Centrifugal fertilizer spreader: control of working width and fertilization quality

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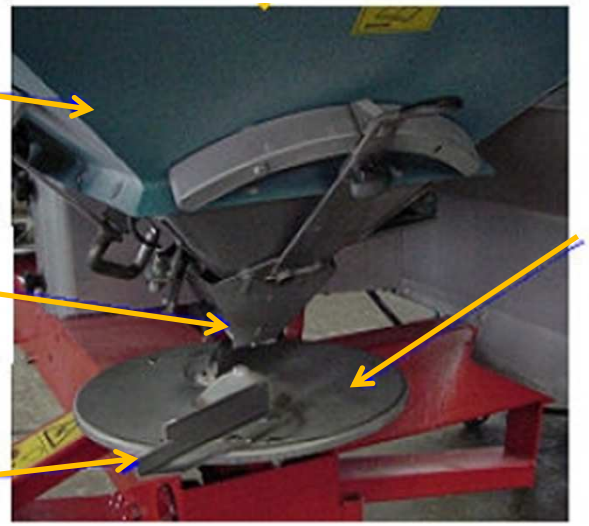
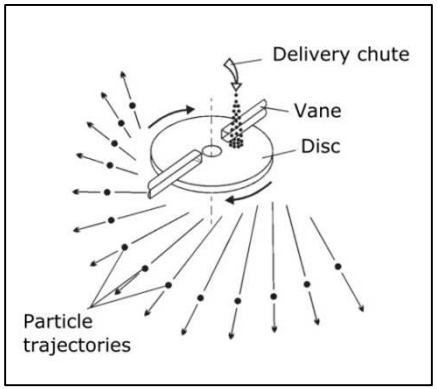
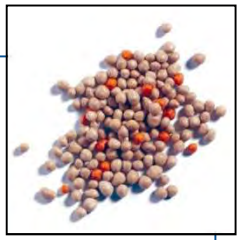
Motivation: centrifugal spreader





Mineral fertilizers:
$\overline{\phi} = [3,\ 4]$ mm
Acceleration phase:
140 – 220 km/h
Distance traveled:
10 – 35 m from center of disc

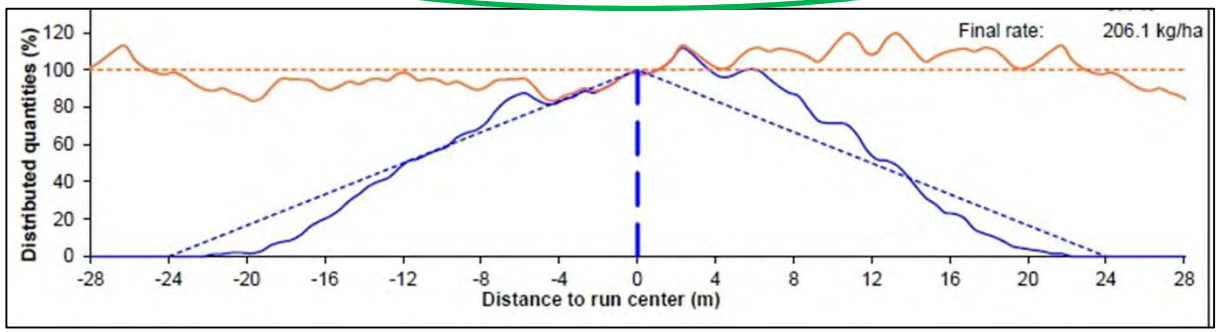


Motivation: measurement

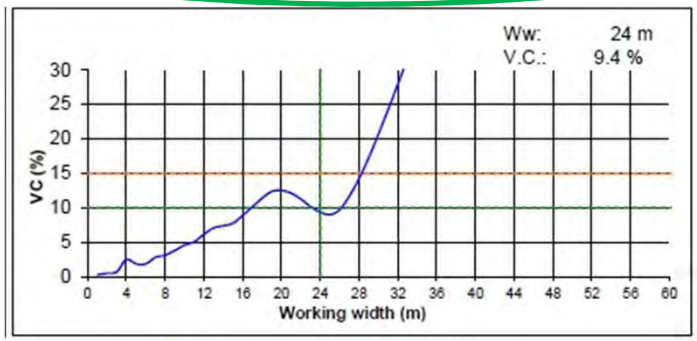
Cemib device: (Ref: Piron et al., EurAgEng, 2010)

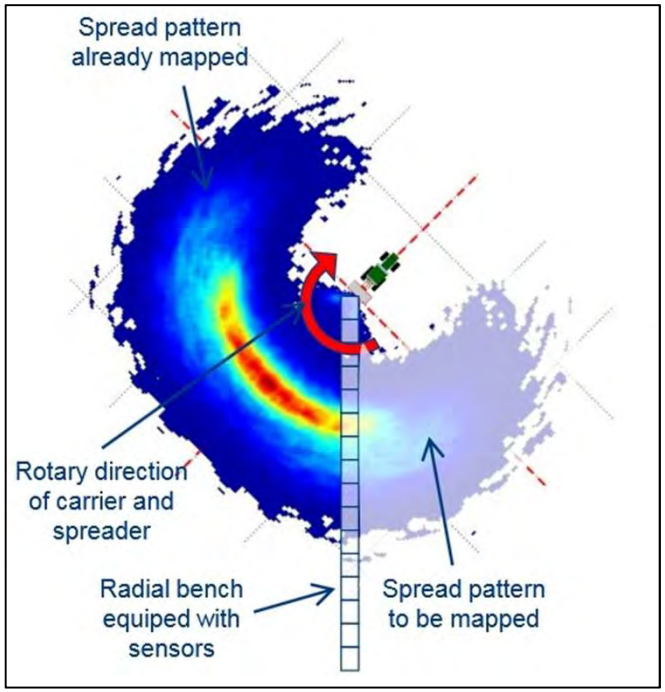
1. Measure the spread pattern;
2. Establish the spreading chart.

Transverse distribution curves



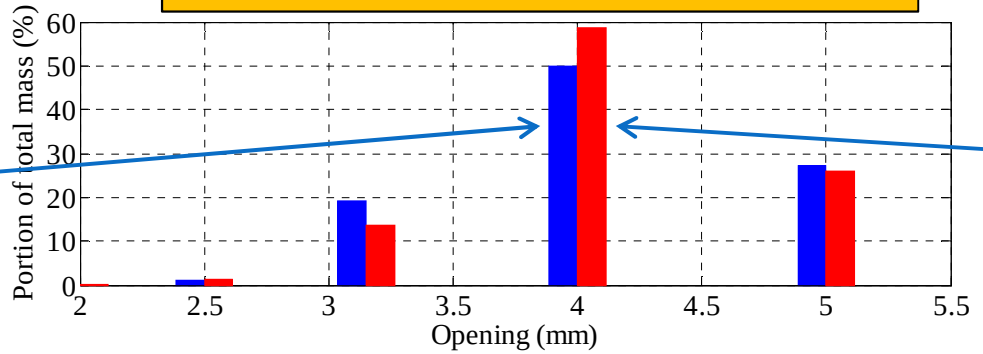
Variation coefficient curve



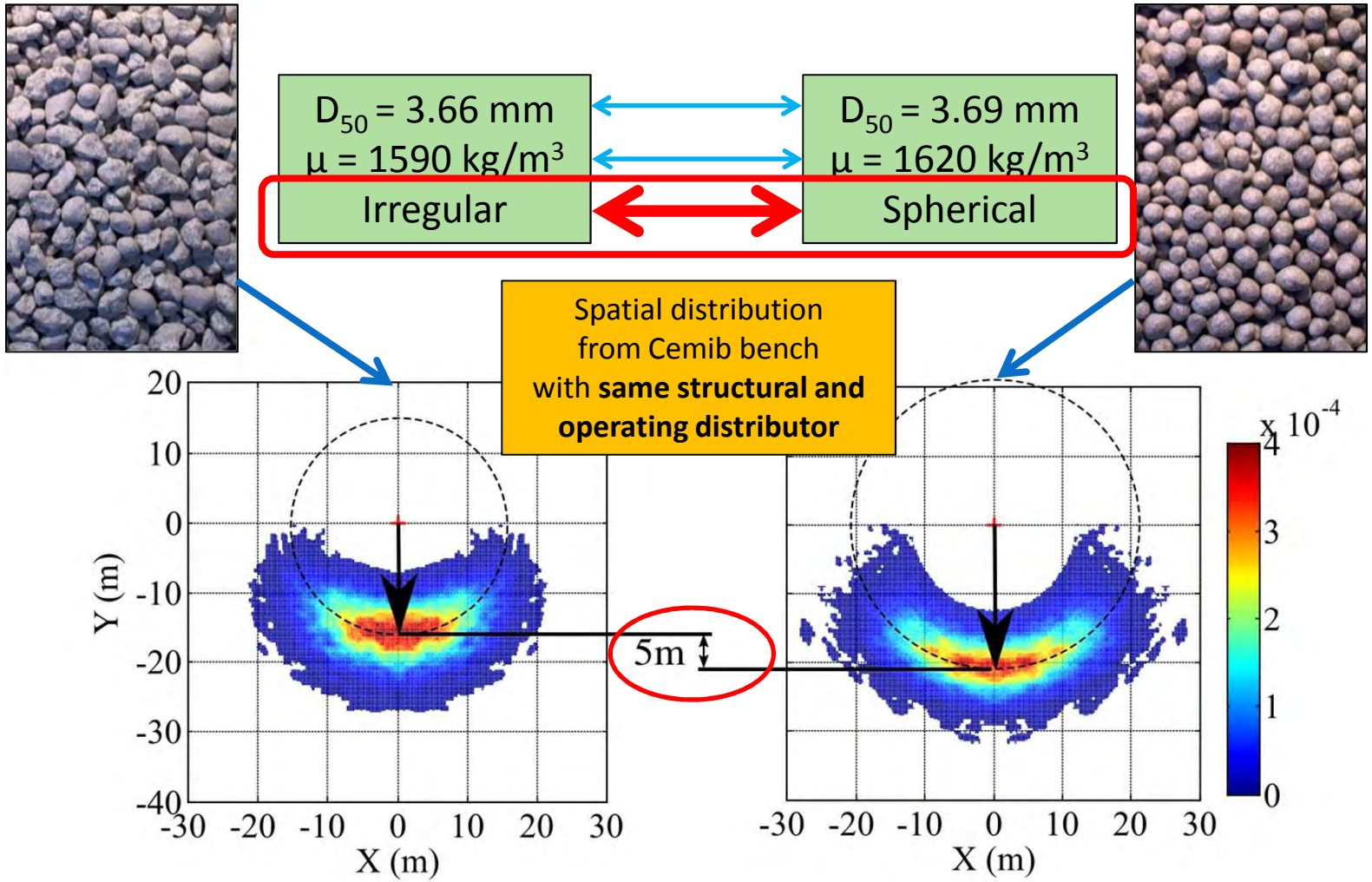


Motivation

Sieve tests (carried out at Irstea)



Motivation


D_{50} = 3.66 mm
μ = 1590 kg/m³
Irregular
D_{50} = 3.69 mm
μ = 1620 kg/m³
Spherical
Spatial distribution
from Cemib bench
with **same structural and operating distributor**
Y (m)
X (m)
X (m)
5m
x 10⁻⁴

Motivation

If we want to model and simulate the spreading process:

1. The morphology of particles plays an important role;
2. The size of particles from sieve analysis is insufficient.

In order to increase the accuracy of predicted landing position

➔ **New calibration of physical characteristics of fertilizers**

Motivation

Objective of this reasearch:

1. **Characterization of physical characteristics** of particles;.
2. **Construction and identification of a prediction model** to estimate numerically the spatial distribution of fertilizers **in real conditions of spreading process**.

Methodology:

- Characterization of physical characteristics of fertilizers using **image analysis method**;
- Construction of an optimization procedure to **identify aerodynamic behavior** of particles in the **ballistic flight**;
- Construction of a **prediction model** of spread pattern using aerodynamic properties identified previously;
- Application of the proposed model to **control the fertilization quality and working width**.

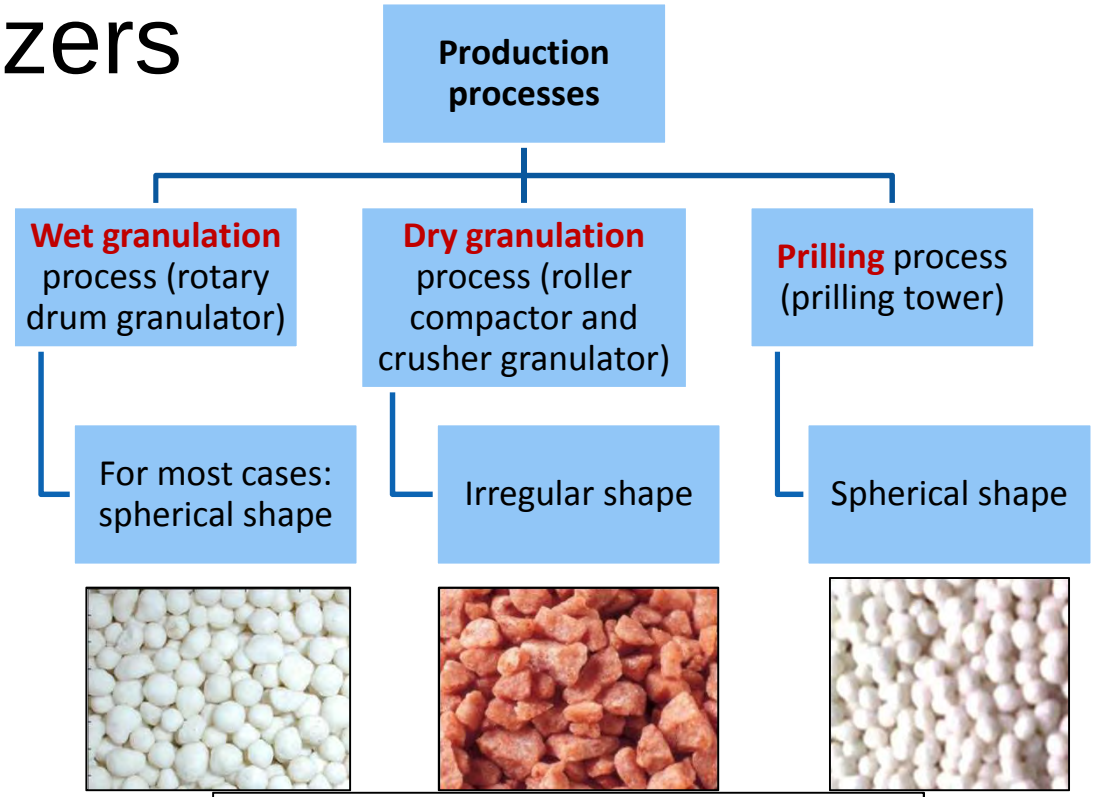
Plan

- Characterization of particles using image analysis
- Identification of aerodynamic properties of fertilizers
- Construction of prediction model to estimate spread pattern
- Control of fertilization procedure using proposed prediction model

Mineral fertilizers

Production processes of fertilizers determine their physical characteristics

But from this point of view: the determination of morphology **is not** quantitative, representative, repetitive and reproducible



Ref: Nielsson, 1986; Dehont, 1999

Regarding number of particles, cost, acquisition, processing time and limitation of instruments

➔ **2D image analysis is chosen to characterize particles**

Image analysis: conclusions

Development of software to extract geometrical and shape parameters from images

+

Setting up of equipment in optimized conditions

→

Characterization of fertilizers

- Better understanding of the origin of fertilizer shape (production processes);
- Statistical correlation between each pair of parameters, deduce independepent parameters;
- Ranking of particle shape with respect to independent and relevant parameters;
- Construction of particle size distribution from both sieve and image analysis;
- Modeling and simulation of the spreading process.

Ref: LE et al., submitted to Comput Electron Agric, 2016

Conclusions

1. **Characterization of physical characteristics** of fertilizers:
   - Setting up of image analysis equipment (video-granulometer) under optimal photographic and statistical conditions;
   - Definition of geometrical and shape parameters;
   - Development of software to analyze captured images.

2. **Construction and identification of prediction model** to estimate spread pattern and establish spreading chart:
   - Modeling of spreading process;
   - Identification of drag coefficient based on data of Cemib;
   - Construction of prediction model, example of use.

Perspectives

The proposed prediction model has a potential application in the control of working width and fertilization uniformity:

- **Development of active control devices taking into account**: feed position on the disc, drop angle, vane profile, variable rate, field elevation, tractor motion, weather …
  and our particle analyzer (video-granulometer).

- **Available methods** at Irstea Montoldre for fertilizer manufacturers.

Thank you for your attention !

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