POST-HARVEST RESIDUE TREATMENT EFFECT ON THE WINTER WHEAT PRODUCTIVITY

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ABSTRACT

The investigation was carried out at Dobrudzha Agricultural Institute during 2017-2019. The effects of the traditional (TS) and combining (CS) soil tillage systems and sowing machines, the type of the previous crop post-harvest residue (common bean, maize, sunflower) and their treatment on the yield from cv. Enola (*Triticum aestivum* L.) was investigated in six-field crop rotation. The spring crop post-harvest residues (PHR) were utilized in three different ways - removed from the field (RF); burned (B) and chopped and subsequently incorporated into the soil (CSIS). During the studied period, a wide dynamic was established in the productivity of the wheat, depending on the type of the predecessor and the method of utilization of its plant residues. The traditional system of soil preparation and wheat sowing for the Dobrudhza region provides higher yields compared to the combined system in all years of the study. The average increase is 352.17 kg/ha (6.61%). The role of the predecessor also has a stronger impact on productivity in the TS. The cv. Enola was expected to have the highest yields in both systems after the predecessor bean. The lowest productivity in the experiment was found after the predecessor sunflower, where the biggest difference between the systems was also found - 552.30 kg/ha in favor of the TS. To obtain the maximum expression of the productive possibilities of the wheat, a differentiated approach to the ways in which we will use the post-harvest residues (PHR) of the predecessor and the technical means for this is required. In areas with minimal presence of PHR, the CS of soil preparation and sowing contributes to obtaining 403.3 kg/ha more compared to TS one. However, it is extremely unsuitable in cases of burning the residues or their complete plowing. The use of the TS in such situations provides higher yields compared to the CS with 314.1 kg/ha (B) and 1145.8 kg/ha (CSIS), respectively. The TS definitely contributes to obtaining a larger grain compared to the CS one of the tested predecessors and ways of utilizing their plant residues. The grain hectoliter is mainly influenced by the weather conditions of the years, but not by the sowing systems. Its values do not always follow the established trends for the 1000 kernel weigth and are characterized by a weaker, although reliable, dynamics. Strength of effect of each of the tested factors on the values of the studied indicators was determined. The correlative dependence between the productivity of the variety and the test weight of the grain is reliable. The correlation with TS has higher coefficient values (0.615**) compared to that with CS (0.486**). The relationship between the yield and the and the 1000 kernel weight is negative and unreliable. There is a positive and reliable correlative relationship between the two indicators characterizing grain physics.

KEY WORDS: utilization of post harvest residue, wheat, yields, grain physical properties

INTRODUCTION

Crop residues worldwide are estimated in billions of tons. A significant part of them are post-harvest residues after harvesting. They are the carriers of various chemical compounds extracted from the soil and converted into organic matter, as well as a large amount of energy as a result of photosynthesis. In one of his studies, Scheffer (2004) points out that the formed plant mass on the planet concentrates 10 times more solar energy than the needs of people. The return of plant residues contributes to the control of erosion processes, recycling of nutrients and their availability to plants, phytosanitary status, soil fertility and others (Yadvinder-Singh, 2005). Scientific research at home and abroad has long proven that post-harvest residues are a natural resource of extreme importance, contributing to soil structure and fertility, as well as crop productivity (Nankova &Yankov,1997; Filcheva, 2004; Nankova M., 2011; Iliev et al., 2018; Nankova & Filcheva, 2020). In the detailed study of Filcheva et al. (2005), the benefits of the intelligent approach to the use of plant residues through the prism of knowledge - Waste or Wealth are clearly indicated.

However, crop residue decomposition has both positive and negative impacts on crop production. Scientific research is the basis of highlighting the effects of different crop residue management practices and improving the positive impact on the environment (Lu, 2020, Gupta et al., 2022).

One of the ways to free the field from "unnecessary" plant residues is their burning. On a global scale, farmers use fire precisely as a tool for their removal (Zhang et al., 1996; Yevich and Logan, 2003; Chen et al., 2005; Korontzi et al., 2006; Yan et al., 2006; Sahai et al., 2007; Yang et al., 2008). In the USA, burning crop residues is a common practice for pest and weed control in preparing fields for seeding. Almost universally, burning is considered a quick and cheap tool to remove plant material after harvest (Canode and Law, 1979; Smiley et al., 1996; Ball et al.,1998; Eiland,1998).

According to Stoynev (2004), the "temporary benefit" of burning plant residues leads to a permanent deterioration of soil fertility. Crop residue burning has also been identified as a significant hazard to human health, causing significant air pollution problems and soil health degradation (Manu et al., 2020). Numerous studies prove that crop residues have the potential to improve soil fertility.

This depends not only on their biochemical properties, but also on the preparation for their return to the soil, as well as the use of the most appropriate technique for this (Viator et al.,2009; Coulibaly 2020). The application of unreasonably intensive agricultural practices in recent decades often cause serious disturbances not only in soil fertility but also in the uneven depletion of various natural resources, which intensifies the process of desertification in many areas of the world. The management of crop residues, i.e. their return to the soil is a key step in modern agricultural production aimed at protecting the environment and obtaining satisfactory production in terms of size and quality.

The article discusses the role and ways of using crop residues from spring field crops on the productivity and physical characteristics of wheat grain. The aim of the study is also the used seeding machine systems.

MATERIALS AND METHODS

The investigation was carried out at Dobrudzha Agricultural Institute during 2017-2019 on Haplic Chernozems. The trial was performed on 5 ha area in 4 replicates. The effect of the traditional systems of soil tillage and sowing machines and the type of the previous crop post-harvest residue treatment on the yields and grain physical properties were investigated in six-field crop rotation. The crops were arranged in crop rotation as follows: grain maize – wheat – sunflower – wheat – common bean – wheat.

Soil preparation and sowing of the wheat (cv. Enola) after sunflower, maize and common bean was done according to the traditional system (TS). According to this system, the sowing of wheat is carried out with a seed drill SZU - 3.6 after double disking at a depth of 10-

12 cm.In the case of the combined system (CS), a single disking of the area is performed in advance. It includes the aggregation of a Fendt 820 Vario tractor and a Horsch 6.0 sowing machine. The second disking in this system is carried out together and immediately with the sowing itself. In both systems, sowing was carried out at a rate of 500 germinating seeds/m^2. The mineral fertilization of wheat is consistent with the predecessor. After beans, the same is $N_{90}P_{100}K_0$, and after the other predecessors - $N_{120}P_{100}K_0$.

The post-harvest residues (PHR) from the pervious spring crops were utilized in three different ways: they were removed from the field (RF); they were burned (B) and they were chopped and subsequently incorporated into soil (CSIS).

The statistical analysis of the data was carried out according to the type of the design (ANOVA), running the analysis of variance, and comparison of means using LSD 0.05. Combined analysis was carried out for the three seasons using SAS 2000.

RESULTS AND DISCUSSION

On the basis of the statistical analyzes made by years of research, the influence of the methods of PHR in TS is statistically unreliable for each of the years (Table 1). In this system, however, the role of the predecessor on the productivity of the Enola variety is decisive.

Table 1. Analysis of variances of wheat productivity according to the ways of predecessors PHR utilization over years

Source	df	2017		2018		2019	
		F	Sig.	F	Sig.	F	Sig.
TS							
Predecessors (1)	2	29.13	0.000	34.20	0.000	29.02	0.000
Utilization of PHR (2)	2	1.13	0.360^{NS}	0.90	0.442^{NS}	1.14	0.362^{NS}
1 x 2	4	0.65	0.640^{NS}	3.37	0.060^{NS}	0.65	0.643^{NS}
CS							
Predecessors (1)	2	50.55	0.000	118.01	0.000	51.15	0.000
Utilization of PHR (2)	2	32.42	0.000	49.94	0.000	32.76	0.000
1 x 2	4	1.30	0.340^{NS}	3.87	0.043^{NS}	1.32	0.332^{NS}

In CS, the independent influence of both factors is statistically significant at the maximum level. The results show that the combined influence between the two factors is statistically unreliable. On average for the research period, the two systems of soil preparation and crop sowing significantly differed in their impact on productivity both in the individual and in the combined interaction between the factors (Table 2). In both tillage and sowing systems, the influence of the *Year* and *Predecessor* factors has been conclusively statistically proven.

In TS, the way PHR was used and the types of interaction between the factors were statistically unreliable. However, the use of CS shows that single and double combinations of the tested factors strongly influence the productivity of the crop.

Over the years, the dynamics of productivity values depending on the type of predecessor and the way of using PHR varies widely (Table 3). With the traditional method of tillage and sowing machines, the yields, depending on the type of predecessor, range from 4115.6 kg/ha (2018) to 6801.7 kg/ha (2017) and 6800.0 kg/ha (2019). In all three years of the study, the lowest yields were obtained after the predecessor sunflower.

Table 2. Analysis of variances of wheat productivity according to the ways of predecessors PHR utilization averaged for the period 2017 – 2019.

Source	df	TS'2017-2019		CS'2017-2019	
		F	Sig.	F	Sig.
Years (1)	2	88.970	0.000	173.259	0.000
Predecessors (2)	2	91.121	0.000	194.171	0.000
Utilization of PHR (3)	2	3.077	0.063^{NS}	103.651	0.000
1 x 2	4	1.538	0.219^{NS}	9.946	0.000
1 x 3	4	0.007	1.000^{NS}	5.001	0.004
2 x 3	4	0.733	0.577^{NS}	4.335	0.008
1 x 2 x 3	8	2.459	0.038^{NS}	0.973	0.477^{NS}

With the combined system, the yield variation is from 3546.8 kg/ha (2018) to 6589.7 kg/ha (2017) and 6586.7 kg/ha (2019). Again, sunflower is the predecessor whose residues have a more pronounced negative impact on the yields obtained.

Table 3. Mean productivity of wheat over years of investigation, according to trail indices

Indices	2017		2018		2019	
	TS	CS	TS	CS	TS	CS
By Predecessors						
Common Bean	6801.7 c	6589.7 c	5866.6 b	5685.7 b	6800.0 c	6586.7 c
Sunflower	5505.0 a	4961.4 a	4115.1 a	3546.8 a	5503.3 a	4958.3 a
Maize	6006.7 b	5923.0 b	4538.8 a	3797.6 a	6005.0 b	5923.3 b
By Treatments of Plant Residue						
RF	5954.8 a	6506.9 c	4669.9 a	4776.0 b	5953.3 a	6505.0 c
B	6175.8 a	5767.6 b	4914.7 a	4788.9 b	6173.3 a	5765.0 b
CSIS	6182.8 a	5199.6 a	4936.0 a	3465.1 a	6181.7 a	5198.3 a

The established differences in productivity depending on the ways of using PHR in TS are unreliable. However, with CS, the differentiation in the values of the yields obtained is very well expressed.

The highest average yields, regardless of weather conditions during the years of study, were obtained when part of the PHR (at the harvest height of the predecessor) was removed from the field (RF). It has been proven that the obtained yields are the lowest in the variant with their plowing (CSIS).

The obtained results for the wide dynamics in the productivity of the variety require a characterization of the meteorological conditions of the years of study. During the period 01.10.2016 - 31.03.2017 in the area of the Dobrudhza Agricultural Institute - the town of Gen.Toshevo the precipitation is 252.7 mm/m^2, an amount that is above the average annual norm (Fig.1).

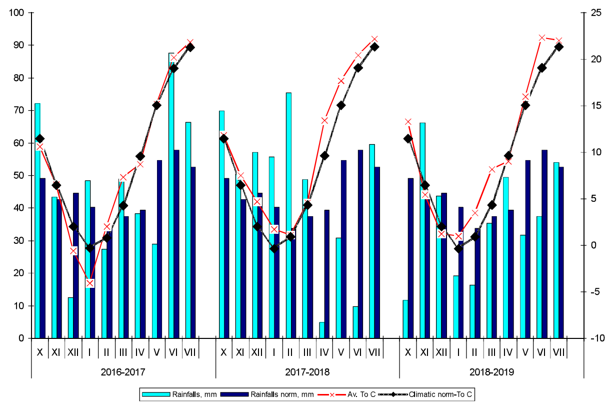


Figure 1. Dynamics of precipitation and temperature values over months during the vegetative growth, and mean long-term norm for 1953-2015

Weather conditions during the winter months are favorable for the normal entry of the culture into the initial phases of its development. Vegetation precipitation is 16.9 mm/m^2 above the climatic norm. The year 2017 is distinguished by intense rainfall in the month of June. The total amount of precipitation is 20 mm/m^2 above the climatic norm (1953-2015) and contributes to obtaining a normal wheat yield.

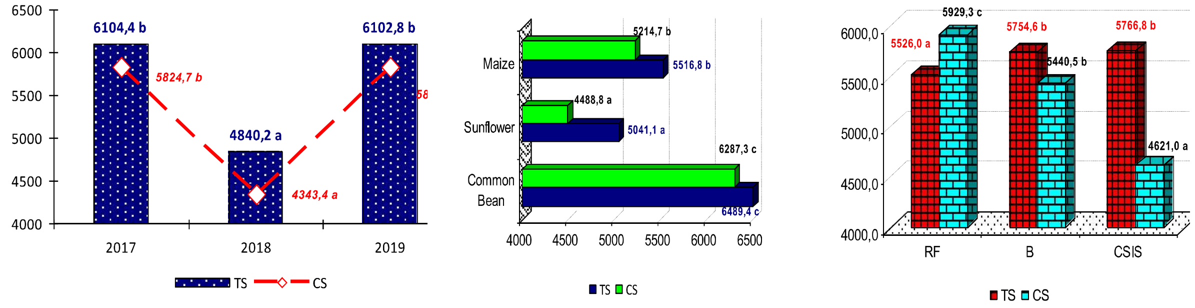
During the autumn-winter vegetation of the 2018 harvest, the precipitation was 357.6 mm/m^2, which is above the average the climatic norm of 110.0 mm/m^2. The 2018 perennial spring growing season was characterized by drought at critical stages of development (spinning and heading) and heavy rainfall at harvest.

The 2019 harvest is characterized by a precipitation deficit of 55.1 mm/m^2 during the autumn-winter vegetation and 33.4 mm/m^2 less precipitation during the period of permanent spring vegetation until harvest. The total precipitation deficit in the 2019 harvest is below the climatic norm with 88.5 mm/m^2. Regardless of this fact, the precipitation that fell is relatively evenly distributed.

In terms of temperature, the conditions during the growing season of crops are distinguished by higher temperatures on average for the growing season of wheat in 2018 and 2019 by 1.5°C-1.2°C. The indicated years are also characterized by significantly higher average monthly temperatures during the permanent spring vegetation. The average temperature for the growing season of wheat during the 2017 harvest period is as close as possible to that of the climatic norm. It is characterized by negative average monthly temperatures in December and January, which distinguishes it from the other years included in the study.

Of the three research years, 2018 stands out with the lowest yields, regardless of the fact that the amount of precipitation for the wheat vegetation period slightly exceeds the same for the period 1953-2015 (Fig. 2). The main reason for this fact is the drastic drought since the beginning of the permanent spring vegetation in combination with significantly higher temperatures compared to the perennial average.

The productivity of the Enola variety under both tillage and sowing systems was approximately the same in 2017 and 2019. The entire study period was characterized by higher yields using TS compared to CS. The excess by year is respectively: 2017 - 4.80%; 2018 - 11.40% and 2019 - 4.81%. For the studied period, the average yield in TS was 5682.47 kg/ha, and in CS - 5330.30 kg/ha, which equals an increase of 352.17 kg/ha (6.61%). The superiority of TS over CS is also preserved across progenitor species. Expected highest yields in both systems were obtained after predecessor bean, the difference between the systems being 202.10 kg/ha in favor of TS. Under the conditions of the experiment, sunflower is the most unfavorable predecessor for the amount of yield, and the difference between the systems is the largest - 552.30 kg/ha. In the case of predecessor corn, it is 302.10 kg/ha in favor of TS.



By Years | By Predecessors | By Treatments of Plant Residue (TPR)

Figure 2. Yields dynamics according to factors of the trail, average for the 2017-2019, kg/ha

Of particular interest are the average results over the period depending on our decision on what to do with the post-harvest residues of the predecessor and how to approach sowing. The most widespread practice based on the removal of crop residues resulted in lower yields when using TS compared to CS by 403.3 kg/ha, or the superiority of CS by 7.30%. In the variants with burning (B) and plowing of plant residues (CSIS), average yields were obtained practically equal in value. In these cases, there is a significant superiority of TS over CS. The same is expressed in obtaining 314.1 kg/ha (5.77%) when burning (B) the residues and 1145.8 kg/ha (24.80%) when completely plowing (CSIS) the non-economic part of the previous crop.

The effect on the yield of the tested ways of using plant residues is strongly influenced by the agricultural technique used when sowing the crop. When using the traditional method of sowing for the region, the average increase in yield compared to the option with removing the residues is +228.6 kg/ha in the option with their burning and +240.8 kg/ha in the option with their complete return to the soil. Qi et all (2019) also reported a positive effect amounting to an average of 8.29% higher yield when crop residues were returned to the soil compared to removal. For the entire study period, the use of a combined machine system is recommended only when removing plant residues from the field. With this system, lower yields were obtained when burning (B) plant residues (- 488.8 kg/ha) and when they were completely plowed (-1308.3 kg/ha).

The strength of influence of the factors by year, as well as their statistical significance, varies depending on the type of preparation and sowing system used (Fig. 3). The yields in the traditional way of carrying out these activities in the favorable conditions of 2017 and 2019 are more than 90% influenced by the type of the predecessor. In the year with less favorable conditions, the strength of this influence drops to 81.74% of that found in the CS. The strength of post-harvest residue treatment methods and their interaction with the predecessor is subject to statistically unreliable dynamics.

In the combined system (CP), the influence of both factors is essential for yield. In years with a favorable combination of the main meteorological components, about 60% of the yield is determined by the predecessor and over 35% - by the ways of utilization of the post-harvest residues. Under unfavorable conditions for the development of culture, the credibility of the power of influence of the two factors is preserved, but that of the predecessor increases to 67.10%.

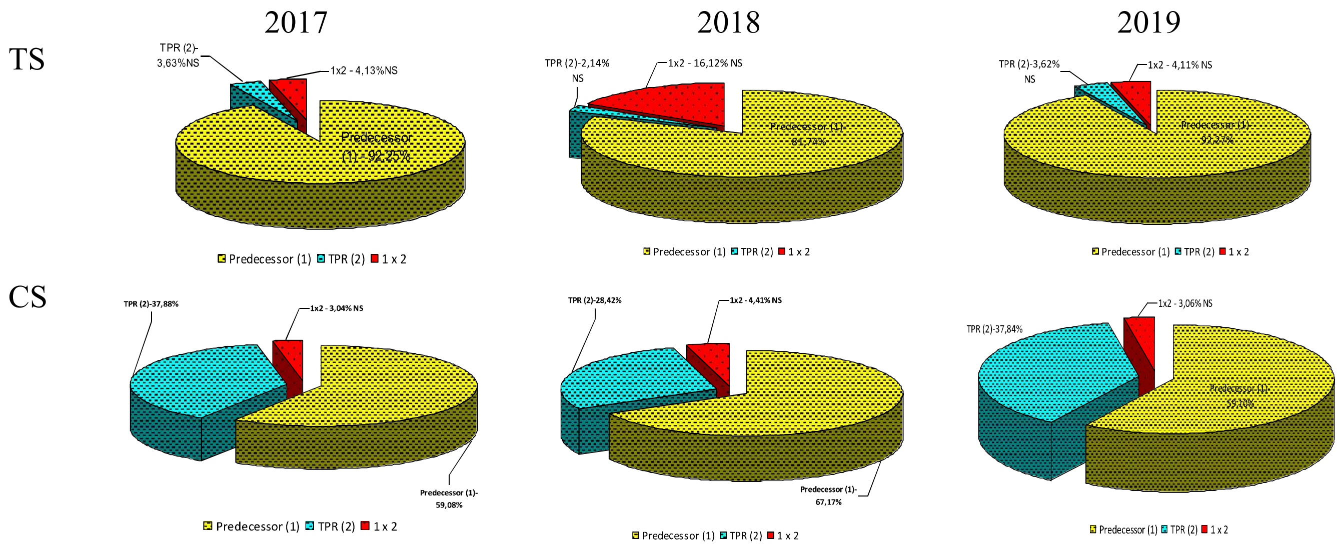


Figure 3. Strength of effect of the factors *Predecessor* and *TPR* on the wheat productivity by years, %

Averaged over the study period, for both tillage and sowing systems tested, the strength of the influence of the predecessor on the yield size was the greatest, followed by that of the weather conditions of the years studied (Fig. 4). In CS, there is a serious redistribution of the power of influence of the three factors, due to the fact that in this system the methods of treatment of plant residues (TPR) have a reliable power of influence both independently and in interaction with the other factors.

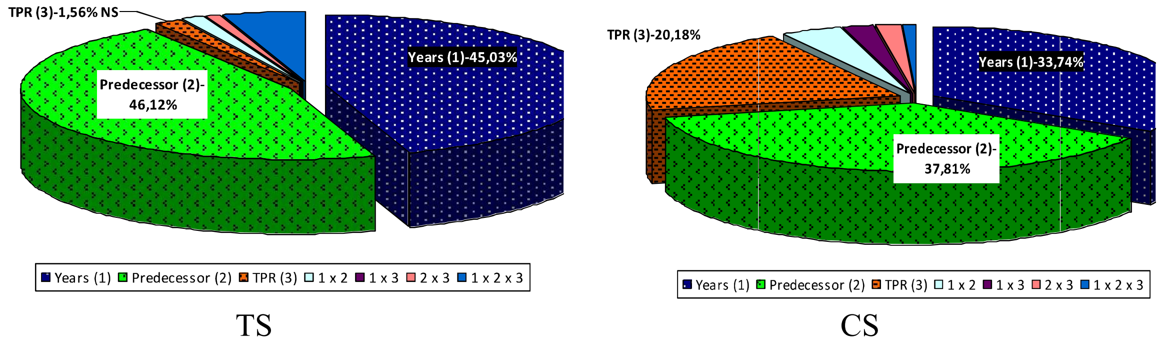


Figure 4. Strength of effect of the trail factors on the wheat productivity for the 2017-2019, %

The values of the physical properties of the grain of the Enola variety are also subject to significant dynamics by year, depending on the type of predecessor and the way of treatment of its post-harvest residues (Table 4). In the tested systems, the reliability of this dynamic varies significantly from year to year depending on the predecessor and the ways of using its plant residues.

In 2017, CS did not lead to significant changes in the 1000 kernel weight depending on the type of predecessor, while in TS the differentiation was very clearly expressed in favor of the bean (Table 5). In this system, the differences between the ways of utilization of plant residues are unproven, and in CS a slight increase in grain size was found in the option with burning (B) of the residues. In 2018, the type of plant residues and the way they are used have little influence on the values of this index when using TS. The application of CS has an unreliable influence on the values of the indicator, but the way they are used leads to a complete differentiation in the values again in favor of burning (B). The data shows that in 2019 the systems show a clear differentiation in the values depending on the tested factors in the study.

In general, the dynamics of changes in the values of the test weight are less pronounced compared to those of the 1000 kernel weight (Table 6). The highest average values of this index were obtained in 2017 for the variant with plowing of the residues (CSIS) - 81.22 kg (TS) and 81.30 kg (CS).

Table 4. Analyses of variances of physical wheat grain properties according to the ways of PHR utilization over years

Source	Dependent Variable	df	2017		2018		2019	
			F	Sig.	F	Sig.	F	Sig.
TS								
Predecessors (1)	1000 KW	2	19.643	0.001	4.993	0.035^{NS}	70.711	0.000
	TW	2	3.946	0.059^{NS}	170.708	0.000	28.545	0.000
Utilization of PHR (2)	1000 KW	2	0.849	0.459^{NS}	10.239	0.005	69.324	0.000
	TW	2	29.327	0.000	21.064	0.000	7.331	0.013
1 x 2	1000 KW	4	2.638	0.104^{NS}	0.751	0.581^{NS}	21.233	0.000
	TW	4	6.043	0.012	19.055	0.000	2.383	0.128^{NS}
CS								
Predecessors (1)	1000 KW	2	1.338	0.310^{NS}	0.665	0.538^{NS}	6.044	0.022^{NS}
	TW	2	0.941	0.426^{NS}	825.113	0.000	14.968	0.001
Utilization of PHR (2)	1000 KW	2	7.754	0.011	20.557	0.000	25.035	0.000
	TW	2	36.618	0.000	39.500	0.000	146.585	0.000
1 x 2	1000 KW	4	10.589	0.002	5.751	0.014	0.347	0.839^{NS}
	TW	4	4.691	0.025^{NS}	35.750	0.000	1.803	0.212^{NS}

Table 5. Values of 1000 kernel weight by years of study depending on the predecessor and the way of treatment of the residue in the tested systems, g

Factors	2017		2018		2019	
	TS	CS	TS	CS	TS	CS
By Predecessors residue						
Bean	46.64 c	44.71 a	43.17 a	43.57 a	40.90 a	42.05 a
Sunflower	45.32 a	45.05 a	44.84 b	43.32 a	42.62 c	41.84 a
Maize	46.10 b	45.36 a	44.52 b	43.67 a	42.21 b	42.87 b
By Utilization of Plant Residue						
RF	45,.90 a	44.40 a	42.84 a	42.54 a	41.08 a	41.20 a
B	45.98 a	45.90 b	45.37 b	44.55 c	42.85 c	42.14 b
CSIS	46.17 a	44.82 a	44.31 b	43.47 b	41.79 b	43.41 c

In addition to the significant differences in the values of the test weight during the individual years of the study, the plant residues of the sunflower have a pronounced negative effect on the values of the index.

Table 6. Values of the test weight by years of study depending on the predecessor and the way of treatment of the residue in the tested systems, kg

Factors	2017		2018		2019	
	TS	CS	TS	CS	TS	CS
By Predecessors						
Bean	80.58 a	80.98 a	75.08 c	75.27 c	77.62 b	77.31 a
Sunflower	80.74 ab	80.93 a	73.27 a	73.18 a	77.17 a	77.53 b
Maize	80.93 b	81.06 a	74.76 b	74.74 b	77.78 b	77.67 b
By Utilization of Plant Residue						
RF	80.24 a	80.54 a	74.17 a	74.17 a	77.42 a	76.91 a
B	80.79 b	81.13 b	74.76 b	74.38 b	77.71 b	77.56 b
CSIS	81.22 c	81.30 b	74.18 a	74.64 c	77.44 a	78.03 c

During the research, the trends of the tested factors in the two used tillage and sowing systems on the values of the physical characteristics of the grain are clearly highlighted (Table 7). The 1000 kernel weight at TS is reliably affected by the independent action of the factors and some of the interactions between them. Using CS excluding the *Year x Predecessor* interaction results in statistically significant effects of the factors and their interactions. The tested factors in both systems have a proven influence on changes in test weight values.

Table 7. Analyses of variances of phyzical wheat grain properties according to the ways of PHR utilization average for period 2017-2019

Source	df	1000 Kernel Weight				Test weight			
		TS'2017-2019		CS'2017-2019		TS'2017-2019		CS'2017-2019	
		F	Sig.	F	Sig.	F	Sig.	F	Sig.
Years (1)	2	199.15	0.000	99.88	0.000	5337.96	0.000	12373.29	0.000
Predecessors (2)	2	7.60	0.002	5.058	0.014	94.20	0.000	148.24	0.000
Utilization of PHR (3)	2	25.10	0.000	31.53	0.000	31.55	0.000	178.53	0.000
1 x 2	4	12.15	0.000	1.162	0.349^{NS}	46.03	0.000	157.18	0.000
1 x 3	4	6.41	0.001	8.484	0.000	17.42	0.000	11.78	0.000
2 x 3	4	1.63	0.195^{NS}	5.573	0.002	5.93	0.001	6.70	0.001
1 x 2 x 3	8	2.47	0.037^{NS}	6.775	0.000	11.16	0.000	10.94	0.000

Average values of 1000 kernel weight were strongly influenced by weather conditions during the years of study (Figure 5). For both tillage and sowing systems tested, the same were highest in 2017. In general, TS contributes to obtaining a larger grain - on average by 0.43 g compared to CS. The conditions of 2019 are the most unfavorable for the formation of a large grain.

The test weight of the grain is also the highest in 2017, and the conditions of 2018 are extremely unfavorable for the formation of heavy grain. Another characteristic feature is that the difference in average test weight values between the two systems is insignificant in each of the years of the study.

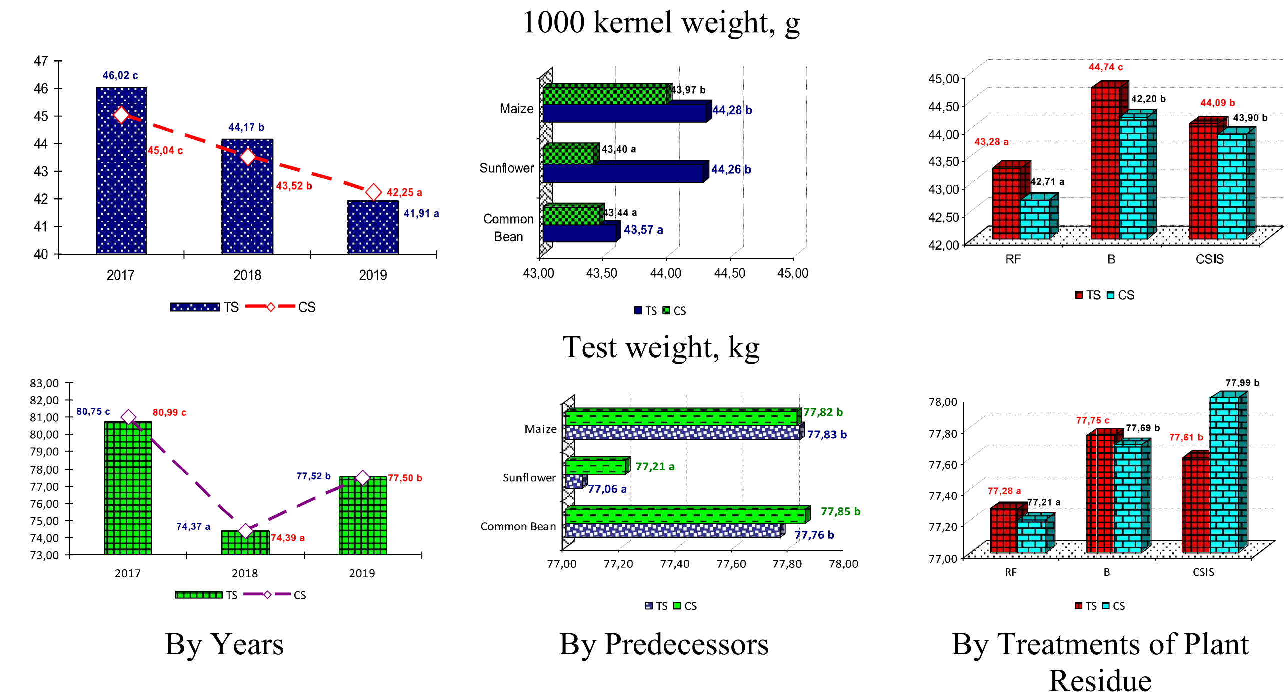


Figure 5. Average values of grain physical characteristics depending on the tested factors in the experiment

The role of the preceding culture on grain physics is very pronounced. Definitely, for both indices, sunflower residues have an extremely negative effect, which is particularly strongly manifested in the values of the test weight at TS. For 1000 kernel weight, except after sunflower predecessor, in both systems, the values of the index are low and after beans. Practically regardless of the technique used for soil preparation and sowing, the largest grain was obtained after a maize predecessor. Using TS after all three predecessors resulted in a grain with a higher 1000 grain weight compared to CS. However, the latter has a more pronounced contribution to obtaining a heavier grain compared to TS. In addition, the positive influence of the predecessors corn for grain and beans on the test weight values is practically equalized.

Depending on what destiny we choose for the post-harvest residues of the predecessor, we also find some changes in the physical characteristics of the grain. They are definitely the lowest in the variant with their removal from the field (RF). This is true for both systems, but it is more noticeable for the 1000 kernel weight, whose average values are higher in TS compared to CS ones. The tendency for better results for grain size in TS was preserved in both the burning of the predecessor crop residue and the chipping and plowing (CSIS) variant. Overall, the largest grain average for the period regardless of tillage and sowing system was obtained by burning (B) the residues (44.47 g), followed by plowing them (44.00 g).

The most unfavorable effect on grain size is their removal from the field (RF). The overall average variation in the values of the test weight depending on the ways in which we use the post-harvest residues is insignificant - from 77.25 kg to 77.80 kg. However, looking at each of the options separately, we find that when removing (RF) or burning (B) the residues, it is preferable to use TS. Averaged over the whole experiment, the heaviest grain was obtained with full tillage of the residues (CSIS) combined with the use of CS.

The physical characteristics of the grain, although relatively conservative, due to its genetic determination for each variety, can be significantly changed depending on the agricultural techniques we apply. The strength of their influence by years of study is clearly manifested and valued as a result of the statistical processing of the results (Figure 6). The power of influence of each of the factors by years of research and its statistical significance in each of the systems giving an initial start to the plants is graphically expressed.

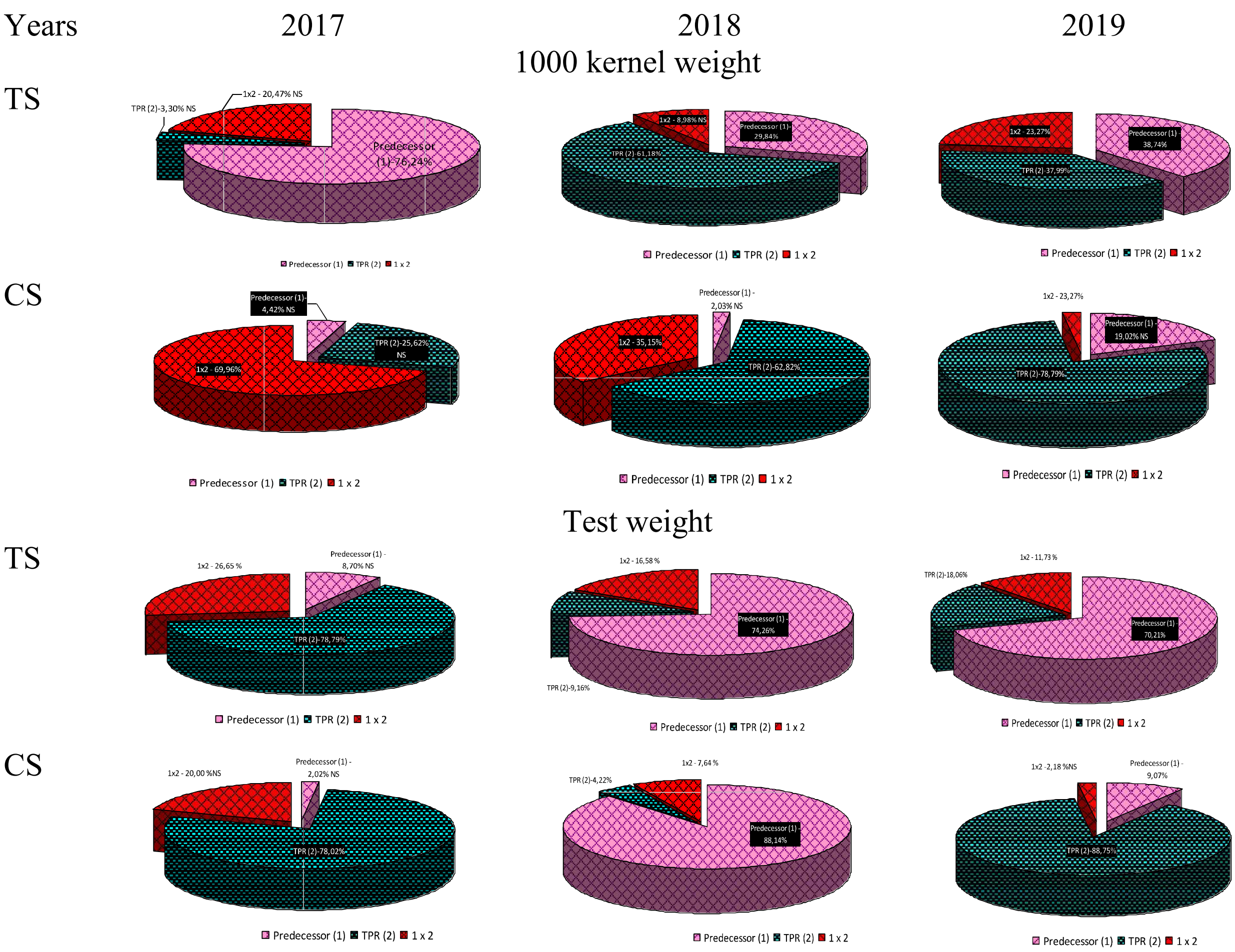


Figure 6. Strength of effect of the factors by years on the grain physical properties of wheat, %

In years with favorable conditions for the development of the crop, the determining force of influence on the 1000 kernel weight in TS is the predecessor, and in CS - the interaction between the predecessor and the way in which plant residues are used. In the favorable conditions of 2017, the test weight values were mainly formed under the strong influence of CSIS in both systems. For the conditions of 2018, a complete synchronicity in the influence of the systems is again established, but this time in favor of the predecessor. For 2019, TS most strongly affects the predecessor, while CS this applies to CSIS.

The established correlation dependences between the studied indeces show that their values are subject to significant dynamics in the years of study (Table 8).

Table 8. Pearson correlations between grain yields and grain physical properties by years (n=18)

Indices	2017			2018			2019		
	Yields	1000 KW	TW	Yields	1000 KW	TW	Yields	1000 KW	TW
TS									
Yields	1	,700(**)	-,099	1	-,462	,578(*)	1	-,488(*)	,452
1000 KW	,700(**)	1	,136	-,462	1	-,052	-,488(*)	1	,087
HW	-,099	,136	1	,578(*)	-,052	1	,452	,087	1
CS									
Yields	1	-,138	-,447	1	,154	,524(*)	1	-,364	-,692(**)
1000 KW	-,138	1	,398	,154	1	,301	-,364	1	,831(**)
HW	-,447	,398	1	,524(*)	,301	1	-,692(**)	,831(**)	1

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed)

,The most pronounced correlation was found in 2017 between yield and mass of 1000 grains (r=0.700**) at TS. All other correlations in this year are statistically unreliable. When using CS, a significant correlative dependence was observed between yield and hectoliter mass in 2018 and 2019.

This means that under the conditions of the experiment in years with unfavorable conditions during the period of permanent spring vegetation, there is a proven relationship between productivity and test weight, while the one with 1000 kernel weight is unreliable.

On average for the research period, this fact has been confirmed for both systems. The correlation with TS has higher coefficient values (0.615**) compared to that with CS (0.486**).

CONCLUSIONS

The result of the present study found wide dynamics in the productivity of the Enola variety depending on the type of the predecessor and the method of utilization of its plant residues. The traditional system of soil preparation and wheat sowing for the Dobrudja region provides higher yields compared to the combined system in all years of the study. The average increase was 352.17 kg/ha (6.61%). The role of the predecessor has a more pronounced positive influence on the productivity of wheat in the traditional sowing system compared to the combined one. The Enola variety is expected to have the highest yields after its predecessor beans, regardless of the applied agricultural technique during sowing.

Sunflower plant residues have a clear negative impact on wheat productivity. With this predecessor, the biggest difference between the systems was found - 552.30 kg/ha in favor of the traditional system. To obtain the maximum expression of the productive possibilities of the Enola variety, a differentiated approach to the ways in which we will use the plant residues of the predecessor and the technical means for this is required. In areas with minimal presence of plant residues, the combined system of soil preparation and sowing contributes to obtaining 403.3 kg/ha more compared to the traditional one. However, it is extremely unsuitable in cases of burning the residues or their complete plowing. The use of the traditional system in such situations provides higher yields compared to the combined system with 314.1 kg/ha (burning) and 1145.8 kg/ha (plowing), respectively.

In the tested predecessors and methods of utilization of their plant residues, the traditional system definitely contributes to obtaining a larger grain compared to the combined one. The test weight values is mainly influenced by the weather conditions of the years, but not by the sowing systems. The values of the test weight do not always follow the established trends for the 1000 kernel weight and are characterized by a weaker, although reliable, dynamics.

The power of influence of each of the tested factors on the values of the investigated indeces was established. The correlative dependence between the productivity of the variety and the hectoliter weight of the grain is reliable. The correlation with traditional sowing has higher coefficient values (0.615**) compared to that with combined sowing (0.486**). The relationship between the yield and the 1000 kernel weight is negative and unreliable. There is a positive and reliable correlation between the two indices characterizing the physics of the grain.

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