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
<table>
<thead>
<tr>
<th>Typology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LONG DAY ONION</td>
<td>(LDO &gt; 13-14 h of light)</td>
</tr>
<tr>
<td>OVERWINTERING ONION</td>
<td>(SDO &gt; 10-12 h of light)</td>
</tr>
<tr>
<td>INTERMEDIATE DAY ONION</td>
<td>(IDO &gt; 11-13 h of light)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dry Skin Color</th>
<th>Yellow, Red, White</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pungency</td>
<td>Pungent and sweet (new)</td>
</tr>
</tbody>
</table>
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
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 appearance of new plant diseases)
CLIMATE CHANGES

Rainfall data in Cesena

Diagramma PIOVOSITA' - 2013

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

Diagramma PIOVOSITA' - 2014
ONION BREEDING

Focus

Specific goals:
- Plant Disease Resistance
  - Fusarium oxysporum f. sp. Cepaeae (FOC)
  - Pink Root
  - Downy Mildew
- Dry Matter Content
- Maturity Time
Plant Diseases
Fusarium oxysporum
f. sp. cepae
Fusarium oxysporum f. sp. Cepae 1

- Fusarium oxysporum f. sp. cepae (FOC) is a soilborne 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.
Early infections occur after germination promoting early death of the seedling (*damping-off*)

*Fusarium oxysporum f. sp. Cepae 2*

FOC is able to infect host plants at any stage of its life cycle.
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 sometimes other species are symptomless hosts

- Other Allium species (shallots, garlic, Japanese bunching)
- Asparagus, mais, wheat, rice, soybean, cucumber, pea, squash
- Alfa-alfa, Oxalis (symptomless hosts)
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 tolerance of plants to FOC in naturally infected soil
Pathogen inoculation

Phytopathometric evaluation

Laboratory testing

Transplanting

Phytopathometric evaluation
Fusarium oxysporum f. sp. Cepae 9

Laboratory Test using a Fusarium inoculum

FOC Test - May 2013 - PLANT MORTALITY RATE

Yellow Onion - Susceptible Material

% dead plants

Days Post Inoculation (DPI)
Fusarium oxysporum f. sp. Cepae 10

FOC Test - May 2013 - PLANT MORTALITY RATE

Yellow Onions - Tolerant Material

% Dead Plants vs. Days Post Inoculation (DPI)
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 produces small plants and bulbs with reduced size 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 serious 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.
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 occurring during the night

High Relative Humidity (RH): ≥ 95%

Start of RH: early

Temperature: 6-[8-15]-22°C

Light Irradiance: low or nothing (night)
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.
Figure 2. Effects of temperature (10°–22°C) and leaf wetness duration on germination of spores of *P. destructor.*
Main condition is that the infected tissues have been covered with a water film for at least 4 hour with a relative low temperature (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.

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

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

[Image with labels: Hf, EC, a, pp, BHF]
D. Mildew management

Chemical treatments (fungicide)

- Dimethomorph + mancozeb (Forum MZ)
- Dimethomorph + pyraclostrobin (Cabrio Duo - sistemic)
- Bentiavalicarb + 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.
It has begun to analyze the material in order to identify material with high% of dry matter.

<table>
<thead>
<tr>
<th>TYPOLOGY</th>
<th>VARIETY</th>
<th>FRESH NET WEIGHT</th>
<th>DRY NET WEIGHT</th>
<th>% DRY MATTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHITE</td>
<td>LIRIKA F1</td>
<td>141.99</td>
<td>10.41</td>
<td>7.33</td>
</tr>
<tr>
<td>WHITE</td>
<td>W.Opera F1</td>
<td>113.01</td>
<td>9.71</td>
<td>8.59</td>
</tr>
<tr>
<td>WHITE</td>
<td>SOLSTICE F1</td>
<td>87.84</td>
<td>6.36</td>
<td>7.24</td>
</tr>
<tr>
<td>YELLOW</td>
<td>UTRERO F1</td>
<td>134.15</td>
<td>10.24</td>
<td>7.63</td>
</tr>
<tr>
<td>YELLOW</td>
<td>CRX 2384 F1</td>
<td>104.65</td>
<td>6.56</td>
<td>8.54</td>
</tr>
<tr>
<td>YELLOW</td>
<td>CROCKETT F1</td>
<td>99.91</td>
<td>9.45</td>
<td>9.46</td>
</tr>
<tr>
<td>YELLOW</td>
<td>CRX 2381 F1</td>
<td>103.93</td>
<td>8.47</td>
<td>8.15</td>
</tr>
<tr>
<td>YELLOW</td>
<td>AMBRADOR F1</td>
<td>97.37</td>
<td>8.87</td>
<td>9.11</td>
</tr>
<tr>
<td>YELLOW</td>
<td>AMIKA F1</td>
<td>86.05</td>
<td>8.29</td>
<td>9.63</td>
</tr>
<tr>
<td>YELLOW</td>
<td>ELENKA F1</td>
<td>104.40</td>
<td>9.65</td>
<td>9.24</td>
</tr>
<tr>
<td>RED</td>
<td>FIAMMAF1</td>
<td>80.12</td>
<td>7.61</td>
<td>9.50</td>
</tr>
<tr>
<td>RED</td>
<td>CRX 3762 F1</td>
<td>74.23</td>
<td>6.16</td>
<td>8.30</td>
</tr>
</tbody>
</table>
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

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).

REF: Ruiz & Escaff, INIA - 1992
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

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

Priority in onion breeding project for farmer among the following topics

Insect
Bacteria
Fungi
Viruses
Nematodes
Abiotic stresses
Quality attributes
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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