THE INFLUENCE OF VARIETIES, FOLIAR FERTILIZATION AND BIOSTIMULATOR ON TRITICALE PRODUCTION IN NORD-WESTERN ROMANIA

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Abstract. *Triticale (Triticosecale Wittmack) are a hybrid created by man by crossing two species, namely Triticum aestivum and Secale cereale. They adopted the good ability to adapt to climatic conditions, high resistance to plant diseases and the utilization of low fertility soils from Secale cereale and the high production capacity and high protein content from Triticum aestivum. In general, triticale is used in feeding animals in different forms (concentrated fodder, straw, silage, pasture), especially in feeding pigs and birds. More recently, it was discovered that this plant has several properties, being similar to wheat. It is also used in the bioethanol, alcohol, cellulose industry and even in aquaculture. Fertilization is one of the most important in the cultivation technology of this plant, ensuring production increases both quantitatively and qualitatively. The experiment is located in the year 2021-2022, in northwest Romania, in Livada, Satu Mare county on a typical preluvosol with an acidic reaction, with a pH of 5.19 in the arable layer. It is placed after the method of subdivided plots, being an experiment with three experimental factors, of which only two factors were studied, the variety and fertilization and their influence on triticale production. Due to the severe climatic conditions, with high temperatures and lack of precipitation, additional fertilization with foliar fertilizer and biostimulator recorded significantly negative differences in production. It was found that the best fertilization option during that testing period was the basic fertilization of the soil with complex fertilizers in the fall and nitrogen-based fertilizers in the springtime.*

Key words: *triticale, experiment, technology, fertilization*

INTRODUCTION

Triticale (*Triticosecale* Wittmack), part of the *Poaceae* family, are the result of human hybridization between the types *Triticum sativium* and *Secale cereale*. They inherited from rye the high capacity to adapt to climatic conditions and high resistance to drought and frost, and from wheat the high protein content and high production capacity (Muntean et al., 2014, Glamoclija et al., 2018). The first crossing between wheat and rye, according to Saprai et al. (1972), was made by the Scot Alexander Stephen Wilson (1827-1893) in 1875, unfortunately the plant resulting from the crossing of the two species was sterile, because the parents did not have the same number of chromosomes (Glamoclija et al., 2018). Thanks to the genetic progress of the last decades, triticale has become one of the most important cereals in the world (Arseniuk, 1996). The intensive period of triticale crossing was in the early 1950s by Árpád Kiss, in Hungary. The center of triticale growth in Europe at the moment is Poland (Pauk et al., 2003). In the 90s, due to their special resistance to drought, they were introduced in the semi-arid areas of Morocco, and together with a fertilization based on nitrogen and phosphorus, they surpassed the cereals in the area in terms of production (Mergorum et al., 1992).

From the point of view of chemical composition, triticale is more similar to wheat than to rye. They have a higher lysine content than wheat, (this being the limiting amino acid in cereals), the lysine content being 0.33–0.71% (Fraś, 2016), (Zhu, 2018). Protein content results differs by variety and author. According to Pettersson and Aman (1987), triticale contains 11.7% crude protein, according to Anna Fraś et al., (2016), they contain between 11.4-14%. Triticale has been shown to have a protein content between 11 and 14% (Heger and Eggum, 1991). The energy value of triticale is 3603 kcal/kg, higher than that of barley (3375 kcal/kg) but lower than that of wheat (3709 kcal/kg) and corn (3796 kcal/kg) (Starodub, 2008). The main purpose of triticale is to feed animals, especially pigs. These are used in different forms, such as concentrated feed, straw and hay and silage (Glamoclija et al., 2018). They are also used in poultry feed, as they are an important source of energy and amino acids (Barneveld, 2002). Lately, they are also used to feed animals through grazing, together with other plant species such as *Lolium multiflorum* (Baron et al. 2015). They are also used in aquaculture, in a ratio of 5-20% triticale, and they have no negative effect on fish health (Dawood et al., 2020). It is used also in the alcohol industry (Cioch-Skoneczny, 2019), the bioethanol industry (Beres, 2013) and the cellulose industry (Bates et al., 2020).

According to FAOSTAT, the total global area in 2021 cultivated with triticale was 3.8 million hectares. The largest area was cultivated in Europe (3.3 million hectares), followed by Asia with 288 thousand hectares and Oceania with 96 thousand hectares (Table 1).

Table 1. Cultivated areas and production of triticale worldwide in 2021 (FAO, 2021)

Crt. No.	The region	Area (ha)	Total production (t)	Yield (kg/ha)
1	Mondial	3.830.794	14.846.162.66	3880
2	Europe	3.356.872	13.832.692.38	4120
3	Asia	288.115	596.279.57	2069
4	Oceania	96.207	170.812	1775
5	South America	49.139	155.727.83	3169
6	North America	19.500	39.148	2007
7	Central America	10.582	27.587.88	2607
8	Africa	10.379	23.915	2304

In Europe, the largest triticale grower was Poland, which had an area cultivated with triticale of 1.2 million hectares, followed by Belarus with 500 thousand hectares and Germany with 300 thousand hectares (Table 2).

Table 2. Largest european growers of triticale (Triticosecale Wittmatck), 2021 (FAO, 2021)

Crt. No.	Country	Area (ha)	Total production (to)	Yield (kg/ha)
1	Poland	1.281.600	5.349.420	6855
2	Belarus	513.270	1.667.284	3248
3	Germany	328.300	1.908.600	5813
4	France	338.600	1.736.910	5129
5	Spain	267.510	787.820	2945
6	China	194.354	367.123	1888
7	Russian Federation	119.480	288.488	2417
8	Australia	96.207	170.812	1775
9	Turkey	93.053	228.000	2450
10	Lithuania	74.510	206.120	2766
11	Romania	64.550	259.210	4015
12	Hungary	61.880	277.440	4483
13	Austria	49.950	265.600	5317
14	Czech Republic	40.860	193.450	4734

It is important in the triticale cultivation technology to establish the most suitable varieties, sown at the most optimal thicknesses and fertilized in reasonable quantities according to the culture area and the type of soil. To establish these technological factors, tests are carried out in different climatic conditions in which they try to highlight the most suitable technology for cultivating triticale. In Romania, studies were made on the production of triticale under the aspect of variety and fertilization (Nita et al., 2015).

In cultivation technology, fertilization is one of the most important links, they ensure the plant's nutrient requirements, nutrients that are not found entirely at the soil level and must be intervened with additional fertilization both at sowing and during the vegetation period. In the past, the most used fertilizer was manure, but nowadays modern agriculture comes with new solutions, namely chemical and synthetic foliar fertilizers, administered 100% mechanized and easy to store (Dobreva, 2016). At the global level, many studies are being done to improve the technology of triticale cultivation, including using different crop plants as green fertilizers, different doses of organic fertilizers and different varieties (Muhova and Kirchev, 2020). Thanks to genetic engineering, through breeding, spring triticale was also obtained, and these are tested together with autumn triticale to establish the production yield (Wójcik-Gront and Studnicki, 2021). Studies are also being done on additional fertilization with foliar fertilizer and biostimulator to increase production per surface unit (Dobreva et al., 2018). Foliar fertilization has a positive effect on production, thousand weight of grains and number of ears per square meter, especially the zinc foliar fertilizers (Kinaci and Gulmezoglu, 2007).

MATERIALS AND METHODS

The experiment was located at the Agricultural Research-Development Station in the city of Livada, Satu Mare County, North-West Romania, during the period 2021-2022, the plot having the geographical coordinates 47051`lat, 230 08` long and the altitude 120-130 m. The method of establishing the experience was the method of subdivided plots, with three experimental factors, in three repetitions. The soil type is typical preluvosol (luvic brown) with a slightly acidic pH between 5.19 and 6.65 and a humus content of 2.82% in the arable layer (Table 3).

Table 3. Soil characteristics from the experimental field in Livada

	MU	Ap	Ao		AB	Bt_1w	Bt_2w
	cm	0-18	18-40		40-55	55-70	70-110
	cm	0.15	20-30	30-40	40-55	55-70	80-95
Humus (Cx1.72)	%	2.82	1.44	0.90	0.90	0.84	3.24
N total	%	0.168	0.102	0.072	0.068	0.064	-
C:N	-	8.21	9.15	10.14	10.34	10.57	-
pH in water	-	5.19	6.24	6.65	6.53	5.62	5.28
Clay (<0.002 mm)	%g/g	20.9	21.1	23.1	27.0	32.4	33.1
Apparent density	g/cm^3	1.35	1.54	1.49	1.48	-	1.48
Hydraulic Conductivity	mm/h	31.27	5.87	3.11	0.35	-	1.04

During the period in which the study took place, an average temperature during the vegetation period of 9.7℃ was recorded, 0.7℃ higher than the multiannual average temperature. The biggest temperature difference between the monthly average and the multiannual average was in June when a difference of 3.1℃ was recorded (Table 4).

Table 4. Climatic data in the 2021-2022 vegetation period

	Specification	2021				2022							Total vegetation period
		IX	X	XI	XII	I	II	III	IV	V	VI	VII	
Temperatur (^{0}C)	Monthly average	15.2	9.0	5.3	1.1	-1.8	2.8	4.4	8.9	16.3	22.1	22.9	9.7
	Multi-year average	15.4	9.8	4.8	0.1	-2.1	0.1	4.7	10.5	15.8	19.0	20.5	9
	Multi-year average ± Difference	-0.2	-0.8	0.5	1.0	0.5	2.7	-0.3	-1.6	0.5	3.1	2.4	0.7

The level of precipitation was very low, registering a humidity deficit of 168.2 millimeters per square meter, the biggest deficit was recorded in May and June, but also in March (Table 5).

Table 5. The level of the precipitation in the 2021-2022 vegetation period

	Specification	2021				2022							Total vegetation period
		IX	X	XI	XII	I	II	III	IV	V	VI	VII	
Rainfall (mm)	Monthly total	34.1	13.5	65.4	119.3	76.6	46.1	1.3	86.9	17.9	10.3	36.8	508.2
	Multi-year average	64.5	54.6	55.8	61.0	48.5	43.9	46.5	49.9	77.4	92.5	81.8	676.4
	Multi-year average ± Difference	-30.4	-41.1	9.6	58.3	28.1	2.2	-45.2	37	- 59.5	-82.2	-45.0	-168.2

The experiment was three-factorial, four varieties of triticale (created at INCDA Fundulea, Romania) , representing the A factor, were studied:

- ✓ A1- Negoiu
- ✓ A2- Utrifun
- ✓ A3- Zvelt
- ✓ A4- Tulnic

Factor B was represented by the fertilization scheme:

- ✓ B1:- basic fertilization, autumn - 150 kg/ha NPK 18:46:0, additional fertilization, spring - 300 kg/ha Calcium ammonium nitrate 27.5% N.

- ✓ B2- basic fertilization, autumn - 150 kg/ha NPK 18:46:0, additional fertilization, spring - 300 kg/ha Calcium ammonium nitrate 27.5% N + foliar fertilization NPK 10:10:10 in a dose of 3 l/ha.
- ✓ B3 - basic fertilization, autumn - 150 kg/ha NPK 18:46:0, additional fertilization, spring - 300 kg/ha Calcium ammonium nitrate 27.5% N + foliar fertilization NPK 10:10:10 in a dose of 3 l/ha + biostimulator in a dose of 1 l/ha

Factor C was represented by the seeding rate of the 4 varieties of triticale (Figure 1):

- ✓ C1- 450 g.g. x m^{-2}
- ✓ C2- 550 g.g. x m^{-2}
- ✓ C3- 650 g.g. x m^{-2}

A1	B1	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B2	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B3	C1	C2	C3	C1	C2	C3	C1	C2	C3
A2	B1	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B2	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B3	C1	C2	C3	C1	C2	C3	C1	C2	C3
A3	B1	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B2	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B3	C1	C2	C3	C1	C2	C3	C1	C2	C3
A4	B1	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B2	C1	C2	C3	C1	C2	C3	C1	C2	C3
	B3	C1	C2	C3	C1	C2	C3	C1	C2	C3

Figure 1. Layout of the experience

The experimental variants were sown in October in the plot of 12 m^2 (10 m^2 harvestable) with the Wintersteiger experimental seeder (Figure 2)



Figure 2. Sowing experience with the Wintersteiger seeder

The cultivation technology was as follows: after harvesting the precursor plant (fodder pea) in July, a weeding work was carried out with a disc harrow, plowing was carried out in September at a depth of 23-25 cm followed by two works with a harrow with disks.

Immediately after that, basic fertilization was carried out with NPK 18:46:0 complex fertilizer in a dose of 150 kg/ha, after which it was incorporated with the combiner.

In March, additional fertilization was carried out with nitrogen-based fertilizer of the type Calcium amonium nitrate 27.5% N in a dose of 300 kg/ha.

Foliar fertilization and biostimulator for variants B2 and B3 was carried out in May. This was achieved with a 10-10-10 time dolar fertilizer + microelements and the Cropmax biostimulator.

RESULTS AND DISCUSISONS

The obtained results were interpreted through the analysis of the variance with the help of the ANOVA program, of the 3 experimental factors. According to it, foliar fertilization registered significantly positive differences on triticale production. The interaction of the variety x fertilization factors did not register any significant difference in production however, factor A (variety) had the greatest influence on triticale production, with distinctly significantly positive differences (Table 6).

Table 6. Analysis of the variance

Variant	Symbol	Sum of square	Degrees of freedom	Mean square	Sample F	Theoretical F	Significance
Variety	A	10296980.00	3	3432328.00	10.282	4.76; 9.78	XX
Density	C	252783.80	2	126391.90	0.450	3.63; 6.23	X
Variety x Density	AC	2112395.00	6	352065.80	1.254	-	-
Fertilization	B	912648.90	2	456324.40	3.673	3.18; 5.06	X
Variety x Fertilization	AB	6673803.00	6	1112301.00	8.954	-	-
Density x Fertilization	CB	204248.60	4	51062.16	0.4111	-	-
Variety x Density x Fertilization	ABC	621096.50	12	51758.04	0.417	-	-
Variety error	A error	2002939.00	6	333823.20	-	-	-
Density error	B error	4490939.00	16	280683.70	-	-	-
Fertilization error	C error	5962956.00	48	124228.20	-	-	-
Total	-	42327090.00	107		-	-	-

From table 7, it can be seen that the Tulnic variety registered significantly negative differences on triticale production, being the only one with production differences. The highest production was obtained by the Utrifun variety (8386.30 kg/ha), this production being close to the Negoiu control.

Table 7. Influence of factor A (variety) on production

Variant	Symbol	Production (kg/ha)	%	Differance	Significance
Negoiu	A1 (Mt)	8202.07	100.0	0.00	-
Utrifun	A2	8386.30	102.2	184.22	-
Zvelt	A2	8130.89	99.1	-71.19	-
Tulnic	A4	7559.93	92.2	-642.15	00
		LSD (p 5%)	385.26 kg/ha		
		LSD (p 1%)	583.40 kg/ha		
		LSD (p 0.1%)	937.21 kg/ha		

Through the use of foliar fertilizers and biostimulators, it is expected to obtain production increases both in terms of quantity and quality. As can be seen in table 8, due to the climatic conditions represented by high temperatures and the lack of precipitation, the application of foliar fertilizers and biostimulators did not lead to production increases, even more, they had a negative influence on the production of triticale. The foliar and

biostimulant fertilized variants recorded significantly negative differences in production. The best fertilization option was the control option, where complex chemical fertilizers of the NPK 18:46:0 type were used in the dose of 150 kg/ha in autumn and nitrogen-based fertilizers of the Nitrocalcate 27.5% N type in dose of 300 kg/ha in spring (Table 8).

Table 8. Influence of factor B (fertilization) on production

Variant	Symbol	Production (kg/ha)	%	Difference	Significance
Chemical fertilization	B1 (Mt)	8197.42	100.0	0.00	-
Chemical fertilization + foliar fertilization	B2	8027.44	97.9	-169.97	0
Chemical fertilization + foliar fertilization + biostimulator	B3	7984.53	97.4	-212.89	0
	LSD (p 5%)	166.98 kg/ha			
	LSD (p 1%)	222.98 kg/ha			
	LSD (p 0.1%)	290.93 kg/ha			

In the wide majority of cases of the interaction between the variety factor and the fertilization factor, insignificant production differences were recorded, with few exceptions.

The interaction between Utrifun and chemical fertilization registered distinctly significant positive differences on triticale production.

The interaction between the Tulnic variety and chemical fertilization + foliar fertilization recorded significantly negative differences on triticale production.

The biggest differences in production, following the interaction of the two experimental factors, was in the case of the interaction between the Tulnic variety and chemical fertilization + foliar fertilization + biostimulator, this recording very significantly negative differences in production (-1378.44 kg/ha) compared to the control (Table 9).

Table 9. The interaction A x B factors (variety x fertilization)

Variant	Symbol	Production (kg/ha)	%	Difference	Significance
Negoiu x Chemical fertilization	A1 B1	7943.00	100.0	0.00	Mt
Utrifun x Chemical fertilization	A2 B1	8779.44	110.5	836.44	**
Zvelt x Chemical fertilization	A3 B1	8156.44	102.7	213.44	-
Tulnic x Chemical fertilization	A4 B1	7910.78	99.6	-32.22	-
Negoiu x Chemical fertilization + foliar fertilization	A1 B2	8244.67	100.0	0.00	Mt
Utrifun x Chemical fertilization + foliar fertilization	A2 B2	8000.22	97.0	-244.44	-
Zvelt x Chemical fertilization + foliar fertilization	A3 B2	8136.00	98.7	-108.67	-
Tulnic x Chemical fertilization + foliar fertilization	A4 B2	7728.89	93.7	-515.78	0
Negoiu x Chemical fertilization + foliar fertilization + biostimulator	A1 B3	8418.56	100.00	0.00	Mt
Utrifun x Chemical fertilization + foliar fertilization + biostimulator	A2 B3	8379.22	99.5	-39.33	-
Zvelt x Chemical fertilization + foliar fertilization + biostimulator	A3 B3	8100.22	96.2	-318.33	-
Tulnic x Chemical fertilization + foliar fertilization + biostimulator	A4 B3	7040.11	83.6	-1378.44	000
	LSD(p 5%)	469.83 kg/ha			
	LSD (p 1%)	679.58 kg/ha			
	LSD (p 0.1%)	1019.96 kg/ha			

From the total of 12 interactions between factor B and factor A, 3 of these interactions did not register significant production differences.

The interaction between chemical fertilization + foliar fertilization + biostimulator x Negoiu variety registered a distinctly significant positive difference in production compared to the interaction between the control (chemical fertilization x Negoiu).

Very significantly negative production differences were recorded compared to the control in the case of the interaction between chemical fertilization + foliar fertilization x Utrifun (-799.22 kg/ha).

The interaction between chemical fertilization + foliar fertilization + biostimulator x Utrifun recorded significantly negative differences in production (-400.22 kg/ha).

The smallest difference in production (-870.67 kg/ha) compared to the control was registered by the interaction between the factors chemical fertilization + foliar fertilization + biostimulator x Tulnic (Table 10).

Table 10. The interaction B x A factors (fertilization x variety)

Variant	Symbol	Production (kg/ha)	%	Difference	Significance
Chemical fertilization x Negoiu	B1 A1	7943.00	100	0.00	Mt.
Chemical fertilization + foliar fertilization x Negoiu	B2 A1	8244.67	103.8	301.67	-
Chemical fertilization + foliar fertilization + biostimulator x Negoiu	B3 A1	8418.56	106.0	475.56	**
Chemical fertilization x Utrifun	B1 A2	8779.44	100.0	0.00	Mt
Chemical fertilization + foliar fertilization x Utrifun	B2 A2	8000.22	91.1	-779.22	000
Chemical fertilization + foliar fertilization + biostimulator x Utrifun	B3 A2	8379.22	95.4	-400.22	0
Chemical fertilization x Zvelt	B1 A3	8156.44	100.00	0.00	Mt
Chemical fertilization + foliar fertilization x Zvelt	B2 A3	8136.00	99.7	-20.44	-
Chemical fertilization + foliar fertilization + biostimulator x Zvelt	B3 A3	8100.22	99.3	-56.22	-
Chemical fertilization x Tulnic	B1 A4	7910.78	100.00	0.00	Mt
Chemical fertilization + foliar fertilization x Tulnic	B2 A4	7728.89	97.7	-181.89	-
Chemical fertilization + foliar fertilization + biostimulator x Tulnic	B3 A4	7040.11	89.0	-870.67	000
LSD (p 5%)		333.96 Kg/ha			
LSD (p 1%)		445.95 Kg/ha			
LSD (p 0.1%)		581.86 Kg/ha			

CONCLUSIONS:

Factor A (variety) had the greatest influence on production among the three experimental factors, having distinctly significantly positive differences of production.

Influence of factor A, the Tulnic variety, registered significantly negative differences compared to the control variety, the highest production being recorded by the Utrifun variety (8386.30 kg/ha).

The influence of the B factor, the highest production was recorded by the chemically fertilized variants with complex fertilizers of the type 18:46:0, in the fall, in a dose of 150 kg/ha and nitrogen-based fertilizers 27.5% N of the type Nitrocalcar, applied in the spring at a dose of 300 kg/ha. The variants that were fertilized with both foliar fertilizer and biostimulator recorded significantly negative differences in production.

Most of the A x B interactions registered insignificant production differences, the biggest production difference was in the case of the interaction between Tulnic and chemical fertilization + foliar fertilization + biostimulator (-1378.44 kg/ha).

The biggest production differences in the case of the interactions between the B x A factors were -799.22 kg/ha, very significantly negative differences (chemical fertilization + foliar fertilization x Utrifun variety), and -870.67 kg/ha very significantly negative differences (fertilization chemical + foliar fertilization + biostimulator x Tulnic variety).

The results of this study are not the expected ones because in agricultural practice foliar fertilization and biostimulator should bring increases in production, but in the present case this did not happen and we can conclude that the main factor that influenced production is the climatic conditions, high temperatures from the fertilization time combined with the lack of precipitation. But this could be confirmed in the following years of study, in climatic conditions different from those existing at the time of this study.

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