Fertiliser spreading: Getting the mechanics right

Fertiliser association of Ireland 2011 meeting

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Teagasc
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Outline

• Machine developments
  » Spreading mechanisms
• Applying the correct rate
  » Rate control
  » Calibration
• Spreading evenly
  » Test hall performance
  » Field performance
• The cost of uneven spreading
• Practical considerations

Basic functions!

• Transport fertilizer
• Spread fertilizer evenly
  » Correct rate
  » Applied evenly
  » i.e. correct rate everywhere (0.25m²)

Think Safety, Farm Safely

2010 – 26 Deaths
6% workforce
53% deaths
9 times rate

Fertilizer spreading
» Loading partic big bags
» Back injuries 50kg bags
» Manoeuvring (partic farmyard)
» Tractor, PTO, high speed discs

Basic functions!

Transport fertilizer
Spread fertilizer evenly
  Correct rate
  Applied evenly
    i.e. correct rate everywhere (0.25m²)
Transport

- Merchant to farm
  - Truck and Pallets
  - Truck and bulk
  - Spreader and spread +/- nurse delivery trailer
- Within farm
  - Pallets on trailer
  - Direct spreading

Which is the most efficient?

Bulk Spread vs others

- Advantages
  - Avoids cost and hassle of packaging and storage
  - Complete fast service, labour etc included
  - Cost efficient?
- Disadvantages
  - Emphasis on fast delivery of accurate quantity.
  - Less emphasis on even spreading?
  - Heavy equipment often on questionable ground conditions (partic. ploughed ground etc)

Spreading mechanism

- Types
  - Twin Disc development dominates
  - Single disc – one sided
  - Reciprocating Spout limited to 9 – 12m max
  - Pneumatic
    - Too expensive particularly >> 12m
    - Maintenance and corrosion issues
    - Test hall CVs no better
    - Windy conditions advantage
    - Sharp shut-off - research farms
Twin disc machines

- Up to 50+ m baulk widths (in test halls!)
- Current machines developed in era of independent testing in 1990s
  - Capable of good test-hall CVs
- Detailed disc design
  - Disc Size, Shape, Speed, Rotation
  - Vane Size/Length, Shape, Angle, Number
  - Delivery point of fertiliser
Applying the correct rate

- Fertiliser flow rate
- Tractor forward speed
- Correct bout width

Flow control mechanisms
- Gravity based with agitators and variable shutter
- Variable belt speed and adjustable shutter
- Force feed type (seed drill type) with variable speed rollers or variable area rollers
- Calibration essential

Calibration

- Without calibration!
  - Farmer with 40ha in 5 fields
  - Start with last years settings or poor ‘book’ value
  - Spread the first field at 20% more than intended
  - Adjust: 2nd field at 15% less than intended rate
  - Adjust: 3rd field at 5% more than intended
  - Adjust: Last 2 fields correct
  - Overall farm rate is correct but 40% of area well outside target rates
Calibration practice

- Manufacturers support
  - Rate charts
  - Web based material
  - Tests of Irish fertiliser
  - Test kits (sieve test and ID charts)
  - Flow testers
  - Calibration procedures
  - On-board weighing and automatic calibration

Calibration practice - 2

- Calibration
  - Flow Rate measurement
    - Time flow and weigh
    - Discs removed, or stopped + calibration kit
    - Varies with machine – easy best
  - Driving speed check (wheelslip - 20% ploughed)
  - Bout width check (GPS, measure)

Active rate control

- Constant rate with:
  - Variable forward speed
  - Variable flow rate
- Can change application rate on the go
  - Manually
  - Variable rate Precision Ag type system
- Controlled headland operation
  - Graduated shut off etc

Spreading evenly

- Machine design
  - Spreading elements:
    - discs, vanes and fertiliser delivery point
- Machine setting
  - Disc speed and type,
  - Vane type, length, number, angle
  - Fertiliser drop position
  - Hopper angle
  - Height over ground / crop
- Absence of wear on spreading components
- Fertiliser characteristics
- Weather conditions
Granule size, shape, density and strength.

Subject of research

Influences:
- Movement on disc
- Throw off from vanes
- Movement through air

Ideal:
- 80% of particles in 2-4mm range
- Rounded and smooth
- Blend components should be similar: mean particle size within 10% of mean

Move to ‘Bulk’ – deterioration in spread characteristics

Interaction between fertiliser and spreader

Evenness testing

Test hall – indoor controlled environment – 0.25m² trays – detailed basic pattern
- Standard tests (Bygholm, CEMAGREF)
- Manufacturers test halls
- CV values and shape of spread pattern
- CV: less than 15% = acceptable but some <5%

Field full testing – very little
- Poor repeatability

Field checking – 4-7 trays
- Overlapped pattern
- Poor repeatability
**Good spread pattern**

- CV = 9%
- Well shaped curve
- +20% to -12%

**Poor spread pattern**

- CV = 16%
- Poorly shaped curve
- +39% to -18%

**Field performance**

- Variations in fertiliser physical quality
- Variations in disc speed
- Angle of disc to crop:
  - Linkage movement
  - Incorrect top link
  - Ground surface variation
  - Sinkage under load / tyres
  - Bumpy ground
- Bumpy conditions: fertiliser delivery point
- Inadequate height over crop
- Incorrect component setting
- Wear in spreading components
- Weather conditions: wind

**1999 - 2000 tests**

- Test Hall tests
- Independent at Bygholm
- All major twin discs tested
- Very comprehensive
- Many Widths and Fert types
- Influenced Fert spreader development
- Little since!!!
Independent test: A 18m

TEST HALL CV: 4.4%

- Wide spread – 48m total
- Well shaped - triangular
- Likely to be more forgiving of
  - Fertiliser, Setting, Wind

Independent test: B 18m

TEST HALL CV: 6.2%

- Narrower spread – 34m total
- Poorer shape – Flat topped, shouldered
- Likely to be less forgiving of
  - Fertiliser, Setting, Wind

CV vs width: Spreaders A, B

A: Excellent CV: 6m to 24m
   ‘Forgiving’
B: Good CV: 17m to 19m
   ‘Sensitive’

Direction of discs!

- Lely, Bogballe, Bredal - towards centre
- Strong overlapping of discs
- More forgiving pattern
- Less ability to shut-off part width
- Not a guarantee of good spread!!

Cost of poor spreading

- Two factors contribute
  - Spread quality on farms – unknown
  - Cost of poor spread quality
- Some research
  - Frequently theoretical studies
  - Millar et al most recent - 2009
  - Theoretical based on winter wheat
  - Effect of problem patterns modelled
    - Impact on CV and Cost
### 5 Pattern Defects

<table>
<thead>
<tr>
<th>Problem</th>
<th>CV Range</th>
<th>Cost Range (£/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skewed side distr. (Pn)</td>
<td>6 - 21</td>
<td>1 - 14</td>
</tr>
<tr>
<td>Incorrect width (disp)</td>
<td>5 - 27</td>
<td>1 - 23</td>
</tr>
<tr>
<td>Asymmetric pattern</td>
<td>5 - 50</td>
<td>1 - 74</td>
</tr>
<tr>
<td>Quadratic spline (disp)</td>
<td>7 - 57</td>
<td>2 - 135</td>
</tr>
<tr>
<td>Twin spline (disp)</td>
<td>7 - 55</td>
<td>2 - 75</td>
</tr>
<tr>
<td>Twin spline asymmetric</td>
<td>8 - 41</td>
<td>2 - 47</td>
</tr>
</tbody>
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### CV and Wheat Loss

![Graph showing CV and Wheat Loss](graph.png)

### Likely Losses

- **Poor spreading:**
  - If visible CV=25% - 40% ?
  - Loss in WW: €22 - €55/ha
  - 5% to 10% = €2/ha

- **Focus on improving ‘field’ performance**

- **Lodging and quality**
  - Lodging - big loss potential
  - Quality - malting barley, grass

### Practical Considerations

- **Spreader choice:**
  - Even spreading: CV + robust pattern
  - Correct spec: hopper, headland equip, control systems, calibration equip.

- **Fertiliser choice:**
  - Actively look for good spread quality

- **Use Manufacturers resources:**
  - Instruction manuals - invaluable
  - Web resources re fert settings
  - Calibration and fert test equipment
  - Calibrate the spreader, tractor and feet!
  - Maintenance and check for wear

### Finally

- **Fertiliser spreading – hugely important technical task**
  - Must get it right
  - Still true of contract spreading

- **Researchers / Manufacturers**
  - Focus on field performance
Poor spread pattern