CHOOSING APPROPRIATE MACHINERY FOR REDUCED TILLAGE

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Abstract: *The paper discusses the gradual transition from conventional tillage through reduced tillage to no-tillage while creating favourable conditions for increase of organic matter. The paper suggests crop and tillage method rotation for a period of five years in order to facilitate this transition. It also reviews tests of soil physical properties which can help farmers determine how their soils are changing and what effect the change of tillage method has on them.*

Keywords: NO-TILLAGE TRANSITION, CROP ROTATION, RESIDUE RETENTION, TESTING SOIL PHYSICAL PROPERTIES

1. Увод

Reducing the number of soil treatments (tillage) is a key pillar in soil protection agriculture. Two main criteria should be observed – increasing the amount of plant residues, left on the field surface and the degree of mechanical impact on the soil. It has been proved that for effective soil conservation at least 70% of the plant residues should be left on the surface after a certain type of soil treatment [5]. What determines the degree of mechanical impact on the soil aggregate structure is the baseline state of the field, including momentum of the soil, crop rotation applied, and stage of application of soil protection measures.

Obtaining the desired effect of soil conserving activities is a process, which cannot be achieved through direct transition from layer reversal tillage to no till. The technology for conserving and/or recovering soil structure requires gradual transition to reduced tillage while at the same time the organic matter content is increased. It has been determined that soils directly subjected to no till require a long period for recovery of the active carbon, lost during the classical tillage [5]. Thus, sandy loam soil requires about three years of no till for each year of intensive tilling, in order to recover the lost levels of active carbon [10]. The organic matter, particularly carbon in soil, recovers faster that the soil structure. The more degraded the soil is, the bigger the difference.

Reducing this difference is achievable through correct application of a reduced number of soil treatments. [6]. In soil conserving agriculture, there are no singularly determined evaluation criteria for the mechanical impact on soil, but it is important for this impact to correspond to soil formation processes. [1,2,3,4,7,8,9]

In this sense, based on experience, the following types of tillage can be accepted as soil conserving:

- ➢ Creating and maintaining a permanent mulching layer on the field surface;
- ➢ Periodical (every 4 to 5 years) deep loosening, followed by surface loosening, in order to avoid the formation of plow pan and to improve soil structure;
- ➢ If necessary, layer reversal tillage can be done any time, but the right approach is to do it once every 4 to 5 years until the optimal values for continuous application of no till technologies have been achieved;
- ➢ The share of surface treatment within the sowing depth should prevail.

2. Choosing the machinery for reduced tillage

Keeping in mind the idea of reducing the number of soil treatments, from a design aspect it would be good for these machines to be of the combined type. At the same time, their performance characteristics should meet the requirements of the technology for growing the crop selected and the type of soil.

One example of machines, selected for minimum soil treatment is based on cereals crop rotation and the types of soil treatment (see Fig. 1).

The first year of crop rotation is the initial stage of implementing soil protection agriculture. The crop rotation in a given field pre-determines the type of soil treatment to be held (surface – ST; deep – StrT). The surface treatment can be held by chisel (stubble) cultivator (see Fig.2, Fig. 3 and Fig.4), and the deep treatment (StrT) – by a strip tiller (see Fig.5 and Fig.6).

Crop		Year				
		I	II	III	IV	V
Wheat		Wheat - ST	Sunflower - StrT	Barley - ST	Rapeseed - ST	Corn - StrT
Barley		Corn - StrT	Wheat - ST	Sunflower - StrT	Barley - ST	Rapeseed - ST
Rapeseed		Rapeseed - ST	Corn - StrT	Wheat - ST	Sunflower - StrT	Barley - ST
Corn		Barley - ST	Rapeseed - ST	Corn - StrT	Wheat - ST	Sunflower - StrT
Sunflower		Sunflower - StrT	Barley - ST	Rapeseed - ST	Corn - StrT	Wheat - ST
Field		ST / StrT	ST / StrT	ST / StrT	ST / StrT	ST / StrT
		Soil treatment				

Transition to no till treatments

Legend: ST- surface treatment of soil; StrT–strip tilling with in-depth introduction of mineral fertilisers

Fig. 1. *Crop rotation and tillage methods*

Taking into consideration the crop rotation given, for each of the five fields there are three surface and two deep treatments. During year one, for field one a surface treatment is conducted preferably with the chisel cultivator shown on fig. 3. During year two, this field is to be subjected to deep strip tilling for disrupting the plow, but no more than 30 cm deep. During years three and four, a surface treatment is held again. During year five, deep strip till should be done in the strips from year two with increased depth to 60 cm if needed. The other four fields are treated in the same way, but the treatments are displaced over the years, according to the crop rotation scheme applied.

With spring-loaded loosening tools, the surface soil layer (10÷12 cm) is well-loosened. The cutting section aligns the plant cover when there is high stubble and green vegetation. A considerable part of the plant vegetation (about 70%) is buried together with the scattered fertilisers.

Fig.2. *Chisel cultivator with rotor type cutting section*

With rigid loosening tools, it is possible to apply deeper tillage (up to 25 – 30 cm), but it results in a lower degree of soil crushing. Thus, combining them with heavy rollers becomes appropriate. Mixing the soil is not so intensive, so most of the plant cover and fertilisers remain on the surface.

The combined type of soil loosening tools allows introduction of fertilisers simultaneously with the tillage. With an appropriate suspension, the working tools can introduce the fertilisers where the predominant part of the root system of the crop grown is.

Fig.3. *Chisel cultivator with disk- type cutting section*

The deep soil loosening tools cause considerable deformation both in the surface and the subsoil layer, fig.3. When the field is strip tilled at 70 cm strips, about 70% of the area remains under plant residue. In combination with fertiliser introduction, the fertilisers are introduced deeply, which is favourable for crops with strong central root. The presence of appropriate pushing wheels guarantees good soil structure on the surface of the treated strip.

Fig.4. *Chisel cultivator with introduction of fertilisers*

Both individual and central dosing result in appropriate fertiliser distribution, but with the latter, the strip tiller is saved from the fertiliser mass in the fertiliser boxes.

Fig.5. *Strip tiller with individual fertiliser dosage*

To achieve better results from the types of tillage presented here, the rule of carrying out these treatments only in the conditions of the so called "mature soil" (with humidity 50÷70% of Maximum Soil Humidity) should be applied. Gradually increasing the depth of strip tilling is recommendable with compacted soils. In this way, a better structure of the soil layer is achieved and an increase of power is not needed.

Fig.6. *Strip tiller with central dosage*

Well-structured soil is a pre-requisite for favourable indexes of its physical properties (see Fig.7). To track the direction of change in the physical properties of soil, it is important to watch its bulk density, which is considered to be a crucial factor for fertility.

Fig. 8. *Handbook with guidelines for good practices in tillage*

The handbook with guidelines for good practices in tillage, shown on Fig. 8, is designed for farmers to use it directly in the field and is a practical tool for determining soil density.

The handbook contains a disk for reading the soil density and a table with recommended tilling procedures. It can be used before and/or after tilling, and it is recommended in both cases the soil to be “matured”. Reading before tillage helps to choose an appropriate way of its application, while reading after it can be used for making an irrigation schedule.

Using the handbook requires the availability of two measuring instruments: moisture meter and soil hardness meter. They can be analog or digital type, but the former is recommended for the practice (see Fig.9).

a) - digital ***b) - analog***

Fig.9. *Soil hardness meters*

Inside the Handbook are the Disk and the Table with recommended tillage (see Fig. 10). The Disk consists of rotating and stationary part. The latter is divided into semi-circles, each with 9 sectors, containing a colour scale. The rotating part has two open sectors, opposite each other, and belts, which represent soil layers.

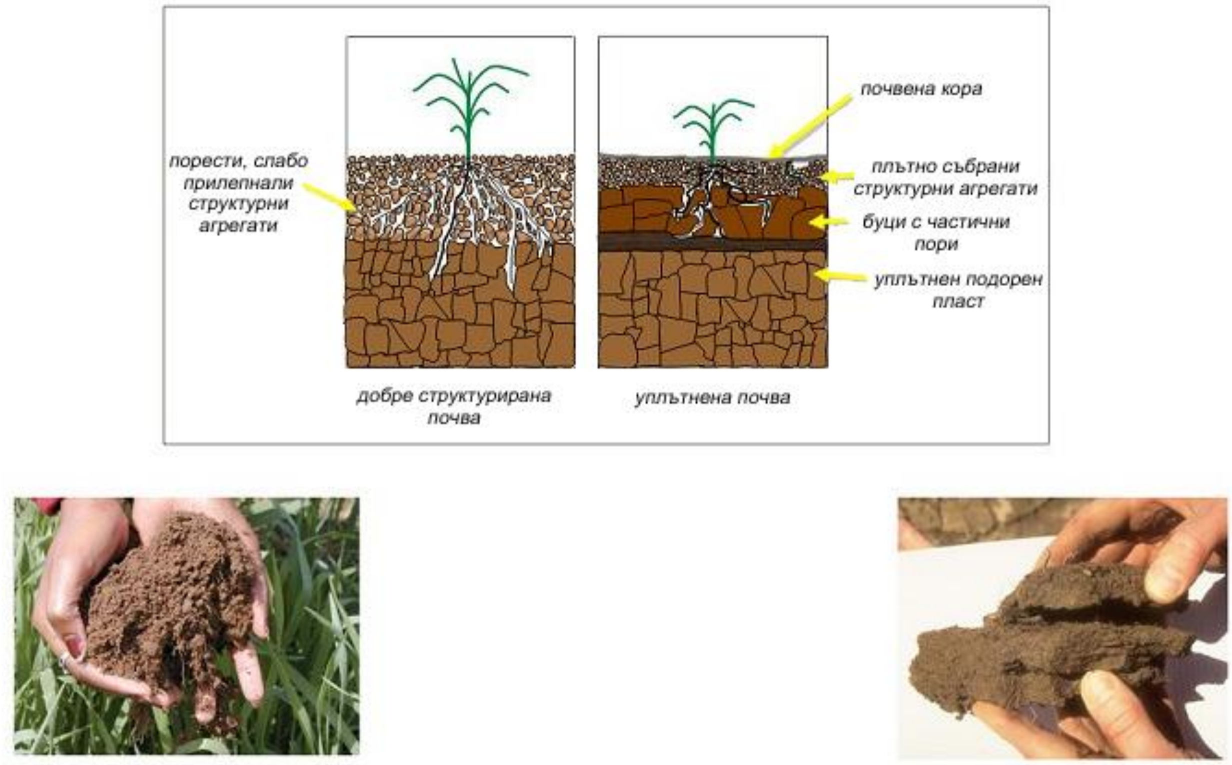
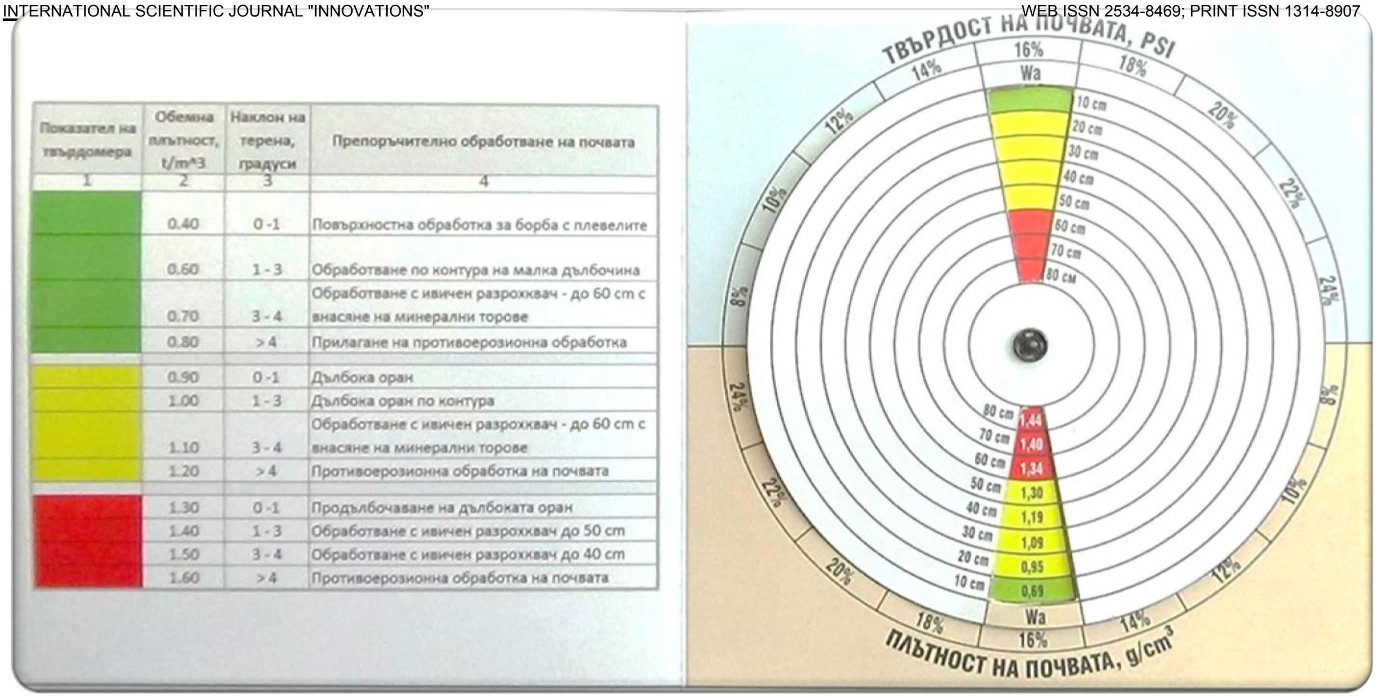


Fig. 7. *Well-structured and compacted soil*



Показател на твърдомера	Обемна плътност, t/m^3	Наклон на терена, градуси	Препоръчително обработване на почвата
1	2	3	4
	0.40	0 -1	Повърхностна обработка за борба с плевелите
	0.60	1 - 3	Обработване по контура на малка дълбочина
	0.70	3 - 4	Обработване с ивичен разрохквач - до 60 cm с внасяне на минерални торове
	0.80	> 4	Прилагане на противоерозионна обработка
	0.90	0 -1	Дълбока оран
	1.00	1 - 3	Дълбока оран по контура
	1.10	3 - 4	Обработване с ивичен разрохквач - до 60 cm с внасяне на минерални торове
	1.20	> 4	Противоерозионна обработка на почвата
	1.30	0 -1	Продълбочаване на дълбоката оран
	1.40	1 - 3	Обработване с ивичен разрохквач до 50 cm
	1.50	3 - 4	Обработване с ивичен разрохквач до 40 cm
	1.60	> 4	Противоерозионна обработка на почвата

Fig. 10. *Inside of the Handbook with instructions for good practices in tillage*

3. Working with the Handbook before tillage is in four subsequent steps.

The first step is to measure the absolute humidity of the soil, which is one of the indicators on the Disk. Using the moisture meter (see Fig. 11), the reading is done directly in the field and the value obtained is used when adjusting the Disk for work.

Fig. 11. *Analog soil moisture meter*

The second step is related to measuring the soil hardness in depth. With the instruments presented, a depth of up to 80- cm can be reached. The analog hardness meter has colour scale, divided into three sectors – green, yellow and red (see Fig.12). The scale in the upper part of the Disk where the soil hardness is shown as another indicator, has the same colours. The interpretation of the scale readings is as follows: green sector – good condition of soil density; yellow – satisfactory; red – poor

Fig. 12. *Soil hardness meter scales*

During the third step, soil compaction is measured. First, the Disk indicators should be set according to the data from the instruments. The adjustment is done in the upper part of the Disk, related to the soil hardness.

There is a blue indicator of absolute soil humidity on the outer belt of the rotating part, which should stand against the sector, showing the humidity measured by the moisture meter. In this way, the colour scale for soil hardness is open, where the colour indication from the soil hardness meter at the respective depth of its penetration (see Fig.13). Thus, from the scale in the lower semi-circular part of the Disk, we read the soil density at the specific depth of penetration. Here, besides the colour indication, the scale shows a numerical one, with the colours interpreted in the same way as in the upper scale and the numbers seen are the mean value of soil density in the specific layer.

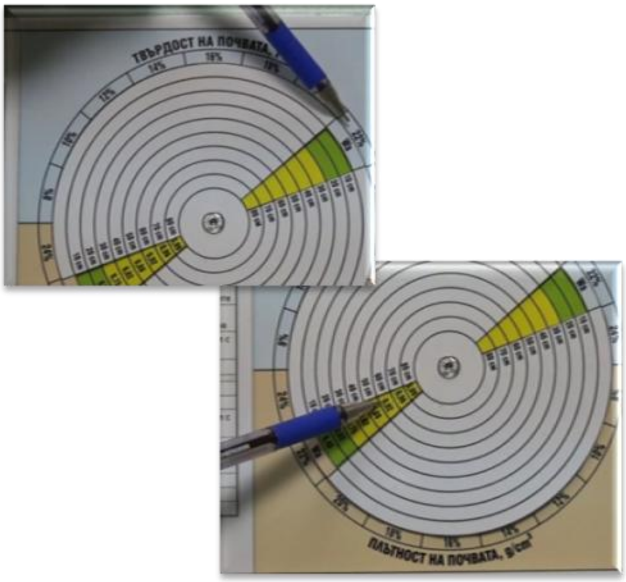


Fig 13. *Disk indicators*

Based on the result obtained, recommendations are offered for the most appropriate mode of tillage. The treatments suggested are also in line with the terrain. Thus, the choice of machinery is in compliance both with the physical properties of the soil and with its erosion resistance.

4. Conclusion

The choice of machinery is correct if the soil treatment performed by it corresponds simultaneously to the physical soil properties, the needs of the crops and the soil conservation procedures planned. Reducing the number of treatments allows the degraded soils not only to accumulate active carbon, but also to improve their structure. For heavily degraded soils, this type of treatment should continue until the soil is ready for no till treatment. Thus, a smooth transition from classical to no till mode of treatment is achieved, which generally characterises the soil conserving agriculture.

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