THE BEHAVIOR OF LOCAL AND FOREIGN WINTER WHEAT VARIETIES IN DIFFERENT SOWING DENSITIES, IN AN ECOLOGICAL SYSTEM IN THE NORTH AREA OF THE COUNTRY

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Abstract

In Romania, climate changes have determined in recent years, the intensification of water deficits (very often associated with drought) during the vegetation of agricultural crops, in almost all areas of the country. Cultivating autumn wheat varieties that can withstand drought and heat well and adapting cultivation technology to climate changes are decisive factors in obtaining stable and economically efficient productions. In the agricultural year 2022-2023, in A.R.D.S. Secuieni, Neamț County, a multifactorial experiment of the 10 x 3 x 1 type was established, which aimed to determine an optimal density depending on the varieties used and the climatic conditions. The experiment was laid out according to the method of parcels subdivided into 3 repetitions, with the following factors: Factor A - variety, cu 10 graduations (a_1 = Trublion; a_2 = Centurion; a_3 = Katarina; a_4 = Glosa; a_5 = Aspekt; a_6 = Izvor; a_7 = Avenue; a_8 = Solehio; a_9 = Alcantara; a_{10} = Hyxperia); Factor B - plant density, with 3 graduations: (b_1 = 250 germinable kernels/sm; b_2 = 360 germinable kernels/sm and b_3 = 500 germinable kernels/sm.); Factor C - location, cu 1 graduation: c_1 = Secuieni. 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 all the Romania country. It achieves high and stable yields (8,559 kg /ha), with a protein contain 14.2, the highest average protein contain on the tested varieties. For the northern part of the country, good results were obtained when 250 g.g/m^2 were used for the variety Centurion, a yield production of 10,008 kg/ha. The hybrid wheat, Hyxperia variety obtained the highest yields (8,745 kg/ha) regardless of the climatic conditions of the year, proving ecological stability and plasticity, with a protein content of 11.9%.

Key words: wheat, ecological system, sowing rate, wheat varieties, hybrid wheat, grains weight per ear, TGW, HLM.

INTRODUCTION

World food production remains dominated by straw cereals, the demand for increasing global food security is one of the main objectives of breeding programs aimed at increasing yields associated with heterosis (hybrid vigor at emergence) in wheat (Whitford et al., 2013; Longin et al., 2012).

In order to achieved a high yield potential of wheat cultivars varieties, the number of harvestable ears needs to be between 600 and 700/sm, which can be accomplished by sowing 500-550 seeds/sm (Cociu, 2014). Winter wheat (*Triticum aestivum*) is a rustic and drought-tolerance plant, with very good adaptability to different climatic and soil conditions, from south to north areas.

Yields capacity is a complex quantitative character, determined by internal 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 & Mackown, 1985; Bruckner & Frohberg, 1987).

Production of winter wheat is dependent on the general genetic potential of the variety, which in turn is realized at the expense of productivity elements. Genotype productivity is dependent on the hereditary factor, on which the environmental conditions have a big impact in the phenotypic characteristics, as well as the

genotype-environment interaction (Knežević et al., 2008). So, wheat yields is a quantitative character with high variability, which is given by many components of yields, by their formation under the influence of environmental conditions (Kraljevic-Balalic et al., 2001).

So, is very good to create 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.

MATERIALS AND METHODS

Researches were carried out in field experiments at the Agricultural and Development Research Station Secuieni (ADRS Secuieni) located in North Romania (Neamț County) in the agricultural years 2022-2023.

The researches were performed under rainfed conditions on a soil of cambic chernozem type.

In the agricultural years 2022-2023, a multifactorial experiment of type 10 x 3 x 1 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 10 graduations (a_1 = Trublion; a_2 = Centurion; a_3 = Katarina; a_4 = Glosa; a_5 = Aspekt; a_6 = Izvor; a_7 = Avenue; a_8 = Solehio; a_9 = Alcantara; a_{10} = Hyxperia.

Factor B density, with 3 graduations (b_1 = 250 g.g./m^2; b_2 = 360 g.g./m^2; b_3 = 500 g.g./m^2);

Factor C location, with 1 graduations (c_1 = Secuieni).

When we have started to counting plant densities, the variety I taken in consideration, the vegetation period, the leaves architecture, the resistance to lodging and sowing period and density.

The biological material used in the experiment consists of 2 common autumn wheat varieties, a creation of INCDA Fundulea, Glosa and Izvor varieties (https://incda-fundulea.ro/fise/fise.html), 7 foreign varieties with a high share in the structure of wheat varieties grown in the south of the country, varieties Trublion, Centurion, Katarina, Aspek (https://www.saaten-union.ro/produse/grau/grau-de-toamna/, https://lgseeds.ro/cataloage/, https://lidea-seeds.ro/crops) and 1 hybrid wheat, Hyxperia (https://www.saaten-union.com/index.cfm/nav/682.html).

The preceding crop was peas. The preparation of the germination bed was carried out with the combinator, one work perpendicular to the pre-sowing. The plots have a size of 12 m^2 of which 10 m^2 will remain harvestable. The sowing was carried out on 13.10.2022. The emergence 29.10.2022.

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 & Săulescu, 1967).

Crop management

The preceding crop was peas.

Seed treatment was with Bordeaux mixture in a concentration of 5%, substance, spring fertilizer with manure. All studied variants were sown on 28th of October.

During the vegetation period no phytosanitary treatments were performed.

For disease and insect control were apply two times the product Ortimag - 100 ml/100 l water, insecto-fungicide homologated for ecological agriculture. The productivity elements were

evaluated at 10 plants chosen at random from each experimental variant.

The calculation and interpretation of the results was done based on the analysis of variance (Săulescu & Săulescu, 1967).

The percentage of protein contain in the wheat seeds was determined with the device Nir Noise Instruments Quick Analyzer, Agri Check Plus model.

RESULTS AND DISCUSSIONS

From a climatic point of view (Table 1), in the winter months, the evolution of the thermal factor was favorable for cereal crops, regardless of the species. Although temperatures below the freezing point were set early (in October).

Table 1. Climatic conditions at Secuieni, Neamț County during the 2022-2023 growing season

Month	Temperature (^{0}C)		Rainfall (mm)	
	Average for 2022-2023	Average*	Average for 2022-2023	Average*
October	8.1	7.2	10.8	46.0
November	5.6	3.5	39.0	56.6
December	0.0	-1.5	5.4	40.6
January	-0.1	-3.9	4.6	18.2
February	2.7	-2.1	0.8	15.7
March	2.5	2.6	38.4	64.5
April	9.5	8.4	20.8	29.3
May	16.9	15.6	40.1	85.0
June	20.8	18.9	56.6	85.0
Average (Oct-Jun)	7.3	5.4	24.1	49.0

*-average for 15 years

In December 2022, rainfall was recorded cumulating 5.4 mm, with 35.2 mm less than the multiannual average (40.6 mm). Against the background of the humidity accumulated in the soil and the higher temperatures (+1.5°C compared to the multiannual average), the development of the wheat started, and at the end of December.

The evolution of rainfall recorded in the following months of 2023 was in average 161.3 mm versus 297.7 mm average of the last 15 years.

The driest month in the vegetation period of wheat in the agricultural year 2022-2023 was May (-44.9 mm compared to the multiannual average).

The abundant, rainfall from May and June of 2023, 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.

The monthly average temperatures of the 2022-2023 growing season were higher than the normal average in the area, according to the climatological norm. High temperatures were registered starting with October (8.1°C) and continuing with November (5.6°C), January (-0.1°C) and February (2.7°C). The coldest month of the year was January, when it was -0.1°C. May had an unfavorable influence on crop growth, given to the temperature and rainfall influence.

Concerning the climatic conditions, in the 2022-2023 growing season, was not favorable for cereals crops due to the lack of water from the rainfall for all the vegetation period (practically from late October to June we had drought conditions).

Due to the high temperatures and water insufficiency in the agricultural year 2022-2023, 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 2).

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, the hybrid Hyxperia is the highest of the tested varieties (97.6 cm on average per year of experimentation) (Table 2).

Table 2. Phenological observations realized on the multifactorial experiment with whinter wheat, ARDS Secuieni

No.	Variety	Density, g.g./m^2	Date of heading	Plant height (cm)	Resistance to lodging (note)		Date of physiological maturity
					at heading	at harvest	
1		250	24.05	78	1	1	15.06
2	Trublion	360	24.05	75	1	1	15.06
3		500	26.05	79	1	1	15.06
4		250	23.05	93	1	1	18.06
5	Centurion	360	25.05	89	1	1	18.06
6		500	26.05	93	1	2	18.06
7		250	22.05	87	1	1	14.06
8	Katarina	360	22.05	89	1	1	14.06
9		500	23.05	86	1	1	14.06
10		250	24.05	85	1	1	14.06
11	Glosa	360	25.05	86	1	2	14.06
12		500	26.05	87	1	3	14.06
13		250	24.05	87	1	1	19.06
14	Aspekt	360	25.05	88	1	1	19.06
15		500	26.05	88	1	1	19.06
16		250	22.05	77	1	1	14.06
17	Izvor	360	22.05	75	1	2	14.06
18		500	24.05	77	1	1	14.06
19		250	23.05	81	1	1	13.06
20	Avenue	360	22.05	83	1	1	13.06
21		500	24.05	85	1	1	13.06
22		250	25.05	68	1	1	19.06
23	Solehio	360	25.05	86	1	2	19.06
24		500	27.05	70	1	1	19.06
25		250	27.05	78	1	1	19.06
26	Alcantara	360	26.05	78	1	2	19.06
27		500	27.05	81	1	2	19.06
28		250	24.05	95	1	1	18.06
29	Hyxperia	360	23.05	98	1	1	18.06
30		500	25.05	100	1	2	18.06

In the first evaluation of the resistance to lodging at heading, all the variants were resistant, but in the second evaluation, before harvest time, a slight sensitivity of the varieties sown at high density was observed. The most sensitive variety to lodging was the variety Glosa sown at an average density of 500 g.g./m^2 over all of experimentation (note 3) (Table 3).
All tested varieties have genetic resistance to the main foliar diseases that are manifested mainly in the northern 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 2023, 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 3).
This, at densities of 500 g.g./m^2 all tested varieties were more sensitive to the attack of pathogens. Of the varieties tested, Katarina was the most sensitive to pathogen attack.

Table 3. Phenological observations realized on the multifactorial experiment with wheat, ARDS Secuieni

No.	Variety	Density, g.g./m²	Main pathogen attack (Notes)				
			Puccinia recondita 2023	*Erysiphe graminis* 2023	*Puccinia striiformis* 2023	*Septoria tritici* 2023	*Fusarium culmorum* 2023
1	Trublion	250	1	1	1	1	1
2		360	1	1	1	2	1
3		500	1	1	1	3	1
4	Centurion	250	1	1	1	1	1
5		360	1	1	1	2	1
6		500	1	1	1	3	1
7	Katarina	250	1	1	1	2	1
8		360	1	1	1	1	1
9		500	1	2	3	1	1
10	Glosa	250	1	1	1	2	1
11		360	1	1	1	2	1
12		500	1	1	1	2	1
13	Aspekt	250	1	1	1	2	1
14		360	1	1	1	2	1
15		500	1	1	1	2	1
16	Izvor	250	1	1	1	2	1
17		360	1	2	3	1	1
18		500	1	2	3	1	1
19	Avenue	250	1	1	1	3	1
20		360	1	1	2	1	1
21		500	1	1	2	1	1
22	Solehio	250	1	1	2	1	1
23		360	1	1	2	1	1
24		500	1	1	2	1	1
25	Alcantara	250	1	1	2	1	1
26		360	1	1	3	1	1
27		500	1	1	1	1	1
28	Hyxperia	250	1	1	1	1	1
29		360	1	1	1	1	1
30		500	1	1	1	1	1

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 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, Aspekt had the highest weight of 1,000 seeds of 41.9 g. The highest number of seeds in the ear was recorded in the variety Glosa (44.3), and in terms of seed weight in the ear, the Katarina variety (1.50 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 360 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. capacity and in grains weight of ears/sm.

Table 4. The influence of experimental factors on the elements of productivity in the multifactorial experiment with wheat, ARDS Secuieni

Variety	Density, g.g./m²	Weight of 1.000 seeds (g)	Number of seeds in the ears no	The weight of the seeds in the ear (g)	Density, ears/m² no
Trublion	250.0	35.8	36.3	1.5	648.0
	360.0	31.8	34.6	1.0	740.0
	500.0	34.7	30.0	1.0	604.0
Average Trublion		**34.1**	**33.6**	**1.2**	**664.0**
Centurion	250.0	38.8	28.8	2.0	828.0
	360.0	36.7	27.2	1.0	840.0
	500.0	41.0	25.5	1.0	836.0
Average Centurion		**38.8**	**27.2**	**1.3**	**834.7**
Katarina	250.0	34.8	44.9	1.4	628.0
	360.0	36.5	43.1	1.7	644.0
	500.0	34.4	42.8	1.3	540.0
Average Katarina		**35.2**	**43.6**	**1.5**	**604.0**
Glosa	250.0	32.0	45.5	1.4	676.0
	360.0	33.2	44.2	1.3	672.0
	500.0	31.0	43.2	1.1	640.0
Average Glosa		**32.0**	**44.3**	**1.3**	**662.7**
Aspekt	250.0	41.1	43.2	1.5	662.0
	360.0	43.8	31.5	1.1	684.0
	500.0	40.9	25.9	1.0	536.0
Average Aspekt		**41.9**	**33.5**	**1.2**	**627.3**
Izvor	250.0	34.8	34.4	1.0	672.0
	360.0	38.4	28.1	1.1	720.0
	500.0	33.4	28.1	1.0	556.0
Average Izvor		**35.5**	**30.2**	**1.0**	**649.3**
Avenue	250.0	31.9	28.4	1.3	820.0
	360.0	35.2	27.3	0.9	900.0
	500.0	30.1	26.5	0.8	736.0
Average Avenue		**32.4**	**27.4**	**1.0**	**818.7**
Solehio	250.0	35.6	36.6	1.6	660.0
	360.0	29.4	29.9	1.0	744.0
	500.0	31.2	28.7	0.9	568.0
Average Solehio		**32.1**	**31.7**	**1.1**	**657.3**
Alcantara	250.0	42.2	40.4	1.1	584.0
	360.0	38.1	36.2	1.0	538.0
	500.0	37.6	33.7	1.0	508.0
Average Alcantara		**39.3**	**36.8**	**1.0**	**543.3**
Hyxperia	250.0	38.1	36.1	1.6	812.0
	360.0	34.5	24.2	1.0	764.0
	500.0	33.1	31.1	1.0	616.0
Average Hyxperia		**35.2**	**30.5**	**1.2**	**730.7**

Analyzing the yields obtained for the ten varieties tested, we can say that the hybrid Hyxperia had the highest yield (8,745 kg/ha), on average in density, in the 2022-2023 year of experimentation (Table 5). At a density of 250 g.g./m² the highest yields were obtained for majority tested varieties, and the hybrid Hyxperia obtained the highest yield (8,745 kg/ha) at this density on average of the year 2022-2023.

Analyzing the data in Table 6, we can observe the influence of variety (factor A) on wheat seeds yields.
The hybrid wheat obtains a significant increase in production (186 kg/ha), statistically assured, compared to the average of the studied standard Glosa variety.

Table 5. Influence of the genotype on physical quality indices TGW and HLM

Variety	Density, g.g./m²	Yields, kg/ha
Trublion	250	8791
	360	7182
	500	7070
Average Trublion		**7681**
Centurion	250	10008
	360	7822
	500	7501
Average Centurion		**8444**
Katarina	250	8560
	360	9034
	500	8267
Average Katarina		**8620**
Glosa	250	8820
	360	8433
	500	9423
Average Glosa		**8892**
Aspekt	250	8467
	360	6783
	500	6544
Average Aspekt		**7265**
Izvor	250	7397
	360	7417
	500	8109
Average Izvor		**7641**
Avenue	250	7587
	360	8975
	500	7278
Average Avenue		**7947**
Solehio	250	8808
	360	6414
	500	6809
Average Solehio		**7344**
Alcantara	250	7612
	360	8881
	500	7604
Average Alcantara		**8032**
Hyxperia	250	9617
	360	7763
	500	7855
Average Hyxperia		**8412**
Average year		**8028**

Table 6. The influence of variety on wheat yields ARDS Secuieni

Variety	Yields		Difference ± Control	Significance
	kg/ha	%		
Trublion	7681	90	-878	
Centurion	8444	99	-115	
Katarina	8620	101	61	
Glosa	8559	100	0	
Aspekt	7265	85	-1294	
Izvor	7641	89	-918	
Avenue	7847	92	-712	
Solehio	7344	86	-1215	
Alcantara	8032	94	-527	
Hyxperia	8745	102	186	**
Average year	**8018**	94	MT	

CONCLUSIONS

Is decisive the correct choice of variety and cultivation technology according to the climatic conditions of the year in order to obtain higher and stabile productions.

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.

All the productivity elements are influenced by sowing density, variety and pedo climatic condition.

The Glosa variety is the common winter wheat variety with the largest share in the structure of varieties grown in the all the Romania country. It achieves high and stable yields (8,559 kg/ha), with a protein contain 14.2, the highest average protein contain on the tested varieties.

For the northern part of the country, good results were obtained when 250 g.g/m^2 were used for the variety Centurion, a yield production of 10.008 kg/ha.

The hybrid wheat, Hyxperia variety obtained the highest yields (8,745 kg/ha) regardless of the climatic conditions of the year, proving ecological stability and plasticity, with a protein content of 11.9%.

In this experiment, at densities of 500 g.g./m^2 all tested varieties were more sensitive to the attack of pathogens. Of the varieties tested, Katarina was the most sensitive to pathogen attack.

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