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AMPLIFICATION OF COMPACTION AND SALINIZATION OF POLYTUNNELS SOILS WITH COARSE TEXTURE AFTER MULCHING WITH PLASTIC FOIL

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Abstract

In Romania, the surfaces of solariums are extended significant in the last period due to high quality of polythene film used to cover greenhouses and due to improving of plants growing technology such as using the best varieties, plastic mulch and drip irrigation. Our studies performed includes determination of the main morphological parameters, penetration resistance, soil sampling in the field and soil analysis (soluble salts, bulk density, size particles, pH, calcium carbonate) in the laboratory. Following the investigations, it was found that mulching with black plastic foil on the entire surface favors soil compaction and local accumulation of soluble salts especially in the marginal area of the wetting front resulting from drip irrigation. The accumulation of soluble salts was also noticed in the superficial layer of soil on the interval between rows of plants. Wetting of the soils with coarse texture on the intervals between the rows of plants took place following the evaporation, diffusion and condensation of water vapor in the space between the foil and the soil surface. Strong soil compaction and salinization allows us to recommend avoiding plastic mulch over the entire soil surface.

Key words: *plastic foil, coarse texture, penetration resistance, compaction, salinization.*

INTRODUCTION

High tunnels have become a popular and profitable method to produce high-value crops. They are simple, tall, plastic-covered structures used for the production of fruits and vegetables, cut flowers, and many other crops. They resemble greenhouses but cost less to erect and operate (William & Lamont, 2009).

Growing vegetables in plastic tunnels has greatly expanded in Romania due to the significant advantages compare with greenhouses covered with glass. In temperate zones some of glass used to cover greenhouses breaks in cold season (due to strong frost) and in the warm season under influence of hail.

The main criterion considered by farmers in order to choose the location for plastic tunnels is the existence of a good quality water source to meet the requirements of plants grown throughout the growing season during the year.

The location of plastic tunnels near the market in order to diminish the transport costs is another main criterion.

Due to the compulsory location imposed by the above conditions, many plastic tunnels are placed on soils considered with a low capability but then through the application of land improvement works satisfactory results have obtained (Canarache, 1995).

The soils of first capability class for plastic tunnels location must have a loamy sand texture (clay- 12-20%) without coarse rock fragments or artefacts (i), large reserve of humus, calcium carbonate content less than 4%, good water and air permeability, good lateral drainage of groundwater, slightly acidic or neutral or slightly alkaline reaction, small content of soluble salts and exchangeable sodium (Florea et al., 1997; Canarache, 1973).

The high soil moisture in plastic tunnels, high values of temperature during the year favors the activity of microorganisms in the organic matter decaying. After this process result high quantities of CO_2. The absence of air currents which assure the change of soil air lead to the necessity of soil air porosity value higher than 10% (v/v), value of which represents the minimum limit of air content for field soils (Filipov et al., 2002).

Interest concerning to processes of plastic tunnels soil degradation developed nowadays, mainly due intensive agriculture management system on lower quality soils and increasing in technological inputs. Various soil degradation processes are considered among them salinization, sodization, crusting, compaction, (Canarache, 1991; Maianu, 1974, Filipov et al., 2004; Filipov & Topa, 2020).

The accumulation of a high content of soluble salts (after the mineralization of the organic material or after irrigation with water containing soluble salts) also restricts the plants growth due to direct ion toxicities (e.g. sodium, chloride, boron, etc.), ionic imbalance of the plants and decreasing of the water availability (physiological drought). The plant growths rate is influenced by the effect of salts on leaf area per plant, on leaf thickness, on daily increment in thickness and area of primary leaves, on the changes in the amount of vascular tissue into stem and other effects (Maianu, 1974; Borlan & Hera, 1984).

Soil with coarse texture (clay <12%) are known under the name of Psamosol (Florea & Munteanu, 2012) and belong to loamy texture class or coarser. These soils have low water-holding capacities, high water permeability, excessive aeration, low content of all essential nutrients, low buffer capacity and are still much less fertile than most soils in the regions they are located in. The sandy or loamy sand soil Are susceptible to physical degradation by wind erosion and compaction processes. Soil vulnerability to compaction increase if the fine sand/coarse sand ratio is lower than 10.

Following compaction, the permeability of coarsely textured soils decreases and the accumulation of soluble salts is amplified.

MATERIALS AND METHODS

The study site was located at poly-tunnels Pahnesti, located in the northwestern part of the Husi Depression and at the eastern edge of the Central Moldavian Plateau.

Average altitude of Pahnesti is 132 m. The village is drained by Pahnesti river with an intermittent discharge.

Some soil profiles were made inside of studied plastic tunnels. These profiles were morphologically described according to the Methodology of soil survey elaborated by the Research Institute for Soil Science and Agrochemistry, Bucharest [12].

After morphological soil description in the field, undisturbed samples from 10 to 10 cm were collected down to, the depth of 50 cm. The bulk density was determined in the laboratory (Figure 1).

Fgure 1. Sampling of soil in stainless steel cylinders to assess the state of soil compactness - three replicates

In the field, also was determined the penetration resistance (Figure 2) of the soils by using a digital penetrologger (Eijkelkamp Equipment, Model 0615-01 Eijkelkamp, Giesbeek, The Netherlands) which had a cone angle of 30° and a base area of 1 cm2.

Figure 2 Determination of penetration resistance in Pahnesti plastic tunnel

It was carefully inserted into the soil profiles in 1 cm increments from the surface to a depth of 80 cm. Ten parallel records were made in each plot and averaged for analysis.

Disturbed samples from the soil profiles were also taken. In the laboratory conduct size particles analyses, pH, bulk density, content of water-according to the current methodology (Dumitru et al., 2009; Lăcătușu et al., 2017).

The period of our investigations of polytunnels soils with coarse texture from Husi Depression was 2019-2020.

Following the processing and analysis of the data obtained in the field and laboratory, several reclamation measures have been recommended.

RESULTS AND DISCUSSIONS

After Romanian System of Soil Taxonomy (Florea & Munteanu, 2012) the studied soil have been diagnosed as Hipohortic Salinic Gleic Aluviosols (Figure 3A).

The studied soil has a coarse texture.

Following studies of the soil profiles, the presence of the plough pan (Figure 3A) was noticed, which we consider to be the cumulative effect of agricultural technologies practiced until and after the establishment of plastic tunnels.

The higher frequency of the roots on the faces of the structural elements within the plough pan is obvious (Figure 3B).

In the lower part of the profile there is the presence of a compact lithological layer with obvious reductomorphic characteristics due to the groundwater infiltration from the Pahnesti river (Figure 4).

Hipohortic Salinic Gleic Aluviosols has an uneven texture, the loamy sand horizons alternate with those with sandy loam layer (Tabele 1).

Figure 3. A- Soil profile of Hipohortic Salinic Gleic Aluviosols; B- Preferential distribution of roots on the faces of structural elements within the plough pan layer

Figure 4. Details with reductomorphic features on the lower part of soil profile

Table 1. Present moisture content, texture and state of soil compactness

Depth cm	Wg %	BD g cm^{-3}	Wv %v/v	Texture	State of compactness
0-10	17.3	1.1	19.03	loamy sand	very loose
10-20	21.8	1.15	25.07	loamy sand	very loose
20-30	19.9	1.33	26.47	loamy sand	loose
30-40	19.5	1.55	30.22	loamy sand	slight compacted
40-50	18.8	1.52	28.57	sandy loam	slight compacted
50-60	18.5	1.61	29.79	loamy sand	slight-mod. compacted

BD - bulk density; Wg- gravimetric water content; Wv -volumetric water content

The higher value of bulk density of 1.61 g/cm^3 is recorded in the lower part of the soil profile. The slight to moderate compaction of this soil layer is due to the previous alluvial processes and not to the current pedoenetic processes.

The lowest value of soil density of 1.1 g/cm^3 is in the hortic horizon (Aho) and is due to the high content of organic matter.

It is noted that the highest value (30.22%v/v) of the gravimetric water content corresponds to the plough pan horizon.

Higher compactness state of plough pan favours water stagnation.

The slight compaction of the soil is also highlighted by the higher values (1.8÷2.0 MPa) of the penetration resistance recorded in the plough pan (Figure 2).

The more intense compaction of the under ploughed horizon favours the accumulation of a larger quantity of soluble salts in the ploughed horizon (Figure 6).

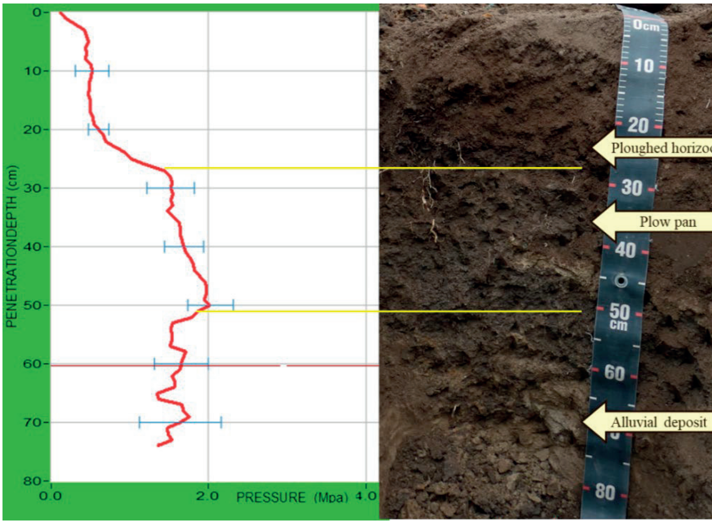

Figure 5. The presence of the ploughpan highlighted by penetration resistance value on the hipohortic stagnic salinic Aluviosol

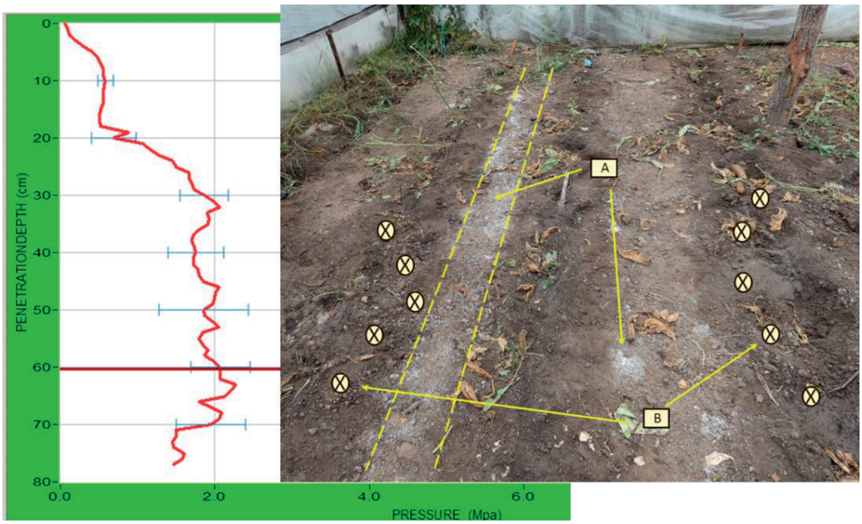

Figure 6. The more intense compaction of the under ploughed layer determines the extension of the wetting strips and the accumulation of soluble salts (A-10 replicates of penetration resistance determination; B- accumulation of soluble salts; The 10 repetitions of determining the resistance to penetration)

The soil contains calcium carbonate in all pedogenetic horizons. Calcium carbonate gives the soil a slightly alkaline reaction with pH values between 7.65 and 8.47 (Table 2).
The high humus content in the plough layer is due to the application of high doses of organic fertilizers represented by old manure.
High contents of organic matter (5.21%) and P_2O_5 (>250ppm) are defining hortic horizon.
Hipohortic stagnic salinic Aluviosol it is well supplied with nitrogen, phosphorus and potassium.

Table 2. Some chemical characteristics of hipohortic stagnic salinic Aluviosol

Depth cm	Soil horiz.	pH	$CaCO_3$ %	OC %	Nt %	P_2O_5 ppm
0-20	Apsc	7.7	2.7	3.1	0.32	431
20-35	Atp sc	8.1	7.0	0.87	0.08	82
50-60	AC sc	8.2	7.1	0.77	0.07	56
60-100	AGosc	8.5	8.6	-	-	-

Soil horizon- simbols of soil horizons; OC – Organic Carbon; Nt-total Nitrogen; ppm mg/kg.

The main limiting factor of the studied soil fertility is the high content of soluble salts. The maximum accumulation of soluble salts of 752 g/100g is recorded in the upper part of the soil (Table 3).

Table 3. Content of anions and soluble salts (ss) of hipohortic stagnic salinic Aluviosol (mg/100g soil)

Depth cm	Cl^-	SO_4^{--}	HCO_3^-	meCl^-/meSO_4^{--}	ss
0-20	178	279	59.8	0.86	752
20-35	184	86	47.8	2.89	464
50-60	134	40	35.9	3.2	306
60-100	48	10	23.7	6.75	11

We consider that the salts from the hortic horizon come from the waters used for irrigation, the decomposition of the organic matter and from the phreatic water coming from the lateral infiltrations from Pahnesti River.
The dominant salts in the soil are sodium chloride and sodium sulphate.
Strong chloride salinization of the soil is highlighted by the high content of chlorine recorded in the upper part of the soil from the depth range 0-60 cm.
It is known that chlorine has a greater negative influence on plants than the SO4 anion.
Among vegetables commonly grown in plastic tunnels, the highest sensitivity to chlorine have plants from *Solonaceae* family (Sala, 2017).

The lowest value of ratio Cl-/SO42- recorded in the ploughed horizon suggests that the soluble salts also come from another source than that of irrigation water.
The main source for the bicarbonate (HCO_3^-) anion is calcium carbonate present in all soil horizons.
The irrigation water contains 420 mg/dm^3 soluble salts. The value of ratio Cl^-/SO_4^{2-} recorded in irrigation waters is 1.4. The high magnesium content is noticeable in the saline composition of the irrigation water (Table 4).

Table 4. Chemical composition of water irrigation (mg/dm^3)

Cl^{l-}	$SO4^{--}$	$HCO3^-$	Na^+	K^+	Ca^{++}	Mg^{++}
92.7	93.1	111.6	15	4	32	51.1

This composition of water may be due to anthropogenic influence. The magnesium content in municipal waters is frequently higher than in groundwater or rivers.
It is necessary to extend the range of analyzes performed in the lab in order to assess the quality of irrigation water. Given that $MgCl_2$ and MgSO4 are toxic salts, we recommend caution in using these waters for irrigation. Lixandru (1991) noticed that magnesium ion associated with exchangeable sodium greatly worsens soil properties.
Given that $MgCl_2$ and $MgSO_4$ are toxic salts, we recommend caution in using these waters for irrigation and repeated monitoring of water and soil quality.
Mulching with the plastic foil has also the negative effect of on the soil by increasing the water content resulting from the condensation of evaporated water from the irrigated soil surface, intensifying soil compaction, local accumulation of soluble salts especially in the border of wetted strip. The compact soil favours the accumulation of soluble salts.

CONCLUSIONS

The studied soil has been diagnosed as Hipohortic Salinic Gleic Aluviosols with slight moderately ploughpan and obvious reductomorphic characteristics in the bottom part of profile.
Higher compactness state of ploughpan highlighted by 1.8÷2.0 MPa of the penetration

resistance favors water stagnation and salt accumulation in the ploughed horizon.

High contents of organic matter and P_2O_5 are defining hortic horizon which is well supplied with nitrogen, phosphorus and potassium.

The main limiting factor of the studied soil fertility is strong chloride salinization of the upper part from the depth range 0-60 cm.

The high magnesium content of water irrigation could be due to anthropogenic influence. Given that $MgCl_2$ and $MgSO_4$ are toxic salts, we recommend caution in using these waters for irrigation and repeated monitoring of water and soil quality.

Mulching with the plastic foil has also the negative effect of on the soil by increasing the water content in soil not moistened with irrigation water, intensifying soil compaction, local accumulation of soluble salts especially in the border of wetted strip.

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REFERENCES

Borlan, Z., Hera, Cr. (1984). Agrochemical optimization Borlan Z., Hera Cr. (1984). Agrochemical optimization of soils (in romanian). Bucharest, RO: Academy Publishing House.

Canarache, A. (1973). Solution for creating of the optimal water regime in greenhouse soils. RO: *Horticulture and Viticulture Journal*, *6*.

Canarache, A. (1991). Factors and indices regarding excessive compactness of agricultural soils. *Soil & Tillage Research, 19*. 145–164.

Canarache, A. (1995). Problems in soil physics of specific interest for horticulture. Scientific Papers of Simposium Ecotehnologies and ecotechinques in soil tillage for horticultural crops. Bucharest, RO: AGIR Publishing House.

Dumitru, E. (2009). Methods of analysis used in the soil physics laboratory, Craiova (RO): Sitech Publishing House Encyclopedia Britanica Arenosols, http://www.britannica.com/EBchecked/topic/707505/Arenosol

Filipov, F., Tomita, O., Jitareanu, G. (2002). The influence of intensive horticultural plants cultivation on some physical and chemical properties of hortic antroposol from the greenhouse Copou Iassy. Scientific Papers of International Conference "Soils under Global Change-a Challenge for 21st Century". Vol. II, Bucaharest, RO: Estfalia Publishing House.

Filipov, F., Tomiţă, O., Lupașcu, A. (2004). Soil degradation processes in greenhouses. *Scientific Papers Pedogenetic factors and processes in the temperate zone*, 3.

Filipov, F., Topa, D. (2020). Amplification of soil compaction between ridges after using plastic mulch on entire surface in plastic tunnels from Northeast of Romania. *Scientific Papers. Series A. Agronomy, LXIII*(1), 24–28.

Florea, N., Balaceanu, V., Rauta, C., Canarache, A. (1987). Inerpreting soil surveys for different purposes. (in romanian), vol. 2. Bucharest, RO: Agricultural publications Publishing House.

Florea, N., Munteanu, I. (2021). Romanian System of Soil Taxonomy (in romanian), Craiova, RO: Sitech Publishing House.

Lăcătușu, R. Lungu, M., Rizea, N. (2017). Global Chemestry Interpretation, determination, processes. Iasi (RO): Terra Nostra Publishing House.

Lixandru, Gh., Marin, N., Calancea, N. (1991). Bucharest, RO: Didactic and Pedagogical Publishing House.

Maianu, Al. (1974) Conservation and raising of soil fertility in the greenhouse. Bucharest, RO: Ceres Publishing House.

Sala, F. (20017.) *Agrochemestry.* Timisoara, RO: Eurobit Publishing House.

Soil Survey Staff, Keys to Soil Taxonomy, 7-th edition, USDA, Natural Resources Conservation Service, 2006

William, J. Lamont, Jr. (2009). Overview of the Use of High Tunnels Worldwide. *Journal of HortTechnology, 19*(1), 25–29.