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RESEARCH ON THE INFLUENCE OF THE CONSERVATIVE TILLAGE SYSTEM ON MAIZE CULTURE, AN AGROTECHNICAL AND ECONOMIC ALTERNATIVE FOR SUSTAINABLE AGRICULTURE, UNDER THE CONDITIONS OF A.R.D.S. PITESTI - ALBOTA

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Abstract

The research was carried out in the experimental field in the ARDS Pitesti area on the typical luvosol soil. The paper contains results obtained in 2022 regarding the effect of pedo-ameliorative and basic soil works - classic and unconventional system direct sowing - on agricultural maize crops. The yields were influenced by the factors studied (scarified, nonscarified; the working depth of the basic soil works), but also by the climatic conditions recorded during the research period. The average grain maize yield in 2022 was 7707 kg/ha in the conventional system with the scarified soil variant and 6681 kg/ha in the conventional system with the nonscarified soil variant with a difference of 1026 kg/ha in the advantage of the scarified soil variants. From an economic point of view, the most efficient soil tillage system, in the ARDS Pitesti-Albota area, for maize culture is the conventional deep plowing scarified system that ensures superior profitability compared to the conservative system sown directly because of the achieved yield.

Key words: *direct sowing, economic efficiency, maize yield, tillage system*.

INTRODUCTION

Currently, the conservative (unconventional) works of the soil define extremely varied processes, from direct sowing (no-tillage, direct drill) in unprocessed soil to deep loosening without turning the furrow. Between these two extremes there are variants such as: reduced works (classically rationalized), minimum works (with coverage below 30%, minimum tillage), minimum works with vegetal mulch (with coverage over 30%, tillage mulch), sowing on balls (ridge tillage), partial works or in strips (strip till, till areas), works with protective layer (cover crops, catch crops) etc. This terminology highlights the specific character that defines that process applied at a certain time, in a certain area, in accordance with the local specificity (Griffith et al., 1992; Horn and Arvidsson, 2000; Moroizumi and Horino, 2002; Guș et al., 2003). Maize is an important agricultural crop, both in Romania and globally, which is evident from the extensive areas on which it is cultivated and the place it occupies in the structure of agricultural crops. Soil work has been a fundamental part of agriculture since the beginning and served several important purposes: preparing the germination bed, reducing soil compaction in order to increase aeration and better development of the plant root system, reducing the degree of weeding, incorporating fertilizers and amendments, managing plant debris (Niţă, 2007; Niţă et al., 2018, Niţă et al., 2019).

These conservative technologies have significantly contributed to strengthening and improvement of soil fertility and productivity and consequently other environmental resources (Guș, 1997).

For reducing fuel consumption and to avoid increased soil subsidence through repeated machines passing on the ground that lead to the worsening of the physical properties of soil, it acts in the direction of the number of soil works or to perform, in a single pass, a multiple operations through minimum system works (Șimon et al., 2013).

Changing yield technologies, through the use of performance machines, as we all know, require extensive research to understand their long-term effects on the physical, chemical and biological properties of soils (Mihalache, 2012; 2015; Marin, 2015).
In the concept of sustainable agriculture development, it is unanimously accepted that there is no valid universal tillage system due to local differences, especially climate and soil, but also due to the technical level of equipment. Soil conservation systems in different areas must have specific characteristics in relation to the ecological particularities of the place and the technological characteristics of the cultivated plants, so that differentiation becomes mandatory (Canarache, 1999; Guş et al., 2004).
The maize, being a species with a high diversity of varieties, with many genetic, morphological and physiological differences, is considered a plant with high ecological plasticity, respectively easily adaptable to environmental conditions (Carena, 2010; Tritean, 2015).
According to the research carried out, it shows that maize is picky about tillage, soil type, climatic conditions, yield results confirming this (Chetan et al., 2014).
The research carried out confirms that the work which include plowing have a major impact on soil structure and fertility (El Titi, 2003), bare soil is exposed to the precipitation and the wind that accentuates erosion processes, productivity reduction and quality (Lal et al., 2007).
The main characteristic of minimum tillage systems is soil conservation, maintaining a proper soil organic matter ratio and amelioration the activity of microorganisms (Ulich et al., 2006; Sarauskis et al., 2009).

MATERIALS AND METHODS

The paper analyzes and presents the results of the research carried out in the year 2022, on some systems and variants of soil works for the maize yield, under the conditions of the ARDS Pitesti-Albota and their correlation with the obtained yields.
The final purpose of these experiences is the establishment of the best tillage system, in the pedoclimatic conditions of ARDS Pitesti-Albota, following the yield results obtained.
The experience had a stationary character and was located in the experimental field of ARDS Pitesti, located at an altitude of 287 m, latitude of 44°51'30", 24°52'30″ in the year 2022, in a three-year crop rotation: 1. weeding plants (maize); 2. annual leguminous plants (peas); 3. grains (wheat).
The soil on which the research was carried out is a typical luvosol, with a clay texture (clay content 46%), poorly supplied with nitrogen and phosphorus (Nt = 0.130 %mg, PAL 33 mg/kg), moderately supplied with potassium (KAL = 89 mg./kg) with a humus content in the arable horizon of 2.26% and pH = 5.3.
The experimental scheme used (Table 1) was that of subdivided plots laid out according to the method of completely randomized blocks in four repetitions.

Table 1.The experimental scheme

SPECIFICATION	Soil tillage variant (B)
A1 SCARIFIED SOIL	b1- deep plowing 28-30 cm b2- normal plowing 23-25 cm b3-disc b4- direct sowing
A2 NONSARIFIED SOIL	b1-deep plowing 28-30 cm; b2- normal plowing 23-25 cm b3-disc b4- direct sowing

The main plots were assigned both in scarified soil and in nonscarified land, and the subplots, for tillage systems, contain four plots each with the gradations: (deep plowing, normal plowing, disc and direct sowing).
The surface of an individual plot was 560 m^2 (5.6 x 100 m).
The influence of tillage systems was determined under loosening and no-tilling conditions, work carried out only at the establishment of the experiment, in the fall of 2021 with the scarifier MAS 5 at a depth of 40-45 cm, the maize crop benefiting from the effects of loosening in the first year of culture.
The vegetable remains of the preceding crop (straw) were chopped and spread evenly on the land, simultaneously with its harvesting. In the spring, two weeks before sowing, a total weeding with glyphosate active substance (1 kg/ha) was applied to the uncultivated plots to control weeds.

Sowing in the conventional system was carried out on the date 15.04.2022, with the SPC8 sowing machine, at a sowing depth of 4-5 cm, using the Olt maize hybrid with good adaptability to the climatic conditions in the area, with a norm of seed of 20 kg/ha, corresponding to a sowing density of 58.000 germinating seeds/ha, and in the non-conventional no-till system sown directly in the stubble, the sowing was also carried out on the date 15.04.2022, with the Mzuri Pro-Til 3T Select sowing machine of at ETU-Farm, observing the same strict technological conditions as in the conventional system.

Before sowing, $N_{16}P_{16}K_{16}$ complex fertilizers were applied, 60 kg s.a./ha.

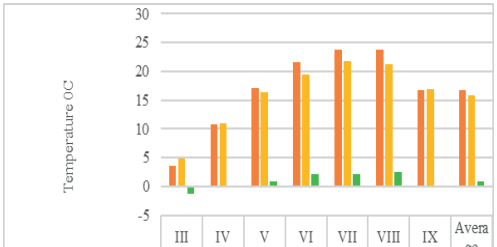
Immediately after sowing, the entire surface was herbicided with Dual Gold, 1.3 l/ha and Gardoprim, 4l/ha. The crop harvesting was carried out on the date 16.09.2022.

The experimental data were processed through variance analysis and the establishment of limit differences (Anova test).

From the climate point of view, ARDS Pitesti is located in an area with a temperate continental climate, with a multiannual average temperature of the last 50 years of 10.7°C.

Temperatures and rainfall registered during the agricultural year (March-September) were monitored for maize, in order to follow the influence of environmental factors on the evolution of plants from the first phases of vegetation to harvesting.

Climatic data were registered at the meteorological station of ARDS Pitesti Albota, located about 750 m from the experimental field. The climatic conditions of the research years 2022 are presented in Figure 1.

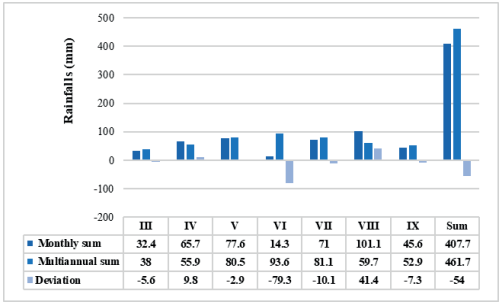


	III	IV	V	VI	VII	VIII	IX	Average
Monthly average	3.61	10.77	17.1	21.6	23.77	23.73	16.69	16.75
Multiannual average	4.8	10.9	16.3	19.5	21.7	21.3	16.9	15.91
Deviation	-1.19	-0.13	0.8	2.1	2.07	2.43	-0.21	0.84

Figure 1. The monthly average temperature registered in the period March-September 2022

The climate data of the 7 months characterizes the year 2022 as hot and dry, an atypical year, with low temperatures in March and April (with negative deviation from the multiannual average of: -1.19°C in March and April and with positive deviation in the months May (0.8°C), June (2.1°C), July (2.07°C) and August (2.43°C), with large day-night temperature alternations, but also from day to day and with quantitatively lower precipitation than multiannual average (Figure 1).

In the 2022 agricultural year, the average annual temperature was 16.75°C, exceeding the multiannual average temperature of 15.91°C by 0.84°C (Figure 1).



	III	IV	V	VI	VII	VIII	IX	Sum
Monthly sum	32.4	65.7	77.6	14.3	71	101.1	45.6	407.7
Multiannual sum	38	55.9	80.5	93.6	81.1	59.7	52.9	461.7
Deviation	-5.6	9.8	-2.9	-79.3	-10.1	41.4	-7.3	-54

Figure 2. The monthly sum rainfall registered in the period March-September 2022

The multiannual sum rainfalls are 683.1 mm. It should be emphasized that their distribution is totally uneven, both from one year to another and within a year.

The rainfalls sum registered in the period March - September 2022 was 407.7, with a deficit of -54 mm, than the multiannual sum of 461.7 mm (Figure 2).

RESULTS AND DISCUSSIONS

The increase in the average annual temperature, as well as the uneven distribution of precipitation, inevitably leads to the approach of unconventional tillage options that facilitate the accumulation and preservation of water in the soil (Popa et al., 2019; Cheţan, 2020; Cheţan et al., 2021).

The basic soil works carried out in the two systems: classic system with plowing and conservative direct seeding system experienced in the Agrotechnics-Soil Works laboratory at the ARDS Pitesti-Albota, influenced the yields.

The yields were influenced by the factors studied (scarified, not scarified; the working depth of the basic soil works), but also by the climatic conditions recorded during the research period.

The influence of the tillage system on the average height of the maize crop

In the version sown directly in the stubble due to the presence of plant residues on the surface, a lower temperature, a higher relative humidity, a lower development of the root system is recorded in the soil, which causes the phenomenon of slow plant growth, in the first part of the vegetation period. As the plants advance in vegetation, the gap in their growth and development gradually diminishes, so that until the flowering and maturity of the plants, the differences between the tillage variants are reduced (Figure 3).

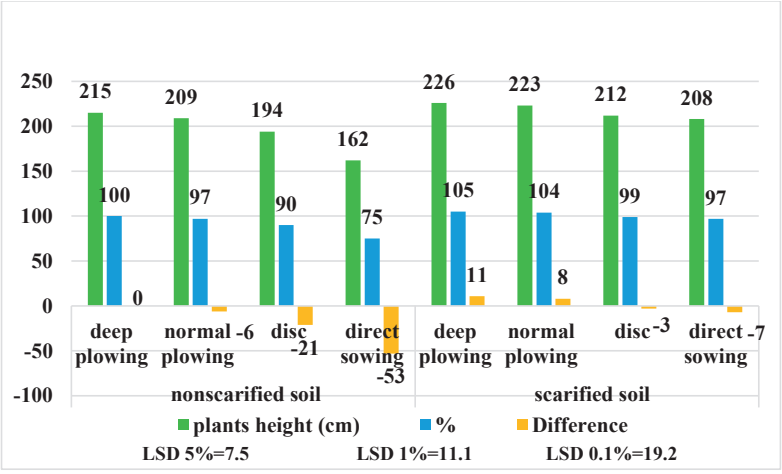


Figure 3. The influence of the tillage system on the average height of the maize crop

The influence of the pedoameliorative and basic soil work system on the maize crop

In Figure 4 shows results regarding the effect of applying the pedoameliorative and basic soil work system to the maize crop.

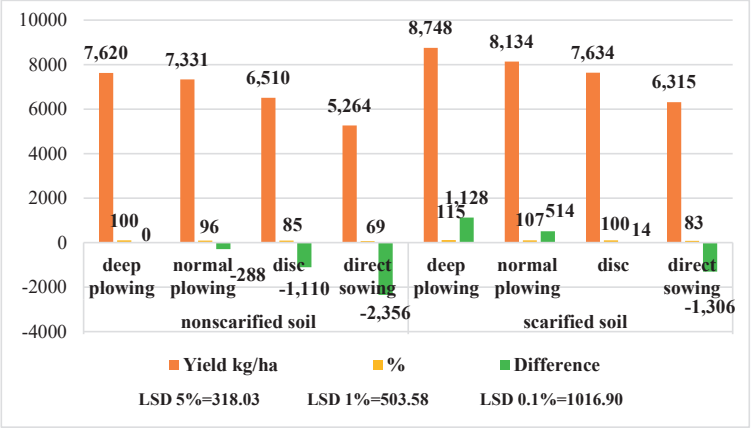


Figure 4. Grain maize yield (kg/ha)

The pedoameliorative work (scarification) of the soil carried out in 2021 brought increases in yield in both tillage systems in the experimental field.

The average grain yield in 2022 was 7,707 kg/ha in the scarified soil variant and 6,681 kg/ha in the nonscarified soil variant with a difference of 1,026 kg/ha in favor of the scarified soil variants.

The average grain maize yield in 2022 with the highest value was recorded in the conventional system, the scarified soil variant, deep plowed with a value of 8,748 kg/ha, followed by the normal plowed scarified soil variant with 8,134 kg/ha, discussed with 7,634 kg/ha and directly sown with 6,315 kg/ha and as yield with the lowest value was registered in the conservative system nonscarified soil directly sown with only 5,264 kg/ha.

From the results obtained, it is found that the value of grain maize yield, in the conventional tillage system, is higher than in the conservative direct sowing system. Comparing the two tillage systems, a difference of 2,356 kg/ha is observed, in the variants with nonscarified soil and a difference of 1,306 kg/ha in the variants with scarified soil.

The influence of the pedoameliorative and basic soil work system on total biomass yield

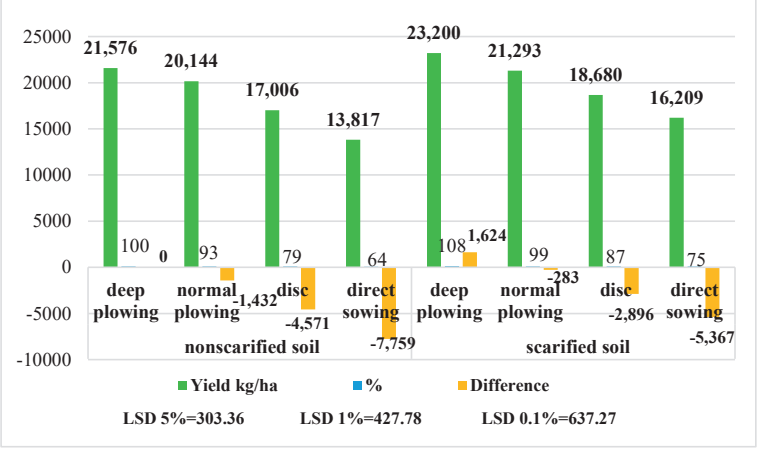


Figure 5. Maize Biomass yield (kg/ha)

Following the influence of the pedoameliorative and basic soil works system on the total biomass yield in the nonscarified soil variant, it can be observed, from the data presented in Figure 5, that in the period of 2022, the highest yield in the experimental area was recorded in the deep plowed variant (28-30 cm), with a value of 21,576 kg/ha, followed by the normal plow variant with a yield of 20,144 kg/ha, disc with a yield of 17,006 kg/ha, respectively direct sowing 13,817 kg/ha.

In the scarified soil variant, the highest biomass yield value of the Olt hybrid maize was also recorded in the deep plowed variant, 23,200 kg/ha, followed by the normal plowed variant, 21,293 kg/ha, disk 18,680 kg/ha and direct sowing 16,209 kg/ha.

The conservative system registers very significantly negative differences compared to the conventional system with values of 7,759 kg/ha, in the nonscarified soil variant and of 5,367 kg/ha in the scarified soil variant.

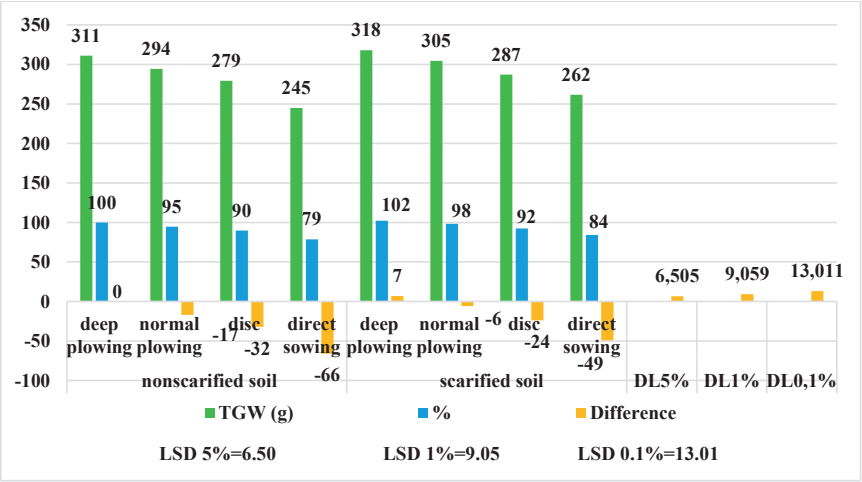


Figure 6. The influence of the system of pedoameliorative and basic soil works on the absolute mass of TGW

Influenced by the tillage system, the average thousand grain weight of the maize Olt hybrid varies with statistically assured differences in the conventional system versus the conservative system. Thus, compared to the conventional system, in the direct sown conservative system, the thousand grain weight (TGW) was -66 g lower in the direct sown nonscarified soil variant and -49 g lower in the scarified soil variant, both differences being very significantly negative from a statistical point of view (Figure 6).

Economic efficiency of maize crop, comparison between soil tillage (lei/ha)

The main characteristic of conservative systems refers to the reduction of fuel consumption by reducing or eliminating the number of technological works to reduce costs in order to achieve agricultural yield. In addition to the fuel economy achieved following the application of conservative tillage systems, the degree of soil degradation and environmental pollution with CO_2 is reduced. In order to introduce some tillage variants in a technology of cultivated plants, it is necessary to know the level of suitability of the soil for different processing methods.

The main agrotechnical factors (soil work, fertilization, plant protection and harvesting) are the biggest energy consumers, soil work and crop fertilization being technological stages at which, by introducing conservative systems, the necessary costs to apply an optimal technology to agricultural crops can be reduced. In the conservative system, on nonscarified soil, the fuel consumption was 38.6 l/ha, while in the classic system the fuel consumption was 66.4 l/ha. Comparing the two tillage systems shows a higher fuel consumption in the classic system by 27.8 l/ha.

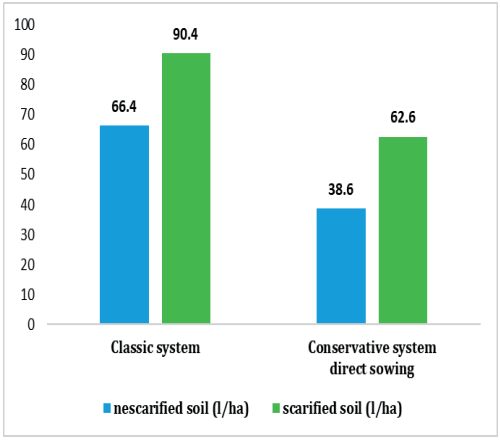


Figure 7. Total diesel consumption (l/ha)

On the scarified soil, in the conservative tillage system, the fuel consumption was 62.6 l/ha, while in the classic system the fuel consumption was 90.4 l/ha (Figure 7).

The fuel consumption was influenced by the tillage method. Scarification, soil improvement

work and ploughing, as a basic work, consume the largest amount of fuel in the total of a culture system (24 l/ha and 22 l/ha respectively).

The average grain maize yield in 2022 was 8748 kg/ha in the conventional system with the scarified soil variant and 7260 kg/ha in the conventional system with the nonscarified soil variant with a difference of 1488 kg/ha in favor of the scarified soil variants (Figures 7, 8). In the conservative system, the average grain maize yield in 2022 was 6315 kg/ha in the scarified soil variant and 5264 kg/ha in the nonscarified soil variant, with a difference of 1051 kg/ha in favor of the scarified soil variants.

From the analysis of the presented data, it follows that the scarification work brings a significant increase in yield to both soil work systems, achieving a profit of 1858 lei/ha in the conventional system and 1159 lei/ha in the conservative system.

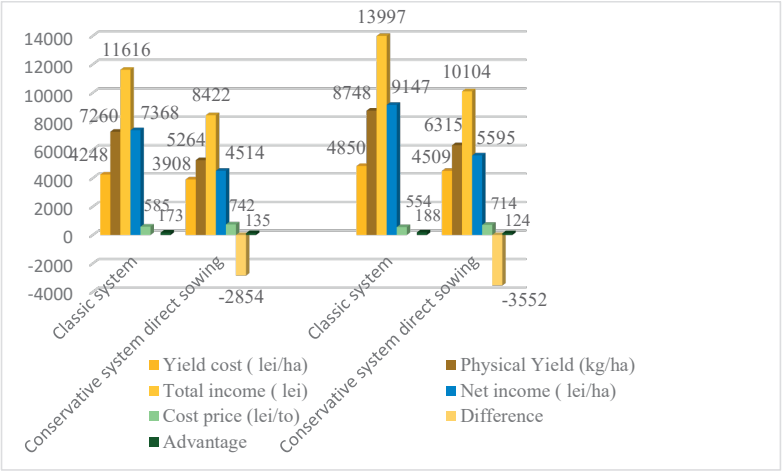


Figure 8. Economic efficiency of maize crop, comparison between soil tillage systems - nonscarified soil and scarified soil

Although the scarification work has a high cost price (523 lei/ha), I recommend that it be executed, because it has a high economic efficiency and a number of advantages by changing the physico-chemical and biological conditions in the soil, as well as a regime favorable aerohydric, which positively influences plant development and current yields. Referring to the total expenses for the achievement of a work system, we observe from table 2 that in the classic system the cost is 4248 lei/ha, and when is applied the conservative system (direct sowing) the cost is reduced by 8.1%, 3908 lei/ha, in the nonscarified soil.

The cost of the necessary materials (seed, pesticides, etc.) is the same in the two tillage systems and represents the largest part of the total technology, reaching up to 2085 lei/ha.

The highest profit value was recorded in the conventional system, the scarified soil variant (9147 lei) with a higher yield compared to the value recorded in the conservative system.

In the results presented in Table 2, the conventional system with nonscarified soil generates a yield of 1.73 lei per 1 leu of operating expenses, while the direct seeded system generates 1.15 lei of profit per 1 leu of operating expenses.

In the conventional system, in the scarified soil variant, the yield is 1.88 lei per 1 leu of operating expenses compared to the conservative, direct-sown system where the yield was 1.24 lei profit per 1 leu of operating expenses.

From an economic point of view, the most profitable type of tillage was in the classic deep plowed scarified system (28-30 cm), because of average operating costs of 4850 lei/ha, and through a good yield of 8748 kg/ha, this generating an average profit of 9147 lei/ha and a yield of 1,88 lei profit per 1 leu spent on

establishing, maintaining and harvesting the crop (Table 2).
At the opposite pole, the lowest average profit was recorded for the work in the direct sown conservative system, with a value of 4514 lei/ha and a yield of 1.15 lei, recording exploitation costs lower than 3908 lei/ha, but also a yield lower than 5425 kg/ha.

Table 2. Economic efficiency of maize crop, comparison between soil tillage systems

Soil tillage systems		Yield Cost lei/ha	Earned income lei/ha	Advantage/ profit lei/ha	Randament* lei
Conventional system	nonscarified	4248	11616	7368	1.73
	scarified	4850	13997	9147	1.88
Conservativ system direct sowing	nonscarified	3908	8422	4514	1.15
	scarified	4509	10099	5590	1.24

*The yield per surface unit (hectare), representing the amount of net profit obtained per 1 leu of allocated operating expenses

CONCLUSIONS

The yields were influenced by the factors studied (scarified, nonscarified; the working depth of the basic soil works), but also by the climatic conditions recorded during the research time.
The average grain yield of the Olt maize hybrid obtained in 2022, under the influence of the soil tillage system in the ARDS Pitesti-Albota area, was very significantly reduced under the conditions of applying the minimum soil tillage system directly sown both in the variant scarified soil, as well as in the variant with nonscarified soil.
The average grain maize yield in the direct sown conservative system was 5264 kg/ha in the nonscarified version, -3484 kg/ha lower than the yield value recorded in the conventional system, in the nonscarified soil version. In the conservative system directly sown scarified soil variant, the average yield of the Olt hybrid was 6314 kg/ha, -2434 kg/ha lower than in the conventional deeply plowed scarified system where the value is 8748 kg/ha.
Through the influence of the type of tillage on the yield of grains obtained in 2022, the highest yields are recorded for deep plowing (28-30 cm), for all the researched variants, with values between 7620 kg/ha (nonscarified version) and 8748 kg/ha (scarified version). The increases in yield obtained with the deep plowed variant compared to the other variants were statistically ensured, with values between: -615 kg/ha (normal plowed variant); -1114 kg/ha (discussed version); and -2434 kg/ha (direct sowing variant).
The lowest yields, with very significantly negative differences compared to the deep plowed variant, were recorded for the direct seeding operation, both in scarified and nonscarified soil conditions.
The influence of the tillage system on the thousand grain weight (TGW) obtained in 2022 is manifested by its significant reduction under the conditions of the application of the direct sown conservative system both in the scarified soil and in the nonscarified soil variant.
The average TGW of maize for which specific works were applied to the direct sown conservative system was 245 g in the nonscarified soil variant, -66 g lower than the value recorded in the conventional system, in the nonscarified soil variant. In the scarified soil variant, the thousand grain weight in the direct sown conservative system was 262 g, -56 g less than in the conventional system.
The influence of the type of tillage on the thousand grain weight is distinguished by recording the highest values of the indicator for deep plowing, both in the nonscarified soil and in the one with scarified soil. For this type of work, the TGW values were between 311 g, the variant with nonscarified soil and 318 g, the variant with scarified soil.
The classic system with the deep plowing variant recorded the highest TGW values between 311g of nonscarified soil and 318 g of scarified soil.
The lowest values of TGW were obtained in the direct sown conservative system of 245 g in the nonscarified soil variant and 262 g in the scarified soil variant.
The scarification work brings a significant increase in yield to both soil work systems, making a profit of 1858 lei/ha in the conventional system and 1159 lei/ha in the conservative system.
The most profitable tillage system, in the area of ARDS Pitesti-Albota, is the conventional deep plowing scarified type with an average profit of 9147 lei/ha and a yield of 1.88 lei profit per 1 leu spent on establishing, maintaining and harvesting the crop. At the opposite pole, the lowest average profit was

recorded in the conservative direct sown system with a value of 4514 lei/ha and a yield of 1.15 lei.

The highest profit was obtained by the conventional system in the deeply plowed scarified soil work variant, with a value of 9147 lei/ha and a yield of 1.88 lei.

The lowest profit value, of 4514 lei/ha, was obtained by the conservative direct sowing system, with a yield of 1.15 lei.

From an economic point of view, the most efficient soil tillage system, in the ARDS Pitesti Albota area, for maize culture is the conventional deep plowing scarified system that ensures superior profitability, the conservative system sown directly because of the achieved yield.

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