

# CULTIVAR IMPACT ON THE CHEMICAL CONTENT AND GRAIN TECHNOLOGICAL QUALITIES OF SOME DURUM WHEAT CULTIVARS

## ВЛИЯНИЕ НА СОРТА ВЪРХУ ХИМИЧНИЯ СЪСТАВ И ТЕХНОЛОГИЧНИТЕ КАЧЕСТВА НА ЗЪРНОТО НА СОРТОВЕ ТВЪРДА ПШЕНИЦА

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### Abstract

A comparative experiment was carried out with five Bulgarian and five foreign durum wheat cultivars. The aim of the experiment was to determine the chemical content and grain technological quality of some Bulgarian and foreign durum wheat cultivars grown under the agrieological conditions of Southern Bulgaria. The Vazhod cultivar proved to give the highest durum wheat grain yield, followed by Beloslava cultivar. Out of the foreign durum wheat cultivars the Durumko was notable for its higher productivity. The crude protein content in the grain was highest in Zagorka, Yavor and Yukon. The highest yield of gluten was reported in Beloslava, Vazhod and Zagorka.

**Keywords:** durum wheat, cultivars, environment, yield, grain quality

**Ключови думи:** твърда пшеница, сортове, околна среда, добив, качество на зърното

### Detailed Abstract

An experiment was carried out in the period 2004-2007 on the experimental field of the Agricultural University in Plovdiv, Bulgaria. The following Bulgarian durum wheat cultivars were tested: Progress (standard), Zagorka, Beloslava, Vazhod, Yavor as well as the foreign ones Beleno, Durumko, Yukon, Duetto, Duramar.

The block method was applied to the field trial in four replications, the yielding plot being 15 m<sup>2</sup>. The aim of the experiment was to ascertain the chemical content and grain technological qualities of some Bulgarian and foreign durum wheat cultivars grown under the agrieological conditions of Southern Bulgaria.

The Vazhod cultivar proved to give the highest durum wheat grain yield – 3.92 t/ha, (11.7%), which surpassed the standard by 410 kg/ha. Second ranked the Beloslava cultivar – 3.86 t/ha (9.7%), which surpassed the standard by 350 kg/ha. Out of the foreign durum wheat cultivars the Durumko was notable for its higher productivity – 3.67 t/ha (4.6%) which was 160 kg/ha of grain more than the Progress cultivar yielded.

The crude protein content in the grain was highest in Zagorka, Yavor and Yukon. The highest yield of gluten was reported in Beloslava, Vazhod and Zagorka.

Grain quality, as a polygenically dependant trait, is a combination of biological, physical and chemical, technological and utility characteristics, determining grain suitability for using it in accordance with its purpose: for staple, industrial and forage designation or as sowing-seed (2). They depend on a number of factors, such as: cultivar genetic resources (3; 11; 12); the growing technology (7; 1); wheat harvesting (2); the ecological conditions during vegetation (4; 8) and especially during kernel-fill and ripening of the grain, and during grain storage and processing (10).

The aim of the investigation was to establish the chemical content and grain technological qualities of some Bulgarian and foreign durum wheat cultivars grown under the agricological conditions of Southern Bulgaria.

## MATERIALS AND METHODS

We conducted a field experiment in the period 2004 - 2007 at the Experimental and Development Unit of the Agricultural University in Plovdiv, Bulgaria applying the block method in four replications on a yielding plot of 15 m<sup>2</sup>.

We studied the impact of the ecological conditions of Southern Bulgaria on the productivity and grain quality of the following Bulgarian durum wheat cultivars: Progress, Beloslava, Vazhod, Yavor, Zagorka and of the foreign Beleno (Spain), Durumko, Yukon (Germany), Duetto (France), Duramar (Austria), comparing them with the standard Progress cultivar.

We preceded durum wheat with sunflower. The trial plants were treated with phosphorus on a yearly basis - 8 kg/da a.s. (the entire quantity of superphosphate was incorporated during tillage prior to sowing) and the nitrogen fertilizer – ammonium nitrate, 12 kg/da a.s. was applied as follows: 1/3 prior to sowing and the remaining 2/3 – in early spring, as feeding. The sowing was completed within the optimal period for Southern Bulgaria – October 15<sup>th</sup> – November 5<sup>th</sup>. We managed the weeds and pests in compliance with the established growing technology (9).

The field trial was conducted on calcaric fluvisol, slightly saline sandy-loam, the top layer being crumbly and granular and the lower horizons – nutty in structure (6). The humus content was quite high – about 4.5%, gradually decreasing with depth increase. The soil reaction was weakly alkaline and varied from 6.5 to 7.5 pH.

According to the nutrient content in the 20 cm-deep soil layer is respectively as follows: N – 23.5mg/1000g; P<sub>2</sub>O<sub>5</sub> – 39.3 mg/100 g; K<sub>2</sub>O – 27.5 mg/100 g; CaCO<sub>3</sub> – 7.3% (5).

We measured the plant height (cm); ear length (cm); number of spikelets and kernels in the ear; mass of kernels in the ear (g); grain yield in t/ha; mass of 1000 kernels (g); hectoliter mass (kg/hl); vitreousness (%); overall nitrogen content (%); crude protein (%); wet gluten (%); dry gluten (%).

The chemical analyses were conducted at the Testing Laboratory Facilities of the Agricultural University in Plovdiv and at the Durum Wheat Grain Evaluation Laboratory of the Cotton and Durum Wheat Research Institute in Chirpan

## RESULTS AND DISCUSSION

The amount of rainfall during the durum wheat vegetation period (October - June) was as follows: 2004/2005 – 364.0 mm and 2005/2006 – 427.3 mm and during 2006/2007 – 485.9 mm, the figure for a multi-year period being 419.0 mm. There occurred a good rainfall distribution in 2005/2006, which turned out to be a favorable year for the growth and development of durum wheat. That was the time when all tested cultivars gave the highest grain yields. The farming 2006/2007 year conditions exerted extremely adverse effects on the plant growth because of the severe drought

Table 1. *Influence of variety on physical characteristic of grain and grain yield of Durum wheat (average 2004 - 2007)*

Varieties	Physical characteristic of grain						Yield of grain	
	Mass 1000 grains		Test weight		Vitreousness, %		t/ha	%
	g	%	kg	%	%	% to st.		
1. Progress - st	55.4	100.0	75.5	100.0	92.1	100.0	3.51	100.0
2. Zagorka	48.2	87.0	74.0	98.0	96.3	104.6	3.45	98.3
3. Beloslava	45.6	82.3	75.8	100.4	98.6	107.1	3.86	109.7
4. Vuzhod	51.5	93.0	75.7	100.3	97.9	106.3	3.92	111.7
5. Yavor	46.8	84.5	79.2	104.9	94.1	102.2	3.54	100.9
6. Beleno	48.5	87.5	74.7	98.9	71.0	77.1	3.10	88.3
7. Durumko	49.6	89.5	74.3	98.4	69.0	74.9	3.67	104.6
8. Yukon	45.7	82.5	76.8	101.7	86.0	93.4	3.59	102.3
9. Duetto	48.1	86.8	71.3	94.4	82.0	89.0	3.39	96.6
10. Duramar	44.6	80.5	73.6	97.5	74.0	80.3	3.42	97.4
GD 5%	6.2	11.2	3.4	4.5	5.8	6.3		

during the winter and spring months and that, in turn, resulted in poor durum wheat productivity. The 2005 harvesting year occupied an interim position compared with the other years of the experiment.

The Vazhod cultivar (table 1) demonstrated the best grain yielding capacity during the trial period. The harvested grain was 3.92 t/ha, (11.7%), out-yielding the control cultivar Progress by 410 kg per hectare. Next followed the Beloslava cultivar with 3.86 t/ha (9.7%) which surpassed the standard cultivar yield by 350 kg per hectare. Third ranked Durumko – 3.67 t/ha (4.6%) out-yielding the control by 160 kg/ha.

The Vazhod and Beloslava yield increase was proved mathematically, while the higher productivity of Durumko, compared with the standard, was not mathematically proven. Yukon, Yavor and Zagorka fell in line with the productivity of the standard. Duramar, Duetto and Beleno produced lower yields, respectively by 90 kg/ha, 120 kg/ha and 410 kg/ha less than the standard cultivar Progress.

The standard cultivar Progress was notable for the highest 1000-kernel mass – 55.4 g, followed by Vazhod – 51.5 g and the lowest values for this specific trait were reported in Duramar – 44.6 g.

The Yavor cultivar had the highest hectoliter mass – 79.2 kg, the lowest being in Duetto – 71.3 kg.

Table 2. *Content of total nitrogen and row protein in Durum wheat grain*

Varieties	Dry substance	Total N	Row protein content	
	%	%	N 5.7	%
1. Progress - st	89.5	2.56	14.6	100.0
2. Zagorka	90.1	2.68	15.3	104.8
3. Beloslava	87.8	2.65	12.5	85.6
4. Vuzhod	87.6	2.09	11.9	81.5
5. Yavor	87.4	2.17	15.2	104.1
1. Beleno st.	88.9	2.44	13.9	95.2
2. Durumko	88.7	2.39	13.6	93.1
3. Yukon	88.9	2.61	14.9	102.0
4. Duetto	88.8	2.49	14.2	97.3
5. Duramar	88.5	2.25	12.8	87.7
GD 5 %	1.56	0.21	0.65	4.4

Vitreousness is also a significant quality trait and its high values determine the obtaining of larger quantities and higher-quality semolina flours. There exists a strong correlation between vitreousness and protein- and starch-content. It is influenced by both the biochemical and technological conditions but the cultivar-specific traits, fertilization and climatic conditions during kernel-fill and ripening are of crucial

importance. According to the standard strong wheat quality requirements, vitreousness must not be below 40% for common wheat and 70% for durum wheat.

Vitreousness varied in the tested cultivars from 71.0% in Beleno to 98.6% in Beloslava, the value being 6.5% higher in comparison with the standard.

The absolute dry matter content in durum wheat cultivars varied insignificantly (table 2). Among the tested cultivars, Zagorka, Yavor and Yukon recorded the highest kernel protein content, the increase over the Progress cultivar being by 4.8%, 4.1% and 2.0% respectively. The other tested durum wheat cultivars demonstrated lower protein content, Vazhod and Beloslava showed from 14.4% to 18.5% lower values than the standard (table 2).

The obtained results confirmed the established pattern of a negative relationship between grain yield and the percentage of grain protein content.

A similar pattern is found when analyzing the data for the quantity of the overall amino acids in the grain of the tested cultivars (table 3).

The concentration of the overall amino acids in the grain for Zagorka and Yavor exceeded the standard by 2% to 3.3%, while the fall of that index was 7.2% for Beloslava, 11.0% for Vazhod and 14.85% for Duramar. The drop affected all groups of amino acids. A similar trend was observed in the quantity of essential amino acids in the grain of the studied cultivars (table 4).

The increased content of grain amino acids for Zagorka, Yavor and Yukon was most probably due to enzyme systems responsible for the biosynthesis of all amino acids participating in the protein biosynthesis.

Important wheat quality characteristics are gluten quantity and quality, both wet and dry (%). The gluten content was higher in Beloslava by 15.1% (wet) and 7.8% (dry), in Vazhod by 8.2% (wet) and 4.3% (dry), in Zagorka by 4.6% (wet) and 3.6% (dry) as compared with Progress. In the other tested Bulgarian and foreign cultivars lower values of wet and dry gluten were observed as compared with the standard Progress cultivar (table 4). The Duramar cultivar was found to have the lowest wet and dry gluten content of the grain.

Sedimentation is a method for determining the swelling property of flour. The sedimentation number in common wheat has a positive correlation with its physical, chemical, technological and baking properties. It evaluates indirectly the baking power. The sedimentation number is positively dependent on crude protein and wet gluten and is in fact swelling of gluten proteins in a dilute acid solution. The Beloslava and Vazhod cultivars were notable for their high sedimentation number in our investigation (table 5).

Table 3. Content of total amino acid in Durum wheat grain

Varieties Aminoacids	In % from total dry substance									
	Progress st	Zagorka	Beloslava	Vuzhod	Yavor	Beleno	Durumko	Yukon	Duetto	Duramar
Monoaminocarboxylic acids										
Glycine	0.54	0.59	0.41	0.43	0.50	0.49	0.53	0.51	0.54	0.44
Alanine	0.55	0.55	0.44	0.43	0.52	0.48	0.51	0.51	0.51	0.43
Valine	0.50	0.54	0.44	0.45	0.53	0.51	0.51	0.53	0.54	0.45
Dicarboxylic acids										
Aspartic acid	0.78	0.84	0.58	0.72	0.90	0.69	0.68	0.69	0.75	0.70
Glutamic acid	4.22	4.24	4.21	3.82	4.54	3.52	4.18	4.38	4.37	3.67
Oxiaminocarboxylic acids										
Serine	0.63	0.66	0.58	0.64	0.61	0.61	0.64	0.66	0.61	0.51
Threonine	0.39	0.41	0.35	0.32	0.39	0.37	0.37	0.40	0.37	0.31
Basic acids										
Lysine	0.51	0.51	0.36	0.43	0.47	0.43	0.42	0.47	0.41	0.39
Histidine	0.35	0.31	0.26	0.32	0.34	0.33	0.27	0.35	0.29	0.27
Arginine	0.75	0.74	0.63	0.65	0.71	0.73	0.70	0.72	0.71	0.70
Sulphur containing acids										
Methionine	0.13	0.14	0.14	0.09	0.14	0.04	0.06	0.10	0.08	0.08
Cystine	0.12	0.12	0.11	0.14	0.14	0.11	0.10	0.08	0.10	0.09
Aromatic acids										
Phenylalanine	0.65	0.67	0.62	0.58	0.73	0.60	0.63	0.69	0.64	0.57
Tyrosine	0.28	0.29	0.27	0.25	0.31	0.26	0.22	0.22	0.22	0.19
Proline	1.41	1.38	1.45	1.32	1.51	1.32	1.41	1.48	1.47	1.21
Leucines										
Leucine	0.84	0.91	0.80	0.80	0.92	0.86	0.87	0.90	0.88	0.74
Isoleucine	0.41	0.42	0.37	0.37	0.43	0.42	0.41	0.43	0.44	0.37
Total	13.06	13.32	12.12	11.62	13.50	11.77	12.51	13.12	12.93	11.12
%	100.0	102.0	92.8	89.0	103.3	90.1	95.8	100.5	99.0	85.15

Table 4. Content of irreplaceable amino acids in Durum wheat grain

Varieties Aminoacids	In % from total dry substance									
	Progres st	Zagorka	Beloslava	Vuzhod	Yavor	Beleno	Durumko	Yukon	Duetto	Duramar
Lysine	0.51	0.51	0.36	0.43	0.47	0.43	0.42	0.47	0.41	0.39
Threonine	0.39	0.41	0.35	0.32	0.39	0.37	0.37	0.40	0.37	0.31
Valine	0.50	0.54	0.44	0.45	0.53	0.51	0.51	0.53	0.54	0.45
Methionine	0.13	0.14	0.14	0.09	0.14	0.04	0.06	0.10	0.08	0.08
Leucine	0.84	0.91	0.80	0.80	0.92	0.86	0.87	0.90	0.88	0.74
Isoleucine	0.41	0.42	0.37	0.37	0.43	0.42	0.41	0.43	0.44	0.37
Phenylalanine	0.65	0.67	0.62	0.58	0.73	0.60	0.63	0.69	0.64	0.57
Total:	3.43	3.60	3.08	3.04	3.61	3.23	3.27	3.52	3.36	2.91
%	100.0	104.9	89.8	88.6	105.2	94.2	95.3	102.6	98.0	84.8

Table 5. Influence of variety on some technological characteristic of grain

Varieties	Wet gluten		Dry gluten		Sedimentation value, cm <sup>3</sup>	Loose of gluten, mm
	%	% to st	%	% to st		
1. Progres st	37.2	100.0	13.8	100.0	51	2.1
2. Zagorka	38.9	104.6	14.3	103.6	53	3.2
3. Beloslava	42.9	115.3	14.9	107.8	56	2.9
4. Vuzhod	40.3	108.3	14.4	104.3	55	2.6
5. Yavor	36.9	99.2	14.0	101.4	49	2.3
6. Beleno	22.0	59.1	8.3	60.1	39	4.0
7. Durumko	28.0	75.3	10.8	78.3	37	3.0
8. Yukon	29.6	79.6	11.1	80.4	42	3.0
9. Duetto	22.8	61.3	8.6	62.3	33	3.5
10. Duramar	20.0	53.8	7.5	54.3	34	4.0
GD 5%	1.62	4.3	0.6	4.19		

## CONCLUSIONS

Some comparative studies on the impact of cultivar characteristics upon the productivity and grain chemical content have been conducted for the first time, involving five Bulgarian and five foreign durum wheat cultivars.

Under the agriecological conditions of Southern Bulgaria, the Vazhod durum wheat cultivar demonstrated the best grain yielding capacity. The grain harvested from the above cultivar was 3.92 t/ha, (11.7%), out-yielding the control cultivar Progress by 410 kg per hectare. Next followed the Beloslava cultivar with 3.86 t/ha (9.7%) which surpassed the standard cultivar yield by 350 kg per hectare. Third ranked Durumko – 3.67 t/ha (4.6%) out-yielding the control Progress by 160 kg/ha.

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The concentration of the overall amino acids in the grain for Zagorka and Yavor exceeded the standard by 2% to 3.3%, while the fall of that index was 7.2% for Beloslava, 11.0% for Vazhod and 14.85% for Duramar. The drop affected all groups of amino acids. A similar trend was observed in the quantity of essential amino acids in the grain of the studied cultivars.

The gluten content was higher in Beloslava by 15.3% (wet) and 7.8% (dry), in Vazhod by 8.3% (wet) and 4.3% (dry), in Zagorka by 4.6% (wet) and 3.6% (dry) as compared with the Progress cultivar.

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