RESEARCH OF SOILS IN THE REPUBLIC OF MOLDOVA FOR THE QUALITATIVE DEVELOPMENT OF SEA BUCKTHORN

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ABSTRACT

Sea buckthorn cultivation in the Republic of Moldova represents a young but profitable branch with development perspectives due to the nutritional value of the products, to the protection qualities of eroded soils and to the accumulation of biosynthesized nitrogen in the soil by the plant root system. The current sea buckthorn plantations in the Republic of Moldova occupy a very wide spectrum of soils and their textural varieties, from typical chernozems in Balti steppe (Sangerei district - Dobrogea Veche), to the gray and brown forest soils in the Central Moldavian Plateau - Codrilor Plateau (Orhei district - Putintei and Clisova, Calarasi district - Leordoaia) and the carbonate chernozems of the terraces of the Dniester river (Dubasari district - Pohrebea).

The morphological description and the physical-chemical analysis allowed to highlight some ecological factors determining the productivity of the sea buckthorn plantations: degree of compaction, porosity, structure, moisture, effervescence - for several types and subtypes of soil, textural varieties, complexity of the soil cover, slope exposure and others.

It was shown that typical chernozem and light gray soil have more favorable agro-physical conditions for sea buckthorn cultivation, compared to the brown soils and typical gray forest soils, heavy by texture.

The high loam content, especially in the drought periods of the year, causes the processes of swelling-contraction. Disorders in the optimal development of plantations - insufficient development or total drying can occur as a result of exceeding soil moisture above the field capacity limit for water or below the wilting coefficient of the plant. In order to optimize the moisture regime depending on the soil texture and type, it is recommended to irrigate the sea buckthorn plantations established on chernozems. Gray and brown forest soils are not suitable for drip irrigation. In some periods, depending on the climatic conditions, there may be a need to optimize soil moisture.

On the plantations with unsatisfactory development of sea buckthorn, it is recommended to monitor the bulk density, the soil penetration resistance depending on the hydro-physical constants and the accessibility of water for plants.

INTRODUCTION

Fruit growing as the main agricultural branch in the Republic of Moldova registered over the period 2010-2020 an increase in areas of approx. 25 thousand ha and an increased rate of 120%.

The cultivation of sea buckthorn in the Republic of Moldova represents a young but profitable branch with development perspectives due to the nutritional value of products, to the protection qualities of eroded soils, to the accumulation of biosynthesized nitrogen in the organic matter of the soil by the plant roots etc.

At present, in the Republic of Moldova there are 350 ha of sea buckthorn plantations, including 200 ha of newly established plantations.

The soils and lands allocated to these plantations are very diverse according to pedogenetic and ecopedological characteristics, potential and effective fertility indices, while some areas may even have limiting agro-productive factors, because of the geomorphological heterogeneity of soils, soil cover, soil properties and regimes.

Currently existing sea buckthorn plantations in the Republic of Moldova occupy a very wide spectrum of soils and soil/their textural varieties, from typical chernozems in Balti steppe (Sangerei district - Dobrogea Veche), to the gray and brown forest soils in the Central Moldavian Plateau - Codrii Plateau (Orhei district - Putintei and Clisova, Calarasi district - Leordoaia) and the carbonate chernozems on the terraces of the Dniester river (Dubasari district - Pohrebea).

Researches on soil properties, soil cover characteristics by morphological description of profiles, specific agro-pedological indices - degree of compaction, structure, porosity, pedogenetic processes associated with the main elementary solification processes, determination of general physical and chemical properties were performed during 2020 -2021 in order to highlight the influence of geomorphological, pedological and general physical properties on the optimal development of different sea buckthorn varieties cultivated in the Republic of Moldova.

MATERIAL AND METHOD

Current sea buckthorn plantations established in the Republic of Moldova recorded soil areas specific for the ecopedological districts. The research was carried out in:

1. The 3rd ecopedological district, „Preambula" Ltd., Sangerei district, Dobrogea Veche village, (39.78 ha), the predominant soil is typical medium humiferrous weakly eroded clay-loamy chernozem;
2. The 8th ecopedological district, SPANDOR Ltd., Orhei district, Putintei village (30 ha), with predominantly gray and brown forest soils with various textures;
3. The 8th ecopedological district, „Big Cuker" Ltd., Orhei district, Clisova village (30 ha) with weakly eroded light gray soils, levigated chernozems, typical moderately and weakly humiferrous chernozems, mainly clay-loamy according to texture;
4. The 7thecopedological district, AF Stoica Silvia Victor, Calarasi district, Leordoaia village (21 ha), with soils depending on the geomorphological conditions, the predominant soils - forest brown and alluvial carbonate soils;
5. The 14th ecopedological district, Monsterax-GSG Ltd., Dubasari district, Pohrebea village (150-152 ha) with carbonate clay-loamy chernozem.

For all the sites included in the study, the soil cover was researched according to the main relief elements, the pedological profiles were placed up to a depth of 150 cm, semi-profiles 80-100 cm deep, the morphometric description of the soil was done, the effervescence depth was established, samples were taken for general physical-chemical analysis. Also according to the methods applied in agroecological monitoring (Cerbari V., 2010), there were determined both in the field and laboratory the following characteristics: soil texture, physical-chemical indices, soil moisture (% and mm), bulk density and penetration resistance.

RESULTS AND DISCUSSIONS

It has been established that sea buckthorn development is largely influenced by soil moisture, soil horizon characteristics, root system location conditions dependent on soil location and pedogenetic profile.

The degree of change in soil compaction in the layer of 0-60 cm was highlighted as well as the texture and bulk density of humiferrous horizons A in chernozems, AE in gray forest soils

(griziom), Aw and Bw in brown forest soils and soil moisture characteristics. The structure of genetic horizons, the degree of compaction that favors the root system or creates some impediments was highlighted both in the morphological description of the field soils (Table 1) and in the evaluation of the bulk density (Table 8) and soil moisture (Table 7). Here we will present some morphometric descriptions, which had a significant influence on the development of sea buckthorn plants, including physical-chemical characteristics of some soils specific for the district of established plantations, various in texture, the latter significantly influencing soil moisture content, mobility and retention of active and surplus water and development of the plants' root system.

Table 1.

Morphological characteristics of the typical clay-loamy chernozem, Clisova, Orhei

Ap (0-53 cm)	Dark gray with gradual transition to B, weakly compacted, moderately porous, dusty lumpy, clay-loamy, dry.
Bh (53-105) cm	Light brown with gradual transition to the rock, compacted, weakly porous, grainy - lumpy, clay-loamy, dry, effervescence from 60 cm.
C (105-150) cm	Pale yellow, moderately compacted, porous, lumpy, clay-loamy, dry, effervescent.

The experimental plot for sea buckthorn cultivation located in Leordoaia village, Calarasi district, is characterized by a general wave-hilly highly dismembered relief. The research site is located on a slope with south-western exposure, the inclination is of 8-12%, the researched profile in the middle part, weakly pronounced micro-relief.

The morphological characteristic of the soil, representative for the 8th ecopedological district, along with data presented in Table 2 and research data on the physical-chemical properties highlight a brown strong and moderately deep clay-loamy forest soil on loamy clays.

The obtained results highlighted that on the Leordoaia site, Calarasi district, the brown forest soil has a useful edaphic volume exceeding 100 cm, conditioned by the thickness of the humus-accumulative (Aph) and iluvial (Bhw) horizon, a thickness favorable

for the optimal development and growth of the root system, qualitative formation of yield, but sometimes registering marks of glazing and hydromorphism on some relief elements.

Table 2.

Morphological characteristics of the brown forest soil, Leordoaia, Calarasi

Aph (0-23 cm)	Dark brown with gradual transition; loose, weakly compacted; porous with pore size of 1-3 mm, 3-5 mm, rarely spongy pores of 5-10 mm; dusty on the surface; granular, nuciform (5-7 mm) weak - moderately stable structure; clayey-loamy; heterogeneous moisture, dry or freshly moistened in some places.
Bhw (32-79) cm	Brown with gradual transition; weakly compacted, more compacted compared to the Aph horizon; pores of 1-3mm, 3-5mm; granular nuciform, rocky; clay-loamy; moistened, damp in some places.
C (70-150) cm	Yellow - brown with glaze spots; porous; rocky, prismatic; effervescence from 120 -130 cm; moistened.

In the village Putintei, Orhei district, the soil cover is more heterogeneous and diverse according to the texture and physical-chemical characteristics, phenomena that will appear in the aero-hydric and oxidation-reduction regimes, in the degree of compaction and others. The gray and brown forest soils were highlighted by three described profiles, with the clayey-sandy, clay-loamy and heavy loamy textural varieties. Table 3 presents the morphological characteristics of a brown forest soil of clay-sandy texture. This allowed to determine the good, optimal and unfavorable conditions in the development of the sea buckthorn root system and the risk problems in the drought years when the precipitations were minimal.

Given that soil texture is light and the porosity is good over the entire depth of the profile, it ensured optimal permeability for the air, the water and the root system.

The comparative characteristic of the physical-chemical properties of light, medium and heavy soils by texture are presented in the Tables 4-6.

Table 3.

Morphological characteristics of a soil representative for Putintei, Orhei

Depth, cm	Morphological indices
Ah 0-35	Dark brown with gradual transition; heterogeneous after establishment, weakly compacted, looser up to 11cm; without pores on compacted surfaces (porous, 1-3mm in some places, even spongy, 5-5 mm, rarely spongy); general nuciform structure, from small size (5-7 mm), to medium (7-10 mm) and big size (over 10 mm), in a stable dry state, with degraded - weakly stable rocky structure on the tracks caused by the agricultural machinery; insect and earthworm galleries; clay-sandy; without effervescence, non-carbonate; heterogeneous horizon after moisture - dry at the top, moistened at the bottom.
Bhw1 35-52	Brown in color with gradual transition; weakly compacted, porous, spongy, rarely spongy; moderately and highly nuciform, moderately stable; earthworm galleries, roots; rust stains caused by R_2O_3; moderately clay; carbonates are missing; weakly moistened.
Bhw2 52-91	Brown, lighter than the upper horizon, gradual transition by color, compaction, structure; weakly compacted; porous - spongy; nuciform structure, moderately stable; roots, humus leaks, rust spots (limonitic); clay-sandy; carbonates are missing; weakly moistened.
C over 91 cm	Yellow with shades of brown; weakly compacted, fine pores (<1mm) and porous (1-3 mm); prismatic rocky; weakly stable; rust and pale brown spots; sandy - clay; carbonates are missing; weakly moistened.

The analysis of bibliographic references (CimpoiesGh., Popa S., 2018) indicates a high economic efficiency of the sea buckthorn plantations established on fine textured soils, well aerated, with pH 6.0-7.5, representing ecological factors determining the soil with optimal influence on the development of the plants' root system. Research has shown a variability of soils by texture. The texture of brown soils and forest gray soils essentially influences soil properties. In the village Putintei, Orhei district, the physical loam content ranges from 19-24% to 61-69%, and this causes the heterogeneity of the sea buckthorn plantation development. The texture of the researched soils influences the physical-chemical and physical characteristics, the humus content (organic carbon) in the

superficial horizons, as well as water reserves in the soil. It should be mentioned that sometimes the types of soil included under sea buckthorn plantations are not suitable for irrigation (brown soils, gray forest soils), but currently, on some sites, these soils are included under drip irrigation installations, actions required by intensive agriculture.

Table 4.

Physical-chemical characteristics of the brown forest soil strongly on clay sandy, profile 1

Depth, cm	Physical loam, < $0,01_{mm}$	Hygroscopic water, %	Humus,%	Carbon, %	Azote,%	$CaCO_3$,%	pH	Electrical conductivity, µS/cm
0-20	24,01 (clay-sandy)	2,33	1,27	0,74	0,09	-	6,98	34,6
20-40	23,79 (clay-sandy)	2,27	1,16	0,68	0,08	-	6,85	38,2
40-60	21,63 (clay-sandy)	2,17	0,89	0,52	0,07	-	6,49	42,6
60-80	20,03 (clay-sandy)	1,95	0,74	0,43	0,06	-	6,51	31,3
80-100	18,86 (sandy-clay)	1,52	0,26	0,15	0,03	-	6,43	22,1

The light-textured soils (Table 4) register a humus content below 2% - very low, and with the depth, it decreases significantly from 1.27% to 0.26%. The pH index values vary in the weakly acidic (pH = 6.43) - neutral (pH = 6.98) limits, which ensures a favorable microbiological activity, particularly due to the fact that sea buckthorn species is a nitrogen-fixing plant. The values of electrical conductivity (EC) indicate 66.4 µS/cm in the surface horizon, an agrophysical and agrochemical state favorable for the development of the sea buckthorn species.

The humus and nitrogen content increases in the loamy-clay and clay-loamy soils (Tables 5 and 6).

Table 5.

Physical-chemical characteristics of the typical gray forest soil (vertic), profile2

Depth, cm	Physical loam, < 0,01mm	Hygroscopic water, %	Humus, %	Carbon, %	Azote, %	$CaCO_3$, %	pH	Electrical conductivity, µS/cm
0-20	60,92 (loamy-clay)	6,8	2,51	1,45	0,12	-	6,91	66,4
20-40	68,54 (loamy-clay)	7,7	1,92	1,11	0,1	-	7,01	45,6
40-60	67,86 (loamy-clay)	7,9	1,17	0,68	0,07	-	7,06	33,1
60-80	67,11 (loamy-clay)	7,3	0,83	0,48	0,06	-	7,22	32,9
80-100	66,36 (loamy-clay)	7,0	0,31	0,18	0,03	-	7,37	32,4

Table 6.

Physical-chemical properties of the gray forest clay-loamy soils

Depth, cm	Physical loam, < 0,01 mm	Hygroscopic water, %	Humus,%	Carbon, %	Azote,%	$CaCO_3$,%	pH	Electrical conductivity, µS/cm
0-20	49,27 (clay-loamy)	5,28	2,21	1,28	0,19	-	6,94	43,9
20-40	47,82 (clay-loamy)	5,16	2,13	1,23	0,16	-	6,85	46,7
40-60	46,63 (clay-loamy)	4,85	1,95	1,14	0,13	-	6,78	58,7
60-80	48,09 (clay-loamy)	5,23	0,94	0,55	0,06	-	6,56	48,6
80-100	47,66 (clay-loamy)	5,08	0,32	0,18	0,02	-	6,49	49,3

The comparative evaluation of the moisture and bulk density of typical chernozems and forest soils - brown and gray with various texture (Table 7 and Table 8) shows that the moisture of chernozems per profile is more homogeneous, being influenced by the root system and texture and in the upper part of the profile the moisture is lower. The moisture of forest soils is higher throughout the pedogenetic profile being influenced by the texture and exposure of the slope.

The researched soils (Table 8) recorded a favorable bulk density on the typical chernozem (Dobrogea Veche) for sea buckthorn development, as well as for the light and moderate structural varieties, while on the brown soil (Leordoaia) and some sectors (Clisova) - under the bulk density constitutes 1,35-1,45 g/cm^3, parameters that influence the development of plantations. The bulk density of brown soils (Leordoaia) correlates with the pedogenetic manifestation of the soil profile horizons. The maximum value of the bulk density 1,39 g/cm^3, highlighted in Bhw, at a depth of 40-50 cm, evaluated with unfavorable agrophysical indices by porosity and structure, is unfavorable for the optimal development of the root system.

Table 7.

Comparative characteristic of the soil moisture, %, of the researched sites, 2020

Depth, cm	Dobrogea Veche	Clisova	Putintei, profile 3	Leordoaia	Pohrebea
0-10	10,78	15,12	23,39	8,78	14,4
10-20	16,34	12,86	23,68	19,14	15,41
20-30	18,65	14,47	22,17	19,14	18,27
30-40	14,46	11,22	24,31	18,72	18,02
40-50	21,73	17,23	24,15	19,75	16,59
50-60	22,3	16,94	23,66	19,34	13,26
60-70	21,25	20,34	23,01	18,58	17,1
70-80	21,24	19,36	22,36	21,01	15,51
80-90	20,9	19,55	21,49	21,79	12,78
90-100	20,83	19,33	21,54	22,53	9,25
100-110	20,97	17,48	21,65	22,17	9,31
110-120	20,7	18,56	21,79	22,01	9,46

Table 8.

Comparative characteristics of the bulk density, g/cm^3, of the researched sites, 2020

Depth, cm	Dobrogea Veche	Clisova	Putintei	Leordoaia	Pohrebea
0-10	1,02	1,14	1,01	1.11	1,03
10-20	1,09	1,35	1,03	1,21	1,17
20-30	1,05	1,45	1,05	1,28	1,15
30-40	1,19	1,23	1,08	1,25	1,08
40-50	1,21	1,21	1,12	1,39	1,04
50-60		1,18	1,18	1,33	1,05

In 2020, concomitantly with determining the bulk density on all the researched sites established with sea buckthorn plantations in the Republic of Moldova, measurements of the soil penetration resistance up to a depth of 80 cm were performed.

Penetration resistance data show a significant change in soil compaction during drought periods of the year as a result of anthropogenic technical impact. The highest values of this parameter were recorded in the tracks caused by the agricultural machinery, values observed even on the plantation line, and these may be the consequences of performing mechanized work in humid conditions above the lower plasticity limit of the soil. These effects were also recorded by the bulk density data, especially on the gray and brown forest soils.

CONCLUSIONS

In order to create sustainable sea buckthorn plantations in the Republic of Moldova, various types and subtypes of soil, textural varieties located in the ecopedological districts 3, 7, 8 and 14, soils representative for these regions, were researched.

The morphological description and the physical-chemical analysis allowed to highlight some ecological factors determining the productivity of the sea buckthorn plantations - compaction degree, porosity, structure, moisture, effervescence for several types and subtypes of soil, structural varieties, complexity of the soil cover, slope exposure and others.

Soil type and texture significantly influence soil moisture, bulk density and penetration resistance.

It was determined that the typical chernozem and the gray soil light texture have more favorable agrophysical conditions for sea buckthorn cultivation, compared to the brown soils and gray forest soils, which are heavy textured soils.

The analysis of the morphological characteristics and the physical-chemical properties of the soils under the poorly developed sea buckthorn plantations and in some places recording dried plants allows to show the causes of this phenomenon.

The high loam content, especially in the drought periods of the year, causes the processes of swelling-contraction, and the structural aggregates are pressed against each other, causing soil compaction and cracking, a phenomenon highlighted by the data on bulk density and soil moisture, parameters that sometimes result in insufficient plant development or even total drying.

Disorders in the optimal development of plantations - insufficient development or total drying can occur as a result of exceeding soil moisture above the field capacity for water, (at the expense of capillary water migrated through the capillary fringe, when groundwater is located close to the surface, 2- 3m). This moisture excess sometimes leads to the appearance of glazing processes (blue spots, grayish-blue spots, purple spots) as a result of the processes caused by the reduced mineral content of the soil. This influences some physical-mechanical processes in the soil.

Moisture excess causes the swelling (increase in volume) of the loam particles, which causes the aggregates to press on each other, to slide on top of each other, to turn and as a result to have polished (glossy) surfaces, to form a structure of compacted massive blocks and a massive aggregation on drying.

In order to optimize the moisture regime depending on the texture and type of soil, it is recommended to irrigate the sea buckthorn plantations established on chernozems. Gray and brown forest soils are not a favorable for drip irrigation. In some periods, depending on climatic conditions, there may be a need to reduce soil moisture, by lowering the groundwater level which can cause hydromorphism or other negative effects on the root system. As a remedial measure, it is recommended to drain the water using a classic or natural drainage, with grassy ditches.

On the sea buckthorn plantations with heavy soils – loamy-clayey and loamy, in order to improve the heavy texture, compaction and rocky structure of massive blocks, it is recommended the

application of organic fertilizers (green organic fertilizers, manure, organic vegetable waste).

As for the plantations with unsatisfactory development of the sea buckthorn plants, it is recommended to monitor soil penetration resistance depending on the hydrophysical constants and the accessibility of water for plants and to research physical-mechanical properties, including the plastic limit.

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