

BEHAVIOR OF LOCAL AND FOREIGN WINTER WHEAT VARIETIES AT DIFFERENT SOWING DENSITIES IN THE SOUTHERN PART OF THE COUNTRY

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Abstract: *in Romania, climate change has determined in recent years, the intensification of water deficits (often associated with scorching heat) during the vegetation of agricultural crops, in almost all areas of the country. The cultivation of winter wheat varieties that can withstand drought and heat well and the adaptation of cultivation technology to climate change are decisive factors in obtaining stable and economically efficient yields. In the agricultural years 2018/2019 - 2019/2020, at ARDS Teleorman, a multifactorial experiment of type 3 x 3 x 2 was set up, which aimed to determine an optimal density depending on the varieties used and climatic conditions. The experiment was placed according to the method of plots subdivided into 3 repetitions, with the following factors: Factor A variety, with 3 graduations (a_1 = Glosa; a_2 = Avenue; a_3 = Rubisko); Factor B density, with 3 graduations (b_1 = 400 g.g./m²; b_2 = 650 g.g./m²; b_3 = 750 g.g./m²); Factor C year, with 2 graduations (c_1 = 2018-2019; c_2 = 2019-2020). The highest yield was obtained by the variety Rubisko (9,282 kg/ha), compared to the average of the tested varieties. On average, the highest yields were obtained at a density of 650 g.g./m² (9,266 kg/ha).*

Keywords: *wheat, variety, climatic conditions, density, yields.*

INTRODUCTION

Yields capacity is a complex quantitative character, determined by intrinsic factors (components of production) and influencing factors (resistance to unfavorable action of external factors). Each element of production is in turn a complex quantitative character, conditioned by hereditary factors and external factors.

Wheat yields, after KAMALUDDIN (2007) depends on the number of grains / unit area and the weight of the grain, the latter being the resultant between the grain filling rate and the time period in which it was made (GEBEYEHOU, 1982; VAN SANFORD and MACKOWN, 1985; BRUCKNER and FROHBURG, 1987).

Wheat production is dependent on the general genetic potential of the plant, which in turn is realized at the expense of productivity elements. The elements of productivity represent in their turn complex properties, which have a polygenic determinism, conferring the specificity of each genotype. Genotype productivity is dependent on the hereditary factor, on which the environmental conditions have a major role in the phenotypic expression, as well as the genotype-environment interaction (KNEŽEVIĆ, 2008). Wheat yields are therefore a quantitative character with high variability, which is given by many components of yields, by their formation under the influence of environmental conditions (KRALJEVIĆ-BALALIĆ et al., 2001).

The complex interaction of plant density factors is reflected in the fact that it is not a widely accepted optimal plant density defined even for major crops such as maize (*Zea mays L.*), peanuts (*Arachis hypogaea L.*) and soybeans (*Glycine max L.*) (BOQUET, 2005; EGLI, 1988; ROSSINI et al., 2011; WELLS, 1991).

Creating the optimal nutrition space for each plant, ensures their uniform growth and development, with the rich leaf area that quickly occupies the land and suppresses weeds, maintain high relative humidity inside the field, helping to reduce perspiration, water consumption, giving the crop drought resistance. Optimal density is the limit at which the reduction of a plant's productivity cannot be compensated by the increase in the number of plants / ha. As the number of plants increases, the leaf area increases, but the net assimilation decreases. The density of the plants must ensure an optimal index of the leaf area that achieves the net assimilation corresponding to a maximum production.

MATERIAL AND METHODS

Researches were carried out in field experiments at the Agricultural and Development Research Station Teleorman (ARDS Teleorman) located in South Romania (Teleorman county) in the agricultural years 2018/2019 and 2019/2020.

The researches were performed under rainfed conditions on a soil of cambic chernozem type, the vertical subtype, having a loam-clay texture on the depth of the ploughed layer (0-25 cm). From the point of view of the physical and chemical properties, the soil is characterized by a clay content of 45%, humus content of 3.1%, weakly acid soil reaction (pH varies between 6.1 and 6.5), total nitrogen content of 0.166%, phosphorus mobile of 40-60 ppm, and mobile potassium of 250 ppm.

The main hydro-physical indices of the soil on the horizon 0-80 cm have the following average values: bulk density of 1.43 t/m³, field capacity of 27.3% (310.4 mm), and permanent wilting point of 15.0% (171.0 mm).

In the agricultural years 2018/2019-2019/2020, a multifactorial experiment of type 3 x 3 x 2 was set up, which aimed to determine an optimal density depending on the varieties used and the climatic conditions.

Experimental design. The field experiments were placed according to the method of subdivided plots with 3 replications, with the following factors:

Factor A variety, with 3 graduations (a_1 = Glosa; a_2 = Avenue; a_3 = Rubisko);

Factor B density, with 3 graduations (b_1 = 400 g.g./m²; b_2 = 650 g.g./m²; b_3 = 750g.g./m²);

Factor C year, with 2 graduations (c_1 = 2018-2019; c_2 = 2019-2020).

When establishing plant densities, the variety is taken into account, which is the vegetation period, the architecture of the leaves, the resistance to falling; natural soil fertility and applied cultivation technology; soil moisture at sowing.

The biological material used in the experiment consists of 3 common autumn wheat varieties, a creation of INCDA Fundulea, Glosa variety (<https://incda-fundulea.ro/fise/fise.html>) and 2 foreign varieties with a high share in the structure of wheat varieties grown in the south of the country, varieties Avenue (<https://www.lgseeds.ro/catalog/avenue/>) and Rubisko (<https://www.brisegroup.ro/p/rubisko>).

Crop management: The preceding crop was peas. The preparation of the germination bed was carried out with the combinator, 2 works perpendicular to the pre-sowing. After preparing the germination bed, the picketing and marking of the land for sowing was carried out. The plots have a size of 7 m² of which 5 m² will remain harvestable. The sowing was carried out on 17.10.2018, respectively 17.10.2019 with the seed drill of experimental plots at a depth of 4-5 cm, the distance between rows of 12.5 cm. After sowing, a work was carried out with the smooth roller to put the seed in contact with the soil. The emergence in the agricultural year 2018-2019 started in the second decade of December in stages, and in the agricultural year 2019-2020, the wheat emerge on 9.11.2019. In the winter windows, the foliar fertilization was performed with nitrocalcare at a dose of 200 kg / ha (54% N s.a.). Along with weed control, a preventive treatment against diseases and pests was applied on 18.03.2019, respectively 1.04.2020.

Resistance to lodging was assessed based on the following scale: Very resistant - 1-3% fallen plants - grade 1; Resistant - 4-10% fallen plants - grade 2; Middle resistant- 11-20% fallen plants - grade 3; Middle sensitive - 21-50% fallen plants - grade 4-6; Sensitive -51-75% fallen plants - grade 7-8; Very sensitive - 76-100% fallen plants - note 9.

The attack of pathogens was assessed by grades 1 to 9 in which 1 is very resistant and 9 very sensitive.

The production data obtained were statistically processed by analyzing the variance and establishing the limit differences (LSD 5%, 1% and 0.1%) (SĂULESCU and SĂULESCU, 1967).

RESULTS AND DISCUSSION

Climatic data: The climatic conditions recorded in the period pre-sowing were difficult in both years of experimentation, which led to soil work and sowing to be carried out in more harsh conditions due to lack of soil moisture.

In terms of temperature throughout the vegetation period of wheat, the average monthly temperatures exceeded the multiannual average by 2.7°C in 2019 and 2.6°C in 2020, on average during the vegetation period (Figure 1).

All winter months were warmer compared to the multiannual averages, so the wheat benefited from a mild winter from a thermal point of view.

In April and May the level of monthly temperatures oscillates around the values of the multiannual average. In April, the average monthly temperature in 2019 was 11.4°C, 0.6°C less than the multiannual average (11.9°C), and in 2020 the average monthly temperature was at the level of the multiannual average (11.9°C), but the wheat were affected by the differences between average daytime and nighttime temperatures by yellowing of the leaf and stagnation in vegetation. In May, the average monthly temperature was 17.0°C, with 0.2°C more than the multiannual average (16.8°C) in 2019, and in 2020 with 0.2°C less than the multiannual average.

June was warmer by 2.1°C in 2019, respectively 0.5°C in 2020, and July by 0.8°C in 2019, respectively 2.1°C in 2020.

In terms of water, in the agricultural year 2018-2019, between 1 October 2018 and 30 June 2019, were recorded 580.3 mm of rainfall, with 181.8 mm more than the multiannual average (398.5 mm), and in the agricultural year 2019-2020, during the vegetation period 1 October 2019 -30 June 2020, 401.9 mm of precipitation were recorded, 102.9 mm less than the multiannual average (Figure 2).

In October 2018, only 18.2 l mm of rainfall were recorded, which due to the lack of water in the soil were not sufficient to germinate and emergence. Although in November 2018, 70.0 mm were registered compared to 42 mm value of the multiannual monthly average (+28 mm), the emergence of wheat does not start due to the decrease of temperatures in the second decades and third when the precipitation fell.

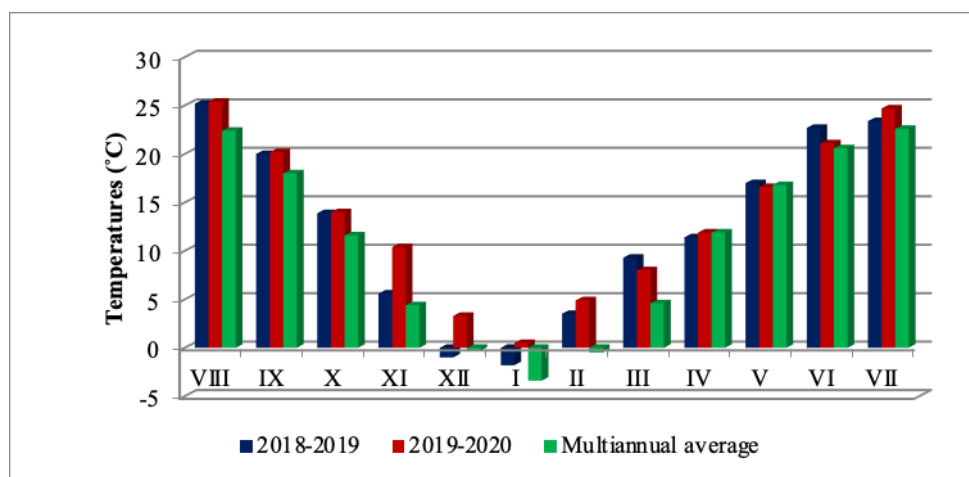


Figure 1. Average monthly temperatures at ARDS Teleorman in 2019 and 2020

In December 2018, rainfall was recorded cumulating 53.4 mm, with 12.2 mm more than the multiannual average (41.2 mm). Against the background of the humidity accumulated in the soil and the higher temperatures (+ 0.7°C compared to the multiannual average), the emergence of the wheat started, and at the end of December.

The evolution of rainfall recorded in the following months of 2019 was around the values of the multiannual average ± 8.2 -14.1 mm, except for the months of May and June when the multiannual average was exceeded by 48.1 mm, respectively 99.3 mm.

The driest month in the vegetation period of wheat in the agricultural year 2018-2019 was October (-19.8 mm compared to the multiannual average), and the rainiest was June when rainfall totaled 171, 6 mm (+99.3 mm compared to the multiannual average), followed by May when precipitation totaled 109.2 mm (+48.1 mm compared to the multiannual average).

The abundant, rainfall from May and June of 2019, in the presence of relatively high temperatures, had an unfavorable influence on the foliar apparatus through the explosion of foliar diseases, implicitly reducing the assimilation surface of the plants. As a result, although the yields obtained were high, the values of useful agronomic indicators (weight of 1,000 seeds and hectolitre mass) were low.

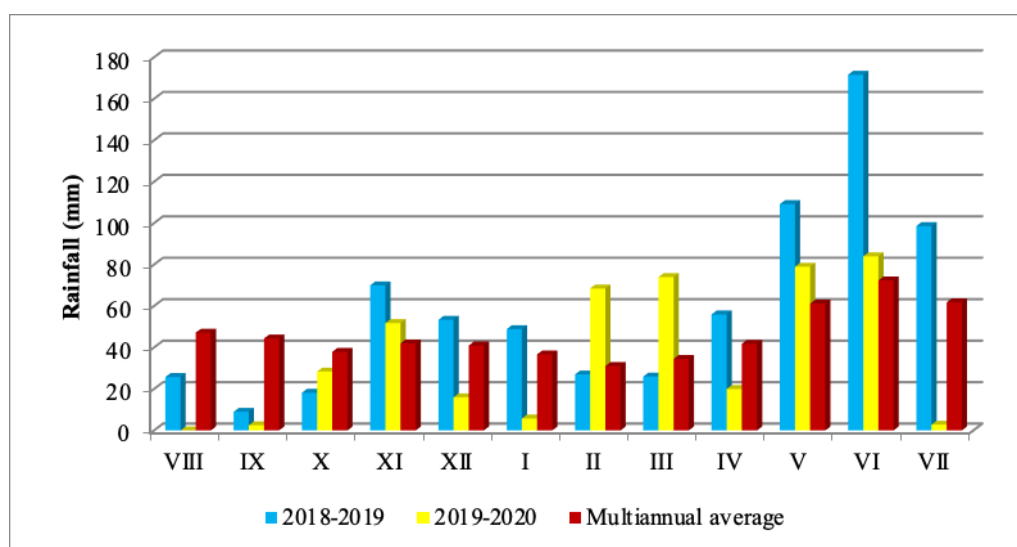


Figure 2. Sum of the monthly rainfall at ARDS Teleorman in 2019 and 2020

In the winter months of the agricultural year 2019-2020, the recorded rainfalls were below the level of the multiannual average. Compared to the multiannual average, the values of rainfall falling in the winter months were: -25.0 mm in December, -30.3 mm in January, +37.4 mm in February. In the spring months they had an uneven distribution as follows: +38.5 mm in March, -21.8 mm in April and +17.8 mm in May. In March, on the 8th and 9th, the first snow (snow layer 20 cm) was registered, accompanied by blizzard.

During the harvest (June - July) wheat did not benefit from sufficient rainfall. The deviation from the multiannual average in June was +11.6 mm and in July - 59 mm.

Due to the high temperatures and water insufficiency in the agricultural year 2019-2020, the wheat had a weaker tillering depending on the genotypic expression of each cultivated variety.

During the wheat growing period, phenological observations and biometric determinations specific to the cultivation of wheat were performed (date of heading, plant height, resistance to lodging at heading, attack of pathogens before and after heading, resistance to lodging at harvest, date of physiological maturity).

Following the observations made, it was found that the density of the plants does not influence the date of the heading, the differences between the variants were insignificant. Of the varieties tested, Avenue is the earliest variety (Table 1).

The height plant was not significantly influenced by the sowing density, significant influence has the variety used and climatic conditions in the year of experimentation, Glosa is the highest of the tested varieties (84 cm on average per years of experimentation) (Table 1).

Table 1.

Phenological observations performed on the multifactorial experiment with wheat, ARDS Teleorman

No crt.	Variety	Density g.g./m ²	Date of heading		Plant height (cm)		Resistance to lodging (note)				Date of physiological maturity	
			2019	2020	2019	2020	at heading		at harvest		2019	2020
							2019	2020	2019	2020		
1	Glosa	400	10.05	8.05	87	86	1	1	1	1	15.06	20.06
2		650	10.05	8.05	84	84	1	1	2	2	15.06	20.06
3		750	10.05	8.05	84	84	1	1	2	2	15.06	20.06
4	Avenue	400	6.05	4.05	67	69	1	1	1	1	14.06	15.06
5		650	6.05	4.05	64	69	1	1	1	1	14.06	15.06
6		750	6.05	4.05	64	68	1	1	1	1	14.06	15.06
7	Rubisko	400	15.05	15.05	78	74	1	1	1	1	18.06	24.06
8		650	15.05	15.05	76	73	1	1	2	2	18.06	24.06
9		750	15.05	15.05	74	73	1	1	3	3	18.06	24.06

In the first evaluation of the resistance to lodging at heading, all the variants were resistant, but in the second evaluation, at harvest, a slight sensitivity of the varieties sown at high density was observed. The most sensitive variety to lodging was the variety Rubisko sown at an average density of 750 g.g./m² over the years of experimentation (note 3) (Table 1).

All tested varieties have genetic resistance to the main foliar diseases that are manifested mainly in the southern part of the country, namely: leaf rust (*Puccinia recondita*), powdery mildew (*Erysiphe graminis*), yellow rust (*Puccinia striiformis*), septoria leaf spot (*Septoria tritici*) and medium resistance to head blight (*Fusarium culmorum*). In 2020, the attack of pathogens was reduced due to unfavorable climatic conditions for their development, the only pathogen present being leaf spot (*Septoria tritici*), with a very low degree of attack (Table 2).

In 2019, the abundant rainfall in May and June, in the presence of relatively high temperatures, had an unfavorable influence on the foliar apparatus through the explosion of foliar diseases. Following the observations made, it was found that a higher density of plants per unit area intensifies the incidence of pathogens. Thus, at densities of 750 g.g./m² all tested varieties were more sensitive to the attack of pathogens. Of the varieties tested, Avenue was the most sensitive to pathogen attack.

Table 2

Phenological observations performed on the multifactorial experiment with wheat, ARDS Teleorman

No crt.	Variety	Density g.g./m ²	Main pathogen attack (Notes)									
			<i>Puccinia recondita</i>		<i>Erysiphe graminis</i>		<i>Puccinia striiformis</i>		<i>Septoria tritici</i>		<i>Fusarium culmorum</i>	
			2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
1	Glosa	400	1	1	1	1	1	1	2	1	1	1
2		650	1	1	2	1	1	1	3	2	1	1
3		750	1	1	2	1	2	1	3	2	1	1
4	Avenue	400	1	1	2	1	2	1	3	2	1	1
5		650	1	1	2	1	3	1	3	2	1	1
6		750	1	1	3	1	3	1	4	3	1	1
7	Rubisko	400	1	1	2	1	2	1	2	2	1	1
8		650	1	1	2	1	2	1	2	2	1	1
9		750	1	1	2	1	3	1	3	3	1	1

In order to highlight the mode of action of the experimental factors on the productivity elements, as well as the existing interactions between the factors, the analysis of the variance for the productive characters in wheat was performed (Table 3).

The variety has a very significant influence on the weight of 1,000 seeds and the number of ears/m² and a distinctly significant influence on the weight of the seeds in the ear; density has a very significant influence on the weight in the ear, distinctly significant on the weight of 1,000 seeds; the year of experimentation (climatic conditions) has a very significant influence on all productive characters. The variety x density interaction is significant only in the case of the weight of 1,000 seeds and the number of ears/m², the variety x year interaction is also very significant on the two characters, and the density x year interaction is significant only in the case of the number of ears/m².

Analyzing table 4 we can see that on average per variety, Glosa and Rubisko had the highest weight of 1,000 seeds of 42.5 g. The highest number of seeds in the ear was recorded in the variety Glosa (32.1), and in terms of seed weight in the ear, the Rubisko variety (1.32 g/ear) stands out.

From the collected data it is observed that with the change of sowing density the net assimilation is reduced, the weight values of 1,000 seeds, the number of seeds in the ear and the weight of the ear decrease, but this decrease is compensated by the increase in the number of ears/m².

On average, it is observed that the highest values of productive characters are recorded at a density of 400 g.g./m², a phenomenon that can be explained by the fact that they had a larger nutrition space and the plants had a higher rate of net assimilation.

The analysis of the variance performed on wheat productions indicates a very significant influence of factor A (variety), factor B (density), but the most important contribution to the achievement of wheat production in the years of experimentation was the climatic conditions (factor C). The interaction variety x density, density x year and the triple interaction variety x density x year had a strong significant influence on wheat yields, and the interaction density x year a distinctly significant influence.

Table 3

The influence of experimental factors on the elements of productivity in the multifactorial experiment with wheat. ARDS Teleorman

Variety	Density g.g./m ²	Year	Weight of 1,000 seeds		Number of seeds in the ear		The weight of the seeds in the ear		Density ears/m ²	
			(g)	Average density	No.	Average density	(g)	Average density	No.	Average density
Glosa	400	2019	44.9	44.95	32	31	1.44	1.39	592	540.5
		2020	45.0		30		1.35		489	
	650	2019	42.7	41.45	34	31	1.45	1.29	715	667.5
		2020	40.2		28		1.13		620	
	750	2019	40.1	40.95	29	28	1.16	1.15	803	741.5
		2020	41.8		27		1.13		680	
Average Glosa			42.5		32.1		1.28		649.8	
Avenue	400	2019	39.8	40.30	34	30	1.35	1.21	669	644.5
		2020	40.8		26		1.06		620	
	650	2019	38.6	39.25	33	31	1.27	1.22	775	747.5
		2020	39.9		29		1.16		720	
	750	2019	34.7	37.15	30	29	1.04	1.07	737	668.5
		2020	39.6		28		1.11		600	
Average Avenue			38.9		30.0		1.17		686.8	
Rubisko	400	2019	45,9	44.40	35	33	1.61	1.45	655	615.5
		2020	42,9		30		1.29		576	
	650	2019	43,8	41.90	34	32	1.49	1.34	780	730.0
		2020	40,0		30		1.20		680	
	750	2019	43,4	41.10	30	29	1.30	1.17	790	745.0
		2020	38,8		27		1.05		700	
Average Rubisko			42.5		31.0		1.32		696.8	

Analyzing the yields obtained for the three varieties tested, we can say that the variety Rubisko had the highest yield (9,283 kg/ ha), on average in density, in the two years of experimentation (Table 4).

At a density of 650 g.g./m² the highest yields were obtained for all tested varieties, and the variety Rubisko obtained the highest yield (10,041 kg/ha) at this density on average over the years of experimentation.

In 2020, the year in which the wheat had a very weak tillering due to the lack of rainfall, the variety Avenue stands out, which at a density of 650 g.g./m² obtained the highest production 8,387 kg/ha. Due to the fact that it is the earliest variety tested, it managed to tillering, so to increase its production through the contribution of the tillers.

Analyzing the data in Table 7, we can observe the influence of variety (factor A) on wheat seed yields. The variety Rubisko obtains a very significant increase in production (677 kg/ha), statistically assured, compared to the average of the studied varieties.

Table 4

The influence of experimental factors on yield on the multifactorial experiment with wheat
ARDS Teleorman

ARDS Teleorman						
Variety	Density g.g./m ²	Year	Yields kg/ha	Average/density kg/ha	Average/year kg/ha	
					2019	2020
Glosa	400	2019	8,520	7,602	9,405	7,085
		2020	6,683			
	650	2019	10,275	8,618		
		2020	6,960			
	750	2019	9,419	8,515		
		2020	7,611			
Average Glosa			8,245			
Avenue	400	2019	9,015	7,846	9,290	7,289
		2020	6,676			
	650	2019	9,889	9,138		
		2020	8,387			
	750	2019	8,965	7,884		
		2020	6,803			
Average Avenue			8,289			
Rubisko	400	2019	10,689	9,050	10,971	7,594
		2020	7,410			
	650	2019	11,964	10,041		
		2020	8,118			
	750	2019	10,260	8,757		
		2020	7,253			
Average Rubisko			9,283			
Average years					9,889	7,322

Table 5

The influence of variety on wheat yields
ARDS Teleorman

Variety	Yields		Difference ± Control	Significance
	kg/ha	%		
Glosa	8,245	95.81	-361	
Avenue	8,289	96.33	-316	
Rubisko	9,282	107.87	677	***
Average variety	8,605	100	MT	

LSD 5% = 102.9 kg/ha

LSD 1% = 170.3 kg/ha

LSD 0.1% = 318.7 kg/ha

The influence of sowing density is reflected on the average yield achieved in the two experimental years, as can be seen in table 6. The tested wheat varieties react positively to higher sowing densities, so that the highest yields of 9,266 kg/ha, is achieved at a density of 650 g.g./m² and has a very significant positive influence in the yields compared to the variant of 400 g.g./m², taken as a control (8,297 kg/ha). The yields obtained by the mice tested at a density of 750 g.g./m² exceed the control with a distinctly significant yields increase (220 kg/ha), ensured statistically

Table 6

The influence of density on wheat yields -ARDS Teleorman

Density	Yields		Difference $\pm$ Control	Significance
	kg/ha	%		
400	8,166	100	MT	
650	9,266	113.5	1100	***
750	8,385	102.7	220	**

LSD 5% = 121.4 kg/ha LSD 1% = 170.4 kg/ha LSD 0.1% = 240.6 kg/ha

The influence of climatic conditions on the yields of wheat is presented in table 7. It is found that, compared to the average of the two years, the yields made for each year are strongly differentiated. Thus, the yields in 2019 is very significant, statistically assured, with a production increase of 1283 kg/ha.

Table 7

**The influence of year on wheat yields.
ARDS-Teleorman**

Year	Yields		Difference $\pm$ Control	Significance
	kg/ha	%		
2019	9,889	114.9	1283	***
2020	7,322	85.1	-1283	
Average years	8,606	100.0		

LSD 5% = 92.7 kg/ha LSD 1% = 127.2 kg/ha LSD 0,1% = 173.1 kg/ha

CONCLUSIONS

The correct choice of variety and cultivation technology according to the climatic conditions of the year are decisive factors in obtaining stable yields. Sowing density is an important technological sequence in increasing productivity and is established depending on the cultivation area and the phenotypic characteristics of the variety.

The morphological characteristics of wheat are not significantly influenced by the sowing density, they are influenced by the variety and to a large extent by the climatic conditions.

Productivity elements are influenced by sowing density, variety and experimental conditions.

The Glosa variety is the common winter wheat variety with the largest share in the structure of varieties grown in the southern part of the country. It achieves high and stable yields (8,245 kg/ha), with a protein content of 14.6%, the highest average protein content on the tested varieties.

The Rubisko variety obtained the highest yields (9,282 kg/ha) regardless of the climatic conditions of the year, proving ecological stability and plasticity, with a protein content of 11.9%.

The Avenue variety is the earliest variety tested, with high production potential but with a lower protein content (11.3%).

For the southern part of the country, good results were obtained when 650 g.g/m² were used, a density at which the reduction in productivity was offset by the increase in the number of plants/ha, the yields obtained being 9,266 kg/ha on average over the years experimentation. Relevant is the year 2020 when due to the climatic conditions the wheat had a very weak tillering and the sowing density had a major influence on the wheat yields.

BIBLIOGRAPHY

1. Boquet D.J. Cotton in ultra-narrow row spacing: plant density and nitrogen fertilizer rates, *Agron. J.*, 2005, 97: 279-287.
2. Bruckner P.L.;Frohberg R.C., - Rate and duration of grain filling in spring wheat, *Crop Sci.*, 1987, 27: 451-455.
3. Egli D.B. - Plant density and soybean yield, *Crop Sci.*, 1988, 28. <http://dx.doi.org/10.2135/cropsci1988.0011183X002800060023x>.
4. Gebeyehou G.;Knott D.R.;Baker R.J. - Rate and duration of grain filling in durum wheat cultivars, *Crop Sci.*, 1982, 22: 337-340.

5. Kamaluddin Rishi; Singh M.; Lal C. Prasad; Malik Z. Abdin; Arun K. Joshi - Combining ability analysis for grain filling duration and yield traits in spring wheat (*Triticum aestivum* L. em. Thell.), *Genetics and Molecular Biology*, 2007, 30(2): 411–416.
6. Knežević D.; Veselinka Zečević; Nevena Đukić; Dodig D. - Genetic and phenotypic variability of grain mass per spike of winter wheat genotypes (*Triticum aestivum* L.), 2008, *Kragujevac J. Sci.*, 30: 131-136.
7. Kraljevic-Balalic Marija; Worland A.J.; Porceddu, E.; Kuburovic, M. - Variability and gene effect in wheat, 2001, In: *Monograph Genetic and Breeding of Small Grains*. (eds. S. Quarrie et al.) pp.: 9-49.
8. Rossini M.A.; Maddonni G.A.; Otegui M.E. - Inter-plant competition for resources in maize crops grown under contrasting nitrogen supply and density: variability in plant and ear growth, 2011, *Field Crops Res.*, 121: 373-380.
9. Săulescu N.A., Săulescu N.N. - Câmpul de experiență, Editura Agor-Silvică, Ediția a II a, 1967, 255-270.
10. Van Sanford D.A.; Mackown C.T. - Cultivar differences in nitrogen remobilization during grain-fill in soft red winter wheat, *Crop Sci.*, 1985, 27:295-300.
11. Wells R. - Soybean growth response to plant density: relationships among canopy photosynthesis, leaf area, and light interception, *Crop Sci.* 31. 1991, <http://dx.doi.org/10.1007/BF00052541>.
12. <https://incda-fundulea.ro/fise/fise.html>
13. <https://www.lgseeds.ro/catalog/avenue/>
14. <https://www.brisegroup.ro/p/rubisko>