

GABRIELA LORENC-PLUCIŃSKA

The effect of SO₂ on the photosynthesis and dark respiration of larch and pine differing in resistance to this gas*

INTRODUCTION

Considerable extent of injuries to trees and shrubs caused by SO₂ has resulted in the undertaking of intensive investigations which among other aims attempt to select more resistant individuals of trees to use them as replacements for those that proved susceptible to the gas. Studies on the choice of more resistant tree species go in several directions. One of the more important ones is the selection of trees which in a given set of conditions including industrial pollution were found to have a greater degree of resistance. Another approach is to test selected resistant and susceptible trees in order to establish the mechanisms determining the greater resistance.

The effect of SO₂ on coniferous trees is manifested primarily by the injury to foliage. Such needles change colour to lighter dark brown, change shape and size and loose turgor.

These symptoms are caused by aberrations in the physiological and biochemical processes (Faller et al., 1970 a and b). Sulphur dioxide causes a strong reduction in the intensity of photosynthesis. The degree of reduction of this process will depend on the duration of SO₂ action and its concentration (Keller, 1957; Vogl et al., 1968). Inhibition of photosynthesis may take place already in the first hours of exposition of plants to an SO₂ atmosphere (Paul, 1972; Malhotra, 1976; Godzik, 1976). It was also observed that when the concentration of SO₂ is low (from 0 to 25 pp hm) in the first hours of exposition the rate of photosynthesis increases, and it is only a longer fumigation of several days that causes a successive drop in the intensity of this process to its complete termination (Bull and Mansfield, 1974).

Inhibition of photosynthesis is accompanied by a decline in the concentration of the assimilatory pigments, particularly chlorophyll a. Under the influence of sulphur dioxide chlorophyll gets degraded to feophytin

* This work has been partially supported by grant No. FG-Po--326 from the US Department of Agriculture under PL-480.

Rac and Le Blanc, 1966) and frequently the cells of mesophyll undergo plasmolysis (Williams et al., 1971).

In isolated chloroplasts of spinach Ziegler (1972) has observed an inhibition in the activity of ribulodiphosphate carboxylase (RuDPC) by the sulphite ion (SO_3^-). This inhibition was competitive to HCO_3^- .

Puckett (1973) claims that the toxicity of SO_2 depends on the amount of sulphite and disulphite ions accumulated, which he considers to be acceptors and donors of electrons in the electron transport chains of the chloroplast systems I and II.

Sulphur dioxide inhibiting the rate of photosynthesis at the same time either stimulates or inhibits the rate of dark respiration (Keller, 1957; Van Auker, 1973). Ziegler (1975) claims that SO_2 inhibits also the CO_2 production in light. Reduction in photorespiration Zelitch (1957) explains as an inhibition by SO_2 of the activity of glycollate oxidase, which results in an accumulation of glycollate in the leaves (Libera et al., 1974).

From the above literature review it appears that the mechanism of injuring the CO_2 exchange process under the influence of sulphur dioxide is known. However it still remains to explain the effect of this gas on the CO_2 exchange in plants differing in the degree of resistance to SO_2 . It was the purpose of the present investigation to establish whether CO_2 exchange in SO_2 resistant and susceptible individuals of pine and larch is similarly affected by exposition to SO_2 or whether there are differences in extent or method of injury. Also the capacity to regenerate normal CO_2 exchange on termination of fumigation was compared in these individuals.

MATERIALS AND METHODS

For the experiment use was made of detached shoots of Japanese larch (*Larix kaempferi* Carr.) and Scots pine (*Pinus silvestris* L.) coming from two regions from Kórnik. One year old shoots have been cut from 4 trees, of each species in Kórnik which as a result of a previously conducted selection were considered resistant (2 trees) or susceptible (2 trees) to the action of sulphur dioxide (Bartkowiak et al., 1975; Białobok, 1976). Under the term "resistant" were included trees, which in selection tests have had the lowest percentage needle injury following exposition to SO_2 . On the other hand "susceptible" were those individuals, the needles of which were injured most by the gas. Also two Scots pine trees differing in extent of injury were tested from Silesia (Tarnowskie Góry). For the experiments each time 20 shoots were taken, and the experiments were replicated three times. The assimilation chambers were illuminated with halogen lamps. They gave a light intensity of PhAR $4 \times 190 \text{ Wm}^{-2}$. In order to eliminate the thermal radiation from the halogen lamps filters were used which consisted of antisol glass and a water mantle (5.0 cm thick) pla-

ced over the assimilation chambers. The CO₂ exchange was measured with the help of an infra-red gas analyser of the Infralyt type, produced by Juncalor (DDR), operating in an open system (Czarnowski, 1972; Czopek and Starzecki, 1970; Żelawski and Góral, 1966). The studies were conducted in two ways:

1. Detached pine shoots from Kórnik placed in water containers, were treated with SO₂ for 4 days, 6 hours daily. Since the experiments were conducted in the autumn, that is at the time when sensitivity to SO₂ is much lower than in the summer — an SO₂ concentration of 7.0 ppm was used (lower concentrations did not cause changes in CO₂ assimilation). The pine shoots from Silesia were exposed to a lower concentration of SO₂, of the order of 2.0 ppm (a higher concentration of SO₂ caused strong injuries, manifesting themselves as complete yellowing of the needles). Larch shoots were fumigated for 3 days (6 hour daily), and the concentration of SO₂ was maintained at 2.5 ppm. The CO₂ exchange was measured before fumigation (control) and immediately after each day of fumigation with SO₂.

2. Detached shoots placed in containers with water were treated with SO₂ for one or four days, 6 hours daily. The concentration of SO₂ was maintained at a level of 2.5 ppm for larch and 7.0 ppm for pine from Kórnik. The exchange of CO₂ was measured before treatment with SO₂ (control), immediately after fumigation and on the first, second, third and fourth day after termination of fumigation.

The intensity of photosynthesis or dark respiration was calculated according to the following formula (Czarnowski, 1972):

$$F = \frac{d \times n}{I}$$

where:

F — intensity of respiration or photosynthesis in mg CO₂ × g dry weight⁻¹h⁻¹,

d — value of one unit on the CO₂ recorder, dependent on the rate of air flow and temperature during measurement and expressed as mg CO₂ × h⁻¹,

n — difference in the number of units on the CO₂ recorder between the measurement of control air and the studied air (on exit from the assimilation chamber),

I — dry weight of needles in grams.

RESULTS AND DISCUSSION

1. JAPANESE LARCH

The purpose of the experiment was to obtain information on changes in CO₂ exchange of detached larch shoots following treatment with SO₂. Since the experiments were conducted in the period preceding yellowing and

falling off of the needles (from 15th of August to 25th of September) a low activity of CO_2 exchange was expected.

Data from the literature indicates that maximum photosynthetic intensity occurs in early summer, from mid-May to mid-July (Polster and Weise, 1962). In our experiments, in spite of the late vegetative season for the trees, the selected individuals of Japanese larch were characterized by high photosynthetic activity, which was on the same level as that in the summer. The net photosynthesis of non-fumigated shoots was much higher in sensitive individuals ($5.0 \text{ mg CO}_2 \times \text{g dry weight}^{-1} \times \text{h}^{-1}$) than in the more resistant ones to SO_2 ($3.2 \text{ mg CO}_2 \times \text{g dry weight}^{-1} \times \text{h}^{-1}$).

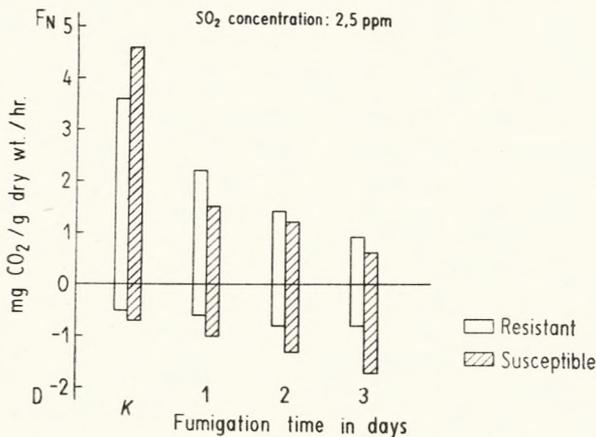


Fig. 1. The effect of SO_2 on net photosynthesis (F_N) and dark respiration (D) of detached Japanese larch shoots (autumn 1975). The measurements were made before fumigation (K) and after 1, 2 and 3 days of fumigation

Sulphur dioxide at a concentration of 2.5 ppm inhibits the rate of photosynthesis in both the SO_2 resistant and susceptible individuals however this reduction is thrice as high in the latter than in the former (Fig. 1).

Reduction in the intensity of photosynthesis depends on the duration of the treatment with the toxic factor (Keller, 1957; Vogl et al., 1964). The longer was the fumigation of the larch shoots both resistant and susceptible ones, the greater was the reduction in the rate of photosynthesis. A similar relationship was found between the duration of SO_2 action and the rate of photosynthesis by Puckett (1973) and Inglis and Hill (1972). The process of photosynthesis regeneration after termination of the fumigation of Japanese larch, similarly as in other coniferous species (Vogl and Börtitz, 1969; Rjabinin, 1965), takes place rather slowly. Resistant individuals after three days of fumigation required 48 hours to regenerate their effective photosynthesis to a 70% level (effective photosynthesis is defined here as the sum of CO_2 absorbed in net photosynthesis and CO_2 emitted during dark respiration). The same length of

a break in the fumigation treatments in the sensitive individuals permits a regeneration of effective photosynthesis only to 30% (Fig. 2).

Sulphur dioxide inhibiting the rate of photosynthesis in larch simultaneously changes the process of dark respiration. In the autumn SO₂ sti-

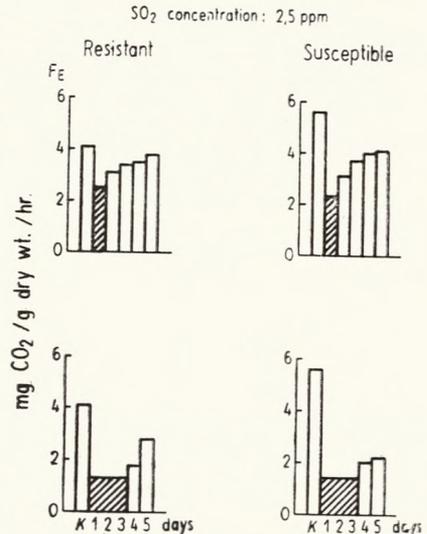


Fig. 2. The influence of SO₂ on the effective photosynthetic production and the duration of its regeneration in detached Japanese larch shoots. F_E — see x text, K — measurement of CO₂ exchange before fumigation (control). The hatched areas indicate the measurements of processes after one or three days of fumigation, and the clear columns beyond are levels of F_E on consecutive days following the fumigation treatment

mulates dark respiration both in resistant and susceptible individuals (Fig. 1), and the extent of the increase depends on the duration of the action of the toxic factor. In resistant individuals dark respiration attains its maximum in the second day of exposition and then remains unchanged after the next day of fumigation. In susceptible individuals dark respiration increases during the studied period proportionally to the duration of the SO₂ action. A similar effect of SO₂ on dark respiration was observed by Keller (1957), after Ziegler (1975) in pine and spruce fumigated with SO₂ at a concentration of 1.6 ppm. After the first days of the action of this gas there occurred a 30% increase in the intensity of respiration. A longer exposition (a dozen days or so) has resulted in a successive drop in CO₂ emission in the dark.

2. SCOTS PINE IN KÖRNIK

Parallel with the seasonal rhythm in the ability of pine to absorb and emit CO₂ the intensity of CO₂ exchange observed was much lower in the autumn (15th Aug. to 30th Nov.) than in other parts of the year. A reduction in the intensity of photosynthesis at that time is particularly obvious in individuals resistant to SO₂ in which photosynthesis is maintained at a level of 1.7 mg CO₂ × g dry weight⁻¹ × h⁻¹ while in the susceptible individuals it is 2.6 mg CO₂ × g dry weight⁻¹ × h⁻¹, or 1.6 times more (Fig. 3).

The action of sulphur dioxide at a concentration of 7.0 ppm during the autumn causes an inhibition of photosynthesis in both resistant and susceptible individuals (Fig. 3). In agreement with data from the literature (Börnitz et al., 1968, 1969; Ziegler, 1972; Bennett et al., 1973, 1974)

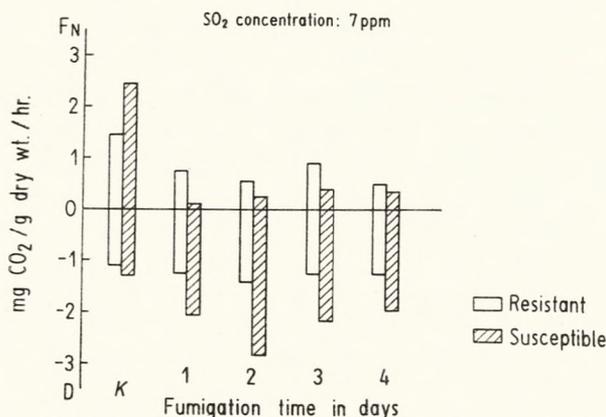


Fig. 3. The effect of SO₂ on net photosynthesis (F_N) and dark respiration (D) of detached Scots pine shoots from Kórnik (autumn 1975). The measurements were made before fumigation (K) and after 1,2,3 and 4 days of fumigation

the decline in photosynthesis is dependent on the duration of SO₂ action.

In the studies the relation between assimilation inhibition and duration of SO₂ treatment was not proportional as was claimed by Keller (1957). In the sensitive individuals the intensity of photosynthesis was most inhibited after the first six hours of treatment with SO₂. Later photosynthesis slightly increased (Fig.3). This is not observed in the resistant trees since the inhibition after the second and fourth of fumigation was greater than after the first or third day. Lack of a logical pattern in the rate of photosynthesis inhibition is probably caused by the discontinuous action of the toxic factor. Zahn (1961, 1963) and Guderian (1970) report that the use of periodic SO₂ treatments, with breaks between the successive exposures leads to differences in the degree of injury. In the present studies fumigation lasted 4 days, 6 hours daily. Immediately after each 6 hour exposition to SO₂ the measurements of CO₂ exchange were made. Such a method of arranging the experiments was necessary from the technical point of view, and it resulted in the shoots being exposed to SO₂ 6 hours daily and for 18 hours to an atmosphere devoid of this gas.

Zahn (1963) suggests that during the breaks between successive exposures the plants have had an opportunity to regenerate the affected metabolic processes provided the changes caused by the toxic gas were not too great.

The ability to regenerate CO₂ exchange in resistant and susceptible individuals to SO₂, following fumigation with the latter gas depends, in agreement with Rjabinin (1965), on the duration of the fumigation (Fig. 4).

If the shoot was fumigated for 1 day (6 hrs) than in the next day after termination of exposition (24 hrs) the susceptible individuals regenerate the effective photosynthetic production to an 80% level, while in the resistant individuals the value is greater than prior to fumigation. On

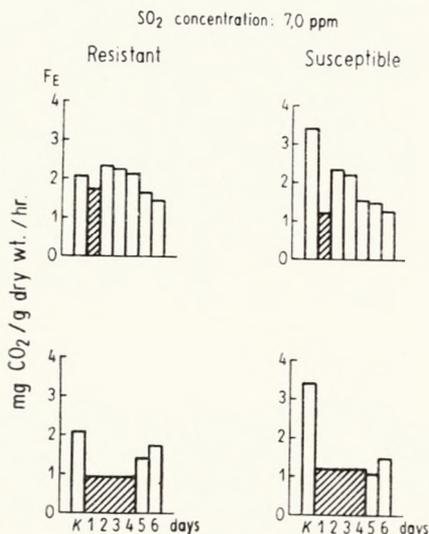


Fig. 4. The influence of SO₂ on the effective photosynthetic production and the duration of its regeneration in detached Scots pine shoots from Kórnik. F_E — effective photosynthetic production (see text)

the other hand when the shoots were treated with SO₂ for 4 days, than in the second day (48 hrs) after fumigation the resistant individuals regenerate 80% of photosynthesis and susceptible ones only 40% compared to the level of the process prior to fumigation (Fig. 4).

The action of sulphur dioxide on the pine shoots has caused a stimulation in dark respiration in susceptible trees (Fig. 3). The degree of stimulation was greatest in the second day of fumigation. In contrast to the susceptible individuals dark respiration in shoots from SO₂ resistant trees is not affected by fumigation with this gas.

3. SCOTS PINE FROM SILESIA

In order to compare the effect of SO₂ on the processes of CO₂ exchange in trees in which "resistance" and "susceptibility" to this gas was determined experimentally (Białobok, 1976) with those which grew in industrial regions having a polluted atmosphere use was made of pine shoots from one resistant and one susceptible individual growing besides chemical plants in Silesia.

As a result of the conducted experiments it was found that in the autumn (September–November), in contrast to the pine growing in Kórnik, the shoots of the resistant pine from Silesia were characterized by a higher photosynthetic activity ($2.2 \text{ mg CO}_2 \times \text{g dry weight}^{-1} \times \text{h}^{-1}$) than those of the susceptible tree ($1.0 \text{ mg CO}_2 \times \text{g dry weight}^{-1} \times \text{h}^{-1}$) (Fig. 5 and 6).

Sulphur dioxide at a concentration of 2.0 ppm inhibits the rate of net photosynthesis in both the susceptible and resistant tree. The degree of inhibition is not dependent on the duration of fumigation. It occurs already after the first 6 hours of treatment with SO_2 . The further fumigation of

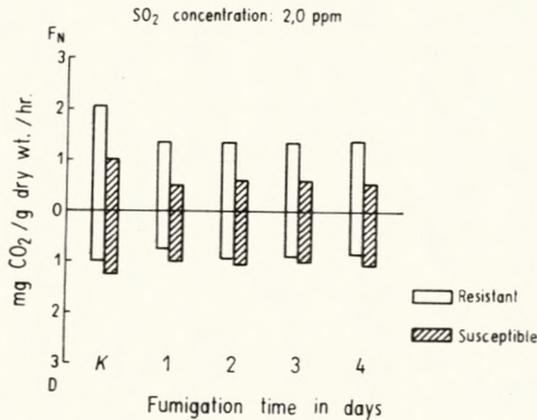


Fig. 5. The effect of SO_2 on net photosynthesis (F_N) and dark respiration (D) of detached Scots pine shoots from Silesia. The measurements were made before fumigation (K) and after 1, 2, 3 and 4 days of fumigation

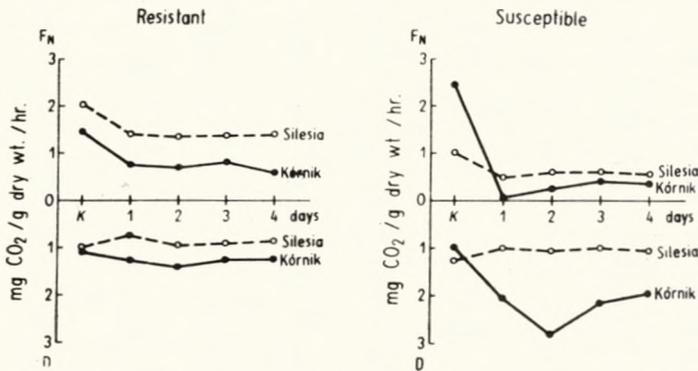


Fig. 6. The effect of SO_2 on net photosynthesis (F_N) and dark respiration (D) in Scots pine individuals from two origins, Kórnik and Silesia. The measurements were made before fumigation (K) and after 1, 2, 3 and 4 days of fumigation

the shoots has practically no effect on the intensity of CO_2 assimilation. Reduction in the intensity of photosynthesis under the influence of SO_2 is stronger in the more susceptible individual.

Sulphur dioxide at a concentration of 2.0 ppm inhibits the intensity of dark respiration (in the pine from Kórnik it was stimulative). The reduction of this process is greatest after the first six hours of fumigation. A further fumigation alters only slightly the intensity of dark respiration, both in the resistant individual and in the susceptible one to SO_2 (Fig. 5 and 6).

Summarising the data presented above it needs to be said that sulphur dioxide acts on the process of CO₂ exchange to a varying degree within a population of one species (pine from Kórnik and from Silesia) and also between different species (larch and pine). Variability in the toxicity of the gas is dependent on its concentration and on the duration of its action. Exposition of shoots to an atmosphere with SO₂ has altered CO₂ exchange reducing the intensity of photosynthesis and either stimulating (in larch and pine in Kórnik) or inhibiting (in pine from Silesia) the intensity of dark respiration. Since these changes took place in both the resistant and susceptible individuals it appears that the "resistance" is primarily dependent on the ability to rebuild the destroyed photosynthetic potential quickly and effectively after termination of exposition and thereby to overcome the negative effect of sulphur dioxide.

SUMMARY

The effect of SO₂ on CO₂ exchange of resistant and susceptible individuals of Japanese larch and Scots pine have been studied in the period August to November. The intensity of net photosynthesis and dark respiration have been measured with the help of an infra red CO₂ analyser. It was shown that SO₂ causes an inhibition of the rate of photosynthesis in pine and larch. The extent of the inhibition of photosynthesis was always greater in sensitive individuals, both of pine and larch. The regeneration of photosynthesis after termination of fumigation was faster in the resistant individuals than in the susceptible ones, of both pine and larch. In contrast to photosynthesis, SO₂ stimulates the process of dark respiration in larch. In pine it was observed that dark respiration was either inhibited or increased. Changes in the intensity of dark respiration depended on the duration of action of the toxic factor.

Institute of Dendrology
Kórnik nr. Poznań

LITERATURE

1. Bartkowiak S., Białobok S., Rachwał L. — 1975. Ocena stopnia uszkodzeń drzew i krzewów przez SO₂ dla potrzeb hodowli. Arb. Kórnik. 20 : 375 - 384.
2. Białobok S. — 1976. Studies on the effect of sulphur dioxide and ozone on the respiration and assimilation of trees and shrubs in order to select individuals resistant to the action of these gases. Second Annual Report PI — Fs — 74; FG-Po-326 July 1, 1975 - June 30, 1976.
3. Börtitz S., Vogl M. — 1969. Physiologische und biochemische Beiträge zur Rauchschadenforschung. 9. Mitt. Physiologische Untersuchungen zur individuellen Rauchhärte von *Pinus silvestris*. Arch. Forstwes. 18 : 55 - 60. Berlin.
4. Börtitz S. — 1969. Physiologische und biochemische Beiträge zur Rauchschadenforschung. 11 Mitt. Analysen einiger Nadelinhaltsstoffe an Fichten unter-

- schiedlicher individueller Rauchhärte aus einem Schadgebiet. Arch. Forstwes. 18: 123 - 131.
5. Bennett J. M., Hill A. C. — 1973. Inhibition of apparent photosynthesis by air pollutants. J. Environ. Quality 2: 526 - 530.
 6. Bennett J. H., Hill A. C. — 1974. Acute inhibition of apparent photosynthesis by phototoxic air pollutants. Reprinted from ACS Symposium Series, No 3: Air Pollution Effects on Plant Growth, 115 - 127.
 7. Bull J. N., Mansfield T. A. — 1974. Photosynthesis in leaves exposed to SO_2 and NO_2 . Nature 250: 443 - 444.
 8. Czarnowski M. — 1972. Urządzenia stosowane w gazometrycznych metodach pomiaru fotosyntezy. Biull. Warzyw. 13: Supl. 129 - 160.
 9. Czopek (Czarnowski) M., Starzecki W. — 1970 A field laboratory for photosynthesis measurement. Bull. Acad. Polon. Sci. 18: 657 - 662.
 10. Faller N., Herwig K., Kühn H. — 1970 a. Die Aufnahme von Schwefeldioxyd (S^{35}O_2) aus der Luft. II. Aufnahme, Umbau und Verteilung in der Pflanze. Plant and Soil 33: 283 - 295.
 11. Faller N., Herwig K., Kühn H. — 1970 b. Die Aufnahme von Schwefeldioxyd (S^{35}O_2) aus der Luft. II. Einfluss auf den Pflanzlichen Ertrag. Plant and Soil 33: 177 - 191.
 12. Godzik S. — 1976. Pobieranie $^{35}\text{SO}_2$ z powietrza i rozmieszczenie ^{35}S u niektórych gatunków drzew. Badania porównawcze. Prace i studia. Ossolineum. PAN, 16: 1 - 159.
 13. Guderian R. — 1970. Untersuchungen über quantitative Beziehungen zwischen den Schwefelgehalt von Pflanzen und dem Schwefeldioxyidgehalt der Luft. Pflkrankh. 77, Teil I: 200 - 220, II: 289 - 308, III: 387 - 399.
 14. Inglis F., Hill A. C. — 1974. The effect of sulphite and fluoride on carbon dioxide uptake by moses in the light. Photol. 73: 1207 - 1213.
 15. Keller H. — 1957. Beiträge zur Erfassung der durch schweflige Säure hervorgerufenen Rauchschäden an Nadelhölzern. Dissertation München.
 16. Libera W. H., Ziegler I., Ziegler H. — 1974. The action of sulfite on the HCO_3 — fixation and the fixation pattern of spinach chloroplasts and leaf tissue slices. Z. Pflanzenphysiol. 74: 420 - 433.
 17. Malhorta S., Hocking D. — 1976. Biochemical and cytological effects of sulphur dioxide on plant metabolism. New Phytol. 76: 227 - 238.
 18. Paul R. — 1972. Metabolisme des plantes en presence D' anhydride sulfureux. Photosynthese apparente de *Ph. vulgaris* L. var. Sensation. Bull. Rech. Agron, Gembloux, 1 - 4: 244 - 252.
 19. Polster H., Weise P. — 1962. Verbleichende. Assimilationsuntersuchungen an Klonen verschiedener Laircherkünfe. Der Züchter 32: 25 - 34.
 20. Puckett K., Nieboer J. E., Flora W. P., Richardson D. — 1973. Sulphur dioxide: its effects on photosynthesis ^{14}C fixation in lichenes and suggested mechanisms of phototoxicity. New. Phytol. 72: 141 - 154.
 21. Rao D. N., Le Blanc F. — 1966. Effects of sulfur dioxide on the lichen alga with special reference to chlorophyll. Bryologist 69 - 75.
 22. Rjabinin W. M. — 1965. Les i promyszlennyje gazy. Izdatelstwo Lesnaja Promyszlennost 6. Moskwa.
 23. Van Auken O. W. — 1973. Effects of SO_2 on photosynthesis and respiration in bean leaves and cellular organelles. Plant Physiol. 51, Suppl. 21.
 24. Vogl M., Polster H. — 1964. Des Einfluss stossartiger SO_2 — Begasung auf die CO_2 -absorption und die Nadelinhaltsstoffe von Fichte und Bergkiefer unter Laborbedingungen. Arch. Forstw. 13: 1031 - 1045.
 25. Vogl M., Börtitz S. — 1968. Investigations the physiology of gas exchange in

- excised conifer twigs and their use in rapid tests of fume resistance. B ol. Zbl. 37 : 313 - 324.
26. Williams R. J. — 1971. Effects of atmospheric pollution on deciduous woodland. 1: Some effects on leaves of *Quercus patraea* (Mattuschka). Liebl. Environ. Pollut. 2 : 57 - 68.
 27. Zahn R. — 1961. Wirkungen von Schwefeldioxid auf die Vegetation, Ergebnisse aus Begasungsversuchen. V.D.J. Berchte 53 : 24 - 28.
 28. Zahn R. — 1963. Über den Einfluss verschiedener Umweltfaktoren auf die Pflanzenempfindlichkeit gegenüber Schwefeldioxyd. Z. Pflanzenkr. Pflanzensch. 70 : 81 - 85.
 29. Zelitch J. — 1957. α -alpha-hydroxysulfonates as inhibitor on the enzymic oxidation of glycolic and lactic acid. J. Biol. Chem. 224 : 251 - 260.
 30. Ziegler I. — 1972. The effect of SO₃— on the activity of ribulose — 1,5-diphosphate carboxylase in isolated spinach chloroplasts. Planta 103 : 155 - 163.
 31. Ziegler I. — 1975. The effect of SO₂ pollution on plant metabolism, Residue Rewews 56 : 79 - 105.
 32. Zelański W., Góral J. — 1966. Gazowy analizator IR w badaniach z zakresu fizjologii i ekologii roślin. Wiad. Bot. 10 : 75 - 85.

GABRIELA LORENC-PLUCIŃSKA

Wpływ SO₂ na fotosyntezę i oddychanie ciemniowe modrzewia i sosny o różnym stopniu odporności na ten gaz

Streszczenie

Wpływ SO₂ na wymianę CO₂ odpornych i wrażliwych osobników modrzewia japońskiego i sosny zwyczajnej badano w okresie od sierpnia do listopada. Oznaczano natężenie fotosyntezy netto i oddychania ciemniowego za pomocą analizatora CO₂ w podczzerwieni. Wykazano, że dwutlenek siarki powoduje zahamowanie natężenia fotosyntezy u sosny i u modrzewia. Rozmiary hamowania fotosyntezy są zawsze wyższe u osobników wrażliwych zarówno modrzewia, jak i sosny. Wykazano, że regeneracja fotosyntezy po ukończeniu fumigacji jest szybsza u osobników odpornych zarówno modrzewia, jak i sosny. W przeciwieństwie do fotosyntezy SO₂ stymuluje natężenie oddychania ciemniowego u modrzewia. Natomiast u sosny obserwowano wzrost lub hamowanie oddychania w ciemności. Zmiany w natężeniu oddychania ciemniowego zależały od czasu działania czynnika toksycznego.

ГАБРИЕЛЯ ЛОРЕНЦ-ПЛУЦИНЬСКА

Влияние SO₂ на фотосинтез и темновое дыхание лиственницы и сосны, обладающих различной устойчивостью по отношению к этому газу

Резюме

Влияние SO₂ на обмен CO₂ устойчивых и чувствительных особей лиственницы японской и сосны обыкновенной исследовали в период с августа по ноябрь. Была обозначена интенсивность фотосинтеза нетто и темнового дыхания при помощи инфракрасного газоанализатора CO₂. Выявлено, что сернистый ангидрид вызывает торможение интен-

сивности фотосинтеза у сосны и лиственницы. Размеры торможения фотосинтеза всегда выше у особей чувствительных как у сосны так и у лиственницы. Определено, что регенерация фотосинтеза после окончания окуривания наступает быстрее у устойчивых особей лиственницы и сосны. В отличие от фотосинтеза сернистый ангидрид стимулирует интенсивность темнового дыхания у лиственницы. У сосны наблюдается рост или задержка дыхания в темноте. Изменение интенсивности теневого дыхания зависит от продолжительности действия токсического фактора.