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Some effects of exposure to sulphur dioxide on the metabolism of Scots pine in winter. II. Effects on the photosynthetic carbon metabolism*

Abstract

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The effect of sulphur dioxide was examined on the uptake of $^{14}CO_2$ and the distribution of ^{14}C among photoassimilates during the winter depression of activity and emergence from it in SO_2-tolerant, SO_2-relatively tolerant and SO_2-susceptible clones of Scots pine (*Pinus sylvestris* L.). Detached twigs were treated with 1.0 ppm SO_2, 6 h daily over 3 consecutive days. The fumigated twigs were then exposed to $^{14}CO_2$ for 5 min. Low winter temperatures and exposure to SO_2 inhibited the subsequent total $^{14}CO_2$ uptake, decreased the percentage of label in starch, glycolate, glycine and serine. On the other hand there was a marked increase in the percentage of label in sucrose, aspartate, glutamate, alanine and malate. The degree of inhibition or stimulation varied with the susceptibility of trees to SO_2 and was greatest in the most susceptible one.

Additional key words: *Pinus sylvestris*, $^{14}CO_2$ uptake, photoassimilates.

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INTRODUCTION

The inter- and intraspecific variation in resistance to SO_2 has been widely studied, however the mechanisms responsible for these differences are little understood.

It has been suggested that the variation in SO_2 resistance which exists between plants could reflect differences in the rate of SO_2 absorption (Caput et al. 1978), in SO_2 avoidance (Bressan et al. 1978), in stomatal conductance and in resistance of photosynthesis to SO_2 (Winner and Mooney 1980), and in biochemical (enzymatic or nonenzymatic) detoxication of SO_2 incorporated into cells (Kieliszewska-Rokicka 1979).

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Abbreviations: RuDP – ribulose 1,5 biphosphate, PEP – phosphoenolpyruvate.

Studies on the level of variation in the sensitivity of plants to SO_2 basically concentrate on herbaceous plants (Bressan et al. 1978, Omura et al. 1980). It is rarely that differences in the SO_2 phytotoxicity are being investigated on trees, particularily coniferous ones (Börtitz 1969, Eckert and Houston 1980). This is most probably caused by differences in the activity of trees during the vegetative season and the related variability in the degree of injury by SO_2 (Czarnowski 1977). Thus the majority of results concern the effect of SO_2 on trees during the summer period, i.e. when the photosynthetic activity is at its maximum. There is very little data on the variation in SO_2 resistance during the winter and after warming up in the spring.

In an earlier study (Lorenc-Plucińska 1986) it has been shown that the action of SO_2 on Scots pine during the winter and later as the weather warms up causes a much greater depression of photosynthesis (P_N) and photorespiration (R_L) in the sensitive clones than in the tolerant ones. On the other hand the direction of change in dark respiration (R_D) was different depending on the duration of fumigation with SO_2 and the time of warming up.

In the present study the influence of SO_2 under controlled conditions was investigated during winter depression of CO_2 exchange and after its termination due to warming up on the assimilation of $^{14}CO_2$ and the distribution of ^{14}C among the first products of photosynthesis in Scots pines differing in resistance to SO_2.

MATERIAL AND METHODS

Current year twigs of Scots pine (*Pinus sylvestris* L.), that is grown in the preceding vegetative season, have been used in the study. They were collected from 18 years old clones differing in susceptibility to SO_2. They are registered in the Institute of Dendrology under the numbers K-08-02 (tolerant to SO_2 – T), PSI-6 (relatively tolerant to SO_2 – I) and K-01-16 (susceptible to SO_2 – S) (Lorenc-Plucińska 1982).

The twigs were treated with SO_2 for 3 days, 6 h a day at a concentration of 1.0 ppm according to the method of Karolewski and Białobok (1979). Twigs which were detached at the same time were left in SO_2 free air to be used as controls. The products of photosynthesis labelled with radioactive carbon were synthesized directly after the third fumigation. Twigs were placed in a photosynthetic chamber with plexiglass integrated with a closed circulation system of 2.67 l capacity. After 20 min of pre-illumination with 240 Wm^{-2} irradiance at 18-20°C in a normal atmosphere $^{14}CO_2$ was introduced into the system. The total radioactivity introduced was 100 μCi and the initial CO_2 concentration was 0.04%. The twigs were exposed to $^{14}CO_2$ for 5 min. Photosynthesis was stopped by killing the needles in boiling 80% ethanol.

The methods employed for extraction, separation and radioactivity assays of the photosynthetic products have been described by Grishina et al. (1974). The following photosynthetic products were analysed: glucose + fructose, sucrose, raffinose + maltose, starch, glycolate + glycine + serine, alanine, malate, aspartate + glutamate.

The results presented are the mean values obtained from 10 SO_2-treated twigs and 10 unfumigated controls from each of the three pine clones. The experiment was performed in the winter (January).

RESULTS

Fig. 1 illustrates the intensity of ^{14}C assimilation by pine needles after 5 min of exposition in an atmosphere of $^{14}CO_2$ in light. The intensity of $^{14}CO_2$ assimilation by needles of the tolerant clone and by the relatively tolerant clone after they were

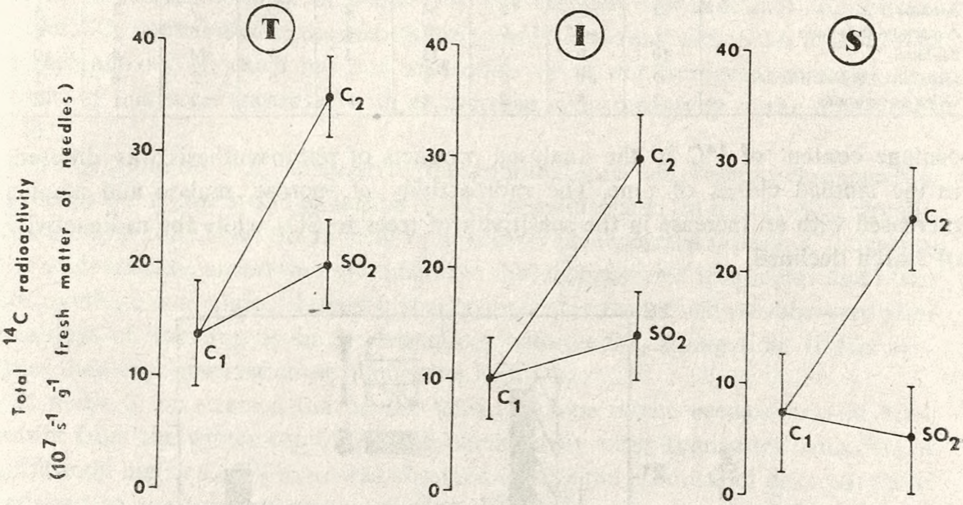

Fig. 1. The effect of SO_2 action on $^{14}CO_2$ uptake after 5 min of photosynthesis of Scots pine twigs (in January)

C_1 – control, 1 h after transferring twigs from natural conditions into the laboratory, C_2 – control (unfumigated twigs) 3 d after transferring twigs from natural conditions into the laboratory, SO_2 – twigs treated with 1.0 ppm SO_2 for 3 d, 6 h per day. T – clone tolerant to SO_2, I – clone relatively tolerant to SO_2, S – clone sensitive to SO_2. Bars indicate standard errors of the means.

transferred from the cold conditions (+5°C) into the laboratory (+20°C) was much lower compared to that which was noted after three days of maintaining twigs in the conditions of room temperature and after treating the twigs for 3 days 6 h daily with SO_2. On the other hand in the sensitive clone the intensity of $^{14}CO_2$ assimilation by twigs transferred from the field into the laboratory was similar to that observed after exposition to SO_2, but substancially lower than observed after 3 days of maintenance in warm room temperature conditions without SO_2.

In Table 1 the percentage content of assimilated ^{14}C in the analysed products of photosynthesis is presented. After transfer of twigs from natural conditions into the laboratory it was found that the labelled carbon is being incorporated primarily into sucrose and glucose+fructose and to a lesser extent into malate, then into starch, aspartate+glutamate, alanine, glycolate+glycine+serine and raffinose, but not maltose (no colour stain for maltose in the raffinose+maltose splot). The per-

Table 1

Effect of SO_2 on the patterns of relative label distribution after 5 min of ^{14}C fixation by needles in light (in January)

Otherwise: see Fig. 1.

Compounds	% of total ^{14}C fixed								
	T			I			S		
	C_1	C_2	SO_2	C_1	C_2	SO_2	C_1	C_2	SO_2
Glucose + fructose	18	10	7	17	11	7	10	12	5
Raffinose	5			3			5		
Raffinose + maltose			11			10		.	18
Sucrose	34	14	30	39	16	33	44	20	35
Starch	15	56	27	12	50	25	10	43	15
Alanine	5	1	5	4	2	5	7	2	4
Aspartate-glutamate	7	2	7	7	2	5	6	2	8
Malate	10	2	5	13	3	7	14	4	10
Glycolate + glycine + serine	3	10	6	3	8	5	2	6	2
Other compounds	3	5	2	2	8	3	2	11	2

centage content of ^{14}C in the analysed products of photosynthesis was different in the studied clones of pine. The radioactivity of sucrose, malate and alanine increased with an increase in the sensitivity of trees to SO_2 while the radioactivity of starch declined.

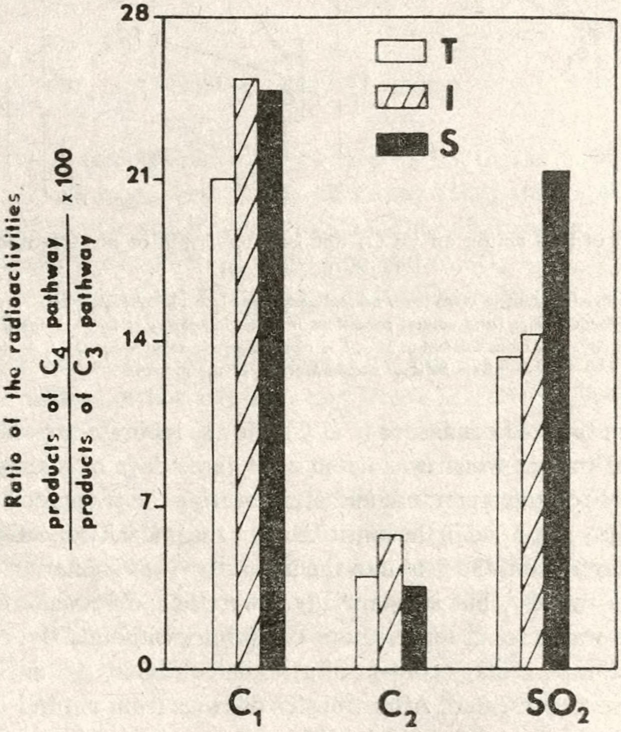

Fig. 2. Effect of SO_2 on the radioactivity ratio $\frac{\text{products of } C_4 \text{ pathway}}{\text{products of } C_3 \text{ pathway}}$ in pine needles after 5 min of ^{14}C-fixation in light

Otherwise; see Fig. 1

After three days of holding twigs at room temperature a percentage change was observed in the content of assimilated ^{14}C in individual products. It was manifest by a substancial, almost three-fold increase in the incorporation of labelled caıbon into starch and glycolate+glycine+serine, particularily in the tolerant clone. At the same time the participation of assimilated ^{14}C declined in all other products of photosynthesis.

On the other hand as a result of the action of SO_2 the percentage content of labelled products of photosynthesis was similar to that observed in the needles immediately after transfer from the natural low temperature conditions except for glucose+fructose the label of which was substancially lowered after fumigation. Besides, SO_2 contributed to the incorporation of ^{14}C into maltose, that is to a product the radioactivity of which has not been observed in non-fumigated material. The content of this sugar increased with an increase in the sensitivity of the pine clones to SO_2.

In Fig. 2 the ratio of radioactivity incorporated into the products characteristic for the C_4 and C_3 pathways of carbon reduction is illustrated. In the material straight from the cold conditions the ratio of radioactivity incorporated into the C_4 dicarboxylic acids (malate, aspartate+glutamate) to that incorporated into sugars and other photosynthates was almost 4 times higher compared to that which was observed after three days of warming up in the laboratory without SO_2 fumigation. It was also higher than that observed after fumigation with SO_2.

It needs to be stressed that in the sensitive clone in the needles straight after transfer from the winter conditions and particularily after fumigation with SO_2 a significantly higher C_4/C_3 ratio was observed among the products of photosynthesis compared to the tolerant and relatively tolerant clone.

DISCUSSION

The presented results indicate that SO_2 changes the intensity of $^{14}CO_2$ assimilation and the metabolism of carbon in a similar manner as low temperature does, and the similarities in the inhibition of photosynthesis by these two stress agents increase with an increase in the sensitivity of the studied trees to SO_2 (Fig. 1).

Literature reports indicate that the winter depression in photosynthesis in coniferous trees is caused by the inactivation of chloroplasts, a decline in the transport of electrons from water to NADP, a lower permeability of the cuticule to CO_2 and an increase in the resistance of mesophyll to CO_2 penetration (Hashimoto and Suzuki 1978, Martin et al. 1978). A reduction in the photosynthetic assimilation of CO_2 under the influence of SO_2 is also usually explained by injuries to chloroplasts (Malhotra 1976), by changes in resistance of leaves (Sisson et al. 1981) or by an inhibition of carboxylation (Gezelius and Hällgren 1980).

Similarily as low temperature SO_2 resulted in a reduced incorporation of ^{14}C into starch and glycolate+glycine+serine while at the same time an increase in label is observed in sucrose, malate and aspartate+glutamate. On the other hand low temperature caused an increase in the incorporation of ^{14}C-glucose+fructose while SO_2 into maltose which was not observed in non-fumigated material (Tab. 1).

It is reported that a winter accumulation of sucrose and monosaccharides as a result of starch hydrolysis lowers the freezing temperature of water in the tissues, stabilizes lipoprotein membranes of chloroplasts and mitochondria and constitutes the main source of energy for oxidation (Heber 1968, Santarius and Heber 1972).

On the other hand Koziol and Jordan (1978) and Koziol and Cowling (1980) suggest that increased amounts of free carbohydrates and decreased starch after exposure to SO_2 might serve as readily accessible substrates for respiratory/repair metabolism. Energy utilisation of these substrates is reflected in increased respiration. As injury to plants by SO_2 increases a greater amount of energy is needed for its repair, as a result of which the level of sugars will become lower as respiration increases (Koziol and Jordan 1978).

In our study an inhibition of the rate of $^{14}CO_2$ assimilation as well as an accumulation of soluble sugars due to the action of SO_2 was greatest in the clone most sensitive to this gas. On the other hand an increase in respiration after exposition to SO_2 was noted only in the tolerant clone (Lorenc-Plucińska 1982), in which the reduction of photosynthesis and the accumulation of sucrose and raffinose+maltose was lower than in the other trees (Fig. 1 and Tab. 1). Thus the commonly accepted hypothesis of Koziol and Jordan (1978) is only partially capable of explaining the results. It needs to be remembered however that the increased level of soluble sugars may have an inhibitory effect on the activity of RuDP carboxylase, the consequence of which is a lowering of photosynthesis.

Exposition to SO_2 and the low winter temperature (winter stress) have lowered the level of labelled glycolate+glycine+serine (Tab. 1). Incorporation of ^{14}C into these products declined proportionately with an increase in the sensitivity of the trees to SO_2. This inhibition is reflected also in the inhibition of photorespiration (Lorenc-Plucińska 1982). Decrease in the accumulation of the glycolic acid pathway intermediates and of the rate of photorespiration cannot be regarded simply as a consequence of glycolate oxidase inhibition or glycolate synthesis caused by SO_2 as it is commonly assumed (Libera et al. 1975).

It has already been shown that the action of SO_2 changes the content of individual amino acids and organic acids (Jäger and Grill 1975, Malhotra and Sarkar 1979, Sarkar and Malhotra 1979). In the present investigation both the action of SO_2 and the low temperatures (winter stress) have contributed to an increase in the labelling with radioactive carbon of malate, aspartate+glutamate and alanine (Tab. 1). Particularily the labelling of malate increased significantly together with an increase in the sensitivity of the studied pines to SO_2.

The high radioactivity of malate was the decisive factor in the increase of the ratio of radioactivity in the C_4/C_3 products in the material under winter conditions compared to the control after 3 days of maintenance under room temperature (Fig. 2). This result might indicate that during the winter PEP carboxylation is injured less than RuDP.

A lowering of the level of activity of carboxylase RuBP during winter stress has been observed by Öquist et al. (1980) and Gezelius and Hallen (1980). The latter authors have established that in the middle of the winter RuBP carboxylase extracted from needles of Scots pine demonstrated only 50% activity of the summer period.

Changes in the level of glutamate, aspartate, alanine or malate under the influence of SO_2 and the reasons for them and consequences have been already well documented (Jäger 1977, Hällgren 1978).

However in the present study it needs to be stressed that the increase in the radioactivity of malate was differentiated depending on the degree of sensitivity of the studied trees to SO_2. In the sensitive clone the labelling of malate was twice as high as in the tolerant one (Tab. 1). This difference was one of the main reasons why the proportion of radioactivity passing through the C_4/C_3 pathways after the action of SO_2 was 60% higher in the sensitive clone compared to the other ones (Fig. 2). This result may indicate that in the sensitive clone after fumigation with SO_2 there is a greater need for compounds which could be carriers of a reductive potential (malate), and therefore an accumulation of NADPH and inhibition of Calvin's cycle may result.

The results presented have demonstrated that: 1° during the winter under the influence of SO_2 there occur abnormalities in the carbon metabolism during photosynthesis evidenced by an increased labelling primarily of malate and sucrose, which was also observed during the summer (Lorenc-Plucińska 1982); 2° the direction of metabolic changes in carbon assimilation are similar under the influence of an SO_2 stress as during the winter depression; 3° the pine clones previously selected on the basis of differences in visible needle injuries following SO_2 treatment (Lorenc-Plucińska 1982) maintain their differential sensitivity to this gas also during the winter.

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SUMMARY

The effect of sulphur dioxide was examined on the uptake of $^{14}CO_2$ and the distribution of ^{14}C among photoassimilates during the winter depression of activity and emergance from it in SO_2-tolerant, SO_2-relatively tolerant and SO_2-susceptible clones of Scots pine (*Pinus sylvestris* L.). Detached twigs were treated with 1.0 ppm SO_2, 6 h daily over 3 consecutive days. The fumigated twigs were then exposed to $^{14}CO_2$ for 5 min. The labelled soluble sugars, starch, amino acids and dicarboxylic acids were fractionated nad determined using ion-exchange chromatography, paper chromatography and autoradiography. Low winter temperatures and exposure to SO_2 inhibited the subsequent total $^{14}CO_2$ uptake, decreased the percentage of label in starch, glycolate, glycine and serine. The degree of inhibition varied with the susceptibility of trees to SO_2 and was greatest in the most susceptible one. On the

other hand there was a marked increase in the percentage of label in sucrose, aspartate, glutamate, alanine and malate. Changes in ^{14}C labelling of sucrose and especially of malate increased to a much greater degree in susceptible individuals than in tolerant ones. It is concluded that cold winter temperatures and SO_2 fumigation alters $^{14}CO_2$ uptake and the carbon reduction in photosynthesis in a similar manner. Fumigation with SO_2 during wintertime (in controlled conditions) distinctly hampered the labelling of the C_3 pathway and the products of β-carboxylation increased. These disturbances are dependent on the degree of susceptibility of trees to SO_2.

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LITERATURE

1. Böritz S., 1969. Physiologische und biochemische Beiträge Rauchschadenforschung. 11. Mitt. Analysen einiger Nadelinhaltsstoffe an Fichten unterschiedlicher individueller Rauchhärte aus einem Schadgebiet. Arch. Forstwes. 18, 123 - 131.
2. Bressan R. A., Wilson L. G., Filner P., 1978. Mechanisms of resistance to sulfur dioxide in the *Cucurbitaceae*. Plant Physiol. 61, 761 - 767.
3. Caput C., Belot Y., Auclair D., Decourt N., 1978. Absorption of sulphur dioxide by pine needles leading to acute injury. Environ. Pollut. 16, 3 - 15.
4. Czarnowski M., 1977. Seasonal changes of photosynthetic rate in deciduous tree growing within the region of industrial emissions. Bull. Acad. Polon. Sci. Ser. Biol. 25, 443 - 450.
5. Eckert R. T., Houston D. B., 1980. Photosynthesis and needle elongation response of *Pinus strobus* clones to low sulfur dioxide exposure. Can. J. For. Res. 10, 357 - 361.
6. Gezelius K., Hallen M., 1980. Seasonal variation in ribulose bisphosphate carboxylase activity in *Pinus silvestris*. Physiol. Plant. 48, 88 - 98.
7. Gezelius K., Hällgren J.-E., 1980. Effect of SO_3^{-2} on the activity of ribulose bisphosphate carboxylase from seedlings of *Pinus silvestris*. Physiol. Plant. 49, 354 - 358.
8. Grishina G. S., Maleszewski S., Frankiewicz A., Voskresenskaya N., Poskuta J. 1974. Comparative study of the effects of red and blue light on $^{14}CO_2$ uptake and carbon metabolism of maize plants in air and oxygen. Z. Pflanzenphysiol. 73, 189 - 197.
9. Hällgren J.-E., 1978. Physiological and biochemical effects of sulfur dioxide on plants. In: Sulfur in the environment. Part II. Ecological impacts (Ed. Nriagu J. O.), 163 - 209.
10. Hashimoto R., Suzuki T. 1978. Resistance to carbon dioxide transfer in leaves of *Cryptomeria japonica* in winter and influence of soil temperature on them. J. Jap. For. Soc. 60, 24 - 30.
11. Heber U. 1968. Freezing injury in relation to loss enzyme activities and protection against freezing. Cryobiology 5, 188 - 201.
12. Jäger H.-J., Grill D. 1975. Einfluss von SO_2 und HF auf Aminosäuren der Fichte (*Picea abies* (L.) Karsten). Eur. J. For. Pathol. 5, 279 - 286.
12. Jäger H.-J. 1977. Auswirkungen phytotoxicher Immissionnen auf enzymatische aktivitäten und Reaktionen. Angew. Bot. 51, 1 - 7.
13. Karolewski P., Białobok S. 1979. Wpływ dwutlenku siarki, ozonu, mieszaniny tych gazów i fluorowodoru na uszkodzenie igieł modrzewia europejskiego. Arboretum Kórnickie 24, 298 - 305.
14. Kieliszewska-Rokicka B., 1979. Peroxidase activity in varieties of *Weigela* and *Pinus sylvestris* resistant and susceptible to SO_2. Arboretum Kórnickie 24, 313 - 320.
15. Koziol M. J., Cowling D. W., 1980. Growth of ryegrass (*Lolium perenne* L.) exposed to SO_2. III. Effects on carbohydrate concentrations. J. Exp. Bot. 31, 1687 - 1699.
16. Koziol M. J., Jordan C. F., 1978. Changes in carbohydrate levels in red kidney bean (*Phaseolus vulgaris* L.) exposed to sulphur dioxide. J. Exp. Bot. 29, 1037 - 1043.

17. Libera W., Ziegler I., Ziegler H., 1975. The action of sulfite on the HCO_3^- fixation and the fixation pattern of isolated chloroplasts and leaf tissue slices. Z. Pfanzenphysiol. 74, 420 - 433.
18. Lorenc-Plucińska G., 1982. Influence of SO_2 on CO_2 assimilation and carbon metabolism in photosynthesic processes in Scots pine. Arboretum Kórnickie 27, 285 - 310.
19. Lorenc-Plucińska G., 1986. Some effects of exposure to sulphur dioxide on the metabolism of Scots pine in the winter. I. Effects on photosynthesis and respiration. Arboretum Kórnickie 31: 229 - 236.
20. Malhotra S. S., 1976. Effect of sulphur dioxide on biochemical activity and ultrastructural organization of pine needle chloroplast. New. Phytol. 76, 239 - 246.
21. Malhotra S. S., Sarka S. K., 1979. Effect of sulphur dioxide on sugar and free amino acid content of pine seedlings. Physiol. Plant. 47. 223 - 228.
22. Martin B., Martensson O., Öguist G., 1978. Seasonal effects on photosynthetic electron transport and fluorescence properties in isolated chloroplast of *Pinus sylvestris*. Physiol. Plant. 44. 102 - 109.
23. Omura T., Satoh H., Fujima Y., Aiga I., 1980. Inheritance of sensitivity ot sulphur dioxide in rice, *Oryza sativa* L. In: Studies on the effects of air pollutants on plants and mechanisms of phytotoxicity. Res. Rep. Natl. Inst. Environ. Stud. 11, 263 - 265.
24. Öguist G., Brunes L., Hällgren J.-E., Gezelius K., Hallen M., Malmberg G. 1980. Effects of artificial forest hardening and winter stress on net photosynthesis, photosynthetic electron transport and RuBP carboxylase activity in seedlings of *Pinus silvestris*. Physiol. Plant. 48, 526 - 531.
25. Santarius K., Heber U., 1972. Physiological and biochemical aspects of frost damage and winter hardiness in higher plants. In: Proceedings of a colloquium on the Winter Hardiness of Cereals Agricultural Research Institute of the Hungarian Academy of Sciences. (Ed. Rajski S.) Martonvaser.
26. Sarkar S. K., Malhotra S. S., 1979. Effect of SO_2 on organic acid content and malate dehydrogenase activity in jack pine needles. Bioch. Physiol. Pflanzen 174, 438 - 445.
27. Sisson W. B., Booth J. A., Throneberry G. O., 1981. Absorption of SO_2 by pecan (*Carya illinoensis* (Wang) K. Koch) and alfalfa (*Medicago sativa* L.) and its effect on net photosynthesis. J. Exp. Bot. 32, 523 - 534.
28. Winner W. E., Mooney H. A. 1980. Ecology of SO_2 resistance: II. Photosynthetic changes of shrubs in relation to SO_2 absorption and stomatol behaviour. Oecologia (Berl.) 44, 296 - 302.

Wpływ SO_2 na metabolizm sosny zwyczajnej podczas zimy. II. Wpływ na metabolizm węgla w fotosyntezie

Streszczenie

Badano wpływ dwutlenku siarki na asymilację $^{14}CO_2$ i metabolizm węgla w fotosyntezie podczas zimowej depresji i po jej przełamaniu wraz z ociepleniem u SO_2 – tolerancyjnego, SO_2 – względnie tolerancyjnego i SO_2 – wrażliwego klonu sosny. Obcięte pędy traktowano SO_2 w stężeniu 1,0 ppm przez 3 dni po 6 godz. dziennie. Ekspozycja pędów w atmosferze znaczonego dwutlenku węgla trwała 5 min i następowała bezpośrednio po ukończeniu fumigacji. Zawartość radioaktywnych cukrów rozpuszczalnych, skrobi, aminokwasów i kwasów dwukarboksylowych oznaczano za pomocą chromatografii jonowymiennej, bibułowej i autoradiografii.

Niska temperatura podczas zimy oraz dwutlenek siarki hamują asymilację CO_2 i obniżają procentową zawartość radioaktywnej skrobi, glikolanu, glicyny i seryny. Obniżenie zależało od stopnia wrażliwości badanych klonów na SO_2 i było największe w klonie wrażliwym. Z drugiej

strony notowano znaczny wzrost zawartości radioaktywnej sacharozy, asparaginianu, glutaminianu, alaniny i jabłczanu. Zmiany w znakowaniu sacharozy, a szczególnie jabłczanu były znacznie większe w klonie wrażliwym w porównaniu z tolerancyjnym.

ГАБРИЭЛЯ ЛОРЕНЦ-ПЛЮЦИНЬСКА

Влияние SO_2 на метаболизм углерода сосны обыкновенной в зимний период. 2. Влияние на метаболизм углерода в фотосинтезе

Резюме

Исследовали влияние сернистого ангидрида на ассимиляцию $^{14}CO_2$ и метаболизм углеродав фотосинтезе в период зимней депрессии и после ее прохождения во время оттаивания у SO_2 — устойчивого, SO_2 — относительно устойчивого и SO_2 — чувствительного клона сосны. Срезанные ветки обрабатывали SO_2 в концентрации 1.0 частей/млн в течение 3 дней по 6 часов в день. Побеги экспонировали в присутствии меченой двуокиси углерода в течение 5 минут непосредственно после газации. Содержание меченых растворимых сахаров, крахмала, аминокислот и дикарбоксиловых кислот определяли путем ионообменной и бумажной хроматографии и авторадиографии.

Низкая температура в зимний период, а также сернистый ангидрид тормозили ассимиляцию CO_2 и понижали процентное содержание меченого крахмала, гликольевой кислоты, глицина и серина. Понижение зависило от степени чувствительности исследуемых клонов к SO_2 и было самым значительным в чувствительном клоне. С другой стороны, отмечено значительный рост радиоактивного сахароза, аспарагиновой, глутаминовой и яблочной кислот, а также аланина. Изменения в мечении сахароза, а в особенности яблочной кислоты были значительно большими у чувствительного клона по сравнению с толерантным.