Definition Variable Depth Tillage

Variable depth tillage (VDT) refers to a tillage approach where processing depth is adapted to determined soil parameters and other estimations. The adaptation takes place site-specifically and continuously, and ideally even in real-time.

Types of soil cultivation (use of VDT)

- a. **Strip-till**: the common strip-till approach is based on the strategy of reducing the impact on soil, thus avoiding erosion, improving soil structure, and thereby improving water retention and reducing operating costs. By considering soil texture and densification, optimized soil cultivation strategies can be implemented using VDT.

- b. **Strategic tillage**: this relatively new variant based on occasional, event-specific soil treatment with a general abdication of soil processing. Again, VDT can be used to make the procedure as gentle as possible while still achieving the strategically desired effects.

Relevant observations from field studies

In recent years, an increased number of studies and field trials have been carried out to consider the variable application of seed and fertilizer (variable rate technology), whereas profound analyzes for site-specific soil treatment are still rare. In the following, we have summarized relevant arguments regarding site-specific soil tillage from literature and expert talks:
German Federal Foundation Environment Project „Supporting strip-till by developing and testing a sensor and process combination for precision soil cultivation“, 2007 - 2010, final report

- Several years of field trials showed the effect of reducing the working depth from 18 to 10 cm
  - Reduced energy consumption of 4.2 l/ha (~45%)
  - Increase of output rate by 0.5 ha/h (~20%)
  - Reduced slip (~53%)
- There is a conflict between decreasing soil coverage ratio (erosion protection) and increasing depth of soil tillage
- Factors of influence for soil tillage depth:
  - Desired residue ratio
  - Soil type: high clay content (heavy soil) usually requires shallower, a high sand fraction deeper tillage
  - Terrain (peaks, valleys): there is a tradeoff between inferior soils which should be tilled at a deeper level and a higher rate of residue desired for erosion protection on peaks
- A decrease in yield with shallow soil cultivation cannot be observed
- In case of contradictory information, tillage should be rather carried out at a deeper level

DI Dr. Gerhard Moitzi, University of Natural Resources and Life Sciences, Vienna, Lecture at the Ackerbautag II of the Winter Conference 2006 of the Austrian Eco-social Forum:

- 1/3 of the total cost of a tractor hour accrue for fuel
- The draught increases with the square of the vehicle speed. Therefore, an increase in the operating width is more efficient than an increase in speed.
- Therefore there is a conflict between calculated working time and energy efficiency. The variable depth control helps to partially compensate this.
- Depending on the type of soil one has to calculate with 0.5 - 1.5 l / ha additional consumption per cm additional working depth.

Dr. H.H. Kowalewsky, chamber of agriculture Niedersachsen, Department of Energy, Building, Technology (Article from 29th October 2009)

- 50% of the diesel consumption in agriculture is used for soil cultivation
- On loess sites it is possible to save about 0.8 l per cm working depth

Dr. Reza Alimardani, Department of Agricultural Machinery, Biosystem Engineering College, University of Tehran „Energy Savings with Variable-Depth Tillage “A precision Farming Practice”“, 2007

- Field tests were carried out in fall of 2004 at Research Center of Clemson University, South Carolina
  - 6-acre test field with three different soil types (loamy sand, sandy loam, sand)
  - Twelve treatments (two tillage systems, three levels of tractor speed, two levels of soil moisture contents)
Conclusions after finishing the randomized complete blocks with three replications in each soil type:

- Loamy sand:
  - Energy savings of 50%
  - Fuel savings of 30%
- Sandy loam:
  - Energy savings of 21%
  - Fuel savings of 8%
- Sand:
  - Energy savings of 26.1%
  - Fuel savings of 8.5%

B. Basso, L. Sartori, M. Bertocco and G. Oliviero, Dipartimento di Produzione Vegetale, Università degli Studi della Basilicata, Potenza, Italy “Evaluation of variable depth tillage: economic aspects and simulation of long term effects on soil organic matter and soil physical properties”, 2003

- Field tests were carried out on the San Basilio farm, at Ariano Polesine, near Rovigo, Italy
  - 20ha field
  - Homogeneously textured field
- Conclusions:
  - Average unit fuel consumption was lower
  - Unit cost was lower (-31%)
  (Unit cost include: 1. annual fixed costs for implement and tractor, 2. annual use of tools, 3. variable costs: repairs and maintenance, fuel, labour)
  - Bulk density decreased after tillage

Example calculation: Cost savings by using site specific cultivation

The economic viability of VDT is most clearly quantified when considering fuel savings:

<table>
<thead>
<tr>
<th>Reduction cultivation depth</th>
<th>500 ha</th>
<th>1000 ha</th>
<th>2000 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 cm</td>
<td>€ 1 875</td>
<td>€ 3 750</td>
<td>€ 7 500</td>
</tr>
<tr>
<td>10 cm</td>
<td>€ 3 750</td>
<td>€ 7 500</td>
<td>€ 15 000</td>
</tr>
<tr>
<td>15 cm</td>
<td>€ 5 625</td>
<td>€ 11 250</td>
<td>€ 22 500</td>
</tr>
</tbody>
</table>

Assumptions:
- Saving fuel (medium-heavy soil)*: 0.75 l/cm
- Diesel costs: 1€/l
- Processing cycle per year: 1

* Average of the examined studies
On average, when using VDT (with strip-till), a reduction of the working depth of 8-10 cm can be expected.

Even an average reduction of the working depth of 5 cm can result in substantial savings for large farms with 2000 ha one tillage operation a year. Even for a 500-hectare farm with two tillage circles and a significant reduction in working depth the Topsoil Mapper amortizes within 2.5 years.

In addition to these fuel savings, the tractor and the implement are better conserved, thus extending their service life. Furthermore, work rates can be increased by 25% without a raise in operating speed. The resulting economic benefits depend on the respective cost structure.

**TSM soil cultivation strategies**

Based on the studies and practical tests of recent years, three generic soil cultivation strategies have been implemented in the TSM. These can also be inverted or „over ruled“ by the user when he has additional information about the field:

**Shallow Cultivation**

Flat soil tilling for clayey soils respectively increased erosion protection due to a higher residue rate.

**Sub soiling**

Deep soil treatment on sandy soils and for breaking up deep, compacted areas.

**Depth Contour**

In this soil treatment, the breaking up of compacted soil layers shall be avoided.

Further details on the TSM strategies will be published in White Paper 7.