

# The Effects of Crop Rotation and Nutrient Supply on the Leaf Area Values of Winter Wheat in a Long-Term Experiment

Gergely Szilágyi, Péter Pepó

**Abstract**—Our field experiments were set at the RISF Látókép Experimental Farm of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen, on lime-coated chernozem soil. During our studies, we have investigated two winter wheat varieties (GK Óthalom, Mv Csárdás) of different genotypes. The preceding crops were sunflower and grain maize. We examined wheat leaf area index (LAI) five times during by BBCH scale. We have found that during the different stages of the vegetation period, the LAI values were different depending on the preceding crop, variety and nutrient levels. According to our results, the lowest LAI values were experienced in the control treatment, in the case of both preceding crops. According to our studies we can conclude that crop rotation and fertilizer treatment influenced the studied physiological trait to different extents.

**Keywords**—Winter wheat, crop rotation, fertilization, genotype, LAI.

## I. INTRODUCTION

WINTER wheat plays decisive role among our domestic field crops. Besides corn, it is produced on the largest areas. In Hungary, winter wheat was produced on 1.063 million hectares in 2012 with a yield average of 3740 kg ha<sup>-1</sup> [10]. During the past decades, the domestic crop structure became simplified to cereals and oil plants (sunflower, oilseed rape). According to the research results of long-term experiments, we have concluded that in the case of winter wheat, the crop rotation and nutrient supply influenced the size of leaf areas. Wheat yields in monoculture were lower in all cases than in crop rotation. The yield-increasing effect of crop rotation was inversely proportional to the ratio of wheat in the sequence. The yield-increasing effect (t/ha) was greatest in the Norfolk rotation (1.505), followed by the alfalfa-maize-wheat triculture (1.069), the wheat-maize diculture (0.692) and the wheat-alfalfa diculture (0.35) [1]. The domestic field crop production is extremely one-sided, the total ratio of cereals (spiked cereals, corn, others) significantly exceeds (65.1%) those of the world (47-49%) and of the most important agricultural countries of the EU (France: 48.4%,

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Germany: 55.1%) [7]. Winter wheat is a nutrient demanding crop that responds to the applied nutrients very well. The harmonic nutrient supply (NPK) is a decisive, yield increasing agrotechnical element, even besides favourable nutrient and water management conditions of the soil [6]. The LAI values are strongly dependent on the nitrogen content of the soil [2]. The maximal LAI values during the growth of the flag leaf, independently of nitrogen and sulphur fertilization [8]. In a dry crop year, the LAI index was mainly influenced by the N supply, while in favorable crop years, the genotype also considerably influenced the LAI values [9]. By the maximal LAI values could estimate the aboveground dry material mass during vegetative growth [5]. Correlation between the LAI and the yield of winter wheat is highly significant [4]. The maximal LAI values experienced during flowering [3].

## II. MATERIALS AND METHODS

Our field experiments were set at the RISF Látókép Experimental Farm of the Centre for Agricultural and Applied Economic Sciences of the University of Debrecen, on lime-coated chernozem soil. The plots of the preceding crop and fertilization were set in four replicates, in a split-plot design. The preceding crops were sunflower and grain maize. During our studies, we have investigated two winter wheat varieties (GK Óthalom, Mv Csárdás) of different genotypes. In our experiments, we have studied three nutrient levels: in addition to control treatments N=60 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub>=45 kg ha<sup>-1</sup> and K<sub>2</sub>O=53 kg ha<sup>-1</sup>, and N=120 kg ha<sup>-1</sup>, P<sub>2</sub>O<sub>5</sub>=90 kg ha<sup>-1</sup> and K<sub>2</sub>O=106 kg ha<sup>-1</sup> fertilizer doses. The whole P and K fertilizer amounts were applied during autumn, while the first half of the nitrogen during autumn and the other half during spring. The applied fertilizer doses in the case of the different nutrient levels are listed in Table I.

TABLE I  
APPLIED FERTILIZER DOSES (DEBRECEN, 2013)

| Treatment | N                   | P <sub>2</sub> O <sub>5</sub> | K <sub>2</sub> O |
|-----------|---------------------|-------------------------------|------------------|
|           | kg/ha <sup>-1</sup> |                               |                  |
| Kontroll  | 0                   | 0                             | 0                |
| N60+PK    | 60                  | 45                            | 53               |
| N120+PK   | 120                 | 90                            | 106              |

The precipitation and temperature data are during the vegetation period of the year 2013 are listed in Table II.

TABLE II  
MAIN METEOROLOGICAL DATA OF VEGETATION PERIOD (DEBRECEN, 2012/2013)

|                                    | OCT. | NOV. | DEC. | JAN. | FEBR. | MARCH | APR. | MAY  | JUNE | Total/Average | Difference |
|------------------------------------|------|------|------|------|-------|-------|------|------|------|---------------|------------|
| Precipitation (mm)                 | 22,4 | 16,6 | 65,8 | 38,7 | 52,9  | 136,3 | 48,0 | 68,7 | 30,8 | 480,2         | 79,3       |
| Precipitation (mm) 30-year average | 30,8 | 45,2 | 43,5 | 37,0 | 30,2  | 33,5  | 42,4 | 58,8 | 79,5 | 400,9         | -          |
| Monthly average temperature (C°)   | 11,1 | 7,2  | -1,2 | -1,0 | 2,3   | 2,9   | 12,0 | 16,6 | 19,6 | 7,72          | 0,79       |
| Temperature (C°) 30-year average   | 10,3 | 4,5  | -0,2 | -2,6 | 0,2   | 5,0   | 10,7 | 15,8 | 18,7 | 6,94          | -          |

The temperature averages of the 2012/2013 cropyear and those of the 30-year average are depicted in Fig. 1 by the Walter-Lieth climate diagram. The year 2013 is considered as favourable, since the amount of precipitation (480.2mm) exceeded the 30-year average (400.9mm) by 79.3mm. The distribution of the precipitation was balanced from November to May. During the vegetation period, considerable amounts of precipitation fell in December, March and May (65.8 - 136.3 - 68.7mm). The temperature was considerably lower in

March (2.9°C), compared to the 30-year average (5.0°C). The snow-blanket provided adequate protection to the wheat stock. The favorable water supply of the vegetation period positively affected the vegetative and generative growth of the crop. In May, during milky ripeness, the appropriate amount of precipitation and the favorable average temperature was satisfactory for the stock. The average temperature of the vegetation period exceeded the 30-year average by +0.79°C.

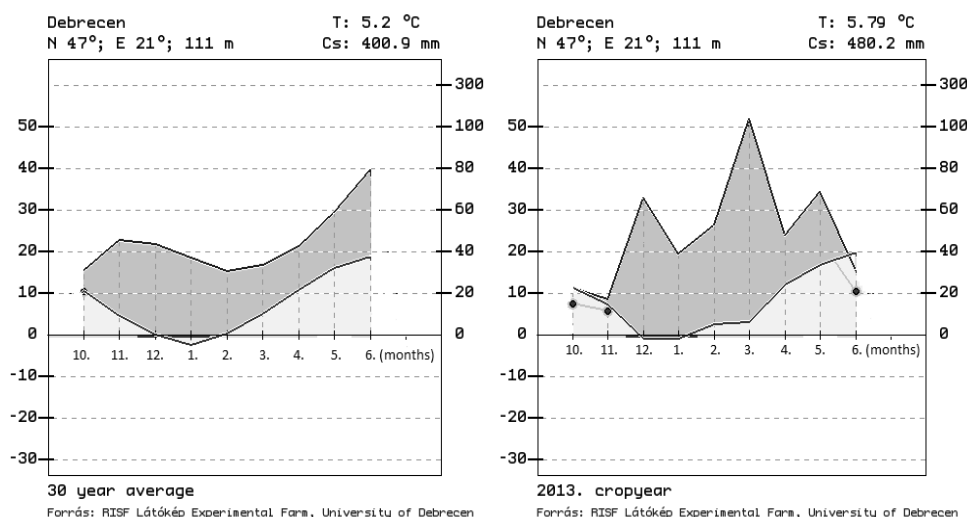


Fig. 1 Walter-Lieth climate diagram (Debrecen, 2012/2013)

The wheat leaf area index (LAI) was determined by SunScan Canopy Analysis Systems (SS1) mobile leaf area measuring equipment. The leaf area indices were determined five times during the studied vegetation year, by the BBCH scale: according to phenological maturation during shooting (24/04/2013), at the 2-3-nodal stage (09/05/2013), during flowering (29/05/2013), at milky ripeness (10/06/2013) and wax-ripening (29/06/2013). The obtained data were processed by Microsoft Excel.

### III. RESULTS AND DISCUSSION

We have investigated two winter wheat varieties of different genotypes (GK Óthalom, Mv Csárdás) after maize and sunflower preceding crops. The LAI values and standard deviations are listed in Tables III and IV. We have found that during the different stages of the vegetation period, the LAI

values were different depending on the preceding crop, variety and nutrient levels. According to our results, the lowest LAI values were experienced in the control treatment, in the case of both preceding crops. The lowest standard deviation was found in the case of the control treatments in the two studied genotypes. This suggests that the control treatment results in stabile LAI values. We have found that the LAI values significantly increased as an effect of the increasing fertilizer doses. The highest LAI values were obtained in the case of the N120+PK fertilizer treatment (GK Óthalom: 2.4 m<sup>2</sup>m<sup>-2</sup>; Mv Csárdás: 3.3 m<sup>2</sup>m<sup>-2</sup>). According to the data of Table III, the highest LAI values were measured after maize preceding crop, during flowering.

TABLE III  
AVERAGES AND STANDARD DEVIATIONS OF WINTER WHEAT LAI VALUES AFTER GRAIN MAIZE PRECEDING CROP (DEBRECEN, 2013)

| Varieties | GK Óthalom           |                    |        | Mv Csárdás |                    |        |         |
|-----------|----------------------|--------------------|--------|------------|--------------------|--------|---------|
|           | Date of measurements | Controll Treatment | N60+PK | N120+PK    | Controll Treatment | N60+PK | N120+PK |
|           | 2013.04.24           | 0,4                | 1,1    | 1,3        | 0,4                | 0,9    | 1,3     |
|           | 2013.05.09           | 0,9                | 1,5    | 2,3        | 0,7                | 1,3    | 3,0     |
|           | 2013.05.29           | 1,0                | 1,8    | 2,4        | 1,0                | 1,9    | 3,3     |
|           | 2013.06.10           | 0,9                | 1,8    | 2,3        | 0,9                | 1,9    | 3,3     |
|           | 2013.06.29           | 0,2                | 0,8    | 1,2        | 0,2                | 0,9    | 2,5     |
|           | Mean:                | 0,67               | 1,40   | 1,92       | 0,63               | 1,37   | 2,69    |
|           | CV:                  | 0,36               | 0,46   | 0,59       | 0,36               | 0,49   | 0,83    |

Table IV shows the changes of the LAI values after sunflower preceding crop. In the case of the LAI averages, we have also concluded that the lowest values were obtained in the case of the control and the N60+PK fertilizer treatments. In the case of the control treatment, the values of standard deviation in the case of the varieties were lower than after maize preceding crop. Compared to the control, the measured leaf area averages significantly increased in the case of the

N60+PK and N120+PK fertilizer treatments. The maximal LAI value interval (similarly to that in case of maize preceding crop) was measured in the N120+PK fertilizer treatment (GK Óthalom: 2.2 - 3.5m<sup>2</sup>m<sup>-2</sup>, Mv Csárdás: 1.9 - 3.5m<sup>2</sup>m<sup>-2</sup>). According to our results, the highest LAI values were measured at the end of the 2-3-nodal stage in the studied fertilizer treatments.

TABLE IV  
AVERAGES AND STANDARD DEVIATIONS OF WINTER WHEAT LAI VALUES AFTER SUNFLOWER PRECEDING CROP (DEBRECEN, 2013)

| Varieties | GK Óthalom           |                    |        | Mv Csárdás |                    |        |         |
|-----------|----------------------|--------------------|--------|------------|--------------------|--------|---------|
|           | Date of measurements | Controll Treatment | N60+PK | N120+PK    | Controll Treatment | N60+PK | N120+PK |
|           | 2013.04.24           | 0,6                | 1,7    | 2,2        | 0,5                | 1,7    | 1,9     |
|           | 2013.05.09           | 0,6                | 2,4    | 3,5        | 0,5                | 2,3    | 3,5     |
|           | 2013.05.29           | 0,8                | 2,1    | 2,8        | 0,8                | 2,3    | 3,2     |
|           | 2013.06.10           | 0,8                | 2,1    | 2,9        | 0,9                | 2,4    | 3,1     |
|           | 2013.06.29           | 0,5                | 1,3    | 3,1        | 0,4                | 1,9    | 3,2     |
|           | Mean:                | 0,66               | 1,91   | 2,88       | 0,61               | 2,09   | 3,00    |
|           | CV:                  | 0,13               | 0,41   | 0,48       | 0,20               | 0,30   | 0,61    |

#### IV. CONCLUSION

Based on our research results, we can conclude that the LAI values significantly differed as an effect of crop rotation and fertilizer treatments in the case of the studied winter wheat genotypes. We may also conclude that the maximal LAI values were obtained after sunflower preceding crop in the case of N60+PK and N120+PK fertilizer treatments. After sunflower preceding crop, the highest LAI values were measured at the end of the 2-3-nodal stage. After maize preceding crop, the maximal LAI values were measured during flowering, similarly to the data of [4], but contrary to the results of [9]. The LAI values of GK Óthalom and Mv Csárdás were similar after maize and sunflower preceding crops in the case of the control treatments. Considerable differences were observed in the case of N60+PK and N120+PK fertilizer treatments. The lowest LAI values were measured in the case of the control treatment (GK Óthalom: 0.2) confirming the results of [3]. In the case of the studied varieties, the highest LAI values were measured at the nutrient level of N120+PK, after either maize or sunflower preceding

crop, which confirmed the research results of [7]. According to our studies we can conclude that crop rotation and fertilizer treatment influenced the studied physiological trait to different extents.

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