MEASUREMENTS OF CO_2/O_2 CONCENTRATIONS IN THE GAS PHASE OF SOIL-PLANT SYSTEMS IN POTASSIUM-FELDSPAR TREATED SANDY SOIL

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Introduction

A quadrupole mass spectrometric (QMS) method was developed to follow accumulation/consumption of respiratory gases inside plant tissues, with the aim to predict the plants' responses and to follow the response processes to various environmental stresses *in situ* and *in vivo* (Pártay *et al.*1994, Németh *et al.* 1995). In this study the 20 microsensor channel, computer controlled QMS unit was used to investigate a soil-plant system where the soil was enriched with potassium feldspar minerals instead of potassium fertilizer (Szűcs *et al.* 2003) and the plant was a selected maize genotype (Végh *et al.* 2004).

Methods

Laboratory studies were carried out with mixtures of potassium- (80%) and sodium- (20%) feldspars (of Norwegian origin) ground to 100μm to serve as potassium source in a soil column experiment. The experimental soil was the 10 to 20 cm surface layer of a slightly acidic sandy soil from Somogysárd, Hungary with the following properties: pH H_2O: 6.1; pH KCl: 5.3; organic matter: 1.5%; cation exchange capacity: 7 $cmol_c$ kg $soil^{-1}$; silt+clay fraction(<0.02mm): 21%; clay fraction(<0.002 mm): 9.5%; bulk density: 1.5g cm^{3-1}. The soil was air-dried, ground to pass a 2mm sieve and mixed with the feldspar. 500 mg superphosphate kg $soil^{-1}$ was added as fertilizer. A 15x15x40 cm plexiglass container (to study root development) was filled up with 15cm quartz sand at the bottom, then with 15cm soil or soil-feldspar mixture, passed through a 1.6 mm sieve and finally with 15 cm quartz sand at the top. Three treatments were used (relative to the total soil amount): 0% feldspar (A), 25% feldspar (B) and 50% feldspar (C); see Fig. 1. and 2.
Maize (*Zea mays* L.) was used as test plant. 5 seeds were sawn into each column. Plants were grown to maturity. Potassium-free macro and micronutrient solutions were given to the soil regularily. Sufficient light (15000 lux) was ensured in 12 hours day/night cycles. Temperature was recorded daily. Irrigation was applied at the soil surface on the basis of TDR (Time Domain Reflectometry) multiplexer measurements. Gas concentrations of the soil (Fig. 1.) and plants (Fig. 2.) and laboratory air were continuously measured. Relative amounts of water vapor, nitrogen, oxygen, carbon-dioxide and argon concentrations were determined with a 4 hour interval between measurements.

Results and discussion

Soil moisture measurements in the top 20 cm layer:
At the beginning of the experiment (first two weeks) "C" soil had the highest moisture content (~ 12 % v/v) and "A" soil the lowest (~ 8 % v/v) with daily peaks at irrigation time. Later these differences disappeared and an average 15 % prevailed. At the end of the experiment, after harvesting (no irrigation), the moisture content became uniform 5 %.
Soil gas measurements:
The increase of the quantity of feldspar slightly lowered the CO_2 concentration. In the control soil ("A" treatment) during the first half of the vegetation period, CO_2 concentration first increased, then decreased, similarly to the treated soils. Daily periodicity was strongest – as expected - at CO_2. (Fig. 1.)

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Plant gas measurements:
Gas composition of the maize plant was determined with the help of the microsensor (diameter: 1.6 mm) implanted in the stem of the plant. It can be concluded that in contrast to the slight alterations in the soil gas phase, there were major changes in the plant gas compositions depending on the feldspar treatment. The order of gas concentrations in the control (A) treatment was the following: water-vapor>N_2>O_2≈CO_2. These values did not change significantly along the vegetation period. However, increasing the amount of added feldspar (as well as the progress of vegetation time) resulted in a continuous increase of CO_2 concentration (even exceeding the N_2 concentration at the 50% treatment) and at the same time decrease of O_2 concentration to a very low level. (Fig. 2.)

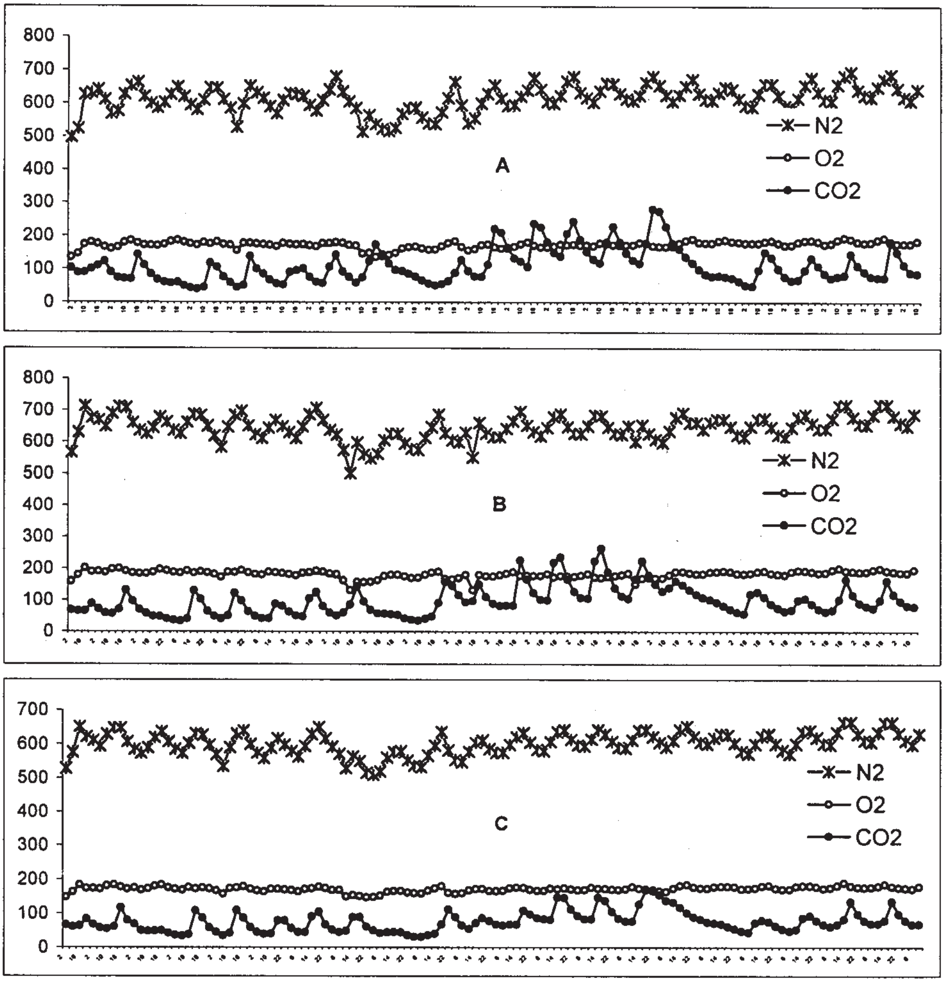

Fig.1. Soil gas measurements.
A, B, C: see text.
Horizontal axis: time; the interval between measurement points is 4 hours
Vertical axis: concentration, arbitrary units

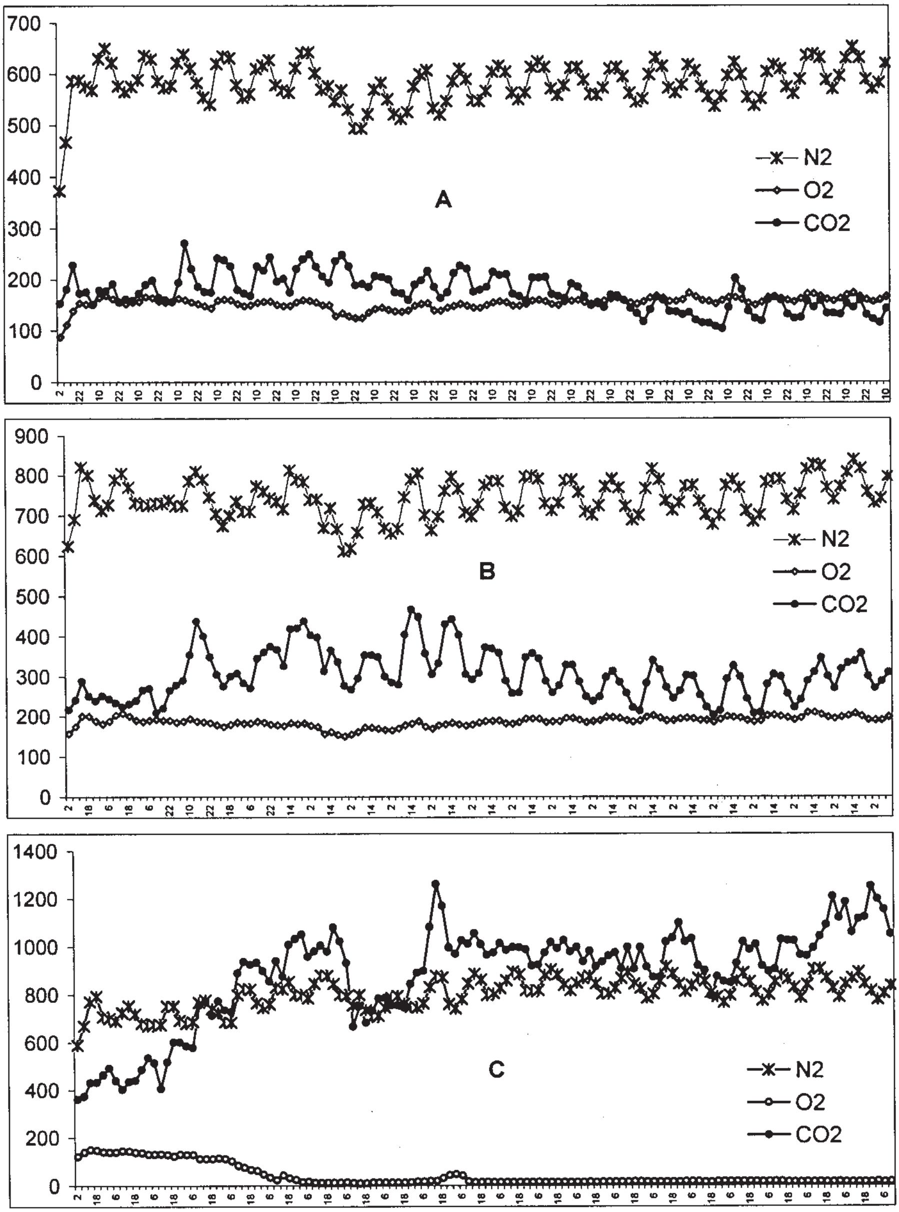

Fig 2. Plant gas measurements
A,B,C: see text
Horizontal axis: time; the interval between measurement points is 4 hours
Vertical axis: concentration, arbitrary units

Conclusions

These results indicate that the change of CO_2 concentration or rather the change of the ratio of the CO_2 and O_2 concentration in the plant follow well the environmental impacts reaching the soil, and thus cause - although not visible externally - significant changes in plant metabolic processes.

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