

Yield and Quality Parameters of Spring Oat Seeds 'Ovidiu' Variety in Relation to Technology Elements

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Abstract. The study evaluated the influence of soil tillage and fertilization on the yield and some seed quality parameters of spring oats, 'Ovidiu' variety. The field experiment was located within Agricultural Research and Development Station (ARDS) Lovrin, in the agricultural year 2024 - 2025. The oat crop was located on a chernozem soil of medium fertility, in a non-irrigated system. Four types of soil work and two types of mineral fertilization were considered. From the combination of the two factors, the following experimental variants resulted: V1 – soil disking, NPK; V2 – soil disking, NPK+GAN; V3 – superficial scarification, NPK; V4 – superficial scarification, NPK+GAN; V5 – deep scarification, NPK; V6 – deep scarification, NPK+GAN; V7 – plowing, NPK; V8 – plowing, NPK+GAN; NPK type 15:15:15 in a dose of 150 kg/ha commercial product; GAN – granular ammonium nitrate, 200 kg/ha commercial product. The size of an experimental variant was 145 m², and the variants were placed in three replications. Yield (Y, kg/ha) and seed quality parameters, thousand kernel weight (TKW, g), hectoliter weight (HW, kg/hl), protein (PRO, %), and grain moisture at harvest (MST, %) were evaluated in relation to the experimental variants. Low variability was recorded in the experimental data series, within the yield and quality parameters considered. Positive correlations, very strong and strong, were recorded between PRO and TKW parameters ($r = 0.93$), between yield and the PRO parameter ($r = 0.94$), between yield and the TKW parameter ($r = 0.85$). Multivariate analysis (PCA) explained the positioning and correlation of the variants, with the yield (V2, V4) and parameters considered for seeds, respectively with PRO and TKW parameters (variant V8) and with the MST parameter (variant V6). The other four variants (V1, V3, V5 and V7), which benefited only from NPK fertilization, were positioned independently. Cluster analysis grouped the variants based on similarity in relation to the values of yield and seed quality parameters, considered simultaneously in the analysis. The variants were grouped into two distinct clusters in relation to the applied fertilization, and within each cluster, they were grouped in relation to soil cultivation.

Keywords: comparative analysis, mineral fertilization, oat, seed parameters, tillage systems, yield

INTRODUCTION

Oats (*Avena sativa* L.) are an important crop plant, which ranks sixth worldwide after other grasses (wheat, rice, corn, barley, sorghum) and was cultivated primarily for fodder (Ma et al., 2021; Zhang et al., 2023; Hanoğlu Oral, 2024).

Among cereal crops, oats have a high fiber content, the highest protein content (between 15 - 20%), low calorie content, and a series of bioactive compounds, which has made oats of great interest for human nutrition (Ma et al., 2021; Paudel et al., 2021).

Some studies have indicated the multifunctional uses of oats, through the production of grains and biomass (straw, fresh biomass) in human food, industrialization, animal feed (Ahmad et al., 2014; Chand et al., 2025).

Oats have a specific nutritional profile, which includes fiber, high-quality proteins (globulins), unsaturated fats (the highest fat content among cereals), polyphenolic compounds, and mineral elements, which makes them recommended for human nutrition, and in some cases in the category of functional elements (Rasane et al., 2013; Sterna et al., 2016; Alemayehu et al., 2023).

In temperate climates, oats are an annual crop (Sterna et al., 2016), and are integrated into different crop structures and rotations (White and Finnan, 2017; Enesi et al., 2025). Oat crop was studied in relation to climatic conditions, rainfall regime, and various stress factors (Jia et al., 2019; Sharma et al., 2023; Pitann and Mühling, 2024).

Oat yield and protein content were evaluated in relation to soil type and oat genotype, in an organic cropping system (Pużyńska et al., 2021). The effect of some agricultural practices was evaluated in oats, based on yield, some yield components, thousand kernel weight, and other agronomic parameters (McCabe and Burke, 2021; Kolmanič et al., 2022).

The variation in oat hulled grain yield was evaluated through modeling in relation to different variables included in agronomic, climatic and physiological factors of oat plants (Wojtacki et al., 2025). The influence of oat plant density was evaluated in relation to yield, and in relation to agronomic aspects of oat cultivation, such

as plant growth and plant drop, weed control to improve crop technology (Li et al., 2018; Liu et al., 2024).

The aim of the study was to evaluate the influence of soil tillage and mineral fertilization on the yield and seed quality parameters of spring oats, 'Ovidiu' variety, in a non-irrigated crop system.

MATERIAL AND METHODS

The spring oat crop study was conducted within Agricultural Research and Development Station (ARDS) Lovrin, in the 2024-2025 agricultural year. The field experiment was located in chernozem soil conditions, medium fertility, non-irrigated crop system. The 'Ovidiu' variety of spring oats was cultivated. The experimental variations were given by soil and fertilization treatments.

The experiment was conducted using four soil tillage systems: minimum with disk, shallow scarification, deep scarification, and conventional by plowing. Each tillage system was combined with two mineral fertilization regimes. Complex NPK fertilizer (15:15:15) was applied in autumn at a rate of 150 kg ha⁻¹ (commercial product), while granular ammonium nitrate (GAN) was applied in spring at 200 kg ha⁻¹ (commercial product). The factorial combination of tillage system and fertilization regime resulted in eight treatments: V1 – disk + NPK; V2 – disk + NPK + GAN; V3 – shallow scarification + NPK; V4 – shallow scarification + NPK + GAN; V5 – deep scarification + NPK; V6 – deep scarification + NPK + GAN; V7 – plowing + NPK; V8 – plowing + NPK + GAN.

The climatic conditions recorded during the experimental period are presented in Figure 1. An appropriate, uniform crop technology was applied to all experimental variants.

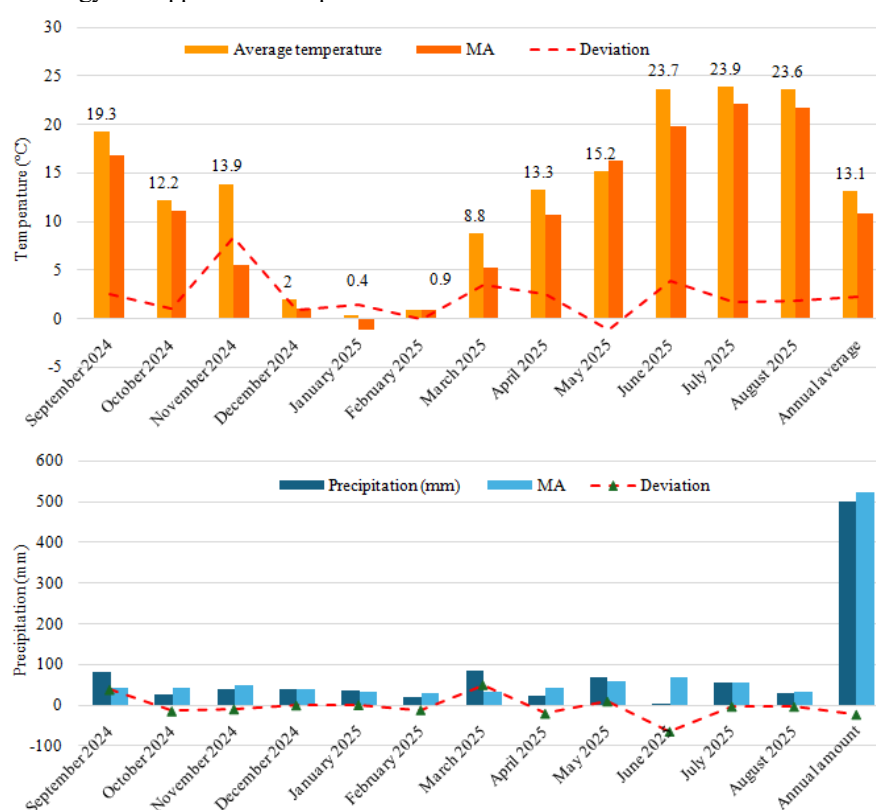


Figure 1. Climatic conditions during the experimental period, 2024 – 2025 agricultural year

The experimental variants were evaluated for yield (Y, kg/ha), thousand kernel weight (TKW, g), hectoliter weight (HW, kg/hl), protein content (PRO, %) and grain moisture at harvest (MST, %).

Experimental data were recorded by variants and repetitions, and the average value was calculated for each variant, and the average values were considered in the study.

The variation of yield and seed quality parameters was analyzed for each experimental variant in relation to the calculated average value. The correlation of the variants with the considered parameters was evaluated, within the multivariate analysis, and the cluster analysis grouped the variants based on similarity in relation to the generated results.

PAST software (Hammer et al., 2001) was used for statistical data analysis and generation of graphical representations.

RESULTS AND DISCUSSIONS

The experimental results of the spring oat crop, 'Ovidiu' variety, for yield (Y), seed quality parameters (TKW, HW), protein content (PRO) and moisture (MST) were analyzed for the statistical description of the data series, and the values obtained are presented in Table 1.

For the TKW parameter, the experimental values ranged between 29.55 ± 0.36 g (V5 variant) and 32.22 ± 0.36 g (V2 variant). For the HW parameter, the experimental values ranged between 46.10 ± 0.20 kg/hl (V2, and V6 variants) and 47.70 ± 0.20 kg/hl (V7 variant). For the yield (Y), the experimental values ranged between 3428.00 ± 127.52 kg/ha (V5 variant) and 4399.50 ± 127.50 kg/ha (V2 variant). For the protein (PRO), the experimental values ranged between $12.80 \pm 0.14\%$ (V5 variant) and $14.00 \pm 0.14\%$ (V2 variant). Grain moisture at harvest (MST) recorded values between $10.80 \pm 0.14\%$ (V7 variant) and $11.80 \pm 0.14\%$ (V4, and V5 variants). The experimental data series presented normal distribution, for each parameter.

Table 1. Descriptive Statistical Analysis results

Statistical parameters	TKW	HW	Y	PRO	MST
N	8	8	8	8	8
Min	29.55	46.10	3428.00	12.80	10.80
Max	32.22	47.70	4399.50	14.00	11.80
Sum	245.40	372.80	31798.50	106.75	90.80
Mean	30.68	46.60	3974.81	13.34	11.35
Std. error	0.36	0.20	127.52	0.14	0.14
Stand. dev	1.03	0.55	360.69	0.41	0.41
Median	30.09	46.45	4032.25	13.30	11.45
25 prentil	30.01	46.13	3642.00	12.99	10.93
75 prentil	31.80	46.90	4286.38	13.70	11.75
Skewness	0.64	1.18	-0.34	0.33	-0.25
Kurtosis	-1.67	1.11	-1.61	-0.87	-1.94
Geom. mean	30.66	46.60	3960.22	13.34	11.34
Coeff. var	3.36	1.19	9.07	3.07	3.59

Comparative analysis of the results was made between the experimental variants, and the average value for yield, parameters and quality indices of oat seeds.

In the case of the TKW parameter, the average value calculated at the experiment level was $\overline{\text{TKW}} = 30.675$ g. In relation to the average value, positive and negative differences were recorded between the experimental variants, according to the data in Table 2. With values above the average, in conditions of statistical safety, were variant V2 ($p < 0.01$, **) and variants V4 and V8 ($p < 0.05$, *). With values below the average, in conditions of statistical safety was variant V5 ($p < 0.05$, o). The graphic representation of the differences is given in Figure 2.

Table 2. Results of differences for TKW parameter in relation to the mean value

Variants	Given mean	Sample mean	95% conf. interval	Difference	95% conf. interval	t	p	Sig.
V1	30.12	30.675 (29.813 31.537)		0.555	(-0.30733 1.4173)	1.5219	0.1719	ns
V2	32.22			1.545	(0.68267 2.4073)	-4.2365	0.0039	**
V3	30.06			0.615	(-0.24733 1.4773)	1.6864	0.1356	ns
V4	31.54			0.865	(0.0026707 1.7273)	-2.3719	0.0495	*
V5	29.55			1.125	(0.26267 1.9873)	3.0848	0.0177	o
V6	30.01			0.665	(-0.19733 1.5273)	1.8235	0.1110	ns
V7	30.01			0.665	(-0.19733 1.5273)	1.8235	0.1110	ns
V8	31.89			1.215	(0.35267 2.0773)	-3.3316	0.0126	*

Note: * - significance for $p < 0.05$; ** significance for $p < 0.01$; o – significance for $p < 0.05$; * symbol for positive differences; o – symbol for negative differences

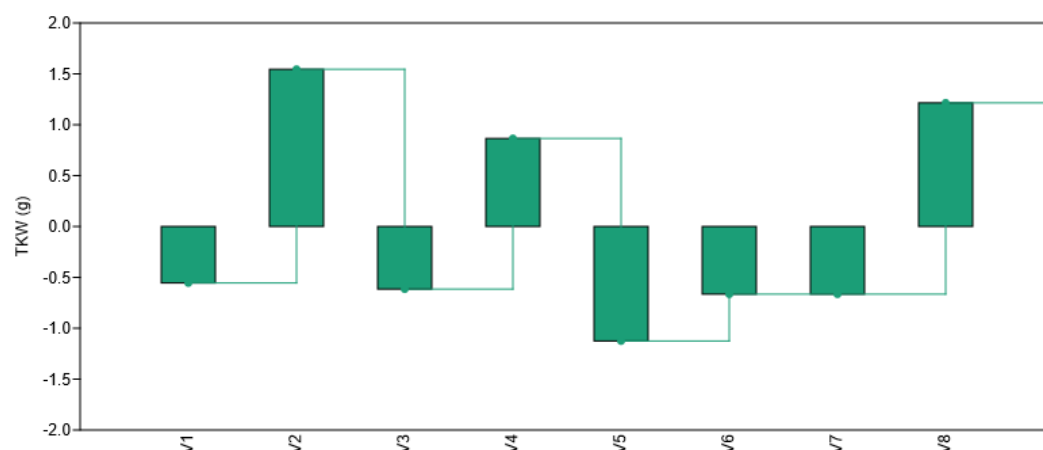


Figure 2. TKW differences of experimental variants, in relation to the average value

In the case of the HW parameter, the average value calculated at the experiment level was $\overline{HW} = 46.60$ kg/hl. In relation to the average value, positive and negative differences were recorded in the experimental variants, according to the data in Table 3. Variant V7 exhibited an above-average value, with results considered statistically reliable ($p < 0.001$, ***). Variants V2 and V6 showed below-average values, also statistically significant ($p < 0.05$, o). For the remaining variants, the differences were not statistically significant. The graphic representation of the differences for the HW parameter, in relation to the average value, is given in Figure 3.

Table 2. Results of differences for HW parameter, relative to the mean value

Variants	Given mean	Sample mean	95% conf. interval:	Difference	95% conf. interval	t	p	Sig.
V1	46.90	46.60	(46.138 47.062)	0.30	(-0.16224 0.76224)	-1.5346	0.1687	ns
V2	46.10			0.50	(0.037762 0.96224)	2.5577	0.0377	o
V3	46.90			0.30	(-0.16224 0.76224)	-1.5346	0.1687	ns
V4	46.60			0.00	(-0.46224 0.46224)	0.0000	1.0000	ns
V5	46.30			0.30	(-0.16224 0.76224)	1.5346	0.1687	ns
V6	46.10			0.50	(0.037762 0.96224)	2.5577	0.0377	o
V7	47.70			1.10	(0.63776 1.5622)	-5.6270	0.0008	***
V8	46.20			0.40	(-0.062238 0.86224)	2.0462	0.0800	ns

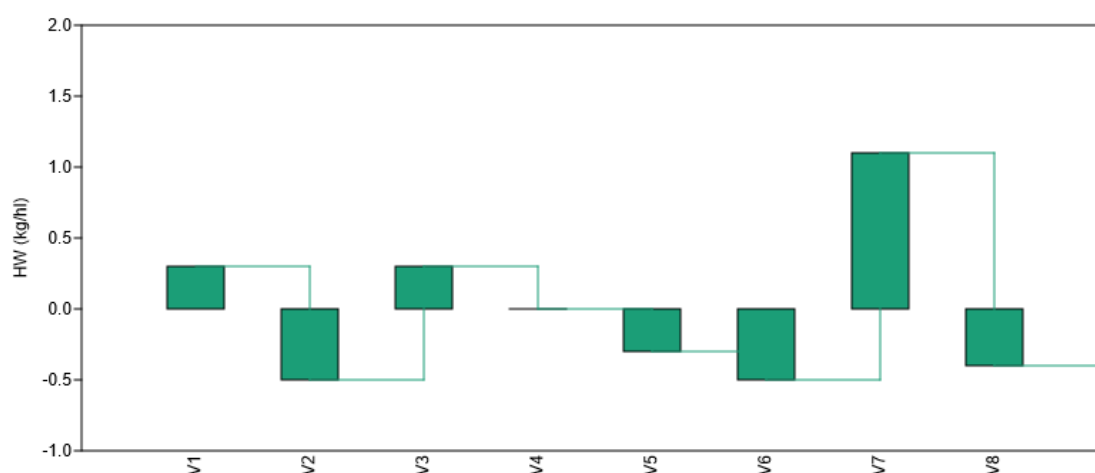


Figure 3. HW differences of experimental variants, in relation to the mean value

In the case of yield (Y), the average value calculated at the experiment level was $\bar{Y} = 3974.80$ kg/ha. In relation to the calculated average value, variants with positive and negative differences were recorded, according to the data in Table 4. With values above the average, in conditions of statistical safety, variants V2 and V8 were recorded ($p < 0.05$, *). With values below the average, in conditions of statistical safety, variant V5 ($p < 0.01$, oo) and variant V7 ($p < 0.05$, o) were recorded. In the case of the other variants, the differences did not present statistical safety. The graphic representation of the differences for yield (Y), in relation to the average value, is given in Figure 4.

Table 4. The results of the differences for Y, relative to the mean value

Variants	Given mean	Sample mean	95% conf. interval	Difference	95% conf. interval	t	p	Sig
V1	3874.50	3974.80	(3673.3 4276.3)	100.31	(-201.22 401.85)	0.7866	0.4573	ns
V2	4399.50			424.69	(123.15 726.22)	-3.3303	0.0126	*
V3	3738.00			236.81	(-64.724 538.35)	1.8570	0.1057	ns
V4	4265.00			290.19	(-11.349 591.72)	-2.2756	0.0570	ns
V5	3428.00			546.81	(245.28 848.35)	4.2880	0.0036	oo
V6	4190.00			215.19	(-86.349 516.72)	-1.6874	0.1354	ns
V7	3610.00			364.81	(63.276 666.35)	2.8608	0.0243	o
V8	4293.50			318.69	(17.151 620.22)	-2.4991	0.0410	*

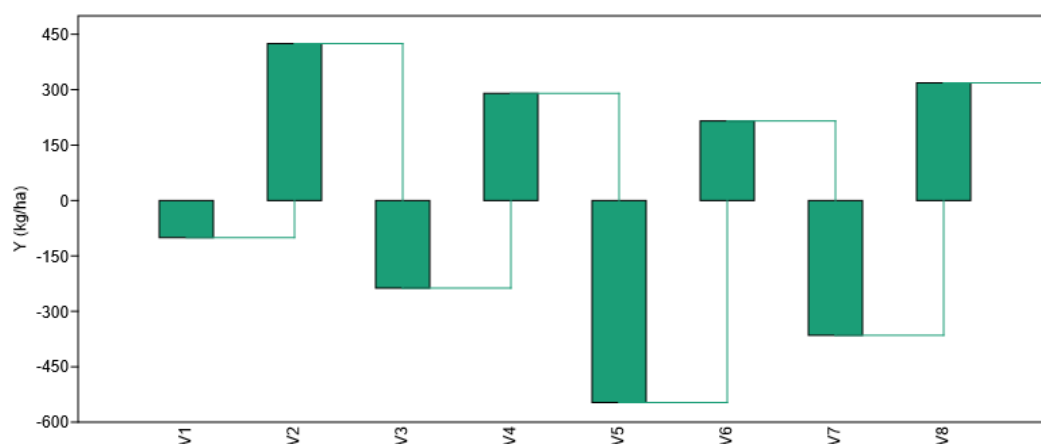


Figure 4. Differences in yield (Y) of experimental variants, in relation to the mean value

In the case of protein content (PRO), the average value calculated at the experiment level was $\overline{\text{PRO}} = 13.34\%$. In relation to the average value calculated, variants with positive and negative differences were recorded, according to the data in Table 5.

Table 5. Results of differences for PRO, relative to the average value

Variants	Given mean	Sample mean	95% conf. interval	Difference	95% conf. interval	t	p	Sig
V1	13.20	13.34	(13.002 13.686)	0.1438	(-0.19835 0.48585)	0.9936	0.3535	ns
V2	14.00			0.6563	(0.31415 0.99835)	-4.5359	0.0027	**
V3	12.95			0.3938	(0.051646 0.73585)	2.7215	0.0297	o
V4	13.55			0.2063	(-0.13585 0.54835)	-1.4256	0.1970	ns
V5	12.80			0.5438	(0.20165 0.88585)	3.7583	0.0071	oo
V6	13.40			0.0563	(-0.28585 0.39835)	-0.3888	0.7090	ns
V7	13.10			0.2438	(-0.098354 0.58585)	1.6848	0.1359	ns
V8	13.75			0.4063	(0.064146 0.74835)	-2.8079	0.0262	*

With values above the average, in conditions of statistical safety, variant V2 ($p < 0.01$, **) and variant V8 ($p < 0.05$, *) were recorded. With values below the average, in conditions of statistical safety, variant V5 ($p < 0.01$, oo) and variant V3 ($p < 0.05$, o) were recorded. In the case of the other variants, the differences did not present statistical safety. The graphic representation of the differences for protein (PRO), in relation to the average value, is given in Figure 5.

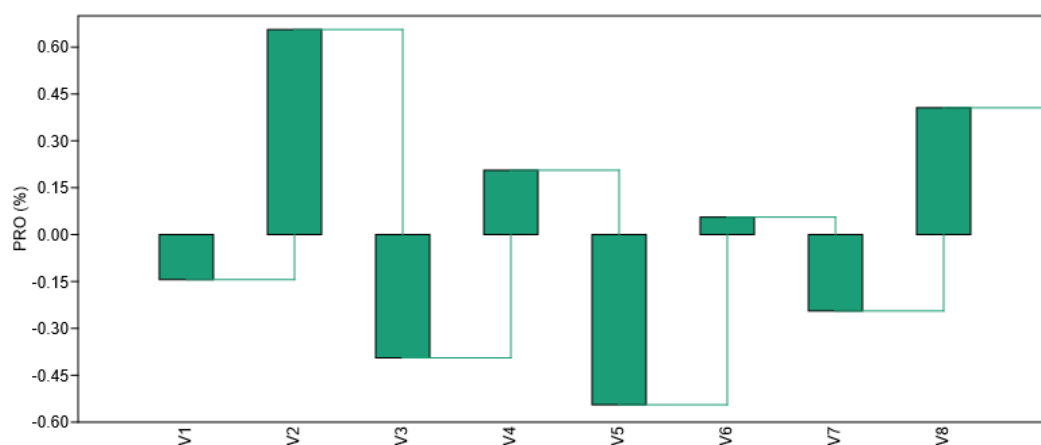


Figure 5. PRO parameter differences of experimental variants, in relation to the mean value

In the case of grain moisture at harvest (MST), the average value calculated at the experiment level was $\overline{\text{MST}} = 11.35\%$. In relation to the average value calculated, variants with positive and negative differences were recorded, according to the data in Table 6, Figure 6.

Table 6. Results of differences for MST, relative to the mean value

Variants	Given mean	Sample mean	95% conf. interval	Difference	95% conf. interval	t	p	Sig
V1	11.00	11.35	(11.01 11.69)	0.35	(0.0096795 0.69032)	2.4318	0.0453	o
V2	11.60			0.25	(-0.090321 0.59032)	-1.7370	0.1260	ns
V3	11.60			0.25	(-0.090321 0.59032)	-1.7370	0.1260	ns
V4	11.80			0.45	(0.10968 0.79032)	-3.1266	0.0167	*
V5	11.80			0.45	(0.10968 0.79032)	-3.1266	0.0167	*
V6	11.30			0.05	(-0.29032 0.39032)	0.3474	0.7385	ns
V7	10.80			0.55	(0.20968 0.89032)	3.8214	0.0065	oo
V8	10.90			0.45	(0.10968 0.79032)	3.1266	0.0167	o

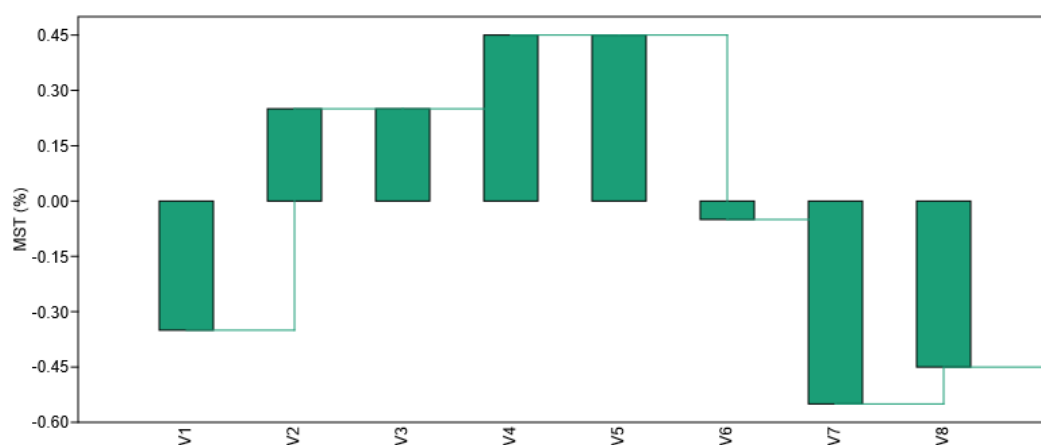


Figure 6. MST parameter differences of experimental variants, in relation to the mean value

With grain moisture values above the average, in conditions of statistical safety, variants V4 and V5 were recorded ($p < 0.05$, *). With values below the average, in conditions of statistical safety, variant V7 was recorded ($p < 0.01$, oo) and variants V1 and V8 ($p < 0.05$, o). In the case of the other variants, the differences did not present statistical safety. The graphic representation of the differences for grain moisture (MST), in relation to the average value, is given in Figure 6.

Correlation analysis showed variable levels of interdependence between parameters considered in spring oat, 'Ovidiu' variety, under experimental conditions, Figure 7.

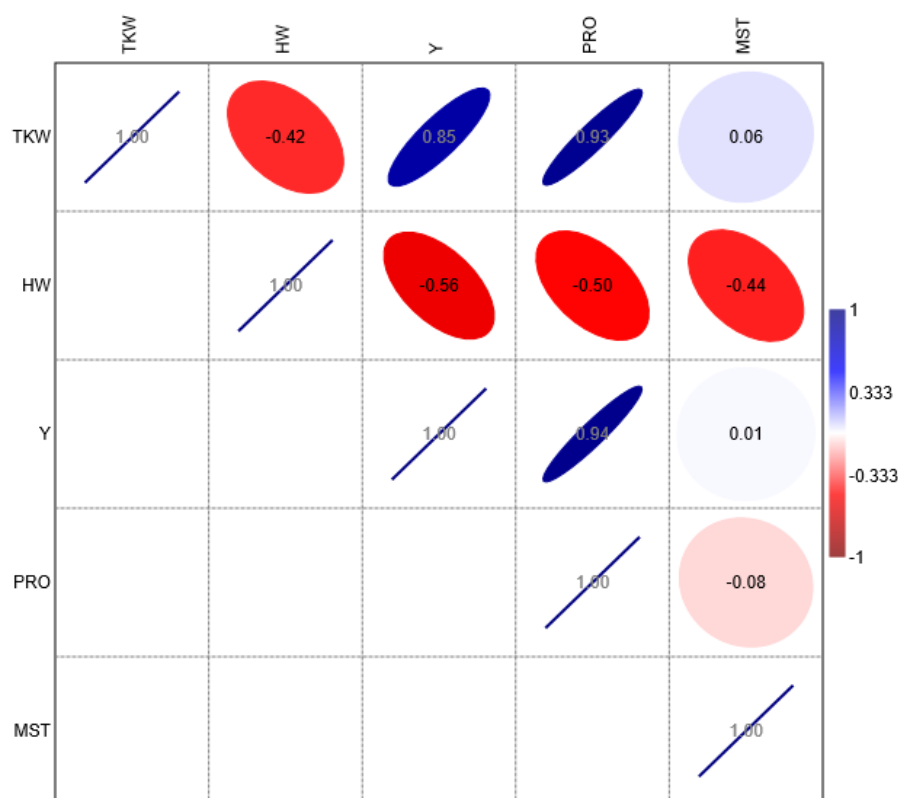


Figure 7. The level of correlation between yield and quality parameters of spring oat seeds, 'Ovidiu' variety

A very strong, positive correlation was observed between protein content (PRO) and thousand kernel weight (TKW), $r = 0.93$, between yield (Y) and protein (PRO), $r = 0.94$, and a strong, positive correlation between yield (Y) and thousand kernel weight (TKW), $r = 0.85$. A weak negative correlation was recorded between the parameter hectoliter weight (HW) and yield (Y), $r = -0.56$, between hectoliter weight (HW) and protein (PRO), $r = -0.50$, and respectively between hectoliter weight (HW) and kernel moisture at harvest (MST), $r = -0.44$.

Multivariate analysis (PCA) showed the correlation of experimental variants in relation to considered parameters, as biplot, Figure 8. The two main components (PC1, PC2) explained 88.69% of the total variance in the experimental data set.

From the PCA diagram, it was observed the positioning of variants V2, V4, V6 and V8 associated with the considered parameters, but in a differentiated way. Thus, variant V2 was positioned closely correlated with the yield (Y), and variant V4 occupied a position close to the yield. Both variants (V2, and V4) generated high values in the grain yield of oats, under the experimental conditions.

Variant V8 was positioned closely correlated with protein (PRO) and thousand kernel weight (TKW). Variant V6 was positioned closely correlated with seed moisture at harvest (MST). Variants V1, V3, V5 and V7 were positioned independently of the parameters considered.

According to the multivariate analysis, the values for the variant scores in the Principal Components, Table 7, and the parameter loading values (as factors) in the Principal Components, Table 8, resulted.

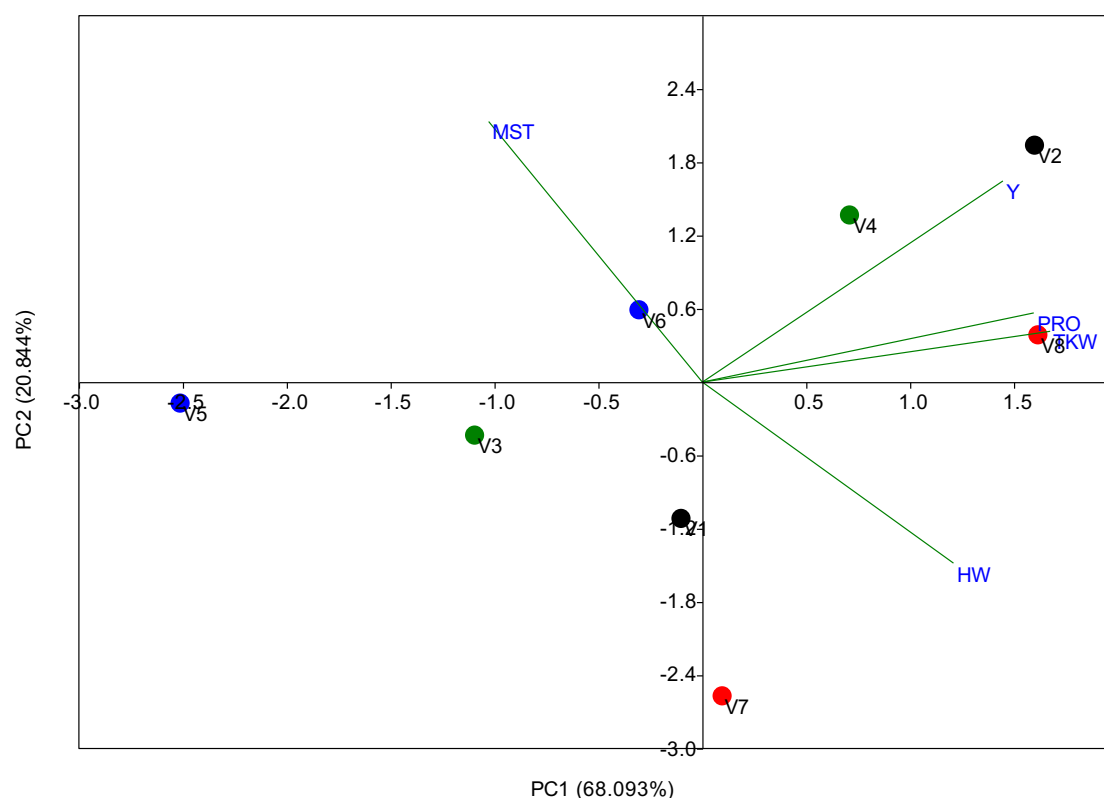


Figure 8. PCA diagram for spring oats, 'Ovidiu' variety

Table 7. Variant score in Principal Components

	PC 1	PC 2	PC 3	PC 4	PC 5
V1	-0.8881	0.7943	-0.2979	0.1221	-0.0226
V2	2.6659	-0.2689	0.3657	-0.1619	0.2397
V3	-1.3429	-0.5994	0.4239	0.1119	-0.1707
V4	1.2223	-0.5943	0.9434	0.2742	-0.1187
V5	-1.8119	-1.7849	-0.3171	-0.4436	0.0603
V6	0.3948	-0.3412	-1.0152	0.5613	0.0728
V7	-2.0551	1.7641	0.4678	-0.0445	0.1427
V8	1.8151	1.0302	-0.5707	-0.4196	-0.2036

Table 8. Parameters loadings in Principal Component

	PC 1	PC 2	PC 3	PC 4	PC 5
TKW	0.5183	0.1430	0.4289	-0.5968	-0.4131
HW	-0.3791	0.4938	0.7316	0.2705	0.0640
Y	0.5380	0.1132	-0.0364	0.7379	-0.3898
PRO	0.5410	0.2096	0.0658	0.0055	0.8118
MST	0.0743	-0.8240	0.5246	0.1613	0.1196

Protein showed a high value in PC1, with positive action (0.5410), grain moisture (MST) showed a high value in PC2, with negative action (-0.8240), hectoliter weight (HW) showed a high value in PC3, with positive action (0.7316), yield (Y) showed a high value in PC4, with positive action (0.7379), protein showed a high value in PC5, with positive action (0.8118).

Cluster Analysis grouped the experimental variants, through simultaneous analysis of the considered

parameters, under conditions of statistical safety (Coph.corr. = 0.848), Figure 9. The variants were grouped based on similarity into two distinct clusters, cluster C1 with variants ((V4,V8), V6), V2), and cluster C2 with variants ((V3,V7), V1), V5).

The highest level of similarity in cluster C1 was recorded between variants V4 and V8, with SDI = 28.52 (SDI – Similarity and Distance Indices), Table 9. In cluster C2 the highest level of similarity was recorded between variants V3 and V7, with SDI = 128.01.

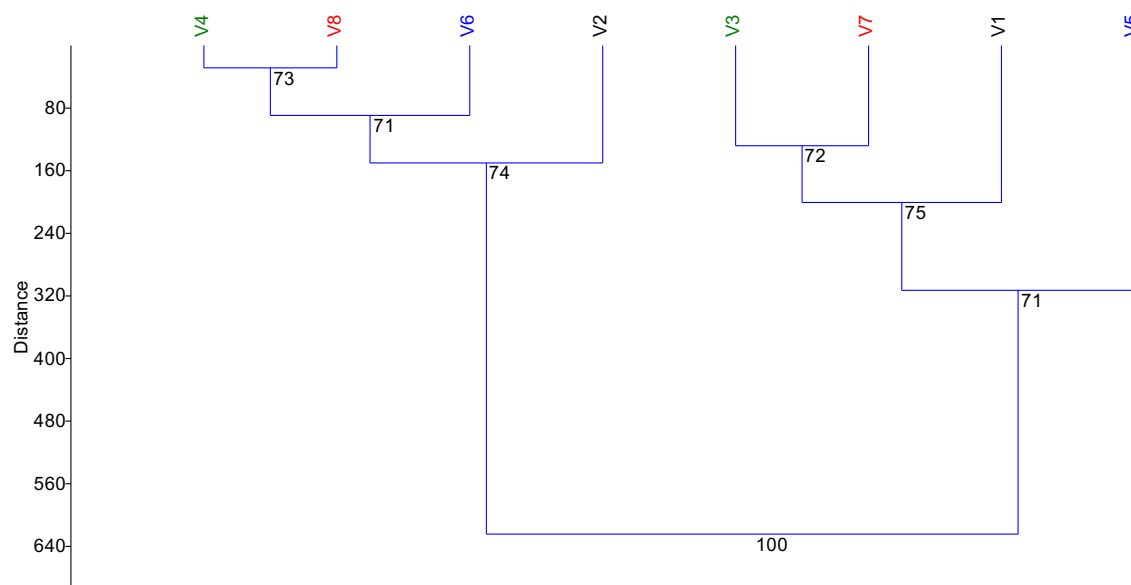


Figure 9. Cluster diagram for experimental variants of spring oats, 'Ovidiu' variety

Table 9. SDI values for experimental variants of spring oats, 'Ovidiu' variety

	V1	V2	V3	V4	V5	V6	V7	V8
V1		525.01	136.50	390.50	446.50	315.50	264.50	419.00
V2	525.01		661.50	134.50	971.50	209.51	789.51	106.00
V3	136.50	661.50		527.00	310.00	452.00	128.01	555.50
V4	390.50	134.50	527.00		837.00	75.02	655.00	28.52
V5	446.50	971.50	310.00	837.00		762.00	182.01	865.50
V6	315.50	209.51	452.00	75.02	762.00		580.00	103.52
V7	264.50	789.51	128.01	655.00	182.01	580.00		683.50
V8	419.00	106.00	555.50	28.52	865.50	103.52	683.50	

Adapting and improving crop technologies is a permanent concern of farmers, with the aim of improving crop performance and farm sustainability (Gamage et al., 2024; Shamshiri et al., 2024; Addorisio et al., 2025; Qian et al., 2025).

Soil works have been adapted and analyzed in relation to soil conditions, climate change, agricultural crops, to ensure proper land preparation, soil water conservation, sustainable use of soil resources and the efficiency of agricultural technologies (Rodenburg et al., 2020; Liu et al., 2021; Yao et al., 2023; Diop et al., 2024; Toth et al., 2025).

Fertilization systems have also been a permanent concern of farmers and researchers, to optimize fertilizer doses in relation to the soil, crops and estimated yields (Boldea and Sala, 2010; Liu et al., 2024; Maaz et al., 2025).

In the spring oat crop, the 'Noni' genotype was studied for its economic performance in relation to different N rates and agricultural practices (Kolmanič et al., 2022).

Under the conditions of the present study, the response of the spring oat crop, 'Ovidiu' variety, in terms of yield values and seed quality parameters, in relation to soil tillage and applied fertilization, was recorded.

The multivariate analysis clarified the positioning and correlation of the variants with the yield and parameters considered at sowing, in relation to the two factors, soil work and fertilization.

Thus, four variants (V2, V4, V6 and V8) were positioned correlated with the yield (V2, V4) and seed quality parameters, respectively with PRO and TKW (variant V8) and with seed moisture, MST (variant V6). These variants had NPK fertilization and ammonium nitrate fertilization, and nitrogen supplementation made the difference compared to the other variants. The other four variants (V1, V3, V5 and V7), which benefited only from NPK fertilization, were positioned independently.

In the case of variants correlated with yield and seed quality parameters, soil cultivation led to their differentiated positioning. Thus, variants V2 (disc cultivation) and V4 (shallow scarification) were positioned correlated with yield. Variant V8 (plowing) was positioned correlated with TKW and PRO parameters. Variant V6 (deep scarification) was positioned correlated with seed moisture at harvest (MST).

Cluster analysis grouped the variants based on similarity in relation to the values of yield and seed quality parameters, considered simultaneously in the analysis. The variants were grouped into two distinct clusters in relation to the applied fertilization, and within each cluster, they were grouped in relation to soil cultivation.

CONCLUSIONS

Under the study conditions, spring oat, the 'Ovidiu' variety, responded differently in terms of yield and seed quality parameters in relation to soil tillage and applied fertilization.

Fertilization with complexes and ammonium nitrate (NPK+GAN) differentiated the experimental variants based on yield values and seed quality parameters compared to the variants fertilized only with complexes. Multivariate analysis (PCA) and cluster analysis (CA) highlighted in statistical safety the differentiation of the variants in relation to fertilization.

Soil tillages differentiated the variants within the two types of fertilization, according to PCA. Variants V2 and V4 were correlated with yield, variant V8 was correlated with TKW and PRO parameters, and variant V6 was correlated with MST parameter. The other variants were positioned independently of yield and seed quality parameters.

Yield showed a very strong positive correlation with the PRO parameter ($r = 0.94$), and a strong positive correlation with the TKW parameter ($r = 0.85$), and the TKW and PRO parameters showed a very strong positive correlation ($r = 0.93$).

Statistically significant differences were recorded between the experimental variants, both for yield and for the seed quality parameters considered, in relation to the calculated average values.

The recorded results have scientific and practical importance, and provide useful information for farmers, in order to optimize spring oat cultivation technology, and management decisions for the sustainability of crops and farms.

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