**Chosen Machine in Technologies of Soil Protective Tillage and Their Energy Consumption**

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**Abstract**

In frame of research of soil protective tillage was measured diesel fuel for soil loosening by chisel tiller Howard Paraplow. There was found diesel fuel specific consumption for three depths of loosening, by regressive function was expressed dependence of diesel fuel specific consumption onto loosening depth. For evaluation of the loosening quality and changes in soil in consequence of loosening there were used values of soil penetration resistance and those expressing spatial disposition of soil matter before and after loosening.

**Key words:** conservation tillage; chisel tiller loosening, energy consumption for soil tillage.

**Introduction**

For utilisation in systems of soil tillage without ploughing are determined tillers for loosening to depth 0,30 – 0,40 m, or as case may be to depth under 0,40 m, without soil taking out from deeper layers to ground surface. These tillers are used in soil protective tillage for periodical sub-ground soil loosening or for separation of compacted layers within soil profile. In the systems of soil protective tillage are prefered the tillers separating soil surface only minimal. The crop residua remain on the soil surface, it is presumed their application for soil protection against water or wind soil erosion (Sommer et al., 1990).

For diesel fuel consumption measuring and work quality assessment was chosen chisel tiller with oblique standards equipped by edge and chisels connected with adjustable wings for loosening intensity regulation (Howard Paraplow).

**Methods**

For diesel fuel consumption was used the flow meter Mannesmann Kienzle EDM 1403 with electric frequency output and pulse counter. The apparatus enables measuring of diesel fuel consumption with accuracy 0,1 litre. The methodical process of measuring was subject to this fact - choice of operational measuring with long measuring trajectories. The measuring trajectory length, time of measuring and aggregate working speed were sensed within 3-second interval by means of 12-channel one-frequency receiver GPS Garmin 35.

The measuring was carried-out in first half of November 2000. The diesel fuel consumption and soil properties changes in consequence of loosening by chisel tiller were measured under following conditions:

- plot margins after sugar-beet harvest – loamy brown soil (soil moisture in top soil 17,2 % wt), adjusted loosening depth: 0,40 – 0,45 m
- plot after shallow skimming after wheat-loamy brown soil (soil moisture in top soil 17,8 % wt), adjusted loosening depth: 0,30 – 0,35 m
  
  0,35 – 0,40 m
  
  0,40 – 0,45 m
Used aggregate: Tractor CASE 7230 (165 kW)
Chisel tiller Howard Paraplow, 5 loosening bodies (working width 2.5 m)

Before and after soil loosening was measured the penetration resistance by registration penetrometer BUSH and spatial disposition of soil matter was assessed by method of non-separated soil sampling to physical cylinders and following laboratory analysis. Cross profile of soil surface and bottom of soil tilled layer were recorded by VÚZT profilograph.

Results

Graph in fig. 1 shows values of soil penetration resistance before and after loosening of strongly compacted soil (plot margin after sugar-beet harvest).

The differences within course of soil penetration resistance in places of loosening bodies scratches and between those scratches are given by tiller Howard construction: the loosening bodies standards are oblique, in the places of scratches the soil is loosened into lower depth than between scratches (soil tilled profile bottom is shaped ridge – like – fig. 2)

![Graph showing soil penetration resistance before and after loosening](image)

**Fig. 1** Soil penetration resistance before and after loosening of plot margin by chisel tiller (plot after sugar-beet harvest)
During loosening of compacted plot margins by chisel tiller was recorded relative low consumption of diesel fuel (average 14.7 l.ha⁻¹). The cause is that during operation of tiller the big clods with unchanged inner structure have been created. Other cause is that the adjusted depth is not maintained within whole course of measuring due to tractor regulation hydraulic function – in points of high increase of tiller tractor resistance partial decreasing of loosening depth has occurred.

Other diesel fuel consumption measuring at chisel tiller operation was performed on plot where after winter wheat followed sugar-beet grown with utilisation of technology with ploughing substitution by chisel tiller. The plot after wheat harvest was skimmed by sweep tiller Horsch Phantom to depth 0.10 m. On the port of the plat was spreaded manure and then followed second skimming by sweep tiller Kverneland CLD 4.7 to depth 0.16 m. In four weeks after second skimming was realized deep loosening by chisel tiller Howard Paraplow where the diesel fuel consumption was measured at three adjustments of working depth: 0.25 – 0.30, 0.35 – 0.40 and 0.45 – 0.50 m. For dependence of diesel fuel specific consumption \(y\) on loosening depth \(x\) was chosen linear model of regressive function with high tightness of relation:

\[
y = 21.72x + 9.436
\]

\[r = 0.95\]

The deep change from 0.25 m to 0.45 m the diesel fuel consumption has increased from 14.9 l.ha⁻¹ suprisingly only to 19.2 l.ha⁻¹. Diagram in fig. 3 sufficiently describes diesel fuel consumption at different deep. For all measurements with different deep are statistically proved differences at diesel fuel specific consumption, when consumption variability increases with tillage depth.
Fig. 3  Statistical characteristics of diesel fuel consumption measuring for chisel tiller Howard Paraplow (loosening after skimming)

Graphs in fig. 4 show course of soil penetration resistance before and after loosening by chisel tiller at tiller adjustment on three different loosening depth (plot after shallow skimming after wheat). It was proved, that character of loosening is similar, loosening reaches the deepest value in places between loosening bodies scratches.

Shallow loosening
In tab. 1 are presented results of indicators determination results of soil matter spatial disposition in a part of soil profile which was influenced by chisel tiller loosening. It is evident from the table, that volume weight values and porosity in depth of 0.10 – 0.15 m before loosening have exceeded the limit values signalling negative soil compaction. In depth 0.30 – 0.35 m there values (including values of minimal air capacity) expressively exceeded critical values what implicates symptoms of significant soil compaction in sub-soil – in depth 0.30 – 0.35 m no system of soil tillage in growing technologies was applied.

Further, from table 1 is evident, that after soil loosening by Howard Paraplow tiller (adjusted depth of loosening 0.45 m) has occurred a considerable change of soil matter spatial distribution – the volume weight has decreased, total porosity has increased and soil minimal air capacity also increased, what is indicator of non-capilar pores important for exchange of soil and atmospheric air and for favourable water infiltration to soil.

Fig. 4  Soil penetration resistance before and after loosening by chisel tiller Howard Paraplow – loosening to three different depths
The presented values of soil volume weight, porosity and minimal air capacity prove considerable positive change in soil in consequence of loosening by chisel tiller. There results correspond with measured values of soil penetration resistance.

The necessary condition of deeper loosening success is appropriate soil moisture in time of loosening-soil moisture has to be in whole loosening profile bellow plasticity limit. It means, that soil is crumbled in time of loosening. At excessive soil moisture there exists a risk that soil with be liable to plastic deformations and beside requested loosening there could even occur to unfavourable soil compaction.

The requirement for favourable soil moisture was met for presented measurements.

The problems of compacted layers loosening in soil profile was subject of research mainly in the 80, s. The acquired knowledge from that time can be updated even for present time. The problem is viability of loosing process and total regeneration of soil physical properties (Bullock et al., 1985; Chaney et Swift, 1986).

Tab. 1 Indicators of soil matter spatial disposition before and after loosening by chisel tiller

<table>
<thead>
<tr>
<th>Off-take Depth (cm)</th>
<th>Depth (cm)</th>
<th>ρ_d (g.cm^-3)</th>
<th>W_obj</th>
<th>W_h</th>
<th>P (% vol.)</th>
<th>θ_MKVK (% vol.)</th>
<th>θ_MVK (% vol.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before loosening</strong></td>
<td>10 - 15</td>
<td>1,5</td>
<td>24,3</td>
<td>16,2</td>
<td>43,6</td>
<td>31,9</td>
<td>11,7</td>
</tr>
<tr>
<td></td>
<td>30 - 35</td>
<td>1,7</td>
<td>24,4</td>
<td>14,9</td>
<td>36,1</td>
<td>31,4</td>
<td>4,7</td>
</tr>
<tr>
<td><strong>After loosening by chisel tiller</strong></td>
<td>10 - 15</td>
<td>1,2</td>
<td>22,1</td>
<td>18,5</td>
<td>54,9</td>
<td>26,9</td>
<td>28,0</td>
</tr>
<tr>
<td></td>
<td>30 - 35</td>
<td>1,2</td>
<td>20,8</td>
<td>17,8</td>
<td>54,9</td>
<td>29,9</td>
<td>25,0</td>
</tr>
<tr>
<td>Indicator of compaction harmfulness (Lhotský – 2000) – loamy soil</td>
<td>above</td>
<td>1,45</td>
<td></td>
<td></td>
<td>45,0</td>
<td></td>
<td>10,0</td>
</tr>
</tbody>
</table>

| r_d - volume weight of soil after drying to constant weight | W_obj - moisture (volume %) | W_h - moisture (weight %) | P - porosity in total | θ_MKVK - maximum capilar water capacity | θ_MVK - minimum air capacity |

References