EFFECT OF CLIMATIC CONDITIONS ON SOME PHYSIOLOGICAL INDICATORS OF WINTER WHEAT CULTIVATED IN ORGANIC FARMING SYSTEM

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Abstract

Leaf area index, normalized index of vegetation and yield are important traits affected by environmental factors. The objective of this study was to evaluate the effect of three different year on leaf area index, normalized index of vegetation and its implication on the winter wheat yield cultivated in organic farming system. Twenty wheat cultivars were sowing during 2016-2018 under rainfed conditions at National Agricultural Research and Development Institute Fundulea, Romania, on a cambic chernozem soil. Climatic conditions and cultivars strongly influenced all studied traits in this study. The highest leaf area index and NDVI were reached in 2016, while the lowest ones were recorded in organic farming system for all cultivars in 2018. In conditions of 2018 year LAI ranged from 1.6 (Bezostaia) to 3.1 m^2/m^2 (Glosa), reflecting less favorable conditions of water and nutrients supply than in 2016 when in the same genotypes the LAI values were 0.35 and 0.54, respectively. The correlations between leaf area index, normalized index of vegetation and yield obtained in experimental years, were very significantly positive, suggesting that a higher yield in organic farming system can be associated with capacity of cultivar for a higher leaf area to achieve a good ground cover.

Key words: wheat, organic farming system, leaf area index, NDVI, yield

Wheat is the most commonly grown cereal in Romanian organic farming systems. Organic wheat production requires attention to soil fertility, rotation, agronomy, and grain storage to ensure product quality and marketability.

The theory and the agricultural practice concerning the formation of photosynthetic system with high productivity at wheat and not only shown that, no matter the culture system, the high and qualitative yield is conditioned by numerous factors. Among them, leaf area –main photosynthetic acceptor - depends both the air temperature, humidity, radiation, morphological traits and the agricultural practices, (Yuan L. *et al*, 2000; Rahman M.A. *et al*, 2000; Petcu E. *et al*, 2011). The NDVI index (Normalized Difference Vegetation Index) reflects the total amount of vegetation and the simplest approach considers NDVI as a predictor of grain yield, where a simple linear regression is used to predict yield. (Qi H. *et al*, 2020; Pismennaya D. *et al*, 2021; Atanasova E.V. *et al*, 2021).

In this context this paper aims to analyze the evolution of physiological indicators in some wheat varieties in organic farming system in the pedo-climatic conditions from Fundulea during three different years in order to established its implication on the grain yield of different winter wheat genotypes cultivated in organic farming system.

MATERIAL AND METHOD

The experiments were conducted in triplicate using a randomized block design during 2015-2018 in the field of organic farming on cambic chernozem soil from NARDI Fundulea (South – eastern part of Romania). It were used 25 genotypes of winter, most of them are Romanian wheat cultivars.

Leaf area index (coverage of ground vegetation) was measured at anthesis stage with a PCA-2000 plant canopy analyzer manufactured by LI-COR Inc.

Spectral reflectance was measured by a spectroradiometer (Green-Seeker Hand Held optical sensor unit, model 505; NTech Industries, Inc.,), above the canopy at 50 cm height at booting stage of wheat.

Statistical Analysis of the data was performed by analysis of variance and correlations between the characters studied.

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RESULTS AND DISCUSSIONS

The years of experimentation were totally different from the viewpoint of quantity and monthly reparations of rainfall. In vegetation period for wheat 2015-2016, from sowing to physiological maturity stage the cumulated rainfall was of 435.9 mm, by 91.2 mm above the multiannual average while in agricultural year 2018 the cumulated rainfall was of 344.7 mm, by only 20.5 mm above the multiannual average of the zone *(table 1)*. The moisture deficits from April up to May 2018 created unfavorable conditions during anthesis and filling of grain stage, determining the obtainment of relatively small yields in this year *(figure 1)*.

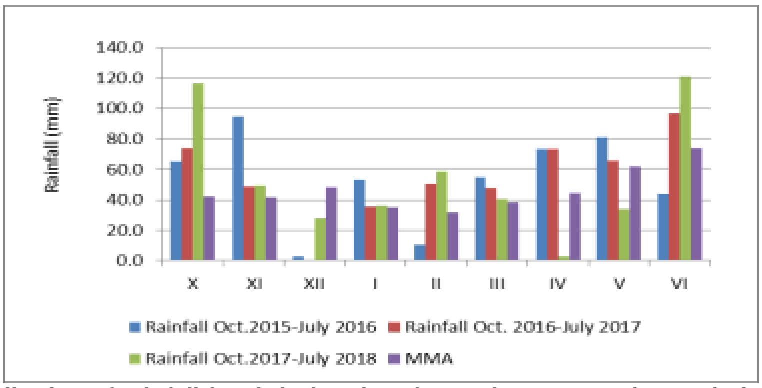

Figure 1 **Monthly distribution of rainfall (mm) during the winter wheat vegetation period. Fundulea, 2015 -2018**

In terms of temperatures, they were above the multiannual average in 2018 on entire period except March while in 2017 the temperatures were below the multiannual average during winter period and in April *(table 1)*.

Table 1

Average temperature (°C) during the winter wheat vegetation period. Fundulea, 2015 -2018

Month	2015 - 2016	2016 - 2017	2017 - 2018	*Multianual average*
X	10.8	10.3	11.7	*11.70*
XI	7.8	5.7	7.0	*5.75*
XII	3.1	-0.13	3.6	*0.15*
I	- 4.3	-5.5	0.8	*-1.8*
II	6.2	-0.3	1.6	*0.8*
III	7.7	8.6	3.3	*5.8*
IV	13.7	10.6	15.8	11.6
V	16.1	16.8	19.4	17.3
VI	22.9	22.4	22.6	21.5

Thus, the year 2018 was unfavorable both by the level of low rainfall and high temperatures compared to the agricultural year 2016 which was favorable. About 2017 the distribution of rainfall was less favorable and in addition the low temperatures in March delayed the growth processes in spring.

The moisture deficits from April (-42.2 mm) up to May (-28.3 mm) from 2018 created unfavorable conditions during reproductive anthesis and grain filling stages, determining the obtainment of relatively small average yields of 1709 kg/ha as compared cu 3193 kg/ha and 2385 kg/ha obtained under 2016 and 2017 conditions *(figure 2)*.

Analysis of variance for grain yield in comparative culture of winter wheat shows the very significant effect of year, genotype and its interactions *(table 2)*.

Table 2

Analyses of variance for yield

Source of variance	DF	Mean of squares	F factor
Factor A (year)	2	33186227	1824***
Error A	4	1821.93	
Factor B (Cultivar)	19	833726	155.97***
Interaction AxB	38	543735	101.72***
Error B	114	5345	

The studied wheat cultivars had a different yeld, from 2436 to 4183 kg/ha in 2016 and from 939 to 2333 kg/ha in 2018. Of the studied cultivars Voievod 1, A 4-10, S 119 and Bezoistaia presented the lowest average yield and Vestitor, Semnal, Izvor, Voinic Glosa and Litera the highest value (>2500 kg/ha) *(table 3).*

Table 3

The grain yield of studied cultivars

Cultivar	2016	2017	2018	Average
Glosa	3162	2749	1690	2534
Boema 1	3222	1927	1390	2180
Litera	3004	3410	2080	2831
FDL Miranda	2740	2065	1418	2074
Izvor	3245	3650	1506	2800
Otilia	2839	1909	2334	2361
Pitar	3314	2539	1764	2539
Pajura	3250	2120	1104	2158
Semnal	3747	2857	2040	2881
Ursita	2877	2668	1720	2422
Unitar	3507	1989	1926	2474
Vestitor	4183	2730	2138	3017
Voinic	3539	2578	1900	2672
Voevod 1	3636	1450	938	2008
A4 - 10	3424	1464	1529	2139
Adelina	3120	2006	1574	2233
S 119	2875	2486	1264	2208
Alex	2900	2449	1831	2393
LV 6110/12	2843	2525	2489	2619
Bezostaia	2436	2043	1555	2011
Average	*3193*	*2385*	*1709*	
STDEV	406.0	565.9	396.2	
CV (%)	12.71	23.73	23.19	

The highes leaf area index in organic farming system for all cultivars were reached in 2016 while the lowest ones was recorded in 2018 experimental year *(figure 2).*

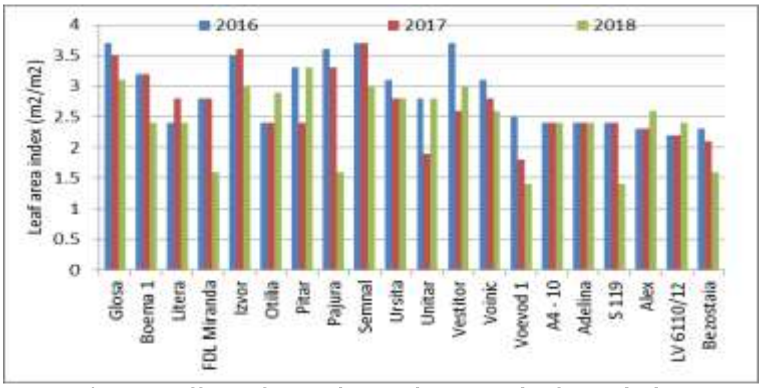

Figure 2 **Effect of experimental year on leaf area index**

It should be noted that the degree of overlap of leaves is optimal for production when photosynthetically active radiation [often abbreviated PAR, designates the spectral range (wave band) of solar radiation from 400 to 700 nanometers that photosynthetic organisms are able to use in the process of photosynthesis] are absorbed in their passage through the leaves.

In the most dicotyledonous crops, the leaves of which tend to be more or less horizontally, the optimum LAI is around value by 3 m^2/m^2. Cereals and grasses have narrower leaves which held more vertically so that light penetrates further into canopy and they tend to have higher values of optimal LAI, common around values of 4 to 5 m^2/m^2.

Research conducted in wheat (Slafer and Araus, 2007) revealed that an increase in leaf area index value depends on air temperature and its humidity, in some genotypes on ultraviolet-B radiation and responses to CO_2 and ozone, agricultural practice like irrigation and morphological characteristics of genotypes.

The existence of a variability in terms leaf area index shows the different capacity of the winter wheat cultivars studied in the management of water resources, which also reflect the positive correlation with the grain yield.

The correlation between grain production and the leaf surface index was positive, the correlation coefficients having values of 0.56-0.57 and 0.63 respectively for the three years of experimentation *(figure 3).*

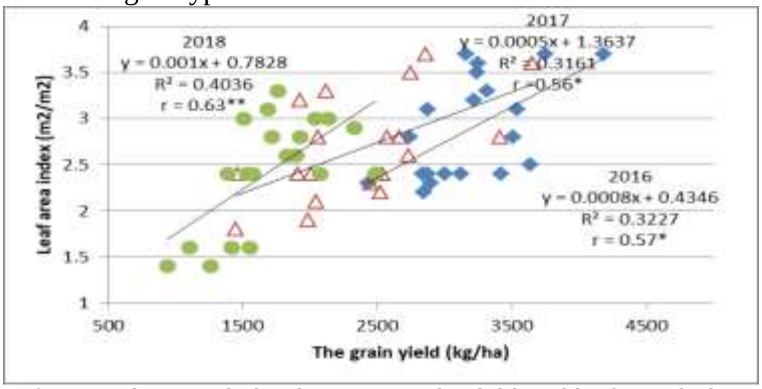

Figure 3 **The correlation between grain yield and leaf area index**

Indeed, it is observed that, for example, for 2018 the genotypes Voievod, S 119, Bezostaia, Pajura and FDL Miranda that had low values of LAI (between 1.4-1.8) achieved the lowest productions. The high yield, in the conditions of 2018, were obtained by the genotypes Lv 6110/12, Vestitor, Litera and Semnal, which had higher values of LAI between 2.4 and 3 m^2/m^2. There were also genotypes that, although they had high LAI values of 2.4-3 m^2/m^2 (eg Glosa, Boema) achieved relatively low yields. The data suggest that a great production does not always get a high leaf area index *(figure 3).*

In fact, as shown other researchers under field conditions, crop growth is dependent on the ability of canopy to intercept incoming radiation, and convert it into biomass (Golik S.I. *et al*, 2005).

In recent years, spectral vegetation indices (such as normalized difference vegetation index (NDVI) have been widely used to evaluate the fractional vegetation cover qualitatively and quantitatively and monitor crop growth.

Our research shown that the highest NDVI values were reached in 2016, while the lowest ones were recorded in organic farming system for all cultivars in 2018. In conditions of 2018 year NDVI values ranged from 0.2 (Voievod and Bezostaia) to 0.44 (Ursita), reflecting less favorable conditions of water and nutrients supply than in 2016 when in the same genotypes the NDVI values were 0.35 and 0.5, respectively *(table 4).*

It should be noted that of all the varieties studied, Ursita and Glosa showed superior NDVI values regardless of the year of experimentation.

Table 4

The normalized index of vegetation of studied cultivars

No	Cultivar	2016	2017	2018
1	Glosa	0.56	0.49	0.43
2	Boema 1	0.45	0.33	0.36
3	Litera	0.46	0.42	0.41
4	FDL Miranda	0.38	0.4	0.38
5	Izvor	0.45	0.38	0.38
6	Otilia	0.45	0.38	0.36
7	Pitar	0.48	0.45	0.38
8	Pajura	0.45	0.38	0.33
9	Semnal	0.46	0.38	0.33

10	Ursita	0.5	0.5	0.44
11	Unitar	0.48	0.4	0.4
12	Vestitor	0.46	0.36	0.35
13	Voinic	0.48	0.4	0.35
14	Voevod 1	0.48	0.2	0.2
15	A4 - 10	0.46	0.35	0.34
16	Adelina	0.36	0.3	0.34
17	S 119	0.37	0.33	0.28
18	Alex	0.36	0.38	0.36
19	LV 6110/12	0.36	0.38	0.38
20	Bezostaia	0.35	0.32	0.28
	Average	*0.44*	*0.37*	*0.35*
	STDEV	0.06	0.1	0.06
	CV (%)	13.0	17.5	15.5

The correlation among NDVI with grain yield was positive (*r = 0.51*, 0.52, 0.53*.*) *(figure 4).*

Relationship between LAI and NDVI is positive and linear (*r* = 0.62, 42 and 0.66**) during years 2014-15, 2016-17 and 2017-18, respectively *(figure 5)*.

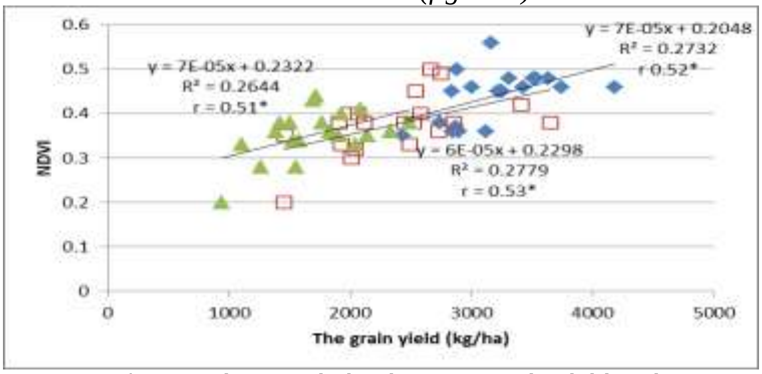

Figure 4 **The correlation between grain yield and NDVI**

Other studies evidentiated that the NDVI is well correlated with LAI and is more sensitive to changes in the crop canopy when the LAI is low (during the early stage), with the signal becoming saturated when the crop canopy is finished. Through NDVI from spectroradiometer and its slope curves to monitor winter wheat development, the results demonstrate that they could be used as cultivar-independent phenological indicators. However, using NDVI to conduct research on light distribution in crop populations is still barely reported (Karimpour M. *et al*, 2013; Sultana R.F. *et al*, 2014).

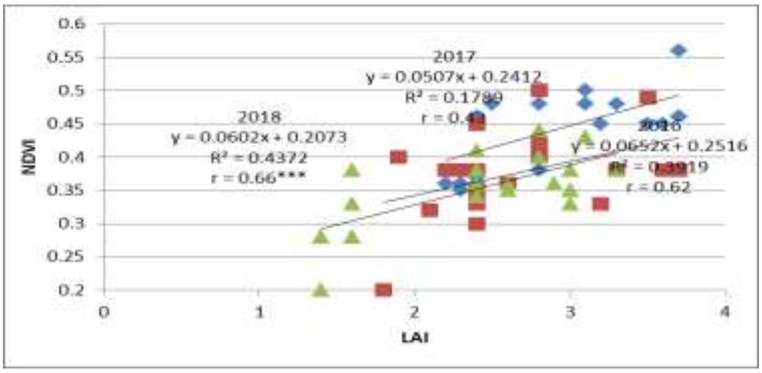

Figure 5 **The correlation between grain yield and NDVI**

The correlations between leaf area index, normalized index of vegetation and yield obtained in experimental years, were very significantly positive, suggesting that a higher yield in organic farming system can be associated with capacity of cultivar for a higher leaf area to achieve a good ground cover.

CONCLUSIONS

Wheat genotypes studied reacted differently to the weather conditions in terms of achieving physiological indicators and grain yield.

In organic conditions due to the microheterogenity of local conditions the correlation between NDVI and yield on different wheat cultivars is not sharp-related therefore, for yield forecasting models also pedoclimatic data should to be analyzed.

Further researchers and modelling work could be used for linking NDVI and quality parameters of wheat (Reznick J.P. *et al*, 2021), like protein content.

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