Residual Air Pollution Effects on Soybean Seed Quality

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ABSTRACT

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The secondary or subsequent effects of air pollution on the percent seed germination and on the chemical composition of seeds derived from ozone-treated plants has not been reported. Our objectives were to determine if ambient ozone influences: 1) seed germination and 2) percentages of oil and protein in soybean seed (*Glycine max*). Seed sources were from soybeans grown in open-top field chambers with carbon-filtered air, in unfiltered air chambers, or in nonchambered plots. Percent oil and percent protein were determined by A.O.A.C. procedures 7.044 and 7.016, respectively. Seed germination was ascertained by standard seed test methods. Percent seed germination was statistically the same for seed produced in filtered and unfiltered air chambers; percent seed protein was significantly greater in seed produced in unfiltered air than in filtered air, but percent oil was significantly higher in seed produced in filtered air. Plants grown in nonchambered plots produced seed that had significantly lower germination but had protein contents similar to seed produced on plants from chambered plots. Percent oil in seed from nonchamber-grown plants was significantly lower than in seed of plants from carbon-filtered air but was statistically the same in seed produced in unfiltered air. Stressing seed by chilling lowered percent seed germination by nearly 5%. Variations in parameters investigated were more influenced by years than by environments.

Vegetative growth is reduced in soybeans exposed to ozone and sulfur dioxide, although sensitivity differs among cultivars (8,10). The residual effects of these pollutants on seed germination and percentage of oil and protein from seeds have not been reported. Seed from four soybean cultivars grown in 1973, 1974, and 1975 in open-top field chambers with carbon-filtered air weighed significantly more than seed from the same cultivars grown in chambers with unfiltered air or in plots without chambers (5). Hamblin (4) reported that seed of *Phaseolus vulgaris* L. was larger from plants grown in plastic houses than from plants grown in field plots.

The objective of this research was to determine the residual effects of ozone on seed. We analyzed seed for percentage of germination, oil, and protein and present the percentages from the 3-yr study previously reported (5).

MATERIALS AND METHODS

Seeds were obtained from plants grown in open-top field chambers with carbon-filtered air, in unfiltered air chambers, and in plots with no chambers during 1973, 1974, and 1975 at Queenstown, Maryland (5). All analyses were completed within 30 days after each harvest. Ozone concentrations at the site were reported previously (5).

Seed germination. Data were collected under agreement with the Seed Testing Laboratory, Maryland Department of Agriculture, College Park, using standard methods for soybeans (2). Sixteen groups of 25 seeds were rolled into paper "rag dolls," moistened, and placed upright in a germinator at 25 C for 7 days. Percentage of seed germination was determined on the eighth day. The influence of chilling stress was determined by placing similarly prepared packets in a chamber at 5 C for 5 days and then in a germinator at 25 C for 7 days. Counts were made on the eighth day.

Protein and oil analysis. Percentage of protein and oil were determined by the State Chemist Laboratory, Maryland Department of Agriculture, College Park, using standard methods for nitrogen and oil in soybean seed (1). Nitrogen was determined by the Kjeldahl method and multiplied by 6.25 to obtain percentage of protein. Oil was determined by extracting pulverized seed with anhydrous ethyl ether for 16 hr in soxhlet, removing the ether, and weighing the ether-soluble residue (1).

Table 1. Percentage of seed germination of four soybean cultivars grown in Maryland

Environment	1973	1974	1975	Environment means
Filtered air	87.9 a[z]	84.8 a	77.6 b	83.4 a
Unfiltered air	87.2 a	88.0 a	76.2 b	83.8 a
Plot	80.0 b	84.3 a	60.3 c	75.0 b
Mean	85.1 a	85.7 a	71.4 b	
C.V.	6.06%			
		After chill stress		
Filtered air	83.7 ab	79.6 c	74.6 d	79.3 a
Unfiltered air	81.6 abc	84.6 a	73.0 d	79.7 a
Plot	75.6 d	80.4 bc	53.7 e	69.9 b
Mean	80.3 a	81.5 a	67.1 b	
C.V.	7.05%			

[z]Means followed by the same letter are not significantly different ($P = 0.05$).

Table 2. Content of soybean seed grown in Maryland

Environment	1973	1974	1975	Environment means
		Protein (%)		
Filtered air	36.9 f[z]	38.2 de	41.3 b	38.8 b
Unfiltered air	37.3 ef	38.9 cd	42.4 a	39.6 a
Plot	37.4 ef	39.4 c	41.0 b	39.2 ab
Mean	37.2 c	38.8 b	41.6 a	
C.V.	3.59%			
		Oil (%)		
Filtered air	20.2 a	17.8 c	17.3 cd	18.4 a
Unfiltered air	18.8 b	17.3 cd	17.0 cd	17.7 b
Plot	20.0 a	17.2 cd	16.4 d	17.9 b
Mean	19.7 a	17.4 b	16.9 b	
C.V.	7.56%			

[z]Means followed by the same letter are not significantly different ($P = 0.05$).

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RESULTS

Seed germination. Mean percentage of seed germination in all environments was essentially the same for 1973 and 1974, but in 1975 percentage of germination was significantly reduced (Table 1). Germination in 1973 and 1975 was significantly poorer for seed from plants grown in nonchambered plots than for that in filtered or unfiltered air chambers. The mean percentage of germination for the 3 yr is slightly but not significantly higher for seed from plants grown in unfiltered than in filtered air chambers. Seed of plants grown in nonchambered plots had significantly less germination. Percentage of germination was similar from all environments in droughty 1974.

In general, percentage of germination of chill-stressed seed from all air environments was reduced 4–5% from that of unstressed seed. Interaction between year and environment did not significantly influence percentage of germination (Table 1).

Protein and oil. Percentage of protein in soybean seed did not differ significantly among the three environments in 1973, but in 1975 seed from plants grown in unfiltered air had significantly more protein than did seed grown in filtered air (Table 2). In 1974, protein of seed from nonchambered plots significantly exceeded that from seed produced in filtered air. Mean percentage of protein for the 3 yr was significantly higher in seed from plants grown in unfiltered than in filtered air. Mean protein contents of seed from nonchambered plots and from filtered air plots were not significantly different. Percentage of protein of soybean seed was significantly different by year (1973 > 1974 > 1975).

Percentage of oil (Table 2) of soybean seed in 1973 was similar for seed from filtered air and nonchambered plots. Seed produced in unfiltered air had significantly less oil. In 1974 and 1975, percentage of oil did not differ significantly among the three groups. The 3-yr means for oil were significantly higher for seed from filtered air than from seed of unfiltered air or nonchambered plots. Oil content was significantly higher in seed produced in 1973 than in 1974 or 1975.

DISCUSSION

We did not find a significant difference in percentage of seed germination for seeds produced in filtered and unfiltered air. Seed from nonchambered plots in 1973 and 1975 had the lowest germination. We know of no data to explain why seed produced in field chambers would have significantly higher germination. Germination was nearly equal in 1973 and 1974 but was significantly lower in 1975. We believe that the lower germination in 1975 is attributable to a high incidence of smaller and deformed seed and a higher incidence of seed infested with *Diaporthe phaseolorum* var. *sojae* (Lehman) Wehm. and *Cercospora kikuchii* (T. Matsu & Tomoyasu) Chupp. Excessive rainfall and warm temperatures in early September provided appropriate conditions for fungal infection. The incidence of infection was nearly the same in seed grown in chambered and nonchambered plots.

Chilling produced a small general decrease in germination, but chilling the seed during germination did not result in a significant environment × seed germination interaction.

Percentage of protein was significantly greater in seed from unfiltered than filtered air. The reverse is true for percentage of oil in the same seed. The percentage of oil and percentage of protein were statistically the same for seed from plants grown in unfiltered air chambers and in nonchambered plots. These data are typical of oilseed crops in that when percentage of protein increases in seed, the percentage of oil decreases. The reverse also occurs. Climatic conditions, especially moisture, influence percentage of protein (3,7,9). For example, limited rainfall generally contributes to low seed yields; such seeds have higher protein and lower oil. Higher temperatures tend to encourage higher oil (7) and lower protein contents. Seed diseases may also encourage higher protein and lower seed oil percentages. In this investigation, percentage of seed protein was inversely correlated with seed yields. Seed yields were 36.0, 27.3, and 21.3 q/ha for 1973, 1974, and 1975, respectively (5), but protein percentages were 37.2, 38.8, and 41.6 for 1973, 1974, and 1975, respectively. Percentage of protein in alfalfa grown in unfiltered air is also significantly greater than in alfalfa grown in filtered air (6). The percentages of oil in the seed paralleled seed yields.

We used standard analytical procedures and agronomic testing practices to evaluate soybeans and conclude that percentage of seed germination is not significantly influenced by air quality within chambers and is not associated with relative soybean yields. Seed yields in filtered and in unfiltered air were separated by a significant 20%, but percentage of seed germination was not significantly different for the two environments. Protein was significantly higher in seed produced in unfiltered air than in filtered air, but percentage of oil was significantly higher in seed from filtered air.

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