CORRELATION ANALYSES BETWEEN LEAF AREA INDEX, SPAD-VALUES AND YIELD OF WINTER WHEAT

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Abstract

The aim of our research was to investigate questions related to field crops that enable us to study the relationships between the environment and yield as well as its forecast under different ecological circumstances. The experiments were carried out at the Látókép experimental station of the Centre for Agricultural and Applied Economic Sciences, University of Debrecen on chernozem soil in a long term winter wheat experiment. The research focused on the effects of previous cropping and fertilizers on the LAI and SPAD-values and amount of yield. N fertilization has an outstanding role in the changes in leaf area index (LAI), and SPAD-values of winter wheat. According to our results, the interaction effect of leaf area index, SPAD-values and fertilization resulted in the maximum yield in biculture and triculture.

Key words: winter wheat, forecrop, fertilization, SPAD-values, Leaf Area Index, yield.

INTRODUCTION

The aim of our research was to investigate questions related to field crops that enable us to study the relationships between the environment and yield as well as its forecast under different ecological circumstances. The effects of treatments show significant differences in the amount of yield, however, ecological and physical factors causing yield differences and the interactions between them are less well-known. We have placed particular emphasis on ecophysiological tests, especially on the relationship between yield and leaf area as well as yield and nitrogen supply of the plant. The size of the leaves and the green area in general are the main factors that determine assimilation capacity, therefore it is important to measure several variables such as leaf width and length, petiole length or the combinations of all the former ones (Robbins, Pharr, 1987; Montero et al. 2000). Several portable instruments exist to measure these former factors and show the Leaf Area Index (LAI) which represents the leaf area per 1 m^2 (Sági F., 1987). According to Dhiman et al. (1980) and Lönhardné, Ragasits (1994) there is indeed a strong relationship between yield and the leaf area. 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). Chlorophyll content of the leaves provides information on the physiological condition of the plant (Carter, 1994) and there is a strong relationship between SPAD values, nitrogen and chlorophyll content of the leaves (Wood et al., 1993).

MATERIAL AND METHOD

The experiments were carried out at the Látókép experimental station of the Centre for Agricultural and Applied Economic Sciences, University of Debrecen on chernozem soil in a long term winter wheat experiment. The experimental site is located in north-eastern part of Hungary, on the area of the aeolain loess of the Hajdúság (N: 47º33’, E: 21º27’). The soil of the research site is plain and homogen, its genetic soil type is calciferous chernozem. As forecrop rotation, we set up two models: a biculture (wheat and corn) and a triculture (pea, wheat and corn). We applied three levels of nutrients during the fertilization process (control, $N_{50}P_{35}K_{40}$ and $N_{150}P_{105}K_{120}$). We spread 100% of phosphor and potassium fertilizer and 50% of nitrogen fertilizer in autumn, in 11:15:17 complex form. During the application of fertilizer in spring we spread 50% of the nitrogen fertilizer in form of 34% NH_4NO_3. The third variable studied was irrigation in case of which we tested non-irrigated variables (Ö1) and irrigation variables complemented up to the optimum (Ö3). 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 in the vegetation period of winter wheat (Debrecen, Hungary, 2012/2013)

Month	Precipitation mm	30-year average	Difference	Temperature ^{0}C	30-year average	Difference
October	22.4	30.8	-12.7	11.1	10.3	-1.7
November	16.6	45.2	-45.2	7.2	4.5	-3.9
December	65.8	43.5	27.6	-1.2	-0.2	1.7
January	38.7	37	-9	-1	-2.6	2
February	52.9	30.2	-12.4	2.3	0.2	5.5
March	136.3	33.5	-32.1	2.9	5	1.3
April	48	42.4	-21.7	12	10.7	1
May	68.7	58.8	13.1	16.6	15.8	0.6
June	30.8	79.5	12.2	19.6	18.8	2.1

The assimilation efficiency highly depends on the leaves, usually on the size of green area (LA= Leaf Area), which used to be characterized by the Leaf Area Index (LAI). The SunScan Canopy Analysis Systems (SS1) mobile indicator was used to determine the leaf area. The measurements were applied five times in 2013 (30 April, 14 May, 5 June, 19 June, 3 July) and this meant eight measurements by repetition. A mobile Soil Plant Analysis Development chlorophyll indicator (SPAD-502 Plus, Konica Minolta) was used to determine nitrogen supply of wheat. During the cropyear, measurements were five times in 2013 (30 April, 14 May, 5 June, 19 June, 3 July) and this meant thirty measurements by repetition.

RESULTS AND DISCUSSION

The research focused on the effects of previous cropping and fertilizers on the LAI and SPAD-values and amount of yield.

The LAI maximum was reached end of May at the time of flowering and grain filling. After maize and pea forecrop also, N fertilization had a significant effect on leaf area index dynamics and its maximum up to the treatment N_{150}+PK, significant differences were found between the three fertilization treatments (see Fig. 1). Considerably higher leaf area index was measured in triculture applied the control treatment, than in biculture. These results are explicable by the fact that peas increase the nitrogen supply of the soil, have water saving properties on the soil and have a beneficial effect on the soils chemical and physical state. In this way it could help the winter wheat in the formation of dry weight and sufficient LA.

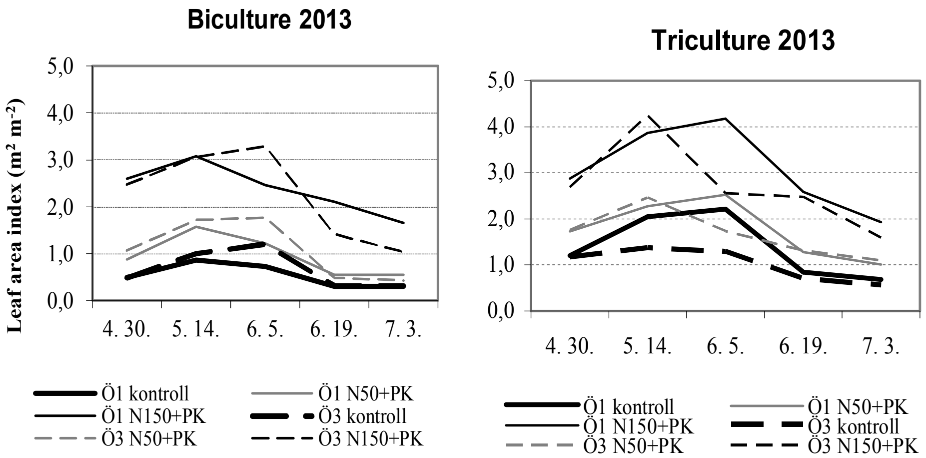

Fig. 1. Effect of irrigation, fertilization and forecrops on Leaf Area Index (LAI) of winter wheat (Debrecen, 2013)

At the time of the first measurement in 2013 showed significant differences between the control, the N_{50}+PK and the N_{150}+PK levels in both rotation systems (Table 2). Until the N_{150}+PK level, nitrogen fertilization had a notable effect on the maximum amount of SPAD values. The highest SPAD values were measured at the middle of May (BBCH 32) in the biculture and in the triculture. Examining the effects of growing doses of fertilizers applied, results showed that yields increased significantly in both rotations until the N150+PK level.

Table 2

Effect of irrigation, fertilization and forecrops on dynamics of SPAD-values of winter wheat (Debrecen, 2013)

Forecrop rotation	Irrigation	Fertilization	BBCH 29	BBCH 32	BBCH 65	BBCH 73	BBCH 80
Biculture	Ö1	control	31.8	25.7	23.9	14.8	5.0
		N_{50}+PK	41.6	41.2	27.3	13.7	4.2
		N_{150}+PK	50.7	52.7	49.7	36.3	16.6
	Ö3	control	31.5	24.1	22.6	15.3	5.9
		N_{50}+PK	39.0	36.6	28.2	13.3	7.9
		N_{150}+PK	48.8	52.7	53.0	24.6	11.5
Triculture	Ö1	control	38.8	44.5	44.8	17.6	7.9
		N_{50}+PK	42.2	49.3	49.3	24.0	9.3
		N_{150}+PK	52.7	54.1	52.5	36.1	14.1
	Ö3	control	39.1	43.4	44.3	17.3	5.5
		N_{50}+PK	44.6	47.8	47.6	13.8	5.6
		N_{150}+PK	50.1	55.4	54.1	38.8	11.5

Table 3

Effect of irrigation, fertilization and forecrops on yield of winter wheat (Debrecen, 2013)

Forecrop rotation	Fertilization	$Ö_1$	$Ö_3$	Average
Biculture	1	1558 kg ha^{-1}	1617 kg ha^{-1}	1507 kg ha^{-1}
	2	3960 kg ha^{-1}	3880 kg ha^{-1}	3950 kg ha^{-1}
	4	7910 kg ha^{-1}	7826 kg ha^{-1}	7919 kg ha^{-1}
Triculture	1	4811 kg ha^{-1}	4601 kg ha^{-1}	4691 kg ha^{-1}
	2	6954 kg ha^{-1}	6634 kg ha^{-1}	6845 kg ha^{-1}
	4	8660 kg ha^{-1}	8560 kg ha^{-1}	8680 kg ha^{-1}

CONCLUSIONS

N fertilization has an outstanding role in the changes in leaf area index (LAI), and SPAD-values of winter wheat. According to our results, the interaction effect of leaf area index, SPAD-values and fertilization resulted in the maximum yield in biculture and triculture.

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