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TESTING NEW DURUM WHEAT VARIETIES FOR PRODUCTIVITY

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Abstract

In the Educational, Experimental and Implementation Base of the Agrucultural University of Plovdiv, a field trial was conducted in 2018-2021, in which new varieties of durum wheat (Triticum durum Desf.) were tested, including: Viomi, Saya, Railidur and Helix. The varieties were compared with the Predel variety, which is the productivity standard in Bulgaria. From the field trial it was proved that the productivity of durum wheat variety Helix was the highest 4.732 t/ha which is 0.511 t/ha (12.1%) higher grain yield compared to the standard variety Predel. The yields of the other durum wheat varieties studied were as follows: variety Viomi 4.572 t/ha with 0.351 t/ha (8.3%); variety Saya 4.421 t/ha with 0.200 t/ha (4.7%) and variety Railidur 4.379 t/ha with 0.158 t/ha (3.7%) more grain compared to variety Predel.

Key words*: durum wheat varieties, grain yield.*

INTRODUCTION

The productivity and grain quality of durum wheat are influenced by a number of factors including variety (Delchev et al., 2000; Yanev & Kolev, 2008), soil and climatic conditions (Gómez et al., 2000; Ivanova et al., 2010;) and cultivation technology (Dzhugalov, 2010; Pleshkutsa, 2018; Arduini et al., 2006; Bilgin et al., 2011). Optimization of these factors leads to obtaining high results in the cultivation of durum wheat (Kolev et al., 2020).

Over the last few years, there has been significant success in durum wheat breeding in Bulgaria (Dragov et al., 2019). As a result of the combination of intratype hybridization and traditional breeding scheme, new durum wheat varieties have been developed at the Institute of Field Crops, Sofia, Bulgaria. (Dragov et al., 2017; Dragov et al., 2020).

To realize the genetic potential in terms of productivity and grain quality, an important role is played by growing a variety in the most suitable region of the country under the interaction of relevant environmental factors (Sabella et al., 2020; Asseng et al., 2014) and optimal cultivation technology (Yu et al, 2021).

Durum wheat is grown globally on 13.5 million ha in 2020/2021, accounting for 6.2% of wheat area (Martínez-Moreno et al., 2022). Durum wheat in Europe in 2021 occupies an area of 2348000 ha with an average yield of 3230.0 kg/ha and a resulting production of 7581000 t and in 2022 occupies an area of 2388000 ha with an average yield of 3000.0 kg/ha and a resulting production of 7161000 t (Coceral Crop Forecast, December 2022).

In order to solve the grain problem, an increase in crop production is needed, including the production of durum wheat (*Triticum durum* Desf.). Creation and introduction of new varieties in production contributes to solve the grain problem (Alvaro et al., 2008; Parvaneh et al., 2014; Sabella et al., 2020).

Soil and climatic conditions in Bulgaria are very heterogeneous, so the selection of the appropriate variety composition for the respective ecological region is essential to obtain high and stable yields and good income from durum wheat. This is necessitated by the global changes that have occurred in climatic conditions in recent years and the adaptability of varieties to these conditions.

In conducting the field experiment, we aimed to study the productive potential of new durum wheat varieties under the soil and climatic conditions of the Plovdiv region.

MATERIALS AND METHODS

The experiment was carried out in the Educational, Experimental and Implementation Base of the Agrucultural University of Plovdiv in 2018-2021. The field trial was laid out using

the block method, in four replications with a harvest plot size of 15 m^2. New varieties of durum wheat (*Triticum durum* Desf.) were studied, including Viomi, Saya, Railidur, Helix, being a selection of the Institute of Field Crops in Chirpan. The varieties were compared with the productivity standard Predel variety.

The field trial was conducted on Molic Fluvisols (FAO-UNESCO, 1990), a carbonate alluvial-fluvial soil with a medium sandy loam mechanical composition and a humus content of 1-2%. The soil is characterised by a slightly alkaline pH reaction (7.2-7.7), the presence of carbonates (4.3-7.4%) and the absence of salts. The content of the main nutrients in the 0-20 cm soil layer is as follows: N - 15.1 mg/1000 g; P O_{25} - 30 mg/100 g; K_2O - 45 mg/100 g. (Popova & Sevov, 2010). The soil is characterized by good physical and mechanical properties, loose texture, weak plasticity and stickiness with good moisture and filtration capacity (Tahsin & Popova, 2005).

The durum wheat was grown in accordance with the established technology in Bulgaria (Bozhanova et al., 2018). The field trial was sown after a rapeseed precursor at the optimum time from 20.10. to 5.11. with a sowing rate of 500 germinating seeds/m^2 and mineral fertilization of 80 kg/ha P_2O_5 and 140 kg/ha N in active substance. Mineral fertilizers were applied to the soil according to the following scheme: the whole amount of phosphorus fertilizer and 1/3 of nitrogen fertilizer before the main tillage, and in early spring as feeding the remaining part of nitrogen fertilizer.

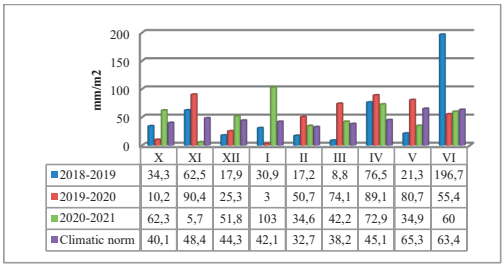
The biometric data of durum wheat varieties were recorded: productive maturity, ear length (cm), number of grains per ear, and grain mass per ear (g). Grain yield (t/ha) was reported by variants and replications.

The following physical properties were taken into account for grading the grain of the tested durum wheat varieties: mass per 1000 grains according to BDS ISO 520:2003; hectolitre mass according to BDS ISO 7971-2:2000; vitreousness of the grain according to BDS EN 15585:2008. The analysis of the grain according to the listed indicators was carried out at the Accredited Laboratory Testing Complex at the Agricultural University of Plovdiv. The field trial was harvested at full grain maturity by direct harvesting with a small Wintersteiger seedmaster universal combine.

The statistical processing of the data obtained for the studied indicators was performed with the BIOSTAT software (Penchev, 1998).

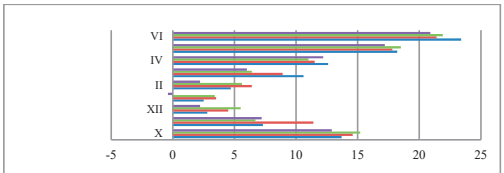
RESULTS AND DISCUSSIONS

In implemented field experiments, a number of authors (Spaldan et al., 1984) have demonstrated the influence on durum wheat grain productivity and quality of rainfall and its distribution over critical developmental phenophases and air temperatures during the growing season. Rainfall availability and average monthly temperatures compared to the climatic norm for the present experiment are presented in Figures 1 and 2.



	X	XI	XII	I	II	III	IV	V	VI
2018-2019	34,3	62,5	17,9	30,9	17,2	8,8	76,5	21,3	196,7
2019-2020	10,2	90,4	25,3	3	50,7	74,1	89,1	80,7	55,4
2020-2021	62,3	5,7	51,8	103	34,6	42,2	72,9	34,9	60
Climatic norm	40,1	48,4	44,3	42,1	32,7	38,2	45,1	65,3	63,4

Figure 1. Precipitation by months, sum mm/m^2



	X	XI	XII	I	II	III	IV	V	VI
Climatic norm	12,9	7,2	2,2	-0,4	2,2	6	12,2	17,2	20,9
2020-2021	15,2	6,7	5,5	3,4	5,6	6,4	11	18,5	21,9
2019-2020	14,6	11,4	4,5	3,5	6,4	8,9	11,5	17,8	21,4
2018-2019	13,7	7,3	2,8	2,5	4,7	10,6	12,6	18,2	23,4

Figure 2. Monthly temperatures (average)

During the durum wheat growing season, rainfall quantity in all three years of the field trial (2018-2021) exceeded those for the multi-year time period. In the first year 2018-2019 the amount of rainfall was 466.1 mm, in the second year 2019-2020 it was 478.9 mm and in the third year 2020-2021 it was 467.4 mm against 419.6 mm for the climatic norm (Figure 1). During the durum wheat growing season, higher average monthly temperatures were observed compared to the climatic norm Figure

2. In terms of rainfall availability during the critical phenological phases of plant development determining the yield quantity and grain quality, the 2020-2021 crop year was more favourable for durum wheat growth. In the spring of 2020, there was more rainfall during flowering in the months of April and May by 44 mm/m^2 and 15.4 mm/m^2, respectively, compared to a multi-year period, which negatively affected pollination and flower fertilisation and this also led to the formation of fewer grains and lower grain yield in 2020 (Figures 1 and 2).

Biometric data of the durum wheat varieties studied

Height of plants

Plant height is a relatively constant value and primarily a varietal trait (Boudersa et al., 2021), but soil and climatic conditions as well as cultivation technology have a significant influence on the values of this indicator. Plant height is significantly influenced by the amount of rainfall from the tillering phenologicaal phase to the end of the ear formation phenological phase (Table 1[a]). In the conducting of this field experiment, it was found that the plants with the tallest stem were those of Railidur variety with an average of 88.1 cm for the study period with 2.2 cm or 2.6% more than Predel variety (Table 1[a]).

Table 1[a]. Biometric data (average 2018-2021)

Variety	Height of the plants, cm	Productive tillering, number	Lenght of the spike, cm
Viomi	87.3	1.58	8.46
Saya	86.7	1.51	8.21
Railidur	88.1	1.46	8.16
Helix	87.8	1.67	8.39
Predel	85.9	1.42	7.87
GD 5%	1.38	0.15	0.42

The varieties Helix (by 1.9 cm), Viomi (by 1.4 cm) and Saya (by 0.8 cm) were taller than the standard variety Predel.

Productive tillering

Tillering depends mainly on durum wheat variety, but soil and climatic conditions, sowing period, sowing depth, sowing rate, seed size, nutrient availability, light, etc. have a significant influence (Spaldan et al., 1984). A number of authors have shown that tillering is highly correlated with yield formation (Saman & Rashidi, 2012; Elhani, 2007; Delchev et al., 2000; Yani et al., 2012). The number of ears formed per unit area relative to the number of maximum tillers formed determines the productive tillering.

The highest productive tillering was observed in the varieties Helix - 1.67 tillers and variety Viomi - 1.58 pcs, respectively by 0.25 tillers and 0.16 tillers more than the standard variety Perdel. Followed by the varieties Saya - 1.51pcs and Railidur - 1.46 pcs which is 0.09 tillers and 0.04 tillers more than the standard, see Table 1[a]).

Ear length

Ear length is a relatively constant quantity because it is a genetically determined trait in each individual durum wheat variety (Yanev et al., 2000).

The longest ears on average during the study period were formed by plants of variety Viomi 8.46 cm (7.5%), followed by variety Helix 8.39 cm (6.6%), Saya 8.21 cm (4.3%), Railidur 8.16 cm (3.7%) compared to standard variety Predel (Table 1[a]).

Number of spikes in an ear

The length of the ear shoot and the number of spikelets per unit length determine the ear density. The formation of a higher number of spikes per ear is influenced by climatic conditions and the application of appropriate cultivation technology for durum wheat.

In the experiment we found that variety Helix had the highest number of spikes in the ear 27.9 pcs followed by variety Viomi by 27.1 pcs, Saya by 26.3 pcs and Railidur by 25.8 pcs, which is 15.3%, 12.0%, 8.7% and 6.6% more spikes than the standard respectively (Table 1[b]).

Table 1[b]. Biometric data (average 2018-2021)

Variety	Number of the spikelets per spike	Number of the grains per spike	Mass of the grain per spike
Viomi	27.1	52.5	2.39
Saya	26.3	51.9	2.27
Railidur	25.8	51.1	2.23
Helix	27.9	53.2	2.47
Predel	24.2	47.9	2.19
GD 5 %	2.76	4.24	0.18

Number of grains per ear

The number of grains per ear is one of the important elements of productivity in cereal crops. Increasing the number of grains is achieved by applying optimal technological

measures, which leads to an increase in grain yield per hectare. Precipitation during the tillering phase until the end of the flowering phase has a significant effect on the number of grains. The amount of rainfall in the months of April and May of the third year of the field experiment was 44 mm/m^2 and 15.4 mm/m^2 more, respectively, compared to the multi-year period. All durum wheat varieties tested in the spring of 2020 formed fewer grains per ear due to more precipitation falling during flowering (Figure 1). This rainfall prevented normal pollination and flower fertilization resulting in lower grain yields.

Hard wheat variety Helix formed the highest number of grains in the ear 53.2 pcs (11.1%) on average over the three years of the experiment. The second place was taken by variety Viomi by 52.5 pcs (9.6%), variety Saya by 51.9 pcs (8.4%) and variety Railidur by 51.1 pcs (6.7%) compared to standard variety Predel (Table 1[b]).

Grain mass per ear

The productivity of durum wheat depends very much on the mass of the grains in the ear. The climatic conditions during the period of grain formation, the optimum conditions for plant development until the end of the growing season, the cultivation technology and the genetic make-up of a variety are all essential for forming the value of this component. During the three-year experiment in field conditions, it was found that, of the durum wheat varieties tested, the highest grain mass per ear was formed by plants of the variety Helix 2.47 g (12.8%) (Table 1[b]). This was followed by the varieties Viomi by 2.39 g (9.1%), Saya by 2.27 g (3.7%), Railidur by 2.23 g (1.8%).

Grain yield

Soil and climatic conditions in the area of durum wheat production and the variety studied have a significant influence on the yield and quality of the grain obtained. The tested new varieties of durum wheat selected at the Institute of Field Crops, Chirpan, exceeded the productivity standard of the Predel variety (Table 2).

The productivity of the tested durum wheat varieties was highest in the climatically favourable year 2021 for plant growth and development, followed by that in 2019. The harvested grain of the durum wheat varieties included in the experiment was lowest in 2020 due to the higher rainfall in spring with 95.7 mm/m^2 more than the climatic norm. The unfavourable climatic conditions during flowering prevented normal pollination and fertilisation of the flowers, and hence to the formation of a small number of grains in the ear with low grain mass and lower productivity of the durum wheat varieties.

Table 2. Grain yield

Variety	2018-2019 t/ha	2019-2020 t/ha	2020-2021 t/ha	Average	
				kg/ha	%
Viomi	4.751	3.547	5.418	4.572	108.3
Saya	4.642	3.434	5.186	4.421	104.7
Railidur	4.601	3.388	5.147	4.379	103.7
Helix	4.960	3.671	5.564	4.732	112.1
Predel	4.425	3.318	4.921	4.221	100.0
GD 5 %	0.294	0.210	0.438		

From the data presented in Table 2, it is evident that both by year and on average for the study period, the highest grain yield was obtained from the Helix variety - 4.732 t/ha (12.1%), compared to 4.221 t/ha for the standard Predel variety. By year, Helix variety yielded 4.960 t/ha (12.1%) in 2019, 3.671 t/ha (10.6%) in 2020 and 5.564 t/ha (13.1%) in 2021. The increase in grain yield by year is 0.535 t/ha in the first year, 0.353 t/ha in the second year and 0.643 t/ha in the third year, or an average by 0.511 t/ha more than the productvity standard Predel variety. The results are unidirectional and mathematically proven. The durum wheat varieties Viomi and Saya yielded an average of 4.572 t/ha (8.3%) and 4.421 t/ha (4.7%) respectively over the study period, which is 0.351 t/ha and 0.2 t/ha more than the variety Predel. The higher productivity of the Helix variety was mathematically proven over the three years of the experiment, while the Viomi variety was proven to have higher yield only in 2021. The increase in grain yield in the Railidur variety is mathematically unproven.

Physical properties of durum wheat varieties

Mass per 1000 grains

Mass per 1000 grains is a varietal trait that is strongly influenced by soil and climate conditions and cultivation technology. This indicator characterises grain well-nourishness and serves as an indication of yield. When

larger grains are used as seed, yields have been shown to be up to 15-20% higher (Dekov et al., 1989).

The variety Helix stands out with the highest mass per 1000 grains of the tested durum wheat varieties (Table 3). On average over the study period, the mass per 1000 grains of this variety was 49.9 g., followed by variety Viomi with 48.3 g., variety Saya 47.5 g. and variety Railidur 47.1 g.

Table 3. Physical properties of durum wheat varieties (average 2018-2021)

Variety	Mass of 1000 grains, g	Hectoliter mass, kg	Vitreousness, %
Viomi	48.3	79.3	96.9
Saya	47.5	77.8	96.1
Railidur	47.1	78.3	95.8
Helix	49.9	80.5	97.4
Predel	46.5	77.1	95.3
GD 5%	3.25	2.14	1.52

Hectolitre mass

Hectolitre mass is an important physical indicator used to determine the quality of grain. This indicator gives an idea of uniformity, surface area and density. The hectolitre mass depends on the type of impurities, weed seeds, unthreshed ears and the consistency of the grain. With higher hectolitre grain mass of the studied durum wheat varieties were Helix 80.5 kg and Viomi 79.3 kg compared to the variety Predel (Table 3).

Vitreousness

Grain vitreousness in durum wheat is strongly influenced by many factors, but the decisive ones are the variety with its genetic make-up, the soil and climatic conditions at the time of grain formation and ripening. Vitreousness is an important physical property and its high values result in high yielding flours.

Durum wheat is characterised by a high vitreous grain. It can be seen from Table 3 that, on average over the three-year study period, vitreousness was very high in all durum wheat varieties tested. In the case of the Helix variety it was 97.4%, followed by Viomy with 96.9%, Saya with 96.1%, Reilidur with 95.8% and in the case of the Predel standard it was 95.3%.

CONCLUSIONS

Under the soil and climatic conditions of the Plovdiv region, the highest grain yield was harvested from the Helix variety with an average of 4.732 t/ha (12.1%) compared to 4.221 t/ha for the standard Predel variety. By year, Helix variety yielded 4.960 t/ha (12.1%) in 2019, 3.671 t/ha (10.6%) in 2020 and 5.564 t/ha (13.1%) in 2021. The increase in grain yield by year is 0.535 t/ha in the first year, 0.353 t/ha in the second year and 0.643 t/ha in the third year, or an average of 0.511 t/ha more than the productivity standard Predel variety.

The yields of the other durum wheat varieties studied were as follows: variety Viomi 4.572 t/ha with 0.351 t/ha (8.3%); variety Saya 4.421 t/ha with 0.200 t/ha (4.7%) and variety Railidur 4.379 t/ha with 0.158 t/ha (3.7%) more grain compared to variety Predel.

The productivity of the tested durum wheat varieties was higher than the standard variety Predel, which was the result of the higher productive tillering, the longer and riper ear and the higher grain mass in the plant ear.

Durum wheat variety Helix had the highest mass per 1000 grains with an average for the experimental period - of 49.9 g., followed by variety Viomi with 48.3 g. Next follow the variety Saya with 47.5 g. and variety Railidur with 47.1 g.

The hectolitre grain mass of the studied durum wheat varieties was higher in the varieties Helix 80.5 kg and Viomi 79.3 kg compared to the variety Predel.

Vitreousness of the new durum wheat varieties tested was very high on average over the three-year study period. It was 97.4% for the Helix variety, followed by Viomi with 96.9%, Saya with 96.1%, Railidur with 95.8%, while - 95.3% for the Predel standard.

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