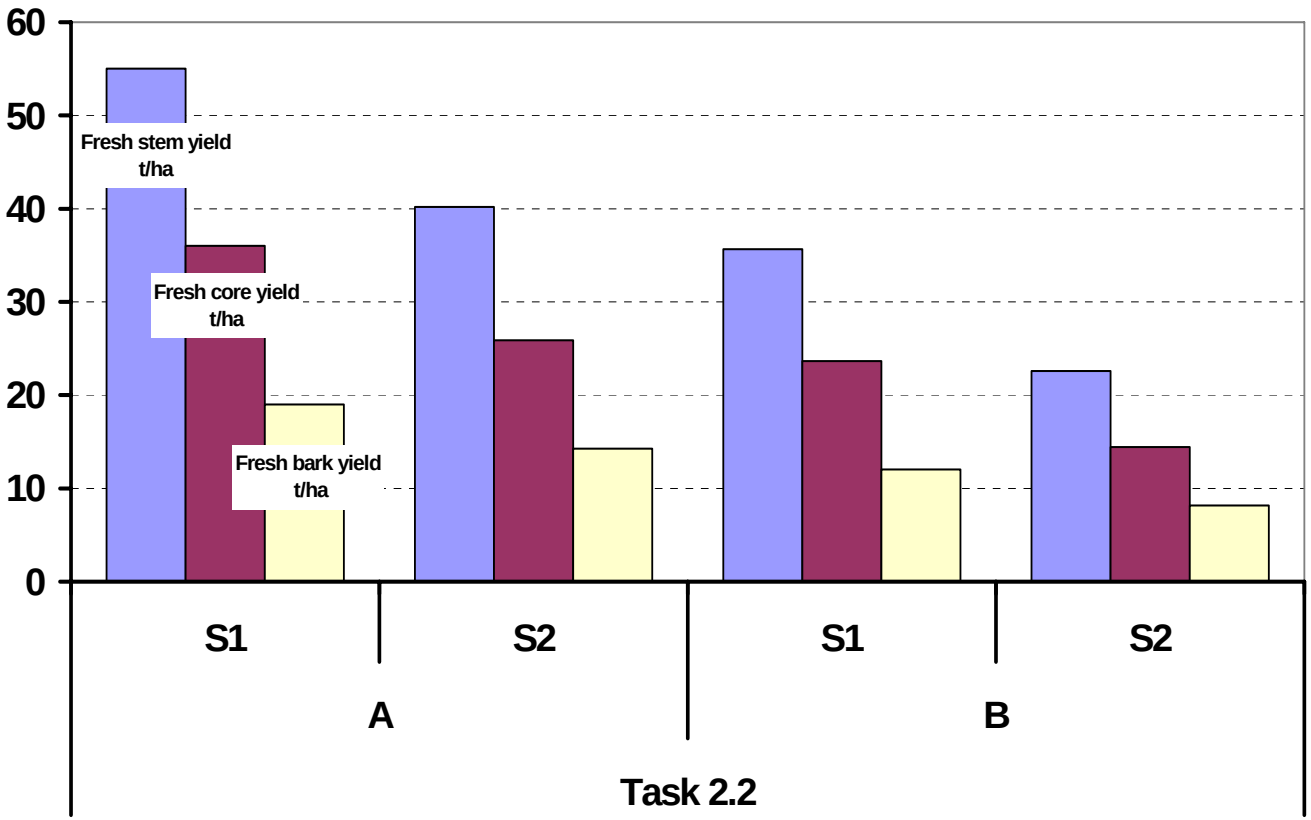




Height and base stem diameter were influenced mainly by tested densities and sowing times,
…as it was observed in 2003.

D1 and S1 treatments reached the higher values.

Trends of some interesting parameters related to the factor that significantly affect their value



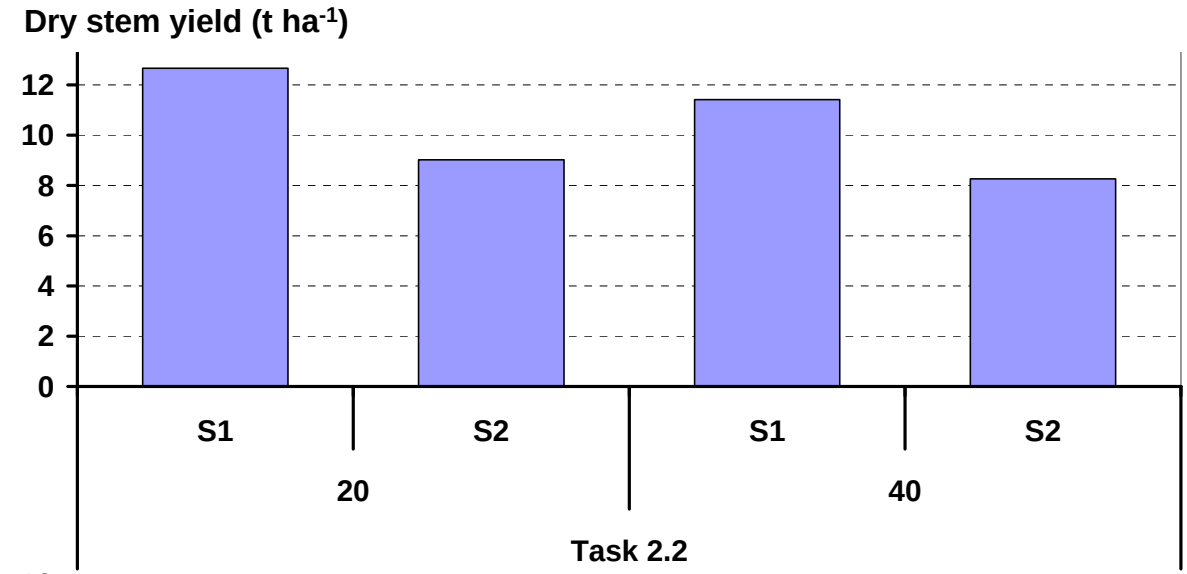
Fresh yields of stems, bark and core were influenced significantly by sowing and harvest time,

The relevant difference between the harvest A and B was mainly due to the lost of moisture, as confirmed by the statistically significant increasing of dry content in stem, bark and core at harvest B respect to harvest A.

Fresh stem yield ranged from up to 55 t ha^{-1} to 20 t ha^{-1}.

Higher values were observed at harvest A by all first sowing time treatments, 55 against 40 t ha^{-1} of S2 treatments.

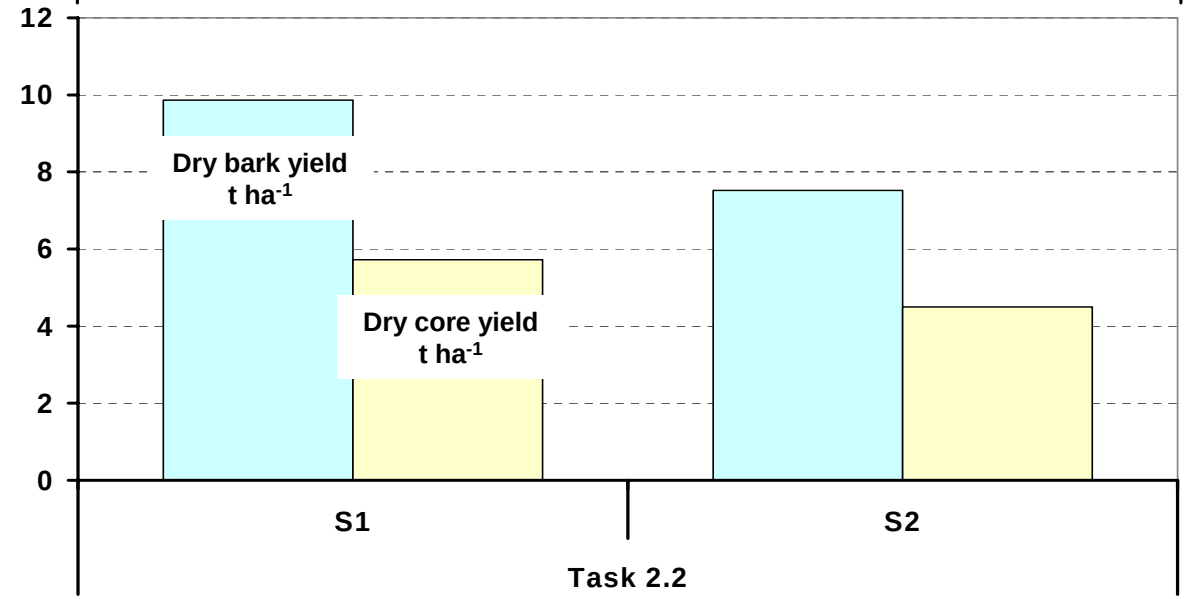
Trends of some interesting parameters related to the factor that significantly affect their value



Dry stem yield was influenced mainly by sowing time and density, while harvest time seemed do not affect it.

D1 and S1 treatments reached the highest values, around 13 t ha^{-1}, against 8 t ha^{-1} of 2003 year.

Also variety and harvest time seems to influence dry stem yield, with a higher production of Tainung2 respect to Everglades41 at harvest A (P=0.05)
… little statistical significance also among replications.



Dry bark and core yields are also influenced by sowing time but not by harvest time and density.

Dry core yield ranged from 6.5 to 10 t ha^{-1}, while dry bark reached at maximum 5.8 t ha^{-1}, higher values were reached in all cases again by S1 treatments.

Trends of some interesting parameters related to the factor that significantly affect their value

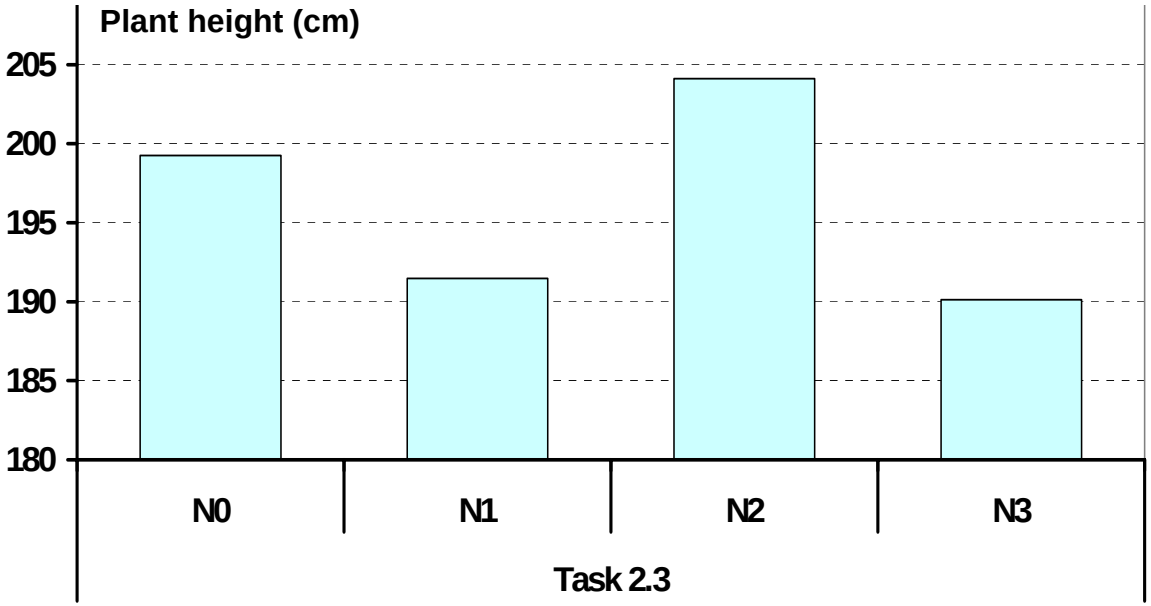
Branched plants (% of harvested plants)

A considerable number of plants, from up to 50 % to 95 % of harvested plants, has a branched stem, with at least 2 important ramifications per plant.

Density influenced significantly the presence of the branches, with higher values of branched plants and n° of ramifications per plants reached by D1 density.

S2 plants present more branched stems.

Trends of some interesting parameters related to the factor that significantly affect their value

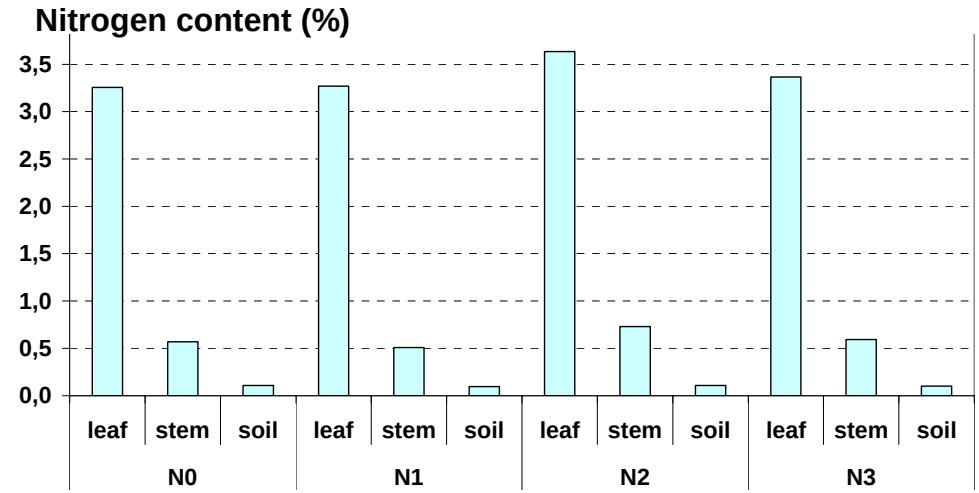


N2: the highest plant height (P=0.05).

The statistical analysis showed that only the harvest factor seems to affect fresh yields, and dry content

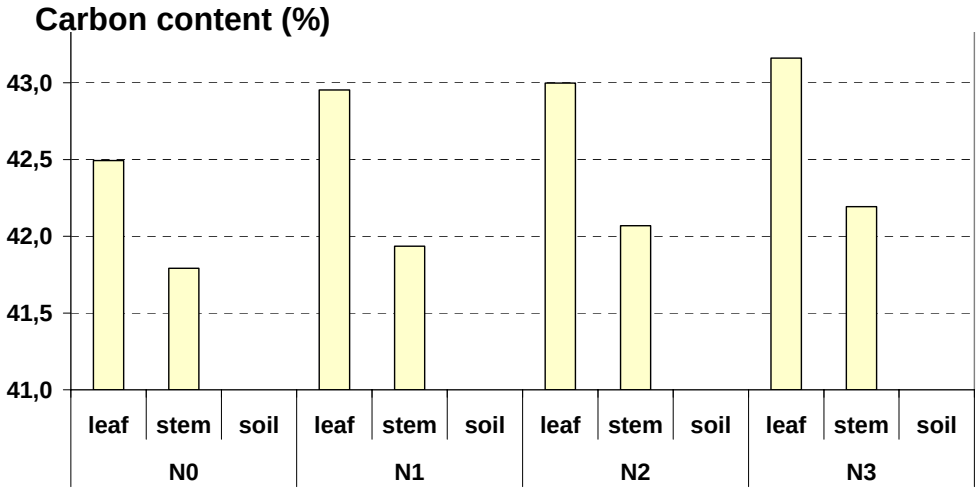
… dry yields were not significantly affected by harvest

N and C content (%) in leaves, stems and soil at final harvest of Task 2.3



N content in stem and leaf seems to increase with N level until N2

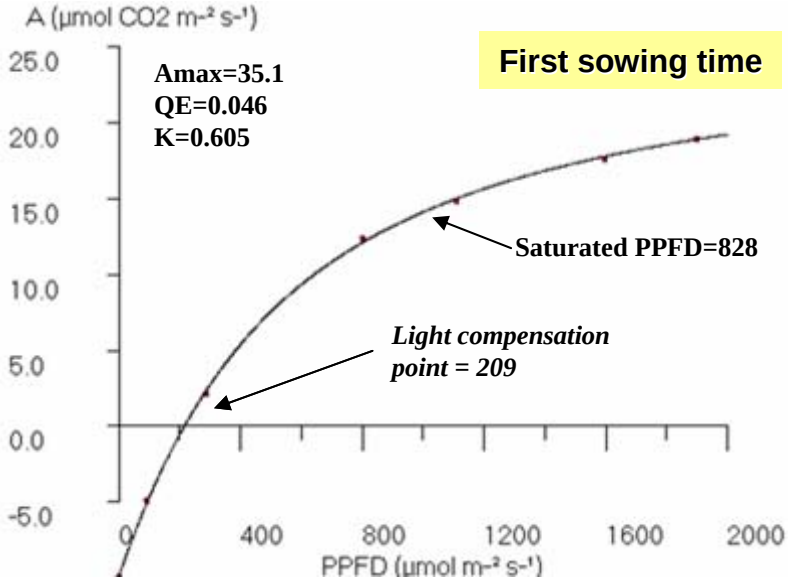
… differences are not relevant, as confirmed by the analysis of the variance



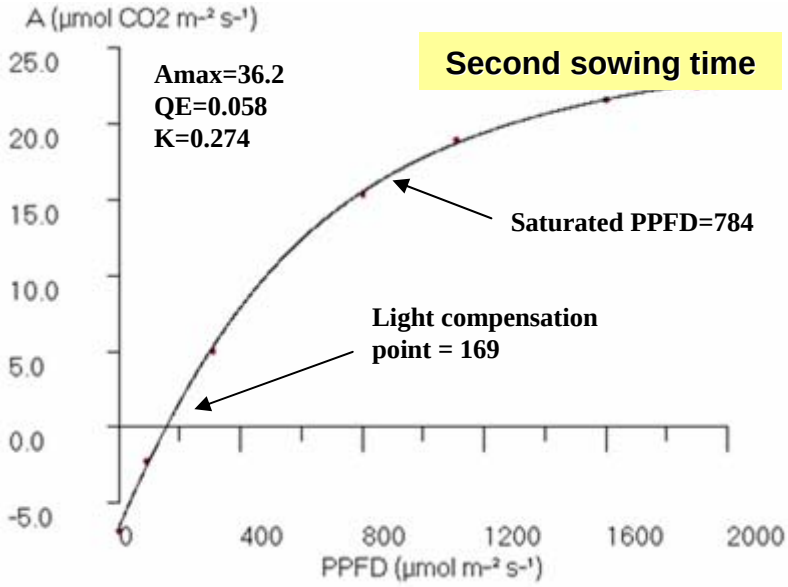
Carbon content in leaf and stems seems also to increase with N level, reaching values up to 43% in leaf of N3 treatment

…differences among treatments are significant at P=0.05

The light response curve of leaf photosynthesis (A)



First sowing time



Second sowing time

QE:
apparent quantum efficiency

Light compensation point

Amax:
light saturated maximum

K:
convexity

S2 higher QE, Amax

S2 lower light compensation point

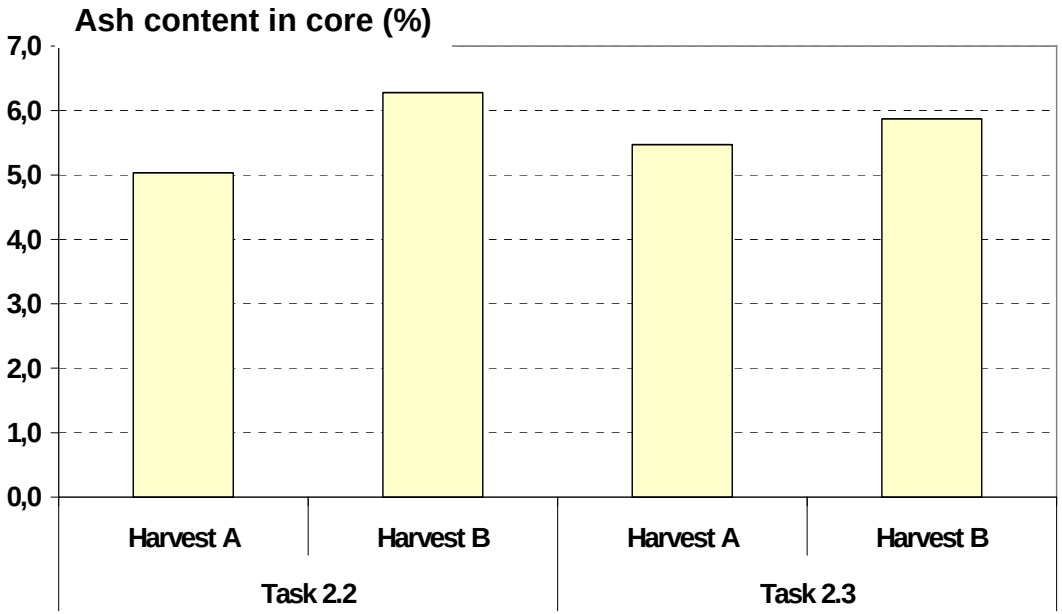
leaves of S2 more effective in photosynthesis

Tainung2; D 40 p m^{-2}

Portable IRGA (CIRAS-2, PP-Systems)

Most recently fully expanded leaves

Ash content in core (%)



		ash %		standard deviation	
		Harvest A	Harvest B	Harvest A	Harvest B
Task 2.2	Everglades41	5,219	6,439	0,708	0,815
	Tainung2	4,848	6,121	0,495	0,822
	S1	5,176	6,414	0,518	0,874
	S2	4,890	6,146	0,712	0,770
	D1	5,174	6,156	0,696	0,841
	D2	4,893	6,405	0,541	0,809

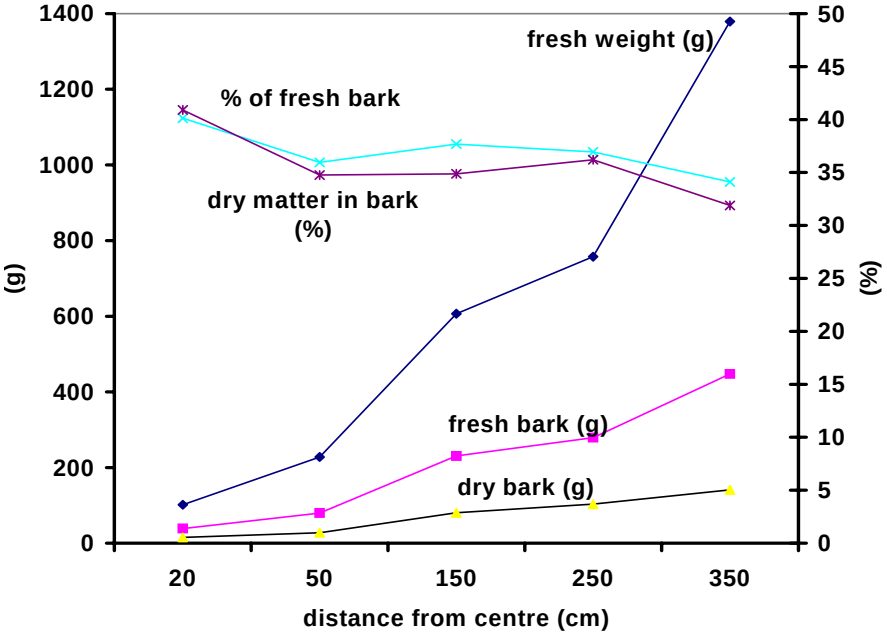
		ash %		standard deviation	
	N level	Harvest A	Harvest B	Harvest A	Harvest B
Task 2.3	N0	5,574	5,672	0,680	0,061
	N1	5,347	6,169	0,366	0,201
	N2	5,322	5,913	0,444	0,745
	N3	5,637	5,667	0,173	1,063

Ash content in Kenaf core is on average around 5.5 %, like more commonly utilized herbaceous plant for energy production

The differences among factors seem to be not important (analysis of the variance)

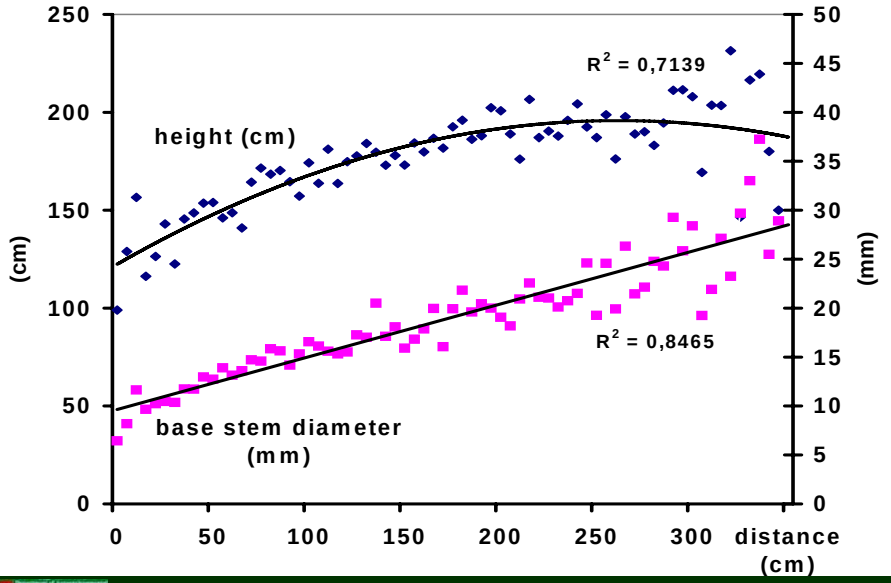
The harvest time: harvest B showed higher values of ash % for all tested factors, increasing of more than 1 % the hash content, observed only in Task 2.2.

Effect of the distance between the rows on plant biometric parameters and yields



In all the cases fresh weight increased significantly with distance from the star centre.

Also bark yields increased, even if bark % respect to the stem seemed to decrease



Both stem height and base diameter increased going far away from the centre of the star (increasing distance between the row)

Height seems to have a stabilization at the end, where in any case it is possible to observe a big variation.

Lower value of R^2 anyway showed a bad estimation of the tendency curve, related to the high variation of the measurement recorded.

A possible reason could be the damages that hail made on plants of this trial, particularly seriously in this trial

CONCLUSIONS

year 2004 more productively than 2003

Fresh and dry yields, stem height and LAI reached values significantly higher than 2003

	Year		Year	
	2004	*2003*	*2004*	*2003*
Height (cm)	234	164	S1 D1 V1	S1 D1 V1
Fresh Yield (t ha^{-1})	75	52	S1 D1 V1	S1 D2 V1
Dry Yield (t ha^{-1})	18	11	S1 D1 V1	S1 D1 V2
Dry stem yield (t ha^{-1})	13	9	S1 D1 V1	S1 D1 V1
LAI (m^2 m^{-2})	10	6	S2 D2 V2	S1 D2 V2

Max reached values of some interesting parameters in 2004 and 2003

Better climatic conditions:

The higher amount of rainfall, mainly in May and June, respect to 2003

Not particular dry season

Not particular cold temperatures were recorded, at the end of the crop cycle

…plants accumulated more growing degree days respect to the first year

it has to be considered that yield levels of 2003 were very low, as observed for the other crops in the same location

CONCLUSIONS

Sowing time affected most of investigated parameters, but the difference was lower than what observed during the last year

Increasing crop cycle length…
Sowing at the beginning of May increased in 2004 the length of the crop cycle respect to 2003, without any kind of problems for the plant growth

Two tested varieties did not show important differences as well as nitrogen levels seem not to influence yields, even if in N1 and N3 levels have been observed significantly higher values of LAI

The effects of density were low for the yield parameter, influencing mainly stem diameter and plant height

Harvest time mainly affected the fresh yields, significantly decreasing the moisture content in the last harvest

KENAF FIBRE

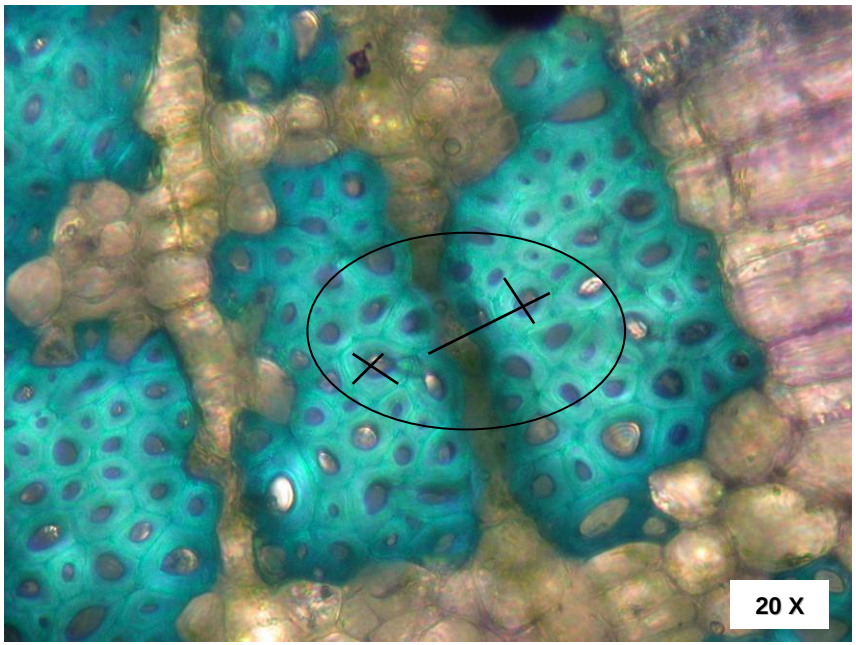
Tainung2

First sowing time

Plant height: 87 cm

Base stem Ø: 11.38 mm

10 cm from stem bottom



Thanks to Federica Pelatti

2005 EXPERIMENTAL FIELDS

Sowing

Task 2.2 **S1: 28 04 2005**

S2: 30 05 2005

Task 2.3: **10 05 2005**

Harvests

21 06 2005

28 06 2005

Task 2.2