ONION BREEDING

Onion Breeder: PAOLO Pagan

Seed Company: CORA Seeds

ONION BREEDING

General Goals:

- Possible improvement of commercial varieties

- Creation of new hybrids with

  - *better agronomic traits like DS Retention, DS Color, single center, storage ability, ecc…*
  - *yield improved*
  - *genetic plasticity to allow better adaptation to new environmental mutations*

ONION BREEDING

BREEDING PROJECTS for:

TYPOLOGY

LONG DAY ONION (LDO > 13-14 h of light)

OVERWINTERING ONION (SDO > 10-12 h of light)

INTERMEDIATE DAY ONION (IDO > 11-13 h of light)

Dry Skin Color Yellow, Red, White

PUNGENCY Pungent and sweet (new)

ONION BREEDING

Fields in Cesena 2014

Field Trial LDO

- Direct sowing (518 plots)
- Transplanting (420 plots)

Field Trial SDO

- Direct sowing (320 plots)
- Transplanting (220 plots)

Field Trial IDO

- Direct sowing (0 plots)
- Transplanting (80 plots)

ONION BREEDING

Breeding steps

FIELD Seed sowing, evaluation of life cycle (germination and emerging from the soil, characteristics of the top, Maturity Time, characteristic of bulbs) and harvesting.

Data Analysis

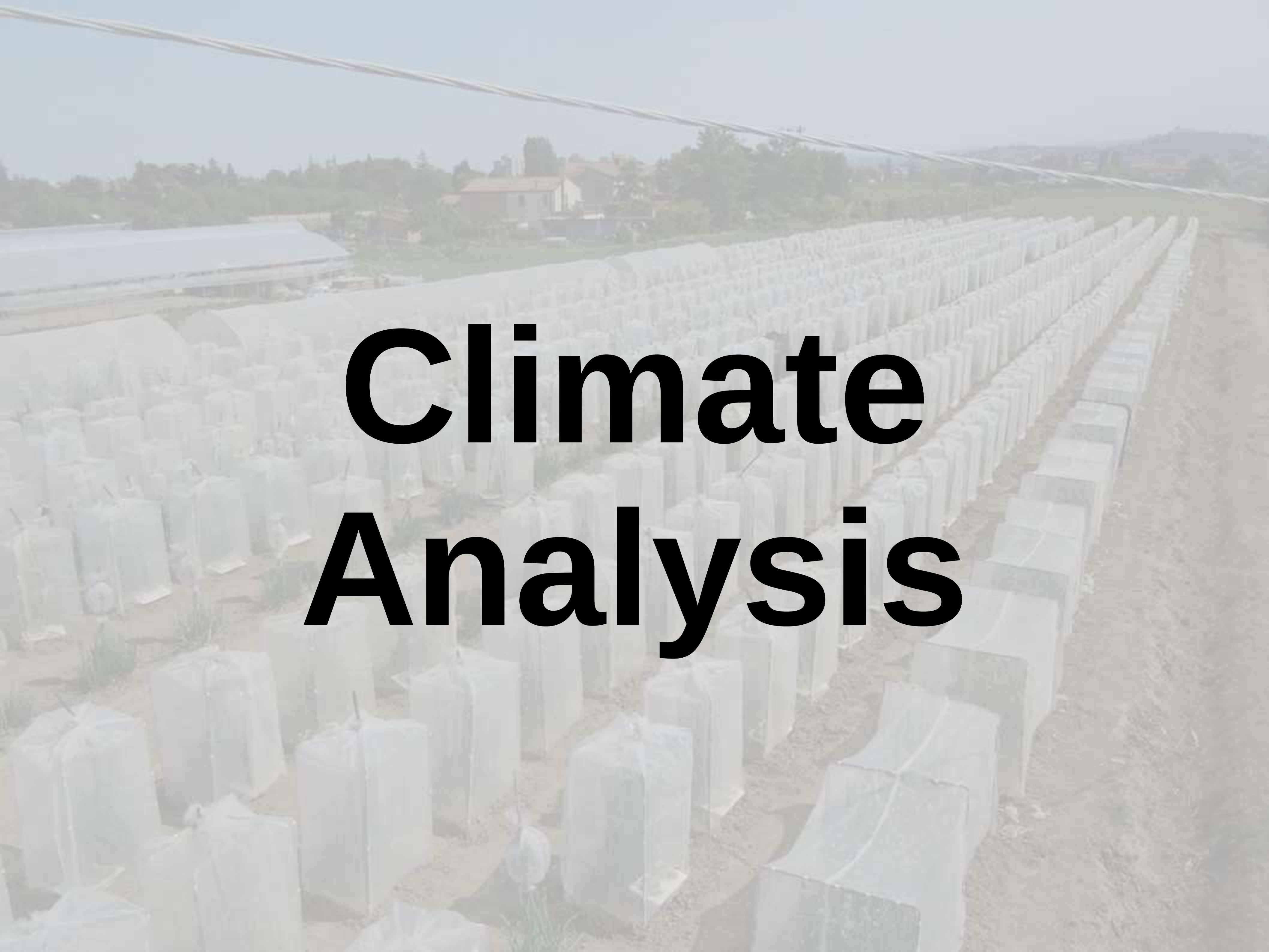
WAREHOUSE evaluation of Storage ability and dry matter content, bulb selection

FIELD Bulb transplanting, position of cages and net, positioning of insects

ONION BREEDING

- Extension of areas where you can SELECT germplasm in order to identify suitable genotypes of specific populations for different latitude and environment conditions:

Italy
USA
Iran
Greece
Tanzania
Czechoslovakia
Jordan



Climate Analysis

CLIMATE

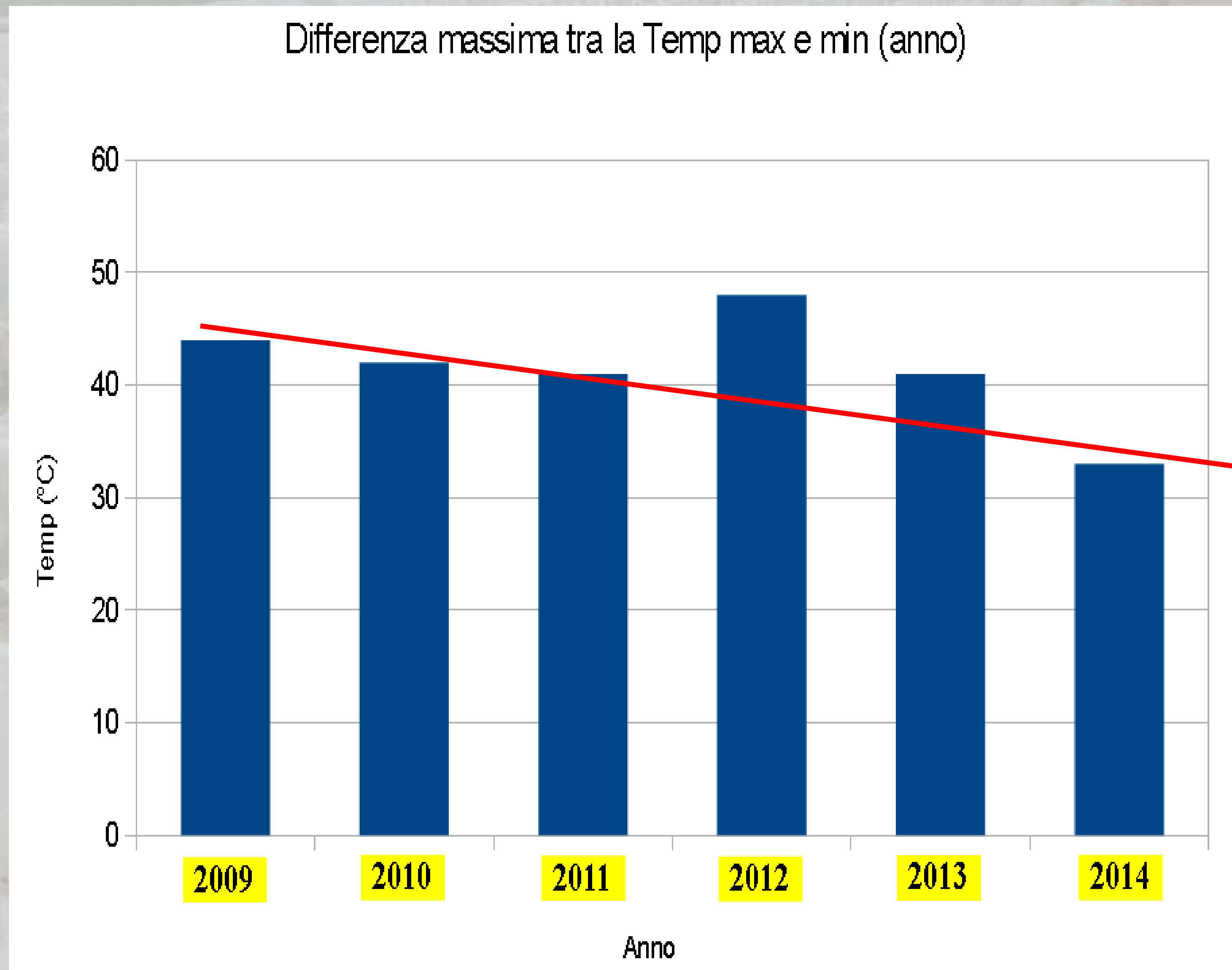
Study and interpretation of climate changes according to passing the time through:

- Temperature
- Precipitations
- Solar radiations

in order to anticipate the consequences (for example: increase and/or appearence of new plant diseases)

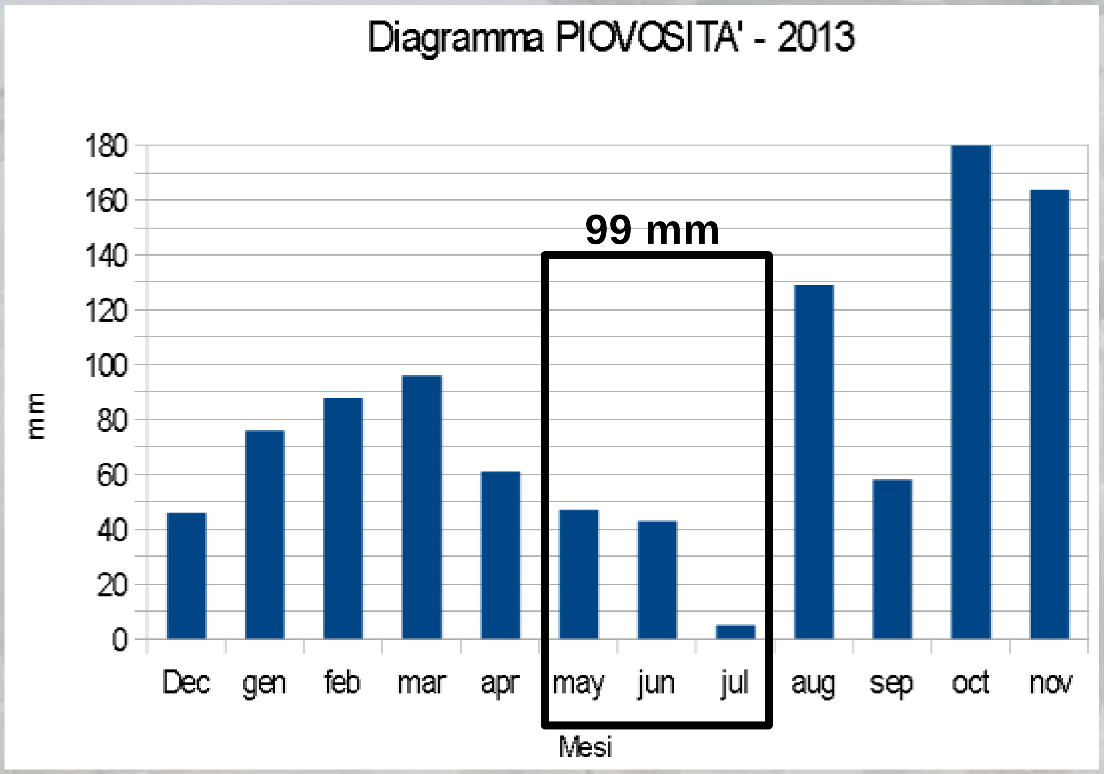
CLIMATE CHANGES
Max & Min Temperatures - Cesena

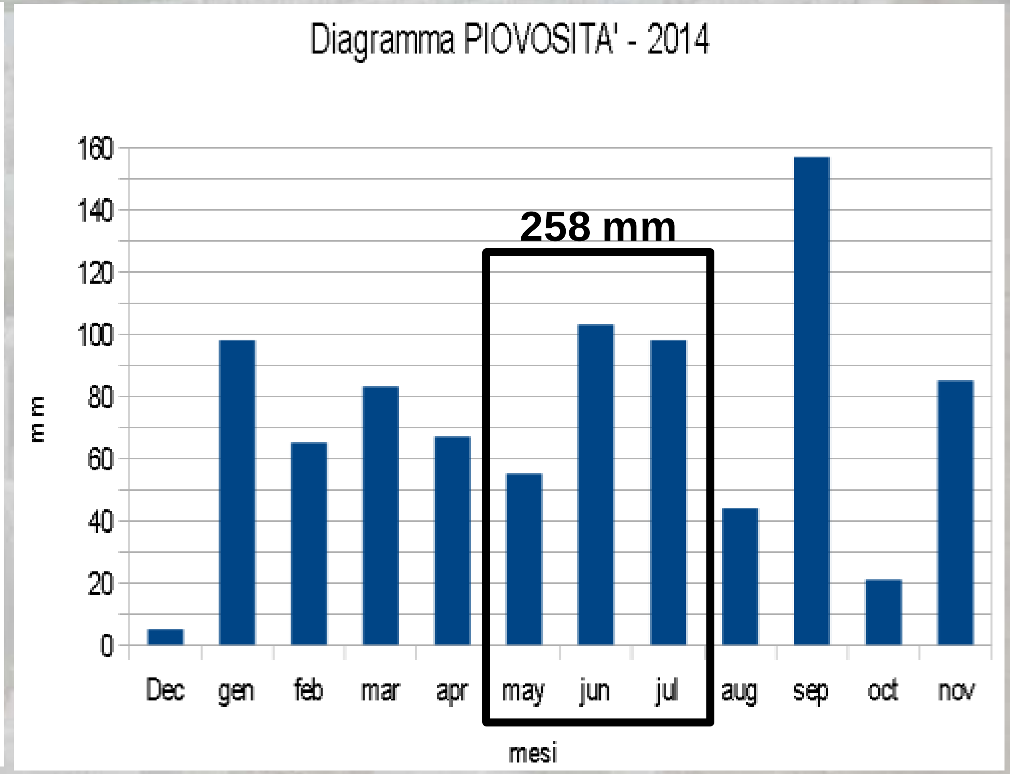
	Min	Max	Delta
2009	-7	37	44
2010	-7	35	42
2011	-5	37	41
2012	-10	38	48
2013	-3	38	41
2014	0,5	34	33



CLIMATE CHANGES

Rainfall data in Cesena





Increase of temperature and relative humidity promote the spread of plant diseases

ONION BREEDING
Focus

Specific goals:

- Plant Disease Resistance

  - **Fusarium oxysporum f. sp. Cepae (FOC)**
  - **Pink Root**
  - **Downy Mildew**

- Dry Matter Content

- Maturity Time

Plant Diseases

Fusarium oxisporum f. sp. *cepae*

Fusarium oxysporum f. sp. *Cepae 1*

Chlamydospores

- Fusarium oxysporum f. sp. cepae (FOC) is a **soilbourne fungus**.
- FOC is able to live in the soil for **long time**
- There are many **strains** of the fungus, each characterized by a different virulence toward the host plant
- FOC penetrates host plants through roots and it causes tracheomycosis (a wilt vascular disease) which originates **basal rot** in onion (one of the most important diseases in onion in field and during storage phase)
- This fungus begins to act when soil temperature is about **25°C**

Fusarium oxysporum f. sp. *Cepae* 2

FOC is able to infect host plants at any stage of its life cycle

Early infections occur after germination promoting early death of the seedling (***damping-off***)

Fusarium oxysporum f. sp. *Cepae 3*

Intermediate infections appear as **general wilt** and a yellow dieback of leaf tips. Affected plants don’t have a normal rate of growth and remain small (dwarf plant)

When plants are strongly ill they can die

Fusarium oxysporum **f. sp.** ***Cepae 4***

- Late infections compromise the health of bulbs and their storage ability.
- Moreover, the bulbs affected by fusarium can cause rot to their neighbors, so FOC is responsible for major storage losses of onion.



Fusarium oxysporum f. sp. *Cepae* 5

ALTERNATIVE HOSTS

FOC is not specific to *Allium cepae* and some times other species are symptomless hosts

- Other Allium species (shallots, garlic, Jappanese bunching)
- Asparagus, mais, wheat, rice, soybean, cucumber, pea, squash
- Alfa-alfa, Oxalis (symptomless hosts)

Fusarium oxysporum f. sp. *Cepae 6*

Disease management

- Programming large field rotations
- Improving health of the soil with fumigation or soil solarization
- Using **resistant varieties** (although R can vary according to changing environmental conditions and various strains of the pathogen)

CORA Seeds

Fusarium tests

Fusarium oxysporum f. sp. *Cepae 7*

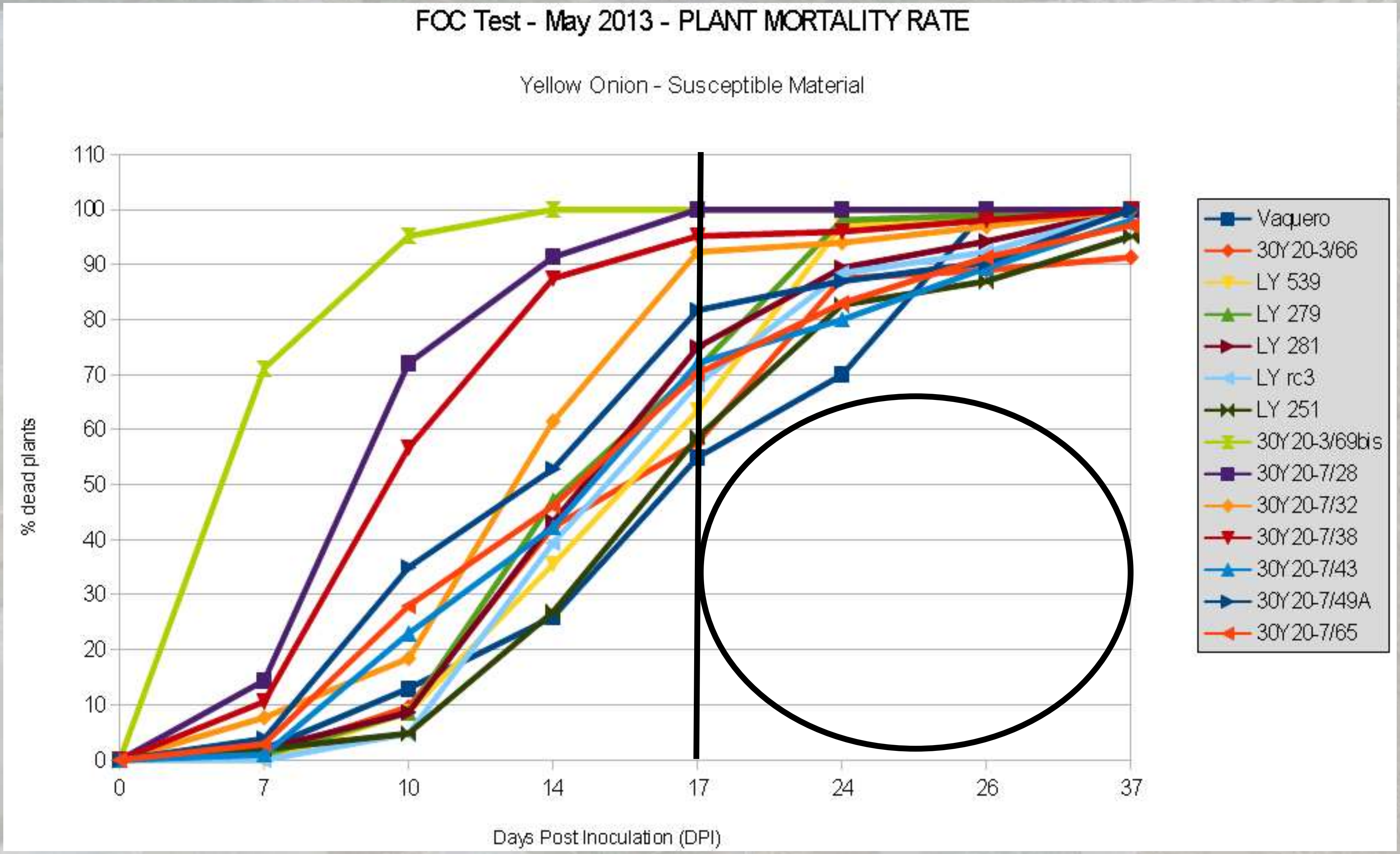
Study of tolerance to Fusarium of the genetic material of CORA Seeds by :

- Laboratory testing
- Evaluation of tollerance of plants to FOC in naturally infected soil

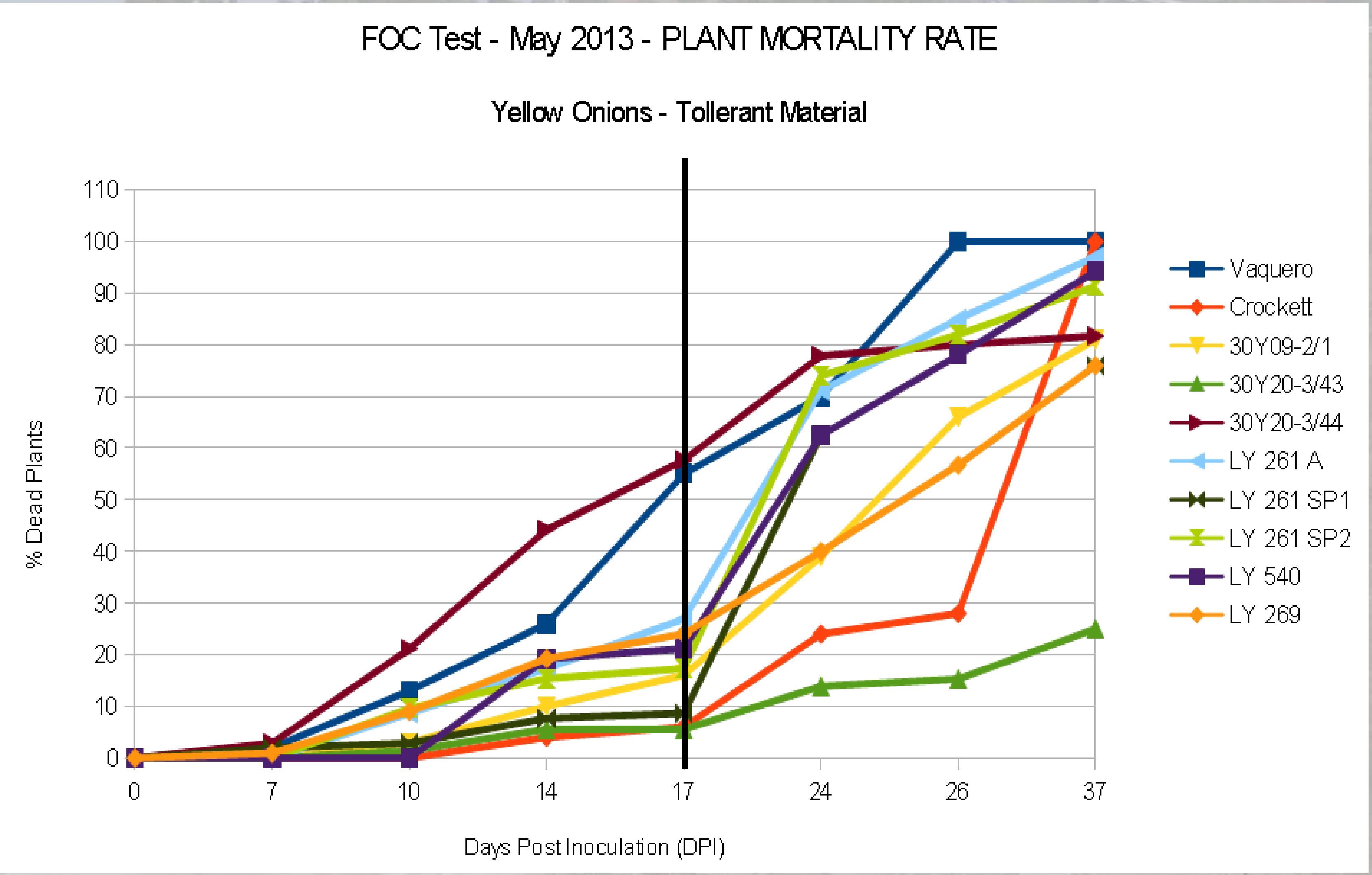
Laboratory testing

Fusarium oxysporum f. sp. *Cepae 9*

Laboratory Test using a Fusarium inocolum



Fusarium oxysporum f. sp. *Cepae 10*



Fusarium oxysporum **f. sp.** ***Cepae 11***

- Tests and results obtained allow to identify materials with good tolerance/resistance to Fusarium

- These materials can be used in a breeding program specifically aimed at creating pathogen insensitive F1

PINK ROOT

Pink Root 1

- Disease caused by the fungus ***Phoma terrestris*** that lives in the surface layers of the soil (first 45 cm)
- The **main host** plant is the onion but occasionally can parasitise **other species** such as cereals, pepper, spinach, corn, etc.
- The optimum temperature for infection by *P. terrestris* on onion is between **24 and 28°C**
- **Plant stress** (drought, cold, lack of food, ...) and other diseases can cause a worsening of the disease

Pink Root 2

SYMPTOMS

Above ground: in more severe cases the leaves start to dry from the ends to fold with time. Early infection produce small plants and bulbs with reduced sized and soft.

Below ground: often roots are pink colored in the beginning and after turn dark red or purple and start to dry up

Pink Root

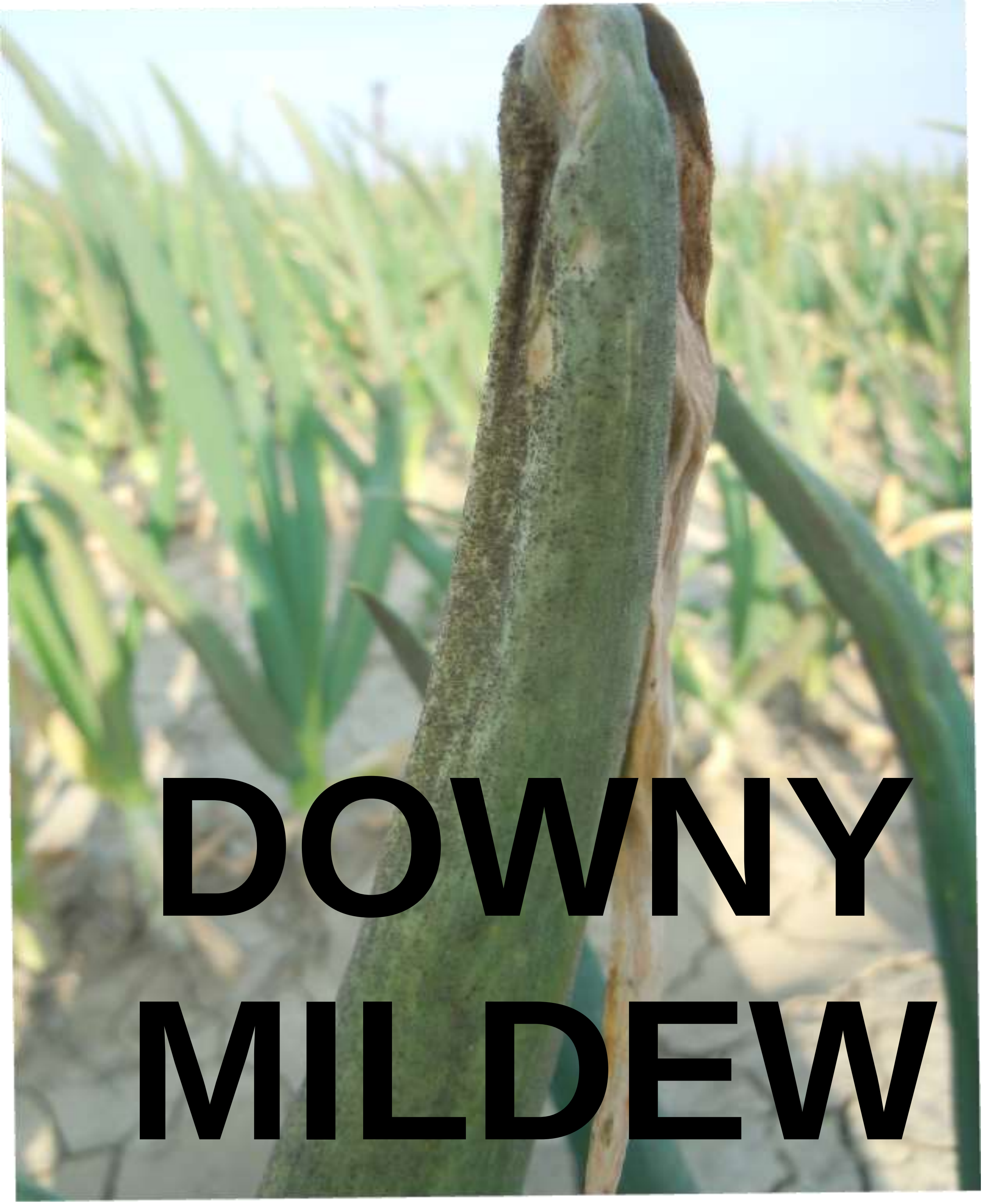
ALTERNATIVE HOSTS

- Other species of the genus Allium
- Cucumber, spinach, carrot
- Cereals (wheat, barley, oats) show few or no symptoms
- Mais, pumpkin, eggplant, cauliflower, tomatoes

Pink Root

Disease management

- Five-year rotation
- Rustic Varieties (as more tolerant to environmental stresses)
- Resistant varieties



CAUSAL AGENT is the fungus *Peronospora destructor* and is one the most seriuos disease on onion.

SYMPTOMS: Firstly appear a flat, distinct, discolored area of elongated shape and with variable dimension on well-developed leaves.

EFFECT: it causes a defoliation of plants which produce bulb with reduced size and storage

DAMAGE: It can cause a yield losses from 50 to 75% in bulb production and a poor quality of seed germination when stalk are infected.

Downy Mildew 1

The Downy Mildew disease is characterized by three different stages:

SPORULATION

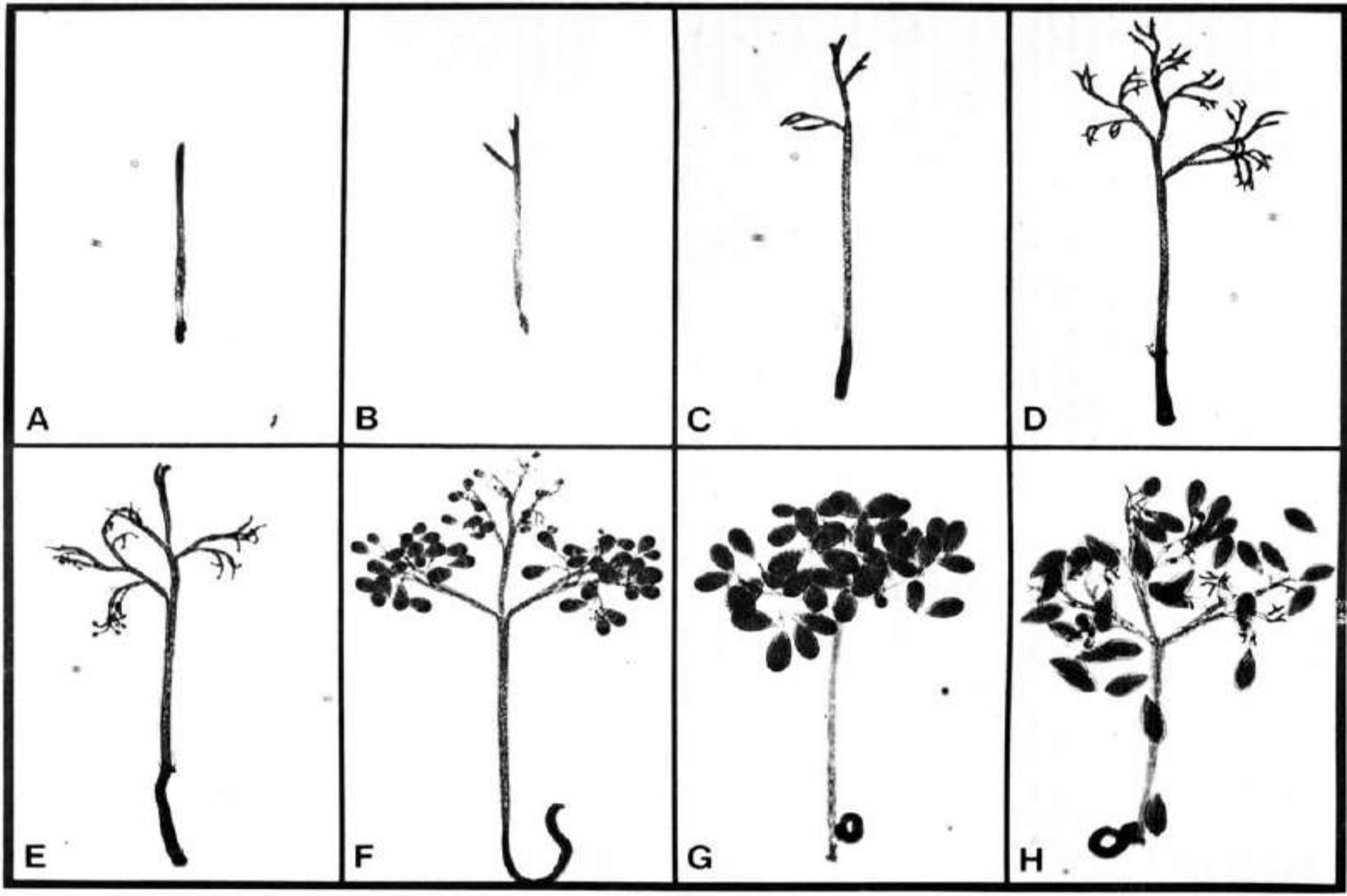
SPORE DISPERSAL

INFECTION

These stages occur in different moments of the day and they are favored by a high content of humidity in the atmosphere, consequently large infections are frequently observed in rainy periods and/or in environments with high humidity.

The **latent period** (= from infection to appearance of the first symptoms) of each infection cycle lasts for 10 to 16 days.

SPORULATION



Different phases of conidia and spores formation

SPORULATION Conditions

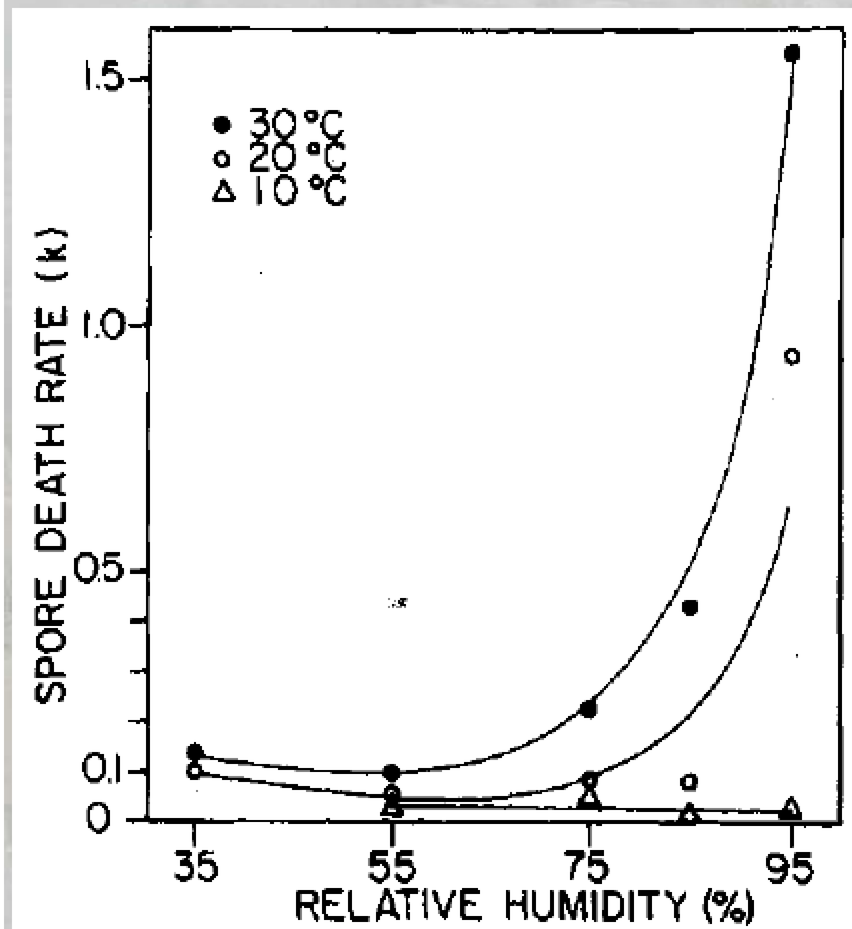
Sporulation occuring during the night

High Relative Humidity (RH): ≥ 95%

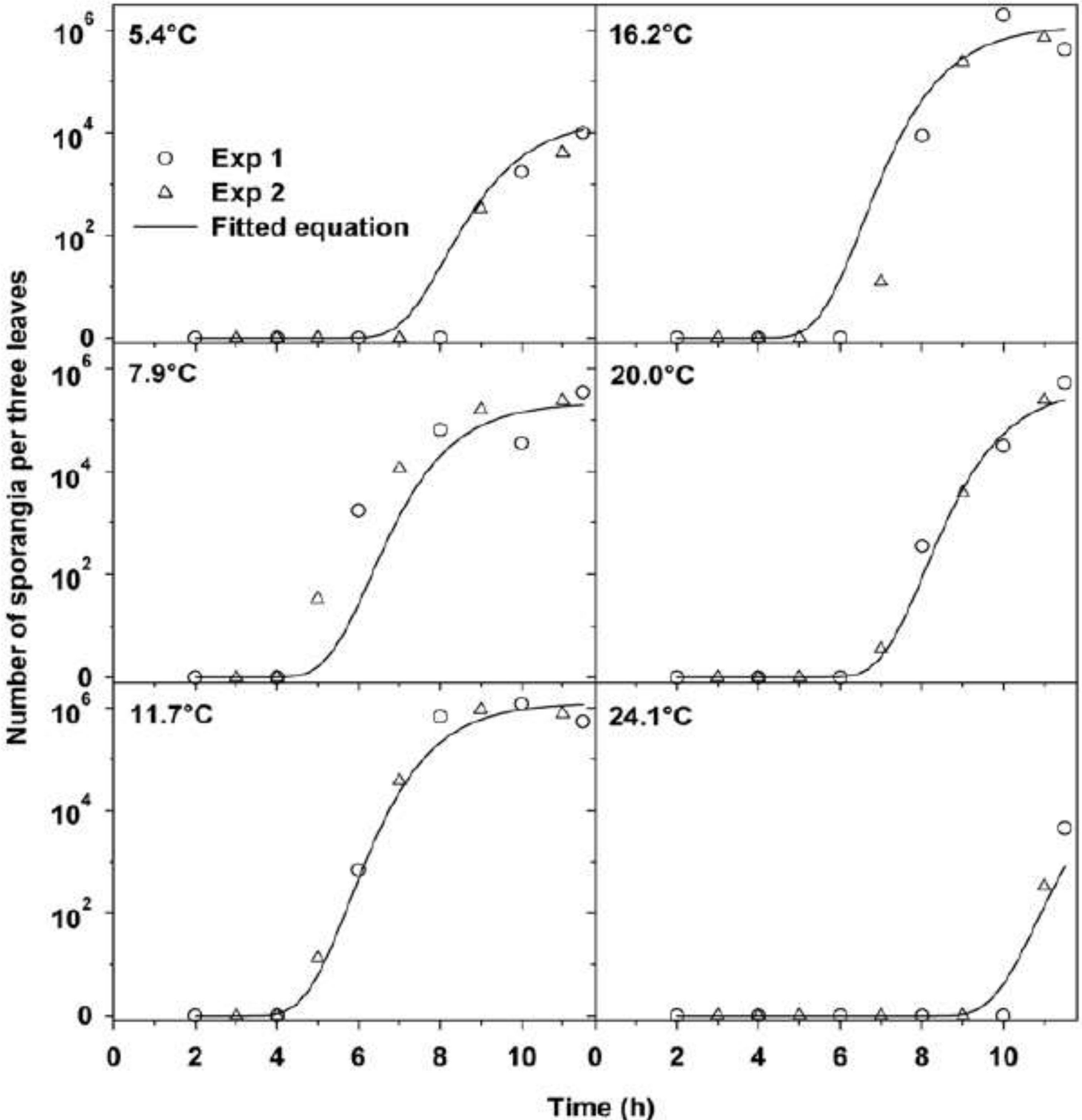
Start of RH: early

Temperature: 6-[8-15]-22°C

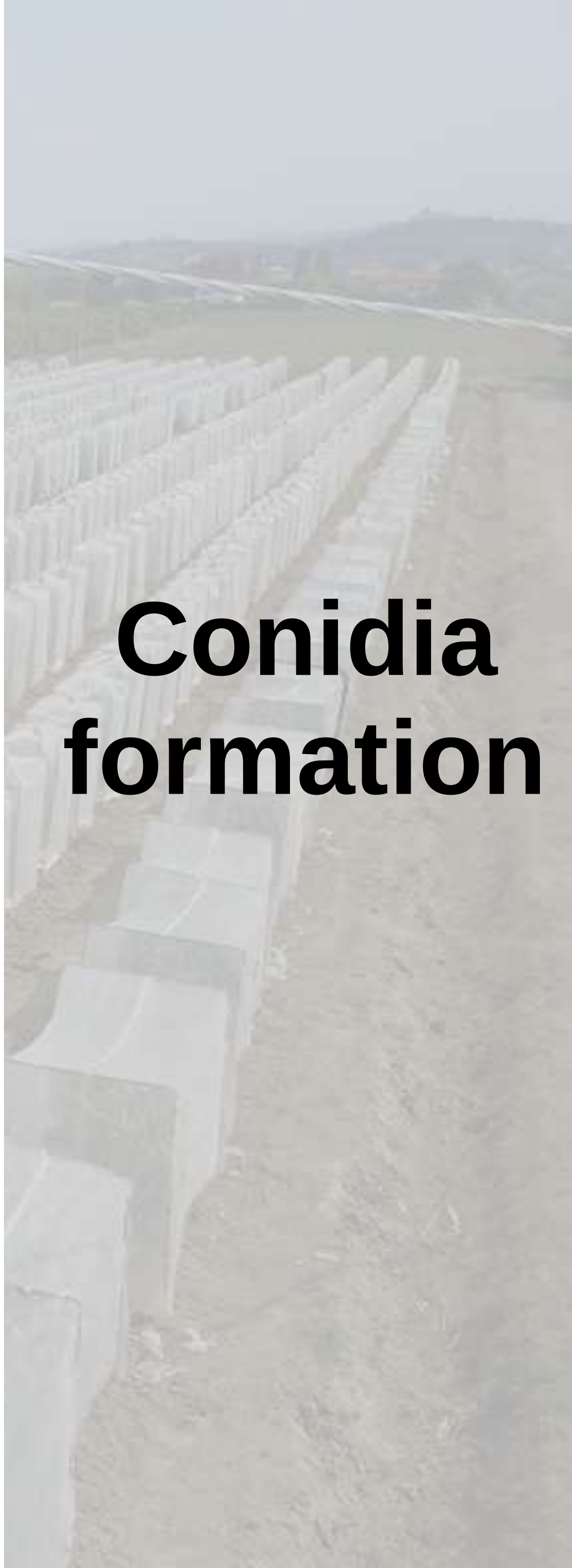
Light Irradiance: low or nothing (night)



Time[a] of onset of high humidity (hours)	Time[a] of observations on sporulation (hours)	Phase of sporulation[b] or number of trapped spores[c] at the following temperatures (C):						
		4	6	10	14	18	22	26
2200	0400	–[d]	P6	18	3	P6	P5	–
	0500	–	1	55	106	16	P6	–
	0600	–	36	940	4,137	1,868	39	–
	0700	–	34	2,366	15,430	5,283	1,721	–
2400	0400		–	P6	4	P5	P3	
	0500		–	P7	170	9	P5	
	0600		–	P8	605	1,011	P7	
	0700		–	P8	3,433	1,209	200	
0100	0400			–	P5	P5	P3	
	0500			–	P7	P7	P5	
	0600			–	42	31	P6	
	0700			–	1,651	6,387	4	
0200	0400				P1	P5	P1	
	0500				P3	P7	P3	
	0600				P4	12	P5	
	0700				P6	105	P8	
0300	0400				–	P1	–	
	0500				–	P3	–	
	0600				–	P5	–	
	0700				–	8	–	
0400	0400				–	–		
	0500					P1		
	0600					P4		
	0700					P6		



Conidia formation



SPORE DISPERSAL

Spores, after being produced at night, mature after dawn and are subsequently dispersed during the day.

Cool temperature, **moderate RH** and **low irradiance** **are favorable for spore survival**.

In case there are no such environment conditions the spores die and there is not infection of the plants

SPORE GERMINATION

SPORE GERMINATION

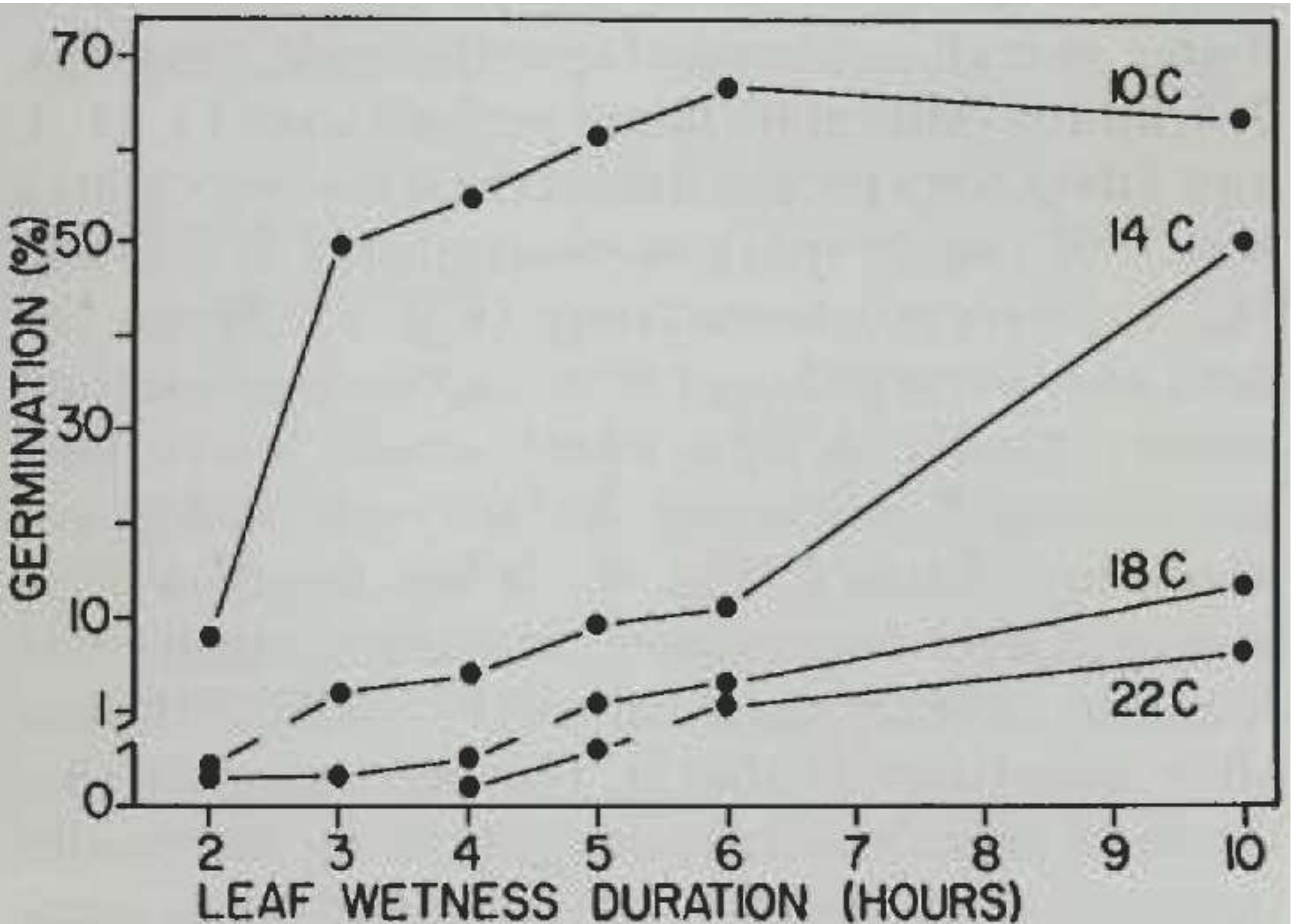
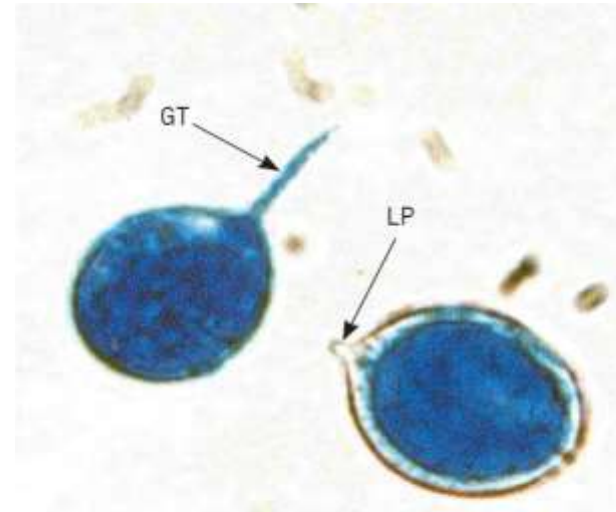


Figure 2. Effects of temperature (10°–22°C) and leaf wetness duration on germination of spores of *P. destructor*.



INFECTION

Main condition is that the infected tissues have been covered with a water film for at least 4 hour with a relative low temperaure (10-13°C).

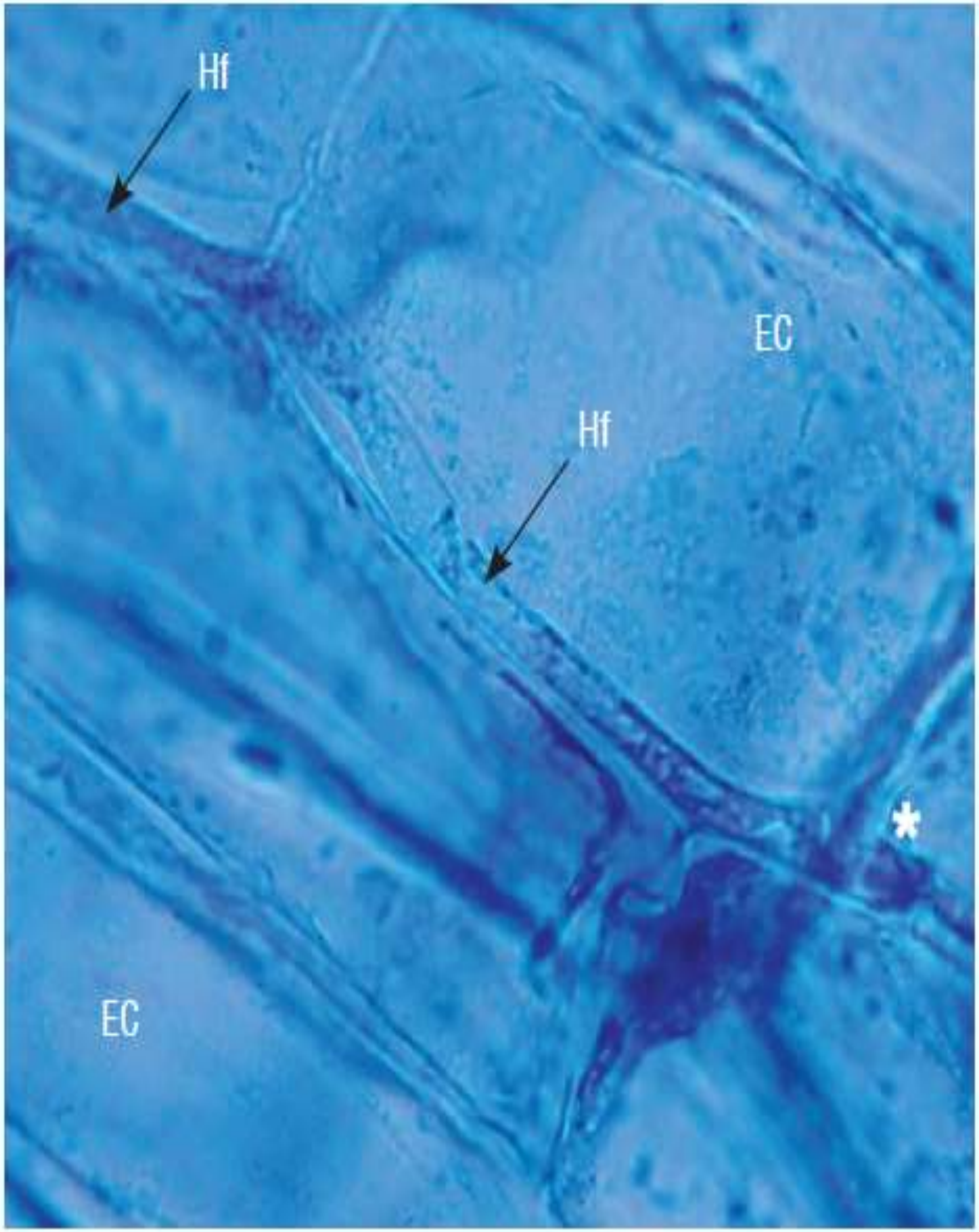
The *Peronospora* grows internally and continues to produce spores as long as weather remains cool and wet. The incubation period range from 9 to 16 days, at the end of which the conidia appear on the surface of the leaves.

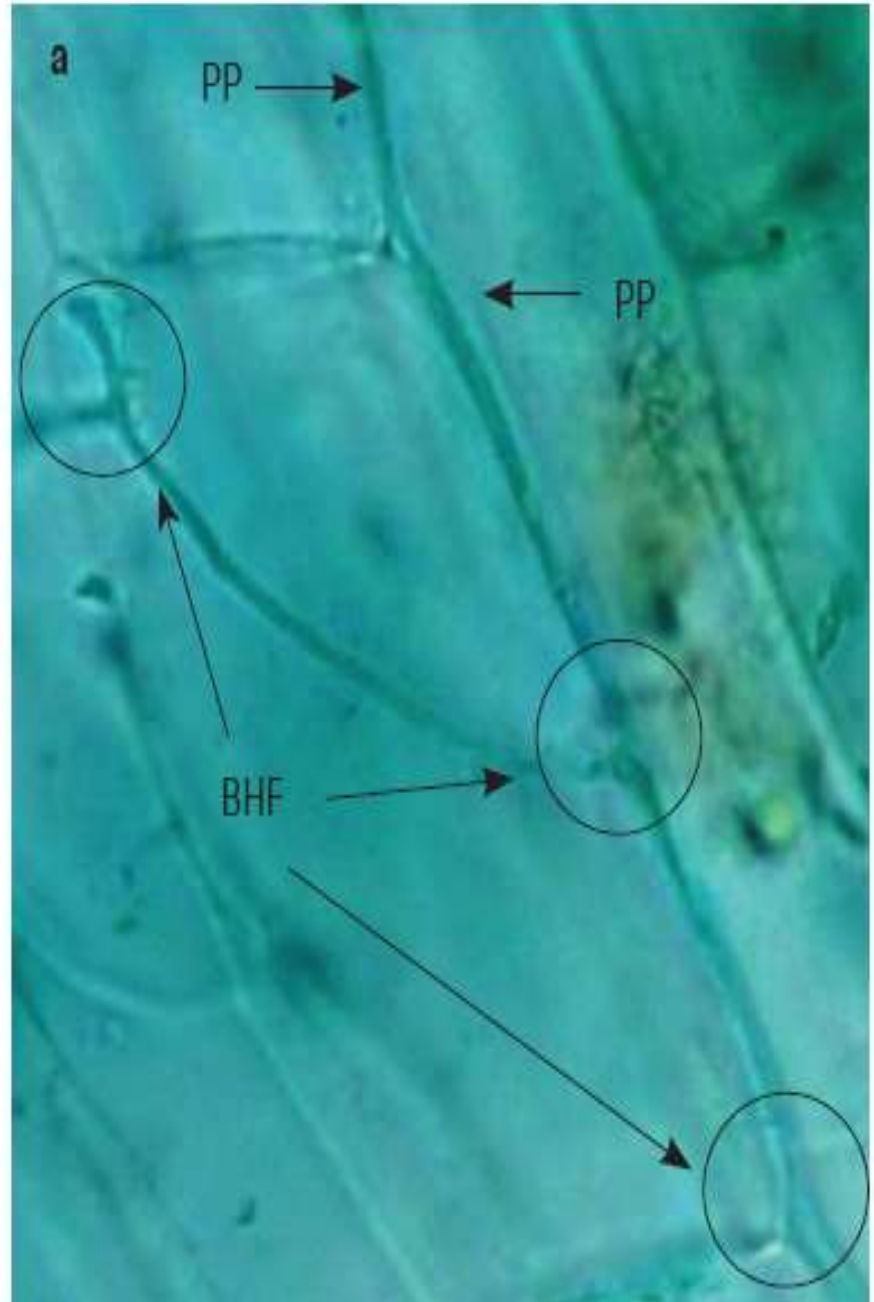
Table 1. Relationships of leaf wetness duration (LWD) and temperature of the wet period to infection of onion leaves by *P. destructor*. Infection was assessed according to number of leaves with sporulating fungus 14 days after inoculation.

LWD	Number of infected leaves (%)* at the following temperatures (°C)					
(h)	6	10	14	18	22	26
2	0	0	0	0	0	0
3	12.5	43.8	43.8	18.8	0	0
4	100.0	100.0	87.5	18.8	6.3	0
5	100.0	100.0	100.0	50.0	18.8	0
6	100.0	100.0	100.0	93.8	43.8	0
10	100.0	100.0	100.0	100.0	94.0	100.0

*Each value is based on 16 inoculated leaves (8 leaves/replicate).

INFECTION





D. Mildew management

Chemical treatments (fungicide)

Dimethomorph + mancozeb (**Forum MZ**)

Dimethomorph + pyraclostrobin (**Cabrio Duo -** *sistemic*)

Benthiavalicarb + mancozeb (**Valbon**)

Metalaxyl + mancozeb (**Ridomil gold -** *sistemic*)

Azoxystrobin (**Ortiva -** *sistemic*)

Mancozeb (**Dithane -** *sistemic*)

These chemical compounds provided a reduction of the infection ranging from 61% to 80% compared to control (no treatment)

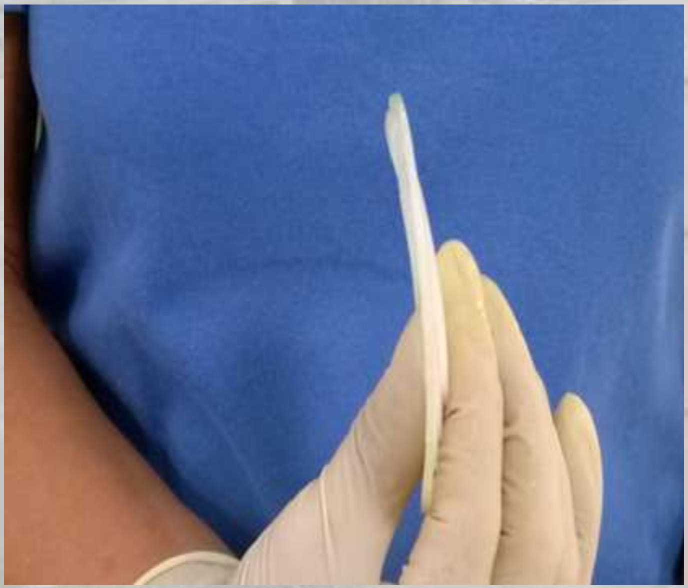
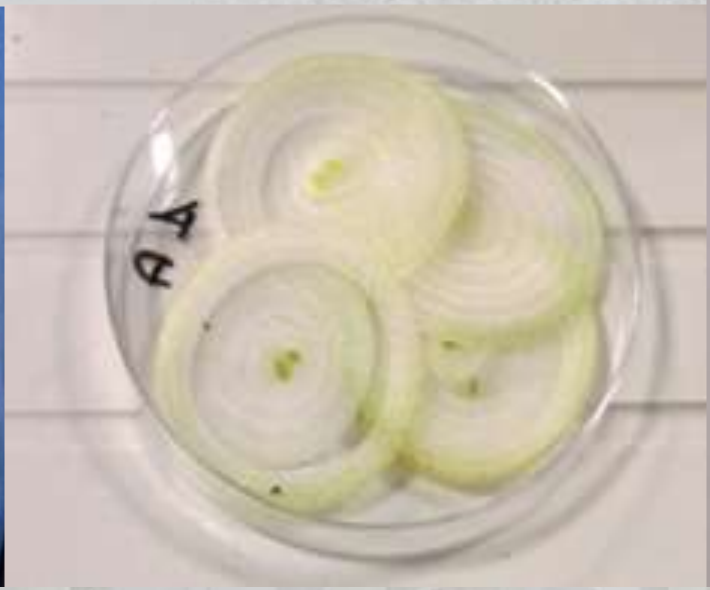
CORA's Breeding activities

We started to evaluated breeding material tolerance in field last year (2013)

DRY MATTER

DRY MATTER 1

- The content of dry matter is the measure of what remains of the bulb after it has been removed the water by evaporation.


- It is an important feature because there is a positive correlation between the quantity of dry matter and storage ability

DRY MATTER 2

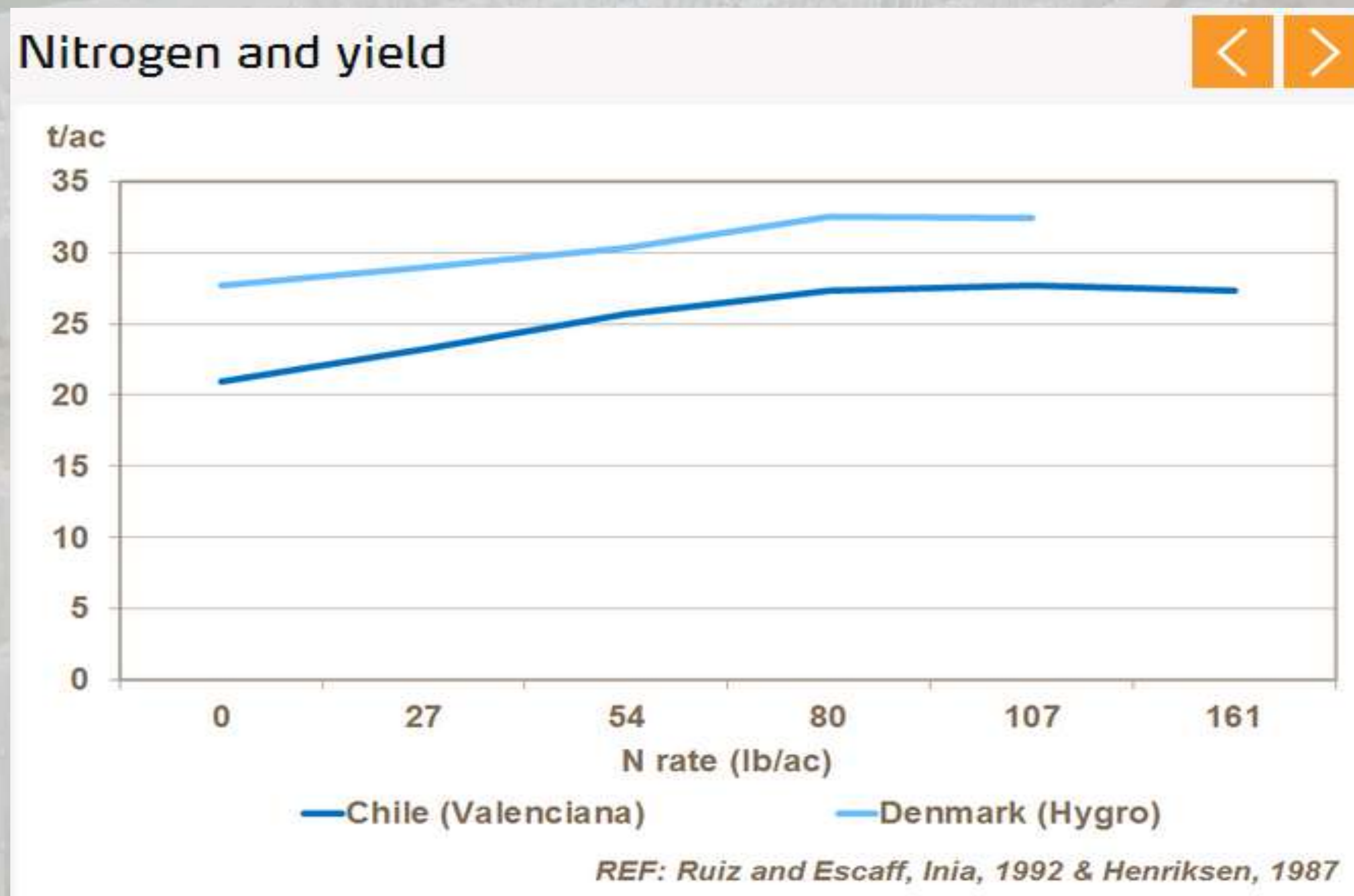
- It has begun to analyze the material in order to identify material with high% of dry matter

TYPOLOGY	VARIETY	FRESH NET WEIGHT	DRY NET WEIGHT	% DRY MATTER
WHITE	LIRIKA F1	141.99	10.41	7.33
WHITE	W.OPERA F1	113.01	9.71	8.59
WHITE	SOLSTICE F1	87.84	6.36	7.24
YELLOW	UTRERO F1	134.15	10.24	7.63
YELLOW	CRX 2384 F1	104.65	6.56	8.54
YELLOW	CROCKETT F1	99.91	9.45	9.46
YELLOW	CRX 2381 F1	103.93	8.47	8.15
YELLOW	AMBRADOR F1	97.37	8.87	9.11
YELLOW	AMIKA F1	86.05	8.29	9.63
YELLOW	ELENKA F1	104.40	9.65	9.24
RED	FIAMMA F1	80.12	7.61	9.50
RED	CRX 3762 F1	74.23	6.16	8.30

DRY MATTER 3

In addition it was decided to start studying the data that will be collected in different environments, as well as identify possible correlations between genes / germplasm and:

- **Agronomic practices (irrigation and concimaz)**
- **Sowing Date**
- **Storage conditions**

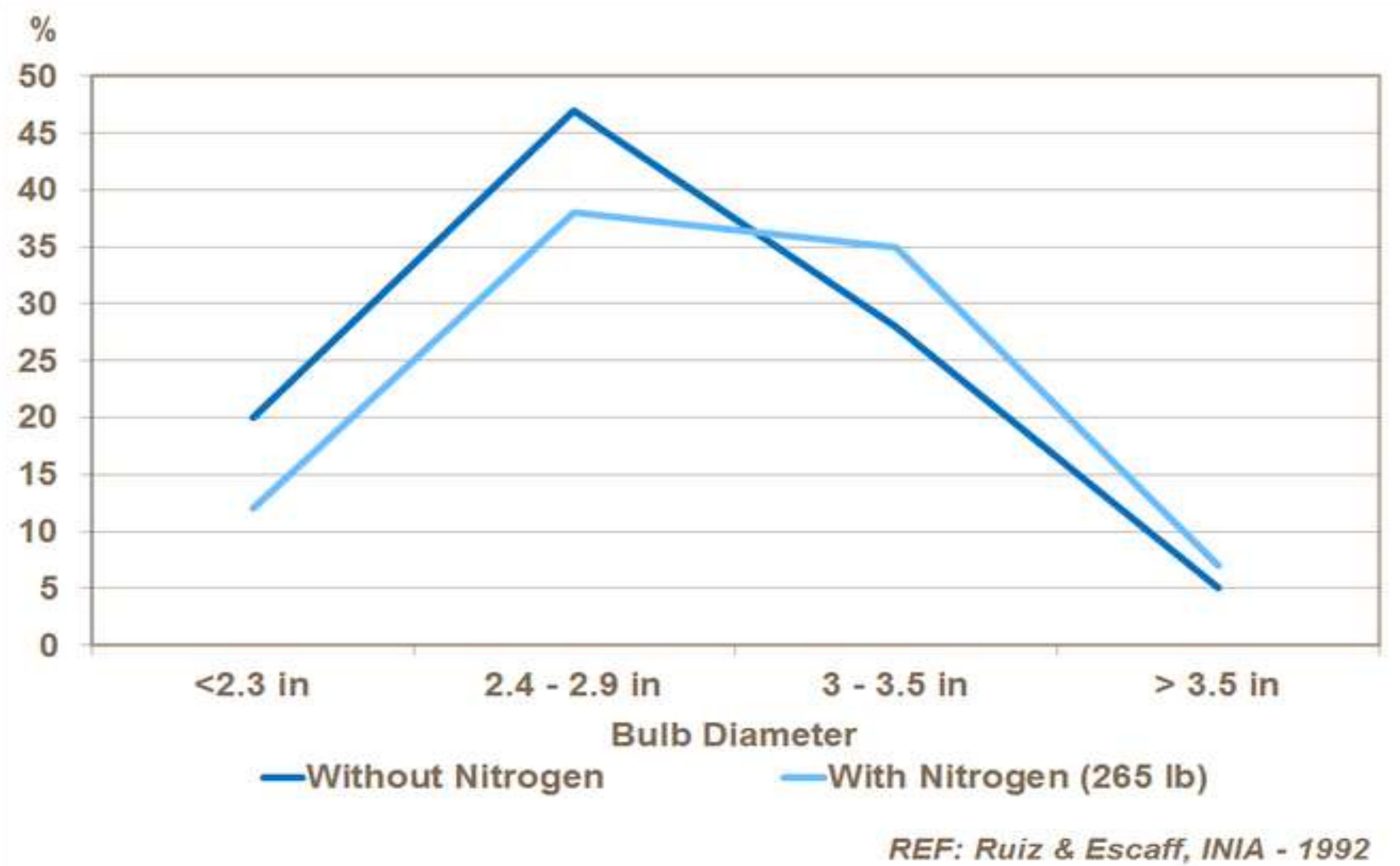


Nitrogen and yield

High application rates of 134 lb/ac or above are usually required in onions for top yields. This is a function of the usually light, hungry soils on which they are grown and also the crop's poor root structure and N-uptake capability.

Nitrogen and bulb size

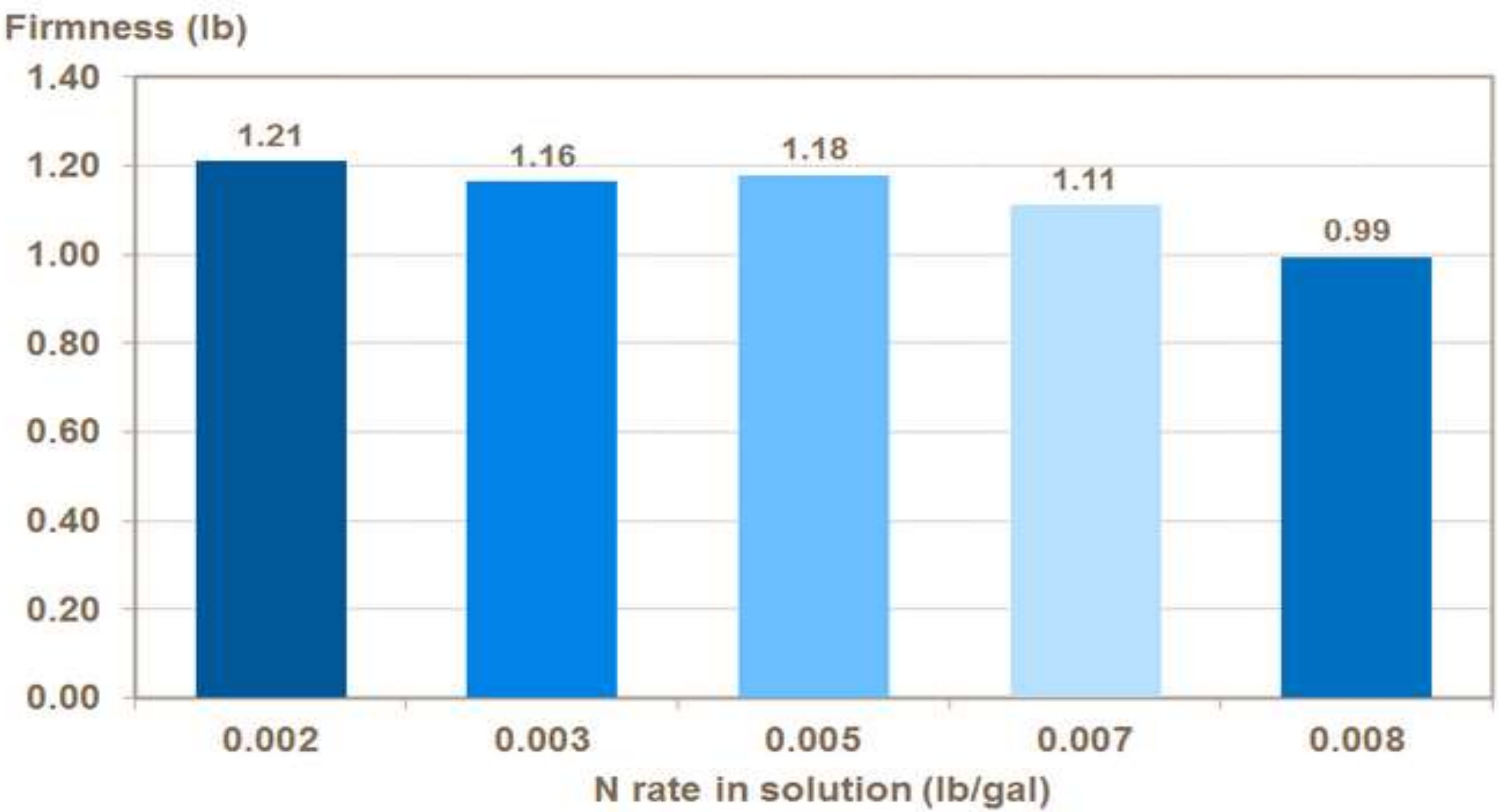
1 in = 2,5 cm



Nitrogen and bulb size

High rates of nitrogen are also important for onion size. The more N-applied the more leaves and hence the number of bulb scales produced, and the bigger the harvested bulb (trials with Valenciana Onions, Chile).

Nitrogen and bulb firmness

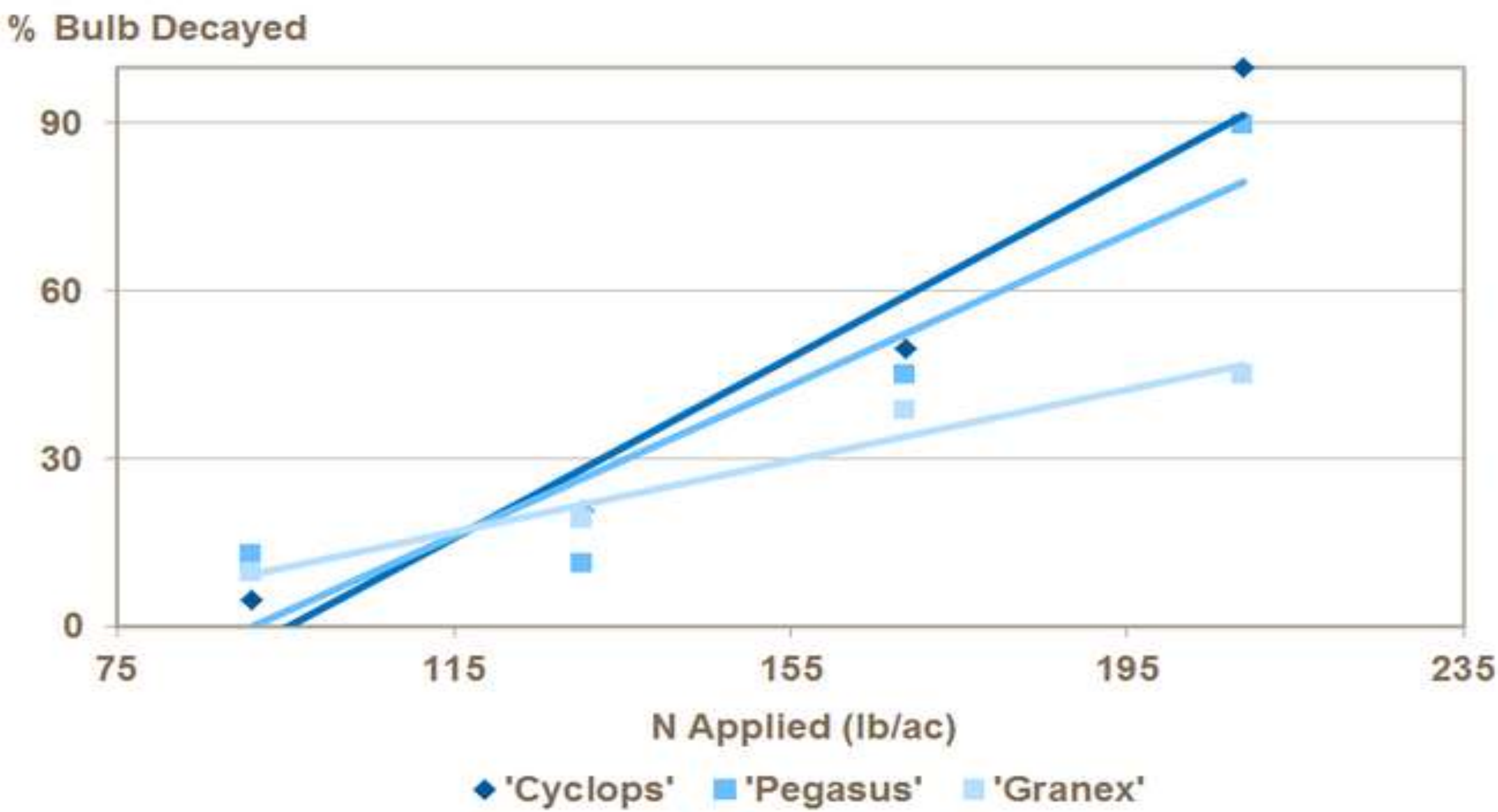


REF: W.M Randle J.Amer.Soc.Hort.Sci 125(2) : 254-259 2000

Nitrogen and bulb firmness

Although nitrogen can also help to improve the bulb's resistance to pressure by increasing the specific weight of the outer skin, reducing damage handling and storage, overall bulb firmness may decrease with high rates of nitrogen due to a softening of internal tissue (trials with Granex 33 Onions, USA).

Nitrogen and bulb decay during storage



REF: Diaz-Perez et al - 2003

Nitrogen and bulb decay during storage

Care has to be taken since excessive nitrogen can result in bulb decay and storage rots, causing yield losses in store. Excessive N can also weaken plant tissues increasing susceptibility to cold damage (USA studies).

USA Farmers survey

USA

Priority in onion breeding project for farmer among the following topics

Insect

Bacteria

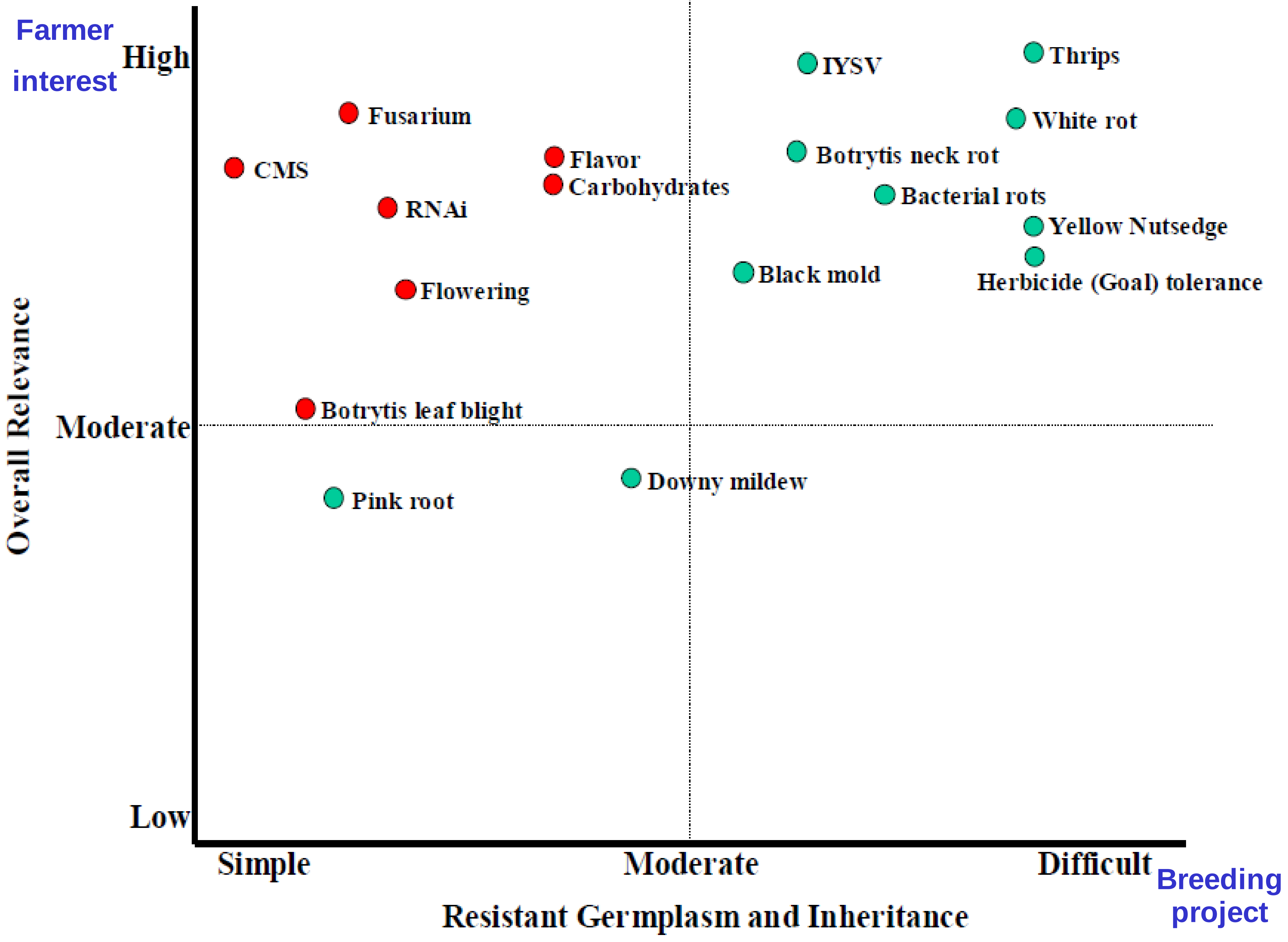
Fungi

Viruses

Nematodes

Abiotic stresses

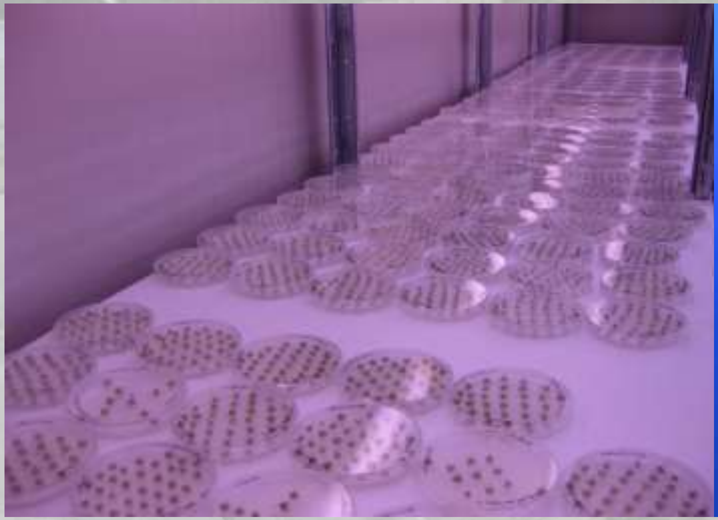
Quality attributes

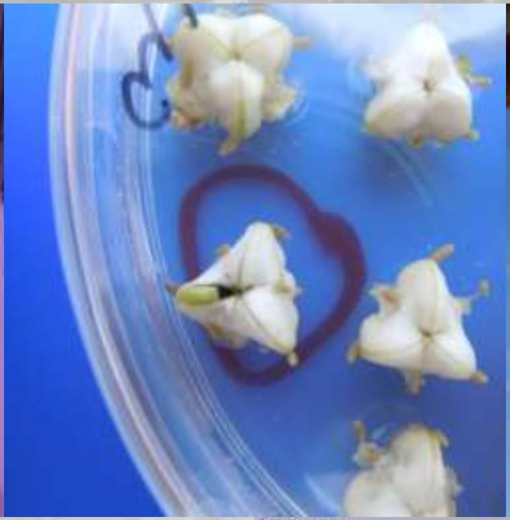


Farmer interest
High
Moderate
Low
Overall Relevance
Fusarium
CMS
Flavor
Carbohydrates
RNAi
Flowering
Botrytis leaf blight
Pink root
Downy mildew
IYSV
Thrips
White rot
Botrytis neck rot
Bacterial rots
Yellow Nutsedge
Black mold
Herbicide (Goal) tolerance
Simple
Moderate
Difficult
Breeding project
Resistant Germplasm and Inheritance

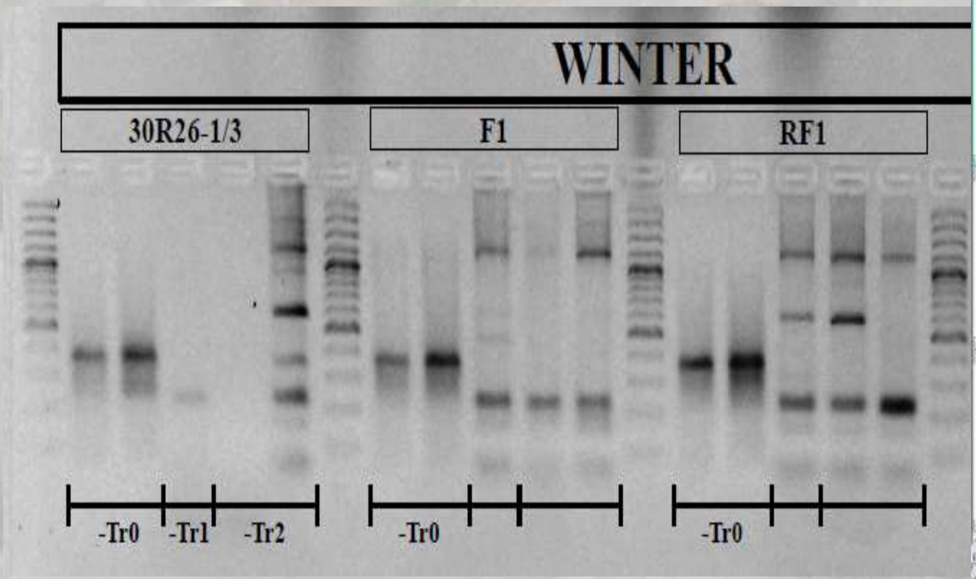
Breeding Tools

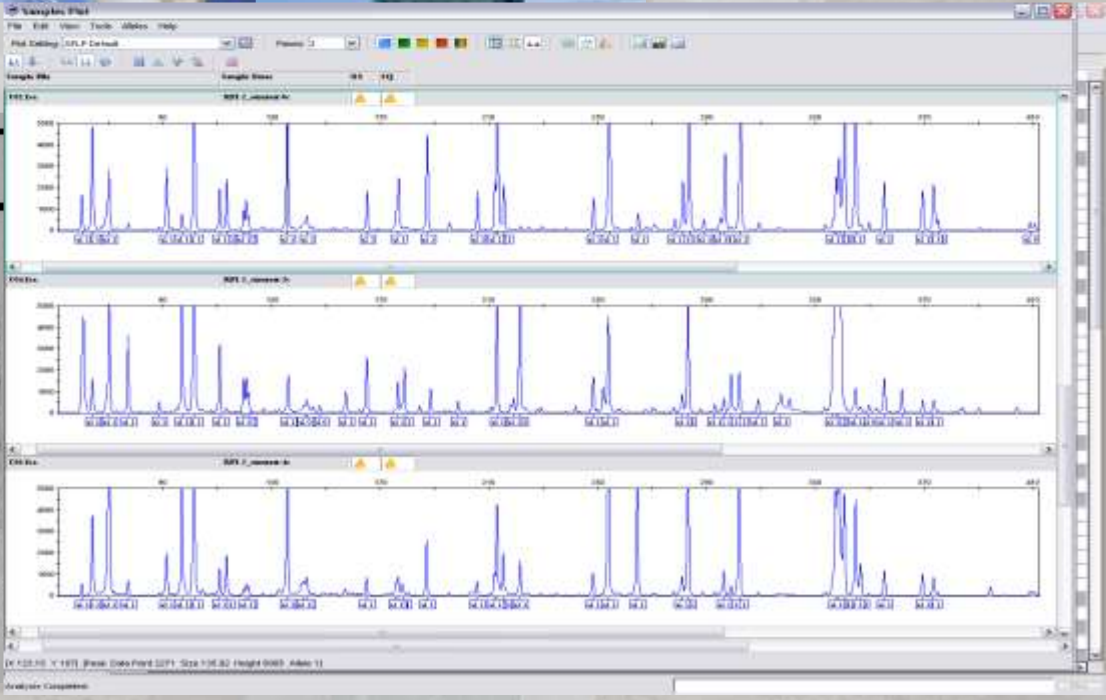
Gynogenesis





Molecular Markers





CONCLUSIONS

Breeding activities in onion are very complicated because:

- ONION is an Allogame species (inbreeding depression)

- Male sterility is more complicated than other species

- Plant pathology and molecular informations , useful for improving the existing breeding programs in the species, are lagging behind major commercial crops

- They require high knowledge of many aspects

- Many environmental variables are changing over time

- Each market and agronomic area needs specific products

- Long time is needed for realising a new hybrid

Onion breeding program is a really expensive entry in the budget of a seed company

Thanks for your attention!

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