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RESEARCH OF SOIL HARDNESS DURING MECHANIZED PLANTING OF VEGETABLE SEEDLINGS UNDER POLYETHYLENE FILM MULCH

Akhmetkanova Gulnar,
Bolashak International Scholarship Research Intern
Vytautas Magnus University, Kaunas, Lithuania

Introduction

Hardness is the resistance of the soil to penetration by a body (metal plunger) of a certain shape. This instrument is called a hardness tester. Hardness tester, as we will show further, under certain conditions can be used in rationing soil tillage operations. Abroad (most of all in the USA), they calculate a similar index called the conic index [1].

The lowest hardness is in the upper layers of ploughed soils. Usually in the seed layer (0-10 cm) hardness rarely exceeds 5-10 kgf/cm^2. In case of ploughing through layers with coarser structure or higher density the hardness values increase slightly. Deeper, depending on the time after the last deep treatment, hardness maintains constant values or gradually increases in the range of 10-20 kg/cm^2. The greatest rise corresponds to the transition from the plow to subsoil layers, where the plow sole is located. Here hardness may increase up to 30-40 kgf/cm^2 and higher. Deeper the hardness decreases a little and then remains constant. The higher is its content, the higher is the hardness. This peculiarity of hardness was pointed out by P.V. Gorokhov (1990) [2].

A large variety of soils in the performance of mechanized works and considerable variability of their specific resistance makes it difficult to obtain such data, and at the same time, the solution of many issues where this indicator is extremely necessary. This is the design of tillage implements, and justification of the optimal mode of their operation, and rationing of labor productivity in the performance of technological operations.

Soil hardness during mechanized cultivation is an important indicator to justify the main parameters of the working body of tillage machines. At mechanized planting of seedlings under the mulch film the working body is a hole-forming tool of the planting machine. To determine the hardness of the soil in this case, a plunger conical tip is used.

Factors affecting soil hardness

So, hardness is a measure of the mechanical permeability of soils. Two groups of factors can be established at a glance on which soil hardness depends. These are the design features of the rams and the soil factors themselves, which determine the resistance ability of soils. Usually when examining ploughed soil, it is assumed that its resistance is low. Therefore the working surface (form) of the plunger is chosen predominantly flat. But already at determination of resistance of deeper horizons of the profile the flat plunger is not suitable and it should be replaced by a wedge or a cone. At the same time it is necessary to take into account precisely the area of contact of the cone with the soil at its immersion into the soil. If a large set of interchangeable plungers is used, and all of them are provided with appropriate parameters (angle of attack, contact area, friction force soil-steel and others), then manipulating plungers in the process of research allows obtaining numerous strength characteristics of soil:

- Carrying capacity (the onset of soil failure when a flat plunger is used, or, if a macroaggregate is taken as an object, its structural cohesion);
- relative density (the force of squeezing the soil before the beginning of its destruction);
- lateral shear (the force of cutting the soil with a cone or wedge);
-dimensions of plastic and nonplastic soil compression zone in the plunger-soil contact zone.

Such research allows us to develop a theory of soil strength formation, dynamics, and destruction. Unfortunately, in soil science, these measurements are not widespread, although they would certainly provide new information for the interpretation of root growth and the work of tillage implements depending on the soil strength characteristics. Yes, and for interpreting the process of soil degradation by atmospheric precipitation. After all, the mechanisms of these seemingly so different processes are actually similar - we are talking about overcoming soil resistance and formation of either a new body, when the soil is irreversibly destroyed, or a soft plastic version, when the soil is only modified.

At the same time we emphasize: Hardness studies with a variety of plungers shed light on the processes of physical soil degradation and its causes and contribute to the formulation of requirements for influences that would not lead to irreversible deformation. Conical plungers must also be differentiated if the hardness results obtained are to be used to interpret data on root growth or on the performance of tillage implements. After all, the resistance parameters in both cases are significantly different.

Materials and methods

Penetrometers are used to measure the hardness of soils - devices designed to introduce metal bodies (plungers) of a certain shape into the soil with minimal disturbance of soil structure. Penetrometers can be dynamic and static. In the first of them the plunger is introduced into the soil by impact or falling weight (mass). Static penetrometers introduce the plunger into the soil slowly and gradually, avoiding the dynamic effect.

In foreign practice there is also a large number of hardness meters (penetrometers) of various designs, especially in those countries where research of physical and mechanical properties of soils is quite popular (USA, UK Germany, Japan). In the USA, as it has been already mentioned, mainly conic tip is used, the parameters of which (angle of attack and cross-sectional area) are standardized. It is believed that standardization makes it possible to compare hardness data obtained on different objects and by different authors. According to P.V. Gorokhov (1990), the most perfect hardness tester was proposed by J.-F. Billot et al. (1977). A strain-gauge is used in it as a recording element, and plunger immersion into the soil is carried out with the help of a guide, which increases the accuracy of measurements [4,5].

A large number of penetrometers (Kirice, Kunze, Florescu-Selinger, Getke, Borisha, and others) were also used in the research practice of Eastern European countries. Their distinctive feature was the use of not only flat and wedge-shaped plungers, but also many other forms. This extended the possibilities of investigating various types of soil resistances. In our practice, we used a hardness tester of Yu.Y. Revyakin having a flat plunger with a working surface of 1 cm2. Other forms of plungers were also used in special model experiments. Under field conditions, plunger depth in the soil reached 30-40 cm, covering arable and top part of subsoil layer, including plough bed. The plunger was dipped into the soil slowly, without jerks, with a uniform force. Number of repetitions - not less than 10 with their even placement on the elementary plot. Moisture at the depths of 0-5, 15-20, 30-40 cm was determined in at least 3 times repetition. Millimeter paper for placing in recorders was prepared in advance. There were as many blanks as it was supposed to perform dips of the hardness tester during the working day. The final result of the determinations was a profile (1-D - one-dimensional) hardness diagram with a continuous distribution of hardness in depth. The raw data was taken from millimeter paper and then converted to kg according to the pre-calibration. 1mm on millimeter paper corresponded to 1 kgf/cm2 of hardness. 2-D and 3-D (2-dimensional and 3-dimensional, respectively) charts were also widely used. They are obtained in the case of hardness measurements in the field by laying a regular network of points and then processing the data using geostatistical tools. Examples of such diagrams will be demonstrated later in the book. The hardness tester is supplied with several springs with wire diameters of 3, 4 and 5 cm. Depending on the range of soil hardness parameters, 1-2 springs were used in the work [6].

Research results

After processing the diagrams drawn by the hardness tester during determination of soil hardness, the following pictures were obtained in the form of graphs describing soil hardness by depth of tillage field. Figure 1 shows a graph of soil hardness of the field by depth of the tilled layer. Usually after the passage of the machine the hardness of the soil along its width changes due to compaction by the mechanisms of the machine. Since the machine mechanisms exert different pressures on the soil depending on their purpose.

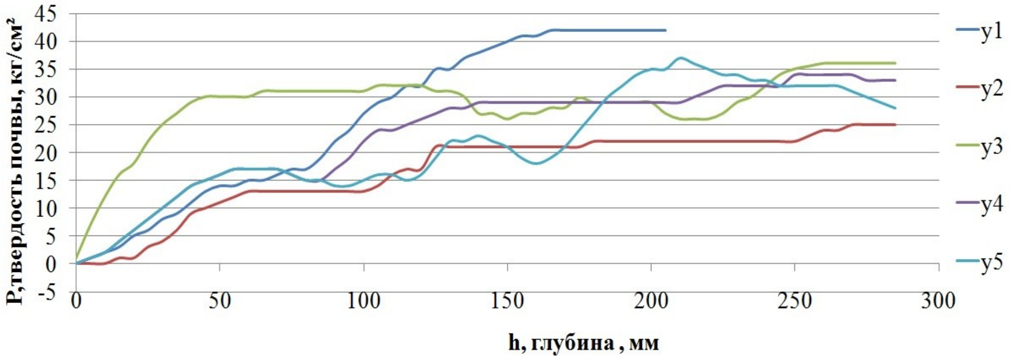

Figure 2 Graphical dependencies obtained with the help of the hardness teste

Conclusions

Thus, according to the hardness requirements on the depth of cultivation for vegetable crops like tomato, eggplant and pepper moisture should be up to 12 cm, as the depth of the roots is located at this depth. For normal crop development, moisture is well held at depths up to 18 cm, this is observed in curves 2, 4 and 5. In this study we used the field after planting an experimental unit for planting seedlings of vegetable crops, developed at the Department of Machine Use and Vocational Training. Soil compaction after the passage of the aggregate does not affect the moisture-absorbing indicators of the soil.

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