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EFFECT OF THE TILLAGE SYSTEMS AND FOLIAR FERTILIZATIONS ON ASSIMILATION, PRODUCTION AND QUALITY OF WHEAT IN THE TRANSYLVANIAN PLAIN CONDITIONS

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Abstract

Research was conducted using Andrada winter wheat variety created at the Agricultural Research and Development Station Turda. The crop was treated with two types of foliar fertilizers, Folimax Gold and MicrofertU which were applied in two tillage systems: conventional and no-tillage. The main purpose of this paper is to assess the influence of foliar fertilization in the two systems of conventional tillage and conservative systems with no-tillage. Various growth stages of the wheat crop, in achieving high yields and quality indices were assessed. The promotion and identification of physiological mechanisms in wheat are useful in assessing biological development, correlated with the productivity elements of winter wheat. Measurements of assimilation of the physiological parameters and chlorophyll concentration were performed on the standard flag leaf five days from the last treatment, using foliar fertilizers considering the duration of adaptation of tissues in flag leaf. Measurements were performed five times per plant and five plants per variant, with three repetitions in June. Technology used in wheat cultivation showed that the net assimilation, physiological parameters, and production were higher, registering higher values for the conventional system (tilling), ranging between 27-30 μmolm^{-2} s^{-1}, and an increase of production, of over 700 kg ha^{-1}. The values were statistically confirmed, as being significantly positive, compared to those from the conservative no-tillage system, in the conditions of the Transylvanian Plain. Physiological parameters taken into study had higher values for the conventional system in the variants treated with foliar fertilizers, compared to the no-tillage system, leaf to air vapor pressure deficit (VPD) being inversely proportional. Foliar fertilization applied to the Andrada wheat variety has beneficially influenced the quality indices in the two tillage systems, the percentage of protein obtained being between 12.1-13.8%, gluten between 23.5-27.3%, Zeleny index between 35-48%, and the mass of one thousand grains (MTG) was between 50-53.1 g.

Key words*: wheat, tillage system, foliar fertilizer, photosynthesis, production, quality.*

INTRODUCTION

Wheat is one of the most adaptable crops to different environmental conditions, having a very wide ecological plasticity to pedoclimatic conditions, occupying the largest agricultural areas (Rusu et al., 2014; Bradshaw, 2016; Racz et al., 2016) and benefiting from efficient biological mechanisms in adapting to soil conditions (Stoian et al., 2015).

Wheat responds to the tillage system in a way that is difficult to predict. The results depend on the association of different practices such as: soil preparation, sowing period, equipment used, crop rotation, variety used, form of fertilization (time and method of application), control of weeds, diseases and pests (Richards, 1996; De Carcer et al., 2019; Liebenberg et al., 2020) and many other parameters (Cappelli et al., 2020e; Guerrini et al., 2020; Sigua et al., 2020). The relationship between production - its quality and the tillage system is largely influenced by the previous management of the soil and weather conditions (Jug et al., 2011; Ernst et al., 2020).

Tillage and fertilization have a direct and indirect influence on the production of winter wheat. Following the effect of the tillage system, there are differences in terms of plant development productivity elements and even density, height of plants, and quality indices.

High production capacity is often associated with a lower grain protein content (Blackman & Payne, 1987). The protein is the main component that determines the baking quality of wheat (Fowler et al., 1990). From the analysis of the average values obtained it results that the

additional fertilization ensures an increase of production as well as an increase of the average values of the other components of the production or of the qualitative indices, also conferring a smaller variation of the values of these characters (Richards, 2000; Racz et al., 2016; Fonteyne et al., 2020). Furthermore, the correct management of fertilization is essential to guarantee the correct milling of wheat kernels (Doblado-Maldonado et al., 2012; Cappelli et al., 2020a; Cappelli et al., 2020b), optimal flour quality (Hackenberg et al., 2018; Bonilla et al., 2019; Cappelli et al., 2020c), improved dough rheology, and best bread and bakery products characteristics (Cappelli et al., 2020d).

Plant respiration is one of the main links in the carbon cycle through which CO_2 fixed by plants returns to the atmosphere (Delian, 2010). At maturity, wheat mainly performs photosynthesis on the standard flag leaf and stem, this being the main source of assimilation for cereals during grain filling (Rawson et al., 1976; Racz et al., 2014). In severe drought conditions the photosynthetic function decreases significantly. To the greatest extent it can damage the photosynthetic apparatus (Petcu et al., 2007). When the drought does not persist for a long time and there are reduced water reserves in the soil, foliar applications may promote physiological mechanisms of adaptation to drought and thus avoid or reduce tissue dehydratation. The application of foliar fertilizer treatments to unprocessed wheat crop in the no-tillage system has the advantage of better water conservation in the soil during drought seasons (Chetan et al., 2016).

The choice of varieties depending on the area represented by the Transylvanian Plain, both macro and micronutrients applied to soil and foliage, contributes to adequate plant nutrition (Alaru et al., 2009; Knapowski et al., 2010; Stankowski et al., 2015; Wojtkowiak et al., 2015). The pedoclimatic conditions associated with the applied technology are decisive factors in the success of wheat cultivation, both productively and quantitatively (De Vita et al., 2007a; Warechowska, 2009; Ceclan et al., 2015; Zain et al., 2015).

The main purpose of this paper is to assess the influence of foliar fertilization, in two systems: conventional tillage and no-tillage, in various phases of formation and development of the wheat crop, in achieving high yields and quality indices. The promotion and identification of physiological mechanisms in wheat is useful in assessing biological development which is correlated with productivity.

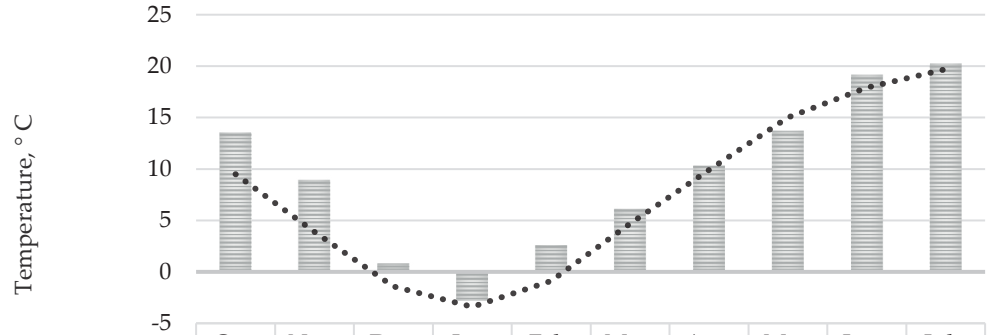
MATERIALS AND METHODS

The data presented in this paper was obtained under the climatic conditions from the Transylvanian Plain at the Agricultural Research and Development Station Turda (ARDS Turda) on a Faeoziom soil (RSST, 2012) (Phaeozem, World Reference Base, 2015). The experiments were carried out on a soil with a neutral pH (between 6.8-7.2; potentiometric method in distilled water), clayey texture (clay between 51.8-55.5%), and a humus content between 2.20-3.00% (Walkley-Black method), total nitrogen 0.162-0.124 % (Kjeldhal method); medium supplied with phosphorous, 0.9-5 ppm and well supplied with potassium, 126-140 ppm (Egner-Riehm-Domingo extraction method). Soil samples for the chemical analyses were collected along a depth of 0-30 cm.

Regarding the location of the crop, the climatic conditions in the fall of 2019 were generally oscillating from month to month, from dry to normal, the amounts of precipitation making it difficult to prepare the soil, respectively tilling. Despite that a uniform emergence and rooting (growth stage - BBCH 10-11 (Racz et al., 2016) occurred for the Andrada wheat variety.

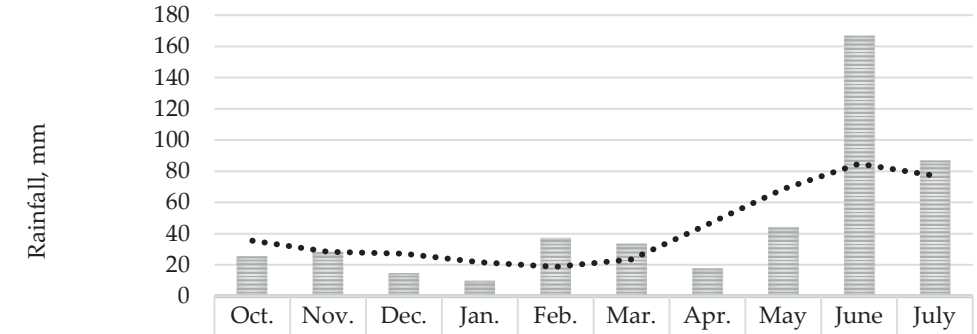
Year 2019-2020 had warmer weather, the spring temperatures being higher, by over +1.7 °C compared to the multiannual average of the last 60 years. The influence of the water deficit in the soil led to the decrease of the number of tillers and during April and May it caused a slow development of wheat. The characterization of the thermal and pluviometric regime for the wheat crop in the period 2019-2020 was made based on the primary data recorded by the ARDS Turda Meteorological Station, longitude: 23°47' latitude 46°35' (Figures 1 and 2).

The months of February, March, June, and July compensated with rainfall, ensuring sufficient water in the soil and causing a good development of the crop especially in the stages of straw elongation (BBCH 28-30), appearance of standard flag leaf (BBCH 37-39), beginning of earing (BBCH 51-53) and during seed filling (BBCH 69-71).



	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
2019-2020 Years	13,5	8,9	0,8	-2,8	2,6	6,1	10,3	13,7	19,1	20,2
Average 60 Years	9,5	3,9	-1,4	-3,4	-0,9	4,7	9,9	15	17,9	19,7

Figure 1. The average monthly temperatures recorded during October 1st, 2019 - July 31st, 2020



	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
2019-2020 Years	25,6	28,4	14,8	10,0	37,4	34,0	17,8	44,4	166,6	86,8
Average 60 Years	35,6	28,5	27,1	21,8	18,8	23,6	45,9	68,7	84,8	77,1

Figure 2. The average monthly rainfall recorded during October 1st, 2019 - July 31st, 2020

The studies were carried out in the period 2019-2020 using the Andrada wheat variety, very productive, with high quality indices (Moldovan et al., 2012) and with a very good net assimilation, ranging from 28-35 $\mu molm^{-2}s^{-1}$ on the standard flag leaf (Bărdaș et al., 2019), presenting a mechanism with a good resistance to drought and high temperatures, as Austin found in 1990 following experiments on wheat (Austin, 1990).

The experimental factors: *Factor A* - Soil tillage: a_1 - conventional system with plow (CS, control variant); a_2 - no-tillage system (NT). *Factor B* - Foliar fertilizers: b_1 - unfertilized variant control; b_2 - basic fertilization + 2 treatments (BBCH 37-39 and BBCH 51-53) with Folimax Gold; b_3 - basic fertilization + 2 treatments (BBCH 37-39 and BBCH 71-73) with Folimax Gold; b_4 - basic fertilization + 3 treatments (BBCH 37-39, BBCH 51-53 and BBCH 71-73) with Folimax G; b_5 - basic fertilization + 4 treatments (BBCH 29-31, BBCH 37-39, BBCH 51-53 and BBCH 71-73) with Folimax Gold; b_6 - basic fertilization + 2 treatments (BBCH 37-39 and BBCH 51-53) with Microfert U; b_7 - basic fertilization + 2 treatments (BBCH 37-39 and BBCH 71-73) with Microfert U; b_8 - basic fertilization + 3 treatments (BBCH 37-39, BBCH 51-53 and BBCH 71-73) with Microfert U; b_9 - basic fertilization + 4 treatments (BBCH 29-31, BBCH 37-39, BBCH 51-53 and BBCH 71-73) with Microfert U.

During the vegetation period 2019-2020, in the conventional tillage system, tilling was done 30 cm depth with a Kuhn reversible plow, followed by the preparation of the germination bed with a Gaspardo rotary harrow. The sowing and autumn fertilization were done at the same time using a universal straw seed drill. For the no-tillage system sowing was done together with the autumn fertilization using a Directa 400 sowing machine. In both variants the sowing was done in optimal conditions on October 24, 2019. The depth of seed incorporation was 3-5

cm and the distance between rows of 18 cm, ensuring optimal conditions of humidity and aeration, as well as favoring the formation of twinning nodes at 2-3 cm. The optimal germination temperature was between 23-25 °C, ensuring a density of 550 bg m^{-2}, and the amount of seed per hectare was 280 kg.

Basic fertilization (BF) was performed on a 40 kg ha^{-1} nitrogen and phosphorus assured background, simultaneously with the sowing (N_{20} P_{20} K_0 - 200 kg ha^{-1}) as well as application of ammonium nitrate - 60 kg ha^{-1} N active substance in the spring at the resumption of vegetation.

The vegetation stages in which the treatments were carried out were: growth stage 1 - at the end of twinning (BBCH 29-31); growth stage 2 - at the appearance of the standard flag leaf (BBCH 37-39); growth stage 3 - at the beginning of sprouting (BBCH 51-53); growth stage 4 - when filling the seeds (BBCH 71-73).

The number of treatments and application growth stage were different, resulting in eight graduations and a control variant in which mineral fertilization was not supplemented by foliar fertilization (Table 1).

The total area of the experience with the two experimental variants of winter wheat was 3,680 m^2.

Table 1. Foliar fertilizers used on winter wheat crop

No	Trade name, content dose - kg, l ha^{-1}	Dose kg, l ha^{-1} / 250 l of water
1	Folimax Gold Aminopower – 27 % N, + 1.5 % MgO + 1.0 % Mn + 0.13 % Cu + 0.02 % Zn, B, Fe (produced by Fertinova)	3.0 and 5.0
2	Microfert U - NPK - 90:30:30 g l^{-1} + Mg + S, B, Co, Cu, Fe, Mn, Mo, Zn (produced by Alchimex SA Bucharest)	3.0 and 5.0

Wheat production was determined by weighing it on the experimental plots. Measurements of physiological parameters and chlorophyll concentration were performed directly on the flag leaf, after the last treatment with foliar fertilizers in June, depending on the duration of tissue adaptation in the flag leaf cuvette.

The research method used was non-destructive (the leaves were not detached from the plant) and was based on the use of the CIRAS-3 (PP System, 2014) foliar gas analyzer (net assimilation, evapotranspiration, saturation deficiency of water vapor) and the Apogee MC-100 which directly measures and shows the concentration of chlorophyll without damaging the plant material.

The quality indices (mass of 1,000 grains, gluten, protein) were made using the Inframatic 8800 NIR analyzer.

The statistical analysis was exploratory, the correlations between experimental parameters and observations, respectively multiple comparisons (Fisher LSD - Least Significant Difference) evaluated the effect of fertilization on the biological development of plants.

The results obtained regarding the quality indices and establishment of smallest significant differences were statistically processed by ANOVA (analysis of variance), for LSD 5%, 1% and 0.1% (ANOVA, 2015).

RESULTS AND DISCUSSIONS

The average production in the 2019-2020 (Table 2) vegetation year shows that wheat responds very well to the conventional tillage system with increases of over 900 kg ha^{-1} compared to the no-tillage system. A similar reaction was obtained in wheat in the Transylvanian Plain on fertile soils (Chețan et al., 2017), while the results are varied in soils with medium fertility (Moraru & Rusu, 2013). The production differences are therefore related to the soil, then to the conservation of water in the soil (controlled by the particularities of the tillage system) (Rusu et al., 2014). The results were ensured statistically with a very distinctly significantly negative correlation. The average net assimilation (An), chlorophyll concentration and evapotranspiration had higher values in the conventional tillage system compared to the no-tillage one, results being significantly negative. A similar trend was obtained by He et al. (2020) at winter wheat (by reducing the intensity of tillage) and Monneveux et al. (2006) at maize crop, suggesting less nitrogen uptake to no-tillage. The average experience of leaf to air vapor pressure deficit (VPD- kPa) had higher values in the no-tillage system, with a statistically significant positive difference compared to the conventional tillage system.

The highest yields for the Andrada wheat variety in the conventional tillage system with the largest production increases of over 600 kg ha^{-1}, were obtained in 2019-2020 for variants b_4 and b_7 treated with foliar fertilizers Folimax Gold and Microfert U, where 3 and 2 treatments with foliar fertilizer were applied, being statistically assured as being very significant positive compared to the control variant. In the no-tillage system, the large production increases of over 620 kg ha^{-1} were obtained for variant b_5, with 4 treatments of Folimax Gold fertilizer and for variants b_7 and b_8, with Microfert U 2 and 3 were application, respectively foliar fertilizer treatments, being statistically assured as being significantly positive compared to the control variant (Table 3).

Table 2. The average influence of experience, of different factors, on different tillage systems

Measured property	Unit	Value		Difference		Significance		LSD		
		CS	NT	CS	NT	CS	NT	p=5%	p=1%	p=0.1%
Yield	kg ha^{-1}	6,620	5,630	0.00	-990	cv	000	111.9	258.6	822.9
Net assimilation	µmol$m^{-2}s^{-1}$	28.85	26.60	0.00	-2.25	cv	00	0.36	0.83	2.65
Chlorophyll concentration	µmolm^{-2}	609.7	575.0	0.00	-34.7	cv	00	8.2	18.9	60.3
Evapotranspiration	µmol$m^{-2}s^{-1}$	3.24	2.84	0.00	-0.40	cv	00	0.11	0.26	0.82
Leaf to air vapor pressure deficit	kPa	0.78	1.01	0.00	0.23	cv	**	0.06	0.14	0.46

Note: CS - conventional system with plow; NT – no-tillage system; ** - distinctly significant positive; 0 - significant negative; 00 - distinctly significant negative; 000 - very significant negative; LSD - Least Significant Difference.

Table 3. Effect of different tillage systems on wheat yield in different foliar fertilization variants

Variants	Yield, kg ha^{-1}		Difference		Significance	
Fertilizer / Systems	Conventional tillage	No-tillage	Conventional tillage	No-tillage	Conventional tillage	No-tillage
b_1 - Control variant (cv)	6,330	5,270	0.0	0.0	cv	cv
b_2 - BF + 2 treat with FG	6,675	5,635	342.0	363.3	***	***
b_3 - BF + 2 treat with FG	6,450	5,620	118.3	350.0	-	***
b_4 - BF + 3 treat with FG	6,995	5,440	665.0	170.0	***	*
b_5 - BF + 4 treat with FG	6,545	5,900	215.0	615.0	**	***
b_6 - BF + 2 treat with MU	6,510	5,500	180.0	230.0	*	**
b_7 - BF + 2 treat with MU	6,985	5,880	655.0	610.0	***	***
b_8 - BF + 3 treat with MU	6,525	5,800	195.0	530.0	*	***
b_9 - BF + 4 treat with MU	6,590	5,615	260.0	345.0	**	***
LSD (p 5 %) = 157; LSD (p 1 %) = 211; LSD (p 0.1 %) = 280						

Note: BF - Basic fertilization; FG - Folimax Gold; MU - Microfert U; - not significant; * - significant positive; ** - distinctly significant positive; *** - very significant positive; LSD - Least Significant Difference.

The net assimilation was between 25.5 and 27.1 µmol$m^{-2}s^{-1}$ in the variant treated only with mineral-based fertilization and the variants treated, in addition, with different foliar fertilizers, the net assimilation had values between 26.1 and 30.0 µmol$m^{-2}s^{-1}$. Foliar fertilization positively influences the assimilation in both tillage systems, as found in wheat Hausherr Lüder et al., 2020 and Sobolewska et al., 2020.

In the conventional tillage system, the highest values were obtained for the b_5 variant, using the Folimax Gold fertilizer and for the Microfert U fertilizer with b_6, b_7 and b_9 variants, being statistically assured as being very significantly positive compared to the control variant. In the no-tillage system, the values of net assimilation on the fertilized variants were between 25.5 and 28.1 µmol$m^{-2}s^{-1}$ and were also obtained for variant b_5, Folimax Gold fertilizer and variant b8 and b_9 at Microfert U, being statistically assured as being very significantly positive compared to the control variant (Table 4).

For Andrada wheat variety, the application of foliar fertilizers in different growth stage of crop development was well used by plants, with a positive correlation between yields and net assimilation as found by Natr, 1975 and Marshall and Biscoe, 1981. The wheat crop for which the foliar fertilizers were applied obtained a higher net assimilation, eliminating more carbon per unit time (Ernst et al., 2020; Wozniak & Rachon, 2020).

Chlorophyll is vital for photosynthesis and its concentration indicates the health and nutrition of plants, but it can also be an indicator of the availability of nitrogen in the soil (Fiorentini et al., 2019). In the variants treated with foliar

fertilizer the concentration of chlorophyll is higher than in the control variant treated only with basic fertilization. Between the control variant and the variants treated with different foliar fertilizers the chlorophyll concentration had values between 575 and 620 μmolm^{-2} (Table 5).

Table 4. Effect of different tillage systems on net assimilation in different foliar fertilization variants

Variants	Net assimilation, μmolm^{-2}s^{-1}		Difference		Significance	
Fertilizer / Systems	Conventional tillage	No-tillage	Conventional tillage	No-tillage	Conventional tillage	No-tillage
b_1 - Control variant (cv)	27.1	25.5	0.0	0.0	cv	cv
b_2 - BF + 2 treat with FG	28.9	26.3	1.77	0.77	**	-
b_3 - BF + 2 treat with FG	28.1	26.4	0.97	0.90	-	-
b_4 - BF + 3 treat with FG	28.7	26.5	1.63	0.95	*	-
b_5 - BF + 4 treat with FG	29.0	27.0	1.90	1.40	**	*
b_6 - BF + 2 treat with MU	29.8	26.1	2.73	0.57	***	-
b_7 - BF + 2 treat with MU	29.9	26.4	2.90	0.90	***	-
b_8 - BF + 3 treat with MU	28.5	27.3	1.43	1.73	*	**
b_9 - BF + 4 treat with MU	29.4	28.1	2.33	2.63	***	***
LSD (p 5 %) = 1.25; LSD (p 1 %) = 1.68; LSD (p 0.1%) = 2.23						

Note: BF - Basic fertilization; FG - Folimax Gold; MU - Microfert U; - not significant; * - significant positive; ** - distinctly significant positive; *** - very significant positive; LSD - Least Significant Difference.

Table 5. Effect of different tillage systems on chlorophyll concentration in different foliar fertilization variants

Variants	Chlorophyll concentration, μmolm^{-2}		Difference		Significance	
Fertilizer / Systems	Conventional tillage	No-tillage	Conventional tillage	No-tillage	Conventional tillage	No-tillage
b_1 - Control variant (cv)	573.7	520.0	0.0	0.00	cv	cv
b_2 - BF + 2 treat with FG	613.0	561.0	39.3	41.0	***	***
b_3 - BF + 2 treat with FG	622.0	570.0	48.3	50.0	***	***
b_4 - BF + 3 treat with FG	615.7	595.0	41.7	75.0	***	***
b_5 - BF + 4 treat with FG	616.7	598.3	43.0	78.3	***	***
b_6 - BF + 2 treat with MU	595.7	568.3	22.0	48.3	*	***
b_7 - BF + 2 treat with MU	614.0	586.7	40.3	66.7	***	***
b_8 - BF + 3 treat with MU	615.7	596.7	42.0	76.7	***	***
b_9 - BF + 4 treat with MU	621.3	579.0	47.7	59.0	***	***
LSD (p 5 %) = 16.8; LSD (p 1 %) = 22.6; LSD (p 0.1 %) = 29.9						

Note: BF - Basic fertilization; FG - Folimax Gold; MU - Microfert U; * - significant positive; *** - very significant positive; LSD - Least Significant Difference.

In the conventional tillage system, the concentration values are higher and more uniform for variant b_3, Folimax Gold fertilizer and Microfert U fertilizer for variant b_9 with a chlorophyll concentration of over 620 μmolm^{-2}, being statistically assured as very significant positive compared to the control variant.

In the no-tillage system, the chlorophyll concentration values were very uniform. The fertilized variants were over 595 μmolm^{-2} for the b_4 and b_5 variants, for the Folimax Gold fertilizer and for the b_7 and b_8 variant for Microfert U, being statistically assured as very significantly positive compared to the control variant.

The application of foliar fertilizers in the different growth stage of crop development was well exploited by plants with a positive correlation between net assimilation and chlorophyll concentration. This has a positive influence on the productivity components of wheat (Sanchez-Bragado et al., 2017).

The interaction between assimilation and production in wheat during the studied year indicates an increase in assimilation directly proportional to production (Figure 3). In general, the regression line indicates differences in the net assimilation between the two tillage systems.

In the conventional tillage system, the net assimilation has a range of variation from 28.0-30.0 μmol^{-2} s^{-1}, with yields between 6,500 to over 7,000 kg ha^{-1}. In the no-tillage system, the net assimilation has values from 26 to 27 μmol^{-2}s^{-1} at yields exceeding 5,700-6,000 kg ha^{-1}. The

phenomenon is based on a physiological stress in 2020, due to lack of water during May, at the beginning of the bellows stage (BBCH 37-39), leading to a decrease in production and assimilation.

The interaction between net assimilation and chlorophyll concentration in wheat crop during the experimental year is directly proportional. As the concentration of chlorophyll increases, the regression line generally indicates an increase in the assimilation between the two tillage systems. In the conventional tillage system, the chlorophyll concentration has a range of variation from 580-650 μmol^{-2} with net assimilations between 28.0-30.0 $\mu mol^{-2}s^{-1}$. In the no-tillage system the concentration of chlorophyll has values of 550-600 μmol^{-2} at a net assimilation from 26.0-30.0 $\mu mol^{-2}s^{-1}$.

By closing the stomata, the assimilation decreases and with this a decrease in production (Figure 4).

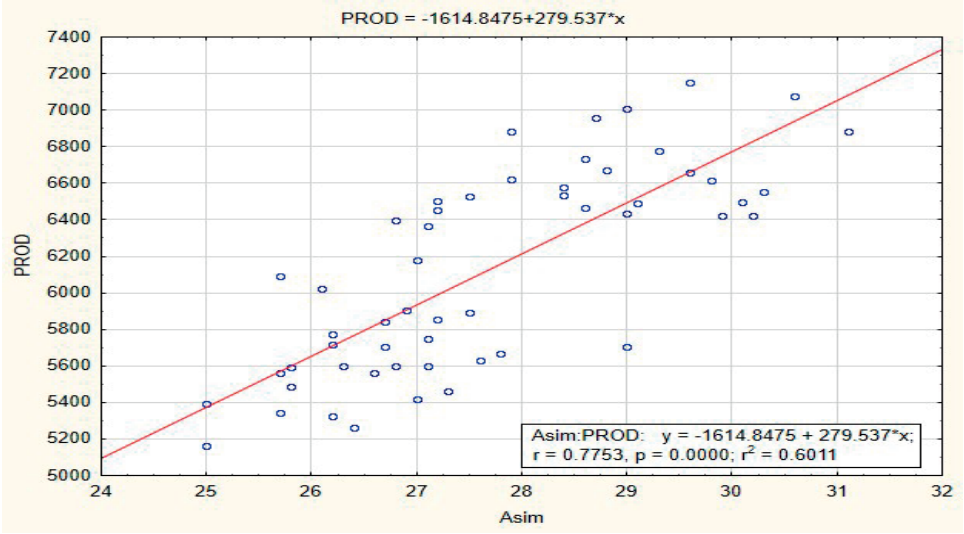


Figure 3. Multiple interaction between production and net assimilation

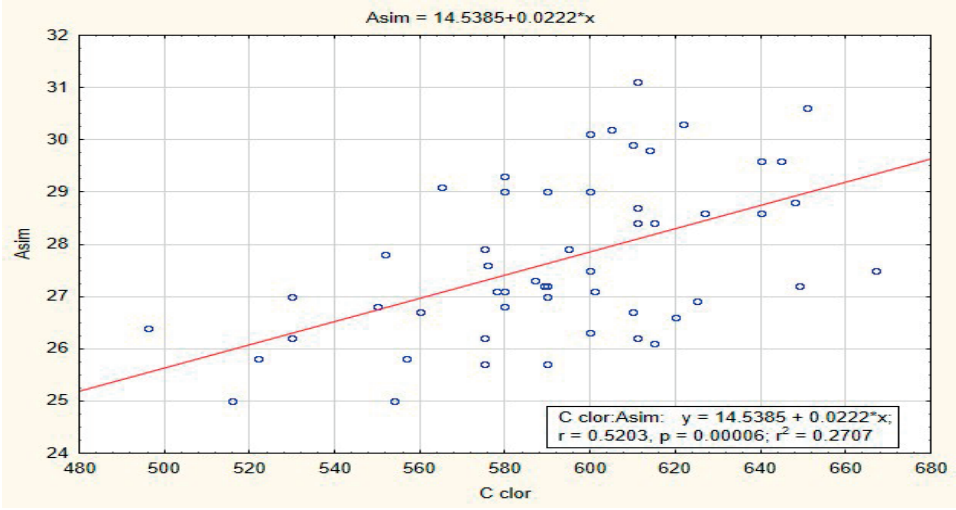


Figure 4. Multiple interaction between net assimilation and chlorophyll concentration

Data processing shows a Gaussian dynamic, where the normal data curve shows an increase in production of over 6,800 kg ha^{-1} with increasing assimilation from 28 and 32 μmol^{-2} s^{-1} in a range of leaf to air vapor pressure deficit, after which, when the temperature rises to over 30 °C, the leaves begin to reduce. From the production graph it can be seen that the Andrada wheat variety has a special consistency when applying foliar fertilization in addition to basic fertilization, with a positive correlation between production and assimilation and inversely proportional to leaf to air vapor pressure deficit (VPD) (Rees et al., 1993) as the activity is

reduced by closing the stomata, the assimilation decreases and with it the production also decreases (Figure 5).

The Andrada wheat variety maintains its pronounced stability, the mass of 1,000 grains (MTG) in both favorable and unfavorable environmental conditions (Ceclan et al., 2015; Blackman and Payne, 1987; Rees et al., 1993). The obtained values were higher and more balanced in the fertilized variants and the conventional tillage system, registering statistically significant negative differences compared to the control variant (Table 6).

Regarding MTG for the Andrada wheat variety, the values obtained in the conventional tillage system were higher in variants b_3, b_5 and b_9 where 2 and 4 foliar fertilizations with Folimax Gold and 4 foliar fertilizations with Microfert U were applied, registering statistically assured differences as significant and distinctly significant compared to the control variant. Regarding the quality indices, the protein values were higher than the control variant both in the conventional tillage system and in the no-tillage system obtained in all b_2, b_3, b_4 and b_5 variants foliar fertilized with Folimax Gold and the b_8 variant at Microfert U statistically assured differences as very significant positive compared to the control variant. In the no-tillage system, all foliar fertilized variants with both Folimax Gold and Microfert U were statistically assured as being significantly positive compared to the control variant.

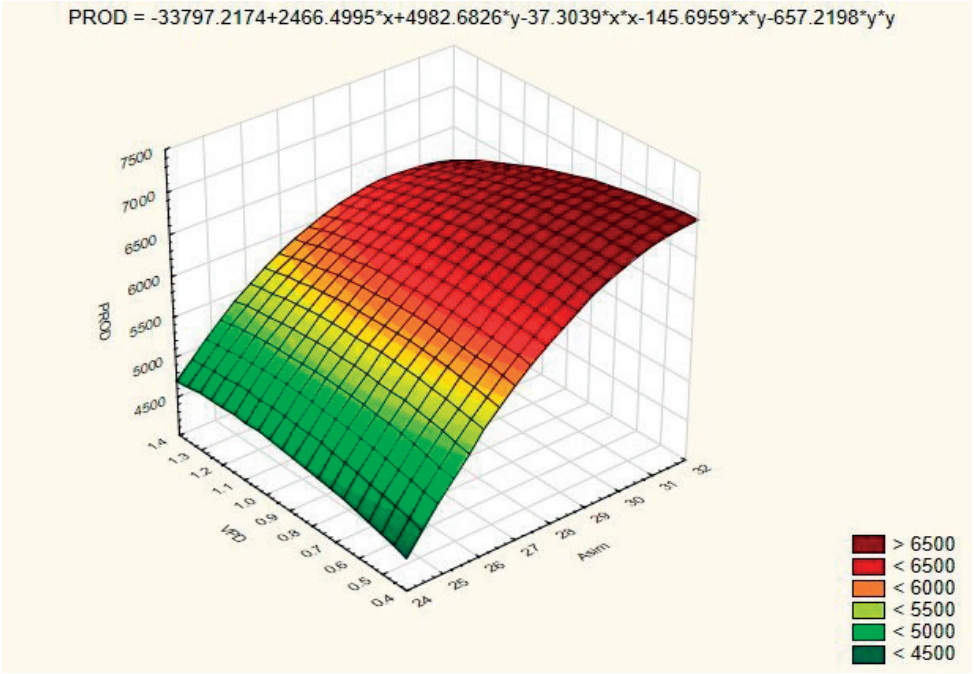


Figure 5. Multiple interaction between production, leaf to air vapor pressure deficit (VPD) and net assimilation (An)

Table 6. Quality indices for winter wheat Andrada in the years 2019-2020

Variants	Mass of 1,000 grains (MTG, g / significance)		Protein (% / significance)	
Fertilizer / Systems	Conventional tillage	No-tillage	Conventional tillage	No-tillage
b_1 - Control variant (cv)	51.2 / cv	51.2 / cv	11.8 / cv	11.7 / cv
b_2 - BF + 2 treat with FG	52.1 / -	52.0 / -	12.2 / *	12.7 / ***
b_3 - BF + 2 treat with FG	52.9 / *	50.6 / -	12.8 / ***	12.8 / ***
b_4 - BF + 3 treat with FG	51.7 / -	50.5 / -	12.0 / ***	13.3 / ***
b_5 - BF + 4 treat with FG	52.7 / *	50.5 / -	12.4 / ***	13.3 / ***
b_6 - BF + 2 treat with MU	52.3 / -	51.8 / -	11.8 / -	13.6 / ***
b_7 - BF + 2 treat with MU	51.3 / -	49.8 / 0	11.9 / -	12.5 / ***
b_8 - BF + 3 treat with MU	52.1 / -	51.4 / -	12.5 / ***	12.1 / *
b_9 - BF + 4 treat with MU	53.1 / **	52.1 / -	12.1 / -	12.2 / **
	LSD (p 5 %) = 1.37; LSD (p 1 %) = 1.84; LSD (p 0.1 %) = 2.43		LSD (p 5 %) = 0.36; LSD (p 1 %) = 0.48; LSD (p 0.1 %) = 0.64	

Variants	Gluten (% / significance)		Zeleny index (% / significance)	
Fertilizer / Systems	Conventional tillage	No-tillage	Conventional tillage	No-tillage
b_1 - Control variant (cv)	23.1 / cv	23.5 / cv	34.5 / cv	34.0 / cv
b_2 - BF + 2 treat with FG	24.1 / -	23.8 / -	38.1 / **	36.8 / *
b_3 - BF + 2 treat with FG	24.2 / -	25.4 / **	37.8 / **	42.2 / ***
b_4 - BF + 3 treat with FG	24.6 / *	26.5 / ***	39.8 / ***	45.9 / ***
b_5 - BF + 4 treat with FG	24.6 / *	26.5 / ***	39.8 / ***	45.8 / ***
b_6 - BF + 2 treat with MU	23.1 / -	27.3 / ***	34.9 / -	48.7 / ***
b_7 - BF + 2 treat with MU	22.7 / -	24.3 / -	32.6 / -	38.9 / ***
b_8 - BF + 3 treat with MU	24.2 / -	23.6 / -	38.1 / **	34.4 / -
b_9 - BF + 4 treat with MU	23.2 / -	26.2 / -	34.0 / -	37.6 / **
	LSD (p 5 %) = 1.22; LSD (p 1 %) = 1.64; LSD (p 0.1 %) = 2.17		LSD (p 5 %) = 2.18; LSD (p 1 %) = 2.94; LSD (p 0.1 %) = 3.89	

Note: BF - Basic fertilization; FG - Folimax Gold; MU - Microfert U; - not significant; * - significant positive; ** - distinctly significant positive; *** - very significant positive; 0 - significant negative; LSD - Least Significant Difference.

The percentage of gluten in the conventional tillage system was lower than in the no-tillage system on the variants where three foliar fertilizations b_3, b_4, b_5 and b_6 were applied with Folimax Gold, and Microfert U, being statistically assured as being very significantly positive compared to the control variant. Other research, regarding soil tillage system, in the Transylvanian Plain shows this trend (Grigoraș et al., 2012), but also in other pedoclimatic conditions (De Vita et al., 2007b).

The Zeleny index, correlated with ecological and technological factors (Gaweda & Haliniarz, 2021), had higher values in the no-tillage system than in the conventional tillage system, which was lower on the variants where foliar fertilizations with Microfert U were applied, being statistically assured as being very positive compared to the variant control.

CONCLUSIONS

Whilst applying foliar fertilizers, higher yields and quality indices for Andrada wheat variety were obtained in both conventional tillage and no-tillage systems compared to those where only basic fertilization was applied. This research results is very important for the technology applied in the Transylvanian Plain area, both in terms of quantity but especially due to the quality obtained.

The highest production in the experiences from 2020 was obtained in the conventional tillage system, with over 6,980 kg ha^{-1} for Folimax Gold and Microfert U fertilizers for variants where in addition to basic fertilization 3 and 2 foliar fertilization were applied.

The values of chlorophyll concentration, net assimilation and physiological parameters were higher for the Andrada variety in the conventional tillage system for all variants in which foliar fertilizers were applied, except leaf to air vapor pressure deficit (VPD), which had inversely proportional values.

Foliar fertilization applied to the Andrada wheat variety has beneficially influenced the quality indices in the two tillage systems, the percentage of protein obtained being between 12.1 and 13.8 %, gluten between 23.5 and 27.3%, Zeleny index between 35 and 48%, and the mass of one 1,000 grains was between 50 and 53.1 g.

The obtained results show the technological ways of influencing the quantity and quality of winter wheat production. Further research must be related to the sustainability of the tillage system, in a variable climatic context and other adaptation measures.

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