

TECHNOLOGICAL ASPECTS OF RYE CULTIVATED IN THE CONDITIONS OF SANDY SOILS IN SOUTHERN OLTENIA

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ABSTRACT

Rye (*Secale cereale* L.) is an important crop in Europe, where it occupies about 90% of the world's area cultivated with this cereal (FAOSTAT, 2018), mainly in the countries of Central and Eastern Europe. The main research highlights the mechanisms of adaptation of rye culture to climate change, aimed at identifying genotypes that have a good behavior in culture under conditions of abiotic (thermohydric) and biotic stress (pathogens and pests) in order of restoring the production capacity and protection of agroecosystems in the area of sandy soils by promoting in culture some genotypes tolerant to thermohydric stress.

In the two experimented years of 2020 and 2021 the obtained results prove the new genotypes promoted on the market had a higher capacity of production than the Control (Suceveana variety), with an average yield of over 4555 kg/ha registered at Serafino genotype in the conditions of a sandy soil with a low natural fertility, poorly supplied with total nitrogen (0.05-0.07%). In average, during the tested years, the attack frequencies of pests manifested in the comparative rye culture, as well as the attack intensities did not show significant differences from one variety to another, significant differences compared to the control variety (Suceveana) being observed only in the case of Serafino variety.

INTRODUCTION

Rye is the second most commonly grown cereal after wheat and it can be used in human nutrition due to its chemical composition similar to that of wheat grain. Rye flour is used to make a darker variety of bread than those obtained of wheat, browner, with a specific taste, slightly sour and with lower digestibility, called "Graham bread" (Gh. Matei, 2013).

Rye is a species that exploits the drier areas, with poorly productive soils and which is located where wheat no longer generates economic production (cold, dry areas, with soils with high acidity or salty). It is also a part of the crop rotations in the sandy soils' areas of the south and northwest of the country, as the main crop or as a backdrop for crops that need protection.

Research on the rye crop carried out in Poland during 2010 – 2013 years, focused on the variability of the concentration of anti-nutritive compounds in rye grains depending on the variety, weather conditions and production technology shows that the evolutions of the productivity depended significantly on the genotype and weather conditions (Grabinski, Jerzy et al., 2021).

In order to determine agronomic characteristics, and forge yield and quality responses of rye variety to location and year for a double-cropping system in South Korea Kim, JD et al. (2005) studied the behavior of five forage rye varieties. The study showed that there are differences in forage production and quality from location to location, year to year and variety to variety.

Selection of an appropriate sowing time for some winter rye (*Secale cereale* L.) cultivars could reduce the need for crop protection measures. A study conducted by

Huusela-Veistola, E. et al. (2006) the occurrence and status of pests and weeds in relation to sowing time and growth habit of winter rye was studied in southern Finland. The early sown rye was severely affected by pests (*Oscinella frit*, *Mayetiola destructor*) and weeds, whereas postponing sowing for two weeks after the recommended sowing time in late August resulted in considerably less damage and the optimal establishment of crop stands.

Similar conclusions related to the necessity of protect crops in order to minimize damages generated by the attack of pests both in field crops, orchards or grassland were obtained by Paraschivu Mirela (2020, 2021), Elena Partal (2000) and Carmen Claudia Durău (2021).

MATERIAL AND METHOD

The research carried out in the period of 2020-2021 years, at ARDCSSDăbuleni, aimed at the behavior of three foreign rye genotypes (Binnto, Serafino, Inspector), compared to a local genotype (Suceveana), in the conditions of sandy soils in Southern Oltenia. The experiment was organized by the method of randomized blocks in three repetitions, in the conditions of a sandy soil with a low natural fertility, being poorly supplied with total nitrogen (0.05-0.07%), medium to normal supplied with extractable phosphorus (33-65 ppm), reduced to medium supplied with exchangeable potassium (50-121 ppm) and with a strong acid soil reaction (pH H₂O = 4.66-4.79).

Sowing was realized 10th of October in 2019 and on 19th of October in 2020 on a land fertilized with equal rate of macro elements of N₈₀P₈₀K₈₀ applied on the preparation of the germinative bed. During the vegetation we applied a rate of N₇₀ in the form of ammonium nitrate, in the spring when the vegetation of rye plants resumed (2nd decade of the month March).

During the vegetation period were determined biometrical features of the tested varieties (plant's height, number of spike/square meter, spike length, number of seeds/spike and drop resistance of rye genotypes).

In order to evaluate the genotypes that have a good behavior in culture under conditions of abiotic (climatic factors) and biotic stress (the action of the pests) we made observations on the identification of pests and also determined the frequency of the attack, the intensity of the attack, the degree of attack.

ANOVA program was used for the statistical calculation. Photographic images were taken with different pests identified and with their attack in different phases of vegetation.

RESULTS AND DISCUSSIONS

During the vegetation period of rye cultivation (October-July) there was an average air temperature of 11.85°C, with +2.15°C higher compared to the multiannual average, thus noticing the accentuation of the arid climate in the area of sandy soils, which forces us to cultivate plants with increased drought tolerance, rye being part of this category of plants.

The length of the day influences the resistance of the rye plant to frost (Marilyn Griffith and Heather C. H. McIntyre, 1993). The results obtained in this sense underlined that the rye plant grows well in short day conditions, conditions that also characterize the Romanian climate, being more tolerant to frost, than the plants grown in long day conditions.

Although the precipitations recorded at the weather station of SCDCPN Dăbuleni exceeded the multiannual average by about 25.9 mm, in the agricultural year 2019/2020 (figure 1) and by 39.54 mm, in the agricultural year 2020/2021 (figure 2), they were unevenly distributed over the vegetation period of rye, being necessary to complete the water deficit in the soil by an irrigation rate with a value of 250 m³ water/ha.

Also, the registration of an extremely dry period, when for 25 days (year 2020) only 19.8 mm of precipitation was recorded, and in 2021 for a period of 30 days only 23 mm of precipitation fell, required the application of irrigation during the flowering period of the plant. Adverse weather conditions (especially droughts) in recent years, which often last a long part of the growing season, have a negative effect on the yield of plants, not only on sensitive ones, but also on resistant species such as rye (Ilona Czyczyło-Mysza and Beata Mysków, 2017).

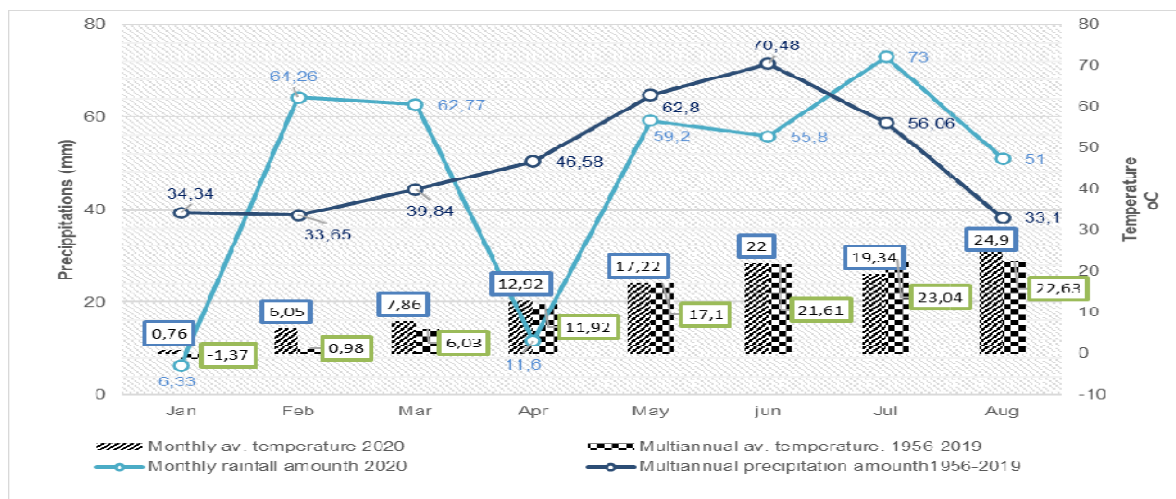


Figure 1 – Climatic condition of the agricultural year of 2019/2020 registered at ARDCSS Dăbuleni

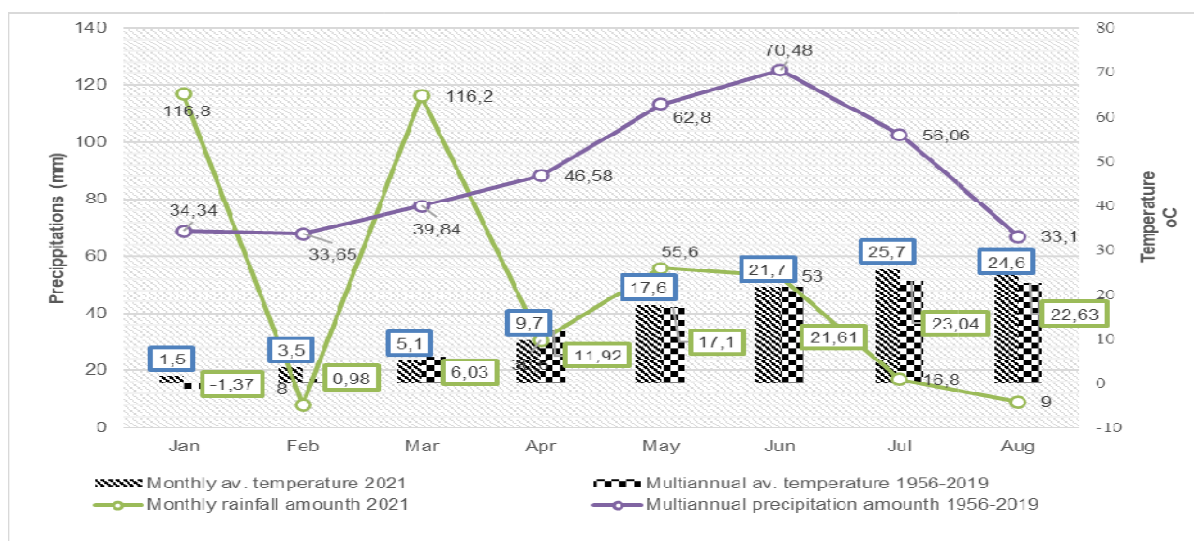


Figure 2 – Climatic condition of the agricultural year of 2020/2021 registered at ARDCSS Dăbuleni

The main determinations regarding the growth and development of the plants in the 4 studied genotypes assortment showed a plant height varied between 127.1 from Binnto variety to 156.5 cm at Suceveana genotype, an element that was negatively correlated with the drop resistance (table 1) were the used as Control had the single notation of 2.

The analysis of the productivity elements of the plant, highlighted the Serafino genotype, in which 542 ears/square meter, an average of 10.45 cm length of spike and 57.5 grains/ ar were registered.

Form the point of the studied characters presented in table 1, even in case of the situation of lower values registered to the spike length (in comparison with Inspector and Suceveana varieties) and number of seeds/spike (related to Binnto and Inspector

varieties) the main factor which has definitely contributed to higher production rate proved to be the number of ears per square meter, values which ensure the highest production to Serafino genotype (table 2).

Table 1

Biometrical measures and drop resistance on the experimented rye varieties in the conditions of ARDCSS Dăbuleni

Variety	Height (cm)	Spike no /m ²	Spike length (cm)	Seeds/spike	Drop resistance (scale 1-9)
Binnto	127.1	540.5	10.00	59.6	1
Serafino	133.6	542.0	10.45	57.5	1
Inspector	130.5	534.0	11.45	59.0	1
Suceveana	156.5	522.5	10.80	56.1	2

Analysis of production results (table 2) highlighted, in average on the experimented years of 2020 and 2021, a variation which range between 3087.9 kg/ha observed at Control – Suceveana variety – and Serafino genotype with 4555.4 kg/ha with an increase in production of 47.5% related to control.

Table 2

Yields and their significances of the experimented rye varieties in average on 2020 – 2021 in the conditions of ARDCSS Dăbuleni

Variety	Yields		Differences	Signification
	Kg/ha	%		
Binnto	4358.3	141.1	1270.4	**
Serafino	4555.4	147.5	1467.5	***
Inspector	4102.0	132.8	1014.1	**
Suceveana	3087.9	100	Control	Control

DL 5%=511.8 kg/ha; DL 1%=775.0 kg/ha; DL 0,1%=1245.0 kg/ha

Distinct increases in production were observed at Binnto and Inspector genotypes. Quality analysis of rye genotypes (table 3) studied revealed differences in protein content, gluten, Zeleny index and hardness index.

Iuliana Banu (2004) shows that the protein content of rye grains can be a good indicator of its ripening quality. The chemical composition of the rye grain shows values of crude protein in the range of 10.55%, with maximum values for the Suceveana variety, of 12.59%, a variety that also showed increased values of gluten content, grain durity and Zeleny index.

Table 3

Quality parameters of yields of rye varieties in average on 2020 – 2021 in the conditions of ARDCSS Dăbuleni

Variety	Protein	Gluten	HW	TWG	Zeleny Index	Durity
	(%)	(%)	(Kg/hl)	(g)	ml	(%)
Binnto	11.62	22.55	68.5	28.00	32	46.9
Serafino	10.55	17.10	71.5	28.00	17	51.5
Inspector	11.79	23.12	72.0	28.50	36	47.0
Suceveana	12.59	24.92	69.5	30.50	38	46.2

In the literature the protein content reported in rye cultivars, grown in different countries, varied between 7.0 and 14.6% (Hansen et al., 2004, Banu I., 2007, Jansone, 2015).

The durity of the rye grain, like the hardness of any body, is a local, superficial resistance of the given body and is characterized by the property of the body to resist the penetration of another body, which does not acquire residual deformations. The hardness values of the rye grains varied between 46.2% for Suceveana genotype and 51.1% for the Serafino genotype.

Rye grain is important raw material for bread making in middle Europe countries. Development of new indirect traits can be helpful in the breeding programs and can improve the baking quality (Vejrazka, K. et al., 2009). The wet gluten content of the grains and the Zeleny index are very important quality indicators for the technological process, contributing to the characterization of the dough, especially its processing capacity and its baking potential. Gluten is a composite of two proteins, gliadin and glutenin, bound to starch in wheat and rye seeds. In rye grains, the starch content range between 17.10% in the Serafino genotype and 24.92% in the Suceveana genotype. The type of gluten in rye, unlike wheat gluten, is much less elastic and also poorer when caught in bubbles during the baking process, so that rye produces a much less airy bread. It also contains more sugars, which means that the rye ferments faster. The Zelleny index or sedimentation index, which characterizes the quality of proteins, showed the highest values on Suceveana genotype (38 ml) the followed by Inspector genotype with 36 ml.

The mass of 1000 grains registered values between 28 - 30.5 g, with a maximum at Suceveana variety. The last index –hectolitic weight- varied between 68.5 kg/hl (Binnto) and 72 kg/hl (Inspector).

The attack of pathogens and pests remains a major factor in abiotic stress that threatens agricultural production and quality in many parts of the world. This reality requires an intensification of research in order to find more effective control methods, in order to integrate them into the system of integrated control of pathogens and pests of crop plants, a system that needs to be rethought for each crop, especially in the context of the impact of climate change on both plants and these biotic stressors (pathogens/pests) Paraschivu Mirela et al., 2020, Gh. Matei et al., 2010.

In our research we highlight the main pests that we found in our experiment of rye varieties in 2020 and 2021 years. The species of pests and useful fauna identified in the culture compared to different rye genotypes, for 2020 year, these are presented in Table 4.

Table 4

Distribution of harmful species and useful fauna identified between April and June 2020 in comparative experience with rye genotypes at ARDCSS Dăbuleni

Variety	Genotype			
	Binnto	Serafino	Inspector	Suceveana
<i>Schizaphisgraminum</i>	x	x	x	x
<i>Eurygasterintegriceps</i>	x			x
<i>Melolonthamelolontha</i>		x		x
<i>Mayetiola destructor</i>	x		x	
<i>Chloropspumilionis</i>			x	x
<i>Coccinellaseptempunctata</i>	x	x	x	x

The frequencies of attack of pests manifested in the comparative rye culture, as well as the intensities of attack did not show significant differences from one variety to another, in neither of the two moments of determination (beginning of the bellows phase and the beginning of the grain formation), significant differences compared to the control

variety (Suceveana) being observed only in the case of the Serafino variety (year 2020- table 5) and Binnto genotype (year of 2021 – table 7).

Table 5

Distribution of harmful species and useful fauna identified between April and June 2020 in comparative experience with rye genotypes at ARDCSS Dăbuleni

Genotype	Attack degree on 27.04.2020					Attack degree on 30.05.2020				
	F (%)	I (%)	GA (%)	Dif.	Signif.	F (%)	I (%)	GA (%)	Dif.	Signif.
Binnto	28,45	5	1,42	0,87		31,17	5	1,55	1,54	
Serafino	23,29	5	1,16	1,13	o	27,23	5	1,36	1,73	o
Inspector	27,52	6	1,65	0,64		30,09	7	2,10	0,99	
Suceveana	32,74	7	2,29	Mt.		34,42	9	3,09	Mt.	
	DL 5%			0.90					1.58	
	DL 1%			1.16					1.74	
	DL 0.1%			1.38					1.83	

In 2021, the species of pests and useful fauna identified in the culture compared to different rye genotypes are presented in Table 6

Table 6

Distribution of harmful species and useful fauna identified between April and June 2021 in comparative experience with rye genotypes at ARDCSS Dăbuleni

Variety	Genotype			
	Binnto	Serafino	Inspector	Suceveana
<i>Schizaphisgraminum</i>	x	x	x	x
<i>Eurygasterintegriceps</i>				x
<i>Melolonthamelolontha</i>	x		x	x
<i>Mayetiola destructor</i>			x	x
<i>Chloropspumilionis</i>		x	x	x
<i>Coccinellaseptempunctata</i>	x	x	x	x

Table 7

Distribution of harmful species and useful fauna identified between April and June 2021 in comparative experience with rye genotypes at ARDCSS Dăbuleni

Genotype	Attack degree on 22.04.2021					Attack degree on 25.05.2021				
	F (%)	I (%)	GA (%)	Dif.	Signif.	F (%)	I (%)	GA (%)	Dif.	Signif.
Binnto	8,12	3	0,24	0,56	o	12,42	5	0,62	1,32	o
Serafino	11,60	3	0,34	0,46		17,36	5	0,86	1,08	
Inspector	17,21	4	0,68	0,12		19,13	6	1,14	0,8	
Suceveana	20,04	4	0,80	Mt.		27,82	7	1,94	Mt.	
	DL 5%			0.47					1.12	
	DL 1%			0.61					1.32	
	DL 0.1%			0.98					1.57	

Related to the previous presented data, the main conclusion which we want to put into the light is that the cumulative effect of the two biotic stress factors (pathogens, pests), as well as the different genetic potential of each variety, led to differences of production between rye genotypes experienced in the same technological conditions at ARDCSS Dăbuleni.

CONCLUSIONS

Related to the main presented data, we can say that in the climatic conditions of sandy soil from ARDCSS Dăbuleni, the rye crop prove to be one of the adapted species for those areas with dry regime. As synthetic analysis we can highlight as follow:

- The yields level was strongly influenced by the cultivated rye genotype, the most valuable varieties proved to be Serafino, with over 4555 kg/ha in average on the two experimented years and Binnto with a production of 4358 kg/ha;
- Related to the quality of yields, the main indicators showed that the local variety Suceaveana registered highest values of those, proving its processing capacity and its baking potential;
- The results of the pest attack on rye varieties in the comparative crop indicate that there was no specific pest preference for a particular variety.
- In conclusion, in the absence of the application of insecticide treatments, the behavior of the four varieties of rye did not show significant differences in terms of degrees of attack recorded for any of the moments of determination.

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