GROWTH DYNAMICS AND YIELD OF WINTER WHEAT VARIETIES GROWN AT DIVERSE NITROGEN LEVELS

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The growth dynamics determining the yield of winter wheat depends partly on genetic determination and partly on environmental factors, including nutrient supplies. Growth and yield responses to nutrient supplies were investigated for three diverse genotypes. In the dry year of 2007 dry matter production and leaf area were influenced chiefly by N supplies, while in the more favourable year of 2008 the genotypic effect was more pronounced, and in most cases N fertiliser only led to a significant increase in yield up to a rate of 80 kg ha^{-1}. The maximum value of the leaf area index (LAI) was recorded at the 240 kg ha^{-1} N level for all three varieties in 2007 (11.5; 9.9; 8.1), while in 2008 the maximum was observed at the 160 kg ha^{-1} N level for Mv Toborzó and Mv Palotás (8.6 and 8.4, respectively), and only in Mv Verbunkos did LAI continue to increase up to 240 kg ha^{-1} N (9.8). The cumulative BMD and LAD_{LAI} parameters mostly exhibited much higher values in 2007 than in 2008. The maximum grain yield was achieved at 160 kg ha^{-1} N in 2007 and at 80 kg ha^{-1} N in 2008. It could be concluded from the results that the manifestation of genotypic traits was enhanced by favourable weather conditions, which also led to the better utilisation of lower rates of N fertiliser.

Key words: winter wheat, N fertilisation, growth parameters, yield

Introduction

Nowadays, when the need to preserve natural resources (particularly soil and water) justifies the biological and genetic regulation of crop production, it is especially important to obtain information on the nutrient utilisation of different wheat genotypes and on the effect of the environment. Among the macroelements, satisfactory quantities of N fertiliser, adjusted to the development processes of wheat, play an important role. Low rates have a positive effect mainly on the yield quantity, while rates in excess of 100 kg ha^{-1} also influence quality traits (Árendás et al., 2001). The yield of winter wheat depends on numerous growth parameters, which in turn are determined by the environment and by the genetic background of the variety. One of the most important environmental components for wheat production is the nutrient supply.

Due to the unpredictable, changeable weather conditions in Hungary, the year effect has a substantial influence on crop production, so it is essential to grow wheat varieties with stable adaptability. Experiments carried out in Martonvásár confirmed that satisfactory N supplies were able to reduce the yield fluctuations caused by the year effect.

The most detailed methodology of growth analysis was provided by Evans (1972). Growth analysis involves a series of quantitative methods and calculates growth parameters from simple basic data. It describes and characterises the growth of the whole plant or of individual plant organs, and the relationship between the assimilating organs and dry matter production.

The yield of cereals increases up to a certain leaf area index, but once the optimum value is exceeded there is a decline in the economic yield (Petr et al., 1985). It was found by Lönhardné and Kismányoki (1992) that N fertilisation significantly increased the leaf area index (LAI), leaf area duration (LAD) and plant height of wheat. Apart from climatic factors, N fertilisation was found to have the greatest effect on the gluten content of the winter wheat variety tested. Averaged over several years, the effect of N fertiliser was found to be responsible for 40% of the yield of the tested varieties (Jolánkai et al., 1996).

Materials and methods

The data were obtained in the 2006/2007 and 2007/2008 seasons, from the winter wheat plots of a long-term crop rotation experiment set up by Árpád Koltay in 1980 in the Lászlópuszta nursery of the Agricultural Research Institute of the Hungarian Academy of Sciences. The experiment is a two-factor split-plot design with four replications, where eight rates of N fertiliser (in 40 kg ha^{-1} steps from 0–280 kg ha^{-1}) form the main plots and twelve varieties the sub-plots. The present work involved four of the N rates (N_0, N_{80}, N_{160} and N_{240}) and three Martonvásár genotypes, Mv Toborzó (extra-early), Mv Palotás (early) and Mv Verbunkos (mid-early).

Samples of 5 plants per plot were taken once a week on a total of 25 occasions in 2007 and 17 occasions in 2008. The simple basic data were then used to calculate growth parameters (LAI, BMD, LAD, HI) using the classical method of growth analysis (Berzsenyi, 2000). The dry matter production and leaf area index recorded at each sampling date were summed over the whole vegetation period to give the cumulative parameters BMD and LAD, which make it easier to make comparisons over the whole season. Leaf area was measured using an AM300 instrument. Phenological phases (emergence, heading, flowering) were scored and ecophysiological measurements were carried out. The chlorophyll content (SPAD 502) and photosynthesis (LCA-4, LI-6400) of the flag-leaf were recorded, and the grain quality (protein and gluten content) was determined using an NIR instrument.

Results and discussion

In 2007, when the spring was dry, the dry matter production of winter wheat was influenced primarily by the N supplies, and all the varieties exhibited similar responses (Fig. 1). In 2008 a genotype effect was perceptible in addition to the fertiliser effect. Although the maximum dry matter production was generally recorded at the N_{240} level in both years, the increases were only significant up to the N_{160} level. In both years Mv Verbunkos had the greatest dry matter accumulation.

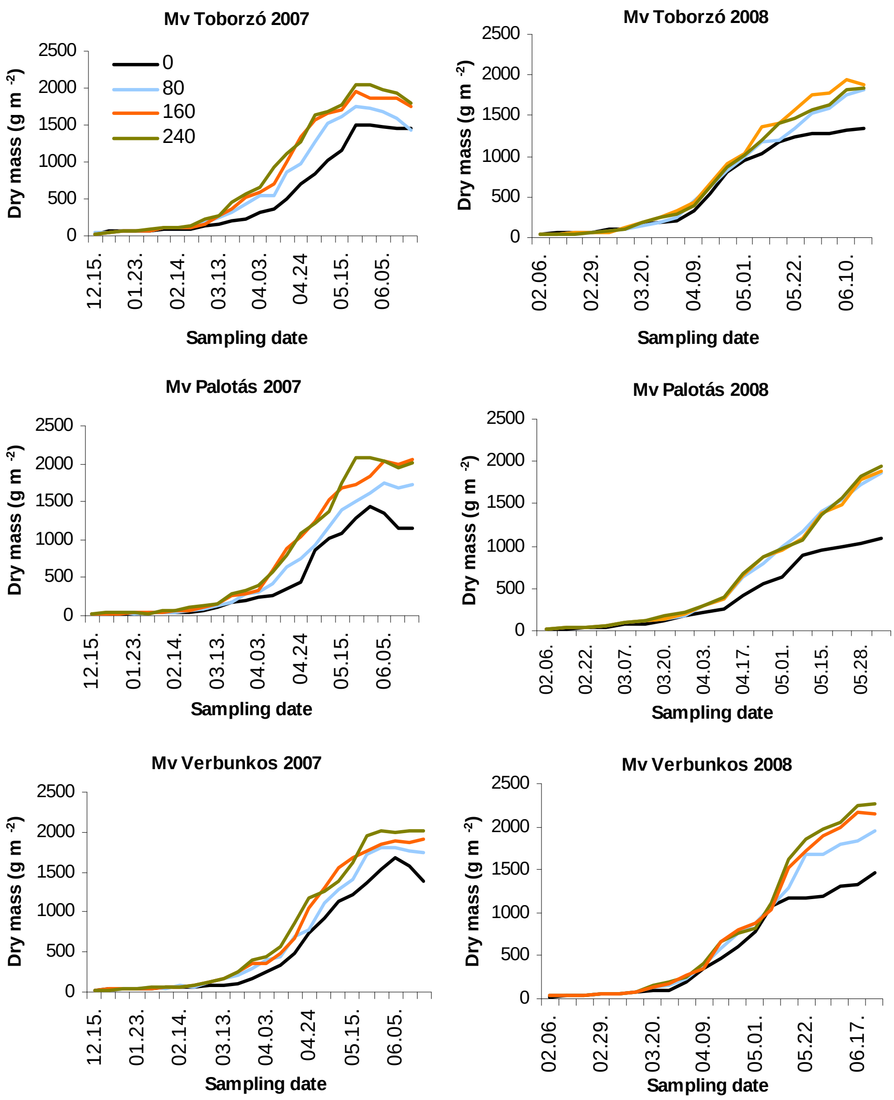

Fig. 1. A Dynamics of dry mass per m^2 in 2007 and 2008

Differences in leaf area index (LAI) were observed as a function of both N supplies and genotypes in both years (Fig. 2). The lowest values were recorded in the N_0 treatment, with a significant increase in the N_{80} treatment and maximum values at the N_{160} or N_{240} levels, depending on the seasonal dynamics.

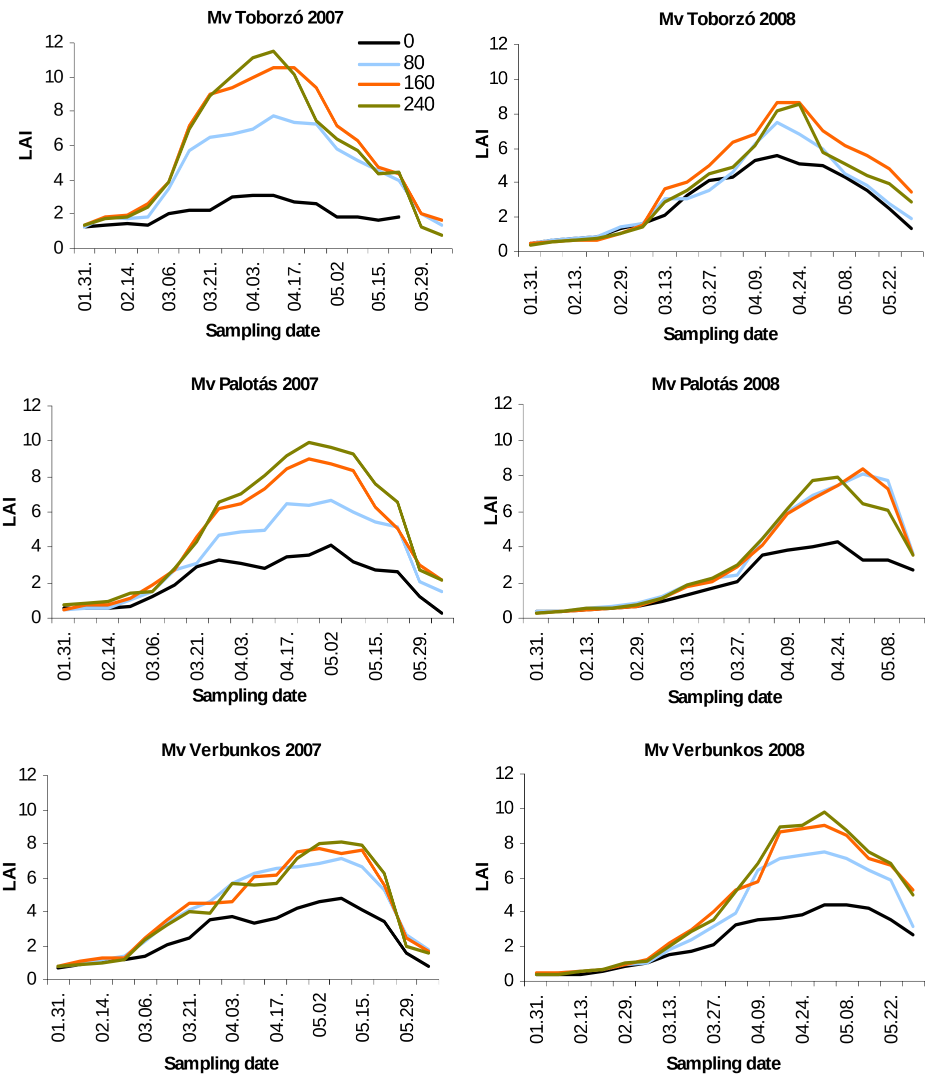

Fig. 2. Dynamics of LAI in 2007 and 2008

In 2008 higher leaf area index values were measured at the N_{80} rate than in 2007, but plots given higher rates (N_{160} and N_{240}) did not differ greatly from each other, with the exception of Mv Verbunkos. It was also observed that the curves of the different N-treatments separated very early. The mid-early variety Mv Verbunkos was able to increase its leaf area index even at higher N rates under the favourable conditions in 2008, and the curves separated by early spring.

Table 1. Maximum values of LAI, cumulative values of *BMD and LAD* and HI in 2007 and 2008

N [kg ha-1]			0	80	160	240
LAI_{max}	*Toborzó*	*2007*	3.1	7.4	10.6	11.5
		2008	5.5	7.5	8.6	8.2
	Palotás	*2007*	3.6	6.7	9	9.9
		2008	4.3	8.1	8.4	7.9
	Verbunkos	*2007*	4.8	7.1	7.4	8.1
		2008	4.4	7.5	9.4	9.8
ΣLAD_{LAI}	*Toborzó*	*2007*	243	573	737	713
		2008	358	407	506	446
	Palotás	*2007*	270	452	580	636
		2008	254	413	403	403
	Verbunkos	*2007*	320	513	532	534
		2008	284	441	525	540
ΣBMD [g day]	*Toborzó*	*2007*	214	264	287	304
		2008	152	184	209	229
	Palotás	*2007*	187	230	261	273
		2008	156	234	243	254
	Verbunkos	*2007*	207	241	259	274
		2008	157	197	219	227
HI %	*Toborzó*	*2007*	39	39	44	42
		2008	38	40	41	40
	Palotás	*2007*	39	43	46	42
		2008	41	43	43	42
	Verbunkos	*2007*	37	42	43	44
		2008	40	42	43	42

Among the growth parameters, the maximum leaf area index (LAI) was obtained at the N_{240} level for all three varieties in 2007 (Table 1), with values of 11.5 for Mv Toborzó, 9.9 for Mv Palotás and 8.1 for Mv Verbunkos, while in 2008 the maximum values were recorded at the N_{160} level for Mv Toborzó and Mv Palotás (8.6 and 8.4, respectively), and only for Mv Verbunkos (9.8) at the N_{240} level, as in the previous year.

The cumulated LAD_{LAI} values were much higher in 2007 than in 2008, with the exception of Mv Verbunkos, where the ΣLAD_{LAI} values were higher in 2008 (540 at the N_{240} level). The cumulated BMD values were also higher in 2007. The harvest index (HI) rose significantly up to the N_{160} treatment (Table 1), but dropped again at the N_{240} level. The values were 37–41% in the N_0 treatment and 41–46% at N_{160}.

The grain yield (Fig. 3) was greater in 2008, reaching the maximum value in the N_{160} treatment in 2007, but at the N_{80} level in 2008, probably due to the favourable weather conditions. Among the varieties, Mv Toborzó had the greatest thousand-kernel mass, with maximum values of 56.2 g in 2007 (N_0) and 54.6 g in 2008 (N_{80}). Nevertheless, the highest grain yield was recorded in 2008 for Mv Verbunkos, thanks to the greater grain number per m². This variety also had the greatest dry matter production, LAI and ΣLAD_{LAI} values (Table 1). The dry matter accumulation and leaf area index also contributed to the maximum grain yield.

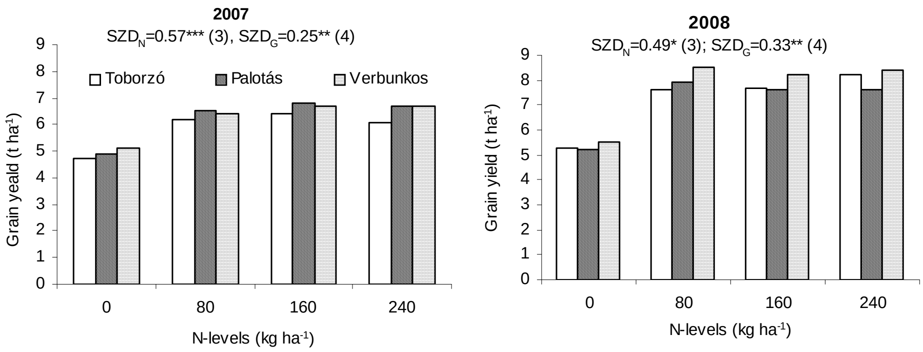

Fig. 3. Grain yields in 2007 and 2008

Among the varieties tested the favourable traits of Mv Verbunkos, the genotype with the longest vegetation period, were only manifested in the year with the better weather conditions. This variety had the best quality parameters (protein, gluten content) in both years at the N_{240} level, with outstanding values in 2007 (16.3% protein content and 38.6% gluten content).

Acknowledgements

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