18 October 1984; Revised 19 January 1985

1. Hussey, D., *Sci. Prog.*, 1979, **65**, 185.
2. Hicks, G. S., *Bot. Rev.*, 1981, **46**, 1.
3. Pareek, L. K. and Chandra, N., *Plant Sci. Lett.*, 1978, **11**, 311.
4. Crisp, P. and Walkey, D. G. A., *Euphytica*, 1974, **23**, 305.
5. Dunwell, J. M., *J. Exp. Bot.*, 1981, **32**, 789.
6. Singh, S. and Chandra, N., *Plant Cell Rep.*, 1984, **3**, 1.
7. Singh, S. and Chandra, N., *Curr. Sci.*, 1984, **53**, 379.
8. George, L. and Rao, P. S., *Ann. Bot.*, 1980, **46**, 107.
9. Bajaj, Y. P. S. and Nietsch, P., *J. Exp. Bot.*, 1975, **26**, 893.
10. Lustinec, J. and Horak, J., *Experientia.*, 1970, **26**, 919.
11. Murashige, T. and Skoog, F., *Physiol. Plant*, 1962, **15**, 473.
12. Singh, S., Banu, S., Pareek, L. K. and Chandra, N., *Indian J. Exp. Biol.*, 1981, **19**, 658.

EFFECTS ON GROWTH AND PHOTOSYNTHESIS OF *VIGNA RADIATA* CV PUSA BAISAKHI IN ENVIRONMENT CONTAINING SO_2 AND/OR NO_2

P. C. PANDE

Department of Biological Sciences, University of Lancaster, Lancaster, LA1 4YQ, U.K.
Present address: Department of Botany, Meerut College, Meerut 250 001, India.

SULPHUR dioxide and nitrogen dioxide are the two most widespread air pollutants of industrialized countries, as combustion of fossil fuels generates SO_2 and NO_2. Considerable information is now available on the effects of SO_2 on leguminous crops of the temperate region. Even low concentrations of SO_2 have been found to reduce photosynthesis[1-3], translocation[4], and biomass production[5] in beans. In ambient environment SO_2 and NO_2 are present together. Recent studies involving mixtures of these two pollutants have shown synergistic, additive or antagonistic effects on the growth and physiological processes of various crops[6].

Since there is no report on the effect of pollutant mixture on legumes of the tropics, the present study was initiated so as (i) to compare the effects of SO_2 and NO_2 both individually and in the mixture on the growth, and (ii) to evaluate the effects of SO_2 and/or NO_2 on the photosynthesis of young plants of mung bean (*Vigna radiata*).

Seeds of *V. radiata* (L) Wilczek CV Pusa baisakhi were grown in 10 cm plastic pots containing John Innes No. II potting compost. Seedlings were raised in a heated green house. Two days after germination, 40 seedlings of fairly uniform size were selected and 10 seedlings were randomly allocated to each of the four treatment chambers of the type described by Whitmore[7]. Three of these chambers were supplied with filtered air containing SO_2 alone, NO_2 alone, and mixture of SO_2 and NO_2. The concentration of gases in these chambers was 266 μg^{-3} SO_2, 191 μg^{-3} NO_2 and 266 μg^{-3} SO_2 + 191 μg^{-3} NO_2 respectively. The fourth chamber with only charcoal filtered air served as control. Concentration of pollutants within these chambers was regularly monitored using a Meloy SA 285 flame photometric analyser for SO_2 and a Meloy NA 520 chemiluminizer for NO_2. The day length was 14 hr and the temperature was maintained at 23°C during the day and 17°C during the night. Illumination was from a horizontally fitted metal halide lamp providing a photon flux density of 350 μEm^{-2} sec^{-1}.

Fumigation continued for three weeks. Thereafter net photosynthesis (*Pn*) of plants from all treatments was measured in clean air using an infrared gas analyser operating on a differential mode. These plants were then separated into root and shoot fractions for dry weight measurements.

In another experiment three-week-old plants were exposed to air containing 106.4, 159.6, 212.8 and 226 μgm^{-3} SO_2 for measuring *Pn* following the technique of Black and Unsworth[1].

Table 1 shows the effect of the two pollutants on the shoot/root dry weight fractions when applied singly and in combination. While the yield reduction was insignificant in NO_2, it was significantly affected by

Table 1 *Shoot and root dry weights of V. radiata after 3 weeks exposure to 191 μg^{-3} NO_2 or/and 266 μg^{-3} SO_2.*

Treatment	Shoot wt (g)	Root wt (g)
Control	0.2788	0.0275
NO_2	0.2603	0.0211
SO_2	0.1918[a]	0.0251
$SO_2 + NO_2$	0.2486[b]	0.0257

Significance of difference from control. [a] $P < 0.001$, [b] $P < 0.05$.

SO_2 and $SO_2 + NO_2$ treatments. The reductions were, however, larger in SO_2 alone ($P < 0.001$) than in $SO_2 + NO_2$ mixture ($P < 0.05$).

Although in most of the crops $SO_2 + NO_2$ treatment has been found more toxic than their individual treatments[6,8,9], mung bean seems to be more sensitive to individually applied SO_2 as has also been reported for *Poa pratensis*[10]. Larger reductions in dry weight in SO_2 may be attributed to the reduced photosynthetic efficiency of leaves after prolonged exposure. *Pn* of plants in this treatment, measured after three weeks of continuous exposure to SO_2 was only 54% of the control. On the other hand, *Pn* was 88 and 84% of the control in NO_2 and $SO_2 + NO_2$ treatment respectively (table 2). *Pn* of mung bean has a very good negative correlation with SO_2 dose when measured in air containing 106.4 to 266 μg^{-3} SO_2. *Pn* was reduced even in air containing as low as 106.4 μg^{-3} SO_2 (40 ppb), and a progressive decrease in *Pn* was observed with further increase in the dosage (figure 1). The inhibition of photosynthesis may be due to a decrease in levels of ribulose bisphosphate carboxylase after pretreatment with SO_2[11].

Table 2 *Net photosynthesis (Pn) V. radiata measured in clean air after 3 weeks exposure to 266 μg^{-3} SO_2 or/and 191 μg^{-3} NO_2.*

Treatment	Pn (In $\mu gm^{-2}s^{-1}$)	
Control	148 32	(16.47)
NO_2	131.64	(21.70)
SO_2	80.73	(11.32)
$SO_2 + NO_2$	125.64	(13.63)

Figures within bracket show the critical difference.

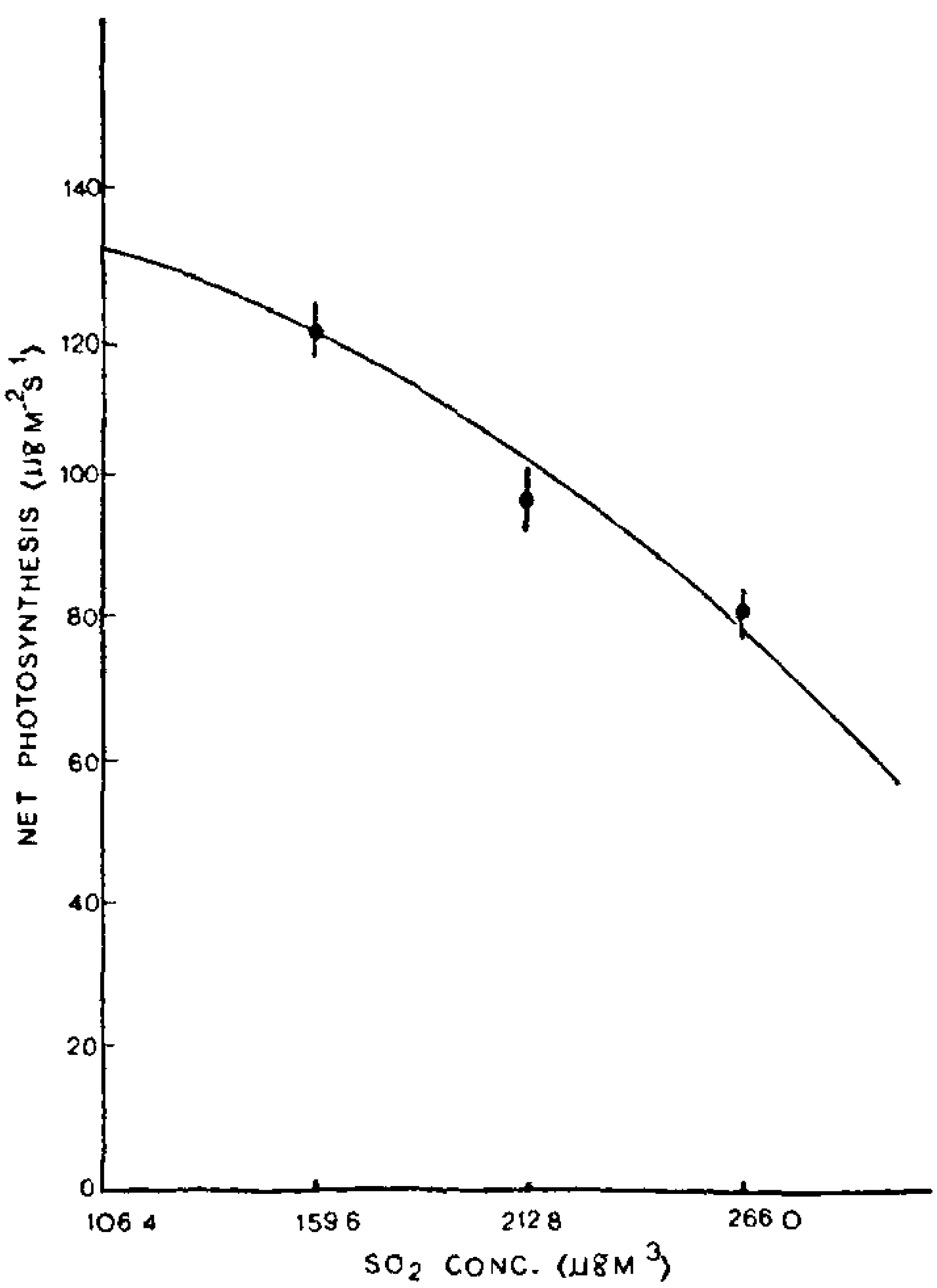

Figure 1. Relationship between rate of photosynthesis of *Vigna radiata* and SO_2 concentration.

These results were obtained with plants grown in the laboratory and thus cannot predict quantitatively the response of field crops to pollutants. But such a study does illustrate the implications of low concentrations of pollutants which might occur in rural agricultural areas far away from industries.

The author is grateful to Professor T. A. Mansfield, Department of Biological Sciences, Lancaster University (U.K.) for providing facilities. Thanks are also due to Dr V. Singh, Meerut University, for helpful discussion during the preparation of the manuscript, and to the Royal Society for financial assistance.

24 September 1984; Revised 23 January 1985

1. Black, V. J. and Unsworth, M. H., *J. Exp. Bot.*, 1979, **30**, 473.
2. Takemoto, B. K. and Noble, R. D., *Environ. Pollut.*, 1982, **28**, 67.
3. Saxe, H., *Physiol. Plant*, 1983, **57**, 101.
4. Teh, K. H. and Swanson, C. A., *Plant Physiol.*, 1982, **69**, 88.
5. Saxe, H., *Physiol. Plant*, 1983, **57**, 108.
6. Ormrod, D. P., In: *Effects of gaseous pollutants in agricultural and horticulture* (Proceedings of 32nd School in Agricultural Sciences, University of Nottingham School of Agriculture), (eds) M. H. Unsworth and D. P. Ormrod, Butterworths, 1982, p. 307.
7. Whitmore, M. E., Ph.D. Thesis, Lancaster Univ. 1982.
8. Whitmore, M. E. and Freer-Smith, P. H., *Nature (London)*, 1982.
9. Pande, P. C. and Singh, V., *Water, Air and Soil Pollution*, 1985. (In press).
10. Ashenden, T. W. and Mansfield, T. A., *Nature (London)*, 1978, **273**, 142.
11. Miszalski, Z. and Ziegler, H., *Phytopathol. Z.*, 1980, **97**, 144.