Equipment for applying organic fertilizers (PART II)

P. Balsari, E. Dinuccio
Department of Agriculture, Forest and Food Science (DISAFA)
University of Turin - Italy

Technical problems related to manure application in orchards

- Difficult localization of manure in the area where nutrients absorption by the plants roots is more efficient
  - Narrow inter-rows ≤ 4m

Slurry spreaders nowadays available on the Italian market don’t allow the slurry application in orchards
C) Development of manure spreaders for orchards

DEFINITION OF THE AREA WHERE MANURE BE APPLIED

PEACH ORCHARD

Maximum nutrients absorption

The slurry spreader for orchards realized by DISAFA – Torino University

- total length: 5.8m
- width: 2.1m
- height: 2.4m
- single axis
- carriageway: 2.30m
- slurry tank volume: 5m³
- galvanized steel atmospheric pressure tank
- low pressure tires (500/60 – 22.5)
- volumetric lobe pump
- electronic system for the application rate control
The machine spreading system

Rotary distributor (12 pipes)

Hydraulic system for the adjustment of the working width (± 1 m)

Trailing hoses

~60cm ~60cm

Minimum working width (~ 2.5 m)

Maximum working width (~ 3.5 m)
Layout of the innovative slurry spreader

How to get the required NPK application rate

Correlation between slurry TS content, TN and TP
The electronic system for the application rate control

Lobe pump driven by an hydraulic motor
How to get the required NPK application rate

Slurry analysis by densimetric method (directly in the field)

<table>
<thead>
<tr>
<th>Bulk density</th>
<th>TS</th>
<th>N (%)</th>
<th>P2O5 (%)</th>
<th>K2O (%)</th>
<th>NH4 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1001</td>
<td>1.3</td>
<td>0.8</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>1002</td>
<td>2.6</td>
<td>1.6</td>
<td>0.2</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>1003</td>
<td>4.6</td>
<td>1.7</td>
<td>0.2</td>
<td>0.9</td>
<td></td>
</tr>
<tr>
<td>1004</td>
<td>6.6</td>
<td>1.9</td>
<td>0.3</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>1005</td>
<td>8.7</td>
<td>2.0</td>
<td>0.5</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>1006</td>
<td>10.7</td>
<td>2.1</td>
<td>0.7</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>1007</td>
<td>12.8</td>
<td>2.2</td>
<td>0.8</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>1008</td>
<td>14.8</td>
<td>2.3</td>
<td>1.0</td>
<td>1.3</td>
<td>1.7</td>
</tr>
</tbody>
</table>

C) The solid fraction spreader for orchards realized by DISAFA – Torino University

- total length: 5.3m
- width: 2.1m
- height: 2.0m
- single axis
- carriageway: 2.10m
- hopper volume 4.5m³
- hydraulic conveyor
- electronic system for the application rate control
The spreading system

1. **Chain conveyor**
2. **Hydraulic rave** (maintained 10cm lifted during spreading in order to guarantee an uniform solid fraction flow to belt conveyor)
3. **Belt conveyor**
4. **2 Spinning disks** (one to each side, adjustable inclination and rotation speed)
5. **System for the adjustment of the working width** (the disks can be spaced 0.5m apart from the right hand side of the spreader)

Layout of the innovative solid fraction spreader
How to get the required NPK application rate

1. Solid fraction analysis (NPK content)
2. Setting of the required NPK application rate and NPK content of the slurry into the central unit
3. Desired NPK application rate to field

Transverse distribution patterns of the solid fraction spreader at different application rates (25, 50 kgN ha⁻¹) and spinning plate inclination (0°, 30°) at 330 rpm
D) Environmental assessment of liquid (slurry) and solid manure spreaders: 
ENTAM certification

**ENTAM (EUROPEAN NETWORK FOR TESTING OF AGRICULTURAL MACHINES)**

International effort to guarantee independent and harmonized testing systems (common methodology) in the field of agricultural engineering:

- 11 members based in ten European countries
- 1 honorary witness (FAO)
- 4 observer members (INTA, AFMSPTC, CEA, VIM) respectively from Argentina, Bulgaria, Brazil, Russia

**ENTAM common methodology** → technical instruction which are discussed, approved and updated unanimously by specific Technical Working Group (TWG)

- PLANT PROTECTION TWG
- IRRIGATION TWG
- MINERAL FERTILIZER SPREADERS TWG
- MIXER FEEDER WAGONS TWG
- ORGANIC FERTILIZER SPREADERS TWG
Environmental assessment of liquid (slurry) and solid manure spreaders

- \( \text{NH}_3 \) emissions
- Soil compaction

**Starting points**

- The spreader environmental evaluation is performed in relative terms, as a comparison with a reference system.

  Spreader (technology) to be tested (candidate) “vs.” reference system

  the nationwide most commonly used method for land application of the specified type of manure.
## ENTAM tests for environmental assessment of manure spreaders: \( \text{NH}_3 \) emissions

### Reference application system for slurry => splash plate

- Distance between the soil surface and the center of the splash plate outlet = 1 \((\pm 0.01)\) m
- Slurry outlet pressure = 1.5 \((\pm 0.1)\) bar

### Test conditions

- **Manure type**
  (according to EN-13080, EN-13406)

- **Application rate** \((t \text{ ha}^{-1})\)
  - shall be related to typical agricultural practice of the specific area
  - measured by weighing the manure tank before and after manure application

<table>
<thead>
<tr>
<th>Manure type</th>
<th>Application rate</th>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

### Diagram

![Diagram of reference application system for slurry => splash plate]
ENTAM tests for environmental assessment of manure spreaders: $\text{NH}_3$ emissions

➢ Test site

 ✓ All tests shall be performed:
   - outdoors
   - in typical field conditions
   - on an even, horizontal surface

ENTAM tests for environmental assessment of manure spreaders: $\text{NH}_3$ emissions

☞ Parameters to be recovered during the test

a) Manure composition
   ✓ Total solids (TS, g kg$^{-1}$)
   ✓ Ash (g/kg)
   ✓ Total Nitrogen (TN, g kg$^{-1}$)
   ✓ Total Ammoniacal Nitrogen (TAN, g kg$^{-1}$)
   ✓ pH
### Parameters to be recovered during the test

#### b) Weather conditions

- **wind velocity (m s$^{-1}$)**, measured 2.0 m above ground level
- **relative air humidity (%)**, measured 2.0 m above ground level
- **air temperatures (°C)**, measured 2.0 m above ground level
- **soil temperatures (°C)**, measured 0.1 m under ground level
- **precipitation (mm)**

#### c) Soil characteristics

- **texture**: content of clay, silt and sand (%)
- **pH**
- **cation exchange capacity (meq 100g$^{-1}$ dry soil)**
- **Total Nitrogen (g kg$^{-1}$)**
- **Total Ammoniacal Nitrogen (g kg$^{-1}$)**
- **moisture content (%)**

#### d) Crop characteristics

- Type and height of crop
ENTAM tests for environmental assessment of manure spreaders: NH₃ emissions

Parameters to be recovered during the test

e) Ammonia emissions

- Funnel system method (Balsari et al., 1994)
- At least 4 replicates

Funnel system

Measurement unit
1: Funnel (0.138 m² surface; 20.6 dm³ volume)
2: 50 mesh (20/10) net
3: Acid trap (1% H₃BO₃ solution)
4: Solid trap
5: Volume meter
6: Flow meter (~ 10 L/min)
7: Pump
General description of the methodology and requirements

Test design

- **Reference system**
- **Candidate**
- Working width (Ww)
- Measurement station
- Circular subplot area
- FUNNELS

Working width (Ww):
- min. 20 m
- 40 - 50 m

Example of test report

**Responsibility and recognition**

Performing competent authority:
- Waste Management Group
- DISAFA - Div. Agro-Forestry and Environmental Engineering
- Largo Braccini, 2
- 1-10095 Grugliasco (TO)

This test is recognized by the ENTAM members:

**ENTAM - Test Report**

**ENVIRONMENTAL ASSESSMENT (AMMONIA EMISSION REDUCTION)**

- Spreader type: Slurry tanker with injection system
- Trade mark: S.A.C. sas di Arduino Claudio
- Model: B201PA
- Manufacturer: S.A.C. sas di Arduino Claudio
- Via Savigliano, 4
- I - 12020 Vottignasco (CN)

Test report: 05/150
April 2014
**Example of test report**

**Technical data of spreader**

<table>
<thead>
<tr>
<th>Slurry tanker</th>
<th>Vacuum pump</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank material: galvanized steel</td>
<td>Pump output: max flow rate 9000 l/min max pressure 1.5 bar</td>
</tr>
<tr>
<td>Number of axles: 3</td>
<td></td>
</tr>
<tr>
<td>Total length: 8800 mm</td>
<td></td>
</tr>
<tr>
<td>Height: 3300 mm</td>
<td></td>
</tr>
<tr>
<td>Width: 2550 mm</td>
<td></td>
</tr>
<tr>
<td>Tare: 6500 kg</td>
<td></td>
</tr>
<tr>
<td>Max capacity: 15 m³</td>
<td></td>
</tr>
</tbody>
</table>

**Slurry injector components**

- Tine: 800 mm height, 60 mm width
- Cutting shoe: 300 mm height, 70 mm width
- Distribution hose: 800 mm height, 35 mm width

**Application system**

4 slurry injectors spaced 750 mm apart
Injection depth: 150-200 mm

**Test results**

![Cumulative ammonia emissions recorded during the test](image1.png)

![Total ammonium nitrogen lost from the land applied manure over the test period, as percentage of total nitrogen applied](image2.png)

Ammonia emission reduction index (Ip) = 0.58

**Free download of the complete test report under:**

www.ENTAM.net or www.ENAMA.it

---

**Conclusions**

Still limited farmers interest in equipments for applying organic fertilizers

Few research and industry innovation

Necessity to improve the research and the market of the already available innovative solutions
Thank you for your attention

For further information: paolo.balsari@unito.it