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EL BIERZO.
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1st International Meeting on
Dryocosmus kuriphilus Yasumatsu

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Cultural practices can reduce damages by *Dryocosmus kuriphilus* in chestnut stands

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Dryocosmus kuriphilus arrived in Europe in 2002, in Northern Italy

Quarantine not effective

Rapid spread in all Italian *Castanea sativa* stands (in 10 years) due to:
-adult dispersal by flight
-movement of plants and scions containing eggs

***Castanea sativa* stands in Italy, about 10% of national forests (INFC, 2007)**

Infested stands in 2010 (CABI, 2011)

The wasp has more recently spread in adjacent countries and has now arrived in Spain

Defense strategies in Italy

Biological control by
Torymus sinensis
(best effective, medium term)
Focus: **insect**

Silvicultural and
cultivation practices
(short term)
Focus: **plants in field**

Genetic selection and
propagation
(medium-long term)
Focus: **cultivars**

Damage: galls on leaves, shoots, buds and flowers

main effect

Reduction

of photosynthetic surface

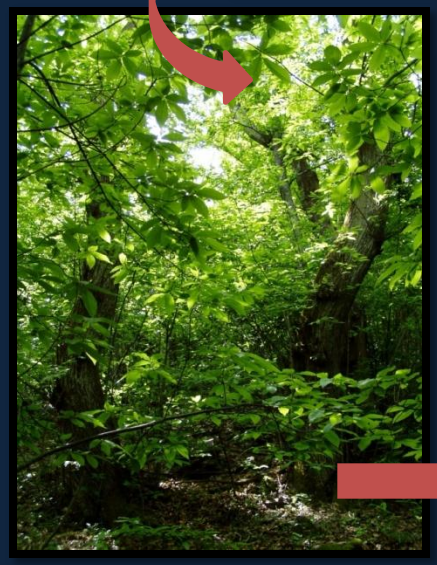
Loss of fruit production in terms of quantity and quality

Reduction of plant growth

Estimated **loss** in fruit production ???
50-70% (CABI, 2011)

Abandonment of cultivation of chestnut orchards

High costs of restoring (as happened after chestnut blight)



During the time gap to the effectiveness of biological control and genetic improvement, it is necessary to reduce the damage to avoid chestnut stands degradation and abandonment

Goal

to maintain a good vegetative state of plants and an acceptable level of fruit production

Preliminary steps

To study the plant-insect interactions

Classification of damage in types (in terms of consequences on plant development)

Analysis of the damage types distribution on the plant

Relationships between damage susceptibility and plant vigor

(Maltoni *et al.*, 2012)

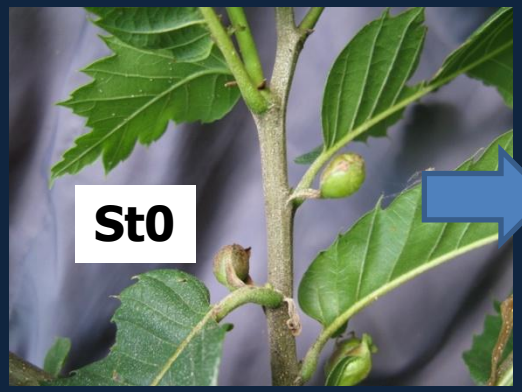
Damage classification

- **POSITION** of the gall (vegetative organ: **Shoot, Leaf, Dormant Bud, Flower**)
- **EFFECT** of the gall on development (**degree of deformity**)

(Maltoni et al., 2012)

Abnormal organ development is directly related to a reduction of photosynthetic area causing different consequences according to the attacked organ

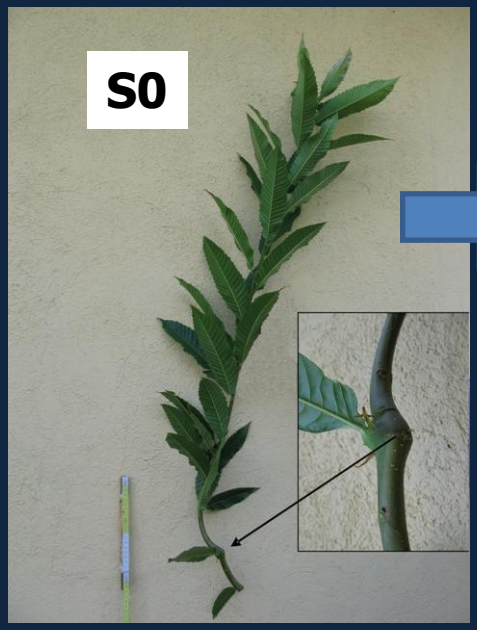
Galls on leaves and stipules



Consequences on plant growth

	Current season	Following seasons
L0 / St0	No	No
L1	Very Very slight	No
L2	Very slight	No

Galls on shoots



The galls are located along the axis or on adjacent leaves and the axis development is nearly normal

The galls are located along the axis; deviation of the axis direction and reduction of axis growth and diameter are evident

The galls cause a complete deformation in shoot development

Galls on shoots

S0

S1

S2

Consequences on plant growth

Current season	Following seasons
Normal shoot growth and development	No
Usually this damage causes a general reduction of the active photosynthetic area during the current growing season	Not predictable (in many cases it doesn't cause the death of the entire shoot) Possible reduction of new shoots
Heavy damage It compromises the shoot development and so the photosynthetic activity	Most severe damage It always causes the shoot death No new shoots

Galls on dormant buds and flowers

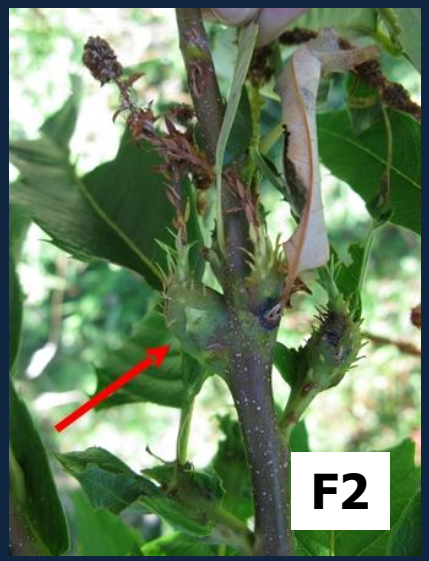
DB2

The gall causes a complete deformation of the bud

F2

The gall causes a deformation of the female or male flowers

Galls on dormant buds and flowers

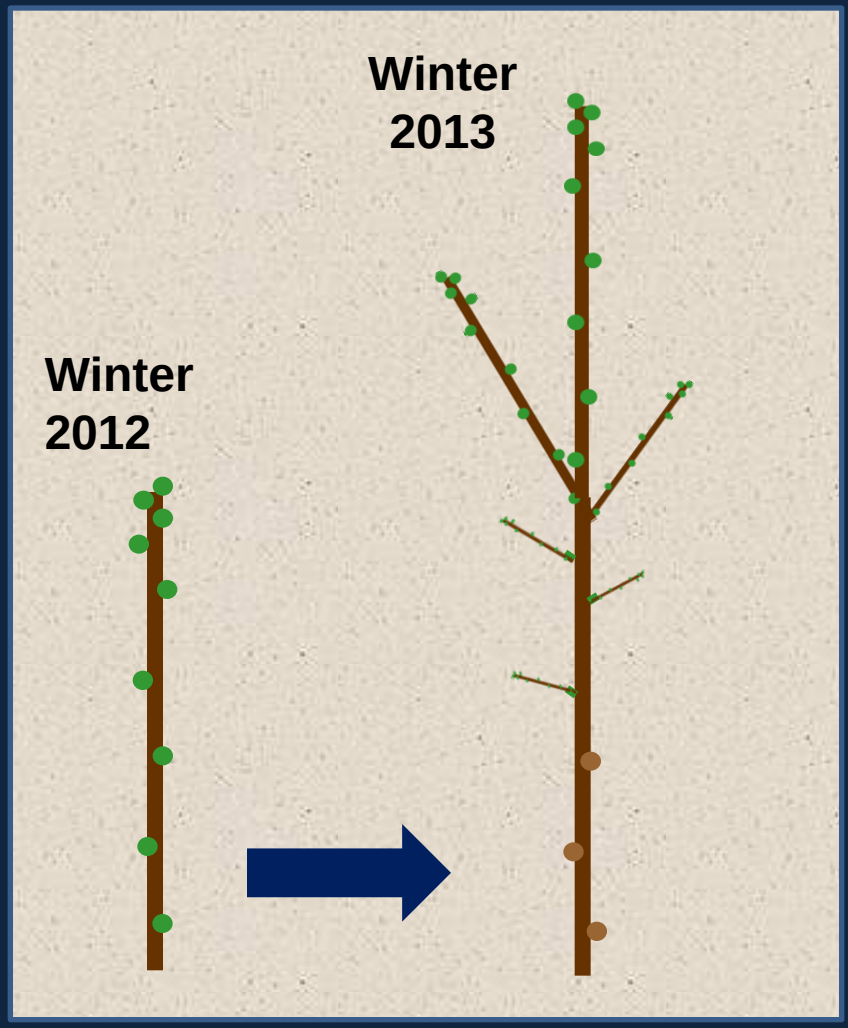


Consequences on plant growth

	Current season	Following seasons
DB2	No damage (no shoots development even in case of normal conditions)	No damage in normal conditions Heavy damage if the development of shoots is required in future
F2	Heavy damage It involves potential fruit production	None

Relevance of damage position on shoots

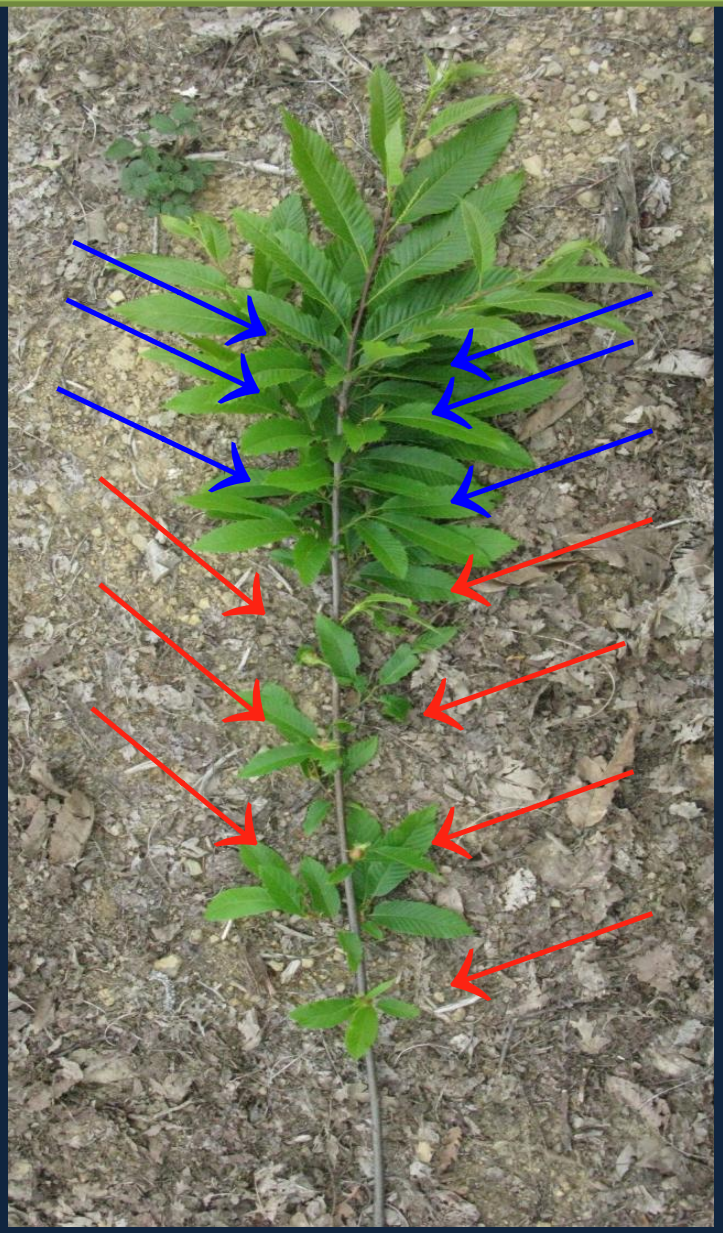
The development of chestnut shoots



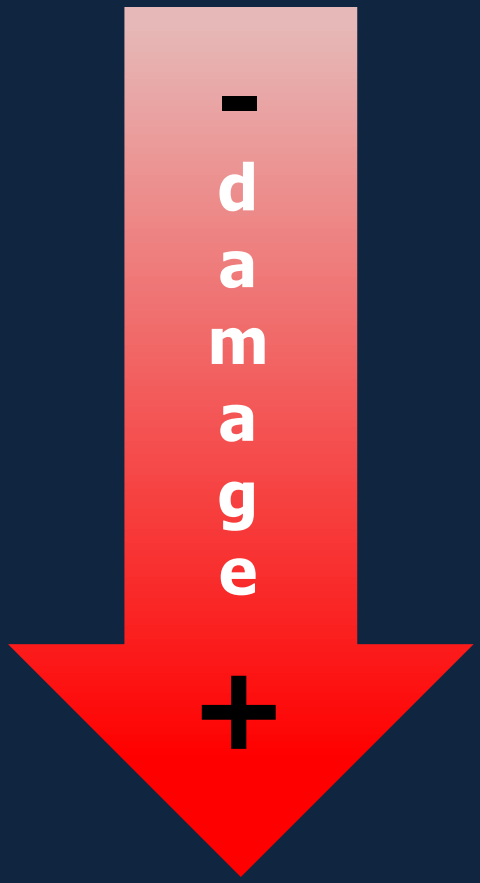
Rough assessment of the reduction of photosynthetic surface in terms of leaves number

	Apical part of the shoot → new shoots				Lower part of the shoot → brachiblasts			
	Y_0	Y_1	Y_2	….Y_{10}	Y_0	Y_1	Y_2	….Y_{10}
St0	0	0	0	0	0	0	0	0
L0	0	0	0	0	0	0	0	0
L1	1	0	0	0	1	0	0	0
L2	1	0	0	0	1	0	0	0
S0	0	0	0	0	0	0	0	0
S1	0-5	0-30	0-90	0-3000	0-3	0-3	0-3	0-3
S2	10	~35	>100	~4500	3	3	3	3
DB2					0	0-?	0-?	
F2	5	0	0	0	5	0	0	0

Analysis of the damage types distribution on the plant



Damage distribution on shoots is not random

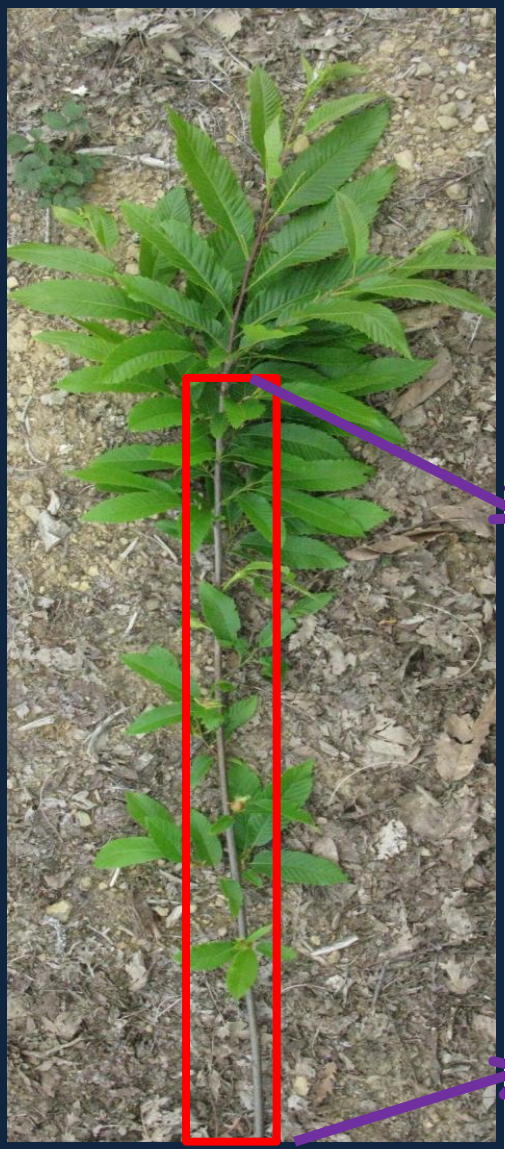


(Maltoni et al., 2012)

Relationships between damage susceptibility and plant vigor

Why is it important to investigate it?

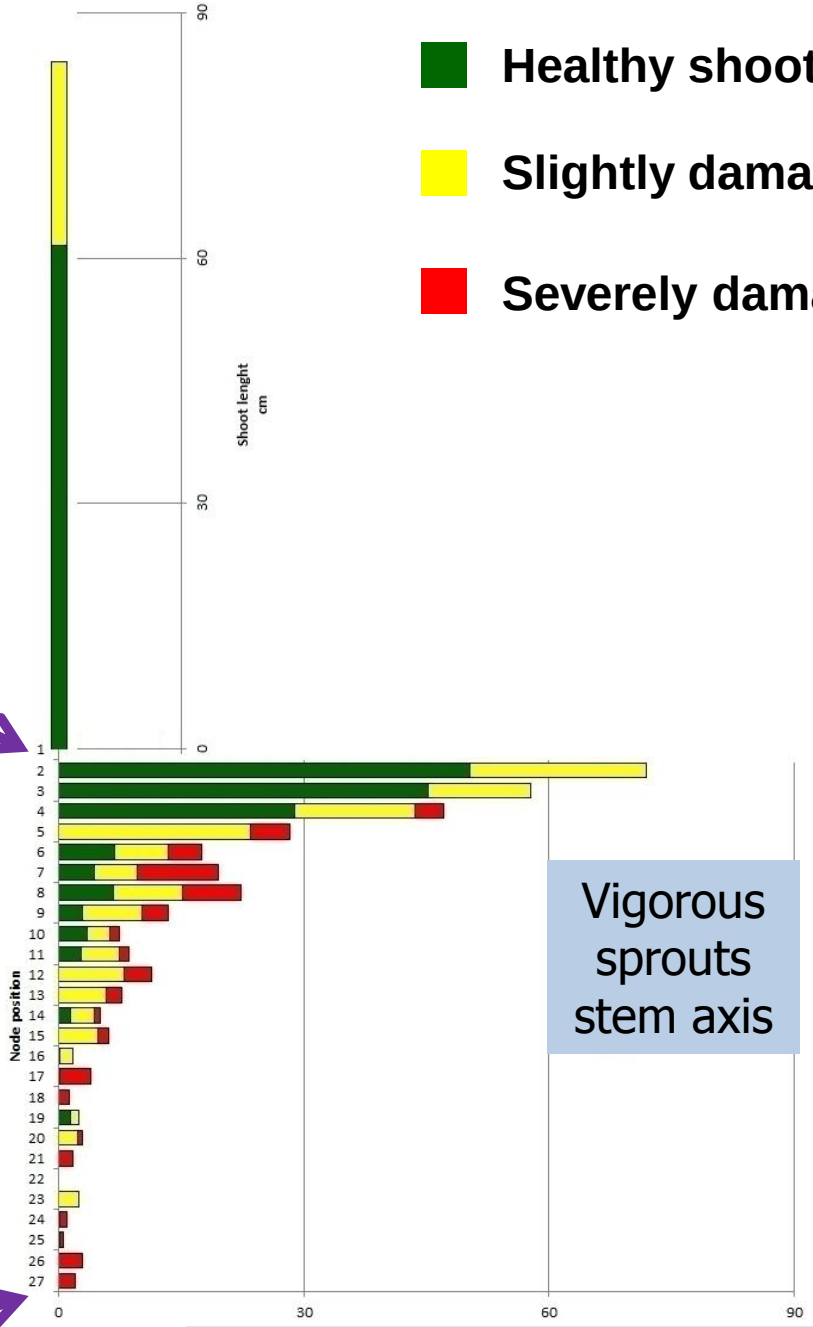
If there is a relationship between the damage and plant vigor, it is possible to experiment with effective cultural practices focused on reducing the damages on the plant



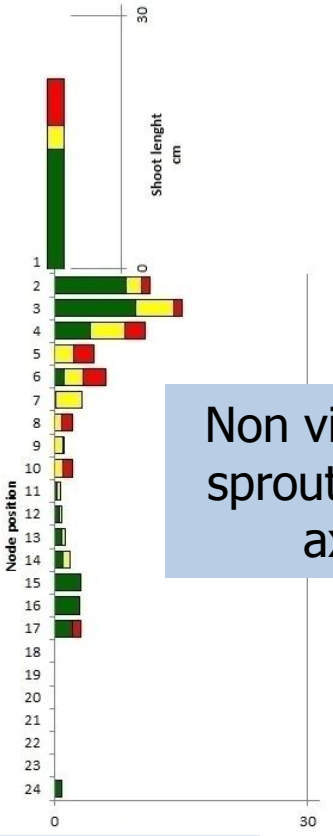
Healthy shoots

Slightly damaged shoots

Severely damaged shoots



Vigorous sprouts stem axis



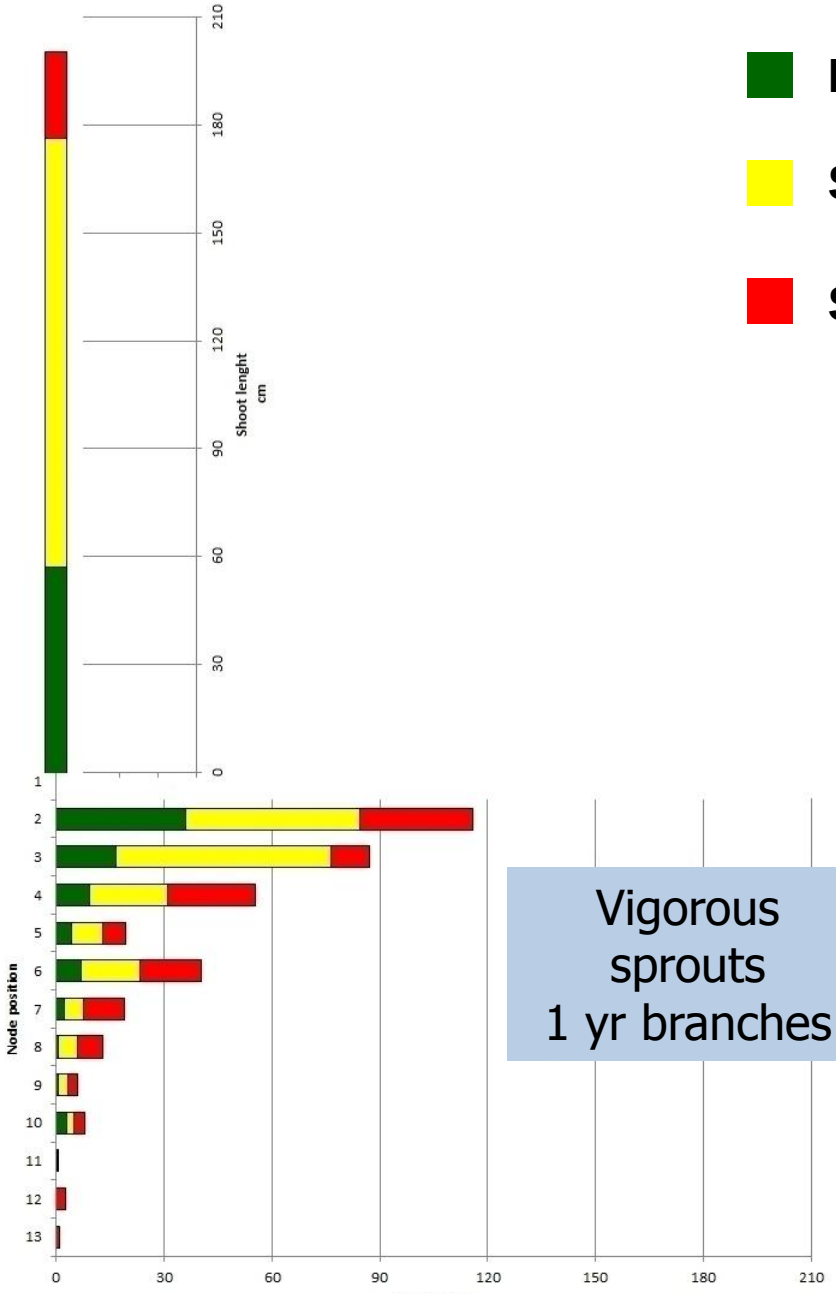
Non vigorous sprouts stem axis

Shoots lenght sum (cm)

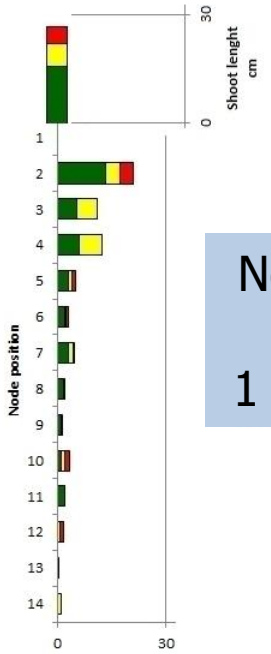
Healthy shoots

Slightly damaged shoots

Severely damaged shoots



Vigorous sprouts 1 yr branches



Non vigorous sprouts 1 yr branches

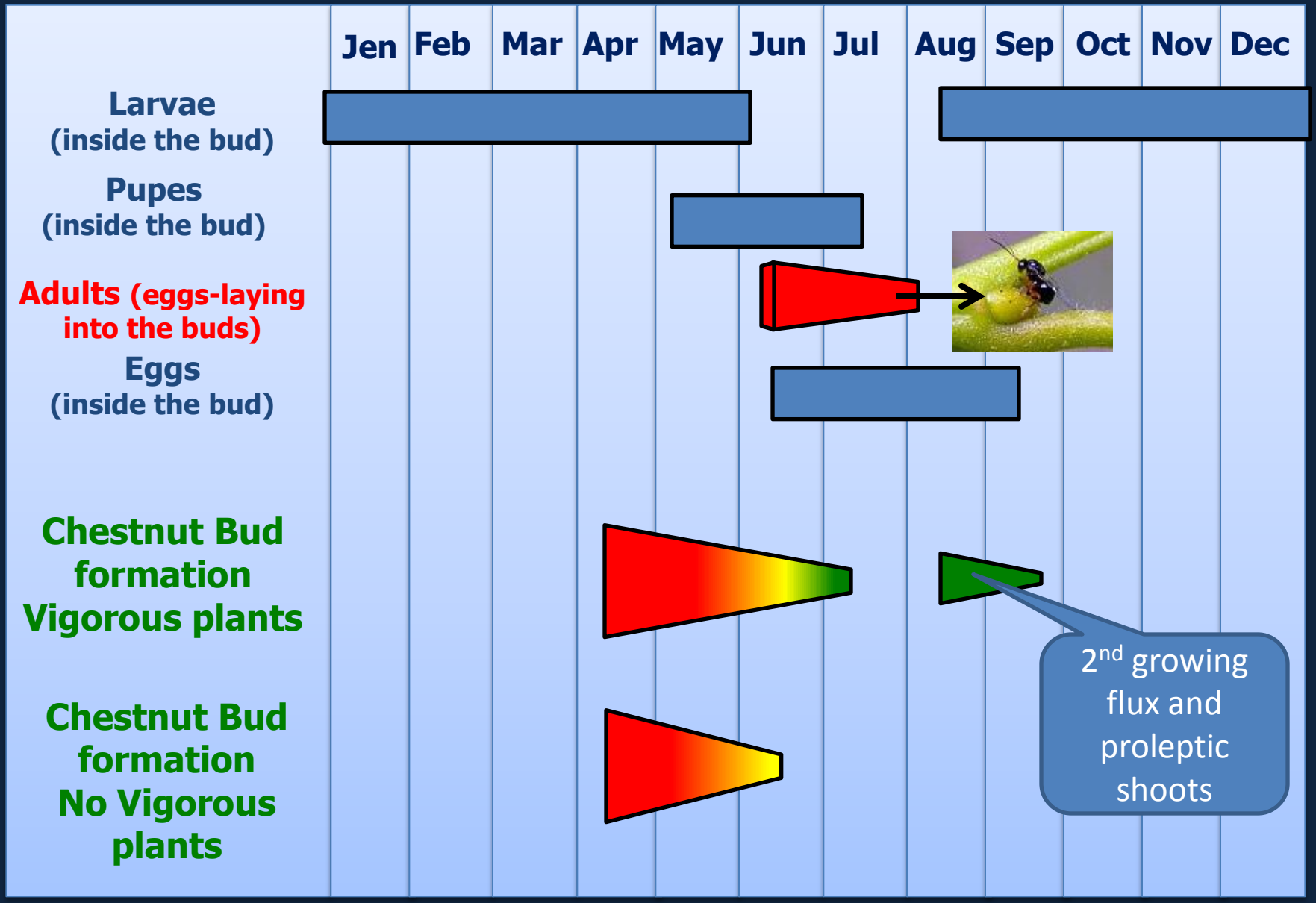
Shoots lenght sum (cm)

Vigorous plants tend to have well developed and healthy (or slightly damaged) growing shoots in apical position

(Maltoni et al., 2012)

Results interpretation

Time of bud formation has effects on damage susceptibility

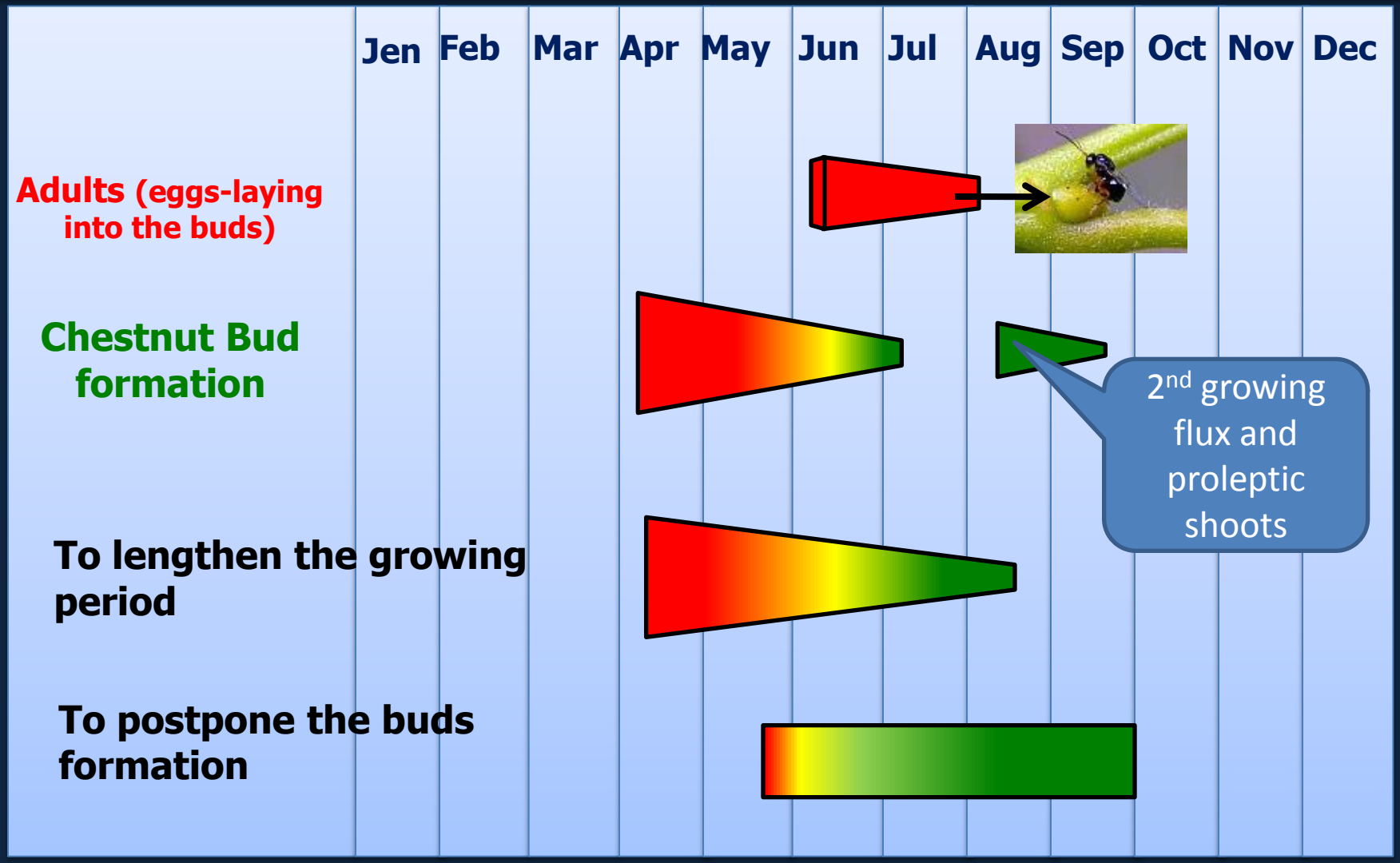


Hypothesis:

Two possible strategies to reduce the damage postponing buds formation

1) Promote the development of vigorous spring shoots

2) Postpone shoot formation



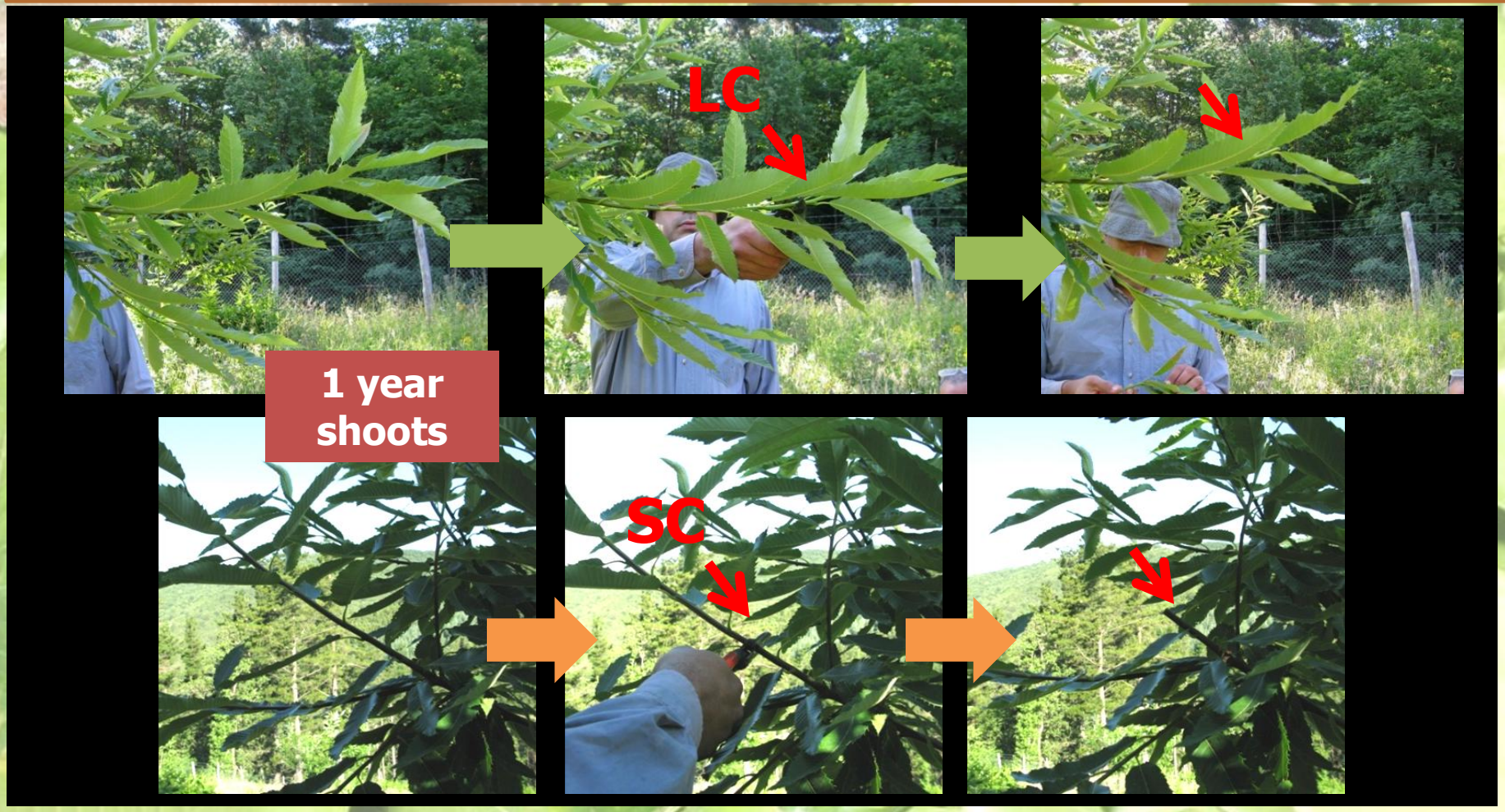
At the beginning we decided to test the more useful option to have clearer evidences in a shorter time. That's why we started testing the 2nd hypothesis: to postpone bud formation

Method: green pruning on growing shoots

Stand: young coppice (juvenile and reactive)

MATERIALS and METHODS

2 different pruning techniques: Short-cut (SC) and ·Long-cut (LC)



4 different pruning times (2010)

-the second half of May (M) - the second half of June (Jn)
-the middle of July (Jl) -the second half of August (A)

- Central Italy (Tuscany)
- 44°07’’03’’N, 10°04’58’’E
- 660 m a.s.l. , West faced
- Climate: sub-oceanic Mediterranean
- 6 years pure chestnut coppice
- Incidence of D.k. 100%

- -63 sprouts (53 pruned and 10 as control)
- -240 shoots were pruned, 126 SC and 114 LC; 60 as control

Data:

✓Nodes number
✓Development of shoots (presence, number, length, new nodes number, ..)
✓Healthy nodes
✓Heavily damaged nodes
✓Slightly damaged nodes

On

- The remaining shoot
- Shoots grown in 2010
- Shoots grown in 2011

Total nodes: 2794

Key points……

- **Is chestnut able to develop new induced shoots in the pruned growing season?**
  - **How many shoots grew after pruning?**
  - **How much do the new shoots contribute to develop the crown?**
- **What kind of pruning technique was the most effective?**
- **Which was the most profitable pruning time?**
- **Which is the best combination between pruning time and pruning technique?**

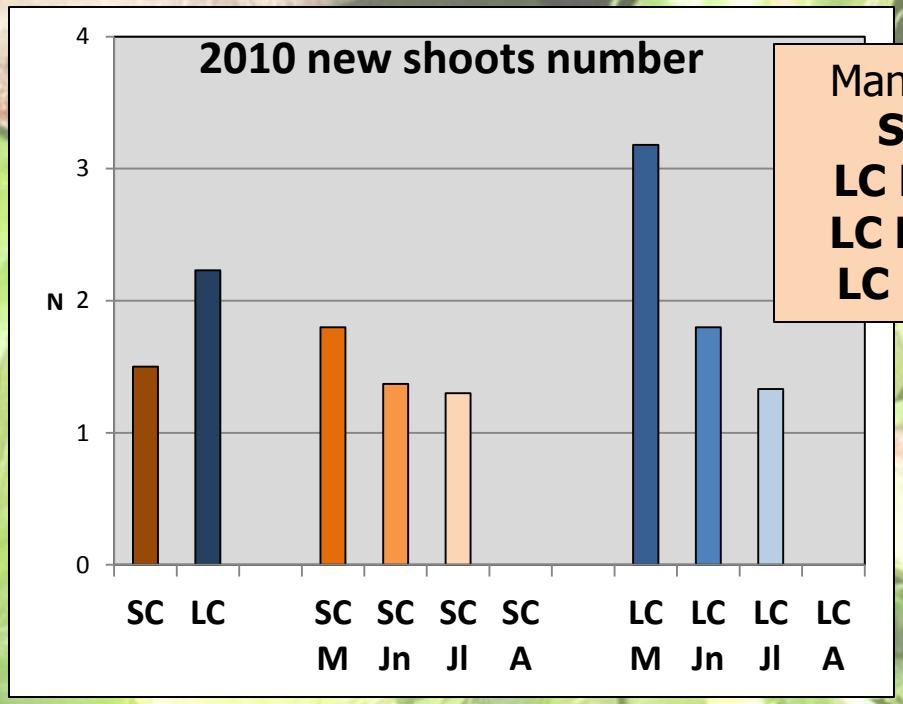
.. Results at the end of season 2010

Is chestnut able to develop new induced shoots in the pruning growing season?

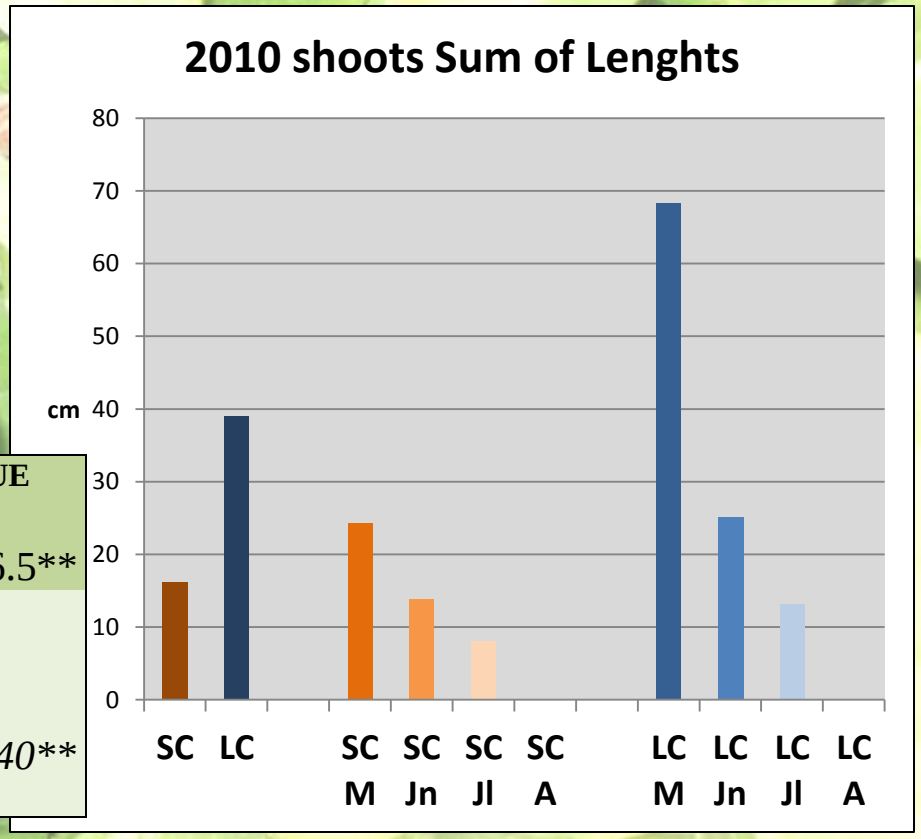
	PRUNING TECHNIQUE		
	LC	SC	
	%	%	
May	100	88.2	χ^2= 2.6
June	86.2	73.1	χ^2= 1.6
July	20.0	37.0	χ^2= 2.1
August	0	0	
	χ^2= 40.5**	χ^2= 13.6**	
	$M_{vs}Jn$ χ^2 = 3.2	$M_{vs}Jn$ χ^2 = 1.7	
	$M_{vs}Jl$ χ^2 = 27.9**	$M_{vs}Jl$ χ^2 = 11.3**	
	$Jn_{vs}Jl$ χ^2 =26.0**	$Jn_{vs}Jl$ χ^2 =7.0**	

Presence of 2010 new shoots per cut

Is chestnut able to develop enough new induced shoots in the pruning growing season?



Mann-Whitney U Test:
SC ≠ LC p<0.01
LC M≠ SC M p<0.01
LC M≠ LC Jn p<0.01
LC M≠ LC Jl p<0.01



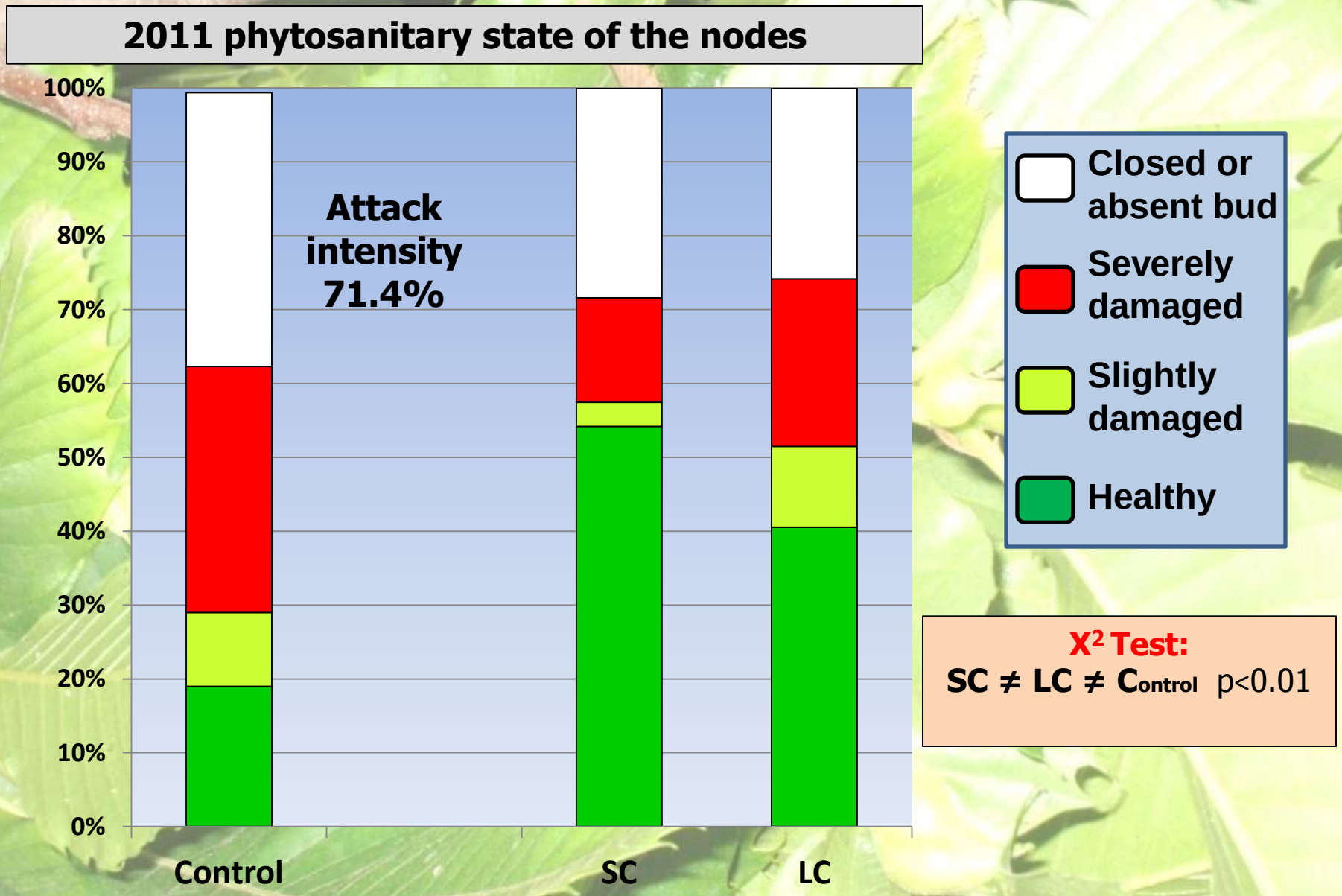
Multifactorial ANOVA			Pruning Technique LC	SC	
			38.9 B	16.1 A	F =16.5**
Pruning time	*M*	47.7 B	*68.3 b*	*24.3 a*	
	Jn	20.2 A	*25.1 a*	*13.8a*	
	Jl	10.0 A	*13.1 a*	*8.0 a*	
		F =15.5**			*F=6.40***

Key points……

- **How effective was the pruning method in limiting the attack?**
  - **Which was the most profitable pruning time to postpone bud formation?**
  - **Does the pruning technique have a significant role?**
  - **Which is the best combination between pruning time and pruning technique?**
- **What would have happened if the plants hadn't been pruned?**

.. Results at the end of season 2011

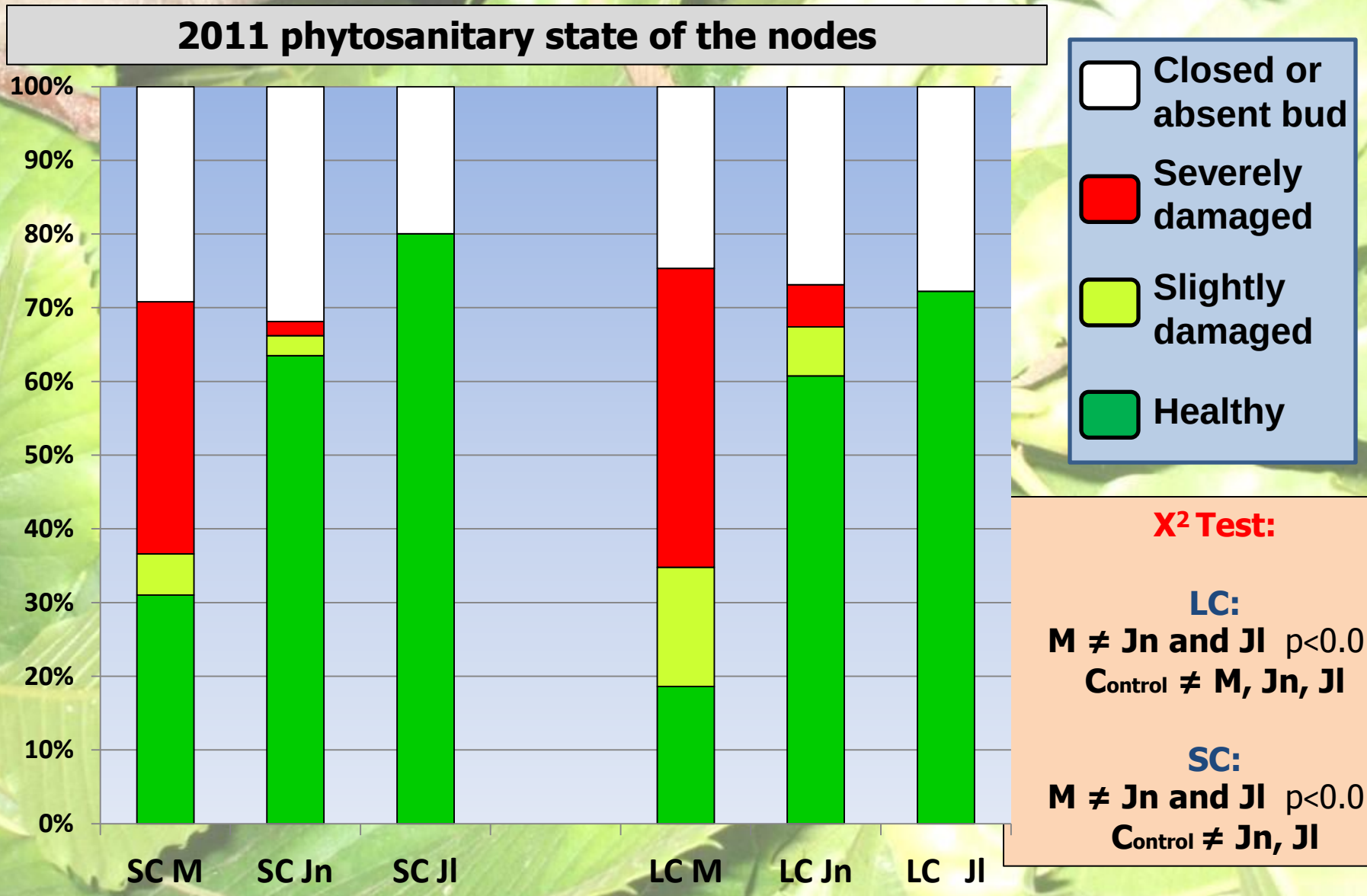
How effective was the pruning method in limiting the attack?



X^2 Test:

SC ≠ LC ≠ $C_{control}$ $p<0.01$

How effective was the pruning method in limiting the attack?



X^2 Test:

LC:

M ≠ Jn and Jl $p<0.01$

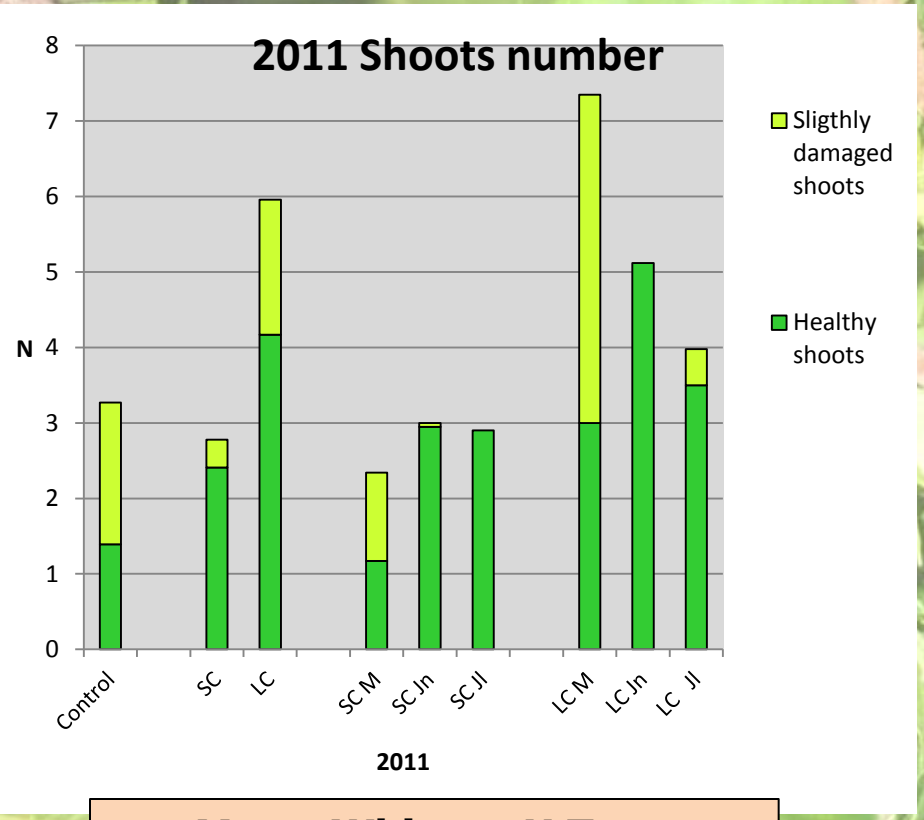
C_{ontrol} ≠ M, Jn, Jl

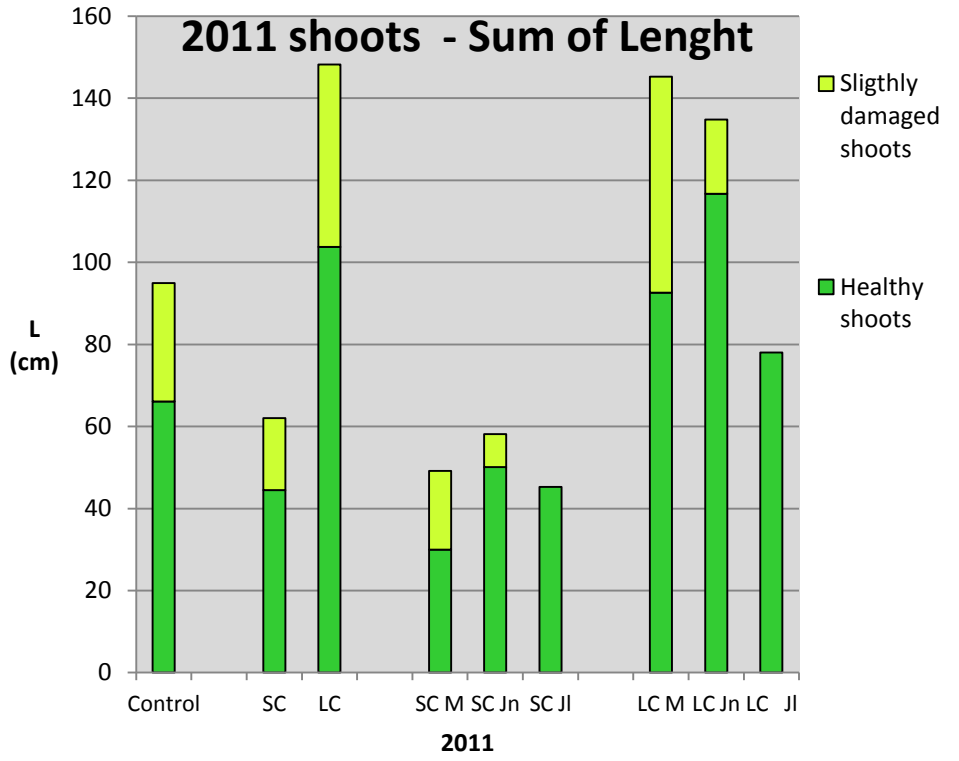
SC:

M ≠ Jn and Jl $p<0.01$

C_{ontrol} ≠ Jn, Jl

Which was the most profitable pruning time to postpone bud formation?
Does the pruning technique have a significant role?

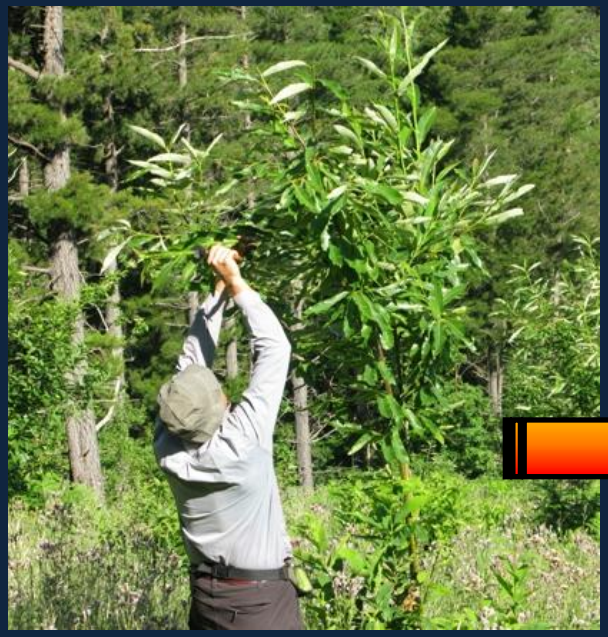




Mann-Whitney U Test:
$p<0.05$ in all cases except SC in M and Control

LC ≠ Control (HS+SDS)

Pruning technique	**Sum of healthy shoots Length (cm)**
LC	103.8 B
SC	44.5 A
Control	66.1 A
	F= 7.30**



On young grafts or in intensively cultivated orchards

?

Traditional chestnut orchards (most spread)

To transfer the results in traditional chestnut orchards is difficult because of:

-lower reactivity of mature trees

-green pruning on 1 yr growing shoots in is not practicable and unaffordable on mature trees

The "postoponing" strategy is not suitable

That's why we are testing the 1st hypothesis:

to lengthen the growing period

inducing the development of vigorous spring shoots

Method: pruning (winter and green) on branches
Stand: old traditional chestnut orchards

Possible criteria

Healthy shoots from dormant buds

healthy but too juvenile so not productive (fruit)

To reinvigorate branches to obtain more vigorous spring shoots

Adopted tecnique

Test on mature trees: preliminary results

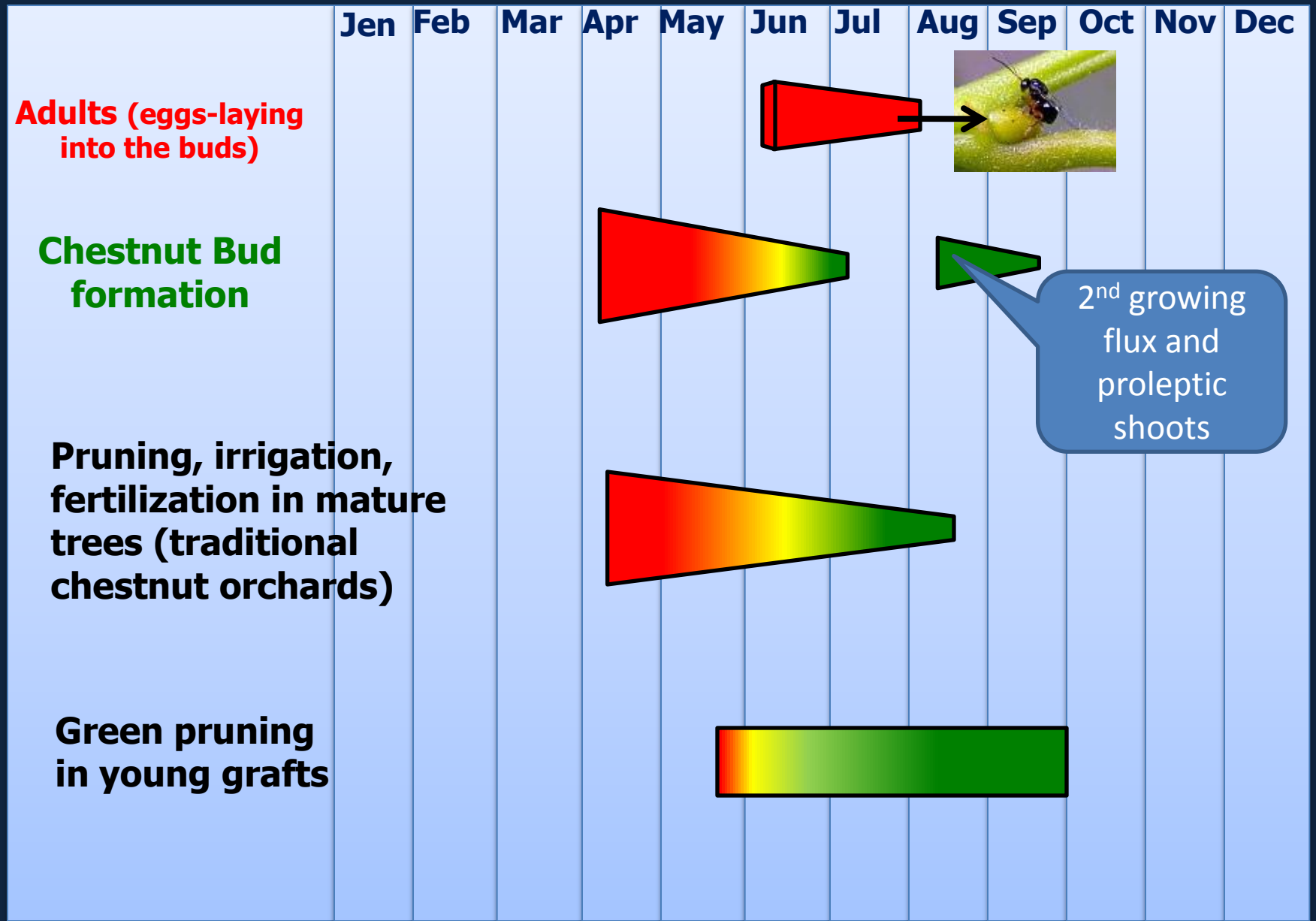
Pruning times:
Winter + May, June, July (green pruning on woody organs)

Damage susceptibility: not statistically significant results between pruned and non pruned plants (low presence of gall wasp?)

Spring shoots development: higher in pruned plants (but not statistically)

Fruit production: no reduction in quantity and bigger nut size in pruned plants (but not statistically different)

Strategies and cultural practices



It is possible to induce new healthy shoots by green pruning. Time plays an important role. The best technique was the LC. The most effective time in obtaining new vigorous shoots is not the most profitable in terms of limiting damages. LC in second half of June is the best combination

The tested method (shortening cuts on 1 years old shoots) is suitable for young plants, as young grafts in orchards.

This method can interact negatively with the early stage of introduction of *Torymus sinensis*, so (in this phase) it have to be used in areas far from the introduction zones

Test on mature trees are in progress

Preliminary results of pruning tests are positive but not significant in reducing damages

Pruning is necessary

Considering that any environmental condition or cultural practice that lengthens the plant growth season improves the phytosanitary state (reduce damages), it will be important to test the best effective combination of different cultural practices (pruning + fertilization and/or irrigation)

More studies are necessary

Thank you!

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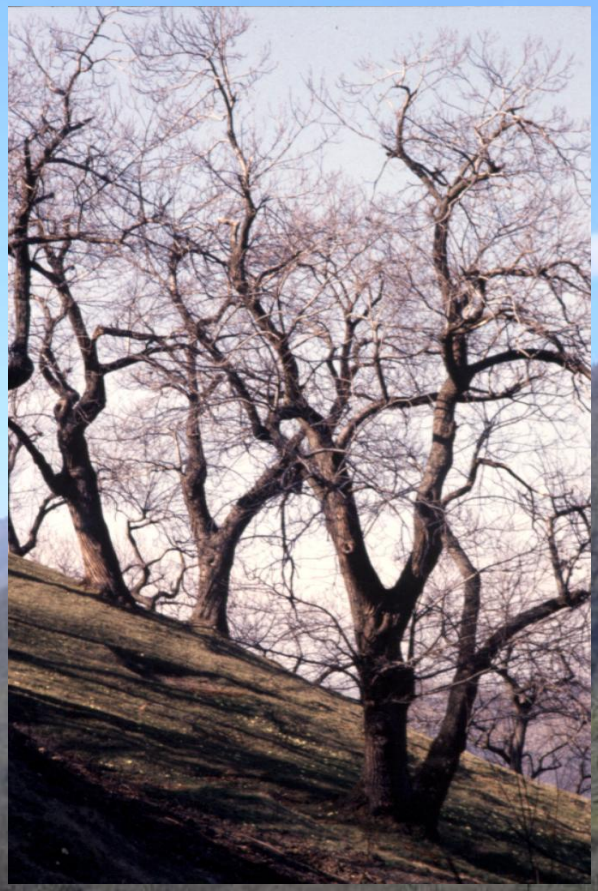

We want to say thank you to Italian chestnut associations and chestnut growers that helped us to start and carry on this study

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Case study of a new method for the classification and analysis of *Dryocosmus kuriphilus* Yasumatsu damage to young chestnut sprouts

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Pruning methods to restore *Castanea sativa* stands attacked by *Dryocosmus kuriphilus*

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