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MORPHOLOGICAL VARIABILITY IN THE NEW VARIETIES OF TRITICALE, HAIDUC AND FDL BOLID

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Abstract
Currently, new varieties of triticale show improved morphological characteristics, according to the requirements of practice. The new directions mainly concern the waist and the components of the ear. Recent research has shown that new varieties, which form chains with relatively lower heights, could be suitable for different levels of intensification. On the other hand, current studies on morphological characters are useful in the progress of variety improvement, characteristic of the current stage. The wide genetic dowry and growing conditions of triticale usually lead to the specific expression of plant morphology. In the autumn triticale varieties Haiduc and FDL Bolid, some new directions were found, these being recently improved. Thus, compared to the two varieties, the straw and its upper segments were shorter in Haiduc. The thickness of the straw at the base was 0.2 mm smaller at Bolid. Both the length of the spike and its weight were similar. The Haiduc variety dominated instead in the number of spikelets in a spike, 31 compared to 29 in the Bolid variety. The membranes that cover the spikelet had similar dimensions: the external glume of 9 mm, the lower palea of 12-13 mm, and at Bolid the awn was 2 cm higher. The two varieties of triticale were more obviously differentiated by the morphological characteristics of the grains. Thus, for the Bolid variety, the number of grains in an ear was higher by 10, and the weight was higher by 0.5 g. Instead, the grain length was higher in Haiduc. The dominant values of the mass of one thousand grains were in both varieties at 50 g. Specific and at the same time important correlations were obtained between the morphological characters of the varieties. Thus, the number of grains in an ear and their weight were positively correlated with all the studied characters, with higher values of the correlation coefficients obtained for the Bolid variety. Both varieties of autumn triticale have demonstrated by their morphological characteristics, a good adaptability to zonal conditions.

Keywords: ears, grains, spikelets, variability.

1.INTRODUCTION

Triticale (x *Triticosecale* Wittm. Ex A. Camus), (pro syn. x *Triticale* Erich von Tschemak ex. Müntzing) being a relatively new species (Becker et al., 2001; Góral et al., 2005), currently has a increasing due to its various uses (Johansson et al., 2000; Hede, 2001; Lorenz, 2003). The species is actually a hybrid between wheat (T*riticum*) and rye (*Secale*) (Chaudhary et al., 2004). From both species the plant has both a certain quality (from wheat) and resistance to climatic extremes (from rye) (Burger et al., 2003). Due to its high adaptability (Chelkowski & Tyrka, 2003), the plant is found in a multitude of growing conditions on virtually all continents. The purpose of its cultivation is the production of grains and total plant material. Winter triticale with the hexaploid genome (the

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most productive) 2n = 42, has the content with the AABBRR genes, namely with 28 wheat chromosomes (AABB) and 14 rye chromosomes (RR) (Cavaleri, 2002; Baenzinger et al., 2003).
Both experimentally grown varieties also contain the modern RHt gene, which determines the short stem/ straw, suitable for rich fertilization and mechanized harvesting. The consequence is the possibility for these new varieties to be more productive. From a botanical point of view, the inflorescence is a terminal spike/ ear, distich, 4-18 cm long, with sessile spikelets, caught solitary on the zig-zag spine. The spikelet is 10-25 mm long, is compressed laterally and contains several flowers. The awn have the tip like a short, blunt tooth, but also an awn of 3-5-10 cm. Each flower (Gonzáles & Jouve, 2004) has a glume and a *lemma*. Depending on the variety, the lemma extends in the form of an awn, or is similar to a hood. The grain (caryopsis) is ellipsoidal, with a central channel on one side. The bean is 4-12-14 mm long and 1.5-4.5 mm thick. The mass of one thousand grains (MMB) is 15-60-70 g. The plant generally forms stems with heights between 50 (60) and 140 (150) cm. The research carried out to observe the variation of some plant characters from the two varieties included: the stem by the total length of the straw, the length of the last three internodes under the spike, the thickness of the basal internode, the length and weight of the spike, the number of spikelets / spike, the length of the outer glume, the length of the lower palea (*lemma*), the length of the awn, the number of grains / ear, their weight, the mass of one thousand grains (MMB) and the dimensions of the grains (length and thickness).

2.MATERIALS AND METHODS

The variants have been cultivated in the last two years with the varieties Haiduc and FDL Bolid, with relatively close morphological characteristics. The experience was set up according to the block method, with variants of 25 m^2 in 4 repetitions/ replicates. The technology used was the one recommended by the resort. At full maturity, 25 plants/ strains from each repetition were randomly selected (a total of 100), cut and brought to the laboratory. The 100 stems were measured and determined: total straw length, upper internodes length, basal internode thickness, spike length and weight, number of spikelets in spike, length of glume, palea and awn, number of grains in one spike and their weight, mass of one thousand grains (MMB), and grain size: length and thickness. The morphological characters obtained were analyzed by the method of histograms (also called frequency polygons). In their expression were used both the absolute values as such and in the form of class intervals, established according to the specific range of values obtained. The study performed on each morphological character included: the mod values (with the highest frequencies), the limits of the intervals of variability of the studied characters and the specificity of each character of the triticale eco-types in the analyzed area. The correlations were established between the analyzed characters, with the help of which their tendencies within the studied eco-types could be observed. Excel was used to express values. The significance of the correlation coefficients was obtained by comparing with the r_{max} values for the levels of 5%, 1% and 0.1% of the transgression probabilities. In the statistical calculation of all the values obtained, the analysis of variance (Anova test) was used, namely on the variation strings. Statistical parameters were calculated using the formulas:

$\bar{a} = \frac{\Sigma x}{n}$, , where ā = average of the determinations, and x = determined values,

S^2 (variance) = $\frac{1}{n-1}\left[\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right]$,

S (standard deviation) = $\sqrt{S^2}$,

S% (variation coefficient) = S/ā.100.

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3.RESULTS AND DISCUSSIONS

Variability of the triticale stem/ straw and internodes dimensions. The stem or straw of triticale consists of several internodes (usually 5-7) with increasing lengths towards the ear. In general, straw has lengths between 50 (60) cm and 150 cm. At harvest maturity, the stems of the two varieties have a vertical position, with a relatively small size. The total length of the straw was between 62 and 95 cm, and the dominant ones were those of 74 cm (27%) for the *Haiduc* variety and those with 86 cm (26%) for the *Bolid* variety. Close to these were those of 77 cm (21%) for the first variety and those of 89 cm (14%) for the second variety (figure 1). The segment/ internode 3 under the spike had lengths between 8 and 16 cm, of which the dominant ones were those of 12 cm (33%) in *Haiduc* and 14 cm (37%) in the Bolid variety (figure 2). It is thus found that the *Bolid* variety had a segmental 3 slightly longer than the first variety. The sub-apical internode had slightly larger dimensions, namely between 15 and 23 cm. Of these, those with lengths of 18 cm had the highest frequencies (26%) for the first variety and 21 cm (32%) for the second variety (figure 3). And in this case the *Bolid* variety had this subapical internode 3 cm longer (figure 3). The apical internode, the one under the spike, had the largest densities, namely between 18 and 30 cm. Of these, it was found that both the *Haiduc* variety and the *Bolid* variety had dominant dimensions of 24 cm (34% for *Haiduc* and 46% for the *Bolid* variety) (figure 4). At the same time, the diameter of the straws in the basal portion of the two varieties had different values. These were between 2.9 mm and 5.1 mm (figure 5). The *Haiduc* variety had dominant diameters at the base of the straw of 4.1 mm (29%), while the *Bolid* variety was dominated by straw with 3.9 mm in diameter (22%). In general, it was found that the *Bolid* variety exceeded in size the straw of the *Haiduc* variety, but having a smaller stem thickness at the base, it is possible to manifest more easily the phenomenon of breaking and falling, respectively (figure 6).

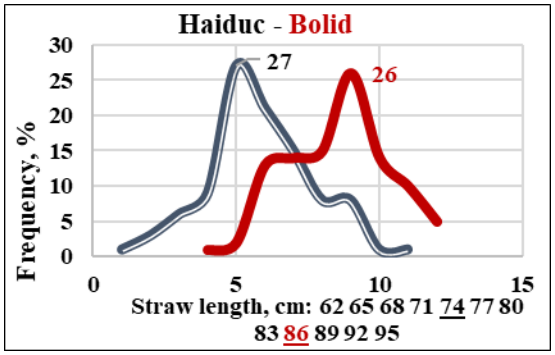

Fig. 1. Frequencies of straw length

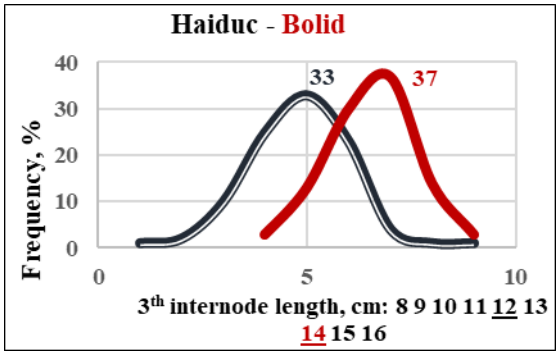

Fig. 2. Frequencies of third internode length

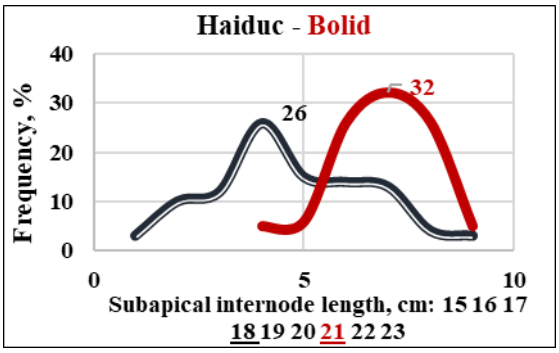

Fig. 3. Frequencies of subapical internode length

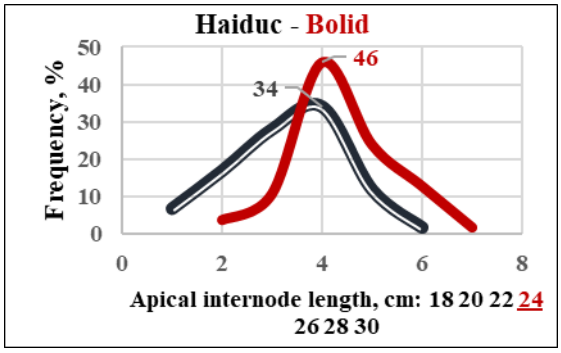

Fig. 4. Frequencies of apical internode length

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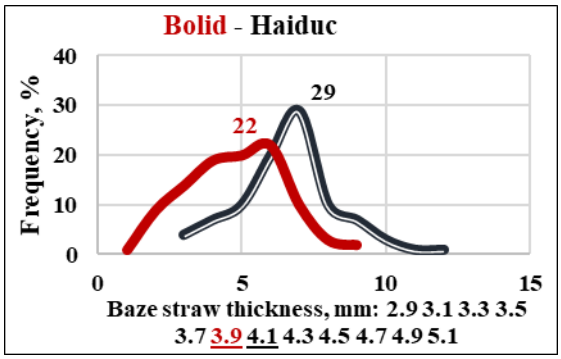

Fig. 5. Frequencies of baze internode thickness

Fig. 6. Haiduc variety morphological aspect

Variability of the triticale characteristics of ears and grains.The species is characterized by spikes with important lengths, reaching to impress by their formation in the chain, after the flowering period. Most often, newly created varieties form ears of lengths ranging from 12 to 14 cm (Lorenz, 2003). In the case of the researched varieties, a variability of the length of the ears between 7 cm and 14 cm was obtained. The dominant dimensions were 10 cm for both varieties. Instead, their frequency was 25% for the *Bolid* variety and 31% for the *Haiduc* variety (figure 7).

The weight of these ears was generally between 1.5 g and 6.5 g, which demonstrates the wide possibilities (Chelkowski & Tyrka, 2003), which triticale had in the conditions of cultivation created (figure 8). The *Haiduc* variety was dominated by ears with a weight of 3 g in a proportion of 30%, and the *Bolid* variety was dominated by those with 2.5 g (19%). The graph shows that the *Bolid* variety, however, showed a tendency to form spikes whose weights exceed the threshold of 4 g, which is an important genetic gain obtained by breeding activity.

The number of spikelets in a spike experienced a fairly pronounced variability (Becker et al., 2001), so that they were generally between 17 and 39 (figure 9). In the case of the two varieties, it was found that *Bolid* had dominant spikes with 31 spikelets (22% - figure 10)), while *Haiduc* dominated spikes with 29 spikelets. On the other hand, in the *Haiduc* variety there was an important tendency to form more spikelets in the register between 33 and 39.

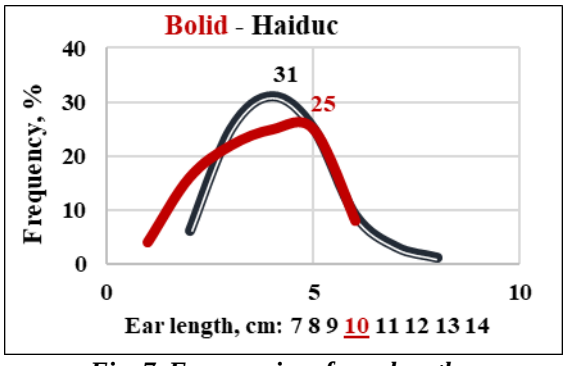

Fig. 7. Frequencies of ear length

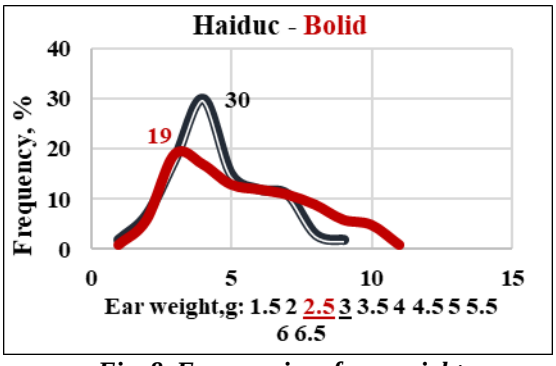

Fig. 8. Frequencies of ear weight

The length of the outer glume and the lower palea showed specific dimensions. Thus, if the external glume of both varieties had a dominant one of 9 mm, the total register was from 6 to 12 mm (figure 11). The other membrane, the lower palea (also called *lemma*), showed lengths between 8 and 15

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mm (figure 12). The dominant *lemma* in the *Haiduc* variety measured 13 mm (24%), while in *Bolid* it was 12 mm (37%). The length of the awns measured in the upper third of the ears had lengths generally between 3 and 9 cm (figure 13). The *Haiduc* variety had dominant awns of 5-6 cm (35%), while in *Bolid* they dominated with a length of 7 cm (39%). Morphological characteristics of the *Bolid* variety ear are shown in figure 14.

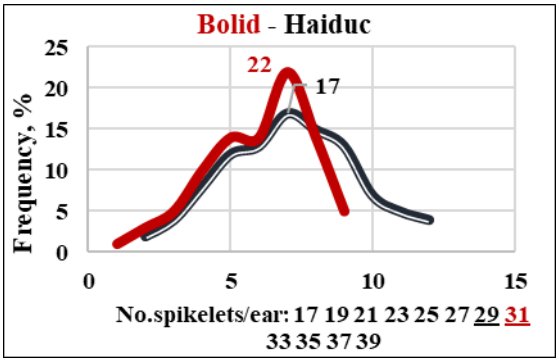

Fig. 9. Frequencies of spikelets no./ear

Fig. 10. FDL Bolid variety morphological aspect

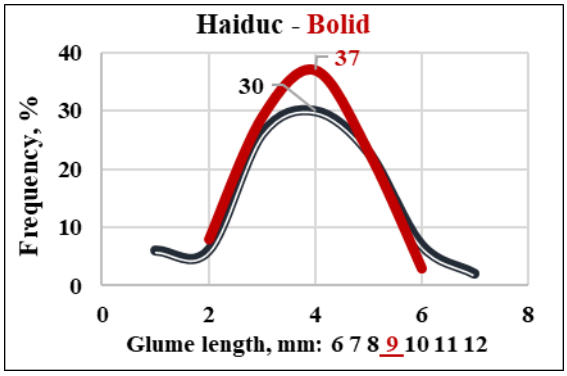

Fig. 11. Frequencies of outer glume length

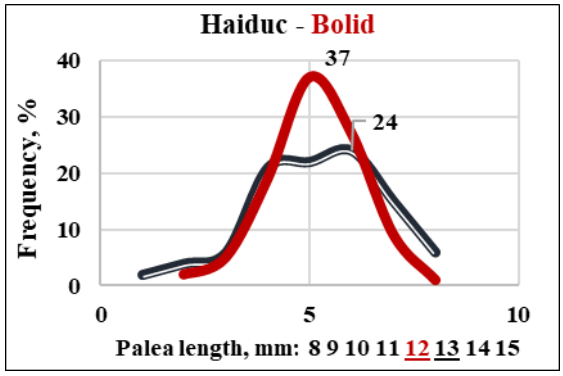

Fig. 12. Frequencies of palea/ lemma length

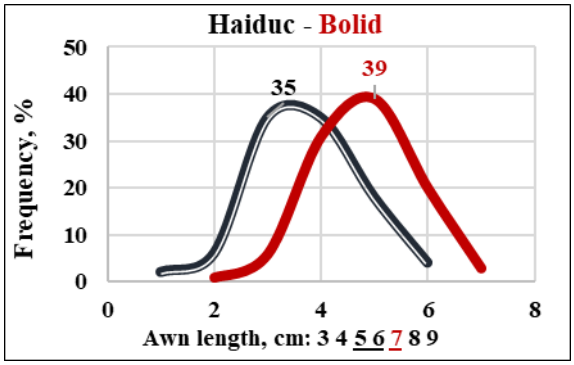

Fig. 13. Frequencies of awn length

Fig. 14. Spike/ ear, spikelet and grains of Bolid variety

Variability of triticale grains. An important economic characteristic of triticale plants is the number of grains in an ear and their weight. Current genetic possibilities (Chelkowski & Tyrka, 2003) have shown that more than 30 grains can generally form in an ear of triticale (Góral et al., 2005). Indeed, the two varieties investigated formed in an ear between 25 and 90 grains (figure 15). In the *Haiduc* variety, the ears with 45 grains (25%) were dominant, and in *Bolid*, those with 55 grains / ear (13%)

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dominated. In both varieties there was a tendency to form a higher number of berries in an ear. The weight of the grains in an ear had values between 1 and 5 g (figure 16). In the *Haiduc* variety, grains weighing 2 g / ear (33%) dominated, and in *Bolid*, those with 2.5 g / ear (21%) dominated.

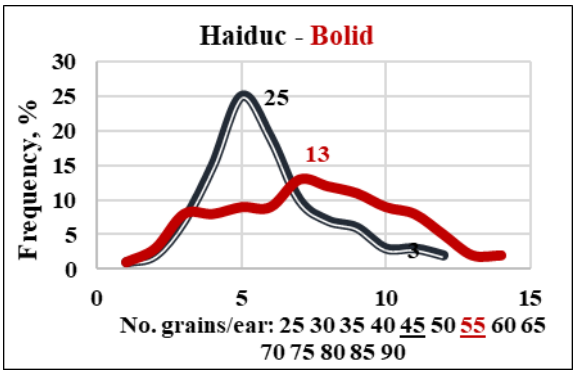

Fig. 15. Frequencies of grains no./ear

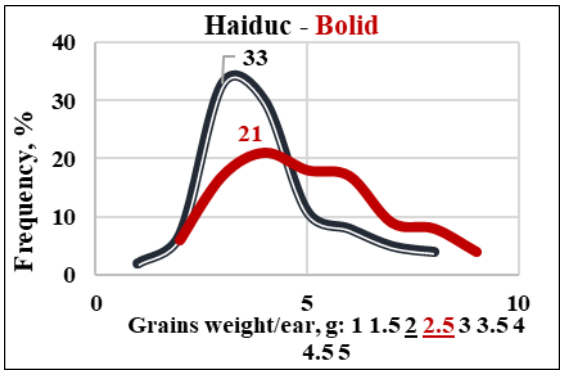

Fig. 16. Frequencies of grains weight/ear

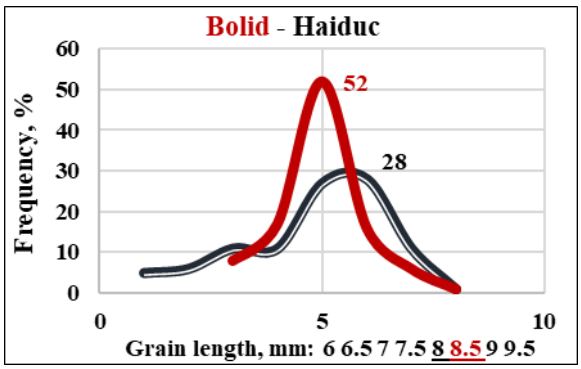

Fig. 17. Frequencies of grain lengths

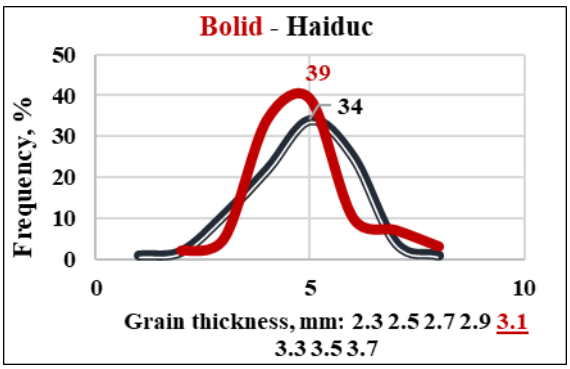

Fig. 18. Frequencies of grain thickness

The dimensions of the grains were expressed specifically in both varieties of triticale. Thus, the grain length was between 6 mm and 9.5 mm (figure 17). There were differences between the two varieties in the sense that in *Haiduc* dominated the grains with lengths of 8 mm (28%) while in *Bolid* dominated the grains with 8.5 mm in length (52%). The thickness of the grains in the central portion had values between 2.3 mm and 3.7 mm (figure 18). Of these, 3.1 mm thick grains dominated both varieties. Their dominance was 34% in *Haiduc* and 39% in *Bolid*.

The mass of one thousand grains - MTG, was between 35 and 70 g (figure 19). The dominant frequencies showed that both varieties had the character of MTG at 50 g, but with modal values of 29% for *Haiduc* and 25% for *Bolid*. Characteristics of the *Bolid* variety grains are shown in figure 20.

Correlations between the main morphological characteristics of triticale plants. If we analyze the whole set of correlations between all the characters analyzed for the two varieties of triticale, specific situations are found (Hede, 2001). Thus, statistically assured correlations were obtained for the *Haiduc* variety in most cases (table 1). Of these, the positive correlations between the weight of the ear with the other characters were noticed, less obvious with the membranes of the ear and with the thickness of the grain. The dimensions of the grain were generally insignificantly correlated with the other characters, with some exceptions.

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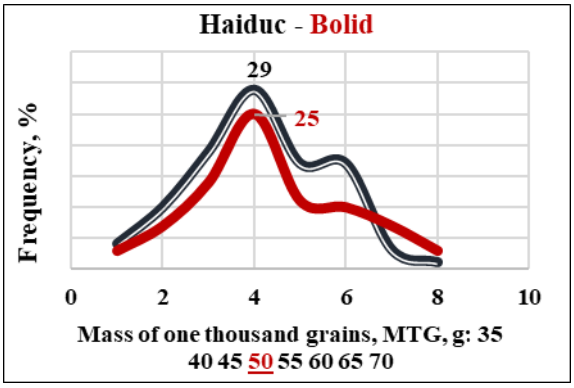

Fig. 19. Frequencies of mass of one thousand grains

Fig. 20. Details of Haiduc variety grains

Table 1. Correlations between the main morphological characters of triticale varieties

HAIDUC Character	Base int.	Sub-apical	Apical	Ø base	Ear length	Ear weight	No. spikelets	Glume	Palea	Awn	No. grains	Grains weight	Grain length	Grain width	MTG
Plant size	**.6788**	**.4343**	**.4525**	**.0400**	**.3567**	**.5078**	**.2073**	-.0008	.0748	.1024	**.3143**	**.3716**	**-.2302**	-.0624	**.2535**
Base internode	1	**.3477**	.1697	**-.0509**	.1442	**.2275**	.0360	-.1400	-.1624	-.0346	.0969	.1621	-.1729	-.1208	**.2109**
Sub-apical int.		1	**.5501**	.0264	-.0911	.0640	-.1813	.0360	-.1024	-.0648	.0387	.0346	**-.2029**	-.0264	-.0031
Apical int.			1	.1857	**.2723**	**.3732**	.1195	.1857	**.2059**	**.2416**	**.3709**	**.3907**	-.1034	.0989	**.1977**
Ø base				1	**.4595**	**.2574**	**.4715**	**.4656**	**.4804**	.1315	**.3856**	.0771	**.2879**	**.3683**	-.0001
Ear length					1	**7837**	**.7161**	**.3401**	**.3988**	**.4048**	**.6791**	**.6272**	.0663	.1256	**.2066**
Ear weight						1	**.5556**	.1240	.1897	**.3685**	**.7387**	**.8332**	-.0616	.0905	**.4738**
No. spikelets							1	**.3915**	**.5235**	**.2073**	**.5563**	**.4427**	.0583	**.2808**	.0812
Ext. glume								1	**.5491**	.1356	**.2653**	.1292	**.3827**	**.3987**	-.1705
Inf. palea									1	**.2289**	**.3734**	.1824	**.4066**	**.3761**	**-.2325**
Awn length										1	**.4324**	**.3991**	**.2154**	**.2712**	.1276
No. grains/ ear											1	**.8681**	.0734	.1886	.1300
Grains weight												1	.0244	.1913	**.5570**
Grain length													1	**.4859**	-.1183
Grain width														1	.0678

BOLID															
Plant size	.6793	**.4125**	.1200	**.2319**	**.2172**	**.3322**	.1849	.2430	.1918	.1428	**.3038**	**.3176**	**.2513**	.0734	.1224
Base internode	1	**.2012**	**-.2428**	.0707	-.0374	.0793	.0100	.0458	.0979	-.0678	.0938	.0714	.1039	-.0800	.0141
Sub-apical int.		1	**.4118**	.1513	-.0932	.0888	-.1424	-.1915	.0692	.1208	-.0447	.0734	.0244	.1311	.1783
Apical int.			1	.1224	.1568	**.3474**	.0921	**.3214**	**.1902**	**.3410**	.1726	**.3360**	**.2247**	**.3004**	**.3471**
Ø base				1	**.4611**	**.4091**	**.4146**	**.3009**	**.3077**	**.1857**	**.3489**	**.3417**	.0848	.0141	.0927
Ear length					1	**.7505**	**.8990**	**.6178**	**.5350**	**.5916**	**.8689**	**.6933**	**.2381**	.1004	-.0948
Ear weight						1	**.7321**	**.6970**	**.6742**	**.6210**	**.8733**	**.9798**	**.4820**	**.4484**	**.3860**
N0. spikelets							1	**.5710**	**.5520**	**.5535**	**.8888**	**.6923**	.1374	.0848	-.1466
Ext. glume								1	**.6791**	**.6126**	**.6630**	**.6630**	**.2844**	**.2437**	.1272
Inf. palea									1	**.5044**	**.6368**	**.6519**	**.2624**	**.2968**	**.1957**
Awn length										1	**.6175**	**.5862**	**.2300**	**.2114**	.0774
No. grains/ ear											1	**.8460**	**.2734**	.1526	-.0519
Grains weight												1	**.4779**	**.4866**	**.4568**
Grain length													1	**.4615**	**.4544**
Grain width														1	**.6228**
	LSD 5 % = .190 **LSD 1 % = .250** **LSD 0.1 % = .320**														

The mass of one thousand grains correlated very significantly positively with the length of the stem and the characters of the ear. Negative correlations were found between the length of the grain and some segments of the stem. In the *Bolid* variety, most correlations were in a greater number positive and statistically assured, compared to *Haiduc*, and insignificant and negative correlations were sporadic. One explanation is that the *Bolid* variety may have adapted much better to the ecology of the resort.

Statistical analysis of the variability of morphological characters in the new varieties of triticale.

The results obtained in the morphological analysis of some triticale characters (Becker et al., 20021), showed specific aspects. Thus, by comparing the *Haiduc* and *Bolid* varieties, the straw

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length measured on average 76 cm compared to 84 cm. The last three internodes under the spike were shorter at *Haiduc*. The diameter of the straw at the base was 4 mm for *Haiduc* and 3.6 mm for *Bolid*. The length of the ears was 9.9 cm compared to 9.3 cm. The weight of the spikes was 3.2 g compared to 3.5 g. The number of spikelets/ spike was on the one hand 29 compared to 28 (table 2). The weight of the ear in both varieties had greater variability.
Between the two varieties, the length of the glume was equal, of 8.8 mm, that of the palea of 12.1 mm for both varieties. In the same order, the number of grains formed in a spike was 48 to 55. The weight of grains in a spike was 2.32 g to 2.76 g. The grains had average dimensions of 7.8 / 2.9 mm compared to 7.8 / 3.0 mm. The mass of one thousand grains was 48 g in *Haiduc* compared to 50.5 g in *Bolid* (table 3). Greater variability was found in the weight of grains from one ear in both varieties.

Table 2. Statistical indices of triticosecale straws and ears

Indices	HAIDUC variety							
	Plant size	Straw characters				Ear characters		
		Basal	Subapical	Apical	Ø Base	Length	Weight	No. spikelets
Mean	**75,51**	**11,82**	**18,71**	**22,16**	**4,088**	**9,902**	**3,1929**	**28,90**
s²	32,89	1,60	3,78	5,28	0,335	1,468	1,3795	24,79
s	5,73	1,26	1,94	2,29	0,578	1,211	1,1745	4,97
VC %	**7,58**	**10,65**	**10,36**	**10,33**	**14,138**	**12,229**	**36,7847**	**17,19**
	BOLID variety							
Indices	**Plant size**	**Straw characters**				**Ear characters**		
		Basal	**Subapical**	**Apical**	**Ø Base**	**Length**	**Weight**	**No. spikelets**
Mean	**83,78**	**13,55**	**20,83**	**24,29**	**3,60**	**9,32**	**3,52**	**27,51**
s²	28,43	1,15	1,39	3,72	0,12	1,63	1,38	18,33
s	5,33	1,07	1,17	1,92	0,34	1,27	1,17	4,28
VC %	**6,36**	**7,89**	**5,61**	**7,90**	**9,44**	**13,62**	**33,23**	**15,55**

s^2 – variance, s –standard error/ standard deviation, VC – variation coefficient

Table 3. Statistical indices of triticosecale ear membranes and grains

Indices	HAIDUC variety							
	Ear membranes			Grains characters				MTG
	Glume	Palea	Awn	No. grains	Weight	Length	Width	
Mean	**8,80**	**12,116**	**5,623**	**48,31**	**2,3208**	**7,768**	**2,917**	**47,6932**
s²	1,58	2,351	0,968	162,13	0,6835	0,642	0,146	67,1501
s	1,25	1,533	0,983	12,73	0,8267	0,801	0,382	8,1945
VC %	**14,20**	**12,652**	**17,481**	**26,35**	**35,6213**	**10,311**	**13,095**	**17,1816**
Indices	**BOLID variety**							
	Ear membranes			**Grains characters**				**TGW**
	Glume	**Palea**	**Awn**	**No. grains**	**Weight**	**Length**	**Width**	
Mean	**8,84**	**12,13**	**6,80**	**55,18**	**2,76**	**7,83**	**3,00**	**50,54**
s²	0,94	1,28	0,92	248,75	0,89	0,24	0,07	78,43
s	0,96	1,13	0,95	15,77	0,94	0,48	0,26	8,85
VC %	**10,85**	**9,31**	**13,97**	**28,57**	**34,05**	**6,13**	**8,66**	**17,51**

s^2 – variance, s –standard error/ standard deviation, VC – variation coefficient

4.CONCLUSIONS

The morphological characteristics of triticale had specific aspects (Góral et al., 2005). The choice of the two varieties was made due to the observation of new morphological characters and the fact that they have recent genetic improvements, especially for the high productive potential (Becker et al., 2001).
By comparison between the two varieties, the stem/ straw had average lengths of 74 cm in *Haiduc* and 86 cm in *Bolid*. The three internodes under the spike had slightly larger dimensions in the *Bolid* variety, while the thickness of the straw at the base was smaller in the *Bolid*. The spike, 10 cm long

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in both varieties, weighed 2.5 to 3 g, in favor of the *Haiduc* variety. The number of spikelets was 29 compared to 31 in favor of the *Bolid* variety. The pieces of the spikelet were: glume with lengths of 9 mm for both varieties and palea of 12 to 13 mm in favor of the *Bolid* variety.
The number of grains in an ear was 45 in *Haiduc* and 55 in *Bolid*, with the corresponding weight of 2 g to 2.5 g. The dimensions of the grains were similar in thickness and longer in *Bolid*. The mass of a thousand grains was 50 g for both varieties.
The morphological characteristics of the grains show that the two new varieties of triticale have morphological characteristics that can ensure higher levels of harvest. Between the two varieties, relative to the same absolute mass of grains, the *FDL Bolid* variety produced about 10 extra grains on the average ear, which is a step forward in improving triticale varieties.
Simple correlations were established between all the studied characters, with some differentiations. Both the positive and significant correlations were obtained between the characters of the straw and those between the elements of productivity. Very close positive links have been established between the components of the ear, which demonstrates the great productive possibilities that the two varieties of triticale have.

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