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MANAGEMENT OF SOIL QUALITY FROM ORCHARDS

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Abstract

Soil cover quality of the Republic of Moldova on most agricultural land is unsatisfactory and critical on a part of land. Anthropogenic factors of soil cover degradation are maximum involvement of land in agriculture and soil compaction by heavy machinery that lead to degradation of soil structure. It is very important to study and manage these factors when soils are mechanically worked and negative consequences occur. Human intervention changes natural variability of soil characteristics both vertically and horizontally. Maximum involvement of land in traditional agriculture (especially for fruit-tree growing) led to humus losses, structure degradation, compaction and soil erosion. It is necessary to study deep tilled soils, which forma group of anthropogenic soils, in order to determine the influence of heavy machinery on changes in physical properties of soils in orchards. At the very beginning deep plowing decreases parameters of bulk density with 9-32%, but from the first year of existence of orchards a series of maintenance operations are made, heavy machinery pass, on average, on the same tracks up to 10-15 times annually. That results in soil compaction between rows especially on machinery tracks. Bulk density is differentiated both vertically and horizontally, having extreme values of 1.59 to 1.60 g/cm^3 in 10-30 cm layer on machinery tracks and is characterized as strongly compacted. Deep tilled soils being used in orchards suffer significant changes and form a new anthropic soil profile as a result of compaction process, a quantitative expression of which is bulk density and degree of compaction.
The purpose of the present research is to highlight soils' physical properties and soil processes that directly and indirectly influence plant life, forming a functional unit called soil ecological complex; assessment of soil quality and its importance for agroecosystems; emphasizing of negative changes in physical quality of the soil and the factors influencing these changes.

Key words*: bulk density, deep plowing, porosity, permeability, soil structure.*

INTRODUCTION

Soil fertility is an objective attribute of the soil, but in the economic aspect it always depends on the proper use of scientific and mechanization achievements influencing each other and being in constant transformation. One of the research directions of modern soil science are the processes that occur in soil. The importance of this issue is to know the methods of control of soil processes to create optimal conditions for plant growth and development preserve and increase soil fertility, protection from negative technological processes (compaction, structure degradation, etc.) (Ursu, 1998). It is necessary to study and control these factors, when soils are mechanically worked negative consequences can usually occur. Human intervention during agricultural production changes the natural variability of soil characteristics both vertically and horizontally. The main anthropogenic factors leading to degradation of soil cover are maximum involvement of land in traditional agriculture (especially fruit growing), humus loss leading to degradation of structure, compaction and erosion.

At present it is necessary to study the deep plowed soils that form a group of anthropogenic soils (Degradarea solurilor…, 2002) in order to determine the influence of heavy machinery on physical properties of soils from orchards. It is known that the growth and development of trees require a number of factors including soil physical characteristics that have great significance. Soil preparation for planting an orchard contains several stages: land leveling, deep plowing, introducing of fertilizers etc. Morphologic profile after deep plowing differs from the natural soil profile, soil is loosened for more than 20 cm depth, there is a mixture of genetic horizons to a depth of 50-60 cm. Deep tillage depth depends on soil type, subtype and degree of erosion. After these

works soil morphology is modified; genetic sequence of horizons changes. On the surface are exposed underlying horizons that have a smaller amount of humus and unstable structure. From the first year of orchards existence soil is subjected to heavy machinery stress: it is worked mechanically between rows, fertilizers are incorporated and chemical struggle to combat pests begin. The result of this is soil compaction between the rows.

The present research was conducted on the main soil types in Moldova used in orchards: greyzems, chernozems, alluvial soils. The aim was to determine changes in the physical properties of deep plowed soils from orchards under the influence of agricultural machinery. The research aims to highlight the physical properties of soils and soil processes that directly and indirectly affect plants life, forming a functional unit called soil ecologic complex; assessment of soil quality and its importance for agroecosystems; emphasizing negative changes in physical quality of the soil and the factors influencing these changes.

MATERIALS AND METHODS

To characterize soil compaction of deep ploughed soils from orchards as a phenomenon of anthropogenic origin that affects 0-30 cm layer and the underlying layer expressed by increase of bulk density, structure degradation and porosity decrease below the normal limits, a number of physical tests was used such as particle size analysis, soil structure analysis, porosity, in the field were determined on soil from the row, between the rows and in the machinery tracks - bulk density and soil permeability. The used research methods were standardized. Interpretation of analytical data was performed according to the current methodology. Research lasted 10 years, during that samples were collected from all types of soils in Moldova used in orchards.

RESULTS AND DISCUSSIONS

The research conducted by Ungureanu (1979) showed that in the deep tilled layer (0-60 cm) soil bulk density decreases with 9-32%, resistance to penetration by 60-79%, total porosity increases by 5-28% and between aggregates by 13-61% compared to soil before deep tillage. But from the first year of existence of orchards a series of maintenance operations are made, heavy machinery pass, on average, on the same tracks up to 10-15 times annually. Soil physical state is determined, in general, by bulk density, that substantially influences the growth and development of fruit crops, whereas on its values depend soil air and moisture regimes and various chemical and microbiological processes. It should be noted that most of the soil works aims to lower bulk density values.

The bulk density of the studied soils from orchards is differentiated both vertically and horizontally. There is an increase in bulk density between the rows, especially in the machinery tracks in comparison with the soil from rows, usually at the depth of 10-30 cm. On greyzems these parameters increased by 0.27-0.31 g/cm^3 in the machinery tracks in comparison with the soil from rows, on chernozems by 0.18-0.31 g/cm^3, and on alluvial soil by 0.25-0.33 g/cm^3. An increase of soil bulk density is characteristic for soil between the rows in comparison with the values in the row but they don't exceed 0.23 g/cm^3 (Table 1).

Table 1. Soil bulk density from orchards

Soil bulk density, g/cm^3				
Soil	Depth, cm	In the row	Between the rows	In the machinery tracks
clay loam greyzems	0-10	1.25	1.31	1.58
	10-20	1.28	1.35	1.59
	20-30	1.30	1.42	1.57
clay loam leached chernozem	0-10	1.00	1.09	1.20
	10-20	1.18	1.36	1.44
	20-30	1.24	1.37	1.48
clay loam typical chernozem with moderate humus content	0-10	1.19	1.31	1.41
	10-20	1.27	1.50	1.58
	20-30	1.30	1.41	1.50
clay loam typical chernozem with low humus content	0-10	1.10	1.28	1.41
	10-20	1.20	1.30	1.47
	20-30	1.27	1.38	1.45
clay loam carbonate chernozem	0-10	1.00	1.11	1.30
	10-20	1.16	1.30	1.47
	20-30	1.26	1.38	1.53
loam typical alluvial soil	0-10	1.16	1.27	1.40
	10-20	1.25	1.45	1.51
	20-30	1.26	1.42	1.59
stratified alluvial soil	0-10	1.32	1.47	1.63
	10-20	1.42	1.57	1.68
	20-30	1.47	1.66	1.72

Soil structure is an inherent characteristic of the soil, of great importance for physical, chemical and biological processes that take place in the soil and the system: soil - plant – atmosphere

(Canarache A., 1990; Унгуряну В., 1979). A well-structured soil provides optimal conditions for growth and fructification of trees. Soils of orchards, being transformed technogenic, are worked from the first year (Cercetări în pomicultură, 2002). Special attention is given to the degradation of soil structure used in perennial crops, where powerful modern mechanized farming leads to soil compaction. It is known that the upper layer of the soil presents a mass divided by structural elements, size of which have a direct influence of aeration, water and temperature regimes. All these affect the root growth.

The results of research showed that content of aggregates >10 mm suffers significant changes in orchards, increasing by 10% between rows and up to 25% in the machinery tracks compared to the soil from rows, showing a trend of blocky structure formation between the rows (Table 2).

Table 2. Water stable aggregates content with a diameter less than 0.25 mm of soil in orchards (%)

Soil	Depth, cm	In the row	Between the rows	In the machinery tracks
clay loam greyzems	0-10	64.20	52.30	48.90
	10-20	61.50	58.50	46.80
	20-30	75.50	66.20	60.80
clay loam leached chernozem	0-10	46.70	39.70	31.20
	10-20	49.30	43.40	39.00
	20-30	48.20	42.50	40.50
clay loam typical chernozem with moderate humus content	0-10	49.20	36.50	23.30
	10-20	50.40	34.00	31.50
	20-30	49.50	31.90	29.30
clay loam typical chernozem with low humus content	0-10	53.80	46.10	25.20
	10-20	53.40	46.40	23.00
	20-30	52.30	51.80	29.30
clay loam carbonate chernozem	0-10	50.40	45.00	39.50
	10-20	49.90	39.20	35.60
	20-30	43.40	35.50	33.30
loam typical alluvial soil	0-10	52.80	48.20	40.40
	10-20	52.10	50.20	39.50
	20-30	50.20	49.00	37.30
stratified alluvial soil	0-10	41.60	35.70	22.90
	10-20	40.10	35.80	22.80
	20-30	42.70	27.10	23.90

Thereafter the content of mezoaggregates (10-0.25 mm), that are considered valuable agronomic and presents structural aggregates of medium size, porous and stable to water action, is changed. If in the soil from rows they make up 70-80%, which is characteristic for investigated soil types and subtypes, then between the rows their amount is reduced by 20% and significantly in the machinery tracks up to 20-30% depending on soil type. A parameter that characterizes stability of soil structure is their hidrostability. The use of soils for perennial plants growing and the works done before planting and orchards maintenance, led to the degradation of soil structure. Aggregates hidrostability of >0.25 mm size proved that the 0-30 cm layer undergoes changes in orchards. These changes are essential for all soil types. In general, the arable layer of all investigated soils is characterized by satisfactory structure between the rows and in the machinery tracks.

Porosity influences water retention capacity, permeability, aeration of soils. In moderately loose soil properties of total porosity components are favorable, ensuring good conditions for plants available water retention, aeration and rapid movement of excess water. At compacted soils, except those with coarse texture, ratio of total porosity components is often less favorable. Total pore volume and bulk density are inversely related: the higher is bulk density, the lower is total pore volume. When aggregates compaction is high, porosity is low (30-40%), pores have small diameter and are hard to penetrate for water and microorganisms. Such structure of the soil is considered unfavorable. Porosity less than 50% is assessed as unsatisfactory, and 25-40% too low and is characteristic for high compacted layers.

In orchards in arable layer and at 20-30 cm there is a differentiation of total porosity parameters as bulk density increases. Soil in the 20-30 cm layer in the rows has medium porosity (47-51%) and is characterized as low compacted, the soil between the rows is characterized by a small and medium porosity (42-51%) and is low and moderately compacted, total porosity values of the soil in the machinery tracks are 36-40% and is characterized as moderately and highly compacted. With all these changes in the bulk density and total porosity of the soil in orchards, porosity of soil aggregates does not undergo significant changes in depth. From agronomic point of view it is important for soil to have a higher capillary porosity that characterizes water retention capacity of the soil. Soil compaction between the rows and in the machinery traces leads to lower noncapillary porosity. In all studied soils soil

porosity between aggregates in the layer 0-30 cm is by 4-9% lower between the rows in comparison with porosity in the row and the highest values are revealed in the machinery tracks.

Conditions of plant growth and development are influenced directly or indirectly by aerohidric regime. Air can only occupy the soil pores that are not filled with water. Water and air content are strictly necessary as the root system and soil processes. One of the categories of pores which determines, or rather ensure the development of the root system, the existence of fauna and flora of soil is aeration porosity. The optimum for plant growth is 15-25%, while the development of the root system is limited at a content of 10%. Soil tillage in orchards leads to obvious changes in aeration porosity. If the soil from the rows has aeration porosity parameters 26-38%, between the rows 16-30%, then in the machinery tracks in some soils (greyzems and calcareous chernozem) it reaches critical values - less than 10%.

Water permeability of soil determines the water from rainfall or irrigation to penetrate the soil, its distribution in the soil, it depends on the soil particle size, soil structure, bulk density, porosity and soil moisture. The conducted research demonstrates that soil water permeability from orchards differ as a result of the increase of bulk density, total porosity reduction and degradation of structure: in the rows it is characterized as good and very good, between the rows as good and in the machinery tracks as satisfactory.

Research conducted on greyzems, chernozems and alluvial soil used in orchards established secondary soil compaction of anthropogenic origin as a phenomenon affecting 0-30 cm layer and the underlying deep tilled expressed by bulk density increase and porosity decrease below the limits that presents one of the main forms of physical degradation of soil.

CONCLUSIONS

Deep tillage and maintenance works are the factors that determine the physical heterogeneity of soil from orchards.

Bulk density is increased in orchards reaching extreme values of 1.58 to 1.72 g/cm³.

The soil from orchards is structured differently: in the machinery tracks aggregate content >10 mm is 1.5-2 times higher compared to the soil in the rows, having high or extreme content of blocky elements.

The hidrostability of the agronomic valuable aggregates (10-0.25 mm) decreases, which motivates the degradation of the structure of orchards.

Total porosity of the soil is “high” in the rows, “small” between the rows and “very small” in the machinery tracks.

The soil in the rows is characterized by “good” and “very good” water permeability, “good” between the rows and “satisfactory” and “unsatisfactory” in the machinery track.

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