Research Journal of Agricultural Science, 53 (3), 2021

STUDY ON THE INFLUENCE OF THE YIELD TRAITS ON THE YIELD CAPACITY OF SOME TRITICALE VARIETIES

Gabriela GORINOIU[1], Karina Roberta SUHAI[1], Georgiana NEGRUȚ[1], Alina AGAPIE[1], Alina RUJA[1], Giancarla VELICEVICI[2]
[1]Agricultural Resarch and Development Station Lovrin, 200, Lovrin, 307250, Romania
[2]Banat's University of Agricultural Science and Veterinary Medicine "King Mihail I of Romania'' from Timisoara, 300645, 119, Calea Aradului, Timisoara, Romania
Corresponding author: karina.suhai@scdalovrin.com

Abstract. *Triticale is the first synthetic cereal, the result of the cross between wheat (Triticum sp.) and rye (Secale cereale L.) being one of the greatest achivements obtained by man and a hardy crop with prolific growth and adaptation to various enviromental conditions that has been grown worldwide mainly for human food consumption and animal feed. The researches were performed in Agricultural Research-Development Station Lovrin during 2019 year, which is located in the northwest side of Banat, at almost equal distances from the cities of Timisoara and Arad (45-50 km). Biological material was composed of 10 varieties of autumn triticale (Plai, Titan, Stil, Haiduc, Negoiu, Pisc, Tulnic, Cascador, Utrifun and Vifor), that were created at National Agricultural Research and Development Institute Fundulea. In general, the studied varieties realise productions close to the average experience with insignificant differences. The amplitude of variability in the 10 triticale genotypes was 1133 kg/ha. The largest increases in production compared to the average experience was recorded in the varieties Plai (497 kg/ha) and Stil (330 kg/ha), without reaching the level of statistical assurance. According to the test of multiple comparisons, it results that any genotypes do it show significant differences in terms of triticale production, but are part of the same homogenity class A. The variation of production in the 10 triticale varieties under study was between 4177 kg/ha and 5300 kg/ha . The analysis of the yield was made by the perspective of yield elements (plant heigh, number of spike/m ^{2} , spike lenght, number of spikelets in spike, spike weight, grain weight and number of grains in spike) and how they influence the yield capacity of the autumn triticale varieties.*

Keywords*: triticale, yield capacity, yield traits*

INTRODUCTION

This study evaluated the diversity of 10 autumn triticale varieties for some plant yield traits and the possibilities of using them in future breeding programs (GORINOIU AND SUHAI, 2020).

Triticale is the first synthetic cereal, the result of the cross between wheat (*Triticum sp.)* and rye (*Secale cereale* L.) being one of the greatest achievements obtained by man, with a complex genetic trait such as yield capacity, witch is transmitted predominantly recessively or intermediate, depending on the variety, productivity elements and influencing factors (POTLOG ET AL.,1982; MERGOUM ET AL.,2019; GORINOIU ET AL, 2021).

The initial main goal for breeders was to create triticale as a new cereal crop that would combine the superior agro-morphological and end-use quality characteristics of wheat with the adaptability, vigor, and resistance or tolerance of rye .With this ability it makes this plant a viable alternative crop, especially in nutrient-deficient environments with various biotic and abiotic stress factors (MERGOUM ET AL., 2019; JESSOP, 1996; BLUM, 2014; RANDHAWA ET AL., 2015; LIU ET AL., 2017).

Triticale is a hardy crop with prolific growth and adaptation to various environmental conditions, grown worldwide mainly for human food consumption and animal feed, as well as forage for livestock in the form of grazing, silage, fodder, green-feed and hay (FURMAN ET AL., 1997; DENNETT ET AL., 2013). Additionally, triticale is grown for bio-energy production and is gaining popularity as a cover crop to improve soil health and reduce nutrient leaching and soil erodation. Although grain quality of triticale possesses a good level of resistance to multiple diseases and pests and multiple genes have been successfully transferred to wheat from triticale that combines the hardiness and nutrient-use efficiency of rye and nutritional qualities and high grain yield of wheat (MERGOUM ET AL.,2019; MERGOUM ET AL., 2004; HABTAMU A. ET AL, 2018; FURMAN ET AL., 1997; DENNETT ET AL., 2013).

This crop is adapted well to a wider range of environments where wheat is grown; additionsly, under stress conditions, triticale cultivars produced greater biomass and grain yield than wheat and are comparable to rye (MERGOUM AND MACPHERSON, 2004; KAVANAGH AND HALL, 2015).

The adaptation of triticale was found to be excellent under limited water supply conditions, but its performance is good when is produced under good soil fertility and irrigation (BLUM 2014; MERGOUM ET AL. 2004). Abiotic stresses, such as drought, cold, salinity, mineral toxicity and deficiency, are a problem in many cereal crop production. Under these abiotic stress conditions, triticale was found to perform better compared to the other cereal crops (BLUM 2014; MERGOUM ET AL. 2004).

MATERIAL AND METHODS

The researches were performed during 2019 year in Agricultural Research-Development Station Lovrin, which is located in the northwest side of Banat, at an equal distance from the cities of Timisoara and Arad (45-50 km)(PUȘCĂ AND ȘANDRU, 2002).

The territory of the station is located in the forest steppe region, with a high level of underground water and various parent rocks, which created a diverse pedological basis. The chernozem and the iambic chernozem dominate, covering 97% of the area, that is characterized by weakly gelled, weakly alkalized, semicarbonate, basis pH (PUȘCĂ AND ȘANDRU, 2002).

Biological material was composed by 10 varieties of autumn triticale (Plai, Titan, Stil, Haiduc, Negoiu, Pisc, Tulnic, Cascador, Utrifun, Vifor), that were created at National Agricultural Research and Development Institute Fundulea. The experiment was organized using a randomized block design with three replications, the surface of plots being 7 m^2. From each plot, 25 randomly selected plants were harvested and evaluated for the yield traits.

The analysis of the yield was made from the perspective of the yield elements (plant heigh, number of spike/m^2, spike lenght, number of spikelets in spike, spike weight, grain weight and number of grains in spike) and how they influence the yield capacity of the autumn triticale varieties.

RESULTS AND DISCUSSIONS

In general, the varieties studied realise production close to the experimental average, with insignificant differences (table 1).

Table 1

The influence of genotypes on yield triticale varieties

Number	Variety	Yield		Difference from the mean (Kg/ha)	Probability value
		kg/ha	(%)		
1	Plai	5300	110	497,00	-
2	Stil	5133	107	330,00	-
3	Utrifun	5033	105	230,00	-
4	Pisc	5033	105	230,00	-

5	Tulnic	5000	104	197,00	-
6	Haiduc	4967	103	164,00	-
Experimental average		**4803**	**100**	**0,00**	**Control**
7	Vifor	4500	94	-303,00	-
8	Cascador	4467	93	-336,00	-
9	Negoiu	4433	92	-370,00	-
10	Titan	4167	87	-636,00	-

$LSD_{5\%}$=1207.75 $LSD_{1\%}$=1641.15 $LSD_{0.1\%}$=2224.80

The amplitude of variability between the first and latest genotyp was 1133 kg/ha. The largest increases in production compared to the experimental average were recorded in the varieties Plai (497 kg/ha) and Stil (330 kg/ha), without reaching the level of statistical assurance.

Table 2

Analisys of variance for the yield of triticale varieties studied

Source	Degrees of freedom	The sum of squares	Mean squares	F ratio	Probability value
Condition	2	468666.667	234333.333	0.4210	
Factor A	9	3823000.000	424777.778	0.7632	-
Error	18	10018000.000	556555.556		
Total	29	14309666.667			

Coefficient of variation:15.53%

The analysis of variance (Table 2) indicates the fact that the production differences between the varieties under study were due exclusively to their genetic potential in the conditions of a very low influence of the environmental conditions.

Table 3

Duncan test

Original data				**Sorted data**			
No	**Factor A (variety)**	**Yield kg/ha**		**No**	**Factor A (variety)**	**Yield kg/ha**	
1	Plai	5300	a	1	Plai	5300	a
2	Titan	4167	a	3	Stil	5133	a
3	Stil	5133	a	9	Utrifun	5033	a
4	Haiduc	4967	a	6	Pisc	5033	a
5	Negoiu	4433	a	7	Tulnic	5000	a
6	Pisc	5033	a	4	Haiduc	4967	a
7	Tulnic	5000	a	10	Vifor	4500	a
8	Cascador	4467	a	8	Cascador	4467	a
9	Utrifun	5033	a	5	Negoiu	4433	a
10	Vifor	4500	a	2	Titan	4167	a

According to the test of multiple comparisons, it results that the 10 genotypes studied do not show significant differences in terms of triticale production but are part of the same homogeneity class A. The variation of production in the 10 study triticale varieties was between 4177 kg/ha and 5300 kg/ha [C_{10}^2 = 45 comparisons].

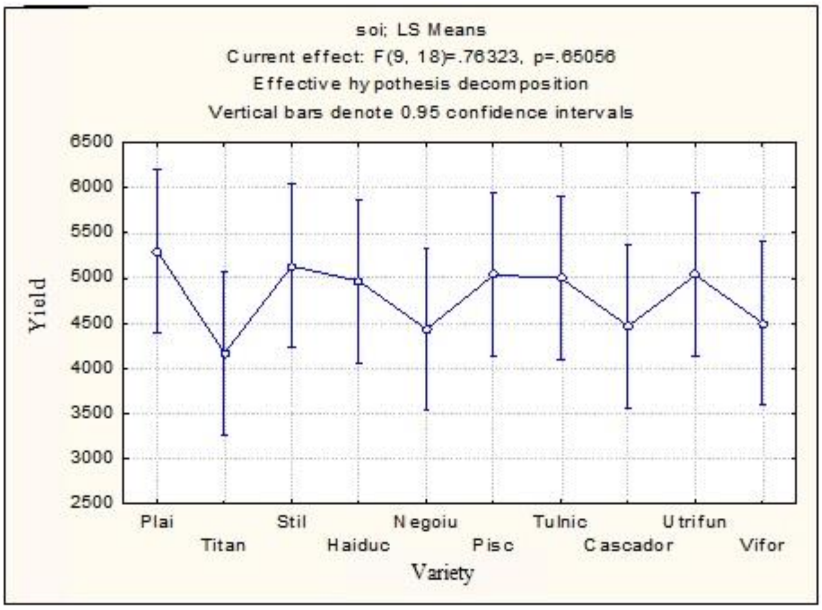

Fig. 1. Yield varation in the 10 triticale varieties studied

According to the figure 1, the probability for the F test is p = 0.65 [p>0.05], which shows that between the varieties of triticale studied there are no significant differences, in terms of production.

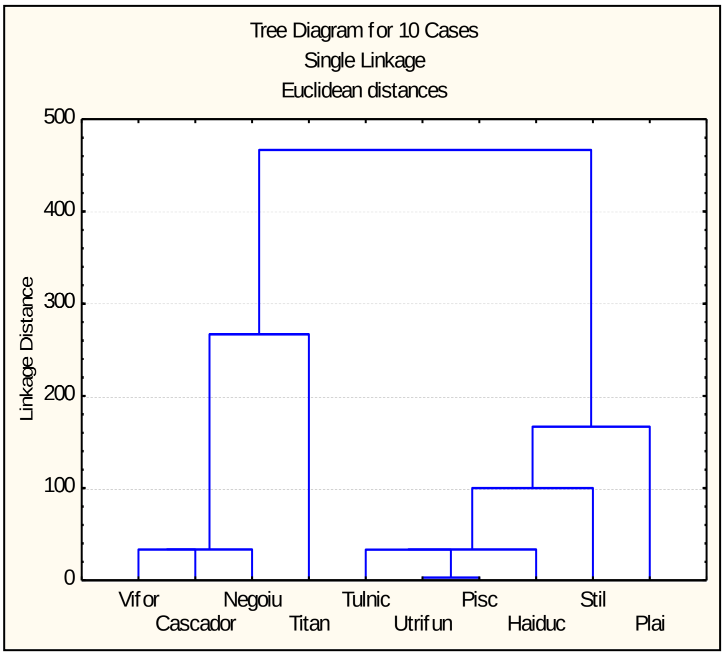

Fig. 2. UPGMA clustering of triticale varieties

Considering the phenotypic similarity between the 10 varieties of triticale, the dendrogram from figure 2 was made by the cluster mean method, from which 2 clusters resulted. The first cluster includes the varieties: Utrifun, Pisc, Tulnic, Haiduc, Stil, Plai, all with similar production. The second cluster includes the varieties: Negoiu, Cascador, Vifor, and Titan, that has the lowest production compared to the other varieties.

According to this dendogram (Figure 2) of the 10 genotypes, it results that both Utrifun and Pisc varieties obtained similar production (5033 kg/ha). Following the Tulnic and Haiduc variety, to which the Stil and Plai varieties are attached.

Table 4

Yield traits of the triticale varieties of studied

Number	**Variety**	**Plant height (cm)**	**Number of spikes/ m^2**	**Spike lenght (cm)**	**Number of spikelets/ spike**	**Spike weight (g)**	**Grain weight/spike (g)**	**Number of grains/ spike**
1	Plai	123	492	12	78	3,08	2,84	66
2	Titan	120	480	10	72	3,06	2,06	44
3	Stil	110	488	10	72	4,28	2,99	64
4	Haiduc	100	492	11	84	4,08	2,79	61
5	Negoiu	100	496	11	90	3,79	2,82	50
6	Pisc	110	432	10	84	3,77	2,65	56
7	Tulnic	102	432	10	90	3,88	2,94	58
8	Cascador	87	340	10	72	3,69	2,51	65
9	Utrifun	85	376	9	66	3,10	2,06	48
10	Vifor	88	368	11	84	3,31	2,82	71

Table 5

Statistical data for triticale yield traits studied

Yield elements	**Valid N**	**Mean**	**Minimum**	**Maximum**	**Variance**	**Std.Dev.**	**Standard Error**
Plant height (cm)	10	102.5000	85.0000	123.0000	178.722	13.36870	4.22756
Number of spike/m^2	10	439.6000	340.0000	496.0000	3539.378	59.49267	18.81323
Spike lenght (cm)	10	10.4000	9.0000	12.0000	0.711	0.84327	0.26667
Number of spikelets / spike	10	79.2000	66.0000	90.0000	70.400	8.39047	2.65330
Spike weight (g)	10	3.6040	3.0600	4.2800	0.193	0.43973	0.13905
Grain weight/spike (g)	10	2.6480	2.0600	2.9900	0.114	0.33813	0.10692
Number of grains/ spike	10	58.3000	44.0000	71.0000	76.678	8.75658	2.76908

The height of the plants for the triticale varieties under study achieved values of this character between 85 cm for the Utrifun variety and 123 cm for the Plai variety, an amplitude of variation of 38 cm.

The number of ears ranged from 340 plants / m^2 in case of Cascador variety and 496 plants / m^2 in case ofNegoiu variety, with an average of 439.6 plants / m^2 of the all 10 genotypes studied, with an amplitude of variation of 156 plants / m^2.

The length of the ear in the triticale varieties studied showed values of this character between 9 cm in the variety Utrifun and 12 cm in the variety Plai, with an amplitude of variation of 3 cm.

The number of ear spikelets in the triticale varieties under study ranged between 66 ear spikelets in the Utrifun variety and 90 ear spikelets in the Tulnic and Negoiu varieties, with an amplitude of variation of 24 ear spikelets.

The weight of the ear in the triticale varieties under study achieved values of this character between 3.06 grams for the Titan variety and 4.28 grams for the Stil variety, with an amplitude of variation of 1.02 grams.

The weight of grains per ear in the triticale genotypes recorded values under study between 2.06 grams for the Titan variety and 2.99 grams for the Stil variety, with an amplitude of variation of 0.93 grams.

The number of ears in the triticale varieties studied showed values of this character between 44 grains in the Titan variety and 71 grains in the Vifor variety, with an amplitude of variation of 27 grains in the ear.

Table 6

Correlation coefficient values between yield traits of triticale varieties

Yield elements	**Plant height (cm)**	**Number of spike/m^2**	**Spike lenght (cm)**	**Number of spikelets / spike**	**Spike weight (g)**	**Grain weight/ spike (g)**	**Number of grains / spike**
Plant height (cm)	1.00	**0.77**	0.38	0.06	-0.08	0.13	-0.15
Number of spike/m^2	0.77	1.00	0.46	0.28	0.25	0.31	-0.24
Spike lenght (cm)	0.38	0.46	1.00	0.49	-0.05	0.57	0.49
Number of spikelets in spike	0.06	0.28	0.49	1.00	0.37	**0.66**	0.17
Spike weight (g)	-0.08	0.25	-0.05	0.37	1.00	**0.65**	0.26
Grain weight/spike (g)	0.13	0.31	0.57	0.66	0.65	1.00	0.**68**
Number of grains in spike	-0.15	-0.24	0.49	0.17	0.26	0.68	1.00

Analyzing the correlation matrix (Table 5) it results that we have positive linear correlations ensured statistically between the weight of the grains in the ear and the number of spikelets in the ear, the correlation coefficient being 0.66; between the weight of the ear and the weight of the grains in the ear, the correlation coefficient being 0.65; between the height of the plant and the number of ears per square meter, the correlation coefficient being 0.77 and between the weight of the grains in the ear and the number of grains in the ear, the correlation coefficient being 0.68.

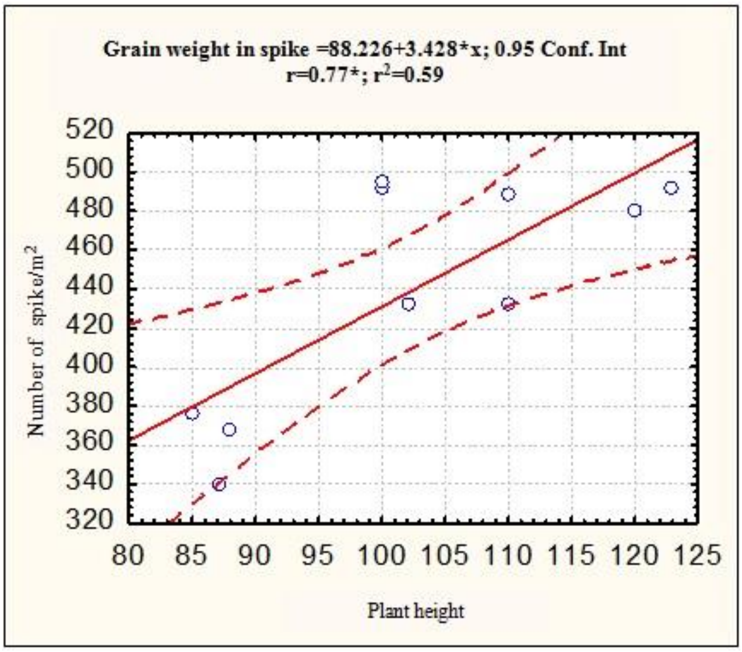

Fig. 3. The correlation coefficient between the plant height and the number of ears/m2

As can be seen in this graph (Figure 3) there is a positive correlation between plant height and the number of ears per square meter, by increasing the plant height by 1 cm and increasing the number of ears/sqm.

The contribution of the height influenced the number of ears per square meter in the proportion of 59%, according to the coefficient of determination (r^2=0,59).

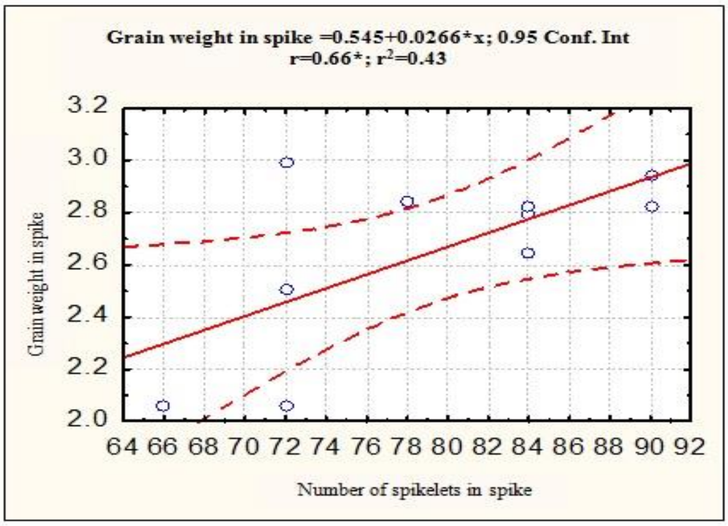

Fig. 4. Correlation coefficient between the number of spikelets in the spike and the weight of the grains in the spike

As can be seen from the Figure 4, there is a positive correlation between the number of spikelets in the ear and the weight of the grains. The number of spikelets in the ear and weight of the grains influenced the weight of the grains by 43% according to the coefficient of determination (r^2=0,43).

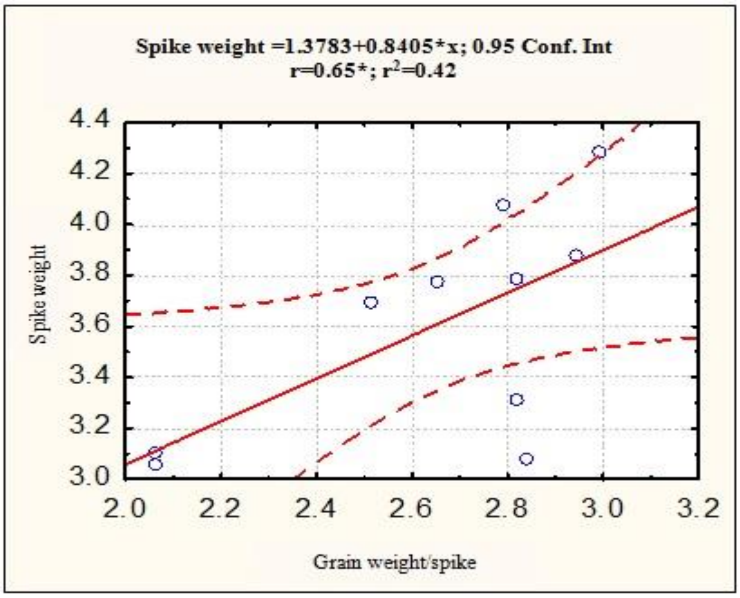

Fig. 5. The correlation coefficient between the weight of the grains in the ear and the weight of the ear

There is also a positive linear correlation between the weight of the grains in the ear and the weight of the ear. The weight of the grains was influenced in the proportion of 42% by the weight of the ear, according to the coefficient of determination (r^2 = 0.42).

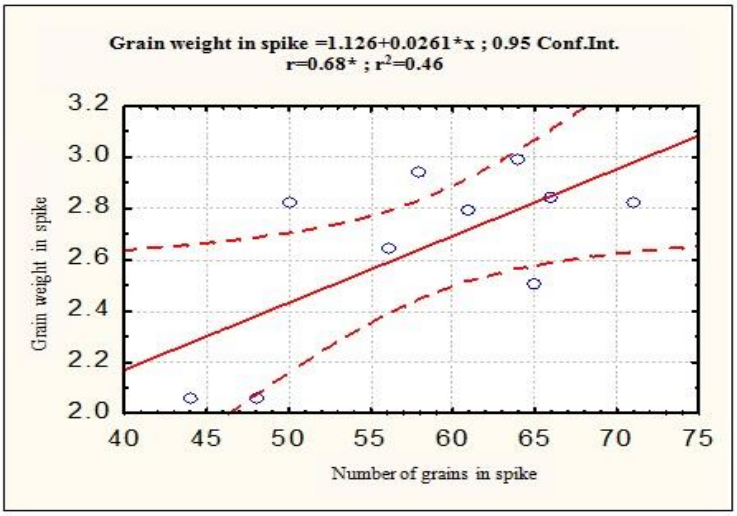

Fig. 6. The correlation coefficient between the weight of the grains in the ear and the number of grains in the ear

As can be seen in the figure 6 regarding the number of grains and the weight of the grains, there is a positive linear correlation, the number of grains positively influenced the 46% increase in grain weight, according to the coefficient of determination (r^2= 0.46).

CONCLUSIONS

Given the values observed from biometric measurements, it can be concluded that the increase in productivity elements (plant height, number of plants / m^2, length of spike, number of spikelets in spike, weight of spike, weight of grains in spike and number of grains from ear) implicitly increases grain yield per hectare.

We can conclude that the orientation of the selection in the direction of increasing the productivity elements (ear length, number of ears in ear, weight of grains in ear, number of grains in ear) can ensure an improvement of ear productivity, thus positively influencing grain production/hectare.

BIBLIOGRAPHY

AYALEW H., KUMSSA T.T., BUTLER T.J., AND MA X.F. , 2018 – Triticale Improvement for Forage and Cover Crop Uses in the Southern Great Plains of the United States, Front. Plant Sci. 9:1130.

BLUM, A., 2014 – The abiotic stress response and adaptation of triticale - A review. Cereal Res. Commun., 42, 359–375. doi: 10.1556/CRC.42.2014.3.1.

DENNETT A. ., COOPER K. V., AND TRETHOWAN R. M., 2013 – The genotypic and phenotypic interaction of wheat and rye storage proteins in primary triticale, Euphytica 194, 235–242.

FURMAN B. J., QUALSET C. O., SKOVMAND B., HEATON J. H., CORKE H., AND WESENBERG D. M., 1997 – Characterization and analysis of North American triticale genetic resources, Crop Sci. 37.

GORINOIU G. AND SUHAI K, 2020. –Research regarding the influence of years of cultivation on production capacity of some triticale varieties, Life Science and Sustainable Development, Vol.1, No.2, pp 8-11.

GORINOIU G., SUHAI K., VELICEVICI G., PETOLESCU C., 2021 – Evaluation of variability for some components of plant yield in winter wheat, Life Science and Sustainable Development, Vol.2, No.1, pp 41-47.

JESSOP R.S., 1996 – Stress tolerance in newer triticale compared to other cereals, in Triticale: Today and Tomorrow, Developments in Plant Breeding, Vol. 5, eds H. Guedes-Pinto, N. Darvey, and V. P. Carnide (Dordrecht: Springer), 419–427.

KAVANAGH V., AND HALL L., 2015 – Biology and biosafety, in Triticale, ed. F. Eudes (Berlin: Springer), pp 3–13.

LIU, W., MAURER, H. P., LEISER, W. L., TUCKER, M. R., WEISSMANN, S., HAHN, V., ET AL. 2017 – Potential for marker-assisted simultaneous improvement of grain and biomass yield in triticale, Bioenergy Res. 10, 449–455, doi: 10.1007/s12155-016-9809-0.

MERGOUM M., AND MACPHERSON, H. G., 2004 – Triticale Improvement and Production., Rome: Food & Agriculture Organization.

MERGOUM M., PFEIFFER W.H., PENA R.J., 2004 – Triticale crop improvement: the CIMMYT programme. In: Mergoum M., Gomez-Macpherson H. - Triticale improvement and production, FAO Plant production and protection paper no. 179, FAO, Rome, pp 11–2.

MERGOUM M., SINGH P., PENA R., LOZANO-DEL RÍO A., COOPER K., SALMON D., ET AL.,2009 – Triticale: a “new” crop with old challenges, in Cereals., pp 267–287.

MERGOUM MOHAMED, SAPKOTA SURAJ, EIDOLIEFY AHMED, NARAGHI SEPEHR, PIRSEYEDI SEYEDMOSTAFA ABUHAMMAD WESAM, 2019 – Triticale (X Triticosecale Wittmack) Breeding, Research Gate.

PUȘCĂ I. AND ȘANDRU I.D., 2002 – Agricultural Research Station Lovrin, Editura Brumar, Timișoara, ISBN 973-8057-83-3.

RANDHAWA H., BONA L., AND GRAF R.,2015 – Triticale breeding progress and prospect, in Triticale, ed. F. Eudes (New York, NY: Springer), pp 15–32.