EFEITO DA POLUIÇÃO POR DIÓXIDO DE ENXOFRE (SO_2) SOBRE BIOINDICADORES HORTÍCOLAS

EFFECT OF POLLUTION BY SULPHUR DIOXIDE (SO_2) ON VEGETABLES BIOINDICATORS

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RESUMO

Plantas de cenoura e nabo mostraram pesos frescos e secos semelhantes quando cultivadas na área próxima à indústria. Entretanto, as plantas das duas espécies, cultivadas a cinquenta e noventa metros de distância da fonte poluidora, apresentaram menor crescimento e consequentemente redução dos pesos frescos e secos. O crescimento das plantas de cenoura e nabo, medido pelo peso fresco, mostrou-se diferente entre os pontos próximos à indústria e à estação de controle a dez quilômetros. O crescimento aumentou com a distância, e consequentemente devido à topografia, com a altitude do local de cultivo das plantas. O peso seco apresentou grandes variações em todas as espécies e entre as estações de coleta. Verificou-se uma redução de 87,4% entre o peso seco das plantas crescendo na estação 2 com o controle. O fator altura também exerceu influência no efeito da emissão industrial sobre o crescimento e desenvolvimento das plantas. As espécies crescendo na estação 1, ao mesmo nível da indústria, e da estação 2, situada 122m acima do nível da indústria, porém, na direção predominante dos ventos, mostraram maior redução no crescimento, com base nos pesos frescos e secos. As condições meteorológicas, como velocidade e direção dos ventos e área de estagnação, associadas à conformação topográfica, podem aumentar os efeitos dos agentes fitotóxicos na atmosfera sobre o ecossistema vegetal. A região onde a indústria têxtil se localiza apresenta condições que favorecem o efeito de poluentes sobre as plantas crescendo nas redondezas onde este estudo foi conduzido. Plantas situadas próximas ao nível da tecelagem mostraram maiores reduções no desenvolvimento, principalmente com relação às cultivadas em áreas livres dos agentes atmosféricos tóxicos.

Palavras-chave: Bioindicadores; Poluição; Dióxido de Enxofre.

ABSTRACT

Carrot and turnip Plants showed fresh and dry weights similar when grown in the area next to the industry. However, plants of two species, cultivated in the fifty and three hundred feet away from the polluting source, showed reduced growth and consequently reduction of fresh and dry weights. Plant growth of carrot and turnip, measured by weight fresh, proved to be different between the dots next to the industry and to the control station to ten kilometers. Growth increased with the distance, and as a result due to the topography, with the altitude of the place of cultivation of plants. The dry weight showed large variations in all species and between seasons. There has been a reduction of 87.4 between dry weight of the plants growing in season 2 with the control. The time factor also exerted influence on the effect of industrial emission on the growth and development of plants. The species growing in season 1, at the same industry-level, and 2 station, located 122 m above the level of the industry, however, in the prevailing wind direction, showed greater reduction in growth, based on fresh and dry weights. Weather conditions such as wind speed and direction and stagnant area, associated with the topographical conformation, can increase the effects of toxic agents in the atmosphere over the plant ecosystem. The region where the textile industry lies presents conditions that favor the pollute effect.

:**Keywoords: Bioindicators; Pollution; Sulfur Dioxine.**

INTRODUCTION

In terms of industrial waste, sulfur dioxide (SO2) is extremely harmful to vegetation, and has been studied more than any other chemical compound. (Jacobson &Hill, 1970; Mudd&KozLowiski, 1975). Substantial analysis of damage to plants and the effects on a large number of plant species susceptible to SO2 been publish (Jacobson &Hill, 1976; Sanders&Reinert, 1982). Sublethal concentrations of SO2 may not cause noticeable effects on the leaves, however, several metabolic processes may be affected resulting in a decrease in growth and hence production, (Hogsettet al, 1984).

This study aimed to assess the degree of air pollution in the vicinity of a textile factory in the city of Petrópolis, RJ, using bioindicator plants.

MATERIAL E MÉTODOS

It was used the species *Daucuscarota* sp (carrot) e *Brassica rapa* (turnip), bioindicator plants proved sensitive to sulfur dioxide (SO_2) (Hicks, 1976; Jacobson & Hill, 1970; Wood, 1962). Turnip and carrot seeds were sown directly into black plastic bags with 26 x 14 cm, two plants per bag and four bags per species, in soil not fertilized and irrigated daily. The plants grow up in a place free of any sign of air pollution from the industries. Thirty days after the sowing, four plants of each species was carried for one of five sampling stations, where they continued to be irrigated daily. The plants were collected 80 days after sowing, immediately weighed to obtain fresh weight and subsequent drying at 40° C in a stove to obtain a constant dry weight. The atmospheric pollution influence of on plants was based on the reduction of the fresh and dry weights of the plants growing on each of five sampling stations.

The data were taken and analyzed by the mathematical model Y_{ijk}=u+ C_i+ P_{ij}+ $\in_{ijk}$ which, Y_{ijk}= observation relative Kth determination within jth plant, in the ith morphospecies; u = total mean of the characteristic analyzed; C_i= random efect of ith level of morphospecies with i = 1, 2,..., I;P_{ij}= random efect of jth plant within the ith com j= 1, 2,...j(characterized as experimental error component); ijk = random error associated with each Yijk observation, assuming NiD (0.62) with k = 1, 2 (characterized as the sampling error component).

Analyses of variance were performed for each measure taken, according to the hierarchical classification model, as Snedecor (1967). There was the composition of the mathematical expectations of mean square corresponding to each of the effects with which it becomes possible to estimate the variance components corresponding to σ^2_c, σ^2_p and σ^2. The values obtained was used to estimate the variance of the overall mean ((S [2 / X]) for each measure studied, using the formula adopted by Snedecor (1967), which: S (2 / X) = Q . M. Plants / IJK = σ^2+ K σP^2+ JK σC^2/ IJK ou S (2 / X) = σ^2 / IJK + (σ^2_p/ IJ) + (σ^2_c / I), which, I, J e K correspond respectively to the number of determinations within Morphospecies and plants. Thus, varying the values in the formula denominators can, then, choose the best combination of Morphospecies and determinations in plants capable of reducing S (2/ X).

In this Methods, two formulas were employed for the estimate of n_i= morphospecies, the first expression: n_i= n $(N_i\sigma_i / \sqrt{C_i}) / (\sum N_i\sigma_i / \sqrt{C_i})$, which n = n.° total number of individuals in the sample, N = number of morphospecies, σ_i= standard deviation of morphospecies or plants, C_i= sampling cost. The second formula was represented: n_i= n $(N_i\sigma_i) / \sqrt{C_i} / \sum (N_i\sigma_i / \sqrt{C_i})$.

RESULTS AND DISCUSSION

Carrot and turnip plants showed similar dry and fresh weights when grown next to industry area. However, plants of both species grown to fifty and ninety meters away from the pollution source, showed lower growth and hence reduction of fresh and dry weights.

Plant growth of carrot and turnip, as measured by fresh weight, showed differences between the points nearby industry and the control ten kilometers station points. The growth increased with distance, and hence due to the topography, with the altitude of plant cultivation. Drastic reductions in fresh weight were observed near the pollution source. About 90% decrease in fresh weight was observed between plants grown nearby industry, compared to control. Substantial changes in fresh weight were also observed among the plants growing in the control site and the other sampling sites.

The dry weight showed large variations in all species and among

Table 1. *Mean Weight of Fresh and Dry Vegetable Species.*

Distance Source Issuer (m)	Altitude (m)	*Daucuscarota*		*Brassica rapa*	
		Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
Station 1 (50)	873	7,8 ± 1,9	0,63 ± 0,4	6,1 ± 1,7	0,81 ± 0,3
Station 2 (90)	995	4,3 ± 1,7	0,32 ± 1,7	8,2 ± 2,2	0,82 ± 0,3
Station 3 (115)	956	7,2 ± 0,6	0,51 ± 0,3	11,3 ± 1,3	1,53 ± 0,2
Station 4 (237)	995	8,4 ± 1,3	1,12 ± 0,5	13,9 ± 2,5	2,57 ± 0,6
Station 5 (10.000)	873	15,2 ± 3,2	2,13 ± 0,7	42,7 ± 12,4	5,45 ± 1,8

sampling stations. There was a reduction of 87.4% of dry weight of plants growing in station 2 with the control. The height factor also exerted influence on the effect of industrial emissions on the growth and development of plants. Species growing at station 1, the same level of industry, and station 2, located 122m above the industry level, however, at the predominant wind direction, showed a greater reduction in growth, based on fresh and dry weights.

Soil analysis made pre-and post-harvest showed an meanpH of 6.8 for all stations, showing no significant changes with respect to the level of altitude and distance from the industry. The phosphorus, potassium, aluminum, calcium and magnesium were within normal level for proper plant growth.

Table 2. *Percentage reductions in the Growth of Plants in Relation to Local Control (Station 5).*

Distance Source Issur (m)	Altitude (m)	*Daucuscarota*		*Brassica rapa*	
		Fresh weight (g)	Dry weight (g)	Fresh weight (g)	Dry weight (g)
Station 1 (50)	873	50,0%	73,6%	88,1%	84,7%
Station 2 (90)	995	72,0%	83,7%	80,2%	85,4%
Station 3 (115)	956	53,3%	74,8%	74,2%	71,3%
Station 4 (237)	995	45,0%	45,7%	67,6%	53,3%

The tables 3-6 contain the components of variance for morphospecies ($\sigma^2 p$) corresponding to the several characters and some indices used.

Table 3. Average Square and Coefficients of Variation Analysis of Variance for each Character Studied.

F.V	G.L	Average square of Characters						
		A	B	C	L	I	S	N
Morphospecies	4	1,67 ns	2,68*	2,69*	3,51*	0,18*	1,95*	0,17*
Plants within Morphospecies	30	1,26 ns	0,45 ns	0,57 ns	0,28 ns	0,03 ns	0,23 ns	0,08 ns
Determinations Within Plants	30	0,62	0,31	0,22	0,18	0,03	0,07	0,07
C.V. (%)		7,03	8,54	7,23	7,98	5,71	9,66	8,58

* $P < 0,05$

Only if the character A, $\sigma^2 p$ component of the effect of plants was higher than σc^2. For Indices was observed the same trend, reaching to find even null values $\sigma^2 p$ (Table 5).

Tabela 4. Mean Square and Coefficients of Variation Analysis of Variance for each Character Studied.

F.V	G.L	Mean Square			
		B/A	A/C	L x 1	S/L x 100
Morphospecies	4	0,079 ns	0,49*	0,64*	36,71*
Plants Within Morphospecies	30	0,038 ns	0,03 ns	0,02 ns	10,75 ns

Determination Within the Plants	30	0,039	0,03	0,79	10,58
C.V. (%)		10,99	7,89	7,91	6,78

* P< 0,05

Table 5. Variance Components for morphospecies (σ²c) and plants (σ²p) for the several Character Study.

Characters	Variance Components [1]		Confidence Intervals [2]
	σ^2_c	σ^2_p	σ^2_c
A	0,03	0,32	
B	0,23	0,08	0,13 – 2,93
C	0,28	0,17	0,03 – 3,84
L	0,21	0,06	0,12 – 2,54
I	0,01	0,01	0,01 – 0,23
S	0,18	0,06	0,11 – 2,18
N.°	0,088	0,049	

1. Estimated on the basis of I = 5 morphospecies, J = 5 plants and K = 2 determinations per plant
2. Calculated in the case of significant effect of Morphospecies

Table 6. *Components of Variance for morphospecies (σ ² c) and plants (σ ² p) for Various Indices Studied.*

Index	Variance Components[1]		Confidence Intervals [2]
	σ^2_c	σ^2_p	σ^2_c
B/A	0,0006	0,001	
A/C	0,07	0,001	0,03 – 0,58
L x1	0,065	0	0,05 – 0,79
S/L x 100	2,61	0,079	0,58 – 39,26

1. Estimated on the basis of I = 5 morphospecies, J = 5 plants and K = 2 determinations per plant
2. Calculated in the case of significant effect of Morphospecies

Therefore, the result shows that the variation between plants and morphospecies is smaller, indeed, than exhibited by morphospecies. The plants growing in nearby atmospheres industrial parks are under environmental "stress" caused by air pollutants (Linzon, 1965; Reinert&Heck, 1982). Plants grown in the textile region showed reduced growth, as measured by fresh and dry weights. The history of the industry as well as the leaf symptoms, suggest that substantial amounts of SO_2 are emitted into the atmosphere every day (Brandt &Heck, 1968).

Weather conditions, such as speed and direction of winds and the area of stagnation, associated to the topographic conformation, may increase the effects of phytotoxic agents in the atmosphere on plant ecosystem.

The region where the textile industry is located presents conditions that favor the effect of pollutants on plants growing nearby where this study was conducted. Plants located close to the level of weaving showed greater reductions in development, mainly in relation to cultivated areas free of toxic elements (Table 2).

Chlorosis and necrosis, yellowish and whitish, leaf symptoms are the presence of SO_2 in the atmosphere (Hicks, 1976; Jacobson&Hill, 1970; Mudd&Koslowski, 1975). Turnip, as a sensitive plant to the pollutant, has yellowish and whitish when exposed to toxic concentrations of SO_2 (Brandt &Heck, 1968; Jacobson & Hill, 1970; Whitmore& Mansfield, 1983). Visually, it was noted similar, typical chlorosis of injury caused by SO_2, plants used in this experiment, suggesting a possible toxicity of SO_2 and other pollutant acting synergistically (Mudd&Koslowski, 1975; Reinert&Heck, 1982; Sansers&Reinert, 1982).

The SO_2 penetrates through the stomata in plants and can cause metabolic changes with a consequent reduction in the growth and development of plants (Elkiey&Ormrod, 1979; Keller, 1984; Kovar, 1982; Majernik& Mansfield, 1970; Miyakeet al, 1984; Unsworth et al, 1972). The degree of penetration is directly correlated with the opening and closing of stomata. Ideal conditions for the opening of the stomata facilitate penetration of SO_2 in plants causing greater degradation in leaf tissue (Elkiey&Ormrod, 1979; Majernik& Mansfield, 1970; Unsworthet al, 1972). Plants grown in the vicinity of the textile industry showed greater reductions in growth than those located in more remote locations.

The sensitivity of plants to certain pollutants may be a bioindicators for the content of phytotoxic gases in the atmosphere (Bediet al, 1982; Hogsett et al, 1984). The species used, As espécies utilizadas, cited as sensitive SO_2, showed symptoms of chlorosis in the leaves of plants growing to fifty and nine meters of pollution source. Bean plants show necrotic symptoms levels 5ppm of SO_2 (Hicks, 1976). This leads to conclude that the area on the nearby of industry, polluting the atmosphere contains indexes to approximate the phytotoxic levels. Probably, native plants of the region should also be being affected by the issue of SO_2 in the atmosphere.

Soil analysis, the containers used in areas near industries, showed no chemical change compared to the samples collected to fourteen kilometers from the emission source.

The average pH of 6.8, and normal levels of chemical elements (P, K, Al, Mg, and Ca) showed that the soil was not the factor of reducing the growth of plants. Results based on fresh and dry weights, showed reductions in growth of cultivated plants at different distances and altitudes near the industry. This observation supports the thesis that the atmosphere was the main factor that caused the reduction in the development and growth of bioindicator plants.

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