NARDI FUNDULEA, ROMANIA
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ROMANIAN AGRICULTURAL RESEARCH, NO. 38, 2021
Print ISSN 1222–4227; Online ISSN 2067–5720

INCREASING THE PRODUCTIVE POTENTIAL OF AGROECOSYSTEMS AFFECTED BY CLIMATE CHANGE USING SHELTERBELTS, IN SOUTHEASTERN PART ROMANIA

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ABSTRACT

The climate change that we are facing today has negative consequences on our ecosystems, especially by increasing the number and intensity of extreme weather events, as heavy rains, hail, drought, and other such weather phenomena. One of the most effective measures to fight against drought is the establishment of shelterbelts to protect agricultural land. These have proved to be necessary especially in plain areas prone to drought, wind erosion, desertification, etc. At national level, 7.5 million hectares should be protected by shelterbelts, of which on 3.4 million hectares measures should be undertaken immediately.

In 2014 the Romanian Academy decided to provide a model for landowners and farmers, by establishing a network of shelterbelts exceeding 120 km, covering an area of over 178 ha. In the period 2017-2020, shelterbelts were established in four different areas, of which we analyze here only two, namely Perișoru, on a typical chernozem and Grădiștea, on a calcaric fluvisol, in the meadow area, both locations in Călăraşi County. The planting schemes were identical, respectively 2 x 1 m, resulting in 5000 seedlings/ha. Two distinct compositions were used, a simple one of *Ulmus pumila* and *Gleditsia triacanthos* and a more complex one of *Quercus pedunculiflora*, *Prunus cerasifera*, *Fraxinus ornus*, *Acer tataricum*, *Pyrus pyraster* and *Prunus mahaleb*. The technology used for planting and maintenance is considered a premiere in Romania, due to high mechanization works, that lead to high quality, low impact and low-cost works. The growth characteristics were compared, for both sites and compositions, providing information that can be further exploited inside the organic or sustainable production systems by farmers. By using a method developed within 28PCCDI UEFISCDI financed project, aiming at evaluating the influence of new agro-bio technologies on the agroecosystem at soil level, further insights on shelterbelt benefits are expected in the future.

Keywords: shelterbelts, windbreaks, mixed forest species composition, chernozem, calcaric fluvisol.

INTRODUCTION

Shelterbelts (windbelts) are areas planted with trees and shrubs, following a rows design, with the aim of forming a barrier against winds close to the Earth surface. They provide wind protection for homes, farms, highways, livestock, agricultural land, and represent a diversity of habitats where diverse species of wildlife find shelter. This biodiversity role is of high importance, contributing to a natural balance of pests and beneficial species, also enhancing the biological control of crop pests. Other main advantages relate to reducing wind speed, reducing plant transpiration and water evaporation, water preservation in the soil, maintaining an even layer of snow throughout the field, stop the snowstorms, prevents wind erosion of soil, etc. Some studies proved that although shelterbelts take only 3-4% of the land, their presence may increase the agricultural production by more than 35%. A network of forest belts, with a perpendicular arrangement to the direction of the prevailing wind, caused a reduction by 25-50% of wind speed and decrease significantly the evapotranspiration, leading to the conservation of water in the soil (Andreu et al., 2008; Mize et al., 2008).

Received 5 April 2021; accepted 8 April 2021. First Online: April, 2021. DII 2067-5720 RAR 2021-91

Shelterbelts improve soil moisture in two ways: by wind speed reductions and evaporation from the soil surface reduction, leaving more water available for crops development and, especially for low-density shelterbelts in fields, by creating a broad zone of a thick snow deposition across the field, leading to an increase in available soil moisture (Kort, 1988), especially good for autumn crops. Also, these `snow fences` help in managing drifting snow. Dense shelterbelts trap the snow close to the trees, reducing snow removal costs from adjacent roadways and improving road safety (Shaw, 1988). Windbreaks can reduce soil erosion by ameliorating wind speed across open fields. The susceptibility of soil to erosion is a function of particle size; clay and silt particles are easily removed from the surface at low wind speeds while sand particles need relatively high wind speeds. The positive impact of shelterbelts is visible mainly on the lee side of trees in the protected zone (Andreu et al., 2008).

The presence of shelterbelts may increase the crops production by more than 35%. In Ukraine, a 25-year study on winter barley revealed that shelterbelts increased yields by 17-18% in dry years, 13-15% in normal conditions, and 6-9% in favorable years of average precipitation. This reflected in increased net revenues by 27-57% in drought years and by 13-26% in moist years (Miloserdov, 1989). Such findings draw attention on the seasonal variability of the windbreaks effect.

A meticulously planned shelterbelt comprises a small portion of the agricultural land, and its advantages are much greater than the loss of productive land. Usually, a shelterbelt has 15-20 m width, with 1 m shrub belt planted on both sides (Constandache et al., 2012; Szigeti et al., 2020).

At a world level, due to 34 years of drought in the 17th century and 40 years of drought in the 19th century, Russia may be considered the pioneer of the fights against extreme drought. The first established shelterbelts, with protective role, date back to 1696, in southern Ukraine, planted at the order of Tsar Peter the Great. In 1843, the first institute having as main aim the shelterbelts research as a measure against drought was founded, while, 40 years later, another step forward is considered the planting of 80 ha shelterbelts, on the N-S direction, in Kamennaya Steppe, after detailed research (Vasilescu, 2004). The scientific evaluation of a soil scientist Dokuchaev, on Kamennaya, led to the idea of the necessity of agroforestry within steppe landscapes, crop fields and grasslands and since then, Russia began to systematically expand agroforestry (Chendev et al., 2015).

Based on the beneficial results obtained by Russian scientists, other countries in Europe, as Denmark, Germany, Italy, Czechoslovakia, Hungary, Bulgaria, or else, as USA, Canada, Japan etc. followed their example, but without having the scale of Russian agroforestry measures (Vasilescu, 2004).

In Romania, the need of shelterbelts was first mentioned by the great agronomist and politician Ion Ionescu de la Brad, in 1866, who established, on the land of his farm in Roman area, Neamț County, in 1870-1872, the first windbelts. As some landowners understood the necessity of shelterbelts, in 1880, in Mărculești, Ialomița County, new plantation started. In 1881 the establishment of “long protective shelterbelts between hills and mountains” is proposed by B. Pizu, as a measure against the strong, cold winter wind, named ”crivăţ”. The soil scientist D.R. Rusescu demonstrates the need of agroforestry in Bărăgan plain in 1904 and receives a Golden Medal at a National Economy Fair, in 1906, for presenting “The General Plan of afforestation of Bărăgan plain” and “Map of afforestation of Bărăgan plain”, awarded with the Gold Medal of the exhibition (Giurgiu, 1995). Through these two works, Romania precedes by 39 years the Roosevelt Great Plains Shelterbelt program and by 42 years the plan of the Soviet Union for the transformation of nature (Popov et al., 2017). The droughts of 1928-1929 and 1933-1935 lead to the establishment of new protective shelterbelts, 89 ha in Brăila County (1933-1937), and 465 ha in Ialomița County (1937-1939, with black locust), which includes 40 ha on agricultural lands (Rubțov, 1947;

Vasilescu, 2004). Shelterbelts proved their necessity and benefits at most in 1947, in Dobrogea, when wheat crops were completely frozen on unprotected fields while the sheltered lands gave 600 kg/ha and in 1949, the driest year of the 20th century, by increasing the harvest with 300% on protected lands. In 1960, the Romanian shelterbelts protected one million hectares of land in Dobrogea and Bărăgan plain, while in 1961, 7,000 km of forest belts were protecting the fields and 1,400 km were protecting the communication routes (Costăchescu et al., 2012; Dănescu et al., 2007). Unfortunately, a large part of these shelterbelts was deforested in 1962 by a communist decree. Some recent studies suggested the use of digital tools, as *Analytic Hierarchy Process* and *Expert Choice Desktop* software, for solving the multi-decision issues related to the choice of plant species (Enescu, 2018; Constandache et al., 2016) in the perspective of increasing the area of forest shelterbelts at national level.

The Romanian Academy, through the Patrimoniu Foundation, initiated in 2014 an agroforestry program on its lands, with the demonstration and research aims, promoting modern technologies for planting and maintenance. The main objectives were to prove the influence on restoring and maintaining local microclimatic conditions, to improve the soil fertility in its research stations, and to deepen research on the effectiveness and importance of forest shelterbelts. Starting 2017, the first trees were planted, and so far, an area of 87.5 ha of the total of 178 ha has been already covered.

The year 2020 was one of extreme drought, with high impact on agriculture, proving the necessity of such initiatives. The present paper intends to raise awareness among scientific community on the stringent need and efforts made by the Romanian Academy to reinstall shelterbelts using a new, high-tech technology and suggests using a new method to evaluate the influence of new measures on the agroecosystem at soil level, to generate further insights on shelterbelt benefits.

MATERIAL AND METHODS

Characterization of physico-geographical conditions

The experiment was conducted in two different locations, in Southeastern part of Romania, in Perișoru area, on a typical chernozem and in Grădiștea area, on a calcaric fluvisol, in a meadow area, as illustrated in Figure 1. Both locations are situated in Călăraşi County.

Figure 1. Shelterbelt's location of the two studied sites, Perișoru and Grădiștea

Forest species were chosen to withstand local climatic conditions, as rainfall deficit, high summer temperatures, bright sunshine, etc. (Table 1). The plant species were associated both for a vertical layer arrangement in front of the prevailing wind and to comply with the ecological requirements of each species. Shelterbelts were set up in the two different locations with different plant compositions, according to the advice given by National Institute for Research and Development in Forestry (INCDS) specialists. In Grădiștea, Călăraşi County, the following species were used: *Quercus pedunculiflora, Prunus cerasifera Fraxinus ornus, Acer tataricum, Pyrus pyraster, Prunus mahaleb* while in Perișoru only a mix of two species was preferred, *Ulmus pumila* and *Gleditsia triacanthos.*

Table 1. Main physical-geographical conditions

Location	Geology and lithology	Climatic factors	Groundwater	Soil types
Perișoru (altitude: 35-40 m)	Bărăgan plain, on the Moesic Platform, sedimentary deposits. - fluvio-lacustrine deposits over which löess and löessoid deposits overlap, some sands; alluvial deposits, often covered by löess, appear on meadows and river terraces.	***min. t.*** >-30°C ***January av.*** -2- -4°C ***max. t*** >40°C ***July av.*** 22-23°C ***aagr*** - 125-127 kcal/cm^2 ***aaat*** - 10.8-11.0°C ***dwf*** - 190-210 d ***aar*** - 450-550 mm	0-5 m in river meadows, 2-5 m in ravine depressions, 5-15 m in most interfluves.	cernisols, with typical chernozem (and vermic)
Grădiștea (altitude: 15-20 m)	The Danube meadow; covered with fluvial and swampy deposits, that consist predominantly of clays (sandy or löessoid), fine and coarse sand, homogenized with gravel.	***min. t.*** >-30°C ***January av.*** -2- -4°C ***max. t*** >38°C ***July av.*** 22-23°C ***aagr*** - 125-127 kcal/cm^2 ***aaat*** - 10.8-11.0°C ***dwf*** - 190-210 d ***aar*** - 400-500 mm	1-2 m in the spring, 2-3 m during summer and autumn.	limnosols, alluviols and gleiosols

min. t. - minimum temperature
January av. - January average temperature
max. t - maximum temperature
July av. - July average temperature
aagr - annual average global solar radiation
aaat - average annual air temperature
dwf - days without frost/year
aar - average annual rainfall

Planting and maintenance works

In both locations, the planting works were performed either manual or mechanical. The fields were prepared before planting by ploughing and disking. For mechanical planting, a 25 cm depth ditch was used. For manual planting, holes of 40 x 40 x 50 cm were dug. The 1-year bare-root young plants were firstly soaked in clay mud, to keep the moist, protect from dehydration, and grant the soil adherence on the roots. For mechanical planting, no mudding was necessary.

The planting schemes were identical, respectively 2 x 1 m, resulting in 5000 seedlings/ha. The surfaces planted during the four years are illustrated in Table 2. A total of 87.5 ha and 438000 seedlings were planted.

All maintenance works, as manual or mechanical hoeing, phytosanitary treatments, grooming, etc.) were performed identically in both locations.

Field analysis

A soil profile was dug in the cadastral plot, where the shelterbelt is located, from which soil samples were collected, both in natural condition and dislocated condition.

Table 2. Number of plants and surface planted in the period 2017-2020

Location	2017	2018	2019	2020
Grădiștea (ha)	17.5	27.3	18.9	6.7
Grădiștea (plants no)	88000	136500	94500	33500
Perișoru (ha)	-	-	11.6	5.5
Perișoru (plants no)	-	-	58000	27500
Total ha	17.5	27.3	30.5	12.2
Total pcs	88000	136500	152500	61000

Soil samples were taken up to a depth of 180 cm, collected in plastic bags and analysed, according to the ICPA methodology, 1987 volume I, which is our national standard. The soil type has been characterized morphologically and physico-chemically according to the guidance for field description of soil profiles and specific environmental conditions presented in the Romanian System for Soil Taxonomy, 2014. The complete characterization of the soil was possible by analyzing the results based on the A.S.R.O. standards, which are in line with international standards.

Soil analysis

The samples were analyzed in INCDPA Bucharest laboratories. Soil samples were dried at room temperature; soil subsamples were homogenized, milled, and sieved through a 250 µm sieve.

The following analytical methods were used to determine the chemical properties:

- organic matter (humus): volumetric determination, based on Walkley-Black humidification method, modified by Donut - STAS 7184 / 21-82;
- $CaCO_3$ (carbonates): gasometric method using the Scheibler calcimeter, according to SR ISO 10693: 1998 (%);
- the nitrogen content was determined indirectly (by calculation) based on the humus content and the degree of saturation with bases (IN = humus x V / 100);
- mobile phosphorus content (mobile P): Egner-Riehm-Domingo method and colorimetric molybdenum blue, Murphy-Riley method (ascorbic acid reduction);
- mobile potassium content (mobile K): Egner-Riehm-Domingo extraction and flame photometry;
- pH: potentiometrically determined, with combined glass electrode and calomel, in aqueous suspension at soil / water ratio of 1/2, 5 - SR 7184 / 13-2001;
- Hydrolytic acidity - extraction with sodium acetate at pH 8.2;
- degree of bases saturation V% - Kappen Schoffield method Charge by extraction with 0.05 normal hydrochloric acid.

The following physical characteristics were determined:

- determination of granulometric fractions:
- pipette method, for fractions ≤0.002 mm;
- wet grinding method for fractions of 0,002-0,2 mm and dry grinding method for fractions >0,2 mm. The results are expressed as a percentage of the material remaining after pretreatment.
- bulk density (BD): the known volume of metal cylinders (100 cm^3) at the instant soil moisture (g/cm^3) - total porosity (PT): by calculation (% by volume - % v / v);
- aeration porosity (PA): by calculation (% volume - % v / v);
- compaction rate (GT): by calculation GT = [(PM - PT) / PMN] x 100 (% by volume - % v / v), where: PMN - minimum required porosity, clay of the sample is calculated with the formula PMN = 45 + 0.163 A (% by volume - % v / v); PT = total porosity (% v / v); A - clay content (% w / w);
- hygroscopicity coefficient (CH): drying at 105°C of a pre-moistened soil sample at equilibrium with a saturated atmosphere with water vapor (in the presence of 10% H_2SO_4 solution) - % by weight (% w / g);
- permanent wilting point (CO): by calculation by multiplying by 1.5 the hygroscopicity factor determined by the modified Mitscherlich method (% vacuum), % by weight (% w / w).

For the complete soil characterization, in terms of both the physico-chemical properties of the soil and physico-geographic conditions in which the soil was formed, soil properties are represented as symbols grouped in ecopedological indicators, according to the methodology in force (ICPA, 1987, vol. III).

RESULTS AND DISCUSSION

Soil characterization

Perișoru location

- Soil type: typical chernozem, vermic;
- Relief: plain;
- Use: arable, corn;
- Rock: loessoid deposits;
- Groundwater: >10 m.

Morphological characterization of the soil profile revealed the following (Figure 2).

Am horizon (0-42 cm), light brown color, in shades of 10 YR 2/1 when wet, in moist moderately develops glomerular structure, clayey texture, porous, permeable, frequent fine roots from vegetation, weak effervescence, presence of hardpan - 28-35 cm, gradual transition to the lower horizon.

AC horizon (42-67 cm), brownish-yellow color, in shades of 10 YR 4/3 when wet, glomerular structure poorly developed in the upper half of the transition horizon, slightly friable, clayey texture, porous, loose, with accumulations of carbonates in the form of pseudomycelias, moderate effervescence.

Cca horizon (> 67 cm), yellowish color in shades of 10 YR 5/4 wet, unstructured, friable, porous, loose, with accumulations of carbonates in the form of pseudomycelias and small crumbly concretions, strong effervescence. The analytical data for the typical chernozem in the studied area are presented in Table 3.

Figure 2. Perişoru soil profile

Table 3. Characteristics of the typical chernozem, Perişoru area

Horizon	Am	AC	Cca	C
Depth (cm)	0-42	42-67	67-105	105-180
Coarse sand (2-0.2 mm)	13.7	14.2	15.1	-
Fine sand (0.2-0.02 mm)	30.0	30.1	29.5	-
Dust (0.02-0.002 mm)	31.6	29.8	29.4	-
Clay (<0.002 mm)	24.7	25.9	26.0	-
Soil texture	LL	LL	LL	LL
Soil reaction (pH)	7.26	8.09	8.56	8.7
Humus content (%)	4.22	3.26	0.89	0.56
Apparent density (g/cm^3)	1.27	1.25	1.30	-
Total porosity (%)	52.5	54.7	51.2	-
Degree of compression GT (%)	2.5	-5	-7	-9
Carbonates (%)	3.2	6.5	12.9	12.5
Degree of saturation with bases V (%)	94	100	100	-
Total content of nitrogen IN	3.96	3.26	0.89	-
mobile P (ppm)	28.0	21.5	15.0	-
mobile K (ppm)	198	191	164	-
Permanent wilting point (%)	12.9	11.1	11.3	-
Field capacity (%)	25.7	25.1	24.3	-
Useful water capacity (%)	12.8	14.0	13.0	-
Total water capacity (%)	41.3	45.2	39.3	-
Humus reserve (t/ha)	225	102	44	-

Grădiștea location

Soil type: calcaric fluvisol;

Relief: meadow;

Use: arable, corn;

Rock: fluvial deposits.

Morphological characterization of the profile 2 (Figure 3).

Ao horizon (0-30 cm), dusty clay, moderately developed glomerular structure, brown with 2.5 Y 3/2 shades when wet and light brown 2.5 Y 4/3 when dry, reclaimed, weak biological activity, non-plastic, non-adhesive, frequent fine pores, thin roots common, gradual wavy transition.

Horizon AC (30-45 cm), dusty sandy clay, moderately developed polyhedral structure, moderately compacted, with oxidation-reduction spots at the base of the horizon, yellowish brown with shades of 2.5 Y 3/3 when wet and 2.5 Y 4/4 when dry, frequent fine roots, clear wavy transition.

Horizon C_1 (45-74 cm), fine sandy clay, light brown with marbled shades of 2.5 Y 4/4 when wet and yellowish brown 2.5 Y 5/3 when dry, friable, unstructured, non-plastic, non-adhesive, frequent coarse pores, frequent fine roots, clear straight transition.

Horizon C_2 (74-110 cm), coarse sandy loam, light yellow with marbled shades of 5 Y 5/3 when wet and 5 Y 6/4 when dry, unstructured, reclaimed, very brittle, frequent $CaCO_3$ pseudomycetes, strong effervescence, clear straight transition.

The analytical data for the typical chernozem in the studied area are presented in Table 4.

Figure 3. Grădiștea soil profile

Table 4. Characteristics of the calcaric fluvisol, Grădiștea area

Horizon	Ao	AC	C_1	C_2	C_3
Depth (cm)	0-30	30-45	45-74	74-110	110-135
Coarse sand (2-0.2 mm)	7.3	7.0	14.0	33.3	12.5
Fine sand (0.2-0.02 mm)	33.7	46.2	47.8	30.3	48.6
Dust (0.02-0.002 mm)	40.6	30.5	27.0	25.8	28.4
Clay (<0.002 mm)	18.4	16.3	11.2	10.6	10.5
Soil texture	SS	SF	UF	UG	UF
Soil reaction (pH)	7.8	8.0	8.2	8.4	8.6
Humus content (%)	2.19	2.04	1.32	0.56	-
Apparent density (g/cm^3)	1.24	1.26	1.31	1.43	1.44
Total porosity (%)	54	52	48	46	45
Degree of compression GT (%)	-6	-8	3.4	4.8	8.2

Horizon	Ao	AC	C_1	C_2	C_3
Carbonates (%)	3.2	6.5	12.9	12.5	3.2
Degree of saturation with bases V (%)	100	100	100	100	100
Total content of nitrogen IN	2.19	2.04	1.32	0.56	-
mobile P (ppm)	44	43	39	37	-
mobile K (ppm)	212	187	167	145	-
Permanent wilting point (%)	5.25	5.5	4.2	3.6	-
Field capacity (%)	9.6	10	7.6	6.5	-
Useful water capacity (%)	4.4	4.5	3.4	2.9	-
Total water capacity (%)	43	41	36	32	-
Humus reserve (t/ha)	81	38	50	29	-

Shelterbelts characteristics

For shelterbelts planting, manual and mechanical methods were compared.

The mechanized planting was realized with one 100 hp tractor unit and one special designed planting equipment, supplied by INMA, named EFP 1 and served by 2 workers (Figure 4). The planting material was previously sorted and prepared (shaping the roots and shortening the stem) a few hours before planting.

Mechanized planting has advantages over manual planting due to the high yield at planting (up to 2 ha planted/day), shortening the planting period and costs are reduced by up to 30-40% compared to manual planting.

Figure 4. Mechanical planting

In the first year of vegetation, the plants form Grădiștea area [the composition of 60% Turkestan elm (*Ulmus pumila*) and 40% honey locust (*Gleditsia triacanthos*)] had shoots growths of 50-80 cm (Figure 5).

Figure 5. First year shelterbelt, in Grădiștea

In the second year of vegetation, in Grădiștea area, intense growths of shoots, exceeding 3 m were observed, which on certain areas already took form a massif vegetation, with the first positive effects becoming visible (Figure 6).

Figure 6. Second year shelterbelt, in Grădiștea

Figure 7. First year shelterbelt, in Perișoru

In Perișoru area, on the typical chernozem, the one year young plants had better growths (Figure 7) and they achieved an average annual growths of 173.6 cm, 73% higher than the plants growths in Grădiștea area, on the alluvial soil, where the average annual growths are 74.2 cm in the second year (Figure 8).

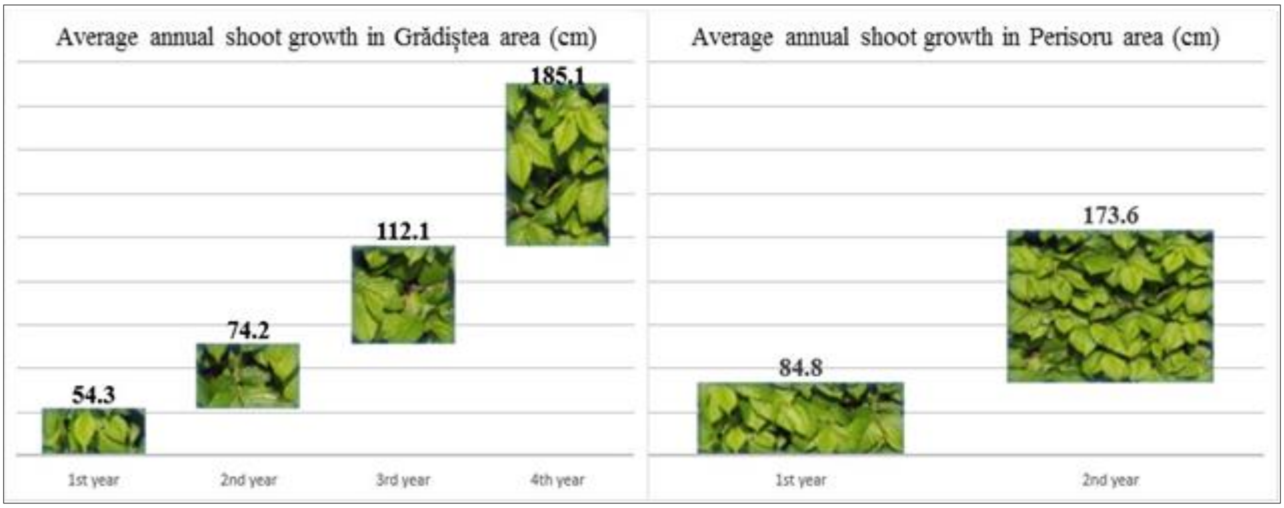

Figure 8. Average annual shoot growth in the two locations (in cm)

The lower growths in the first year of vegetation are due to the seedlings shortening (shortening the one-year trees in the spring, after planting) to better development the root system. Still, the growing speed difference between tree species is obvious if we compare the average plant height in the two locations (Table 5).

Table 5. Average plants height (cm)

Location	1st year	2nd year	3rd year	4th year
Grădiștea	54.3	128.5	186.3	297.2
Perișoru	84.8	258.4	-	-
Difference	52.5	130.1	-	-

Based on the measurements made after a year of vegetation, we found a growth difference of +22.3 cm compared to the plants in the control sample. The research will continue in the 2021 spring with biometric measurements of both the crown and the root system.

The vigorous development of the trees crown might be due to the nutrient-rich substrate and a good aerohydric regime favorable to plant growth, constituting an advantage to take over the protection function faster.

Although the oak from the 3rd year achieves amazing growths in the area (Figure 9), the shelterbelts made of Turkestan elm and honey locust have a better development, will quickly form a compact green wall, reducing maintenance costs, taking over the protection function with at least 3 years earlier than those with oak and making a significant change in the microclimate in the area.

Figure 9. Brown oak in Grădiștea, 4th year

During the vegetative dormancy period, interventions were carried out regarding the grooming of shelterbelts young plants, which consists in cutting greedy shoots and shortening non-compliant branches. During the vegetation period, works were carried out on the application of phytosanitary treatments and foliar fertilization (2 treatments / year). By applying two treatments with foliar fertilizers, intense increases of shoots up to 80-100 cm were found, compared to the untreated control specimens that had increases of 25-30 cm.

Based on the four years experiences, an analysis of the costs will be carried out, to supply relevant information to the farmers regarding the costs and benefits for the establishment of a shelterbelts. For example, for one ha, for the first year the planting and maintenance costs were under 2000 euros.

It is important to mention that due to the feedback from farmers, we understood that some results were already obvious to them and our practical demonstration was able to draw their attention to this simple method to increase the productive potential of agroecosystems that are otherwise very affected by climate change and extreme weather hazards using shelterbelts, in Southeastern part Romania. By analyzing the multiple aspects of soil health that are impacted by the presence of shelterbelts and disseminating the results among locals and farmers, we aim to revive agroforestry concepts in the Southern part of Romania. Inside SEDMAGRO project, financed by UEFISCDI our team aimed to improve the soil analysis concept by combining the analysis of soil physical (21 parameters) and chemical (6 macroelements, 7 microelements, 8 heavy metals) characteristics with the analysis of microbiological indicators, as alkaline phosphatase, acid phosphatase, in filed soil respiration, bacterial and fungi population indices and macro biological indicators, as number of species, biomass, and abundance of earthworms and other macrobiota. Such analysis should attempt to demonstrate that soil and crops health can be promoted not only by adding microbial inoculants in the soil, but also by creating a favorable environment in which natural microbiota grows and develops at their best.

CONCLUSIONS

In both locations, despites the similar technologies applied for planting and maintenance, significant differences in annual growth were visible, mainly due to soil initial fertility and the composition of the shelterbelt. For future trials, the use of appropriate microbial inoculants at planting, is intended.

Both afforestation compositions have proven their effectiveness. The honey locust and Turkestan elm mix are able to play is protective function since the 3rd-4th year, while the oak based shelterbelt would most probably require 5-6 years.

Considering the current climate change challenges (severe droughts, high rainfall aggression, strong winds, heavy evaporation, etc.), and socio-economic challenges, as lack of manual labour and financing for set-up costs, we consider that the technology that was applied can serve as a model for farmers and landowners.

Considering all presented above, we recommend farmers to set up shelterbelts to protect agricultural fields. The decisive argument is of economic relevance: shelterbelts higher than 10 m high, that takes 4-5% of the agricultural area can bring back a surplus of 30-50% on production.

ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian Ministry of Research and Innovation, CCCDI-UEFISCDI, project number PN-III-P1-1.2-PCCDI-2017-0301/ 28PCCDI, within PNCDI III.

REFERENCES

Andreu, M.G., Tamang, B., Friedman, H., Rockwood, D., 2008. *The benefits of windbreaks for Florida Growers*. Historical factsheets of UF, UF School of Forest Resources and Conservation, 6: 1-5. https://journals.flvc.org/edis/article/view/117445

Chendev, Y.G., Sauer, T.J., Ramirez, G.H., Burras, C.L., 2015. *History of East European chernozem soil degradation; Protection and restoration by tree windbreaks in the Russian steppe*. Sustainability, 7(1): 705-724.

Constandache, C., Nistor, S., Untaru, M., 2012. *Research on the behavior of some species of trees and shrubs in the composition of forest protection curtains in Romania*. Revista de Silvicultură şi Cinegetică, 30: 34-44. (In Romanian)

Constandache, C., Peticilă, A., Dincă, L., Vasile, D., 2016. *The usage of sea buckthorn (Hippophaë rhamnoides L.) for improving Romania's degraded lands*. AgroLife Scientific Journal, 5(2): 50-58.

Costăchescu, C., Dănescu, F., Mihăilă, E., Niţu, D., Ianculescu, M., 2012. *Technical solutions for the construction of curtain networks for afforestation of agricultural lands in the Romanian Plain and the Dobrogea Plateau*. Revista de Silvicultură şi Cinegetică, 30: 48-55. (In Romanian)

Dănescu, F., Costăchescu, C., Petrila, M., 2007. *Substantiation study of the need to install shelterbelts to protect the field in Constanţa County*. Analele ICAS: 1-8. (In Romanian) doi:10.3390/su7010705

Enescu, C.M., 2018, *Which shrub species should be used for the establishment of field shelterbelts in Romania?* Scientific Papers, Series A, Agronomy, LXI: 464-469.

Giurgiu, V., 1995. *Protection and sustainable development of Romania's forests*. Editura Arta grafică, Bucureşti. (In Romanian)

ICPA, 1987. *Methodology for elaborating pedological studies*. Volume III: 25-111.

Kort, J., 1988. *Benefits of windbreaks to field and forage crops.* Agriculture, Ecosystems and Environment, 22/23: 165-190.

Miloserdov, N.M., 1989. *Shelterbelts and the yield of winter barley*. Lesnoe Khozyaistvo, 7: 39-41. (In Russian)

Mize, C.W., Brandle, J.R., Schoeneberger, M.M., Bentrup, G., 2008. *Ecological development and function of shelterbelts in temperate North America*. In: Jose, S., Gordon, A.M. (eds.), Toward Agroforestry Design. Advances in Agroforestry, Springer, Dordrecht, 4: 27-54. doi:10.1007/978-1-4020-6572-9_3

Popov, E., Hinkov, G., Kachova, V., Constandache, C., Dincă, L., 2017. *A brief review of forest shelter belt establishments în Bulgaria and Romania*. Revista de Silvicultură şi Cinegetică, 41: 16-23.

Rubțov, Ș., 1947. *Contributions to the problem of shelterbelts in Romania*. Editura autorului, Târgu Mureș. (In Romanian)

Shaw, D., 1988. *The design and use of living snow fences in North America*. Agriculture, Ecosystems and Environment, 22/23: 351-362.

Szigeti, N., Frank, N., Vityi, A., 2020. *The multifunctional role of shelterbelts in intensively managed agricultural land - silvoarable agroforestry in Hungary*. Acta Silvatica et Lignaria Hungarica, 16(1): 19-38. doi:10.37045/aslh-2020-0002

Vasilescu, M.M., 2004. *Forest protection curtains - historical, problematic, stages in the development of the concept of curtains*. The Forest Journal, 6: 7-14.