THE IMPACT OF AGROTECHNICAL FACTORS ON THE LEAF AREA INDEX (LAI), LEAF AREA DURATION (LAD) AND YIELD OF WINTER WHEAT

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Abstract

The experiments were carried out at the Látókép experimental station of the University of Debrecen on chernozem soil in a long term winter wheat experiment. As forecrop rotation, we set up two models: a biculture (wheat and corn) and a triculture (pea, wheat and maize). We applied three levels of nutrients during the fertilization process (control, $N_{50}P_{35}K_{40}$ and $N_{150}P_{105}K_{120}$).

The effect of pre-crops and nutrient-supply levels on LAI, LAD and yield of winter wheat has been investigated in this experiment. We tried to find out the extent of relationship between the different parameters. The increasing N fertilization significantly increased the LAI- and LAD-values. Crop rotation had a significant effect on the LAI and LAD values. The highest yields were obtained after pea in the fertilization treatment of N150+PK. There were significant differences in yield as an effect of higher fertilizer doses and crop rotation. These results have confirmed that the leaf area, the leaf duration, the fertilization and the forecrop have altogether resulted in the production of maximum grain yields.

Key words: Leaf Area Index (LAI), Leaf Area Duration (LAD), yield of winter wheat

INTRODUCTION

The productivity of winter wheat is determined by the genetic factors, by the ecological conditions and thirdly, by the agrotechnical factors. In the production technology of winter wheat, these factors should be harmonized. In line with sustainable crop production, such production biology studies and assimilation surface examinations need to be carried out with which could help in the exploration of the cause and effect relationships in yield formation. The important indicator is the leaf area index (LAI) determining the amount of yield. According to *Lönhardné and Kismányoky* (1992) & *Lönhard and Németh* (1988), N fertilization significantly increased leaf area index (LAI) and leaf area duration (LAD) in winter wheat and the leaf area index determined the yield. *Sugár and Berzsenyi* (2009) found differences in LAI values caused by nitrogen supply in 2007 and 2008 as well. The lowest LAI values were measured in the N_0 treatment which significantly increased at level N_{80} and reached the maximum – in line with seasonal dynamics – at N_{160} and N_{240} levels. *Petr et al.* (1985) found that the yield of cereals was increased leaf area index up to a certain limit. According to Pepó (2002), fertilization is one of the major technological elements of

wheat production, because it has a direct or indirect impact on all other technological elements. Application of N fertilizer is one of the most important measures that increase crop yield in agriculture. The contribution of N fertilizer application to the newly increased yield reaches 50% since 1960's in the whole world. However, misuse of N fertilizer (particularly overuse) will also cause the decline of economic effects and related environmental problems. Thus it is of course significant to optimize N fertilizer application in crop production. The amount, date and methods of N fertilizer application are three key factors that control the effect of N fertilizer on crop yield (*Liu et al.,* 2002).

Knowledge of the changes of leaf coverage over time and space is needed to understand the growth, development and yield formation of wheat (*Yang et al.,* 2007).

MATERIAL AND METHOD

The experiments were carried out at the Látókép experimental station (N: 47º33', E: 21º27') at the University of Debrecen on chernozem soil in a long term winter wheat experiment in the season of 2011, 2012 and 2013 in triculture (pea-wheat-maize) and biculture (wheat-maize) at three fertilization levels (control, $N_{50}+P_{35}K_{40}$, $N_{150}+P_{105}K_{120}$). The experimental parcels were set up in random arrangements in four repetitions. The wheat variety used in the long-term trial was GK Csillag. The most important agrotechnical and meteorological data is summarized in *Table 1.*

Table 1

Meteorological parameters (precipitation, mean monthly temperature) in the vegetation period of winter wheat (Debrecen, Hungary)

Month	mm	^{0}C	mm	^{0}C	mm	^{0}C	mm	^{0}C
	2010/2011		2011/2012		2012/2013		30 year average	
October	22,8	6,9	18,1	8,6	22,4	11,1	30,8	10,3
November	52,9	7,7	0	0,6	16,6	7,2	45,2	4,5
December	104,2	-1,7	71,1	1,5	65,8	-1,2	43,5	-0,2
January	19,2	-1,2	28	-0,6	38,7	-1	37	-2,6
February	16,8	-2,5	17,8	5,7	52,9	2,3	30,2	0,2
March	35,1	5	1,4	6,3	136,3	2,9	33,5	5
April	15,6	12,2	20,7	11,7	48	12	42,4	10,7
May	52,3	16,4	71,9	16,4	68,7	16,6	58,8	15,8
June	22	20,5	91,7	20,9	30,8	19,6	79,5	18,8

The applied research methods in winter wheat were the leaf area measurement and the calculation of leaf area duration.

The assessments were adjusted to the different phenophases of winter wheat (BBCH 22, BBCH 29, BBCH 32, BBCH 65, BBCH 73, BBCH 80). The leaf area index (LAI) per m^2 was determined using a portable leaf area meter (SunScan Canopy Analysis Systems).

Leaf area duration (LAD) is the area under the LAI curve over time. The long term relationship of information found from the leaf Area Index, where the volume of ground covered in relation to upper leaf surface area is measured against time. The statistical evaluation of the data was performed using the programs *Microsoft Excel 2013* and *SPPS for Windows 13.0*.

RESULTS AND DISSCUSIONS

A strong increasing period was observed in the leaf area index until the stages of 2-3 nodes-flowering. The maximum leaf area was obtained at that time, then a slow or steep reduction was found. The leaf area was significantly modified by the year and the agrotechnical factors.

After maize as a forecrop, fertilization had a significant effect on the dynamics and the maximum value of the leaf area index up to the N_{150}+PK treatment.

A similar trend could be observed in triculture and significant differences were measured between the three fertilization treatments in all three years.

When comparing the two crop rotation systems, we found that a moderate effect of the forecrop on the LAI values could be observed at the end of tillering, while at later phenophases the leaf area was significantly higher in triculture at all three fertilization levels. The LAI values were also higher at the last measurement after pea as a forecrop, the dying of leaves was quicker in biculture *(Table 2).*

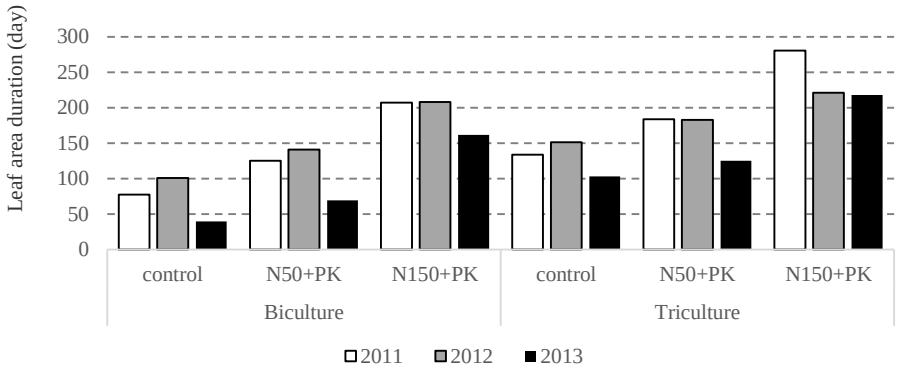
Fertilization had the greatest impact on the duration of leaves in all three experimental years, crop rotation had a weaker modifying effect on LAD values.

The highest LAD values were obtained at the fertilization level of N_{150}+PK in winter wheat, with 207-281 days in 2011, 208-221 days in 2012 and 162-218 days in 2013 (*Figure 1*).

Table 2

Development of LAI-values of winter wheat in a bi-and triculture crop rotation system (Debrecen, 2011-2103.)

	Crop rotation	Fertilization	BBCH 22	BBCH 29	BBCH 32	BBCH 65	BBCH 75	BBCH 80
2011	Biculture	control	0,3	1,1	-	1,3	-	0,6
		N_{50}+PK	0,5	1,8	-	2,0	-	1,1
		N_{150}+PK	0,6	3,0	-	3,4	-	1,5
	Triculture	control	0,4	1,8	-	2,2	-	1,3
		N_{50}+PK	0,8	2,6	-	2,8	-	1,6
		N_{150}+PK	1,0	3,9	-	4,1	-	3,0
	$LSD_{5\%}$ fertilization		0,2	0,8	-	0,8	-	0,6
	$LSD_{5\%}$ crop rotation		0,2	0,5	-	0,6	-	0,6
2012	Biculture	control	0,2	0,7	1,3	2,0	1,1	0,8
		N_{50}+PK	0,3	1,1	2,1	2,5	1,6	1,0
		N_{150}+PK	0,3	1,8	2,9	3,6	2,4	1,6
	Triculture	control	0,2	0,8	2,2	2,8	2,1	1,1
		N_{50}+PK	0,3	1,0	2,8	3,1	2,6	1,3
		N_{150}+PK	0,3	1,4	3,4	3,7	3,2	1,5
	$LSD_{5\%}$ fertilization		0,03	0,03	0,6	0,5	0,6	0,2
	$LSD_{5\%}$ crop rotation		0,03	0,03	0,6	0,6	0,5	0,3
2013	Biculture	control	-	0,5	0,9	0,7	0,3	0,3
		N_{50}+PK	-	0,9	1,6	1,2	0,5	0,5
		N_{150}+PK	-	2,6	3,1	2,5	2,1	1,7
	Triculture	control	-	1,2	2,0	2,2	0,8	0,7
		N_{50}+PK	-	1,7	2,3	2,5	1,3	1,0
		N_{150}+PK	-	2,9	3,9	4,2	2,6	1,9
	$LSD_{5\%}$ fertilization		-	0,3	0,4	1,1	0,4	0,3
	$LSD_{5\%}$ crop rotation		-	0,8	0,8	0,9	0,7	0,5



	LAD 2011.	*LAD 2012.*	*LAD 2013.*
$LSD_{5\%}$ fertilization	*38*	*27*	*37*
$LSD_{5\%}$ crop rotation	*52*	*35*	*46*

Figure 1. Effect of the agrotechnical factors (crop rotation, fertilization) on the Leaf Area Duration (LAD) of winter wheat (Debrecen, 2011-2013.)

The yield of winter wheat was significantly influenced by the fertilization and the crop rotation in the years of 2011, 2012 and 2013.

Table 3

Effect of fertilization and crop rotation on the yield of the winter wheat (Debrecen, 2011-2013)

Crop rotation	Fertilization	2011	Yield increase		2012	Yield increase		2013	Yield increase	
		kg ha^{-1}		%	kg ha^{-1}		%	kg ha^{-1}		%
Biculture	control	2046	0	100	2429	0	100	1558	0	100
	N_{50}+PK	4197	2151	155	5490	3061	226	3960	2402	254
	N_{150}+PK	7742	5696	201	8109	5680	334	7910	6352	508
Triculture	control	6570	0	100	5015	0	100	4811	0	100
	N_{50}+PK	8812	2242	134	6554	1539	131	6954	2143	145
	N_{150}+PK	9830	3260	150	8203	3188	164	8660	3849	180

Comparing maximum yields of wheat following maize and peas in 2011, it can be stated that the yields of wheat in triculture rotations were 2088-4615 kg ha^{-1} higher than the ones in the biculture at the same nutrition levels. The tendency was the same in 2012 and in 2013, statistically-proven positive impacts of crop rotation were also shown these years. Examining the effects of growing doses of fertilizers applied, results showed that yields increased significantly in both rotations until the N_{150}+PK level in all three experimental years (*Table 3*).

CONCLUSIONS

The LAI, LAD and crop results of winter wheat can be influenced mainly by raising the fertilizer amount. In the examined cropyears the effect of crop rotation was the most significant in case of N_{50}+PK treatment and in the control section. In case of the N_{150}+PK treatment the positive effects of peas as forecrop were not that significant in the results of LAI, LAD and yield of winter wheat.

Our results have confirmed that the leaf area, the leaf duration, the fertilization and the forecrop have altogether resulted in the production of maximum grain yields.

REFERENCES

1. Liu X., Z. Zhao, X. Ju, F. Zhang, 2002, Effect of N application as basal fertilizer on grain yield of winter wheat, fertilizer N recovery and N balance. Acta Ecologica Sinica. 22. 7. pp. 1122-1128.

2. Lönhard Mné, I. Németh, 1988, N-trágyázás hatása a búza (Triticum aestivum L.) levélfelületének alakulására. Növénytermelés. 37.4. 337-344.
3. Lönhardné B. É., T. Kismányoky, 1992, Az istállótrágya és egyéb trágyák hatása a búza termésére, LAI, LAD, NAR értékeinek alakulására, vetésforgóban. Növénytermelés 41.5. pp. 433-441.
4. Pepó P., 2002, Az őszi búza fajtaspecifikus tápanyagellátása csernozjom talajon. II. Növénytermesztési Tudományos Nap. pp. 105-110.
5. Petr J., V. Cerny, L. Hruska, 1985, A főbb szántóföldi növények termésképződése. Mezőgazdasági Kiadó. Budapest.
6. Sugár E., Z. Berzsenyi, 2009, Őszi búzafajták növekedésdinamikája és termésprodukciója eltérő N-tápelemszinteken. Tartamkísérletek jelentősége a növénytermesztés fejlesztésében. Jubileumi tudományos konferencia. Martonvásár, 2009. október 15. (ISBN: 978-963-8351-36-4.) pp. 159-164.
7. Yang P., W. B. Wu, H. J. Tang, Q. B. Zhou, J. Q. Zou, L. Zhang, 2007, Mapping Spatial and Temporal Variations of Leaf Area Index for winter wheat in North China. Agricultural Sciences in China. 6. 12., pp. 1437–1443.