

EFFECT OF SOWING DATE AND N FERTILISATION ON GRAIN YIELD AND PHOTOSYNTHETIC RATES IN MAIZE (*ZEAMAYS* L.)

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Introduction

Photosynthesis is the ultimate physiological limitation to crop production. The photosynthetic rate depends on leaf age, genotype, assimilate demands by sinks, and the effects of environment and crop management. Leaf photosynthetic rates decline with age after full leaf expansion. Under non-stressed conditions irradiance is the most important environmental factor causing variations in the photosynthetic rate. Higher transpiration efficiency (the ratio between net photosynthetic rate and transpiration rate) was associated with higher water-use efficiency in several crop species. Genotypes of a species might be expected to differ to a small degree in photosynthetic rate, but in most environments the greatest scope for improvement in photosynthesis will be agronomic. The photosynthetic rate per unit leaf area routinely increased when mineral nutrition or water availability was improved (Edmeades and Daynard 1979).

In earlier studies the authors examined the effect of sowing date on the dynamics of the growth and growth parameters of maize grain yield. The present research was carried out to investigate the effect of sowing date and N fertilisation on the grain yield and photosynthetic rates of maize hybrids under field conditions.

Methods

The effect of N fertilisation and sowing was examined in a three-factor, split-split plot design between 2002 and 2005, with the N treatments in the main plots, the sowing date in the sub-plots and the maize hybrids in the sub-sub-plots. The N rates were: 0, 60, 120, 180 and 240 kg ha⁻¹. There were four sowing dates: 10 days earlier than the optimum (early), optimum (around April 24), 10 days after the optimum (late) and 20 days after the optimum (very late). The five maize hybrids represented different maturity groups (between FAO 200 and FAO 500). The weather during the maize vegetation period differed greatly in the experimental years. The rainfall between April and September (mm) was as follows: 2002: 326, 2003: 178, 2004: 298, 2005: 526.

The N supplies to the maize plants were recorded using a SPAD-502 chlorophyll meter after silking in the leaf next to the ear, on 30 plants per plot. The measurement of photosynthesis was carried out using a portable LCA-4 (ADC, England) photosynthesis system during silking. Measurements were made on three plants per plot, on the leaf next to the ear, between 10 a.m. and 2 p.m., in bright sunshine whenever possible. The radiation intensity during the photosynthesis measurements had the following mean values ($\mu\text{mol m}^{-2} \text{s}^{-1}$): 2002: 1337, 2003: 1570, 2004: 1598, 2005: 1659. The data were first evaluated by analysis of variance for each year separately, after which the data of all four years were subjected to combined analysis of variance.

Results and discussion

Due to the effect of sowing date on the development of the maize plant, silking occurred within a shorter time after late sowing. Averaged over four years, the silking date (expressed

as days from sowing) was as follows: early: 81.0, optimum: 74.2, late: 72.3, very late: 68.0. Compared with the N_0 treatment, silking was delayed by 1–2 days by N fertilisation. Based on the results of analysis of variance, the sowing date and N fertilisation had a significant effect on the net photosynthesis rate of maize in all the years (Table 1).

Table 1. Effect of sowing date and N fertilisation on the net photosynthetic rate of maize plants at silking, 2002–2005

Treatments	Net photosynthetic rate $\mu\text{mol m}^{-2} \text{s}^{-1}$			
	2002	2003	2004	2005
Sowing date				
Early	20.39b	23.58c	23.74a	31.30b
Optimum	22.33a	26.68a	20.67b	33.64a
Late	23.24a	24.93b	21.48b	27.82c
Very late	20.98b	21.58d	19.05c	26.98c
N fertilisation				
N_0	18.76c	22.57b	16.15b	25.23b
N_{60}	21.80b	24.31a	21.81a	30.92a
N_{120}	23.04a	24.50a	22.75a	31.42a
N_{180}	22.96ab	24.78a	22.84a	31.02a
N_{240}	22.11ab	24.81a	22.61a	31.09a

Within the sowing date and N fertilisation columns, means followed by the same letter are not significantly different according to the LSD ($\alpha=0.05$) test

The rate of photosynthesis was greatest after sowing at the optimum date or within ten days of this, while it was lowest after very late sowing. A comparison of the annual data indicated that the rate of photosynthesis was highest in 2005, which had the most favourable rainfall supplies. Compared with the N_0 control, N fertilisation led to an increase in the rate of photosynthesis, but in general there was no significant difference between the N treatments. The effect of sowing date and N fertilisation on the net photosynthesis rate and grain yield of maize hybrids, averaged over the experimental years, is illustrated in Figure 1.

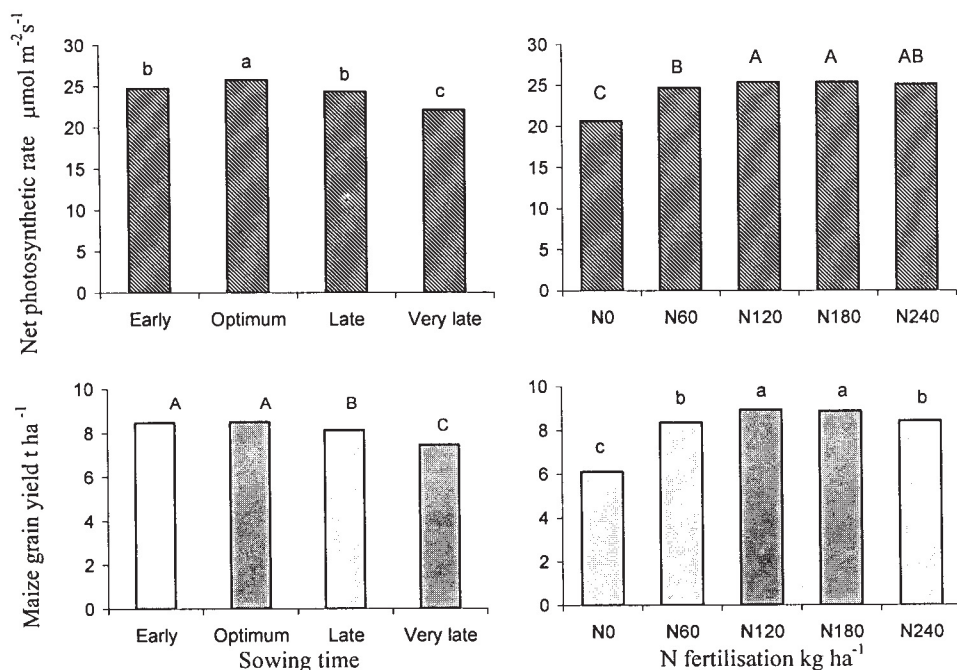


Figure 1. Effect of sowing time and N fertilisation on the photosynthetic rate and grain yield of maize hybrids (2002–2005)

In all the years the sowing date and N fertilisation had a significant effect on the maize grain yield (Table 2). The highest yields were recorded in the early and optimum sowing date treatments, while the yield was significantly lower after very late sowing. As the result of N fertilisation there was a significant difference between the N_0 treatment and plots to which N fertiliser was applied. The effect of N fertilisation on the N supplies to maize was well reflected by the SPAD values, indicative of the chlorophyll content. The following values were obtained in the various N treatments, averaged over the years: N_0 : 44.8, N_{60} : 52.4, N_{120} : 56.3, N_{180} : 57.8, N_{240} : 58.0. Among the ecophysiological indices the effect of the sowing date could best be described using the transpiration efficiency, the value of which declined significantly in the late and very late sowing date treatments. However, the effect of N fertilisation was only significant compared with the N_0 treatment (Fig. 2). A correlation significant at the 0.1 % level was observed between the photosynthesis rate and the yield, averaged over the maize hybrids ($r = 0.680$, $n = 36$).

Conclusions

The effect of sowing date and N fertilisation was well reflected in the efficiency of photosynthesis at flowering. A correlation was found between the maize yield and the efficiency of photosynthesis. Further investigations will be required to reveal differences between genotypes.

Table 2. Effect of sowing date and N fertilisation on the grain yield of maize, 2002–2005

Treatments	Grain yield of maize t ha ⁻¹			
	2002	2003	2004	2005
Sowing date				
Early	7.448ab	7.704a	8.765a	10.070b
Optimum	7.886a	6.393c	8.966a	10.523a
Late	7.820a	6.217c	8.178b	10.342a
Very late	6.922b	6.882b	7.741c	8.208c
N fertilisation				
N ₀	6.195b	5.319b	6.110d	6.801c
N ₆₀	7.739a	7.035a	8.717bc	9.962b
N ₁₂₀	8.111a	7.328a	9.483a	10.671a
N ₁₈₀	7.927a	7.423a	9.207ab	10.721a
N ₂₄₀	7.621a	6.889a	8.546c	10.775a

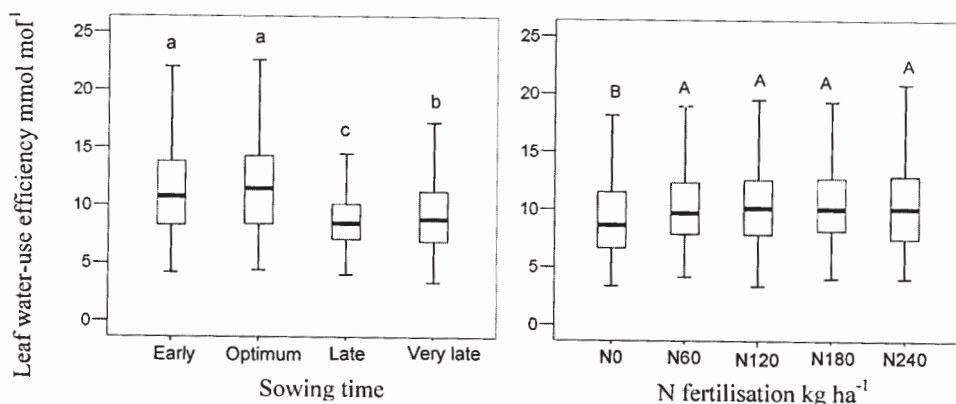


Figure 2. Effect of sowing time and N fertilisation on the leaf water-use efficiency of maize hybrids (2002–2005)

References

- Edmeades GO and Daynard TB (1979). The relationship between final yield and photosynthesis at flowering in individual maize plants. *Can. J. Plant Sci.* 59: 581-601.
- Péli, E.R., Peeva, V., Georgieva, K., Tuba, Z. (2005): Some Responses of the homoiochlorophyllous desiccation-tolerant dicot *Haberlea rhodopensis* Friv. to desiccation and rehydration, *Cer. Res. Com.* 33: 293-295.
- Svetková, K.; Henselová, M.; Morvová, M. (2005): Effects of a carbonization product as additive on the germination, growth and yield parameters of agricultural crops. *Acta Agron. Hun.* 53. (3). 241-250 pp
- Kádár Imre (2005): A műtrágyázás hatása a bab (*Phaseolus vulgaris* L.) termésére és elemfelvételére, *Agrokémia és Talajtan*, 2005, vol. 54, N°s 1-2, 93-104 pp.