



Implementation of somatic embryogenesis as a propagation technique for cacao

October 15, 2009



BACKGROUND



Cacao, *Theobroma cacao* L. is generally a heterozygous plant with a high variability for agronomic and quality traits.

Seed propagation, while efficient, is problematic, since many of the trees are unproductive (80% of the yield from 20% of the trees)

SOMETHING URGENT FOR CACAO

❑ **There is an urgent need to rehabilitate ageing plantations** (*“The government needs to offer cash incentives to farmers who cut down their ageing cocoa trees, many of which are over 40 years old and plant new ones”*, says a Nigerian cocoa farmer) **using improved planting material, preferably elite clones, to help fighting pests and diseases, as well as increasing yields.**

❑ **Efficient vegetative propagation tools are needed to achieve this goal.**



Limits to the vegetative propagation of cacao



- Propagation by rooted cuttings and grafting are current options, but the majority of stem materials available in the cacao tree canopy are plagiotropic branches.
- **“Plagiotropic scions, from lateral canopy branches, develop canopies with unbalanced, spreading habits that require significant attention to heavy formative pruning. Additionally, plagiotropic rooted cuttings more easily succumb to lodging and are susceptible to periods of soil moisture stress during establishment”** (Jagoret *et al.*, 1992)
- Growers used to the morphology of seed-derived trees are often reluctant to adopt grafted trees

Cacao Somatic Embryogenesis



- A somatic embryogenesis (SE) tissue culture system for clonal propagation of cacao has been developed by a number of groups worldwide, especially during the last fifteen years

- The feasibility of production of somatic embryos and trees from a large number of genotypes has also been demonstrated.



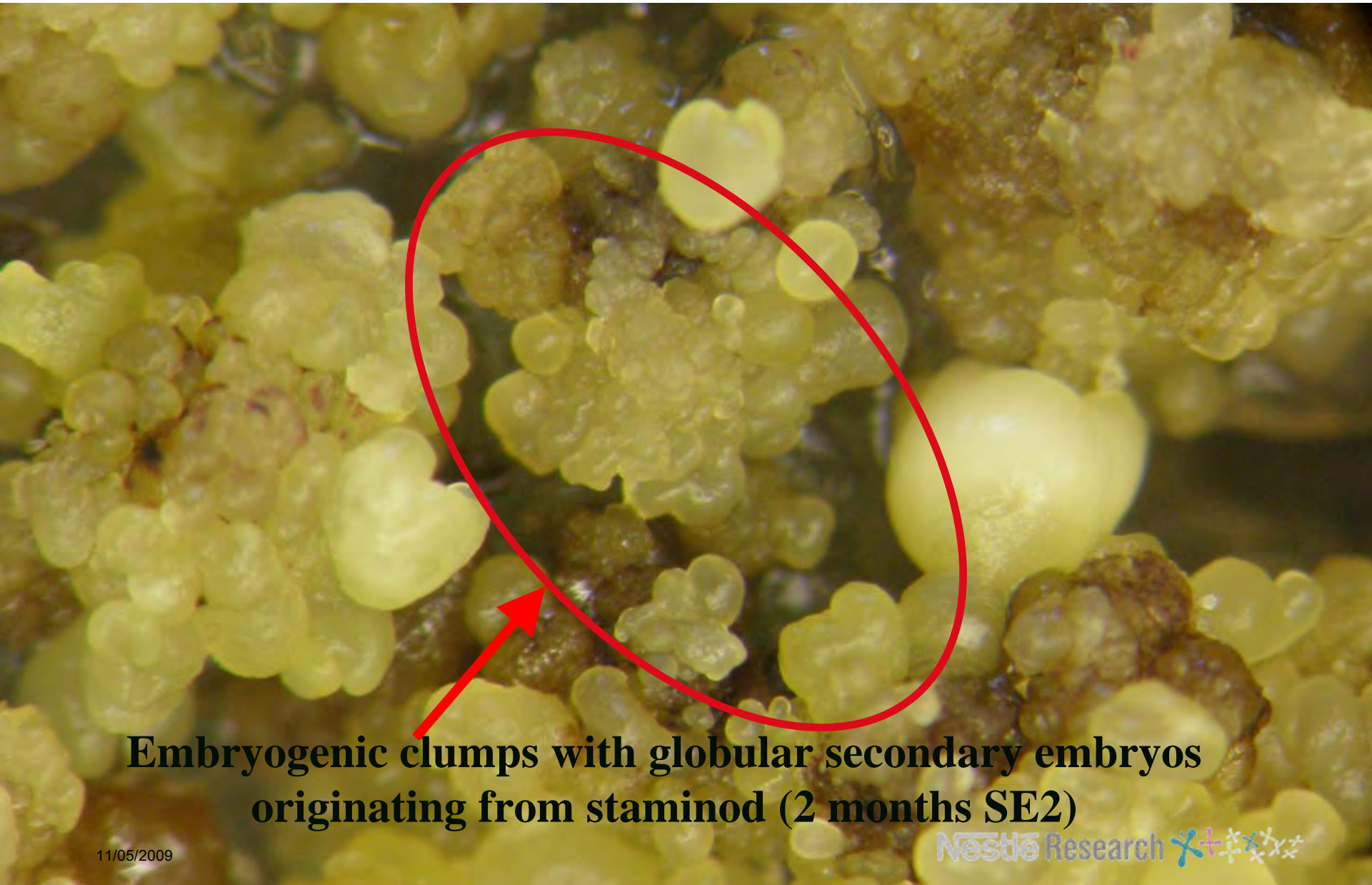
Somatic Embryogenesis on solid medium is a robust technology but labour intensive



Secondary Embryogenic Calli



Good Food, Good Life



**Embryogenic clumps with globular secondary embryos
originating from staminod (2 months SE2)**



SE propagation technology in liquid medium is less labour intensive. It has the potential of considerably speeding up the distribution of elite clones to the farmers



Acclimatized SE plants in the greenhouse...

SE plant in the nursery



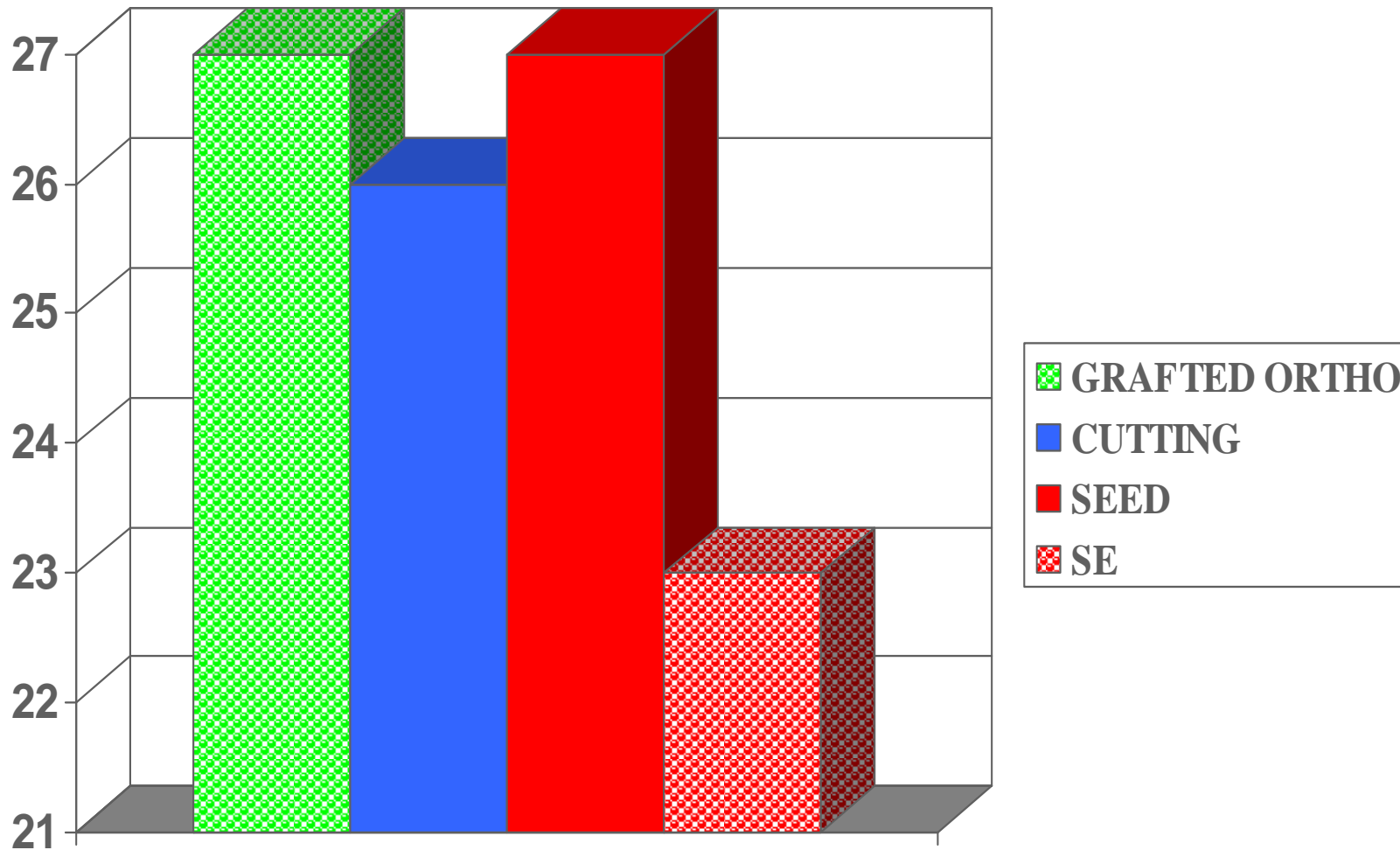
MAIN CHARACTERISTICS OF SE CACAO TREES

- ❑ True-to-type
- ❑ Favorable architecture similar to that of seed propagated trees
- ❑ Vigor, earliness, good performance under drought conditions



COMPARATIVE PROPAGATION TRIAL

Earliness / 1st harvest



Months to 1st Harvest

SE trees produce early

COMPARATIVE PROPAGATION TRIAL



Grafted (left) vs SE

Applications of cacao SE



Clonal gardens for mass production of scions and rooted cuttings

Seed gardens for breeding and the production of hybrid seed

Direct distribution of SE trees

Implementation of somatic embryogenesis



- **The mass propagation of elite cacao trees through SE is in progress:**
 - in Ecuador (Nestlé)
 - in Indonesia (ICCRI using Nestlé technique)
 - and will start soon in Ivory Coast (Nestlé, in collaboration with CNRA)

Implementation of somatic embryogenesis in Ecuador (*Nacional* clones)



- **Establishment of demo-plots (2009)**
- **Development of clonal gardens in collaboration with cooperatives (2009-2010)**
- **Macropropagation from SE-derived clonal gardens by grafting and orthotropic rooted cuttings (2009-2010)**



SE plants in the nursery (Ecuador)

**SE trees bearing
pods in Ecuador**



Implementation of somatic embryogenesis in Indonesia



- One of our projects in the ASEAN region is the **partnership between Nestlé's R&D centre in Tours, France, and the Indonesian Coffee and Cocoa Research Institute (ICCRI) on the large-scale propagation of cocoa trees.**

Cocoa output in Indonesia is under pressure



- 520 000 tons in 2007
- 500 000 tons in 2008
- 470 to 485 000 tons this year,
 - Due to various factors including
 - Sub-optimal farming techniques
 - **Vascular Streak Dieback** (VSD, a vascular disease attacking leaves, branches and tree trunks across the island of Sulawesi and accounting for about three quarters of nationwide output)

The government program includes distribution of **free fertilizers** to boost productivity of cacao trees over an area of 145 000 ha and **better trees produced by SE**

The Indonesian government -through ICCRI- adopted Nestlé SE technology to speed up seed production



- ❑ **7 clones selected for their good field performance: yield , disease resistance**
- ❑ **Training of one scientist to solid medium technology for one year at R&D Tours**
- ❑ **Status at ICCRI:**

| | |
|-----------------------|--|
| 2008 | Over 1 million SE plants produced |
| Objective 2009 | 10 million SE plants expected |
| Objective 2011 | Up to 50 million SE plants |



Large-scale propagation of cacao at ICCRI (October 2008)

Ivory Coast



- **Nestlé inaugurated in April 2009 a new R&D centre in Abidjan**
- **Nestlé will help Ivory Coast plant about one million new, disease-resistant cocoa trees every year to help the world's top cocoa grower boost production in its ageing plantations**
- **This program is in collaboration with CNRA**

SE accelerates cacao propagation efforts but a pragmatic and balanced approach is required

| Type of propagation | Cost | Main Advantage | Main Disadvantage |
|---------------------|--------|---------------------------|--|
| Seed | Low | Good tree architecture | Genetic Heterogeneity |
| Rooting | Medium | Genetic homogeneity | Poor tree architecture and rooting |
| Grafting | Medium | Genetic homogeneity | Poor tree architecture |
| Bending of SE | Medium | Good tree architecture | Some variation for jorquette height |
| SE | High | Good tree architecture... | Capacity of the technique to be still improved |

Optimizing the use of SE clonal gardens: orthotropic cutting production

- The production of **orthotropic shoots from SE** softwood or semi-hardwood shoots **after bending** has been evaluated



Orthotropic cutting production



Bent semi-hardwood SE
plant producing orthotropic
shoots

Orthotropic shoots ready
for rooting stage



Rooted orthotropic shoot
ready for transfer to
nursery

Rooted orthotropic shoots
(4 months old)

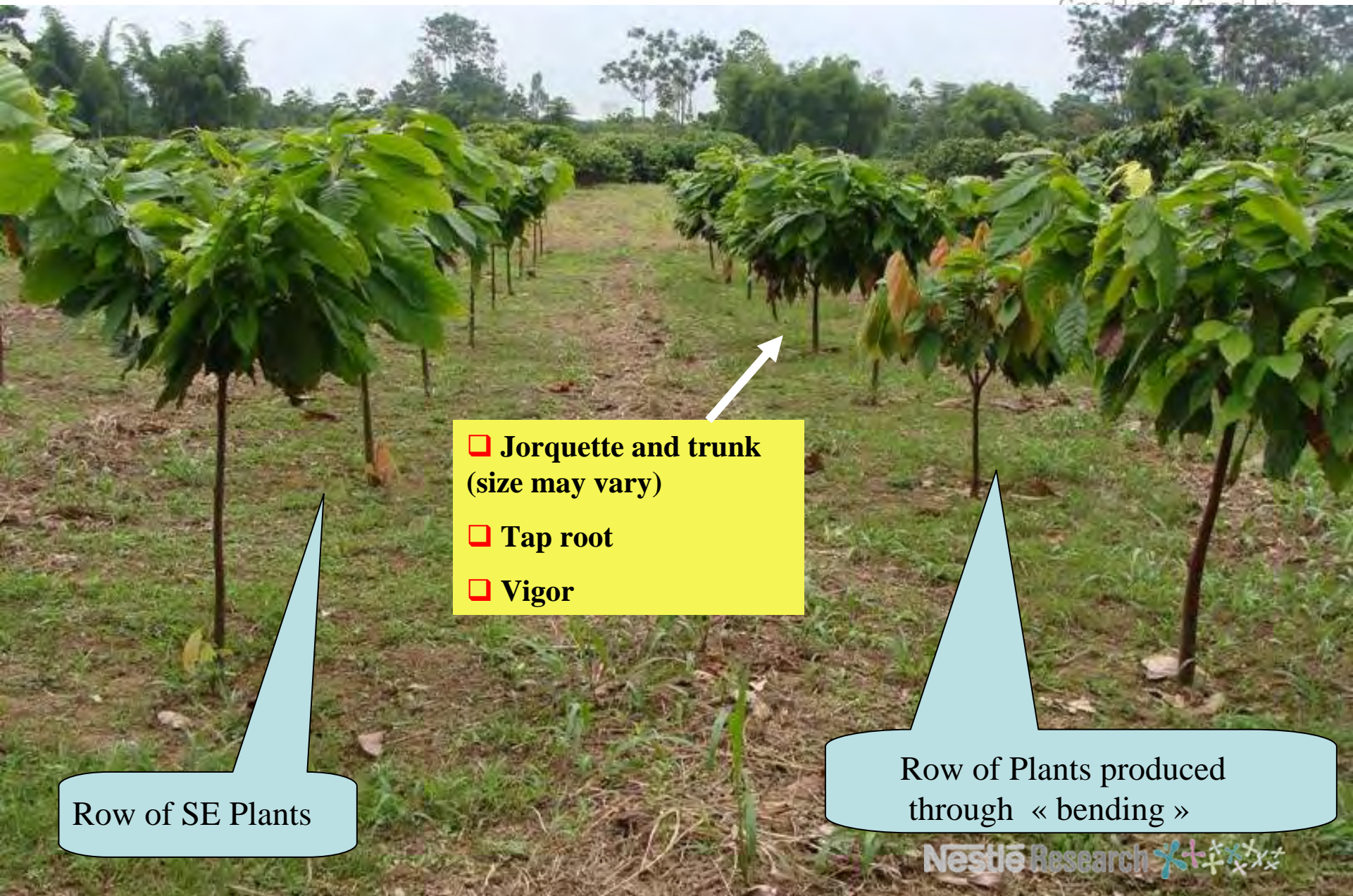
Orthotropic shoots at
rooting stage

Our experience with macropropagation from cacao semi-hardwood shoots



- **Mother SE plants can be used for several years (at least 2) as source of orthotropic shoots**
- **The number of stem cuttings to be collected is almost stable from year to year (can reach 300-400 per year and bent tree)**
- **The rooted percentage of one-node cuttings reaches up to 70-75% (depends on variety...)**
- **At least 100 to 300 rooted cuttings can be produced per year and mother plant**
- **The plants develop one or more tap roots**
- **These observations confirm those of M. Gultinan's group at PSU**

Comparison of Nacional plants produced via SE and Bending techniques... Ecuador May 2009



- Jorquette and trunk (size may vary)
- Tap root
- Vigor

Row of SE Plants

Row of Plants produced through « bending »

Better cacao trees for the benefits of the entire supply chain

THANK YOU

- **BACK UP**

Root Systems of Juvenile Seedlings

vs.

Orthotropic Clones

Seedling

1st Somatic Embryo

2nd Somatic Embryo

Orthotropic R. Cutting

Mini R. Cutting



Source: Penn State University