

STUDY OF THE INFLUENCE OF INTERACTION VARIETY × YEAR × LOCATION ON WINTER WHEAT YIELD CULTIVATED IN DIFFERENT LOCATIONS IN THE PERIOD 2018-2020

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Abstract

The paper aims to analyze the influence of the interaction variety x year x location at 15 varieties of winter wheat of different origins, grown in Romania for 3 years (2018-2020) in three different locations: University of Craiova - ARDS Caracal, NARDI Fundulea and Mircea Vodă - Brăila county. The highest yield was recorded by the Sothys variety in 2020 at Caracal location - 13128 kg/ha and the lowest yield by the Avenue variety in 2020 at Mircea Vodă location - 2600 kg/ha. The analyzed data highlighted the fact that in all the years at the varieties Airbus, Alcantara, Anapurna, Koreli, Lennox, Sothys and Otilia, the yield was very low in Fundulea and Mircea Vodă compared to Caracal. In 2018, the varieties Exotic, Glosa, Izalco and Sofru presented statistically undifferentiated yields, when they were cultivated in Caracal and MirceaVodă. The results showed that the studied interaction strongly influenced the yield. Taken separately, the factors studied also influenced yield. The yields obtained in 2018 and 2020 were distinct significantly and very significantly higher than the average yield of the three years (7109 kg/ha), while the yield of the year 2019 was very significantly lower than average. The yields obtained at Fundulea and Mircea Vodă were much lower than those obtained at Caracal on average over the three years and the 15 varieties tested. The stability of yield was analyzed in terms of the coefficient of variation. The lowest values of the coefficient of variation were recorded by the varieties Lennox (11.57%) and Exotic (13.66%) - the most stable, and the highest value by the variety Izalco (21.13%) - the most unstable.

Key words: winter wheat, variety, year, location, interaction.

INTRODUCTION

The choice of variety is an important link in wheat cultivation technology, anywhere in the world (Nicolescu et al., 2007). This must take into account the interaction between pedoclimatic conditions and cultural practices (Baranger and Bonneau, 2020). Romania's accession to the European Union on January 1, 2007 led to the invasion of the market with many varieties of cereals of which nothing was known about. Until their widespread testing, they were used by farmers, who often suffered significant material damage due to ignorance of their adaptability, productivity and the quality of yield obtained through their use.

In most European countries, there is a network or an institute that deals with testing of varieties and hybrids that aims to disseminate the information obtained to the main beneficiaries - farmers and farmers' associations.

For example, in France there is the Arvalis Institute which is considered the main provider of agricultural information (www.arvalis-infos.fr).

In Romania, 2019 was the fourth year in which APPR (Romania's Association of Corn Producers) tested straw cereal crops. The testing was performed scientifically, in a system of microplots with three repetitions, having 70 varieties of wheat in 5 locations in non-irrigated conditions, one of the locations being SCDA Caracal - the non-teaching department of the University of Craiova. R.I.T.A.C. is the only Independent Field Testing and Analysis Network, scientifically developed in collaboration with service providers, research institutes and in direct partnership with seed companies and that have commercial activity in Romania. The testing followed and continues to follow, first of all, the levels of productivity and humidity at

harvest, but also the other aspects of crop management. The tests are performed in cooperation with seed companies or independent testing companies, and the seeds used for testing are prepared and coded by the APPR technical team (APPR Catalogue, 2020). Farmers are urged to check the results of the APPR in the area most similar in terms of soil and climate to the area of cultivation in which they operate.

Wheat is one of the main plants consumed worldwide and one of the main sources of calories and protein. Approximately 82-85% of the world's population depends on wheat to provide the necessary calories and protein (Chaves et al., 2013).

It is frequently grown in temperate areas, with drought occurring in early summer and limiting grain yield, as stress corresponds to the grain filling period at most cereals, including wheat (Frorgóné, 2009).

Also, the variation of production and quality is influenced by the agrotechnical measures and the genetic characteristics of the varieties or hybrids, both in the case of wheat and other species (Cotuna et al., 2015; Paraschivu et al., 2015; Partal and Paraschivu, 2020; Paraschivu et al., 2020).

The results obtained in wheat testing are greatly influenced by climatic conditions. Half of the area where wheat is cultivated in developed countries and over 70% of the area in developing countries suffers from long periods of drought. Drought can occur throughout the growing season of the crop in areas with low rainfall. Plants that are exposed to water and heat stress reduce their yield all over the world. The combined effect of the two on yield is stronger than the effect of each stress at a time (Dreesen et al., 2012; Rollins et al., 2013). Although Romania's climate is generally characterized as "moderately continental", over the recent years there have been extremely large variations, both in the total amount of rainfall from one year to another and in their distribution during the year, which determines water deficits (often associated with heat) frequent during the vegetation of agricultural crops, in almost all areas of the country (Munial and Dhanda, 2005; Păunescu Aida, 2017).

The response of plants to drought is also influenced by the intensity, duration and frequency of stress, as well as by the plant-soil-atmosphere interaction. Many morphological and physiological strategies have been identified in response to water deficiency, ranging from avoiding dehydration to tolerance to dehydration (Carolina et al., 2012). Research on the influence of water stress on plants (Ciulu, 2005; Păunescu and Boghici, 2008, Boghici, 2008; Urechean et al., 2011; Borleanu, 2012; Păunescu, 2017) was based on numerous observations made in the Oltenia county, with the purpose of identifying drought-resistant genotypes to use in breeding programs.

This paper was made possible by the concept of "open science", which makes available to researchers, on the one hand, and users of the research results, on the other hand, data to which there is open access.

MATERIALS AND METHODS

The paper aims to analyze the influence of the variety x year x location interaction at 15 varieties of winter wheat of different origins (factor A), grown in Romania for 3 years (2018-2020) (factor B) in three different locations (factor C): Caracal (University of Craiova - non-teaching department SCDA Caracal - data from the experience field), Fundulea (INCDA Fundulea - data published in the APPR catalogue) and Mircea Vodă -jud. Brăila (data published in the APPR catalogue).

The tested varieties entered the network following the chain: Limagrain (Airbus, Alcantara, Anapurna, Avenue), Caussade (Izalco, Sofru, Sosthene, Sothys, Solveig), INCDA Fundulea (Glosa, Otilia), Ciproma (Koreli), RWA (Lennox), APPR (Exotic and Silverio).

The pedoclimatic conditions available at SCDA Caracal are favorable for the cultivation of hail cereals, as they possess a soil of baticaric cambic chernozem type with a high potential for fertility and a good yield capacity. In general, chernozems do not pose any particular problem in terms of cultivation with a comprehensive assortment of agricultural plants (Roșculete et al., 2019).

The varieties were tested in microplots of 7 m² in 3 repetitions, in each location and in each of

the years under a coded name that was revealed after the delivery of the results. For each location and for each year, the technology used is specified in the APPR catalogs (www.apprs.ro).

Climatic conditions were very differentiated depending on the year of experimentation and location. In Caracal, the year 2020 was an extremely favorable year for wheat cultivation, a fact reflected in the very high yields obtained. In MirceaVoda, 2020 was considered the driest year in the last 60 years.

The yields obtained were calculated at STAS humidity (14%) and reported in kg / ha. The calculation of the limit differences was performed by the program of plots subdivided with 3 factors.

RESULTS AND DISCUSSIONS

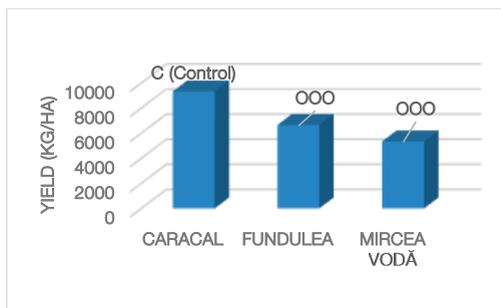
The highest yield was recorded for the Sothys variety in 2020 in Caracal - 13128 kg/ha and the lowest yield for the Avenue variety in 2020 in Mircea Vodă - 2600 kg/ha. All tested varieties obtained the lowest yields in Mircea Voda in 2020 and the highest yields in Caracal in the same year. This highlights the particular importance of climatic factors. Excessive drought in the southeast of the country and extremely favorable conditions in the southwest of the country (Oltenia County), both recorded in 2020, were the basis for the polarization of these results.

Taken separately, the factors studied (location, year, variety) also influenced yield.

The yields obtained in Fundulea and Mircea Vodă was very significantly lower than those obtained in Caracal on average over the three years and for the 15 tested varieties (Figure 1).

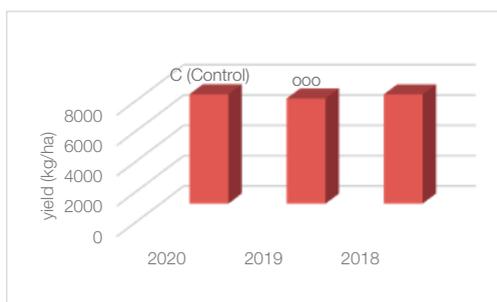
The yields obtained in 2018 and 2020 were distinctly significant and significantly higher than the average yield of the three years (7109 kg / ha), while the yield of 2019 was significantly lower than average.

Taking as control 2020, the year with the highest yield, it was observed that only 2019 was significantly inferior in terms of yield, while 2018 was at the same level as 2020 (Figure 2).



LSD 5% = 52 kg/ha; LSD 1% = 69 kg/ha; LSD 0.1% = 90 kg/ha

Figure 1. Yields of varieties tested according to the location (average 2018-2020)



LSD 5% = 62 kg/ha; LSD 1% = 88 kg/ha; LSD 0.1% = 110 kg/ha

Figure 2. Yields of varieties tested according to the year of experimentation (average 2018-2020)

The most productive variety, on average for 3 years and 3 locations was Sothys (7730 kg/ha) and the least productive was Izalco (6442 kg/ha). All tested varieties were superior to the control variety Glosa, with statistical assurance, except for the Avenue variety which was at control level and the Izalco variety which was significantly inferior to the control (Table 1). When analyzing the lowest yields obtained, all those obtained in MirceaVoda location in 2020, varieties Airbus, Alcantara, Avenue, Izalco, Koreli, Sofru, Sosthene, Otilia, were inferior with statistical assurance to the control variety Glosa.

However, the varieties Anapurna, Exotic, Lennox, Silverio and Sothys, even under these harsh conditions were significantly superior to the Glosa variety (Table 2).

Table 1. Yield of tested varieties - average of the three locations (Caracal, Fundulea, MirceaVodă) and three years (2018-2020)

Variety	Yield (kg/ha)	Diff.	Significance
GLOSA	6809	0	
AIRBUS	6973	164	*
ALCANTARA	7170	361	***
ANAPURNA	7285	476	***
AVENUE	6845	36	
EXOTIC	7261	452	***
IZALCO	6442	-367	ooo
KORELI	6949	140	*
LENNOX	7178	369	***
SILVERIO	7321	512	***
SOFRU	7174	365	***
SOLVEIG	7241	432	***
SOSTHENE	7241	432	***
SOTHYS	7730	921	***
OTILIA	7010	201	**

LSD 5% = 132 kg/ha; LSD 1% = 177 kg/ha; LSD 0.1%=236 kg/ha

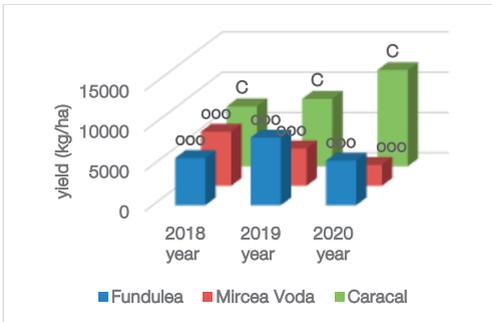
Table 2. Minimum yield of tested varieties (location MirceaVodă in the driest year -2020)

Variety	Yield (kg/ha)	Diff.	Significance
GLOSA	3597	0	
AIRBUS	3038	-559	ooo
ALCANTARA	2647	-950	ooo
ANAPURNA	4220	623	***
AVENUE	2600	-997	ooo
EXOTIC	4591	994	***
IZALCO	2800	-797	ooo
KORELI	3411	-186	oo
LENNOX	4301	704	***
SILVERIO	3897	300	***
SOFRU	3394	-203	oo
SOLVEIG	3474	-123	
SOSTHENE	2891	-706	ooo
SOTHYS	4754	1157	***
OTILIA	3264	-333	ooo

LSD 5% = 132 kg/ha; LSD 1% = 177 kg/ha; LSD 0.1% = 236 kg/ha

To highlight the variety x year x location interaction and its influence on yield, two averages of factor C (location) were compared to the same factor A (variety) and to the same factor B (year).

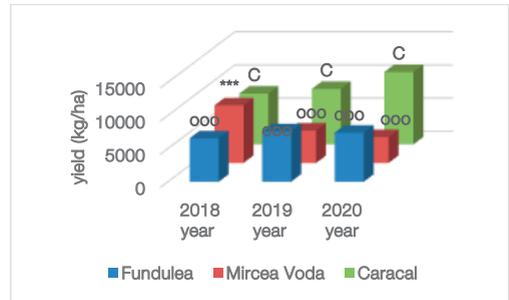
The analyzed data highlighted the fact that in all the years for varieties Airbus (Figure 3), Alcantara, Anapurna, Koreli, Lennox, Sothys and Otilia, the yields were very low in Fundulea and Mircea Vodă compared to Caracal.



LSD 5% = 353 kg/ha; LSD 1% = 466 kg/ha; LSD 0,1% = 600 kg/ha

Figure 3. Behavior of the Airbus variety in 3 locations (average 2018-2020)

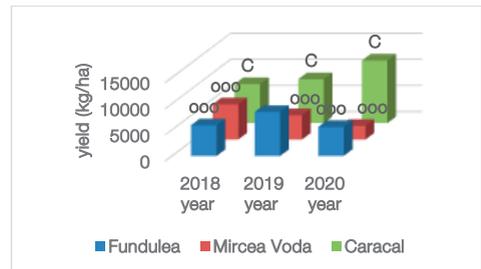
Only the varieties Silverio (Figure 4) and Solveig had significant yield increases for MirceaVodă compared to Caracal, in 2018.



LSD 5% = 353 kg/ha; LSD 1% = 466 kg/ha; LSD 0,1% = 600 kg/ha

Figure 4. Behavior of the Silverio variety in 3 locations (average 2018-2020)

In 2019, the Avenue variety (Figure 5), presented a statistically undifferentiated yield, when it was cultivated at Fundulea in relation to Caracal.



LSD5% = 353 kg/ha; LSD 1% = 466 kg/ha; LSD 0.1% = 600 kg/ha

Figure 5. Behavior of the Avenue variety in 3 locations (average 2018-2020)

The varieties Exotic, Glosa, Izalco, Sofru and Sosthene presented statistically undifferentiated yields, when they were cultivated at MirceaVodă in 2019, in relation to Caracal.

The results showed that the studied interaction strongly influenced the yield.

On average over the three years, the varieties studied, depending on the location, had very differentiated yields.

The varieties Alcantara, Avenue and Otilia had minimum average yields below 5000 kg/ha (4958 kg/ha, 4655 kg/ha, respectively 4997 kg/ha) given maximum average yields over 9000 kg/ha (9483 kg/ha, 9267 kg/ha respectively 9326 kg/ha).

The Glosa and Izalco varieties also recorded minimum average yields below 5000 kg / ha but the maximum average yields did not exceed 9000 kg / ha. The limits were 4967-8758 kg/ ha for Glosa and 4455-8508 kg/ha for Izalco. Most varieties had values of minimum average yield over 5000 kg / ha and maximum average yields over 9000 kg / ha - Airbus (5241-9483 kg/ha); Anapurna (5618 kg/ha); Exotic (5964-9152 kg / ha); Koreli (5366-9106 kg/ha); Sulfur (5292-9468 kg / ha); Solveig (5402-9517 kg / ha); Sosthene (5499-9457 kg /ha).

The following varieties had a distinct behavior: Silverio with a minimum average yield over 5000 kg / ha but a maximum average yield over 9000 kg/ha (4958-9571 kg/ha); Lennox (minimum average yield of 6000 kg/ha and maximum of 9130 kg/ha); Sothys variety (minimum average yield of 5918 kg/ha and maximum of 10499 kg/ha). For all these varieties, without the exception of the average yield for three years with the minimum value, it was obtained at Mircea Vodă and the maximum average yield at Caracal.

The stability of yield was analyzed in terms of the coefficient of variability. It was calculated, eliminating the extreme values (Caracal and Mircea Voda locations in 2020). It was estimated that in a set of three years the probability of finding the worst year in history for one location and the best for another location in the same year is very small. The lowest values of the variability coefficient were recorded by the varieties Lennox (11.57%) and Exotic (13.66%) - the most stable, and the highest value by the variety Izalco (21.13 %) - the most unstable (Figure 6).

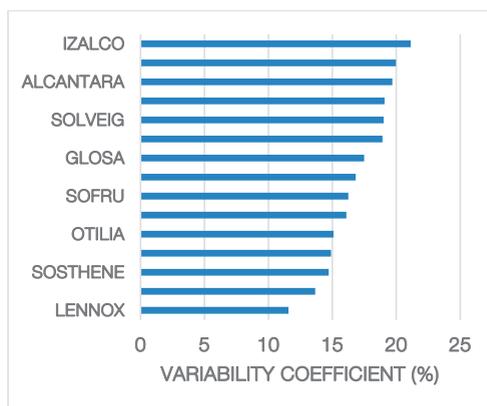


Figure 6. Variability coefficient for the tested varieties (average 2018-2020)

CONCLUSIONS

The choice of variety is an important link in wheat cultivation technology, anywhere in the world.

The highest yield was recorded by the Sothys variety in 2020 at Caracal location - 13128 kg / ha and the lowest yield by the Avenue variety in 2020 at MirceaVodă location - 2600 kg / ha. All tested varieties obtained the lowest yields at MirceaVoda in 2020 and the highest yields at Caracal in the same year. This highlights the particular importance of climatic factors. Excessive drought in the southeast of the country and extremely favorable conditions in the southwest of the country (Oltenia County), both recorded in 2020, were the basis for the polarization of these results.

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ACKNOWLEDGEMENTS

We thank the members of the APPR team who put their trust in us by co-opting us into the R.I.T.A.C. network ever since its very beginning.

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