Scientific Papers. Series A. Agronomy, Vol. LXVI, No. 1, 2023
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

TESTING OF RETARDANTS ON DURUM WHEAT

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Abstract

In 2018-2021, the following retardants were tested at the Experimental and Experimental Base of the Agricultural University of Plovdiv, Bulgaria: Medax Top (1000 ml/ha); Baya (1500 ml/ha) and Bogotá (2500 ml/ha). The treatment of Durum wheat (Desf.) variety Saya was carried out in phenological phase BBCH 30-39. It was found that the highest grain yield was obtained when the durum wheat variety Saya was treated with the Medax Top retardant (1000 ml/ha), with an average of 4.632 t/ha or 9.0 % more than the water control over the three-year period. In second place is the Bogota retardant (2500 ml/ha) with a grain yield of 4.507 t/ha or 6.0%, followed by the Bayja 1500 ml/ha retardant with a yield of 4.410 t/ha or 3.7% more than the control.

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

INTRODUCTION

Durum wheat is one of the most significant socio-economic cereals. In terms of worldwide distribution, it holds second place after bread wheat. It comprises 10% of the wheat production and 8% of the sown land. The attention directed towards this culture is determined above all by the quality of its grain. It depends on the genetic traits of the variety, the technology of growing and harvesting, as well as on abiotic factors during the period of formation and filling of the grain, its storage and processing.

Durum wheat is an excellent raw material for the production of pasta, and the quantity of protein and gluten strength are the most important characteristics (Feillet & Dexter, 1996). On the international markets, durum wheat (*Triticum durum* Desf.) is highly valued also for its glossiness and hard grain with an amber-yellow colour due to the high content of yellow pigments.

In Bulgaria, as a country located between the 40th and 45th parallel, where Northern Spain, Southern France and Central Italy are positioned, and where the land occupied by durum wheat in these countries is significant, a tendency to increase the occupied areas and a restored interest in this traditional culture is expected in our country. The increased demand on the European markets and insufficient supply makes its cultivation profitable and economically rewarding.

It is of interest to study the influence of various growth regulators - stimulants, retardants and anti-stress products on the yield and chemical-technological properties of durum wheat grain and their inclusion in the cultivation technology (Delchev, 2004; Delchev, 2009; Delchev & Panayotova, 2010; Kolev et al., 2006; Jalal. A. Al-Tabbal et al., 2006).

The purpose of the conducted experiment is to establish which of the tested retardants - Medax Top, Baya or Bogota - is the most suitable for growing durum wheat.

MATERIALS AND METHODS

The experimental work was carried out in field conditions on the territory of the Department of Plant Growing at the Educational Experimental and Implementation Unit of the Agricultural University of Plovdiv - Bulgaria for three years, i.e. 2018-2021. The following retardants were tested: **Medax®Top** (active substance - prohexadione-calcium 50 g/l (calcium 3,5-dioxo-4-propionyl cyclohexane carboxylate) + mepiquat chloride 300 g/l (1,1-dimethylpiperidine chloride) in a dose of 1000 ml/ha. The treatment was carried out during phenophase BBCH 30-39 (elongation of the stem - the flag leaf). Recommended volume of the working solution: water 300 l/ha. Recommended acidity of the working solution

4.5-7 pH. Manufacturer: Company BASF SE, Germany.

Baya (active substance - 480 g/l ethephon) in a dose of 1500 ml/ha to limit the growth of the aerial parts of the plants. Application time: BBCH 31-39 (the first node is at least 1 cm above the tillering node - the flag leaf is fully opened). Quantity of working solution: water 300 l/ha. Maximum number of applications: 1. Authorization holder: ADAMA Agriculture B.V., Arnhemseweg 87, 3832 GK Leusden, The Netherlands.

Bogota® (active substances - 300 h/l chlormequat; 150 g/l ethephon) in a dose of 2500 ml/ha. Authorization holder: ADAMA Agriculture B.V., Arnhemseweg 87, 3832 GK Leusden, The Netherlands. Time of application BBCH 31-37 (1^{st} node is at least 1 cm above the tillering node - flag leaf barely visible, still curled). Quantity of working solution: water 300 l/ha. The tested retardants were compared with a water control: 300 l/ha

The indicated retardants were tested on durum wheat variety Saya, which was recognized as an original one in 2016 (Executive agency for variety testing, approbation and seed control, 2016). The variety was created at the Institute of Field Crops in Chirpan by the method of intraspecific hybridization, by crossing the Bulgarian durum wheat variety Zagorka and the M-5359 line, and selection in subsequent generations. The Saya variety belongs to the medium-tall durum wheat group and has a very low lodging resistance compared to the Predel and Saturn 1 standard varieties.

Saya variety durum wheat is grown according to the adopted "Technology for the production of durum wheat" approved as a scientific product by the Standing Committee on Innovations and Technologies at the Agricultural Academy - Sofia with protocol RD-09-10 of 10.11.2017 (Bozhanova et al., 2018). Durum wheat was sown after the chickpea predecessor in the period of 20.10. until 5.11. with a sowing rate of 500 germinating seeds/m^2 and fertilization with 140 kg/ha P_2O_5 and 160 kg/ha N as an active substance, and the entire quantity of phosphorus fertilizer and 1/2 of the nitrogen fertilizer was applied before sowing, and the remaining ½ quantity of the nitrogen fertilizer was used early in the spring as nutrition.

The field experience was carried out on carbonate alluvial-meadow soil Molic Fluvisols (FAO - UNESCO, 1990), which has an average sandy-clay mechanical composition, a humus content of 1-2% and a slightly alkaline pH reaction (7.2-7.7), presence of carbonates (4.3-7.4%) and lack of salts. The content of nutrients in the soil layer from 0-20 cm is as follows: N - 15.1 mg/1000 g; P_2O_5 - 30 mg/ 100 g; K_2O - 45 mg/100 g. (Popova & Sevov, 2010). The soil has good physico-mechanical properties, loose structure, low plasticity and stickiness with good moisture ability and filtration ability (Tahsin & Popova, 2005).

The following structural elements of the yield were recorded: productive tillering (pcs.), wheat-ear length (cm), number of grains in the wheat-ear (pcs.), mass of the grains in the wheat-ear (g), and from the physical parameters of the grain - mass per 1000 grains (g), hectolitre mass (kg) and glossiness quality (%). Grain yield (t/ha) was reported by variants and repretitions. The harvest was carried out at full maturity, by direct harvesting with a small trial harvester Wintersteiger seedmaster universal.

The grain samples taken from the tested varieties of durum wheat were qualified according to the following indicators: mass per 1000 grains (TGW) according to BDS ISO 520:2003; hectolitre mass according to BDS ISO 7971-2:2000; glossiness quality of the grain according to BDS EN 15585:2008; protein calculated according to the formula N x 5.83 according to BDS 13490:1976; gluten BDS EN ISO 21415-1:2007 in Accredited laboratory complex for testing at the Agricultural University - Plovdiv.

BIOSTAT software was used for the statistical processing of the obtained data on the studied indicators (Penchev, 1998).

RESULTS AND DISCUSSIONS

Productivity and grain quality of durum wheat are affected by rainfall and its distribution and air temperatures during plant vegetation. Figures 1 and 2 show the quantity of precipitation and average monthly temperatures compared to the climate norm.

The quantity of precipitation during the vegetation of durum wheat in all three years of the field experiment (2018-2021) exceeded those for a multi-year time period. Their amount is as follows: in 2018/2019 - 466.1 mm, in 2019/2020 - 478.9 mm and in 2020/2021 - 467.4 mm compared to 419.6 mm for the climatic norm (Figure 1).

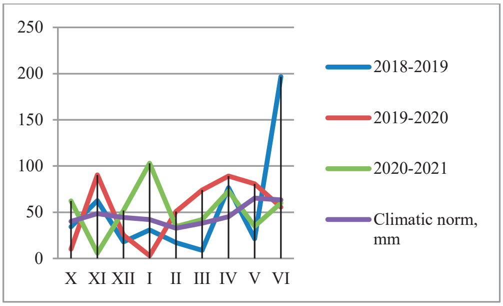

Figure 1. Precipitation by months, mm

Regarding the temperatures during the vegetation of durum wheat, higher average monthly temperatures were observed compared to the climatic norm, except for the months of November and April 2020-2021 and the month of April 2020 (Figure 2).

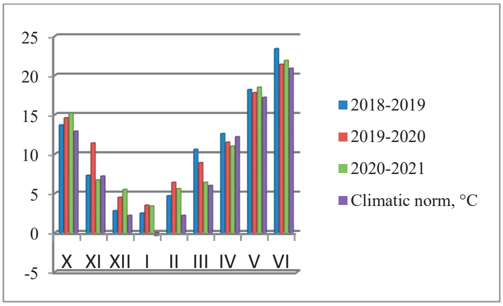

Figure 2. Monthly temperatures (average) (°C)

It is observed that the rainfall during the phenophases requiring normal moisture in the plant development determining the amount of the yield and the quality of the grain in the 2020-2021 harvest is more favourable for the growth of durum wheat. The spring of 2020 was characterized by more precipitation during the flowering period in the months of April and May by 44 mm and by 15.4 mm, respectively compared to a multi-year period, which negatively affected the pollination and fertilization of the flowers and this led to to formation of fewer grains and lower grain yield in 2020 (Figure 1 and Figure 2).

Biometric indicators

Plant height

Researchers such as (Berova et al., 2013) have proven the effect of phytohormones and synthetic regulators on the growth of durum wheat.

The tested retardants had varying degrees of effect in reducing plant height. The highest effect was obtained with the retardant Medax top in a dose of 1000 ml/ha, where the plants were lower by 2.7 cm compared to the water control. Followed by the retardants Bogota in a dose of 2500 ml/ha and Baya in a dose of 1500 ml/ha, in which the reduction of the stem height of durum wheat was respectively 1.4 cm and 0.9 cm. (Table 1[a]).

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

Retardants	Plant height, cm	Productive tillering, number	Wheat-ear length, cm
Medax top 1000 ml/ha	85.2	2.48	8.23
Baya 1500 ml/ha	87.0	2.21	7.95
Bogota 2500 ml/ha	86.5	2.33	8.11
Water control	87.9	2.15	7.86
GD 5 %	1.57	0.16	0.21

Productive tillering varies depending on the applied retardant in the range of 2.21 to 2.48 tillers. A more significant increase in productive tillering was observed with the Medax top retardant by 15.3% (0.33 tillers) and with the Bogota retardant by 8.4% (0.18 tillers) (Table 1[a]).

The length of the wheat-ear

In their research, a number of authors 3emonstrate (Kolev & Terziev, 1996) that the length and density of the wheat-ear is primarily a characteristic of the variety, but the soil and climatic conditions, as well as the cultivation technology, significantly affect the values of this indicator. A favourable combination of these conditions has a positive effect on this indicator. The conditions in April and May of 2021 during the formation of the wheat-ear elements were favourable, which resulted in the reported good values of the wheat-ear length indicator. On average, for the three-year study period, the wheat-ears were the longest in the variants treated with the Medax top and Bogota retardants, respectively by 0.37 cm (4.7%) and by 0.25 cm (3.2%) more than the water control

(Table 1[a]). It can be seen that the application of all three retardants has a positive effect on wheat-ear length (Table 1[a]).

Number of spikelets in the wheat-ear

The number of spikelets and favourable conditions during flowering and fertilization ensure the formation of well-seeded wheat-ears. Weather conditions are good in this period in the spring of 2019 and 2021, which is a good prerequisite for the formation of more spikelets in the wheat-ear of durum wheat variety Saya. The largest number of spikelets was reported in the plants treated with Medax top - 29.1 pieces (8.2%) and in Bogota 28.3 pieces (5.2%) (Table 1[b]).

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

Retardants	Number of spikelets in a wheat-ear	Number of grains per wheat-ear	Mass of grains in the wheat-ear
Medax top 1000 ml/ha	29.1	52.1	2.32
Baya 1500 ml/ha	27.5	48.7	2.26
Bogota 2500 ml/ha	28.3	50.4	2.19
Water control	26.9	47.2	2.11
GD 5%	1.32	3.12	0.14

Number of grains in the wheat-ear

This indicator is strongly related to yield. According to (Bergman et al., 1991), the increase in yield is due to the increased number of grains in the ear. The indicator is closely related to the conditions during the formation of spikelets and flowers. Another author (Rabie, 1996) reported an established relationship between the number of grains formed and the duration of flowering. The supply moisture to wheat during flowering and grain formation is of great importance, both for the number of grains in the ear and for their normal development. Researcher (Richards, 2004) highligths as one of the main focus for the development of modern selection, the increase in the number of grains in the wheat-ear. According to (Sekhon et al., 1994), the increased yield achieved in recent years is probably related to the increased number of grains in the wheat-ear.

The number of grains in the wheat-ear of the main tiller is of essential importance for the achievement of the productive abilities of the variety, as well as for the size of the yield. The number of grains formed depends a lot on the climatic conditions during flowering and fertilization. From the data presented in Table 1, it is clear that the most grains in the wheat-ear were formed in those treated with the Medax top retardant - 52.1 pcs (10.4%). The plants treated with the retardant Bogota follow next - 50.4 pcs (6.8%) and Baya - 48.7 pcs (3.2%) more than the water control (Table 1[b]).

Grain mass in the wheat-ear

Another very important indicator of the productive abilities of the variety and the size of the yield is the mass of grains in the wheat-ear. An important role in the time of formation of the grain is played by both weather conditions and various agrotechnical activities during the cultivation of durum wheat. Higher grain mass values in the wheat-ear compared to the water control were reported for all three retardants tested. For Medax top - 2.32 g (10.0%), Bogota - 2.26 g (7.1%) and Baya - 2.19 g (3.8%) (Table 1[b]).

Grain yield

Grain yield is the most important and accurate criteria for the influence of soil, climate, organizational and technological factors. Thus, the application of retardants together with the introduction of new, more productive varieties and durum wheat cultivation technologies are some of the most effective factors in increasing grain production and satisfying consumer needs. Obtaining more and high-quality grain is unthinkable without optimizing the varietal composition, sowing density, fertilization, disease, enemy and weed control, harvesting, storage and processing of durum wheat.

During the three-year period of the experiment, it was found that the highest grain yield was obtained when the durum wheat variety Saya was treated with the Medax Top retardant at a dose of 1000 ml/ha, and for the three-year period an average of 4,632 t/ha or 9.0% more was achieved than the water control.

The yield increase for plants treated with the Medax Top retardant by year is as follows: in 2019 by 0.439 t/ha, in 2020 by - 0.413 t/ha and in 2021 - by 0.290 t/ha. In second place in terms of productivity is the vairant treated with the Bogota retardant in a dose of 2500 ml/ha with a grain yield of 4.507 t/ha or by 6.0% more followed by the variant with the Baya retardant in a dose of 1500 ml/ha with a yield of 4.410 t/ha or 3.7% more than the water control (Table 2).

Table 2. Grain yield, t/ha

Retardants	2019 t/ha	2020 t/ha	2021 t/ha	Average	
				kg/ha	%
Medax top 1000 ml/ha	4.792	3.984	5.119	4.632	109.0
Baya 1500 ml/ha	4.592	3.657	4.981	4.410	103.7
Bogota 2500 ml/ha	4.659	3.825	5.038	4.507	106.0
Water control	4.353	3.571	4.829	4.251	100.0
GD 5%	0.296	0.245	0.193		

Physical and chemical-technological indicators

Thousand Grain Weight (TGW)

TGW is a physical indicator that characterizes the density of the grain; it depends on the characteristics of the variety and on the growing conditions. The low mass per 1000 grains means poorly fed grain and happens in the case of unfavourable weather conditions during the filling of the grain. From the data presented in Table 3, it is observed that the mass of 1000 grains of the tested retardants is within the limits of 42.1 g for the water control to 43.4 g for those treated with Medax top (Table 3).

Table 3. Physical and chemical-technological indicators

Retardants	TGW (g)	Test Weight (kg/hl)	Glossiness (%)	Protein (%)	Gluten (%)
Medax top 1000 ml/ha	43.4	76.2	97.2	14.89	31.9
Baya 1500 ml/ha	43.1	74.9	96.8	14.32	30.5
Bogota 2500 ml/ha	42.6	75.5	96.2	14.47	31.2
Water control	42.1	74.7	95.5	14.25	30.1
GD 5%	1.22	1.47	1.64	0.59	1.06

Test Weight

Test Weight is a species and variety indicator. It is a generally adopted trade indicator and is a measure of the health status of plants. According to BDS, 76-82 kg/hl is accepted as a base for the wheat. The highest values of this indicator were reported for Medax top 76.2 kg/hl, followed by Bogota with 75.5 kg/hl and Baya - 74.9 kg/hl, while in the water control the hectolitre mass was 74.7 kg/hl (Table 3).

Glossiness

Glassy quality is highly correlated with protein and starch content. It is influenced by many factors, but the genetic predisposition of the variety, the use of nitrogen fertilizers and the weather conditions during the formation and ripening of the grain are decisive.

In relation to the retardants studied, the glossiness quality varies from 96.2% for Bogota, 96.8% for Baya to 97.2% for Medax top. The increase of this indicator is respectively by 0.7%, 1.4 % and 1.8% compared to the water control (Table 3).

Protein

The significance of protein content for the technological qualities of wheat is direct and indirect. The yield of gluten closely correlates with it (Saldzhiev, 2008).

In the course of the field experiment, it was found (Table 3) that the protein content increased with all tested retardants. When treated with the Medax top retardant, the protein content was the highest at 14.89%. The variants treated with Bogota 14.47% and Baya 14.32% follow (Table 3).

Gluten

It has been established that the amount of protein and gluten depends up to 70% on the environmental conditions and on the cultivation technology and up to 30% on the genetic traits of the variety.

One of the important indicators of wheat quality is the quantity and quality of gluten. The amount of gluten depends more on the consistency than on the grain size. Only with the same consistency does the larger grain contain more gluten. The average gluten content for the experimental period was higher in the variant treated with the retardant Medax top - 31.9%, followed by Bogota - 31.2%, Baya - 30.5% and the control - 30.1% (Table 3).

CONCLUSIONS

The productivity of Saya durum wheat variety is the highest when treated with the Medax Top retardant (1000 ml/ha), with an average of 4.632 t/ha, or by 9.0% more grain than the water control over the three-year study period. Second comes the retardant Bogota (2500 ml/ha) with a grain yield of 4.507 t/ha or by 6.0% more that the control, followed by the retardant Baya 1500 ml/ha with a yield of 4.410 t/ha or by 3.7% more than the control variant.

Plants treated with the Medax Top retardant are of the lowest height.

The structural elements of the yield, including productive tillering, wheat-ear length, number of grains in the wheat-ear, mass of grains in the wheat-ear have the highest values in the variants sprayed with the Medax Top retardant.

Plants treated with the Medix Top retardant form the most glassy grain with a high protein and gluten content.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Centre of research, technology transfer and protection of intellectual property rights - Project 14-17, Agricultural University, Plovdiv, Bulgaria.

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