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VARIATION OF SOME PARAMETERS IN AUTUMN CABBAGE HEAD IN RELATION TO GENOTYPE – COMPARATIVE ANALYSIS

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ABSTRACT

This study evaluated the variation of some agronomic parameters in autumn cabbage under open field cultivation conditions. The study was conducted in the area of Orastie, Hunedoara County, agricultural year 2024 - 2025. Three local populations and one hybrid form of autumn cabbage were cultivated: 'Călan' (G1), 'Gelmar' (G2), 'Autumn King F1' (G3) and 'Aurel Vlaicu' (G4). The biological material came from local growers. Head dimensions (height, diameter, weight), shape index, central stem dimension, and usefull leaves number were determined. The presence of variance and statistical reliability of the experimental data were confirmed (ANOVA Test). Comparative analysis (Post Hoc Test) confirmed significant differences between the winter cabbage genotypes for the considered parameters, in conditions of statistical reliability.

INTRODUCTION

Common cabbage (*Brassica oleracea* L. var. *capitata*) is widely cultivated worldwide, and is an important crop, integrated into the world's cuisine and diet under various preparations, an important crop for food safety and security (Tong et al., 2025; Khalilov & Abdimuminov, 2026).

Recent studies have shown the differential response of cabbage plants and cabbage crop yield to soil and climate conditions, irrigation, types and combinations of fertilizers and specific elements of technology (Hou & Chang, 2025; Rolbiecki et al., 2025; Wang et al., 2025; Zhou et al., 2026).

Plant growth rate and cabbage yield were evaluated in relation to varying rates of organic fertilization (Gelaye & Tadele, 2022; Zhou et al., 2026). The quality of cabbage production and ecosystem health were studied in relation to different mineral fertilization rates in open field cabbage cultivation, with the aim of optimizing cultivation technologies through adapted fertilization strategies (Liu et al., 2025).

The variation of some growth parameters of cabbage plants was studied in relation to technological elements, such as planting and harvesting methods (Narwariya et al., 2023). Agronomic parameters of productivity and yield were studied in cabbage, in relation to different genotypes, and to the water factor,

cabbage being a crop with high water requirements (Cervenski et al., 2011; Demir et al., 2024).

In autumn cabbage, both local populations have been studied and are cultivated, with very good adaptation to specific climate and soil conditions, as well as hybrid forms, with specific values of agronomic parameters and quality indices (Cervenski et al., 2011; Ashik et al., 2022).

The present study evaluated the variation of some agronomic parameters in cabbage head in four autumn cabbage genotypes, represented by local populations and hybrid forms, under open field cultivation conditions.

MATERIAL AND METHODS

The study was conducted in the area of Orastie, Hunedoara County, Romania, agricultural year 2024 - 2025. The biological material was represented by four genotypes of autumn cabbage, collected from the area of Orastie locality, from local growers. Autumn cabbage is cultivated in the area, predominantly by local populations, but in recent years hybrid forms have also been taken into culture. Therefore, based on the concerns of growers in the area, the following genotypes were taken into consideration: 'Călan' (G1), 'Gelmar' (G2), 'Autumn King F1' (G3) and 'Aurel Vlaicu' (G4), Figure 1. Genotypes G1, G2 and G4 are local populations, and genotype G3 is the hybrid form. The experimental crop was located in the area of Orastie, with a specific cultivation technology for autumn cabbage.



'Călan' (G1) | 'Gelmar' (G2) | 'Autumn King F1' (G3) | 'Aurel Vlaicu' (G4)

Figure 1. Cabbage genotypes studied

Representative agronomic parameters for autumn cabbage were evaluated, regarding the size and shape of the head. Thus, the following were determined: cabbage head height (CHH, cm), cabbage head diameter (CHD, cm), central stem height (CSH, cm), central stem diameter (CSD, cm), useful leaves numbers (ULN), leaf vein thickness (LVT, cm), cabbage head weight (CHW, kg). Based on the size of the cabbage heads, the shape index (SI) was calculated. For the reliability of the determinations, measurements were made on 25 heads (N = 25) for each genotype.

In relation to the purpose of the study, the recorded data were analyzed to assess the presence of variance and data reliability (ANOVA Test; Alpha = 0.05). Comparative analysis was performed between genotypes for important parameters of cabbage heads (CHH, CHD, SI, ULN, CHW). The Post Hoc Comparisons test was applied, with appropriate statistical safety parameters ($p<0.05$, *; $p<0.01$, **; $p<0.001$, ***). PAST v4.14 software (Hammer et al., 2001) and JASP v.0.16.2 (2022) software were used for the analysis of experimental data.

RESULTS AND DISCUSSIONS

The data series (N = 25, for each genotype) were statistically analyzed, and the mean values of the cabbage head parameters, and the standard error (SE) values, are presented in Table 1. The height of the cabbage head varied between CHH = 9.95 ±0.18 cm ('Călan' genotype), to CHH = 15.10±0.25 cm ('Aurel Vlaicu' genotype). The diameter of the cabbage head varied between CHD = 16.34±0.20 cm ('Gelmar' genotype), to CHD = 20.81±1.14 cm ('Călan' genotype). Useful leaves numbers varied between ULN = 24.42±0.45 ('Aurel Vlaicu' genotype), to ULN = 26.94±0.78 ('Călan' genotype). The weight of the cabbage head varied between CHW = 1.20±0.13 kg ('Aurel Vlaicu' genotype), to CHW = 1.66±0.031 kg ('Autumn King' genotype).

Table 1

Values of parameters in cabbage head, in relation to genotype

Genotip	Cabbage head parameters							
	CHH	CHD	SI	CSH	CSD	ULN	LVT	CHW
	(cm)	(cm)		(cm)	(cm)	(no)	(cm)	(kg)
'Călan'	9.95	20.81	0.49	5.77	2.90	26.94	1.01	1.28
SE	±0.18	±1.14	±0.08	±0.29	±0.07	±0.78	±0.04	±0.14
'Gelmar'	13.60	16.34	0.83	6.18	2.62	25.22	1.05	1.35
Se	±0.28	±0.20	±0.03	±0.16	±0.09	±0.68	±0.07	±0.054
'Autumn King F1'	13.68	19.28	0.71	5.76	2.70	26.59	0.91	1.66
SE	±0.30	±0.26	±0.03	±0.10	±0.09	±0.83	±0.04	±0.031
'Aurel Vlaicu'	15.10	17.49	0.87	7.26	3.29	24.42	0.80	1.20
SE	±0.25	±0.28	±0.09	±0.24	±0.09	±0.45	±0.04	±0.13

Note: SE – standard error

The experimental data presented statistical reliability, and the presence of variance in the data set was confirmed, according to the ANOVA Test (Alpha = 0.05), Table 2.

Table 2

ANOVA Test results

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	7493.082	7	1070.440	907.918	<0.001	2.115
Within Groups	103.753	88	1.179			
Total	7596.835	95				

The comparative analysis was performed between the autumn cabbage genotypes, for the main parameters of the cabbage heads.

In the case of the head height (CHH) parameter, the ANOVA test (Post hoc analysis) led to the results in Table 3. In most comparative analyses there were significant differences between genotypes, at the $p<0.001$ level (***), except for the comparison between genotypes G2 and G3 ($p>0.05$).

Table 3

Post Hoc Test results for CHH parameter

Genotype		Mean difference	95 % CI for mean difference		Statistical parameters			
			Lower	Upper	SE	t	p	Sig
G1	G2	-3.65	-4.321	-2.979	0.209	-17.424	<0.001	***
	G3	-3.73	-4.401	-3.059		-17.806	<0.001	***
	G4	-5.15	-5.821	-4.479		-24.584	<0.001	***
G2	G3	-0.08	-0.751	0.591		-0.382	0.980	ns
	G4	-1.50	-2.171	-0.829		-7.160	<0.001	***
G3	G4	-1.42	-2.091	-0.749		-6.779	<0.001	***

Note: CI – confidence interval

In the case of the cap diameter (CHD) parameter, the comparative analysis (Post hoc analysis) led to the results in Table 4. Significant differences were recorded between genotypes G1 and G2, respectively G1 and G4 at the p<0.001 level (***), between genotypes G2 and G3 at the p<0.01 level (**), and respectively between genotypes G3 and G4 at the p<0.05 level (*). In the case of the other comparisons (G1 with G3; G2 with G4) the differences did not present statistical certainty.

Table 4

Post Hoc Test results for CHD parameter

Genotype		Mean difference	95 % CI for mean difference		Statistical parameters			
			Lower	Upper	SE	t	p	Sig
G1	G2	4.47	2.877	6.063	0.498	8.983	<0.001	***
	G3	1.53	-0.063	3.123		3.075	0.060	ns
	G4	3.32	1.727	4.913		6.672	<0.001	***
G2	G3	-2.94	-4.533	-1.347		-5.908	0.002	**
	G4	-1.15	-2.743	0.443		-2.311	0.174	ns
G3	G4	1.79	0.197	3.383		3.597	0.029	*

In the case of the head shape index (SI), the comparative analysis (Post hoc analysis) led to the results in Table 5. Significant differences were recorded between genotypes G1 and G2, respectively G1 and G4 at the p<0.001 level (***), and between genotypes G1 and G3 at the p<0.05 level (*). At the level of the other genotypes, the differences did not present statistical certainty (ns).

In the case of useful leaf number (ULN), the comparative analysis (Post hoc analysis) led to the results in Table 6. Significant differences were recorded between genotypes G1 and G2, respectively G1 and G4 at the p<0.001 level (***), and between genotypes G1 and G3 at the p<0.05 level (*). At the level of the other genotypes, the differences did not present statistical certainty (ns).

Table 5

Post Hoc Test results for SI parameter

Genotype		Mean difference	95 % CI for mean difference		Statistical parameters			
			Lower	Upper	SE	t	p	Sig
G1	G2	-0.34	-0.507	-0.173	0.052	-6.523	< .001	***
	G3	-0.22	-0.387	-0.053		-4.221	0.012	*
	G4	-0.38	-0.547	-0.213		-7.291	< .001	***
G2	G3	0.12	-0.047	0.287		2.302	0.177	ns
	G4	-0.04	-0.207	0.127		-0.767	0.867	ns
G3	G4	-0.16	-0.327	0.007		-3.070	0.06	ns

Table 6

Post Hoc Test results for ULN parameter

Genotype		Mean difference	95 % CI for mean difference		Statistical parameters			
			Lower	Upper	SE	t	p	Sig
G1	G2	1.72	0.181	3.259	0.481	3.578	0.03	*
	G3	0.35	-1.189	1.889		0.728	0.883	ns
	G4	2.52	0.981	4.059		5.243	0.003	**
G2	G3	-1.37	-2.909	0.169		-2.85	0.082	ns
	G4	0.80	-0.739	2.339		1.664	0.399	ns
G3	G4	2.17	0.631	3.709		4.515	0.008	**

In the case of cabbage head weight (CHW), the comparative analysis (Post hoc analysis) led to the results in Table 7. Significant differences were recorded between genotypes G1 and G3, respectively G3 and G4 at the $p<0.01$ level (**), and between genotypes G2 and G3 at the $p<0.05$ level (*). At the level of the other genotypes, the differences did not present statistical certainty (ns).

Table 7

Post Hoc Test results for CHW parameter

Genotype		Mean difference	95 % CI for mean difference		Statistical parameters			
			Lower	Upper	SE	t	p	Sig
G1	G2	-0.069	-0.332	0.194	0.082	-0.841	0.834	ns
	G3	-0.380	-0.643	-0.117		-4.632	0.007	**
	G4	0.084	-0.179	0.347		1.024	0.741	ns
G2	G3	-0.311	-0.574	-0.048		-3.791	0.022	*
	G4	0.153	-0.110	0.416		1.865	0.313	ns
G3	G4	0.464	0.201	0.727		5.656	0.002	**

The correlation analysis revealed variable levels of interdependence between the parameters considered in the cabbage heads. The head shape index (SI) showed a very strong, positive correlation with CHH (r = 0.924***), and a strong, negative correlation with CHD (r = -0.755**). Strong positive correlation was recorded between CSH and CSD (r = 0.813**), between CSH and SI (r = 0.739**), between ULN and CHD (r = 0.793**). Strong, negative correlation was recorded between CHH and CHS (r = -0.709**), between ULN and CSH (r = -0.717**). Other positive or negative correlations of variable intensity were also recorded between other parameters considered in the description of the cabbage heads, Figure 2.

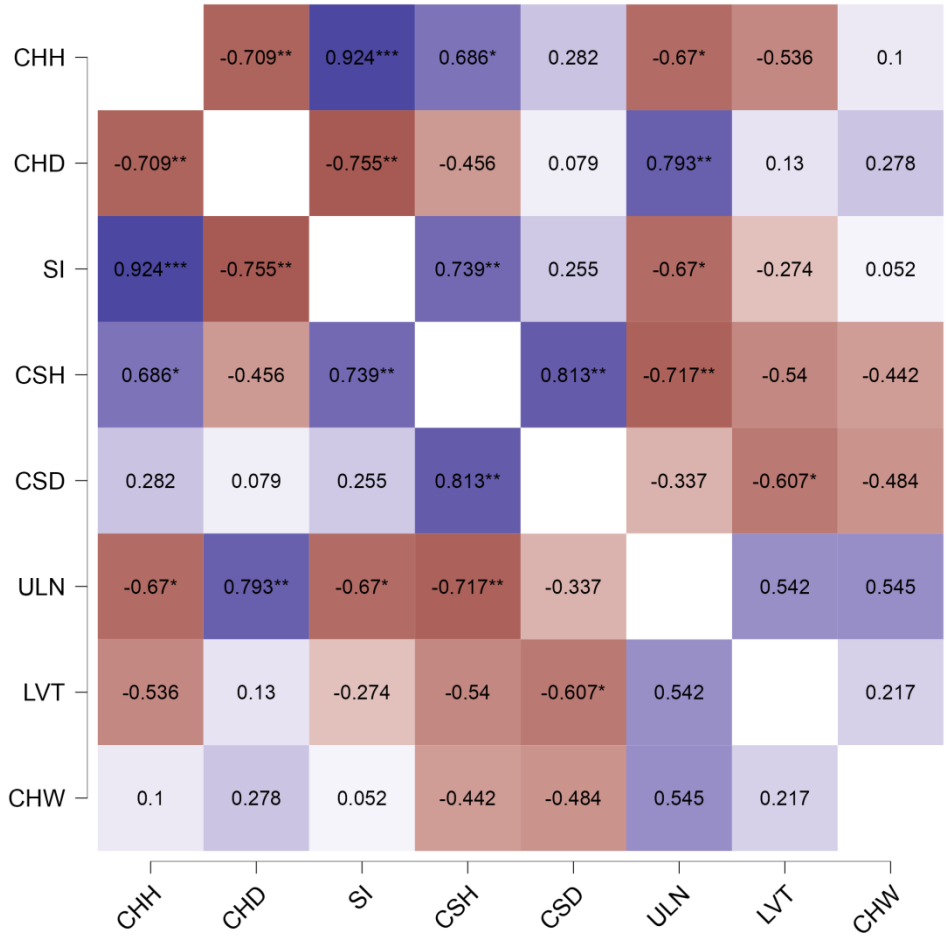


Figure 2. Correlation matriv between cabbage head parameters

Dimensional parameters of cabbage heads were studied in local genotypes and hybrid forms of autumn cabbage, for comparative analysis and evaluation of genotype performances (Cervenski et al., 2011). The variation of agronomic parameters of cabbage plants was evaluated in relation to different planting methods (Narwariya et al., 2023). Morphological characters have been studied in cabbage during the stages of plant growth and development, in order to describe the process

of cabbage head formation (Liu et al., 2024). Methods and models based on image analysis have been promoted for the accurate assessment of cabbage head dimensions, with applicability for mechanized harvesting (Zheng et al., 2024).

In the case of the present study, the recorded results showed obvious differences between genotypes for cabbage head parameters, with differences within statistical safety conditions.

CONCLUSIONS

The four cabbage genotypes presented differentiated values for dimensional parameters and the shape index of the autumn cabbage head. Regarding the shape index (SI) of the cabbage heads, significant differences were recorded between the genotypes G1 and G2, respectively G4 ($p<0.001$, ***) and between the genotypes G1 and G3 ($p<0.05$, *).

Regarding the number of useful leaves (ULN), significant differences were recorded between genotypes G1 and G2 ($p<0.05$, *) and between genotypes G1 and G4, respectively between genotypes G3 and G4 ($p<0.01$, **).

For cabbage head weight (CHW), significant differences were recorded between genotypes G2 and G3 ($p<0.05$, *) and between genotypes G1 and G3, respectively G3 and G4 ($p<0.01$, **).

The level of correlation recorded between cabbage head parameters, associated with the differences between genotypes, explains the contribution of the parameters to head formation, and facilitates the choice of those genotypes that correspond to the final use of autumn cabbage heads.

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