

## PERFORMANCE OF WHEAT QUALITY CHARACTERISTICS IMPACTED BY PRECROP AND PLANT NUTRITION

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**Abstract:** Our field researches took place on the test farm of KIT Látókép of University of Debrecen, Centre for Agricultural and Applied Economic Sciences, in growing seasons 2012/2013 and 2013/2014, after previous cropping of sunflower with control,  $N_{60}+PK$  and  $N_{120}+PK$  fertilizer treatments, with varieties Mv Csárdás and Mv Toldi, on chernozem soil, in long-term experiment. According to our data, variety and the effect of the crop year strongly affected the values of the leaf area index (LAI) and the yield. Due to the mild winter in growing season 2013/2014 varieties had much larger assimilative surface, which caused increase in LAI and in the yield. Therefore the natural nutrient utilization capability of the varieties significantly increased. Compared to the previous year, in control treatment we measured 250.0-270.2% higher yield due to the favourable effect of the crop year. Maximum yield ( $8.21 \text{ t ha}^{-1}$ ) was measured with  $N_{60}+PK$  fertilizer treatment with variety Mv Toldi. According to our results, in the more favourable crop year of 2013/2014, differences of the SPAD values between the  $N_{60}+PK$  and  $N_{120}+PK$  treatments were minimum (changed between 2.8-6.3 units). It means that the effect of fertilization on SPAD values has reached its optimum level according to our yield results.

**Keywords:** winter wheat, crop rotation, nutrient supply, LAI, SPAD, yield

### Introduction

Winter wheat is one of our most important cereal crops. According to Slafer et al. (1994), winter wheat is one of the most widely grown cereal plant, produced in all regions of the world. According to Rajaram and Braun (2008), by 2020, 840-1000 M tonnes of winter wheat will be utilized. According to Richards (2000), compared to the previous century, yield of winter wheat has doubled. As per the data of the Central Statistics Office (2014), in our country the national average yield was  $4.64 \text{ t ha}^{-1}$  in 2013 and  $4.64 \text{ t ha}^{-1}$  in 2014. The crop year, the crop rotation and the nutrient supply affect its production the most extent. According to Pepó and Csajbók (2014), the effect of fertilization is less (26-28%) in crop years with favourable water supply, and more significant (50-75%) in dryer crop years. The second most important factor that affects yield is crop rotation 10.38-37.75%, depending on the crop year. Crop structure of our country has changed in a disadvantageous way, rate of cereal and oil crops has been centralized. Jolánkai et al. (2013) claimed that the negative effect of monoculture was also measurable

from the 6<sup>th</sup> year of continuous cropping. According to Berzsenyi and Danq (2002), nitrogen fertilization has a positive effect on the vegetative development of winter wheat. According to the research results of Lönhardné and Kismányoky (1992), the nitrogen significantly increased leaf coverage, leaf area duration and plant height. The leaf area index was first defined by Watson (1947), who compared the measured leaf area with a unit area of the soil.

According to Yang et al. (2007), the leaf area index (LAI) is an important parameter in such models which are related to the ecosystem, the carbon management, the climate and hydrology. Changing of the LAI values is an important point during production. According to Pepó (2005), maximum values of LAI were produced in the period of coming into ear-flowering in both crop years. In the dry year 2003, with  $N_{120}+PK$  treatment,  $3.31-3.62 \text{ m}^2\text{m}^{-2}$ , while in 2004 with favourable weather  $6.91 - 7.66 \text{ m}^2\text{m}^{-2}$  maximum LAI values were measured. Salvagiotti and Miralles (2008) partly agrees with Pepó's conclusions (2005), according to their results

they measured maximum LAI values up to 9.46 m<sup>2</sup>m<sup>-2</sup>. According to the results of Sugár and Berzsenyi (2009), in 2007 outstanding LAI values (10.6 – 11.5 m<sup>2</sup>m<sup>-2</sup>) were observed with variety Mv Toborzó with N<sub>160</sub> and N<sub>240</sub> fertilizer treatments. According to Kulig et al. (2010), LAI values correlate to the yield, the crop quality, the thousand grain weight as well as to the number of ears. Global warming affects plant production of our country, too. According to Tian et al. (2012), as an effect of warming, the flag leaf area increased by 36%, in the phenophase of flowering the total leaf area increased by 19.2%, which resulted in the increase of the yield.

Winter wheat can be rated to the group of C3 plants, the extent and volume of nutrient usage depend on the chlorophyll content. According to Wood et al. (1993), the Minolta SPAD appliance is a small manual spectrometer that measures the adsorption of light (650 nm) on the surface of the leaf, which is a non-destructive gauge of the chlorophyll and nitrogen content of the plant. According to Markwell et al. (1995) measurement of the chlorophyll content with Minolta SPAD-502 is appropriate. His research results are confirmed by that according to Ommen et al. (1999, there is a strong significant correlation between the SPAD values and the total chlorophyll content. Monje and Bugbee (1992) stated the opposite saying that the relationship between the chlorophyll content and the values measured by the Minolta 502 appliance is not linear. Fekete et al. (2015) claimed that the doses of nitrogen applied have significant impact on the SPAD values. According to Szilágyi (2014), with genotype Mv Csárdás, maximum SPAD value (42.8) was observed with N<sub>120</sub>+PK fertilizer treatment –after sunflower previous cropping - , in latic ripeness (BBCH 73-77). According to his data, there are considerable differences between the varieties. As for differences between the fertilizer treatments, according to Shi et al. (2010), there was no difference between SPAD values measured in N<sub>130</sub> and N<sub>300</sub> kg ha<sup>-1</sup> treatments.

## Material and method

Our researches done in long-term experiment took place on the test farm of KIT Látókép of University of Debrecen, Centre for Agricultural and Applied Economic Sciences, on calcareous chernozem soil in growing seasons 2012/2013 and 2013/2014. We examined to different genotypes (Mv Csárdás and Mv Toldi) after previous cropping of sunflower. The experiment were arranged in 4 replicates in split bands. We examined three different nutrient level. Besides the control treatment we spread dosages of 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>; 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>. We spread the nitrogen in 50-50% autumn and spring split, and spread 100% of the phosphorus and potassium dosages in autumn (Table 1.).

Table 1. Applied fertilizer doses (Debrecen, 2013-2014)

Fertilizer treatment	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
	kg ha <sup>-1</sup>		
Control	0	0	0
N <sub>60</sub> +PK	60	45	53
N <sub>120</sub> +PK	120	90	106

As per our examinations, growing seasons 2012/2013 and 2013/2014 can be considered as favourable, based on the measured meteorological data. According to the precipitation data, in the growing season 2012/2013, 480.2 mm, and in growing season 2013/2014 284 mm of rain fell. In the growing season 2013/2014, the average temperatures of 2.0 °C in January and 3.5 °C in February were extremely mild, which helped the development of winter wheat. We determined the LAI values with SunScan Canopy Analysis Systems (SS1) meter. SPAD results were defined with Minolta 502 hand machine, based on BBCH scale. According to phenological states of development, we carried out our measurements at stem elongation (BBCH 30-39) in stage with flowering (BBCH 61-69) during the stage of latic ripeness (BBCH 73-77) and grain ripening (BBCH 83-89). We averaged the LAI and SPAD values. We

measured our yield results with Sampoo parcel harvester. Our research data were analyzed by Microsoft Excel program. Our results demonstrate correlations between LAI and yield in growing seasons 2012/2013-2013/2014.

## Results

LAI and SPAD values measured in the examined growing seasons are shown in Figure 1. As an effect of fertilization, LAI values of the examined varieties changed on the same extent, no difference was observed between them. During linear regression analysis, close correlation was detected when analysing the LAI values of the varieties (Mv Csárdás  $R^2 = 0.9601 - 0.9908$ , Mv Toldi  $R^2 = 0.9700 - 0.9845$ ). In growing season 2013/2014, a large difference was measured during the analysis of the LAI and the yield (Table 2).

to our results, in the more favourable crop year of 2013/2014, differences between SPAD values measured with  $N_{60}+PK$  and  $N_{120}+PK$  treatments changed between 2.8-6.3 units. It indicates that the effect of fertilizer treatments on SPAD values has reached the optimum level. According to our data (Figure 2.), in crop year of 2013/2014, with the tested varieties, maximum yields were measured with the  $N_{60}+PK$  treatment (Mv Csárdás  $6.27 \text{ t ha}^{-1}$  – Mv Toldi  $8.28 \text{ t ha}^{-1}$ ).

Our data show that in the more favourable crop year (2013/2014) a larger difference (+23.1, +25.1) was detected between the control and the  $N_{120}+PK$  treatments, than in crop year 2012/2013 (+15.9, +18.7).

Based on the data of the analysed years, after previous cropping of sunflower, yield of winter wheat was influenced by the crop year and the

Table 2. Polynomial regression (yield (2013/2014)) and linear regression (LAI – SPAD – yield (2012/2013)) equations (Debrecen, 2013-2014)

Genotypes	Mv Csárdás	Mv Toldi
SPAD (2013. year)	$y = 9,35x + 16,933 \text{ R}^2 = 0,9794$	$y = 7,95x + 16,567 \text{ R}^2 = 0,9693$
SPAD (2014. year)	$y = 11,55x + 14,3 \text{ R}^2 = 0,9356$	$y = 12,55x + 13,5 \text{ R}^2 = 0,8325$
LAI $\text{m}^2\text{m}^{-2}$ (2013.year)	$y = 1,2x - 0,5333 \text{ R}^2 = 0,9908$	$y = 1,15x - 0,4667 \text{ R}^2 = 0,9845$
LAI $\text{m}^2\text{m}^{-2}$ (2014.year)	$y = 1,7x - 0,1 \text{ R}^2 = 0,9601$	$y = 2,3x - 0,5667 \text{ R}^2 = 0,9700$
Yield (2013. year)	$y = -0,61x^2 + 4,32x - 2,3 \text{ R}^2 = 1$	$y = -0,27x^2 + 3,01x - 1,14 \text{ R}^2 = 1$
Yield (2014. year)	$y = -1,375x^2 + 6,585x - 1,4 \text{ R}^2 = 1$	$y = -2,22x^2 + 10,94x - 4,72 \text{ R}^2 = 1$

Considering the SPAD values, in growing season 2012/2013, small differences were observed between the genotypes. As an effect of higher fertilizer treatment, compared to the control treatment, SPAD values of each varieties were higher (10.4-11.7 units) with  $N_{60}+PK$  treatment. Differences between the SPAD values measured with  $N_{60}+PK$  and  $N_{120}+PK$  treatments changed in a narrow interval (5.5-7.0 units)

Differences between those values measured with control and increased fertilizer treatments changed between 15.9-18.7 units. According

genotype. In growing season 2012/2013, the yield changed in nearly the same interval in case of all the nutrient treatments with the examined varieties (Mv Csárdás  $1.41-5.17 \text{ t ha}^{-1}$  – Mv Toldi  $1.60 - 5.46 \text{ t ha}^{-1}$ ). During the analysis of the yield we observed that the varieties utilized the naturally available nutrients of the soil on the same extent (Mv Csárdás  $3.81 - \text{Mv Toldi } 4.00 \text{ t ha}^{-1}$ ). We measured a much higher increase (250.0-270.2%) in the yield compared to the previous growing season in control treatment. Maximum yield was reached with  $N_{60}+PK$  treatment, with variety Mv Toldi. Maximum yield of Mv Csárdás was lower by  $2.01 \text{ t ha}^{-1}$

Figure 1: Average LAI and SPAD values after previous cropping of sunflower at different fertilizer dosages (Debrecen, 2012/2013-2013/2014)

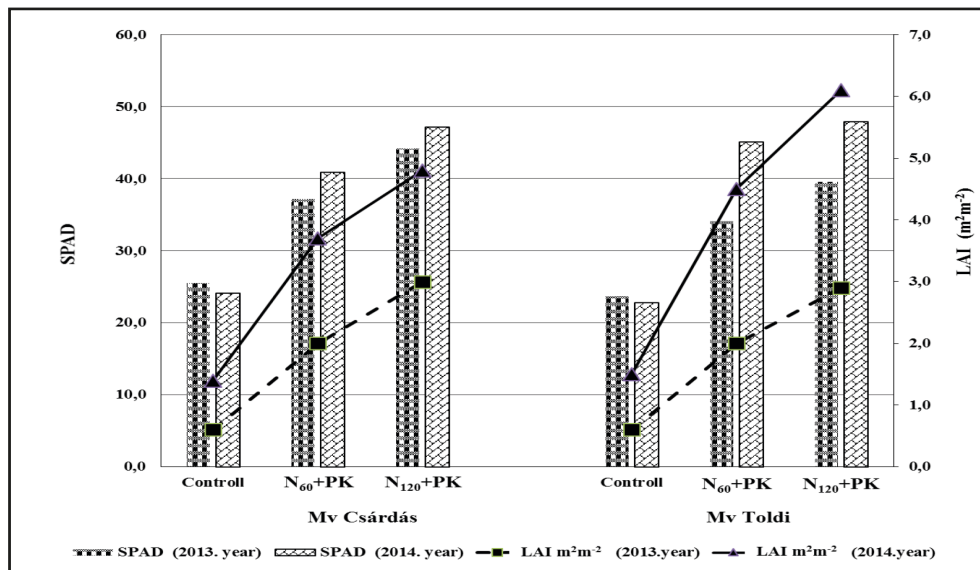
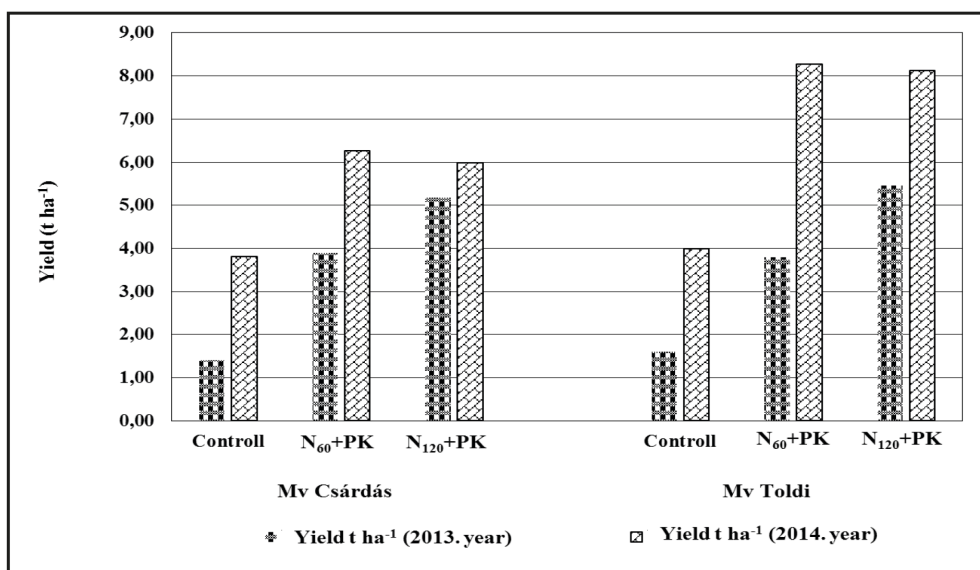


Figure 2. Yield results after previous cropping of sunflower at different fertilizer dosages (Debrecen, 2012/2013-2013/2014)



than with genotype Mv Toldi. According to our results, in growing season 2013/2014 the yield and the LAI values in N<sub>60</sub>+PK and N<sub>120</sub>+PK treatment were much higher than in the previous growing season. During regression analysis, we detected close correlation when we analysed the LAI values ( $R^2 = 0.9601 - 0.9908$ ) and the yields ( $R^2 = 1$ ). Results of our polynomial regression analysis show that there is a close correlation between the SPAD  $R^2$  values of the varieties in the examined years (Mv Csárdás 0.9356 – 0.9794; Mv Toldi 0.8325 – 0.9693).

## Discussion

According to the data of our field researches, the effect of the crop year significantly influenced the leaf area index (LAI), the chlorophyll content (SPAD) and the yield of winter wheat after previous cropping of sunflower. Based on our plant physiological measurements, during the tests of the varieties, we observed considerable differences. Our researches confirm research results of Pepó (2005), according to which significant

differences between the varieties were due to adaptation reasons. Our data confirm the results of Tian et al. (2012): with the increase of the average temperatures of winter months, the varieties reached higher LAI values and yield. This means that the genotypes utilize the naturally available nutrients of the soil and the applied fertilizer dosages also in calcareous chernozem soil, in case of a mild winter. Our results confirm the results of Markwell et al. (1995) and Fekete et al. (2015) also.

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### References

- Berzsenyi Z., Dang Q. L. (2002): Búza és kukorica vetésforgók elkülönítése diszkriminanciaanalízissel tartamkísérletben. *Növénytermelés* 51. 1. 21-37.
- Fekete Á., Tarnawa Á., Pósa B. (2015) Evaluating the correlation between yield characteristics and SPAD values of two different winter wheat variety (*Triticum Aestivum* L.) treated different nitrogen doses. *Növénytermelés* 64. 87-90.
- Jolánkai P., Tóth Z., Kismányoky T. (2013): Comparing the effect on monoculture in case of maize (*Zea Mays* L.) and winter wheat (*Triticum aestivum* L.) on different levels of plant nutrition and crop protection. *Növénytermelés* 62. 163-166.
- Kulig, B., Lepiarczyk, A., Oleksy, A., Kołodziejczyk M. (2010): The effect of tillage system and forecrop on the yield and values of LAI and SPAD indices of spring wheat, *European Journal of Agronomy* 33. 1. 43-51. DOI: <http://dx.doi.org/10.1016/j.eja.2010.02.005>
- Lönhardné B. É., Kismányoky T. (1992): Az istállótrágya és egyéb trágyák hatása a búza termésére, LAI, LAD, NAR értékének alakulására, vetésforgóban. *Növénytermelés* 41. 5. 433-441.
- Markwell J. - Osterman J. C. - Mitchell J. L. (1995): Calibration of the Minolta SPAD-502 leaf chlorophyll meter. *Photosynth. Res.* 46. 467–472. DOI: <http://dx.doi.org/10.1007/bf00032301>
- Monje O. A., Bugbee B. (1992): Inherent limitations of nondestructive chlorophyll meters: a comparison of two types of meters. *Hort. Sci.* 27. 69–71.
- Ommen O. E., Donnelly A., Vanhoutvin S., Oijen M. V., Manderscheid R. (1999): Chlorophyll content of spring wheat flag leaves grown under elevated CO<sub>2</sub> concentrations and other environmental stresses within the 'SPACE-wheat' project. *European Journal of Agronomy*.10. 197–203. DOI: [http://dx.doi.org/10.1016/s1161-0301\(99\)00011-8](http://dx.doi.org/10.1016/s1161-0301(99)00011-8)
- Pepó P., Csajbók J. (2014): Az agrotechnikai elemek szerepe az őszi búza (*Triticum aestivum* L.) termesztésében. *Növénytermelés* 63.3.73-94. DOI: <http://dx.doi.org/10.1556/novenyterm.58.2009.2.7>
- Pepó (2005): Szárazanyag- és levélterület – dinamikai vizsgálatok őszi búza állományokban. *Növénytermelés* 2005.54.1-2.65-75.
- Rajaram S., Braun H. J. (2008): Wheat yield potential. In: M. P. Reynolds, J. Pietragalla, H.-J. Braun (Eds.), *International Symposium on Wheat Yield Potential: Challenges to International Wheat Breeding*. CIMMYT. 103–107. DOI: <http://dx.doi.org/10.1017/s0021859607007034>
- Richards R. A. (2000): Selectable traits to increase crop photosynthesis and yield of grain crops. *J. Exp. Bot.* 51. 447–458. DOI: [http://dx.doi.org/10.1093/jexbot/51.suppl\\_1.447](http://dx.doi.org/10.1093/jexbot/51.suppl_1.447)

- Salvagiotti, F., Miralles D. J. (2008): Radiation interception, biomass production and grain yield as affected by the interaction of nitrogen and sulfur fertilization in wheat. *Eur. J. Agron.*, 28. 3. 282–290. DOI: <http://dx.doi.org/10.1016/j.eja.2007.08.002>
- Shi R., Zhang Y., Chen X., Sun Q., Zhang F., Römheld V., Zou C. (2010): Influence of long-term nitrogen fertilization on micronutrient density in grain of winter wheat (*Triticum aestivum* L.). *Journal of Cereal Science* 51. 1. 65-170. DOI: <http://dx.doi.org/10.1016/j.jcs.2009.11.008>
- Slafer G. A., Satorre E. H., Andrade F. H. (1994): Increases in grain yield in bread wheat from breeding and associated physiological changes G.A. Slafer (Ed.), *Genetic Improvement of Field Crops*. Marcel Dekker Inc. 1–68. DOI: [http://dx.doi.org/10.1016/0378-4290\(90\)90058-j](http://dx.doi.org/10.1016/0378-4290(90)90058-j)
- Sugár E., Berzsenyi Z. (2009): Őszi búzafajták növekedésdinamikájának vizsgálata eltérő N-szinteken Hunt-Parsons modellel. *Növénytermelés* 58. 4. 57-68. DOI: <http://dx.doi.org/10.1556/novenyterm.58.2009.4.4>
- Szilágyi G. (2014): Effects of crop rotation and nutrient supply on the SPAD values of winter wheat. *Növénytermelés* 63. 79-82.
- Tian, Y., Chen, J., Chen, C., Deng, A., Song, Z., Zheng, C., Hoogmoed, W., Zhang W. (2012): Warming impacts on winter wheat phenophase and grain yield under field conditions in Yangtze Delta Plain, China, *Field Crops Research* 134. 12. 193-199. DOI: <http://dx.doi.org/10.1016/j.fcr.2012.05.013>
- Watson J. (1947): Comparative physiological studies in the growth of field crops I. Variation in net assimilation rate and leaf area between species and varieties, and within and between years. *Annals of Botany*, 11. 41–76.
- Wood C.W., Reeves D.W., Himelrick D.G. (1993): Relationships between chlorophyll meter readings and leaf chlorophyll concentration, N status, and crop yield: a review *Proceedings of the Agronomy Society of New Zealand*. 23. 1–9.
- Yang, P., Wu, W. B., Tang, H. J., Zhou Q. B., Zou, J.Q., Zhang L. (2007): Mapping Spatial and Temporal Variations of Leaf Area Index for Winter Wheat in North China, *Agricultural Sciences in China*. 6. 12 1437-1443. DOI: [http://dx.doi.org/10.1016/s1671-2927\(08\)60005-x](http://dx.doi.org/10.1016/s1671-2927(08)60005-x)