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The Behavior of Some Alternative Crops Under the Synergic Effect of Soil Work and Climate Conditions in the Eastern Area of Romania

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RESEARCH ARTICLE

Abstract

Water and thermal stress accentuated in the last decade, hinder farmers from obtaining rich and balanced harvests in the quality-quantity ratio. Thus, it is studied to carry out minimal soil work and to cultivate a wide range of agricultural species that have increased adaptability to climate changes. Dry farming is one of those working systems that allow the exploration of several combinations of soil works and rarely cultivated plants that can replace conventional crops. The present experiment was carried out to observe the influence of tillage on the yield of some alternative types of grassy cereals cultivated under water and thermal stress conditions in the eastern part of Romania, in the 2020-2022 agricultural years, at A.R.D.S., Braila. Rye and triticale crops were sown in three repetitions for each tillage: L1 – Plow (control), L2 – Paraplow, L3 – Scarifier, L4 – Heavy Disc, and L5 – No Tillage. The 2020-2021 agricultural year was rich in precipitation, therefore the difference in yields, for L2, L3, and L4 tillage compared to control - L1, was between -540 kg/ha and +267 kg/ha for the rye crop and between 0 - 535 kg/ha for triticale crop. Climatic conditions influenced yields, especially for triticale crops.

Keywords: dry-farming, productions, rye, triticale, water, thermal stress.

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INTRODUCTION

Agriculture is the mainstay that every country relies on to produce essential food for humans and animals, with survival based on the nutritional capacity of edible agricultural plants (Suresh, 2020). The fear induced by the growing rate of the global population in the coming decades raises concerns regarding food security and the ability of crops to keep up with the demands of the food industry in a situation where climate stress contributes to the deterioration of their quality and production. *Climate stress* is the term used to describe the influence of non-living factors (physicochemical factors of the environment), defined as *abiotic*, on living organisms (Arseniuk, 2015). Wheat, as a vital crop for our country, succumbs to abiotic factors due to the genetic variability already fructified in breeding. Using alternative species that can tolerate harsh environmental conditions, which also have higher yield potential than wheat crops, can be an alternative strategy where this species no longer encounters favorable conditions for growth and development (Suresh, 2020). The resistance and tolerance of crops to the fastidiousness of the

climate are vital for obtaining harvests that can withstand the demands of the agri-food industry market. As a result, breeding techniques and cultivation technologies must be constantly improved so that farmers may be able to grow plants on which everyone's survival depends. Some of these alternative species from the cereal group can be rye (*Secale cereale* L.) and triticale (*Triticale* Muntzing).

Triticale is a man-made grain resulting from the breeding, of two agronomic and economically important cereals in Romania, namely wheat and rye. Triticale combines the resistance of rye to aggressive abiotic factors and the productivity and quality of wheat harvests. Therefore, it results in a superior product with a high adaptability potential compared to other cereals. The triticale crop shows increased adaptability to harsh soil conditions, climate, and intensive technology which is why these factors do not affect the harvests (Biberdzic et al., 2017, Suresh et al., 2020, Dumbravă et al., 2016, Arseniuk, 2015). Triticale is constantly improving thanks to its diversified genotypes and its adaptability to the permanent changes in the environment in which it is grown. A few studies show that triticale as a cover crop, contributes to the sequestration of carbon in the soil and reduces the weed's density (Petcu et al., 2022).

Rye crop is used not only in the European Union but worldwide, in the manufacturing of flour for other derived food products (Peratoner et al., 2016), being second after wheat in terms of gluten protein content used in the food industry (Kaur et al., 2021). Rye proved to have low requirements for fertilizers and pesticides. Yields are influenced not only by environmental factors but also by genotype, so creating new varieties/hybrids is the best way to improve the characteristic qualities of the species (Hansen et al., 2004). Rye grains are rich in starch, fiber, protein, and minerals (Kaur et al., 2021, Jonsson et al., 2019) and they surpass the properties of wheat in the food industry. Rye plants also have allelopathic characteristics, especially when chopped and used as mulch for spring crops sown in conservation farming systems based on minimum tillage (Barbes and Putman, 1983). This green mass delays germination and partially inhibits the growth of weeds such as *Chenopodium album* L., and *Digitaria sanguinalis* (L.) Scop. and *Ambrosia artemisifolia* L. Therefore, the amount of chemicals used to combat harmful organisms can be reduced, and it can be considered a good crop for organic farming.

Along with using rye in the food industry, scientists have discovered the benefits of its biomass for biogas production (Malone et al., 2023).

These two types of grains can be used not only in the food industry but also in the biofuel industry, being productive under the conservative agriculture tillages, with low costs regarding technology and management. Therefore, under these changing climates, rye, and triticale can replace wheat crop where it is no longer profitable. This study was carried out to observe the behavior of these alternative crops under abiotic stress and conservative tillages to consider if it is convenient to cultivate them instead of wheat. Based on the result of this research, the yields of rye and triticale were superior to wheat yields although further study must be made.

MATERIALS AND METHODS

The experience has been set up in the Experimental Field at the Agricultural Research - Development Station, Braila, in 2020 - 2022. In the study, rye and triticale crops were sown in three repetitions, for each tillage. The tillages were L1 – Plow (control), L2 – Paraplow, L3 – Scarifier, L4 – Heavy Disc, and L5 – No Tillage. The experiment was laid out in a Latin rectangle.

The soil in the study area is moist vermic chernozem type, medium supplied with humus (2.4 - 3.1%), and pH varying between 7.9 - 8.4 (dominantly alkaline). It has a calcium carbonate content between 4.5 - 5.0%, specific total nitrogen content, and very good mobile phosphorus (174 - 225 ppm). The mobile potassium in the 0-20 cm depth is excellent and suitable for the rest of the horizons.

The statistical analysis of the obtained results was made by the Data analysis tool (ANOVA Test) in Excel.

RESULTS AND DISCUSSIONS

Environmental pollution causes instability in terms of rainfall and increases in annual temperatures. The temperatures in the eastern part of Romania, compared to the multiannual mean temperature of 10.9 °C, recorded an increase of 1.5 °C in both 2021 and 2022. Although global warming is a constant process, the same cannot be said about rainfall. It oscillates each year, between positive and negative differences compared to the multiannual sum (Table 1).

The 2020-2021 crop season was rich in precipitation, totaling an amount of 618 mm, 176 mm above the multiannual sum of 442 mm. As a result, the effects of heat were diminished, and the obtained yields were higher (Table 2, Table 3). On the contrary, 2021-2022 was dry and hot. The deficit of 178 mm, compared to the multiannual sum of 442, prevented the optimal growth of plants. This was notable especially at harvesting when the obtained yields were quantitatively small and weak.

The drought in 2022 caused production losses of rye crops, between 421 and 818.4 kg/ha (Table 2). Compared to the L1 - control, the highest increases in both 2021 and 2022, were obtained in L2 - Paraplow and L3 - Scarifier (Table 3). The lowest increase was obtained from L4 – Heavy-disk, which proves that regardless of the climatic

conditions, the rye crop lends itself well to the type of tillage that loosens the soil at depths of up to 35 cm. The L5 – No-till performed better than the control in 2021 compared to 2022.

Although there were losses of 209,2 kg/ha in L3 plots in the drier year, that tillage was the most favorable for the rye crop, the obtained productions in both study years being higher than those obtained in the L1 – -control plots.

Similarly, to the rye crop, triticale also recorded yields of 1640 - 2169 kg/hectare in 2022, less than those obtained in 2021 (Table 4). Compared to L1 - control, the triticale crop reacted positively to all the tillages characteristic of conservative agriculture, regardless of the environmental conditions. In 2021, with abundant rainfall, significant increases were obtained in L3 and L5 (Table 5), while under the drought conditions of 2022, the L3 tillage was the most favorable for triticale.

Table 1. Climatic conditions of crop seasons 2020-2021 and 2021-2022, in Braila County

Month	Multiannual mean temperature (°C)	Deviation (°C)		Multiannual sum rainfall (mm)	Deviation (mm)	
		2020 - 2021	*2021 - 2022*		*2020 - 2021*	*2021 - 2022*
IX	11,5	8,8	5,4	32	9,5	-21,6
X	5,6	9,5	4,6	30	-6,5	3,1
XI	0,6	5,1	7,5	33	-11,5	-5,9
XII	-2,1	6,8	4,6	36	39,7	7,8
IX	-0,2	2,4	1,5	28	14,2	-21,5
II	4,7	-2,3	-0,6	27	-18,6	-15,9
III	11,2	-6,5	-7,4	26	-3,6	-12,2
IV	16,7	-7,3	-4,8	35	5,3	-9,9
V	20,9	-4,2	-2,9	48	13,8	-23,7
VI	22,9	-2,7	-0,2	62	127,8	-28,7
VII	22,1	2,7	2,7	46	1,4	-37,1
VIII	17,3	6,1	7,6	39	4,7	-12,1
Average / Sum	***10,9***	***1,5***	***1,5***	***442***	***176***	***-177,7***

Table 2. Yields of rye crop in 2021 and 2022, based on tillage

Rye yields (kg/hectare)			Yield difference compared to L1 - control (kg/hectare)	
Soil tillage	**2020 - 2021**	**2021 - 2022**	**2020 - 2021**	**2021 - 2022**
L1 - Plow (control)	271,3	2292,0	-	-
L2 - Paraplow	2956,7	2280,4	243,3	-11,6
L3 - Scarifier	2980,0	2349,5	266,7	57,5
L4 - Heavy-disk	2173,0	1729,6	-540,3	-562,5
L5 - No tillage	2739,7	1921,3	26,0	-370,8

Table 3. ANOVA Test performed on the yields of rye crops obtained in 2021 and 2022

Statistical analysis - Rye crop						
	2021			2022		
Tillage	**Average yields (kg/ha)**	**Difference compared to L1 - Plow (control)**	**Statistical significatio n**	**Average yields (kg/ha)**	**Difference compared to L1 - Plow (control)**	**Statistical significatio n**
L2 - Paraplow	2956.67	243.33	**	2280.40	-11.62	-
L3 - Scarifier	2980.00	266.67	**	2349.53	57.51	-
L4 - Heavy-disk	2173.00	-540.33	ooo	1729.56	-562.46	oo
L5 - No-till	2739.67	26.33	-	1921.27	-370.76	o
L1 - Plow (control)	2713.33	0.00	-	2292.02	0.00	-
Df 5% =			127.73			249.45
Df 1% =			193.42			377.74
Df 0.1% =			310.73			606.83

* Df – Degrees of freedom; ** - distinctly significant (positive); *** - very significant (positive); o – significant (negative); oo – distinctly significant (negative); ooo – very significant (negative).

Figure 1. Rye crop

Figure 2. Triticale crop

Figure 3. Rye crop (left) and triticale crop (right) during harvesting

Most yield losses in 2022 for both rye and triticale crops were recorded on L5 plots, compared to L2, L3, and L4 plots, between 344 kg/hectare and 1747 kg/hectare. In comparison, wheat yields in the same dry year were between 2826 kg/hectare and 3500 kg/hectare. Based on the triticale yields obtained in 2022 (Table 4), this crop exceeded wheat yields by up to 400 kg/hectare, which proves that it can be a proper alternative to wheat crops in dry areas, with different processing destinations and adaptability to various tillages.

Table 4. Yields of triticale crop in 2021 and 2022, based on tillage

Triticale yields (kg/hectare)			Yield difference compared to L1 - control (kg/hectare)	
Soil tillage	**2020 - 2021**	**2021 - 2022**	**2020 - 2021**	**2021 - 2022**
L1 - Plow (control)	4865,7	3225,3	-	-
L2 - Paraplow	5146,3	3311,8	2433,0	1019,8
L3 - Scarifier	5359,7	3708,9	2646,3	1416,9
L4 - Heavy-disk	5259,7	3261,9	2546,3	969,9
L5 - No tillage	5400,3	3231,5	2687,0	939,5

Table 5. ANOVA Test performed on the yields of triticale crop obtained in 2021 and 2022

Statistical analysis - Triticale crop						
2021				**2022**		
Tillage	Average yields (kg/ha)	Difference compared to L1 - Plow (control)	Statistical significatio n	Average yields (kg/ha)	Difference compared to L1 - Plow (control)	Statistical significatio n
L2 - Paraplow	5146.33	280.67	**	3311.81	86.54	*
L3 - Scarifier	5359.67	494.00	***	3708.93	483.66	***
L4 - Heavy-disk	5259.67	394.00	***	3261.91	36.64	-
L5 - No-till	5400.33	534.67	***	3231.53	6.26	-
L1 - Plow (control)	4865.67	0.00	-	3225.27	0.00	-
Df 5% =			134.66			84.27
Df 1% =			203.91			127.60
Df 0.1% =			327.58			204.99

* Df – Degrees of freedom; ** - distinctly significant (positive); *** - very significant (positive).

CONCLUSIONS

Both crops were influenced by rainfall but in different ways. The rye crop had 18-43% higher yields in the rainy year 2021, while the triticale had increases of 45-67%. Regardless of the amount of rainfall, the triticale crop reacted positively to all the applied soil tillages studied in this research, specific to conservative agriculture, compared to the classical tillage L1 – plow (control). The rye crop proved to be sensitive to both climatic stress and tillage. As a result, the choice of the tillage type in conservation agriculture must be made considering not only the climatic conditions but also the preferences of the crop plant regarding tillage. The triticale crop responded better to the loosened soil in the dry year, while in the year with abundant rainfall, the shallow works with the heavy disk and no-tillage were more favorable. This suggests that plant debris left on the soil surface store and retain soil moisture better when there is in fact, rainfall. The effectiveness of the L5 - no-tillage system for the triticale and rye crops depends on environmental factors.

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Conflicts of Interest

The authors declare that they do not have any conflict of interest.

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