RELATIONSHIP BETWEEN LEAF AREA INDEX, BIOMASS AND WINTER WHEAT YIELD OBTAINED AT FUNDULEA, UNDER CONDITIONS OF 2001 YEAR

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ABSTRACT

Several data of the ADAM (Assimilation of Data within Agricultural Models) project were used to establish the relationships between agronomic variables of winter wheat. During the campaign 2000-2001, ten calibration units from seed production farms of A.R.D.I. Fundulea were selected based on several factors of variation, such as: the cultivar (Dropia and Flamura 85); the preceding crops, soils with different microtopography and nitrogen fertilization. Positive correlations between leaf area index and biomass of winter wheat in different developmental phases were found (from r = 0.66* to r = 0.84*). The biomass was correlated with yield (r = 0.65*), number of seeds and number of ears/m^2 (r = 0.63*, r = 0.72**), too. The results of regression analysis indicate that polynomial models gave the best fit for regression of total biomass and LAI (max) on harvest index and linear model for grain yield. The coefficients of determination between harvest index and total biomass are smaller than those between harvest index and grain yield. This means that wheat crops with the highest harvest index do not necessarily have the highest biomass accumulation. In fact, the opposite can be true. The magnitude of coefficient of determination for the regression of total biomass and grain yield on harvest index indicates that approximately 0.34 % of the total variation of total biomass can be attributed to variation in harvest index of the analysed wheat crop. The low correlation of this study between LAI and TKW (r = 0.29) indicates that these two traits are largely independent of each other. In fact, TKW depends on the genetic background as some researchers have reported.**

Key words: leaf area index (LAI), winter wheat biomass, grain yield

INTRODUCTION

The theory and the agricultural practice concerning the formation of photosynthetic systems with high productivity have shown that the high and qualitative yield is conditioned by numerous factors. Among them, the environmental factors with direct effect on photosynthetic activity, but also the physiological state during growth and development of the plants are very important.

An optimal combination of these factors, is necessary, but the dependence between internal factors with environmental ones is not enough known.

Recently, the leaf area index or other indices of vegetation have been used in agricultural models for biomass estimation and yield prediction (Major et al., 1986; Tucker et al., 1980).

The objective of this paper was to establish the relationship between leaf area index, biomass and wheat yield.

MATERIAL AND METHODS

The investigations were performed at Fundulea during 2000-2003 in the framework of the bilateral collaboration project with France (ADAM project). The paper presents the results of the 2000-2001 campaign, when ten experimental locations were sampled.

The selection was achieved by combining several possible factors of variation including: cultivar, the preceding crop, micro-topography and the nitrogen fertilization; the wheat experimental locations were placed in Progresul 1, Tipei, Culturi Irigate and Ileana farms of A.R.D.I. Fundulea (Table 1).

The leaf area index and biomass measurements were performed on about 10 day basis and the used samples corresponded to 3-4 replicates of 0.5 m on two adjacent rows randomly located. The yield and its components were also determined.

RESULTS AND DISCUSSION

The mean and range for leaf area index (one of the most important biophysical index involved in several canopy functioning processes, Baret and Vintila, 2003) and biomass of the wheat crop in the experimental locations are presented in table 1. The variability obtained in this study is the result of the crop management. The highest leaf area index (6.34) and biomass (1534.4 g dry mat-

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ter/m^2) were reached in location number 4 while the lowest one was recorded in location number 9.

Table 1. The characterization of experimental locations

Locations, sowing date	Genotypes	Soils	Preceding crops	Ferti-lization*
1/10th 2000	Dropia	Cambic chernozem (typical)	Soybean	N+
2/4th 10. 2000	Dropia	Cambic chernozem (typical-cumulative)	Cicer	N-
3/7th 10. 2000	Flamura 85	Cambic chernozem (typical)	Cicer	N+
4/2nd 10. 2000	Dropia	Clay-illuvial chernozem	Maize	N+
5/10th 10. 2000	Dropia	Cambic chernozem (typical)	Maize	N+
6/2nd 10. 2000	Flamura 85	Cambic chernozem (on slope)	Wheat	N+
7/1st 10. 2000	Flamura 85	Cambic chernozem (typical)	Cicer	N-
8/5th 10. 2000	Dropia	Cambic chernozem (typical)	Pea	N+
9/4th 10. 2000	Dropia	Cambic chernozem (typical)	Pea	N+
10/9th 10. 2000	Flamura 85	Cambic chernozem (underground water stage)	Soybean	N+

* N+: satisfactory fertilization level
N-: limitation in nitrogen fertilization

Total biomass and LAI were closely correlated until anthesis.

The linear regression between these parameters indicates the correlation coefficient from 0.72** to 0.66 for inflexion point of LAI(i) to maximal point of LAI(k) (Figures 1, 2, 3).

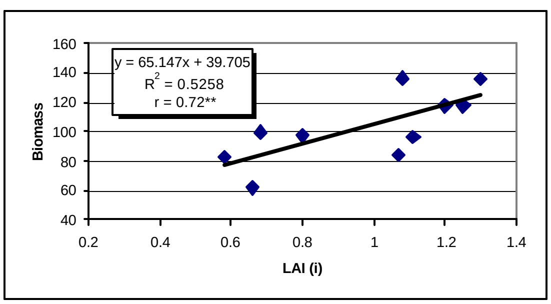

Figure 1. The relationship between biomass and leaf area index in inflexion point of LAI

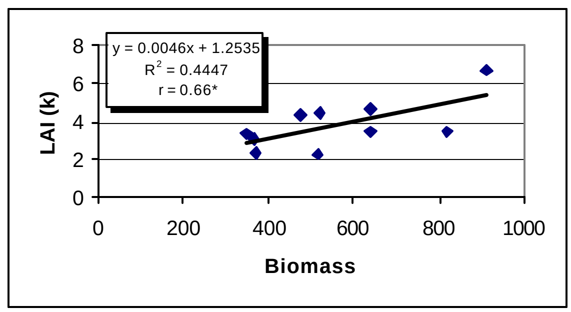

Figure 2. The relationship between biomass and leaf area index in maximal point

The similar correlation for durum wheat under Mediterranean conditions in different developmental phases (r = 0.87; 0.78) was reported by Aparicio et al., 2002.

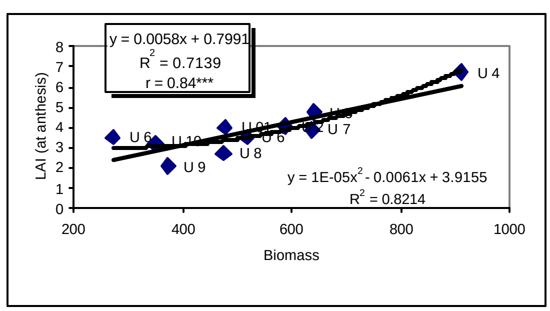

Figure 3. The relationship between biomass and leaf area index in anthesis phase

There is no correlation between biomass and leaf area index in declined point of LAI (Figure 4).

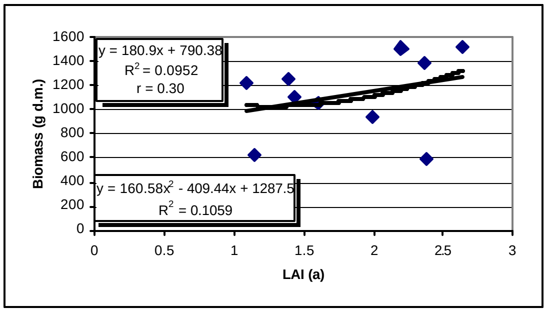

Figure 4. The relationship between biomass and leaf area index in declined point

These results indicate a simultaneous increase of biomass and leaf area index until anthesis phase. Sala geanu and Atanasiu (1981) show that high yields are not always obtained with high leaf area: if the crop leaf area increases up to 30.000-40.000 m^2/ha, the percentage of the absorbed energy increases, but the further increasing of leaf area does not always lead to the increase of this percentage.

In this respect, we studied the correlations between these parameters and wheat yield. In Table 2, the yield, TKW, number of ears and seeds/m^2 and biomass at harvest are presented.

The variability of these elements is due, on the one hand, to the genotype but, on the other hand, to preceding crop, soil and fertilization. The highest yield was recorded in experimental location 4 (Tipei Farm) under the following conditions : clay-illuvial chernozem, maize as preceding

Table 2. The mean yield and its components recorded in experimental locations

Experimental locations	Yield		Ears		TKW		Seeds		Biomass	
	(g/m^2)	S.D.*	(no/m^2)	S.D.*	(g)	S.D.*	(no/m^2)	S.D.*	(g/m^2)	S.D.*
U-1	327.1	52	317	43	39	5.1	8352.95	26	1029.8	102
-2	507.61	97	400	43	40	1.4	12730.3	32	1160.39	86.8
U-3	377.17	123	338	46	41	7.7	9298.56	27	1364.19	422
U-4	598	128	558	67	40	3.7	14927.9	27	1534.41	376
U-5	457.08	127	418	119	40	2.3	11381.8	27	1339.7	441
U-6	339.71	110	349	29	38	5.8	9004.34	26	1053.19	304
U-7	467.99	210	377	112	46	3.3	10222.8	27	1026.05	461
U-8	342.32	85	291	32	40	5.0	8466.56	29	1180.51	400
U-9	501.85	92	406	54	45	1.5	11232.4	28	937.46	272
U-10	503.23	193	410	61	45	3.7	11276.7	28	1214.34	311

*S.D. = standard deviation

Table 3. Relationships between the investigated agronomic variables

Independent variable (x)	Dependent variable (y)	Regression	Determination coefficients R^2	Correlation coeficients r
Biomass	Harvest index	Y = 0.1893 x + 218.1 Y = 0.0012 x^2 – 2.7813 x + 2004.3	0.15 0.34	-0.39 0.58*
Yield	Harvest index	Y = 0.0388 x + 18.977 Y = -0.0004 x2 + 0.406 x – 63.689	0.72 0.58	0.84*** 0.76**
Yield	LAI (k)	Y = 0.0053x + 1.266 Y = 3E-0.5x2 – 0.0202x + 7.1403	0.35 0.51	0.59* 0.71**
Harvest index	LAI (k)	Y = -0.483x^2+5.9031x+23.114	0.12	-0.34
LAI (k)	TKW	Y = -0.66x + 43.77	0.0859	0.29
Yield	Biomass	Y = 1.5552x –119.71 Y = 0.0092x^2-7.4551x+2608.7	0.042 0.278	0.65* 0.51
LAI (k)	Seeds/m^2	Y = 390.76x^2-2109.8x+12.610 Y = 1186x + 6259.1	0.57 0.475	0.75** 0.69*
Ears/m^2	Biomass (at anthesis)	Y = 6.1016x + 7223.5	0.4075	0.63*
Seeds/m^2	Biomass (at anthesis)	Y = 2.1241x-252.87	0.52	0.72**
Ears/m^2	LAI (k)	Y = 40.594x + 227.4	0.475	0.68*

crop, cultivar Dropia and fertilization in optimal rates.

Based on the experimental results, significant and complex relationships between the analysed characters were found (Table 3). The results of regression analysis indicate that polynomial models gave the best fit for regression of total biomass and LAI (max) on harvest index and linear model for grain yield. The coefficients of determination between harvest index and total biomass (R^2 = 0.34) are smaller than those between harvest index and grain yield (R^2 = 0.58). This means that an wheat crop with the highest harvest index does not necessarily has the highest biomass accumulation. In fact, the opposite can be true.

The low correlation of this study between LAI and the TKW indicates that these two traits are independent of each other. In fact, TKW depends on the genetic background as some researchers have reported.

There are also positive correlations between LAI and number of seeds obtained per m^2 (r = 0,69) and between biomass and number of grains and spikes per m^2, with correlation coefficients of 0.63 and 0.72 respectively.

CONCLUSIONS

The experimental results indicate a close correlation between leaf area index and biomass until anthesis phase and between biomass and the yield of tested winter wheat genotypes. Under different crop management conditions (two genoptypes, soil, preceding crop and fertilizer application), statistically assured coefficients of correlation were obtained. So, the values ranged from 0.66* to 0.84*** from the early stage of vegetation to anthesis phases. The biomass was correlated with the yield, number of seeds and number of ears/ m^2 (r= 0.65*; r = 0.63*, r = 0.72**).

These results suggest that LAI (until anthesis phase of development) could be used in agricultural models for biomass estimation useful in yield prediction.

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Table 1

Average yield of experiments with winter wheat cultivars, under irrigation and dry-land in six localities from the South of Romania (2002)

Locality	Average yield under:		Yield percentage diminution
	irrigation (kg/ha)	dry-land (kg/ha)	
Caracal	8560	5601	34.6
Marculesti	4716	3075	34.8
Teleorman	5963	3594	39.8
V. Traian	6941	3794	45.3
Fundulea	4858	1918	60.5
Simnic	(8560)	380	95.6

Table 2

Percentage diminution of some plant features under water stress conditions as compared to irrigation

Locality	Plant number	Plant height	Grain filling period	Spike number	Grain/ear	TKW	Test weight
Caracal	0	14,9	15,0	7,9	10,2	14,1	0,9
Teleorman	0	10,0	19,2	12,0	12,0	11,9	1,0
V.Traian	34,9	21,0	16,9	42,5	12,2	2,9	8,1
Fundulea	4,9	28,8	24,9	6,9	28,9	29,5	3,9

Simnic	27,6	61,7	30,0	65,0	64,5	53,1	10,7
Media	13,5	27,3	21,2	26,9	25,6	22,3	4,9

Table 3

Minimum, maximum and average yields registered at Fundulea in 2002 in international trials WWEERYT with genotypes grouped depending on the originating country

Source	Average yield of the tested genotypes (kg/ha)	Maximum yield of the tested genotypes (kg/ha)	Minimum yield of the tested genotypes (kg/ha)
Romania	2368	2953	2073
Russia	2327	2453	1980
Ukraina-Odessa	2224	3013	1287
Hungary	2181	2780	1320
Ukraina-Mironovka	2108	2753	1500
Moldova	1927	2560	1293
Bulgaria	1898	2873	1313
Turkey	1893	2420	1487
Azerbaidjan	1460	1553	1367
Kazahstan	1422	1833	853
LSD 5%	243	275	

Table 4

Correlations between yield under water stress conditions and different traits

Locality	Average yield diminution because of water stress (%)	Correlation coefficients between yield under water stress conditions and:						
		yield under irrigation	plant height under stress conditions	plant height under irrigation	heading time	spike/ m^2	grain/ear	TKW

Caracal	34,6	**0,48**	0,29	-0,31	-0,12	0,20	0,11	-0,30
Teleorman	39,8	**0,80**	0,35	0,31	**-0,85**	**0,58**	-	-
Valu Traian	45,3	0,04	0,33	0,20	**-0,40**	**0,42**	**0,40**	0,22
Fundulea	60,5	0,00	**0,46**	-0,31	**-0,46**	**0,52**	0,30	-0,17
Simnic	95,6	-0,01	**0,41**	**-0,62**	-0,04	**0,40**	**0,50**	0,15

The bold characters are significant at the probability level of 0.05

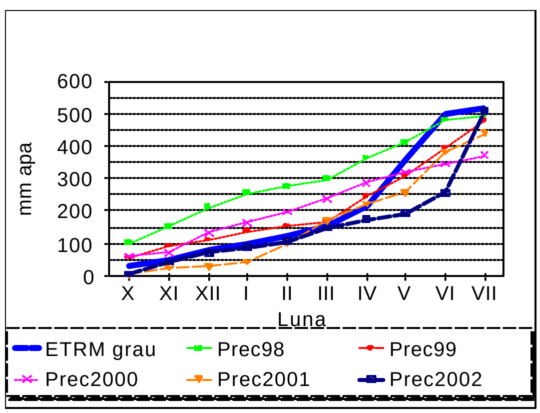

Figure 1. Average evapotranspiration and rainfall during 1999-2002 at Fundulea (mm water; month; wheat evapotranspiration; rainfall)

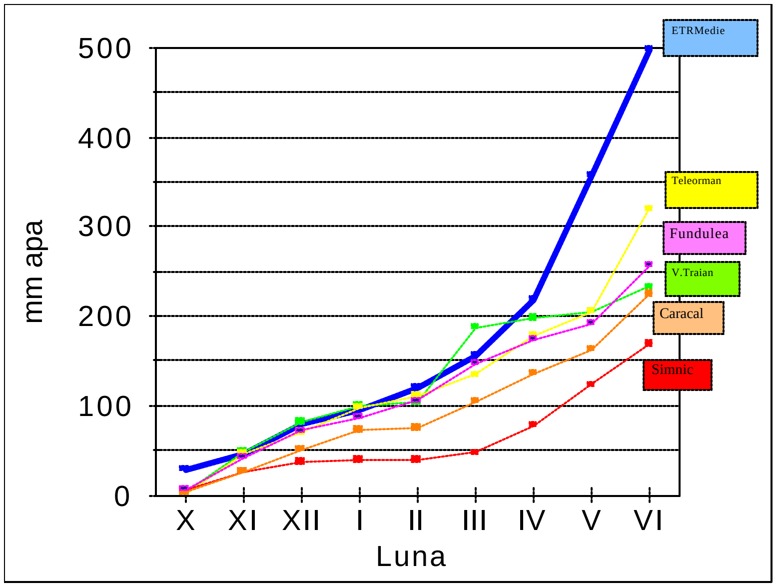

Figure 2. Average evapotranspiration and rainfall during the vegetation period in six locations of Southern of Romania in 2001-2002 year (mm water; month).

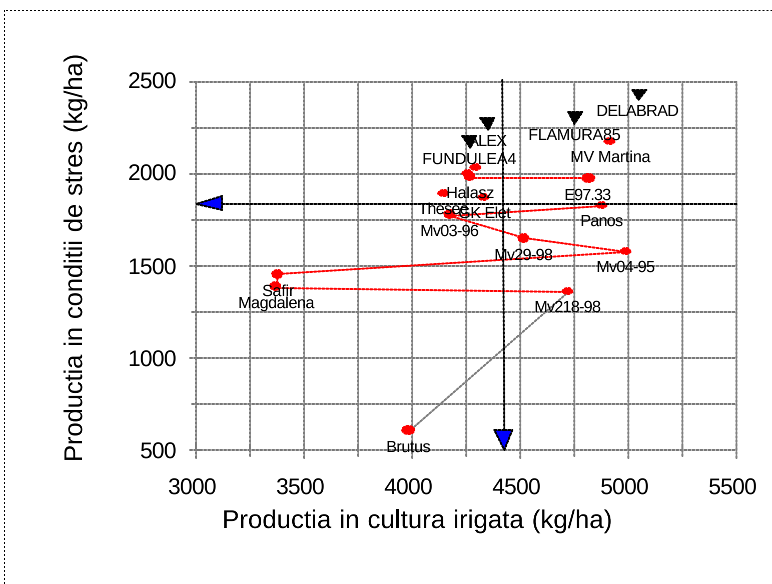

Figure 3. Yield obtained by some Romanian and foreign cultivars under irrigation and non-irrigation, in 2002 at Fundulea (arrows indicate the experiments average yield)(Yield under stress conditions; yield under irrigation).

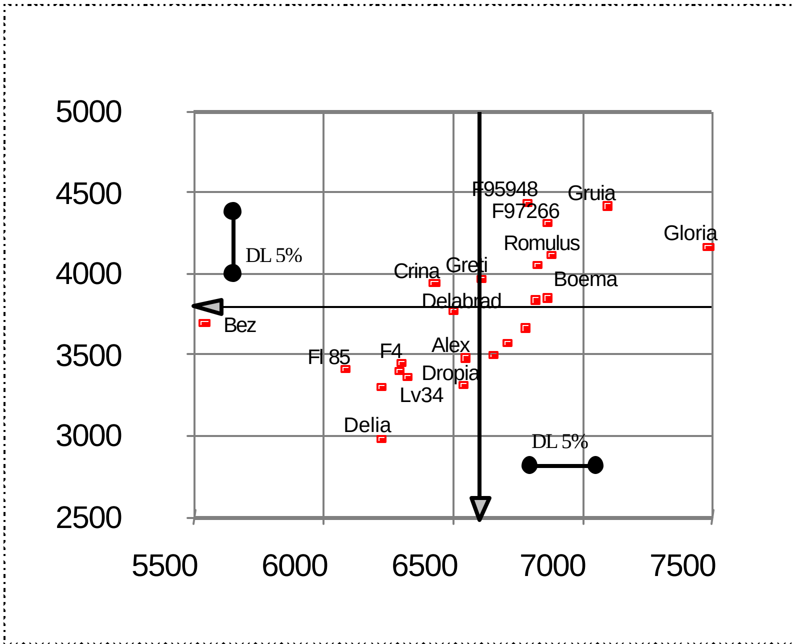

Figure 4. Average yields in four locations, obtained in 2002 by Romanian new lines and cultivars under irrigation and non-irrigation (arrows indicate experiments average yield)(Yield under non-irrigation; Yield under irrigation; LSD).