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EFFECT OF ORGANIC AND CONVENTIONAL FARMING SYSTEMS ON SOME PHYSIOLOGICAL INDICATORS OF WINTER WHEAT

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ABSTRACT

Leaf area index, biomass accumulation and yield are important traits affected by environmental factors. The objective of this study was to evaluate the effect of two different farming systems (organic and conventional) on leaf area index, biomass and grain yield. Twenty four wheat cultivars were planted during 2008/2009 and 2009/2010 under rainfed conditions at National Agricultural Research and Development Institute Fundulea, Romania, on a cambic chernozem soil. Crop farming system and cultivars strongly influenced leaf area index (LAI) in this study. The highest leaf area index was reached in conventional farming system, while the lowest ones were recorded in organic farming system for all cultivars and experimental years. In organic farming system LAI ranged from 1.87 (Flamura 85, 2009 year) to 3.02 (Dor, 2009 year), reflecting less favorable conditions of water and nutrients supply. The organic farming system produced less biomass than the conventional farming system. A significant correlation between biomass and LAI in organic farming system was found, while in conventional farming the correlation of these traits was not significant. The correlations between total biomass and yield, averaged on experimental years, were very significantly positive (r = 0.65* in conventional system, 0.70*** in organic system), suggesting that a higher yield can be associated with a higher biomass accumulation in any crop management system.**

Key words: wheat, conventional and organic farming system, leaf area index, biomass, yield.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's most widely grown crop. In Romania, winter wheat is also an important component of organic farming system. In organic agriculture, a production system based on reducing external inputs in order to promote ecosystem health, can be defined as a system that prohibits the use of synthetic fertilizers, chemical pesticides and genetically modified organisms. In organic agriculture, soil fertility and health are maintained by biological practices, such as crop rotation, hand work, weeding, use of green manure and compost and by selecting genotypes suitable for this type of farming. 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 farming system, a high and qualitative yield is conditioned by numerous factors. Among them, biomass accumulation and leaf area – main photosynthetic acceptor - depend both on the air temperature, humidity, radiation, morphological traits and on the agricultural practices (Yuan et al., 2000; Rahman et al., 2000; Petcu et al., 2003).

This paper aims to analyze the evolution of physiological indicators in some wheat varieties in organic farming system in the pedo-climatic conditions of Fundulea in order to choose the most efficient/suitable genotypes for this system of agricultural practice.

MATERIAL AND METHODS

The experiments were conducted using a randomized block design with 3 replications, during 2008/2009 and 2009/2010 in the field of organic and conventional farming on cambic chernozem soil at NARDI Fundulea (South-eastern part of Romania). 24 genotypes of winter wheat, mostly Romanian cultivars, were used.

Leaf area index (coverage of ground vegetation) was measured at anthesis stage

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with a PCA-2000 plant canopy analyzer manufactured by LI-COR Inc.

The above ground biomass was determined by sampling small plots consisting of 20 consecutive plants from the two central rows from three replicates.

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

RESULTS

The variability obtained in this study concerning leaf area index (LAI) was the result of both the crop farming system and cultivars. The highest leaf area index was reached in conventional farming system, while the lowest one was recorded in organic farming system for all cultivars and experimental years. In organic farming system LAI ranged from 1.87 (Flamura 85, 2009 year) to 3.02 (Dor, 2009 year), suggesting less favorable conditions of water and nutrients availability. Especially nitrogen level in the soil, which is a fundamental factor in determining leaf area index, was low (Figure 1).

Leaf area index (leaf area/unit area) is one of the most important indicators of biophysical processes involved in several canopy functioning processes (Baret and Vintilă, 2003).

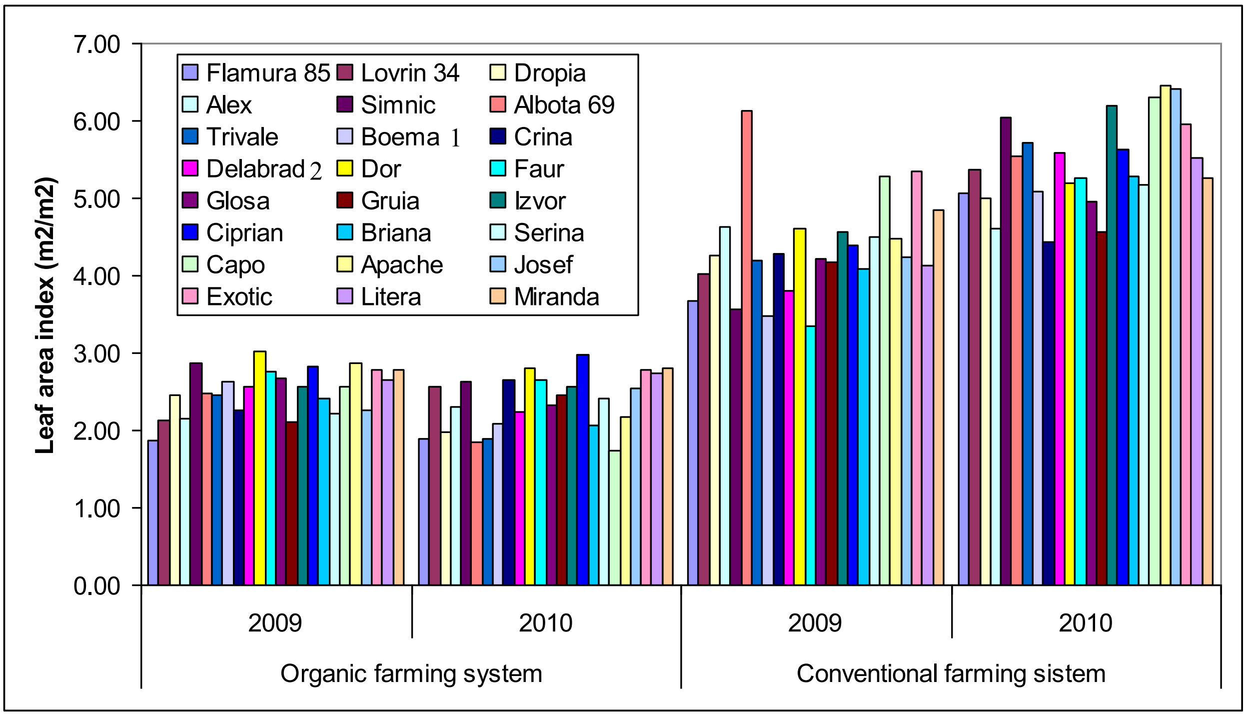


Figure 1. Effect of farming system on leaf area index

It should be noted that the degree of leaves overlapping is optimal for production when the photosynthetically active radiation (PAR), which includes the spectral range of solar radiation from 400 to 700 nanometers, is absorbed in its passage through the leaves. In the most dicotyledonous crops, in which the leaves tend to be more or less horizontal, the optimum LAI is arround 3. Cereals and grasses, which have narrower, more vertical leaves, so that light penetrates deeper into canopy, tend to have higher values of optimal LAI, commonly arround 4 to 5.

Research conducted in wheat (Yuang et al., 2000; 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 practices like irrigation and morphological characteristics of genotypes.

At a lower leaf density (as was the case in the organic system) the same leaf area corresponds to a greater absorption of light by a single plant, but reporting to an area, the crop produces less amount of dry matter.

When foliage area is higher (genotypes from conventional system with LAI more 5), assimilating areas interfere with shadowed areas, in maintaining a positive balance of carbon dioxide (CO_2) uptake. Thus, photosynthesis begins to gradually decline with the increase of LAI.

This might explain why wheat varieties with high LAI (eg. Albota 69) did not achieve high yields. This also explains the lack of co-rrelation between yield and leaf area index in conventional farming system and the significant correlation between these two parameters in organic farming system (Table 1).

Table 1. Relationship between leaf area index and yield

Leaf area index (m^2/m^2)		Yield (kg/ha)			
		Conventional system		Organic system	
		2009	2010	2009	2010
Conventional system	2009	0.089			
	2010		0.054		
Organic system	2009			0.41*	
	2010				0.52*

The data suggest that a high yield is not always associated with a large leaf surface. Sălăgeanu and Atanasiu (1981) showed that when the leaf surface of a culture is larger than 30000-40000 m^2/ha, although the percentage of energy absorbed increases, further increasing of the leaf area does not increase yield.

Under field conditions, crop growth is dependent on the ability of canopy to intercept incoming radiation, and convert it into biomass (Golik et al., 2005).

The results of the analysis of variance showed that the biomass accumulation of winter wheat was affected by the weather conditions, cultivars, as well as by interactions between these factors for both farming system (Table 2).

The biomass produced under organic farming system was less than the one produced in conventional farming system (Figure 2).

Horizontal line represents the average biomass of wheat in organic farming system (1352 g dm/m^2), averaged on the two years of experimentation and the vertical line represents the average biomass of wheat varieties studied in conventional farming system (1915 g dm/m^2) averaged on the two years of experimentation.

Table 2. Analyses of variance for biomass

Source of variance	DF	F factor for organic system	F factor for conventional system
Factor A (Year)	1	89.3517***	31.9254***
Error A	2		
Factor B (Cultivar)	23	16.7112***	52.7952***
Interaction A x B	23	5.2471***	12.9119***
Error B	92		

The analysis of biomass accumulation of each cultivar in the two farming systems, as compared to the average of all tested cultivars, distinguishes four distinct groups of cultivars (Figure 2).

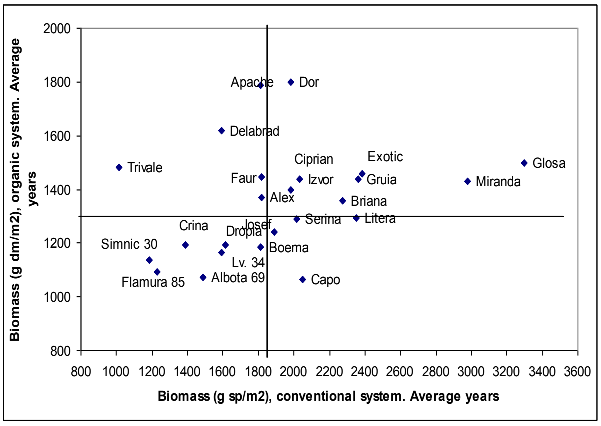


Figure 2. Biomass at flowering in winter wheat varieties in conventional and organic crop systems

Several cultivars (Glosa, Miranda, Exotic, Gruia, Briana, Izvor, Ciprian and Dor), located in the upper right quadrant of the graph produced high biomass in both farming systems. Varieties located in the lower right quadrant (Capo and Josef) produced a lower biomass in organic system. Varieties of left upper quadrant (Apache, Delabrad 2, Faur, Alex, Trivale) were below the average in conventional farming but had higher production of biomass in organic system. And finally, the fourth group includes varieties Şimnic 30, Albota 69, Crina, Flamura 85, Boema 1, Lovrin 34 and had relatively low biomass production in both conventional and organic systems (Figure 2).

The correlation between biomass and LAI was significant in organic farming system and not significant in conventional farming system (Figure 3). This can suggest that, leaf area index over 5 did not contribute significantly to increased biomass.

The years of experimentation were different from the viewpoint of quantity and monthly repartitions of rainfall. In 2008/2009, the cumulated rainfall from sowing to physiological maturity was 257 mm, insufficient for covering the winter wheat water requirements (Table 3). The moisture deficits from March up to May created unfavorable conditions during reproductive organs appearance, determining relatively low yields under organic farming system.

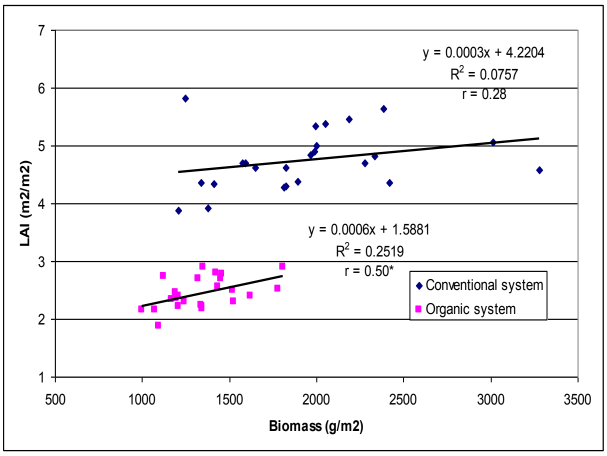


Figure 3. Relationships between biomass and leaf area index (average of experimental years)

In 2009/2010, the cumulated rainfall during Octomber - May exceeded with 92 mm the normal of the zone (336 mm), suggesting favorable conditions for winter wheat crop, but rains were unevenly distributed along the winter wheat vegetation period. Thus, April and May registered a moisture deficit of 31.7 mm, while June was rainier with 32.8 mm vs. multiannual average (Table 3).

Table 3. Average temperature (°C) and monthly distribution of rainfall (mm) during the winter wheat vegetation period. Fundulea, 2008/2009; 2009/2010

Month	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July
Temperature 2008/2009	12.6	5.8	2.5	-1.0	2.4	5.9	11.5	17.6	21.8	24
Temperature 2009/2010	12.1	7.5	0.5	-3.7	-0.5	4.9	11.9	17.3	21.7	23.6
Multiannual average	11.2	5.1	-0.2	-2.4	-0.3	4.7	11.1	16.9	20.6	22.5
Rainfall 2008/2009	25.9	27.5	33.2	69.2	25.5	32.3	22.1	21.3	65.2	23.3
Rainfall 2009/2010	60.1	19.1	54.9	45.4	69.8	105.8	41.8	31.2	104.5	95.0
Multiannual average	38.8	44.6	44.8	33.3	31.8	38.8	45.1	59.6	71.7	69.7

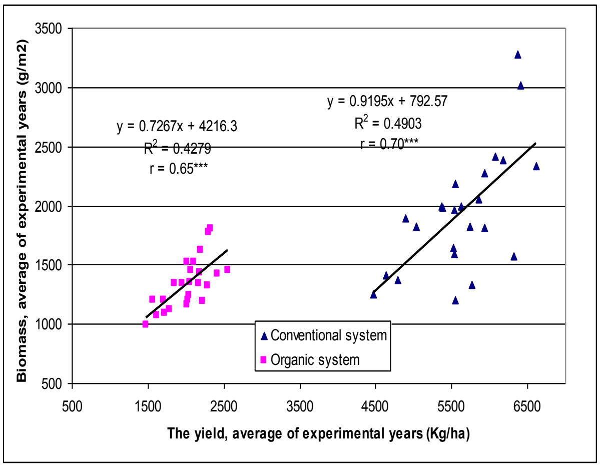
The results of the analysis of variance showed that the yield of winter wheat was significantly affected by the weather conditions of the two years in conventional farming, and not in organic farming. Cultivars, as well as the interaction between cultivars and years significantly influenced yield in both farming systems (Table 4).

A possible explanation might be that in conditions of organic farming factors other than weather conditions limited yield in the more favorable year.

Table 4. Analyses of variance for yield

Source of variance	DF	F factor for organic system	F factor for conventional system
Factor A (Year)	1	0.7282	74.90***
Error A	2		
Factor B (Cultivar)	23	15.61***	8.79***
Interaction A x B	23	11.25***	5.87***
Error B	92		

Very significant positive correlations (r = 0.65*** and 0.70*** in the conventional and organic farming respectively) were found between total biomass and yield, averaged over the two experimental years (Figure 4). This suggests that higher biomass accumulation is a condition for obtaining high yields, in both farming systems. Similar results have been obtained by other authors (Shahanaz et al., 2002; Petcu et al., 2003).



Fiure 4. Relationships between biomass and yield (average of experimental years)

CONCLUSIONS

The studied wheat cultivars responded differently to the farming system used (organic or conventional) in terms of achieving physiological indicators involved in the yield formation.

The study established that, especially in organic farming system higher yield were obtained in the winter wheat cultivars, which were able to form larger leaf area index and higher biomass.

Among the studied genotypes, several cultivars, including Glosa, Miranda, Exotic, Gruia, Briana, Litera, Izvor, Ciprian and Dor, accumulated relatively higher biomass in both farming systems, suggesting a better ability to adapt to different conditions.

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