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THE INFLUENCE OF THE CONSERVATIVE TILLAGE SYSTEM ON THE PEA CROP IN THE PEDOCLIMATIC CONDITIONS OF A.R.D.S. PITESTI

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Abstract

The study presents experimental results obtained in 2023 regarding the effect of pedoameliorative and basic soil works - classical and conservative system (direct sowing) – on the pea crop. The research was carried out in the experimental field in the SCDA Pitești - Albota area on the typical soil-luvosol type. In addition to the factors (scarified, nonscarified, and working depth of basic soil works) that were studied, the research period's climate also had an impact on the yields. In 2023, the scarified soil version produced an average yield of 2715 kg/ha, while the nonscarified soil version produced an average yield of 2476 kg/ha. This represents a 239 kg/ha difference in favor of the scarified soil variants. The conventional deep ploughed scarified system is the most effective tillage method for pea crops in the SCDA Pitesti Albota area. It guaranteed a superior yield when compared to the conservative direct sowing method.

Key words: *conservative system, direct sowing, peas, yield.*

INTRODUCTION

Conservation agriculture is a system of agriculture that aims to protect soil resources by promoting minimal soil disturbance in combination with maintaining permanent soil cover and diversifying crop rotation (Pekrun et al., 2023).

Therefore, conservation agriculture refers to a sustainable cropping system that protects soil from erosion and degradation, increases biodiversity, conserves natural resources and stabilizes yields (Knowler and Bradshaw, 2007; Lahmar, 2010).

Application of Minimum Tillage (MT) and No-Tillage (NT) systems can lead to soil conservation, without affecting crop yields, especially on soils with high initial fertility (Rusu et al., 2015).

Soil conservation tillage, as opposed to conventional tillage, includes no-till and no-till management approaches that aim to minimize the frequency or intensity of tillage operations in an effort to promote certain economic and environmental benefits (Unger and McCalla, 1980). Soil conservation work is also one of the three crop management principles invoked in conservation agriculture (FAO, 2013) and also remains a key component of climate-smart agriculture. The phenomenon of soil conservation has been widely adopted to minimize the degree and frequency of tillage passes and thus mitigate the disturbance of soil aggregates and reduce soil erosion and organic matter losses (Singh et al., 2018).

Arable land is limited to 1.4 billion ha worldwide and efforts must be made to conserve soils, which are threatened by a variety of factors (FAO, 2020). Long-term intensive tillage is one of the main reasons for soil degradation through erosion (Anon, 2002)

The pea (*Pisum sativum* L.*)* is a crop known since antiquity, with a wide ecological and yield potential, it is grown for grains in most countries around the world, the grains being used in food, the processing industry and as fodder. The value of the grains consists of high protein content - up to 27.8%, starch - 43.2% and fats - 1.2%, they are appreciated for their biochemical content (Celac, 2012).

In our country, the first scientific research regarding soil agrotechnics supported the expansion of the "dry farming" strategy, which is highly appreciated in agricultural practice, because it is based on both animal and mechanical agrotechnical works, the good maintenance of physical characteristics of the soil, low energy consumption and effective weed control (Rusu et al., 2009; Marin et al., 2012).

Grain peas draw attention due to their chemical composition, rich in high quality protein substances (high content of the essential amino acids lysine, threonine, and tryptophan), and the presence of large amounts of starch, which confers a special energy value. In three months of vegetation, spring peas can produce 2.5-5 t of dry grains/ha. Dried pea seeds contain 271 kcal/100 g of grains and complex vitamins B, A, K, C. They can be used with good results in poultry feed (2,920 kcal/kg s.u. digestible energy and 88% protein digestibility), ruminants and fattening rams (Roman, 2015).

Pea seeds from intercropping contained 26.75% proteins, 1.42% fats and 38.52% starch, can be said that intercropping had a slight influence on the productivity elements and on the yield (Dusa et. al, 2015).

In the context of forecasted climate change, peas can be the field legume that, in dry areas, due to the short growing season and the fact that it is sown earlier in spring and uses better the moisture accumulated in the soil in the cold season, to perform better compared to other grain legumes (Stoddad et al., 2006).

MATERIALS AND METHODS

In the pedoclimatic circumstances of the ARDS Pitesti-Albota, the study was carried out in 2023 on various systems and variations of soil works for the pea crop. The purpose of this paper is to analyze the research results and their correlation with the yields that were obtained.

The ultimate purpose of carrying out these experiences is to establish, based on obtained yield results, the optimal tillage system for conservative agriculture in the pedoclimatic conditions of the ARDS Pitesti - Albota.

The experience had a stationary character and was located in the experimental field of ARDS Pitesti, located at an altitude of 287 m, northern latitude of 44°51'30", and 24°52'30″ eastern longitude in the year 2023, in a three-year crop rotation (maize - peas - wheat).

The soil on which the research was carried out is a typical luvosol.

The experimental scheme used was that of subdivided plots laid out according to the method of completely randomized blocks in four repetitions.

Within the tillage systems, 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).

Each plot has a surface area of 560 m^2 (5.6 x 100 m^2).

The deep tillage of the soil, the scarification, was only carried out during the experience's establishment in the fall of 2021, with the pea crop benefiting from the loosening's effects in the crop's second year. (Figure 1).

The heavy scarifier MAS 5 was used to carry out the scarification work at a depth of 40-50 cm. This is the optimal soil processing solution after repeated plowing, breaking the hardpan formed by achieving a deep loosening, which contributes to improving the aerohydric regime and increases the amount of water stored in the soil. It's necessary to adapt applied technologies and to make the works in the optimal period (Simon et al., 2016), so as the result should be an efficient use of available water but also the increase of the water reserve in the soil (Marin et al., 2015; Chetan et al., 2016)

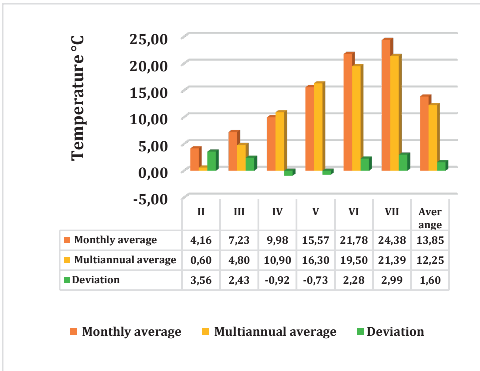
Soil conservation practices are recognized for their advantages in reducing input costs, increasing water use efficiency, and conserving soil carbon (Beare et al., 1994; Liu et al., 2014); and have been adopted on over 155 million hectares of agricultural land globally; which represents 11% of the total arable land worldwide (Kassam et al., 2014). One of the most pronounced benefits of soil conservation works is its ability to improve soil physicochemical properties (Blanco-Canqui et Ruis, 2018).

Deep loosening works are not a lasting solution, because soils are easily recompacted and it seems necessary to repeat them, and over time the intensity of compaction and recompaction increases. For this reason, these works must be complemented by measures to prevent compaction, including long-term rotations with improving plants, organic fertilization and a rational tillage system. The deep loose lands will be destined primarily for hoeing crops, such as maize, sugar beet, potato, etc., which make good use of the created conditions and give significant yield increases. Starting next year, the soil will be used normally, for a wide range of crops. Soils with a high clay content return to their original state of compaction faster than those with medium or light texture.

Figure 1. Scarified 2021 (experimental field)

On March 9, 2023 year, the sowing work was carried out in the classic conventional system with the SUP 29 seeder, using the Avatar pea variety, at a sowing depth of 4-5 cm. To obtain the sowing density of 130 germinating seeds per m^2, we used a seed quantity of 386 kg/ha.
Sowing in the nonconventional no-till system direct sowing was carried out with the Mzuri Pro-Til 3T Select seeder from ETU-Farm, observing the same technological working conditions as in the conventional system on the same date.
I applied complex fertilizers $N_{20}P_{20}K_0$ in a quantity of 60 kg s.a./ha, before sowing.
After sowing the entire area was herbicided preemergently with Dual Gold, 1.3 l/ha (S-metolachlor), and postemergently (in vegetation) we used Pulsar 40 1 l/ha
The direct sown variants benefited from an additional herbicide with Round up Classic (glyphosate from isopropyl amine salt 360 g/l), 3 l/ha due to the higher degree of weeding before sowing.

Regarding pest control, in 2023 we carried out a treatment with the insecticide Faster Gold (lambda cyhalothrin) 150 ml/ha during the flowering phase of the crop.
The crop was harvested on 10.07.2023.
The experimental data were analyzed using variance analysis and the establishment of limit differences (Anova test).
In terms of climate, ARDS Pitesti is situated in a region with a temperate continental climate, characterized by an average temperature of 10.7°C over the past 50 years.
Temperatures and rainfall were observed from February to July in the agricultural year were monitored for pea, in order to follow how environmental factors affect the evolution of pea plants from early stages of vegetation to harvesting.
Climatic data were recorded at the ARDS Pitesti - Albota meteorological station, which is situated approximately 750 meters away from the experimental field. Figure 2 presents the climatic conditions of the research years 2023.



	II	III	IV	V	VI	VII	Average
Monthly average	4,16	7,23	9,98	15,57	21,78	24,38	13,85
Multiannual average	0,60	4,80	10,90	16,30	19,50	21,39	12,25
Deviation	3,56	2,43	-0,92	-0,73	2,28	2,99	1,60

Figure 2. February-July 2023: The average monthly temperature recorded

The temperatures recorded between February and July (the growing season of the pea crop) registered an average positive deviation of 1.6^0C compared to the multiannual average.
In the 2023 agricultural year, the average annual temperature was 13.8^0C, exceeding the multiannual average temperature (12.2^0C) by 1.6^0C (Figure 2).
Thermal stress and high temperatures affect the physiological and biochemical processes from the plants, their research being necessary in relation to the technology applied (Simon et al., 2017).

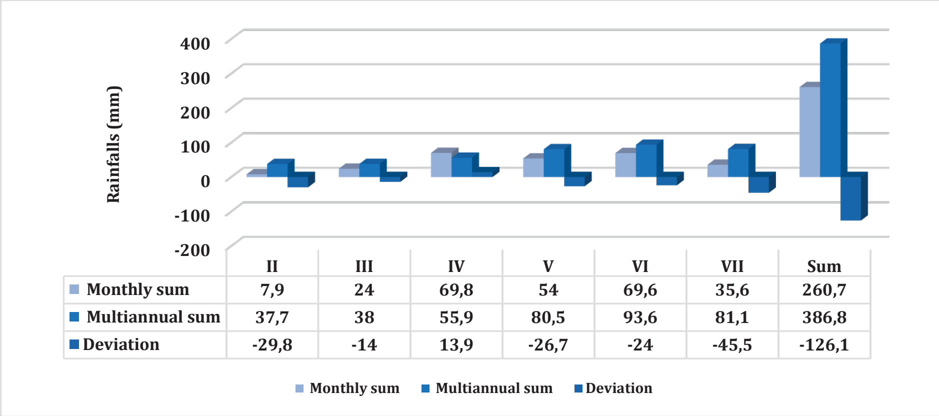


Figure 3. The total amount of rainfall each month from February to July 2023

The multiannual sum rainfalls is 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 from February to July 2023 was 260.7 mm, which was 126.1 mm less than the average sum of 386.8 mm over several years (Figure 3).

The water quantity in the soil available to plants is a crucial factor in determining crop yield.

The application of minimum tillage systems at pea crop leads to a drop in the yield, representing 97.7% from the one of the conventional system, in the case of main yield and 79% in secondary production. Even if the amount of rainfall from the vegetation period corresponds to the value necessary for a good development of pea plants, the non-uniformity of rainfall and its lack during important periods lead to an important decrease of the yield (Simon et al., 2018.

RESULTS AND DISCUSSIONS

The climatic conditions recorded during the research period as well as the studied factors (scarified, non-scarified; working depth of the basic soil works) influenced pea yields.

The number of emerged plants/m^2 is an important element in yield determining because peas do not have twinning capacity and a density too small prevents plants from maintaining their erect stem until maturity.

The determination of the number of emerged plants/m^2 was performed and compared between the two tillage systems, a very important factor regarding the ability of seeds to adapt to different germination conditions.

The best results were registered in the classical tillage system (deep plowed scarified soil variant, control version) where the number of emerged plants/m^2 was 124 while the conservative system sown directly had 83 plants/m^2, 41 lower in scarified soil and 51 lower in nonscarified soil compared to the control variant, showing significant differences and very significant (Figure 4).

In the case of the direct sown conservative system, the number of sprouted plants (83 plants/m^2 in scarified soil and 73 plants/m^2 in nonscarified soil) was largely influenced by the type of soil that is easily compactable and the amount of plant residues that prevented pea seeds to reach the optimal depth (Figure 4).

In the tillage variant in the conservative scarified direct sown system, the number of pods/m^2 achieved was lower than in the classic tillage variant, the difference of 208 pods/m^2 being considered very significantly negative, as can be seen from the Figure 5.

In the scarified soil variant, there was an average of 366 pods/m^2, compared to 345 pods/m^2 in the nonscarified soil variant, resulting in a difference of 21 pods/m^2 in favor of the scarified soil variant.

The highest average number of pea pods was recorded in the conventional system, specifically in the scarified soil variant that was deeply plowed, with 462 pods/m^2. Following closely behind was the normal plowed scarified soil variant with 415 pods/m^2, then the plowed variant with 331 pods/m^2, and sown directly with 254 pods/m^2.

The lowest number of pods/m^2 was in the conservative system's nonscarified directly sown soil, with only 243 pods/m^2. It was observed from the experimental data that there is a higher value of pods/m^2 of peas in the conventional tillage system compared to the conservative direct sowing system (Figure 5).

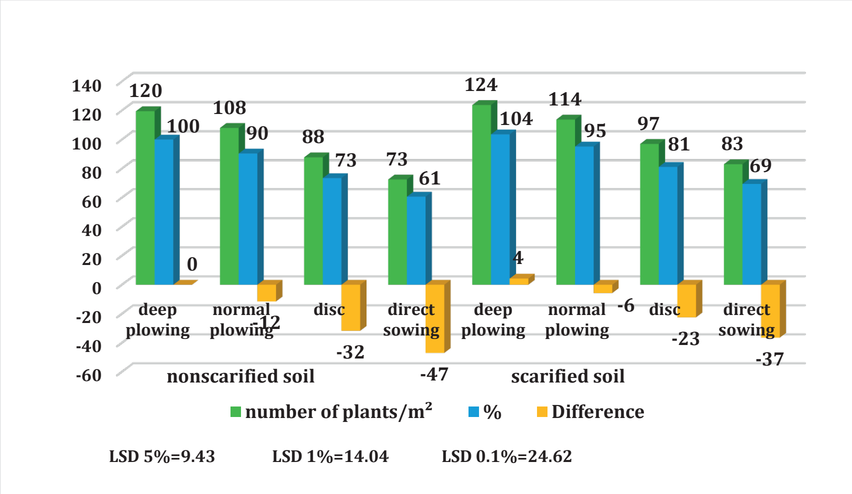


Figure 4. The number of emerged plants

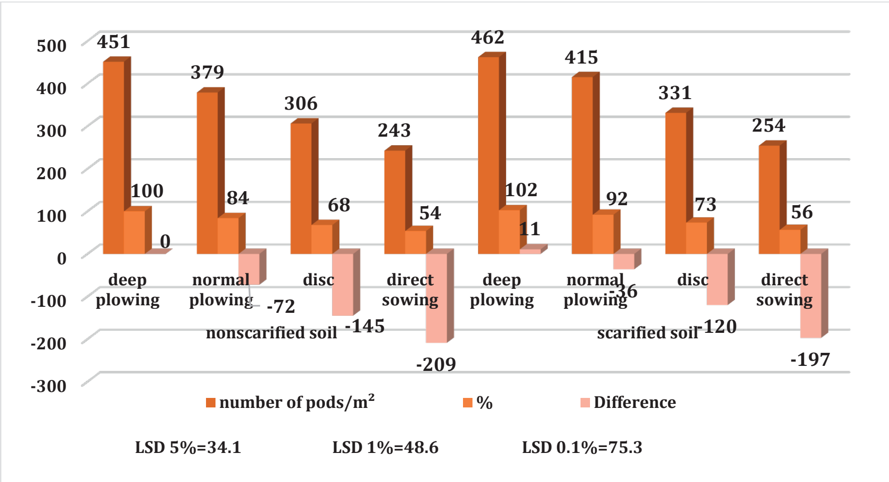


Figure 5. The pea pods crop - average number

The number of grains/m^2 is a very important morpho-productive element in yield determining and can be influenced by experimental factors. In the year 2023, the very large differences recorded in the number of grains achieved between the two systems of traditional conventional soil work and conservative direct sowing were determined by the favorable climatic conditions (Figure 6).

The soil processing method is an important factor in realizing the variety's potential to produce as many grains as possible, and by applying the conservative system, the number of grains is reduced by 708 in the case of the system with minimal tillage (disc), and by 909 in the case of the conservative system sown directly, nonscarified soil, these differences are considered very significantly negative compared to the classical version of tillage, as shown in the Figure 6.

In the scarified soil variant, there was an average of 1433 grains/m^2 of peas, while in the nonscarified soil variant there was an average of 1315 grains/m^2, resulting in a difference of 118 grains/m^2 in favor of the scarified soil variants.

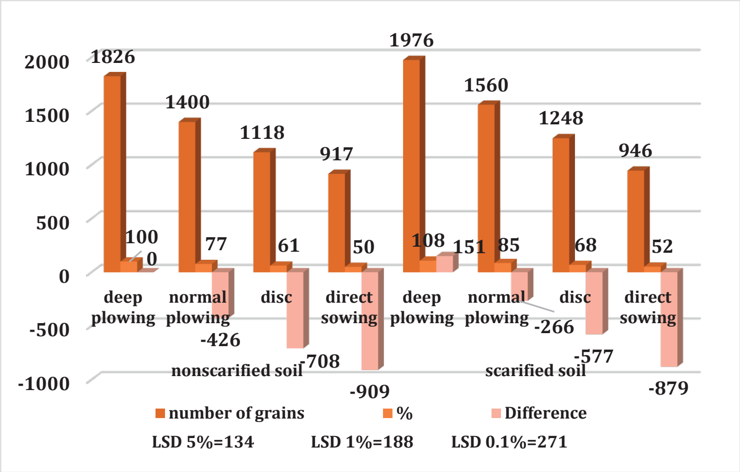


Figure 6. The average number of grains

The conventional system the scarified soil variant, deep plowed had the highest average number of pea grains at 1976 grains/m^2 in the scarified soil variant deep plowed. The normal plowed scarified soil variant followed with 1560 grains/m^2, discussed with 1248 grains/m^2 and directly sown with 946 grains/m^2 while the conservative system nonscarified soil directly sown had the lowest value of 917 grains/m^2 (Figure 6).

The experimental results show that the value of the number of grains/m^2 of peas, in the conventional tillage system, is higher than in the conservative direct sowing system.

The climate of the year under study had a considerable impact on the thousand grain weight (TGW), one of the productivity components examined in this experiment. The results shown in the figure demonstrate the highly significant negative differences of -50 g in the agricultural year 2023.

When the direct sown conservative system is applied, both in the scarified soil variant and in the nonscarified soil variant, the thousand grain weight (TGW) obtained in 2022 is significantly reduced, indicating the influence of the tillage system (Dinuță et Marin, 2023).

The application of the direct sown conservative system resulted in a decrease in TGW of 40 g in the system with minimal work (disc) and 50 g when sowing directly, as can be seen in the figure. These differences are very significantly negative when compared to the classic system where TGW has a value of 235 g. Therefore, the tillage method also had an impact on TGW.

There was a 6 g difference in favor of the scarified soil variant for the thousand grain weight (TGW) of peas, which was 215 g in the scarified soil variant and 209 g in the nonscarified soil variant.

The highest value of the (TGW) for peas in the conventional system, the scarified soil variant, was 237 g in deep plowing. This was followed by 229 g in normal plowing, 205 g in disc, and 188 g in direct sowing. The TGW with the lowest value was recorded in the conservation system, nonscarified soil directly sown, weighing only 185 g (Figure 7).

Tillage in a nonconventional (no-till) direct sowing system results in the pea crop obtaining a lower TGW value compared to the other tillage variants, this being 185 g in nonscarified soil and 188 g in scarified soil by 50 g below the level of the conventional tillage variant of deep plowed nonscarified soil and by 48 g compared to the conventional tillage variant of deep plowed scarified soil (Figure 7).

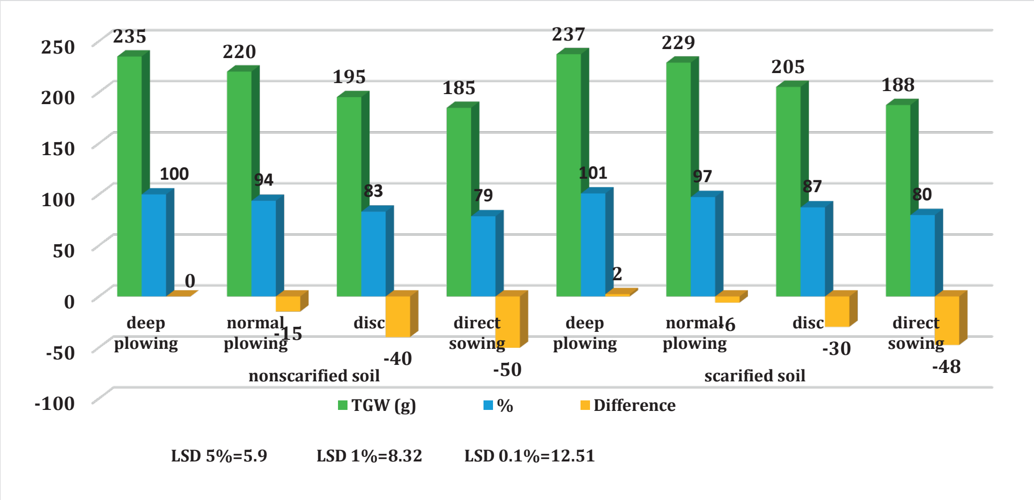


Figure 7. The thousand grain weight (TGW)

Comparing the two tillage systems, a difference of 50 g is observed in the variants with nonscarified soil and of 48 g in those with scarified soil.

The pedoameliorative work (scarification) of the soil carried out in 2021 brought increases in yield in both tillage systems in the experimental field (Dinuță et Marin, 2023).

In 2023, the average pea yield was 2715 kg/ha in the scarified soil variant. In the nonscarified soil variant, the yield recorded a value of 2476 kg/ha, the difference of 239 kg/ha was in favor of the scarified soil variants, the results are presented in Figure 8. It can be observed that in the case of the conservative tillage system (both in the version with nonscarified soil and in the one with scarified soil) there is a decrease in production of -1820 kg/ha respectively -1708 kg/ha, the differences compared to the control variant (the classic conventional system with deep plowed unscarred soil) being very significantly negative (Figure 8).

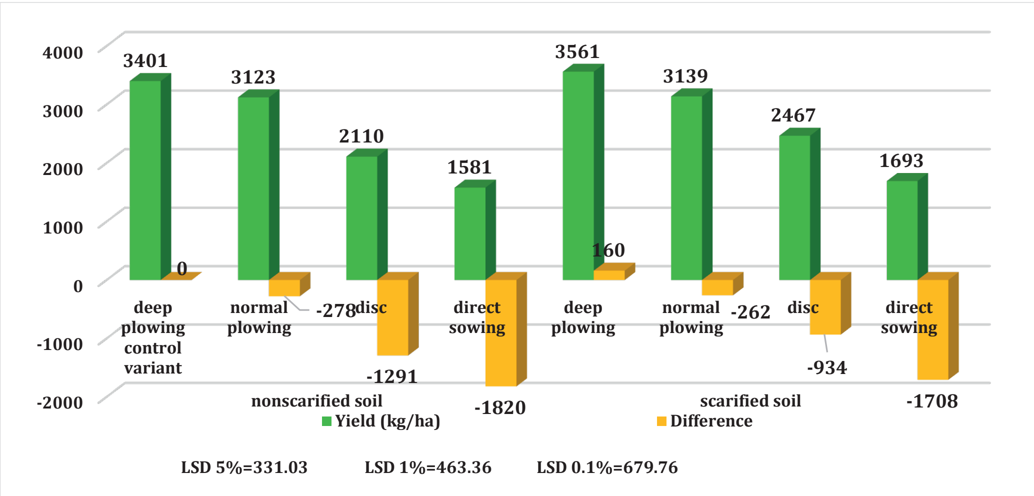


Figure 8. Grain pea yield (kg/ha)

As one can notice in Figure 8, the conventional system's deep plowed scarified soil variant had the highest average grain pea yield in 2023, value of 3561 kg/ha.This was followed by the normal plowed scarified soil variant, which came in at 3139 kg/ha, the discussed version, which came in at 2467 kg/ha, and the direct sown version, which came in at 1693 kg/ha.The conservative system's nonscarified soil, which was directly sown, had the lowest yield, measuring only 1581 kg/ha

CONCLUSIONS

Conservative agriculture is not equally suitable for all area. The need for soil and water conservation requires anticipation of the ongoing process to improve its ecological and socio-economic sustainability.

In terms of the number of emergent plants/m², the best result was recorded in the classic tillage system (deep plowed scarified soil variant, control variant) compared to the conservative direct sown system where the number of plants was lower, the difference from witness being very significantly negative.

In comparison to the conventional method, the plants grow to a considerably lower height when using the conservative tillage system when they are directly sown.

The tillage system also has a great influence on the number of pods, the lowest values were recorded in the case of the conservative direct sowing system, the difference of - 208 pods/m^2 in direct sowing being considered very significantly negative compared to the classic system (Dinuță et Marin, 2023).

A total number of 932 grains/m^2 were recorded in the conservative direct-sown system; this is a very significant decrease when compared to the 1691 grains/m² recorded in the classic conventional system.

In the conservative system, the thousand grain weight (TGW) is 43 g lower than in the classic system, indicating a significant decrease.

The thousand grain weight (TGW) of the pea crop recorded values of 215 g in the scarified soil variant and 209 g in the nonscarified soil variant under the influence of pedoameliorative works (scarified), with a difference of 6 g in favor of the scarified soil variants. After applying the two tillage systems, the conventional (classical) tillage system's HW value changes significantly in favor of it.

The yield was 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.

Regarding the tillage type and the system impact on yield, the direct sown conservative system implementation implies a notable reduction in yield when compared to the classic system on the heavy, acid soils of the Subcarpathian hills.

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