A METHOD FOR DETERMINATION OF THE EFFECTS OF AIR POLLUTANTS ON THE STOMATAL WIDTH

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The water in different parts of a plant forms a continuum throughout the plant body. This makes it possible to record changes in the water content as changes in thickness of any part of the plant. A leaf kept in darkness has been found to change its thickness to a sufficient degree for recordings of changes in transpiration from the rest of the plant. The rapidness of the changes makes it probable that they are mirroring the stomatal movements.

The method has been used for recordings of influences of SO₂ as air pollutant. It has a couple of advantages over direct measurements of changes in transpiration. One is that the measurement can be used without enclosing the plant in a cuvette. Another is that possibly occurring effects on the hygrometer are eliminated.

The method has until now mainly been used for wheat plants but also wooden plants as Pinus and Salix have been tested.

INTRODUCTION

Changes in leaf thickness of a plant appear when its water content is changed as a consequence of changes in transpiration or in water uptake. The changes can be recorded even in one of the leafs kept in darkness. This indicates the existence of an easily movable continuous water column throughout the plant body. We believe that the changes in thickness are due to changes in the water content of the

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The experiments presented in this paper were performed with wheat plants in the two-and three-leaf stages of development which means that the plants were 8–12 days old.

METHODS

Wheat seeds were soaked for 24 hours and germinated on moist filter paper in darkness at 25°C. After 48 hours they were transplanted to plastic holders and grown in a nutrient solution (KNO₃ 0,1 m M, Ca(NO₃)₂ 0,1 m M, KH₂PO₄ 0,1 m M, Na₂HPO₄ 0,1 m M,

MgSO₄ 0,1 m M, Fe-EDTA 0,7 g/l)until an experiment was started. In the growth room the illumination was 5000 Lux, temperature 18°C and RH 55 %.

Leaf thickness was measured with a rectilinear transducer, transpiration with a diffe-

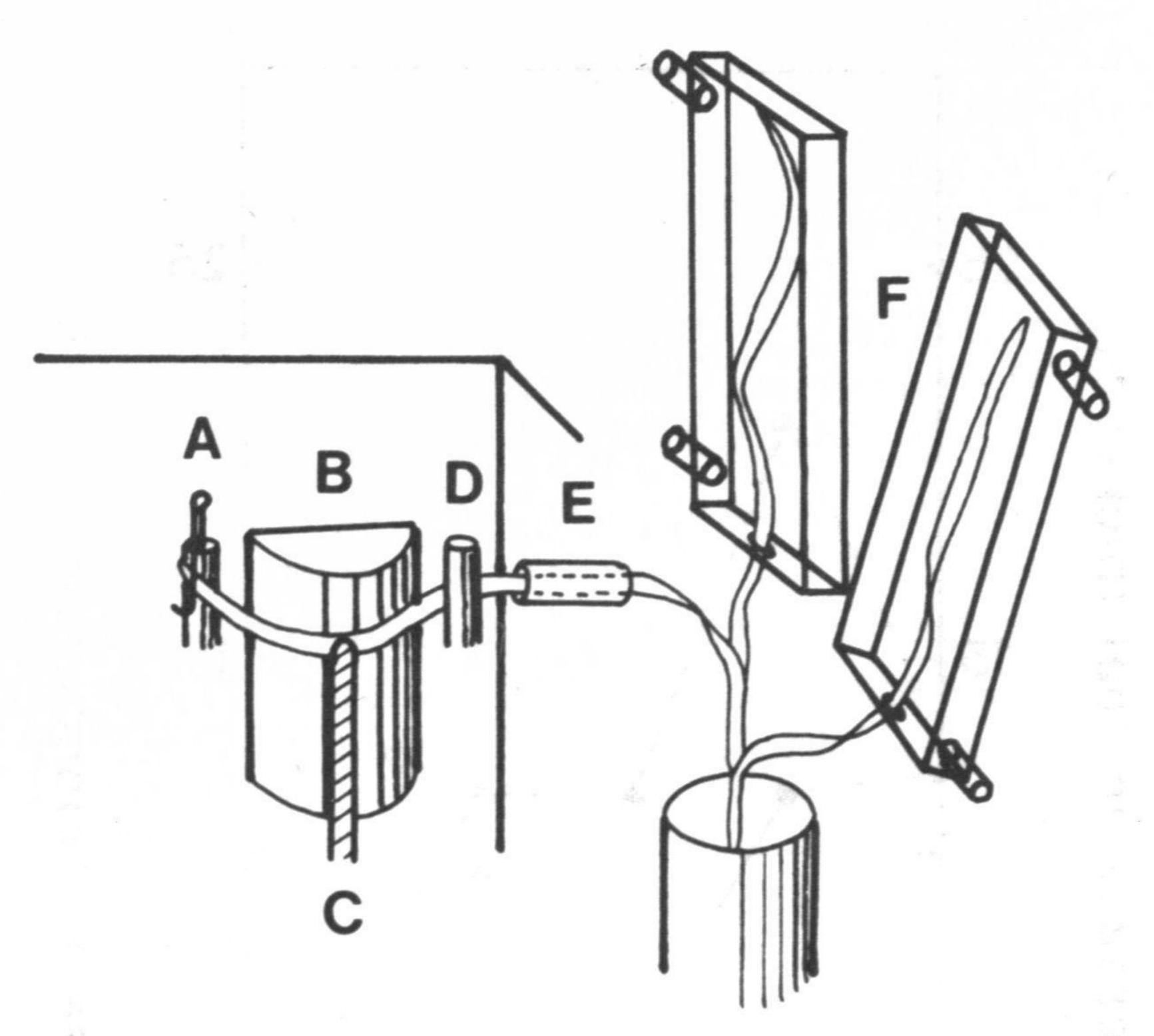


Figure 1. A model for the arrangement of the experiments.

At A the tip of the L-leaf is fixed and by means of the rubber rod D the leaf is extended over the cylinder B. C is the movable arm of the transducer and E is a rubber tube which together with a tightening clay gives a light safe connection to the dark box.

The leaf in one of the cuvettes is treated with the pollutant. Transpiration can be measured from the second (or possibility from the same leaf provided that the pollutant does not influence the hygrometer).

rential psychrometer.

The leaf used for the recording of changes in leaf thickness (the L-leaf) was kept in darkness in a closed box and was supposed to give a very low transpiration. The leaves used

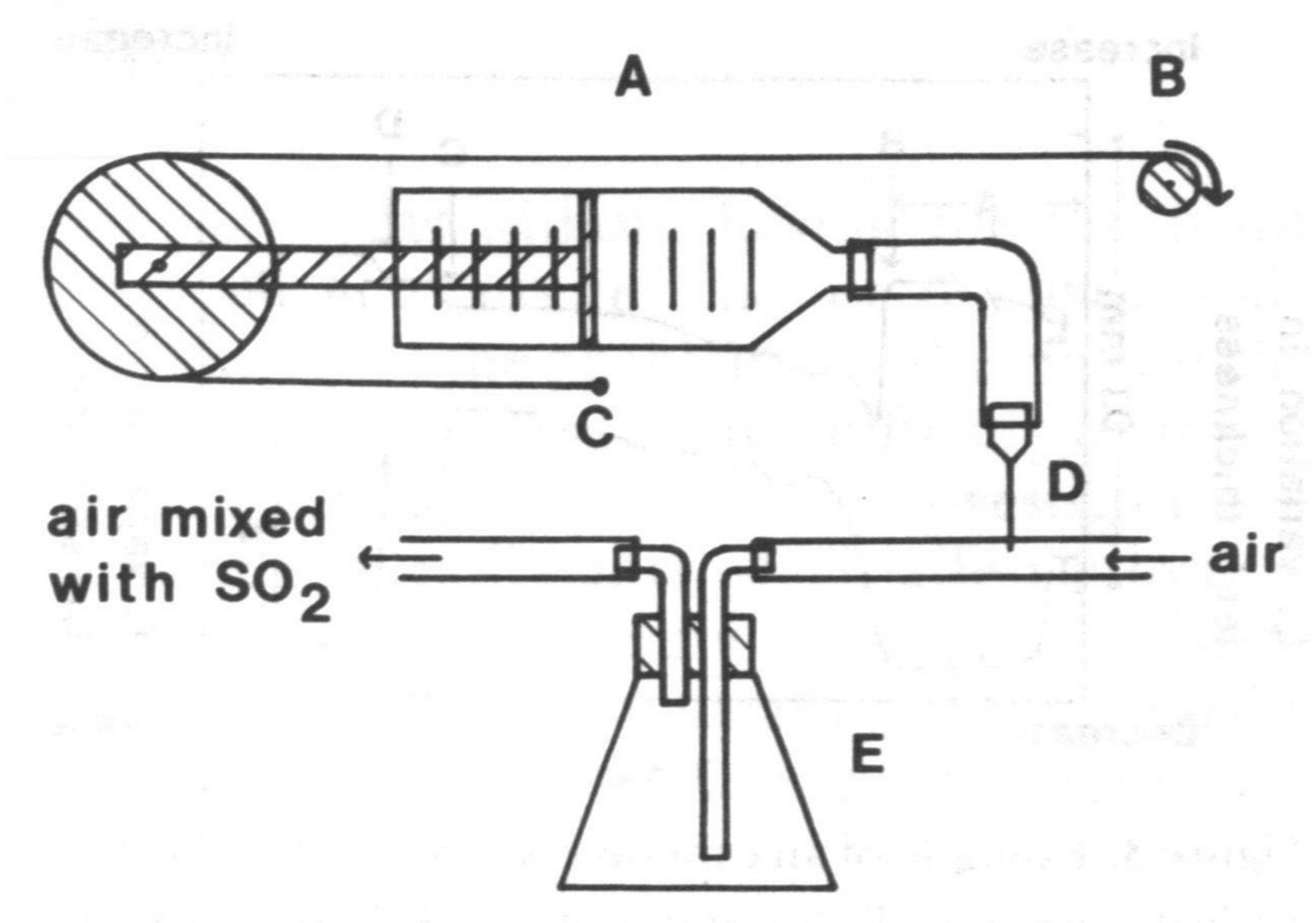


Figure 2. Injector for supply of SO₂ to the air stream.

A is the injector, B is a slowly rotating axis on which the strap is winded up with a constant velocity. The strap is fixed in the point C. D is the needle of a syringe. The flask E increases the mixing of the gases.

for transpiration measurements or treated with an air pollutant (the T-leaves) were enclosed in cuvettes of perspex (Fig. 1). The cuvettes were run through by an air stream, moving about 6 cm/sec. During the experiments the leaves were illuminated with three lamps (Philips Attralux Spot 100 W). Heat irradiance was absorbed in a water filter 7 cm thick. The light intensity was measured with a luxmeter (Eel Lightmaster) to about 50 000 Lux.

In this paper only the effects of SO_2 are shown. The gas was supplied to the air stream by means of an injector (Fig. 2). The concentrations used were 0,05–50 ppm.

EXPERIMENTS

An experiment was performed in the following way. A plant was kept in relative darkness for 10 hours. During this time the transpiration was low and attained a constant level. The leaf thickness increased to a constant value. After that the T-leaf was illuminated. The transpiration increased and the thickness of the L-leaf decreased. After 2-3 hours new constant levels were established. A SO₂treatment was given which caused a decrease in transpiration from the T-leaf and an increase in the thickness of the L-leaf. When a new constant level had been established the T-leaf was cut off. This gave a rethickening of the Lleaf to a level which was very near the original darkness level (Fig. 3).

From the recordings the SO₂-induced relative changes in transpiration and leaf thickness were measured. Because tests with no leaves in the cuvette showed, that the SO₂ concentrations used had no effect on the hygrometer output, the changes in transpiration and leaf thickness could be compared. In Fig. 4 the effects of different amounts of SO₂ are shown. There is a reasonably good proportionality between the two parameters which indicates that any of them can be used to record the effects of the pollutant.

The influence of light intensity and of water deficiency in the plant are shown in Fig. 5 and 6. Again there is a proportionality between the effects on transpiration and leaf thickness

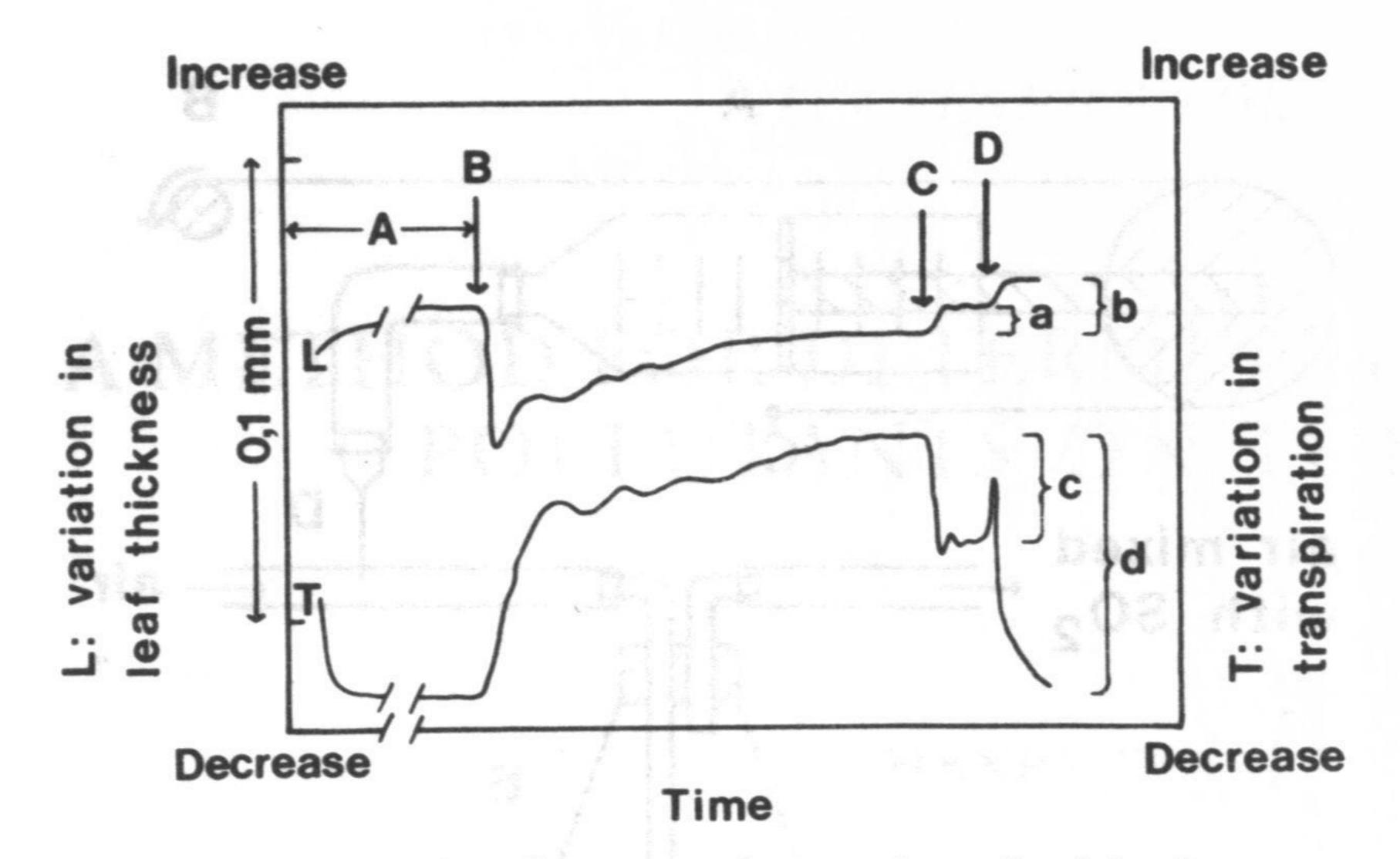


Figure 3. Example of an experiment described in the text.

L: leaf thickness; T: franspiration; ⇐ A⇔: the dark period of 10 hours before the plant was illuminated.

At B light was put on

At C SO₂ was injected to the air stream passing the T-leaf At D the T-leaf was cut off.

The relative change in leaf thickness was calculated from a and b.

Relative change in transpiration from c and d.

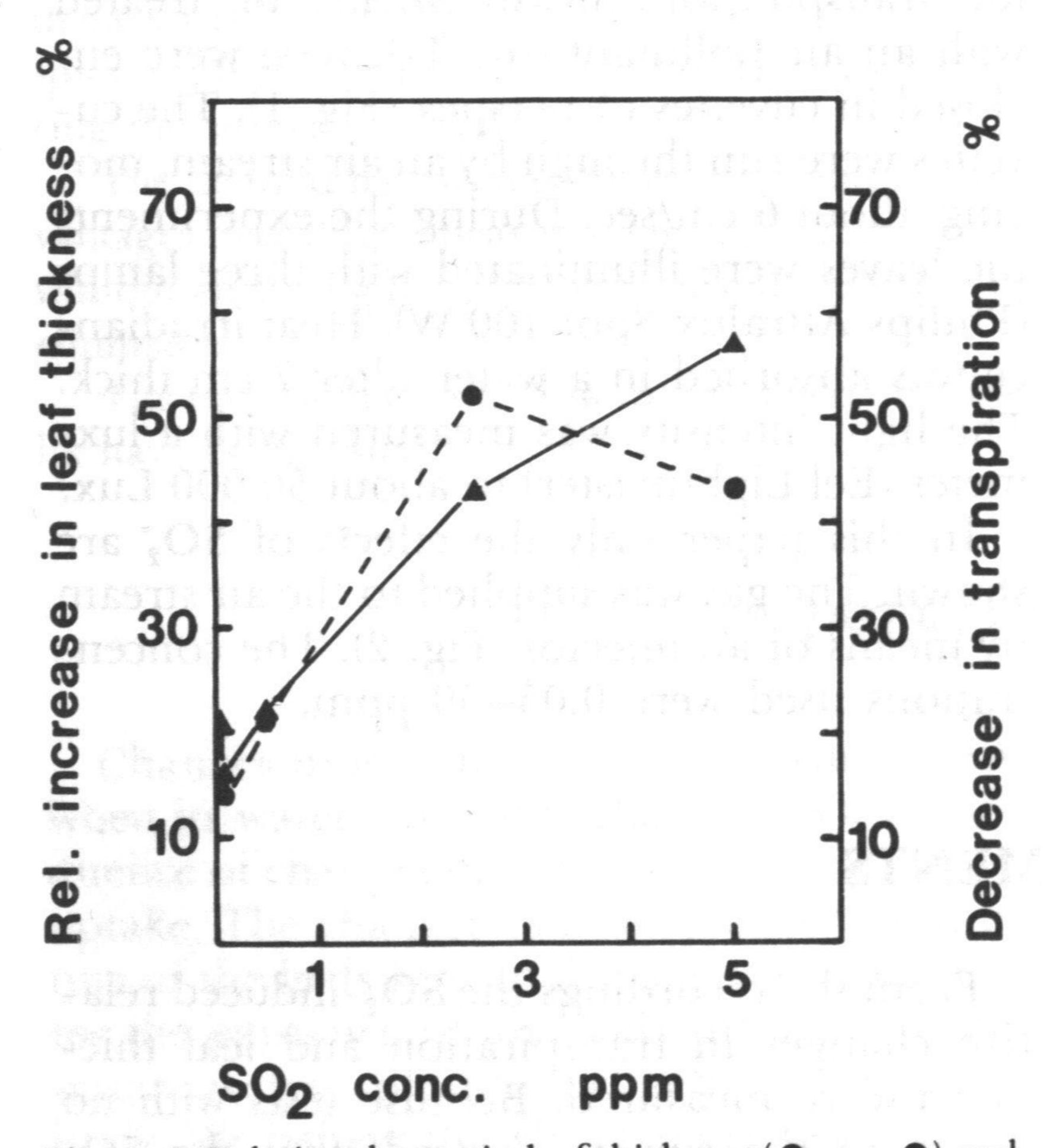


Figure 4. Relative change in leaf thickness (\bullet - - - \bullet) and transpiration (\triangle - \triangle) caused by different concentrations of SO_2 .

calculated as a percentage. On the other hand we have obviously no proportionality between the SO_2 -effect and the stomatal width. Increased light intensity and an unimpeded water supply give both high transpiration rates, presumably in connection with more open stomata. In the first case the lower SO_2 effect coincides with more open stomata and in the second with less open stomata.

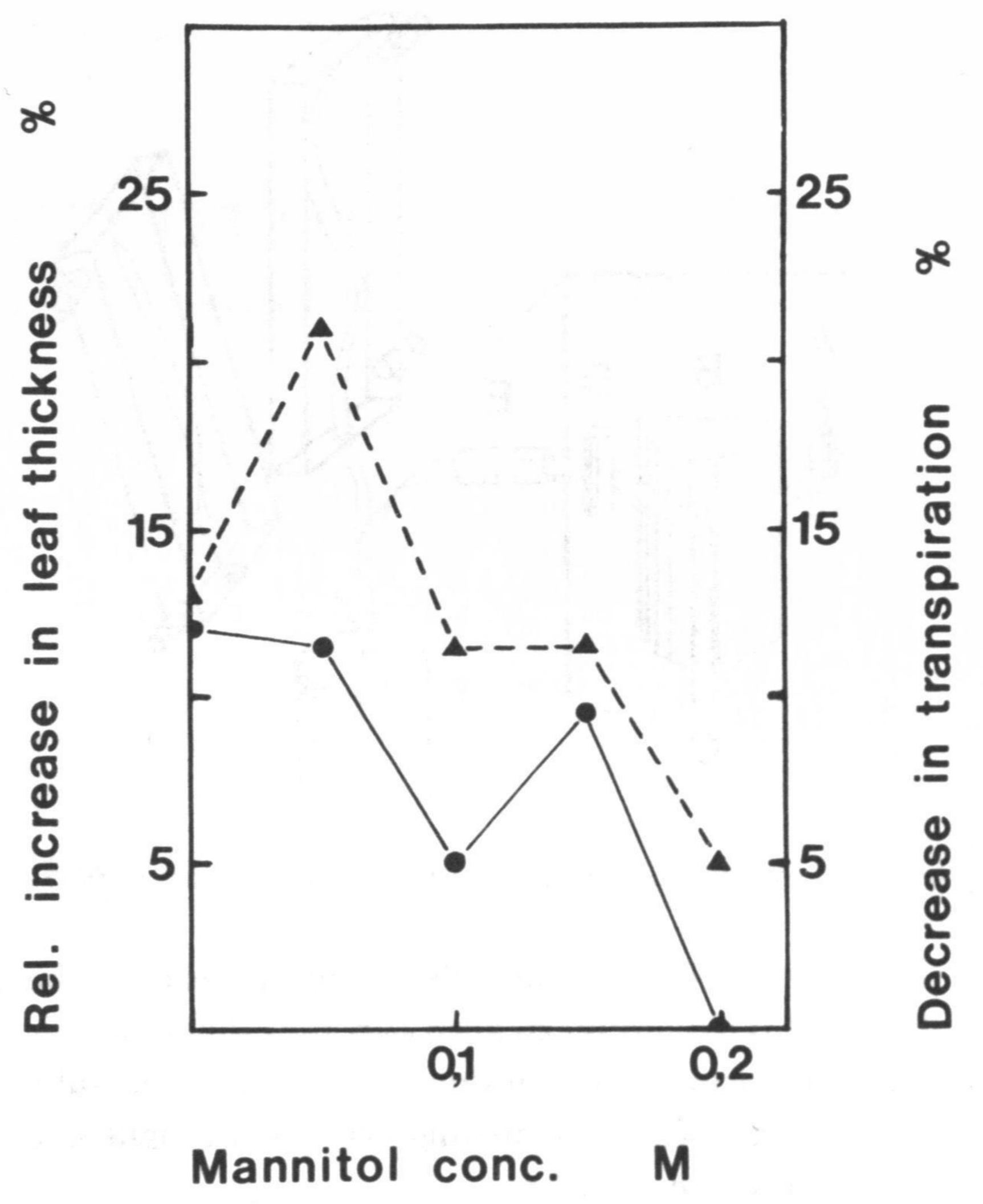


Figure 5. Effect of SO_2 (0,1 ppm) on relative change in leaf thickness (\bullet - - - \bullet) and transpiration (\blacktriangle - \blacktriangle) of plants standing in mannitol solutions of different concentrations.

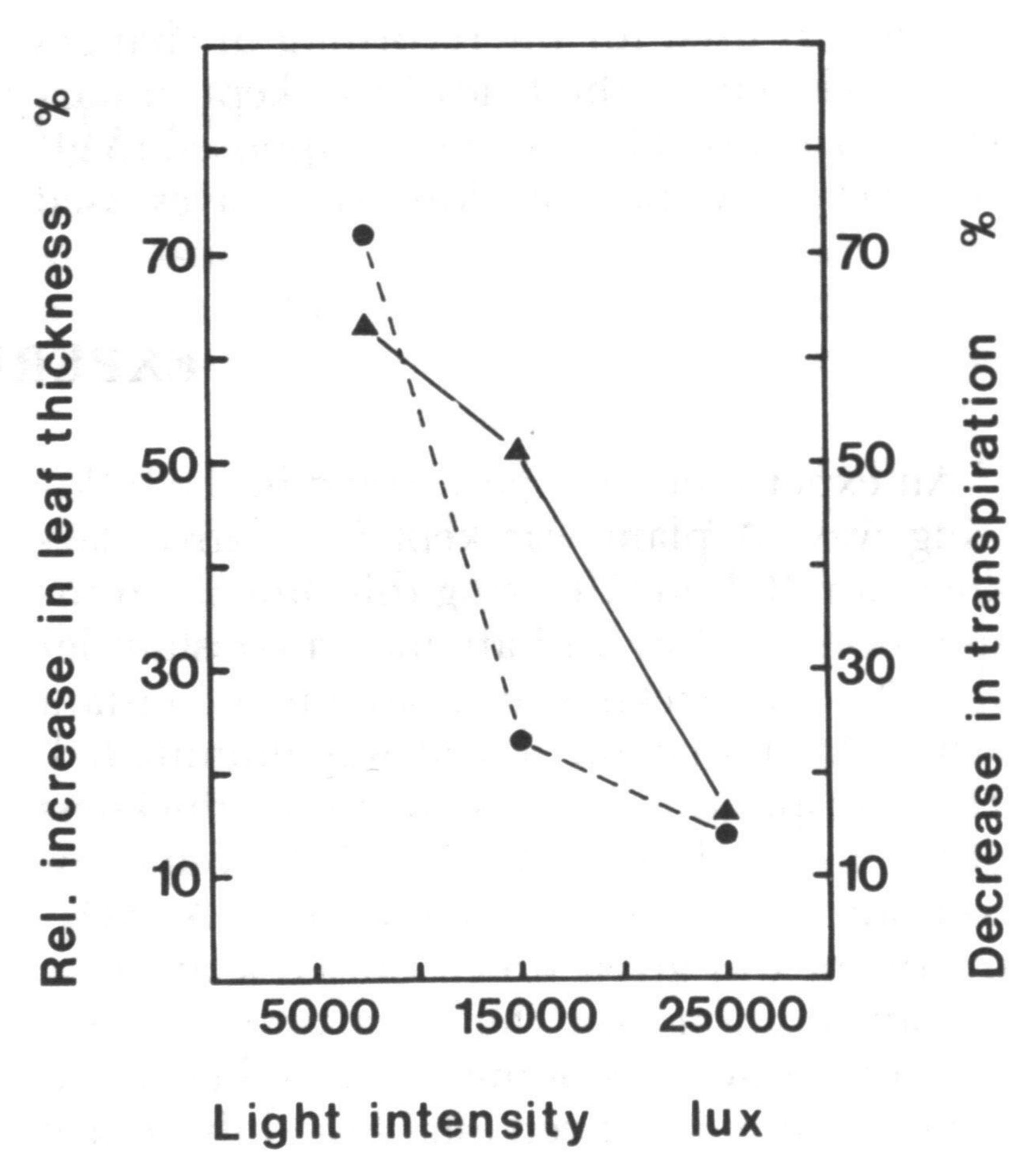


Figure 6. Effect of $SO_2(0,1 \text{ ppm})$ on the relative change in leaf thickness (\bullet - - - \bullet) and transpiration (\blacktriangle - \blacktriangle) at different light intensities.

DISCUSSION

Changes in transpiration recorded at a constant illumination are normally considered to mirror changes in the stomatal width (see for example JONES & HIGGS 1980, SPANNER 1956). The coincidence between changes in transpiration and in leaf thickness makes it probable that the latter can be used to indicate changes in this width. The method gives a couple of advantages. It it possible to record the effect of air trans por-

ted pollutants without having the test plant enclosed in a cuvette. The use of cuvettes always includes the problem of "the cuvette climate" and the results are difficult to interpret. Futher it is possible to investigate the influence of pollutants which affect a hygrometer and consequently introduces difficulties in transpiration measurements. Finally the recording can be undertaken without injuring the test plant.

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