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Ecological Research Series

EFFECTS OF SULFUR DIOXIDE AND/OR OZONE ON SEVERAL OAT VARIETIES
1975 Annual Report

Environmental Research Laboratory
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1975 Annual Report

by

Walter W. Heck and John A. Dunning
North Carolina State University
Raleigh, North Carolina 27607

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Project Officer

Dr. L. C. Raniere
Ecological Effects Research Division
Corvallis Environmental Research Laboratory
Corvallis, Oregon 97330

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY
CORVALLIS, OREGON 97330

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ABSTRACT

Nine experimental designs were run to determine the effect of sulfur dioxide on the important Southeastern oat variety - Carolee. The designs were run under controlled conditions and looked at sulfur dioxide concentration (25-300 pphm), ozone interactions, growth and exposure temperatures, growth and exposure humidities, growth and exposure light intensities, nutrient sulfur levels, number of exposures and exposure ages, and a screen for growth conditions. Plants were grown to from 28 days to 84 days before final harvest. Top dry wt, root dry wt, number of tillers and injury were determined for all experimental designs except #5 and #8. The fifth design also included yield measurements and the eighth did not include the biomass data. The 75 pphm treatments for 1.5 hrs were close to a threshold dose. Growth environmental factors affected the response of the plants and in some cases exposure conditions caused an effect. Sulfur nutrition was a significant factor and showed an interaction with SO_2 concentration on several response measures. Foliar injury was highly correlated with growth reductions. Several designs studied the effects of ozone alone (#6, 7, 8) or in combination with sulfur dioxide (#13). Two designs utilized 2 additional oat varieties, Salem and Coker 227 (#8, 9).

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SECTION I

INTRODUCTION

The research presented in this report is part of a continuing cooperative project between the Agricultural Research Service, the Environmental Protection Agency and the North Carolina Agricultural Experiment Station. The title of the overall project is, "Effects, fates and transformations of selected air pollutants in plants, microorganisms and soils."

The primary objectives of this cooperative program are to understand the impact of air pollutants on plants, microorganisms and soils that are of importance to agriculture, and to assist other agencies in relation to their mission of protecting the agricultural segment of the environment. The research thrust is directed at comparative studies on vegetation effects under phytotron, greenhouse and field conditions. Emphasis is on: (1) dose-response curves; (2) the interaction of various factors on the response of the whole plant to air pollutants; (3) assessing the impact of controlled pollutant additions and ambient pollution on plant biomass, yield and quality in the greenhouse and field, and on pollutant uptake and transformations in the greenhouse; (4) acute and chronic screens; and, (5) varietal responses.

Research reported here contains, as its major thrust, part of the phytotron (controlled environment) portion of the foregoing cooperative program. It was determined that Carolee oat should be intensively studied under carefully controlled conditions. Once this is accomplished the results should be verified under greenhouse and field conditions and using selected other plant species. Carolee oat was chosen as an important oat cultivar of the Southeast. Oat cultivars have generally been sensitive to several of the pollutants. It is a member of the monocotyledonous plants and is a grass. Thus it represents a major plant group.

The specific objectives for this research are given in Section IV.

SECTION II

CONCLUSIONS

Growth reductions were found in oat at 36, 50, and 75 pphm SO_2 for 1.5 or 3 hr exposures. These reductions did not always occur and the concentrations are probably close to threshold for acute exposures. In general there was no indication that low SO_2 tended to enhance growth.

Sulfur nutrition affected growth of oat and interacted with SO_2 concentration. Plants receiving the high S-nutrient (135 ppm) were more resistant to SO_2 but the 45 ppm of S-nutrient made the plants sensitive to 36 pphm of SO_2.

Generally RDW was affected more than TDW. Generally the second harvest showed recovery from SO_2 exposure but showed an increase effect from O_3 exposure.

Oat threshold for O_3 was 10-20 pphm for 1.5 to 3 hr.

Generally oat - Coker 227 was most sensitive to both pollutants and was less affected by varied environmental conditions.

Oat was more sensitive to 22 and 26°C growth temp than to 18 and 30°C. There was a general inverse correlation between exposure temperature and TDW at SO_2 concentrations of 150 and 300 pphm.

There was an indication that humidity during either growth or exposure correlated positively with pollutant effect.

A growth light of 2400 ft-c seemed to give the greatest response of both TDW and TDW and RDW to SO_2. The 2100 ft-c exposure light gave the greatest reduction.

Sulfur dioxide-ozone interactions were primarily additive or less-than-additive. These results are tentative and require confirmation.

SECTION III

RECOMMENDATIONS

Carolee and Coker 227 are widely grown oat cultivars in the Southeast. They are both sensitive to biomass reductions at SO_2 levels around the secondary air quality standards. The present studies report only acute exposures. It is necessary that this work be carried on to include chronic exposures over some time period.

These cultivars are sensitive to ozone. The sensitivity levels are not clear, although for acute exposures they are above the oxidant standard (0.08 ppm for 1 hr). The importance of O_3-SO_2 mixtures needs to be further explored using chronic exposures.

The influence of environmental factors needs to be further developed. Critical studies on temperature, humidity and light should be completed. If possible, preliminary work with SO_2 plus O_3 should be included.

Preliminary exposures to NO_2 and combinations of NO_2 plus SO_2 should be initiated.

All of these experiments should be verified under both greenhouse and field conditions.

SECTION IV

EXPERIMENTAL WORK

Plants are subjected to many environmental fluctuations during their life cycle. These include but are not limited to temperature, light (intensity, duration and quality) humidity, soil moisture. These factors, singly and in various combinations, are known to affect the response of plants to pollutant stress (1-3, 5).

Under greenhouse and field conditions it is not possible to separate the respective importance of these individual factors on the response of plants to pollutants. If the response is to be understood and corrected for pollutant models, it is necessary that these studies be done under controlled conditions. Such studies have been reported for some plants but most have not used growth and yield data.

It is also necessary to understand the effects of environmental stresses that occur at various times in the developmental stages of plant growth and how these stresses affect the response of plants to air pollutants.

Little research has been done on the effects of sulfur dioxide singly or with a mixture of ozone on an important crop plant under carefully controlled and known cultural conditions. The objectives of the present research were to determine the effects of several environmental factors (light intensity, temperature, humidity), nutritional sulfur levels, and sulfur dioxide and/or ozone dose on biomass and foliar injury to oat. The exposures were acute to chronic and single or multiple. Usually the designs included two harvests.

MATERIALS AND METHODS

Nine experimental designs are reported plus elemental analyses for oat #4 from the 1974 Annual Report. Some basic procedures are similar. These are discussed and then each design is presented separately. Results and discussion are handled in the same fashion.

Plant growth, exposure and post exposure were conducted in the facilities of the Southeastern Plant Environment Laboratories. Three oat cultivars (*Avena sativa*, L. *cvs*. Carolee, Salem and Coker 227) were used in these designs with *cv* Carolee as the main test plant. The oat varieties were seeded (5 seed per container) in 5 cm styrofoam cups, 10 cm pots, or 15 cm pots containing a 2:1 (V/V) mixture of gravel and buffered Jiffy mix. Plants were thinned to one plant per pot at 14 days after seeding. When not noted, standard environmental conditions were: first 2 wks. at 18°C day and 14°C night, with a 9 hr photoperiod (3000-4000 ft-C); third wk. at 22°C day and 18°C night, with a 9 hr photoperiod (3000-4000 ft-C) plus a 3 hr incandescent night interruption; the rest of the experiment at 26°C day and 22°C night with the latter light conditions. The RH was @ 50% day and 80% night. Plants received the standard phytotron nutrient solution 3 days a week and distilled water the other 4 days. Treatments were replicated and/or duplicated 2-4 times.

Exposures to sulfur dioxide and ozone were carried out in our standard exposure chambers (4). Plants were placed in the chambers 30 mins prior to exposure

and were removed 30 mins after the exposure terminated. Chambers were continuously monitored with a Davis sulfur dioxide analyzer and/or a Mast ozone meter.

Plant responses included: visual injury (0 to 100% determined 3 days after each exposure), top dry wt in gms (TDW), root dry wt in gms (RDW), tillers-#, some elemental analyses (ppm) and some yield measures. All data was subjected to an analysis of variance.

Design #4: Dose, S-Nutrition and Harvest relating to Carolee oat-exposure to SO_2.

This design was in the 1974 Annual Report. Twelve time-concentration treatments of SO_2 were used with 4 nutrient sulfur levels. The SO_2 treatments, S-levels and interactions were all significant for top wts, only treatment was significant for root wts and treatment plus interactions were significant for injury. This design was originally intended to look at various element concentrations within the plant tissues as a function of SO_2 treatment and S-level, and to determine correlations with growth phenomena.

The tops and roots of six exposure treatments (control; 3 hr at 50, 100 and 200 pphm SO_2; and, 6 hr at 25 and 50 pphm SO_2), over the 4 levels of sulfur in the nutrient, for the 35 day harvest (3 duplicates), were ground in a Wiley mill and send to the analytical laboratory in Athens, Ga. The laboratory performed an emission spectrographic analysis for 14 elements (P, K, Ca, Mg, Mn, Fe, B, Cu, Zn, Al, Mo, Sr, Ba, Na) and a standard analysis for S on 72 top and 72 root samples. Results were carefully reviewed and an analysis of variance was run on the above treatments for the following: tops (P, K, Ca, Mg, Fe, Na, S), roots (P, K, Ca, Mg, S), TFW, TDW, RFW, RDW and Injury.

The pH of the potting medium was determined prior to exposure and after exposure for the control and the 6 hr treatments. A complete analysis of these 3 treatment over S-level was run using the above plant responses and elemental values.

Design #5: Effects of concentration, exposure age and harvest age on yield, biomass and plant injury to Carolee oat exposed to SO_2.

Plants were seeded in 15 cm pots and held at 18°C/14°C-day/night temperatures for 3 wks using a 12 hr photoperiod. After 3 wks the temperatures were slowly raised to 26°C/22°C over the next two wks utilizing a 12 hr photoperiod with a 3 hr interrupted night. The plants were grown to harvest at these latter conditions.

The basic experimental design was:

Exposure duration - 3 hrs

SO_2 Concentration - 0, 50, 100, 200 pphm (4)

Exposure Age - see following table (6)

Harvest Age - see following table (3)

Duplicates - (3)

The exposure and harvest ages are shown in the following table:

Exposure Age (wks)	Harvest Age (wks)									
	3	4	5	-	-	-	9	10	11	12
2	X	X								X
2+3		X	X							X
8							X	X		X
8+9								X	X	X
3+5+7+9								X	X	X
2+4+6+8							X	X		X

Injury was determined 4 days after the last exposure and at final harvest (injury I and II). Plants harvested 1 week after the final exposure used the initial injury data for both injury I and II. TDW, RDW and tillers were taken at all harvests. Yield data was gathered for the final harvest. All data was analyzed using an analysis of variance. The first 2 harvests of each exposure age were analyzed as a separate design from the final harvest. Exposure variation for the first 2 harvests was not obtained.

Design #6: Preliminary concentration, exposure time, exposure number, and harvest age experiments on Carolee Oat - exposed to O_3.

Plants were seeded in 10 cm pots and held at an 18°C/14°C-day/night temperatures for 2 wks with a 12 hr photoperiod. After 2 wks the temperatures were adjusted to 22°C/18°C with a 20 hr photoperiod (1+18+1). After 3 wks the temperatures were adjusted to 26°C/22°C for the remainder of the experiment.

The basic experimental design was:

Exposure duration - 1.5 hrs

O_3 Concentration - 0, 25, 50, 100 pphm (4)

Exposure age - 2, 3, 4 wks from seed and all combinations (7)

Harvest age - weekly 1-6 wks (6)

Duplicates - (3)

The exposure age and harvest age were not a complete design. The design is shown below:

Exposure Age (wks)	Harvest Age (wks)					
	1	2	3	4	5	6
2			X	X	X	X
3				X	X	X
4					X	X
2+3				X	X	X
2+4					X	X
3+4					X	X
2+3+4					X	X
Control	X	X	X	X	X	X

Each of the harvest age by exposure age treatments were complete over O_3 concentration and replication.

The data were analyzed using a regression analysis, and an analysis of variance on the complete factorial design for the 5 and 6 wk harvests - without the controls in the analysis.

Design #7: Compare the effects of O_3 and SO_2 on Carolee oat grown under 2 growth conditions.

Plants were seeded in 10 cm pots and grown under 2 conditions to harvest. Condition 1: as for oat designs 1-4. Plants were grown at 26°C/22°C-day/night temperatures on a straight 12 hr day; at 22°C/18°C-day/night temperatures for 1 wk on a 20 hr day (design #6); and, at 26°C/22°C for-day/night temperatures for the remainder of the experiment on a 20 hr day.

The basic experimental design was:

Exposure duration - 1.5 hrs

Exposure age - 2+3 wks

Harvests - 4, 5, 6 wks (3)

Duplicates - (3)

Growth Conditions - (2)

Concentrations = O_3-0, 25, 50 pphm (4)

or SO_2 - 0, 75, 150, 300 pphm (4)

Each factorial design was analyzed using an analysis of variation.

Design #8: Screen of 3 varieties grown under 6 growth conditions and exposed to O_3 of SO_2.

Plants were seeded in 10 cm pots and grown under 6 different conditions. They were exposed to O_3 or SO_2 at 3 wks from seed and injury was read 3 days later. No biomass data were taken from this screen.

The basic experimental design was:

Exposure duration - 1.5 hrs

Exposure age - 3 wks

Varieties - Carolee, Salem, Coker 227 (3)

Dups - (3)

Growth conditions: 26°C/22°C-day/night; 9 hrs day + 3 hr
26°C/22°C-day/night; 9 hr day
26°C/22°C-day/night; 1+18+1 hr day
26°C/22°C-day/night; 12 hr day
22°C/18°C-day/night; 9 hr day + 3 hr
22°C/18°C-day/night; 9 hr day

Concentrations: O_3 - 50, 75 pphm
or SO_2 - 200, 300 pphm

The complete factorial design was analyzed using an analysis of variance.

Design #9: Effects of SO_2 on 3 oat varieties as conditioned by concentration and nutrient S-level.

Plants were seeded in 5 cm cups and grown for 2 wks at 18°C/14°C-day/night temperatures with a 9 hr day; 1 wk at 22°C/18°C-day/night temperatures with a 9 hr day + 3 hr. At 3 wks the plants were transplanted to 15 cm pots and grown at 26°C/22°C-day/night temperatures with a 9 hr day + 3 hr till harvest at 7 wks of age.

The basic experimental design was:

Exposure duration - 3 hrs (1)

Harvest - 7 wks (1)

Exposures - every other day for 2 wks (7 exposures) during weeks 5 and 6 (1)

Concentration - 0, 36, 75, 150 pphm (4)

S-nutrition - 5, 15, 45, 135 ppm (4)

Varieties - Carolee, Salem, Coker 227 (3)

Replications - (4)

The replications were run in the morning and afternoon of 2 consecutive days. Thus some idea of day and time-of-day can be obtained. The complete factorial design was analyzed using an analysis of variance. TDW, RDW, injury, and # of tillers were determined. Top and root elemental analyses were made for Coker 227.

Design #10: Determine the effects of growth and exposure temperatures on the response of Carolee oat - exposed to SO_2.

Plant and growth conditions were as Design #9. At week 5 the experimental growth conditions were initiated. On days 4 and 6 of this week the plants were exposed under the experimental exposure conditions. At week 6 they were returned to the 4th week growth conditions. All plants were harvested at end of week 6.

The basic experimental design was:

Exposure duration - 1.5 hrs

Exposures - day 4 and 6 of week 5

Harvest - 6 wks

Concentration - 0, 75, 150, 300 pphm (4)

Growth temperature (day)-18, 22, 26, 30°C (4)

(night was always 4°C cooler than day)

Exposure temperature - 18+30, 24+18, 30+24°C (3)

Duplicates - (2)

Replicates - (2)

The entire experiment was replicated a 3rd time using 18, 24 and 30°C exposure temperatures. This replicate was analyzed separately due to the difference in exposure temperatures. Each design was analyzed using an analysis of variance.

Design #11: Determine the effects of growth and exposure humidity on the response of Carolee oat - exposed to SO_2.

This design was carried out as design #10 except that humidity conditions were varied. Only one replication was run because the chamber humidity control systems did not function well. Growth humidty was 48, 56, 63, or 65% RH. Exposure humidity was 70 and 84% RH. The highest exposure humidity was discarded due to equipment malfunction. The single replication was analyzed using an analysis of variance.

Design #12: Determine the effects of growth and exposure light intensity on the response of Carolee oat - exposed to SO_2.

This design was carried out as design #10 except that light conditions were varied. Growth light was 800, 1600, 2400, or 3200 ft-c. Exposure light was 700, 1400, or 2100 ft-c.

The complete factorial design was analyzed using an analysis of variance.

Design #13: Determine the effects of SO_2 and/or O_3 on the response of Carolee oat over 2 harvests.

Plants were grown as for design #9 and exposed as shown in the Exposure Design.

The basic experimental design was:

Harvests - 6 and 7 wks (2)

Duplicates - (3)

Exposures - twice,4 and 5 wks (1)

Combinations of O_3 and SO_2 (30)

Exposure Design -

Time (hrs.)	Control (pphm)	SO_2 (pphm)	O_3 (pphm)	SO_2/O_3
0.75	0	100	20	50/20
		400	40	50/40
			80	100/20
				100/40
1.5	0	75	15	38/15
		300	30	38/30
			60	75/15
				75/30
3.0	0	50	10	25/10
			20	25/20
			40	50/10
				50/20

The complete design was analyzed using an analysis of variance. Then the SO_2 by O_3 combinations for each time period were analyzed to determine additive, less-than-additive, or greater-than-additive effects.

RESULTS AND DISCUSSION

The results are detailed in Tables 1-64. The results are presented through the Tables with a brief discussion of each experimental design. The Tables are placed in order following the discussion of results.

Design #4:

The analysis of variance (Table 1) shows the significance levels of the two main factors and their interaction. Correlation coefficients that are significant (residual or corrected total) and others that appear to have a high correlation when considering treatment or S-level are shown in Table 2.

Tables 3 and 4 show the effects of the single parameters. The threshold for SO_2 effects on growth appears to be about 1 pphm for 3 hrs in this series. Root weights are increased by 50 pphm for 6 hrs. Most of the stem elements tend to increase with increasing SO_2 at the 3 hr exposure but are unaffected by the 6 hr exposures. Stem-S is affected by the longer exposures and root-S decreases with increasing SO_2 at the 3 hr exposure. The stem elements are unaffected by nutrient S-level (Table 4) except for the 135 ppm treatment when they are reduced. Stem-Na and -S increase with increasing nutrient sulfur. Root-Mg decreases while root-S increases with increasing nutrient sulfur.

The interactions shown in Table 5 are not easy to interpret. Generally SO_2 adds to S-S only at the lower levels of nutrient sulfur. Biomass is affected more by SO_2 at the higher nutrient sulfur levels than at the lower. The changes show no readily discernible pattern and thus are not easy to interpret.

This design suggests that SO_2 can be used as a sulfur source for S-deficient plants and that SO_2 has a greater effect on plant biomass when nutrient sulfur is adequate.

Design #5:

The analysis of variance (Table 6) shows that all four response measures were significant for the 2 treatments. The interaction was significant only for injury II and this was not of real importance. The biomass measurements correlated well with injury when concentration was used (Table 7). The two biomass measures were highly correlated.

These results came from an analysis of the first two harvests when exposure ages were not comparable. The harvest ages were expected to be different and are not shown. The effects of sulfur dioxide concentration are shown in Table 8. The 50 pphm treatment for the 3 hr exposure is just significant for TDW but not for RDW. In this experiment the TDW generally was more responsive than the RDW, possibly due to the roots being pot bound.

The analysis of variance for the final harvest (Table 9) shows that 5 of 9 responses were significant for exposure age, 7 of 9 for concentration, and 4 of 9 for the interactions. Again the major biomass measurements correlated well with injury (Table 10).

The exposure age effects (Table 11) could be grouped. Plants exposed at the younger ages were less affected, the plants receiving the 4 exposures were the most affected, and the plants receiving late exposures were between. A close look at the data shows that the plants had recovered from the early exposures and the multiple exposures were probably most affected by exposures from weeks 4-9. The concentration effects (Table 12) are not significant until the 100 pphm treatment. This is probably because the final harvest represented complete recovery for the plants exposed at an early age.

The interactions shown in Table 13 are not easy to explain unless one tends to ignore the results for the 2 wk exposure. The rest show no effect for the 2+3 wk and a decreased growth (TDW and RDW) for the other 5 exposure age treatments with increasing SO_2 concentration. One of the reason's for a reduced significance in the RDW is shown in Table 14. From 9 to 14 wks there is little change

in RDW while TDW almost doubles. We believe the roots are becoming pot bound and thus tend to show a reduced effect from the SO_2 exposure. In spite of this the 100 and 200 pphm concentrations have a marked effect on RDW.

The plants in this design were grown especially to obtain seed production data. However, no seed were produced by the plants. Florets were plentiful but they were not fertile. Subsequently two major designs were developed to try and answer the question of no fertility. No answer was found but it seemed to relate to infertility in the anther and thus a lack of viable pollen. The second possibility is that the anthers failed to open at the time when the stigma was receptive. In spite of trying many different growth conditions we were not able to produce seed. Thus in future experimental work we will not attempt to study seed yield.

Design #6:

This design was developed before it was determined that the longer day length made the plants much less sensitive to ozone effects. It was expected that some reduction might occur because of the effect of photoperiod on the response of pinto bean and tobacco to ozone. It is evident from the results that the Carolee oat was not sensitive to ozone under the growth and/or exposure conditions used. Even where significance is shown, the lack of basic trends suggests that the significance values are misleading. Results are shown in Tables 15-21.

Design #7:

This design included a scan for both ozone and sulfur dioxide. These were run at the same time and were meant as a comparison for use between the early sulfur dioxide experiments (Designs 1-4) and design #6 for ozone. The data for the two gases was kept separate and is presented separately.

The analyses of variance (Tables 22, 27) show that the chamber effect was significant for all responses except for injury II-SO_2. The correlation coefficients are shown in Tables 23 and 28.

Although concentration is not significant (Table 22) the 100 pphm ozone is almost significant for TDW increasing concentration causes a reduction in RDW (Table 24). Although interactions are not shown (Table 22) the concentration by chamber effect appears to interact (Table 25), since concentration affects the response in chamber 1 but not in chamber 2. The threshold effect for RDW appears to be about 25 pphm for 1.5 hrs. The harvest age by chamber interactions are shown in Table 26.

The individual variables as affected by SO_2 are shown in Table 29. Over the total design the 300 pphm is required for a significant effect. Tables 30 and 31 suggest that 150 pphm may produce a significant effect in chamber 1. The interactions in these tables are clearly shown. The concentration by chamber interactions appear similar to those shown for the ozone effects. Why the ozone interactions were not significant is unclear.

This design clearly demonstrated the importance of chamber conditions and was a major reason for developing design #8 as a scan of conditions by variety.

Design #8:

This design was set up as a screen to determine the effects of SO_2 or O_3 on variety as affected by environmental growth conditions. Based on past designs it is known that a good correlation exists between foliar effects and biomass. Thus only injury readings were determined. The analysis of variance showed significance for the three main factors and all the interactions (Table 32). The three-way interaction is shown in Table 33. This Table also shows the 2-way interactions and the effects on individual factors. However, these are more readily seen in Tables 34-36.

Although the 3-way interaction is of interest, from a practical viewpoint the results for the individual factors (Table 34) holds true as a general rule and have been used as a guide to further experimental work. The pol-exp by cond (Table 36) shows a major difference between the 2 gases. The oat appear to be equally sensitive to SO_2 under 26/22°C - 9+3 hr and 26/22°C - 9 hr. For ozone the oat are more sensitive when grown under the 26/22°C - 9 hr conditions. However, these conditions are not those normally found for growth of oat in the field (except for early growth). Thus we went to the 26/22-9+3 hr conditions for the remaining experimental designs. In general the Coker 227 is less affected by the environmental conditions than the other 2 varieties (Table 35).

Design #9:

The analysis of variance (Table 37) shows that the four main factors were significant for the biomass measures and three of four were significant for injury and number of tillers. Four 2-way interactions were important for some of the factors. Correlation coefficients are shown in Table 38.

The individual factors are shown in Table 39. The replications were set up so that the odd were all morning exposures and the even were afternoon. The results suggest that oat were more severely affected during afternoon exposures. The results in Table 39-41 are all suggestive of this and significance levels are found in several places. The interactions of conc by rep (Table 40) shows the effect to hold for RDW at 75 and 150 pphm, for RDW the response is not as pronounced but it does show well at 150 pphm. The var by rep interaction for injury (Table 41) shows a strong afternoon response for Carolee oat, a weak response for Salem and no significant response for Coker 227.

The oats are more sensitive to SO_2 at a sulfur level of 45 ppm and more resistant at 135 ppm (Tables 39 and 40) for TDW. Otherwide nutrient sulfur seemed to have little affect on the response of the oat to SO_2. TDW appears little affected by 36 pphm of SO_2 but RDW is reduced in both Carolee and Salem (Tables 40 and 41). This reduction in RDW is found in all but one replication (Table 40) and occurs at about 5% injury to the top. All factors are strongly affected by the 2 higher SO_2 concentration (Tables 39-41). The var by conc interaction

(Table 41) is so strong that the variety results in Table 39 are not indicative. Coker 227, although not significantly affected by 36 pphm SO_2, is more strongly depressed at 75 and 150 pphm SO_2 than either of the other varieties. At 150 pphm the TDW growth depression for Carolee is 49%, Salem is 66% and Coker 227 is 80%.

These results suggest that Coker may be overall the most sensitive of the 3 oat varieties but that the threshold might be a little higher. Carolee appears to have more of a linear response curve. Their differences are sufficiently pronounced that we are considering using these 2 varieties in subsequent studies.

Design #10:

The analysis of variance for the first two reps is shown in Table 42. The 3rd rep was handed separately and is shown in Table 46. It was handled separately because the exposure temperature was not run as originally designed. The 3rd rep permitted one run at the designated exposure temperatures. Correlation coefficients are shown in Tables 43 and 47.

Concentration effects in both designs were similar with 75 pphm being close to the threshold for RDW in the first design (Tables 44 and 48). This effect of 75 pphm on RDW is more clearly shown at growth temperatures of 22 and 26°C in Table 45.

Generally results in the two designs are similar. Several interactions shown in design #1 were attributed to rep #2 at the 24+18°C exposure. It is possible that some malfunction occurred in the exposure for that run. This does not change the basic results shown in Table 44. The growth temp by rep interactions (Table 45) for tillers is interesting but the ave pattern (Table 44) is the same for both designs (Table 48).

Additional research needs to be done for temperature effects. Two varieties should be covered.

Design #11:

The first rep of this design was run. Neither growth nor exposure humidity controls were functioning properly. Thus the results are suggestive at best and are shown in Tables 50-53. The second rep was included as part of design #10. The system is being re-worked and humidity will be re-studied during the next project year.

Design #12:

The analysis of variance (Table 54) showed that three of the main factors were significant for the 4 measured responses, but only injury was affected by EL. Rep interactions were considered but no real differences were found. The conc interactions with Gl and El light were found for most of the factors and are shown in Table 57. The correlation coefficients are shown in Table 55.

The results for individual factors are shown in Table 56. A concentration of 75 pphm SO_2 caused both TDW and RDW reductions and only 1% visible injury. Biomass increased with growth light as did injury and tiller #. Plants were more sensitive at a 2100 ft-c exp light but the increased injury did not affect the biomass parameters. TDW was affected by replication but rep interactions were not important.

The GL by Conc interaction (Table 57) shows that 75 pphm SO_2 will reduce both TDW and RDW at a 2400 ft-c GL. The EL suggests that 75 pphm is about the threshold for growth reduction of TDW and RDW for the 700 ft-c EL. It also shows that at 75 and 150 pphm the effects are more severe at the lower exposure light intensity but at 300 pphm the response is greater at the high exposure intensity.

This design leaves many unanswered questions in terms of light intensity that will be addressed during the next project year.

Design #13:

The analysis of variance (Table 58) shows the two main factors are significant for the measured parameters except for harvest age for tillers. The interaction is significant for TDW, RDW and injury. The correlation coefficient are shown in Table 59.

The interactions are shown in Table 60. Since this experiment was designed to include some treatments that would cause severe injury from each pollutant for each time period, the design could not be analyzed for pollutant interactions. However, if each harvest date is scanned there is a consistent trend suggesting that effects are more striking at the 49 day harvest than at the 42 day. When specific comparisions are made, most cases suggest antagonistic effects rather than additive or greater-than-additive.

In order to develop a better understanding of these interactions the specific combinations of O_3, SO_2 and control treatments were removed for each time period and analyzed separately (Table 61 shows the analyses of variance and Table 62 the correlation coefficients for these sub analyses). In most cases the interactions were not significant, but the analyses included 2 possible combinations of interactions each with a difference in the SO_2/O_3 ratio. They also included an averaging of the harvest effects because no interactions with SO_2-O_3-Har Age were noted. If each set of data (Table 63) is viewed separately, the case for antagonism becomes fairly strong. At least the trends are there. In several cases the effects are more nearly additive or great-than-additive (i.e. RDW for the 0.75 hr: compare control + mix of 40 O_3-100 SO_2 with 100 SO_2+40 O_3). The significant interaction for injury suggests a greater-than-additive effect (for the 0.75 hr). The significant RDW at 1.5 hr is a clear antagonism for both ozone concentrations. The TDW for 30 pphm O_3 is in agreement with the root data but the injury data suggests an additive effect.

The ozone by harvest age interactions are shown in Table 64. Generally these results show that the ozone treatment does not affect growth until the second harvest (49 day). Thus it might be necessary to re-run out interaction analyses considering only the 49 day harvest.

This design was set-up to cover many different SO_2-O_3 combinations and has not received an exhaustive analysis. The design will be further analyzed before a continuation of the studies are made. These results suggest that threshold O_3 concentration for Carolee oat may lie between 10-15 pphm, for an acute response.

TABLE 1. ANALYSIS OF VARIANCE - OAT #4. 1/ 2/

Source	TMT (DF=5)		S-Level (DF=3)		TMT S-Level (DF=15)	
	Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob> F	LSD (0.05)
S-P	0.01	174	0.01	142	0.58	347
S-K	0.01	2834	0.01	2314	0.35	5668
S-Ca	0.01	224	0.01	183	0.93	447
S-Mg	0.01	198	0.01	162	0.53	397
S-Fe	0.01	9	0.86	7	0.30	18
S-Na	0.01	131	0.01	107	0.29	262
S-S	0.01	111	0.01	91	0.03	222
R-Mg	0.41	551	0.01	450	0.96	1103
R-S	0.01	177	0.01	144	0.31	354
TFW	0.01	1.51	0.06	1.23	0.04	3.02
TDW	0.01	0.21	0.01	0.18	0.01	0.43
RFW	0.01	1.05	0.29	0.86	0.02	2.11
RDW	0.01	0.17	0.38	0.14	0.10	0.35
Injury	0.01	2.05	0.04	1.68	0.01	4.10

1/ Data came from an elemental analysis of tissue from experiment #4 in the 1974 Annual Report. Above ANOV utilized only 6 treatments from the 35 day harvest. Only variables showing significance are included in the table. This is from an exposure of Carolee oat to SO_2.

2/ Tmt (treatment), S-level (sulfur level), S (stem), R (root), TFW (top fresh wt), TDW (top dry wt), RFW (root fresh wt), RDW (root dry wt). The P, K, Ca, Mg, Fe, Na, and S are the elements of interest.

TABLE 2. CROSS PRODUCTS ANALYSIS - OAT #4. [1/]

Variable	Correlation Coefficients (DF) TMT (5)	S-Level (3)	Residual (48)[2/]	Cor. Total (71)[3/]
S-P x S-K	0.99	0.83	0.70	0.85
S-P x S-Ca	0.84	0.91	0.35	0.62
S-P x S-Mg	0.58	0.92	0.51	0.62
S-P x S-Fe	0.62	0.60	0.31	0.41
S-P x R-P	0.67	0.14	0.15	0.31
S-P x R-S	-0.94	-0.92	0.07	-0.41
S-P x TFW	-0.86	-0.99	-0.07	-0.49
S-P x TDW	-0.89	-0.93	-0.27	-0.59
S-P x RFW	-0.86	0.34	-0.04	-0.45
S-P x Injury	0.90	-0.89	0.30	0.56
S-K x S-Ca	0.78	0.86	0.22	0.56
S-K x S-Mg	0.50	0.94	0.43	0.57
S-K x R-P	0.69	0.26	0.19	0.33
S-K x R-Ca	0.23	0.95	-0.04	-0.13
S-K x R-S	-0.97	-0.81	-0.06	-0.41
S-K x TFW	-0.88	-0.83	0.12	-0.44
S-K x TDW	-0.92	-0.98	-0.28	-0.60
S-K x RFW	-0.91	0.09	0.15	-0.44
S-K x RDW	-0.90	-0.66	-0.03	-0.47
S-K x Inj.	0.92	-0.99	0.27	0.55
S-Ca x S-Mg	0.88	0.98	0.75	0.83
S-Ca x S-Fe	0.90	0.86	0.30	0.40
S-Ca x S-Na	0.86	-0.86	0.46	-0.48
S-Ca x S-S	0.17	-0.96	0.20	-0.54
S-Ca x R-Mg	-0.10	0.95	-0.17	0.36
S-Ca x R-S	-0.63	-0.99	-0.02	-0.66
S-Ca x TFW	-0.63	-0.88	-0.04	-0.43
S-Ca x TDW	-0.65	-0.92	-0.20	-0.50
S-Ca x RDW	-0.60	-0.18	-0.05	-0.31
S-Ca x Inj.	0.68	-0.91	0.27	0.38
S-Mg x S-Fe	0.89	0.87	0.22	0.42
S-Mg x S-Na	0.93	-0.75	0.37	-0.29
S-Mg x S-S	-0.14	-0.89	0.10	-0.40
S-Mg x R-S	-0.35	-0.96	0.07	-0.46
S-Mg x TDW	-0.24	-0.97	-0.13	-0.23
S-Mg x Inj.	0.28	-0.97	0.39	0.15

TABLE 2. CROSS PRODUCTS ANALYSIS - OAT #4. [1/] (Continued)

Variable	Correlation Coefficients (DF) TMT (5)	S-Level (3)	Residual (48)[2/]	Cor.Total (71)[3/]
S-Fe x R-K	0.89	-0.75	0.24	0.31
S-Fe x R-Ca	0.66	0.65	0.31	0.40
S-Na x S-S	-0.28	0.97	0.14	0.87
S-Na x R-Mg	-0.40	-0.98	-0.03	-0.63
S-Na x R-S	-0.39	0.91	0.09	0.78
S-S x R-Mg	0.22	-0.99	-0.06	-0.58
S-S x R-S	-0.69	0.98	-0.03	0.76
R-P x R-K	0.54	0.75	0.89	0.77
R-P x R-Ca	0.68	0.37	0.71	0.68
R-P x R-Mg	0.31	-0.38	0.52	0.31
R-P x Inj.	0.90	-0.19	0.06	0.38
R-K x R-Ca	0.86	-0.34	0.70	0.64
R-K x R-Mg	0.58	-0.88	0.45	0.14
R-K x RFW	-0.23	-0.94	0.26	0.02
R-Ca x R-Mg	0.84	0.70	0.77	0.63
R-Ca x TFW	-0.40	-0.95	0.23	0.05
R-Ca x TDW	-0.31	-0.98	0.32	0.06
R-Ca x Inj.	0.41	-0.96	0.03	0.08
R-Mg x R-S	0.39	-0.98	0.07	-0.53
R-S x TDW	0.88	0.89	0.01	0.35
TFW x TDW	0.99	0.93	0.81	0.96
TFW x RFW	0.96	-0.28	0.76	0.88
TFW x RDW	0.97	0.25	0.53	0.85
TFW x Inj.	-0.99	0.88	0.01	-0.84
TDW x RFW	0.99	-0.20	0.67	0.90
TDW x RDW	0.99	0.51	0.55	0.88
TDW x Inj.	-0.99	0.99	-0.08	-0.87
RDW x RFW	0.99	0.64	0.66	0.91
RFW x Inj.	-0.97	-0.19	0.17	-0.84
RDW x Inj.	-0.98	0.56	0.02	-0.80

1/ Data came from 6 treatments of the 35 day harvest from Oat #4 reported in the 1974 Annual Report. This included a series of elemental analyses. It is from an exposure of Carolee oat to SO_2.

2/ All values > 0.35 are significant at the 0.01 level.

3/ All values > 0.30 are significant at the 0.01 level.

TABLE 3. EFFECTS OF SULFUR DIOXIDE ON CONCENTRATION AND DURATION ON SEVERAL PLANT RESPONSES - OAT #4. 1/

Plant 2/ Responses	Time (hrs.)/Concentration (pphm)						
	0	3/50	3/100	3/200	6/25	6/50	LSD-0.05
S-P (ppm)	2763	2950	3100	3300	2917	2783	174
S-K (ppm)	36100	38833	41850	45283	38942	37483	2834
S-Ca (ppm)	2250	2817	2825	2925	2216	2125	224
S-Mg (ppm)	1783	2350	2267	2075	1875	1767	198
S-Fe (ppm)	65	80	72	76	65	64	69
S-Na (ppm)	1424	1553	1618	1497	1428	1388	131
S-S (ppm)	1850	1930	1839	2223	2044	2012	111
R-S (ppm)	1593	1503	1362	1229	1421	1489	177
TFW (gm)	19.58	20.27	17.90	11.11	20.74	20.02	1.51
TDW (gm)	3.15	3.18	2.59	1.53	3.18	3.04	0.21
RFW (gm)	13.71	13.92	10.39	6.40	13.56	12.04	1.05
RDW (gm)	1.40	1.39	1.05	0.52	1.39	1.20	0.17
Inj. (%)	0	5	13	43	1	5.0	2.05

1/ Data from 6 treatments of the 35 day harvest from Oat #4 reported in the 1974 Annual Report - Carolee Oat.

2/ Elemental analyses are reported as ppm on a dry wt. basis.

TABLE 4. EFFECTS OF NUTRIENT SULFUR LEVELS ON SEVERAL PLANT RESPONSES OAT #4. 1/

Plant 2/ Responses	S-Level (ppm)				
	5	15	45	135	LSD-0.05
S-P (ppm)	3092	2972	3006	2806	142
S-K (ppm)	40278	40567	41461	36689	2314
S-Ca (ppm)	2833	2806	2556	1911	183
S-Mg (ppm)	2150	2144	2100	1683	162
S-Na (ppm)	467	946	2086	2440	107
S-S (ppm)	1469	1714	2132	2617	91
R-Mg (ppm)	3583	3361	2772	2250	450
R-S (ppm)	1008	1123	1462	2139	144
TDW (gm)	2.69	2.73	2.68	3.01	0.18
INJ. (%)	11	11	10	13	1.68

1/ Data from 6 treatments of the 35 day harvest from Oat #4 reported in the 1974 Annual Report - Carolee Oat.

2/ Elemental analyses are reported as ppm on a dry wt. basis.

TABLE 5. EFFECTS OF SULFUR DIOXIDE CONCENTRATION AND DURATION BY SULFUR LEVEL ON SEVERAL PLANT RESPONSES OF CAROLEE OAT - OAT #4. 1/

Plant 2/ Response	S-Level (ppm)	Time (hr.)/Concentration (pphm) 0	3/50	3/100	3/200	6/25	6/50
S-S (ppm)	5	1250	1353	1287	1887	1487	1553
	15	1560	1490	1577	1960	1940	1757
	45	1990	2170	2013	2333	2137	2147
	135	2600	2707	2480	2710	2613	2590
	(LSD-0.05=222)						
TFW (gm)	5	18.36	18.60	16.35	11.56	21.69	18.71
	15	19.99	17.76	18.95	10.70	21.67	20.79
	45	19.77	20.47	17.60	11.86	19.28	19.05
	135	20.20	24.24	18.70	10.30	20.31	21.53
	(LSD-0.05=3.02)						
TDW	5	2.86	3.02	2.37	1.55	3.39	2.96
	15	3.06	2.72	2.73	1.54	3.25	3.10
	45	3.16	3.11	2.51	1.58	2.89	2.82
	135	3.54	3.86	2.75	1.44	3.20	3.27
	(LSD-0.05=0.43)						
RFW	5	13.22	14.49	9.57	7.15	15.15	11.87
	15	13.41	13.07	11.56	6.09	15.17	12.67
	45	13.46	14.47	10.38	6.55	12.14	10.59
	135	14.74	13.63	10.07	5.81	11.79	13.02
	(LSD-0.05=2.11)						
INJ.	5	0	5	13	40	0	5
	15	0	5	12	42	0	5
	45	0	3	13	38	2	5
	135	0	5	13	52	0	5
	(LSD-0.05=4.1)						
pH-1 3/ (units)	5	6.22	-	-	-	6.31	5.92
	15	6.50	-	-	-	6.32	6.52
	45	6.37	-	-	-	5.94	6.03
	135	6.28	-	-	-	6.18	6.08
	(LSD-0.05=0.32)						

1/ Data from 6 treatments of the 35 day harvest from Oat #4 reported in the 1974 Annual Report - Carolee Oat.
2/ Elemental analyses are reported as ppm on a dry wt. basis.
3/ Data from 3 treatments of the 35 day harvest from Oat #4 reported in the 1974 Annual Report - Carolee Oat.

TABLE 6. ANALYSIS OF VARIANCE - OAT #5 1/ 2/

Source	DF	Inj. I		Inj II		TDW		RDW	
		Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob >	LSD (0.05)	Prob > F	LSD (0.05)
Har-Age	1	0.04	1.30	0.01	0.96	0.01	0.44	0.01	0.25
Conc.	3	0.01	1.84	0.01	1.35	0.01	0.62	0.01	0.36
Har-Age Conc.	3	0.31	2.60	0.01	1.91	0.26	0.88	0.52	0.51

1/ Data came from an analysis of harvest 1 and 2 in this design with Carolee Oat exposed to SO_2.

2/ Har-Age (harvest age), Inj (injury), TDW (top dry wt.), RDW (root dry wt.).

TABLE 7. CROSS PRODUCTS ANALYSIS - OAT #5. 1/

Variable	Correlation Coefficients (DF)		
	Conc. (3)	Residual (96)	Cor. Total (143)
Inj. I x Inj. II	0.99	0.54	0.93
Inj. I x TDW	-0.99	-0.12	0.06
Inj. I x RDW	-0.98	-0.03	0.15
Inj. IIx TDW	-0.99	0.01	0.09
Inj. IIx RDW	-0.97	-0.02	0.20
TDW x RDW	0.99	0.36	0.92

1/ Data came from an analysis of harvest 1 and 2 in this design with Carolee Oat exposed to SO_2.

TABLE 8. EFFECTS OF SULFUR DIOXIDE CONCENTRATION ON SEVERAL RESPONSES OF CAROLEE OAT - OAT #5. 1/

Concentration (pphm)	Plant Responses over Two Harvest Ages			
	TDW (gms)	RDW (gms)	Inj. 1 (%)	Inj. II (%)
0	10.40	4.4	0	0
50	9.78	4.31	7	6
100	8.01	3.92	18	16
200	6.34	3.21	30	25
(LSD-0.05)	0.62	0.35	2	1

1/ Data came from an analysis of harvest 1 and 2 in this design.

TABLE 9. ANALYSIS OF VARIANCE - OAT #5. 1/ 2/

Source	DF	Inj. I		Inj. II		TDW	
		Prob>F	LSD (0.05)	Prob> F	LSD (0.05)	Prob> F	LSD (0.05)
Exp-Age	5	0.01	2.56	0.01	1.81	0.01	1.88
Conc.	3	0.01	2.09	0.01	1.48	0.01	1.53
Exp-Age *Conc.	15	0.01	5.12	0.01	3.62	0.01	3.75

		RDW		HD-DW		#HD	
		Prob> F	LSD (0.05)	Prob > F	LSD (0.05)	Prob> F	LSD (0.05)
Exp-Age	5	0.01	0.89	0.31	0.73	0.19	2.77
Conc.	3	0.01	0.73	0.01	0.60	0.01	2.26
Exp-Age *Conc.	15	0.01	1.78	0.70	1.46	0.97	5.55

		F-HD		#-TIL		#H-TIL	
		Prob> F	LSD (0.05)	Prob> F	LSD (0.05)	Prob> F	LSD (0.05
Exp-Age	5	0.20	2.89	0.01	2.42	0.08	2.13
Conc.	3	0.11	2.36	0.09	1.97	0.01	1.74
Exp-Age *Conc.	15	0.12	5.78	0.68	4.84	0.23	4.25

1/ Data came from an analysis of the final harvest in this design with Carolee Oat exposed to SO_2.

2/ Exp-Age (exposure-age), Conc. (SO_2 concentration), Inj. (injury), TDW (top dry wt.) RDW (root dry wt.) Hd-DW^2(dry wt. of heads), #Hd (number of heads), F-Hd (number of florets per head), #-til (number of tillers), #H-Til (number of heading tillers).

TABLE 10. CROSS PRODUCTS ANALYSIS - OAT #5. [1/]

Variable	Correlation Coefficients (DF)			
	Exp. Age (5)	Conc. (3)	Residual (48)	Cor. Tot. (71)
Inj. I x Inj. II	0.91	0.99	0.13	0.90
Inj. I x TDW	-0.86	-0.98	0.02	-0.68
Inj. I x RDW	-0.89	-0.94	-0.24	-0.61
Inj. II x TDW	-0.92	-0.96	-0.04	-0.72
Inj. II x RDW	-0.92	-0.92	0.03	-0.58
TDW x RDW	0.98	0.98	0.51	0.81
TDW x Hd-DW	0.78	0.94	0.20	0.56
TDW x F-Hd	-0.56	0.98	0.13	0.25
RDW x F-Hd	-0.69	0.99	0.23	0.16
RDW x Hd-DW	0.82	0.86	-0.09	0.37
Hd-DW x F-Hd	-0.79	0.85	-0.20	-0.01
# Til x # H-Til	0.75	0.89	0.08	0.27

TABLE 11. EFFECTS OF SULFUR DIOXIDE ON SEVERAL PLANT RESPONSES AS AFFECTED BY EXPOSURE AGE AND NUMBER OF EXPOSURES - OAT #5. 1/

Exposure Age	Plant Responses				
	TDW (gm)	RDW (gm)	Inj. I (%)	Inj. II (%)	Hd-DW (gm)
2	22.45	7.08	5	5	2.60
2+3	23.29	7.22	10	6	2.73
2+4+6+8	21.31	6.19	15	10	2.12
3+5+7+9	19.10	5.16	19	13	1.98
8	20.74	5.91	15	8	2.49
8+9	19.80	5.77	20	12	2.39
(LSD-0.05)	1.88	0.89	2.66	1.8	0.73
	Hd (#)	F-Hd (#)	Til (#)	Hd-Til (#)	
2	8.8	30.6	16.2	8.8	
2+3	8.8	30.8	15.6	8.8	
2+4+6+8	5.9	32.6	12.7	7.2	
3+5+7+9	6.4	33.4	12.5	6.0	
8	7.6	32.4	13.4	8.0	
8+9	8.0	30.5	13.0	8.4	
(LSD-0.05)	2.8	2.9	2.4	2.1	

1/ Data came from an analysis of the final harvest in this design for Carolee Oat.

TABLE 12. EFFECTS OF SULFUR DIOXIDE CONCENTRATION ON SEVERAL PLANT RESPONSES - OAT #5. 1/

Concentration (pphm)	Plant Responses				
	TDW (gms)	RDW (gms)	INJ. I (%)	INJ. II (%)	Hd-DW (gms)
0	23.65	6.88	0	0	3.07
50	22.97	6.88	9	7	2.54
100	20.13	5.77	18	11	2.39
200	17.70	5.35	30	18	1.54
(LSD-0.05)	1.53	0.73	2.1	1.5	0.60

	Hd (#)	F-Hd (#)	Hd-Til (#)	Till (#)
0	8.9	33	9.4	14.8
50	7.8	33	7.9	14.7
100	8.4	31	7.6	13.6
200	5.2	30	6.4	12.6
(LSD-0.05)	2.3	2.4	1.7	2.0

1/ Data came from an analysis of the final harvest in this design with Carolee Oat.

TABLE 13. EFFECTS OF SULFUR DIOXIDE CONCENTRATION BY EXPOSURE AGE ON THE RESPONSE OF CAROLEE OAT - OAT #5. 1/

Plant Responses	Conc (pphm)	Exposure Age (wks)					
		2	2+3	2+4+6+8	3+5+7+9	8	8+9
TDW (gm)	0	21.36	22.37	26.38	24.05	23.23	24.53
	50	25.99	22.24	25.32	20.94	21.57	21.78
	100	19.53	23.51	18.60	18.57	20.50	20.08
	200	22.91	25.02	14.93	12.85	17.65	12.80
(LSD-0.05=3.75)							
TDW (gm)	0	6.26	7.15	8.17	6.48	6.43	6.81
	50	8.19	7.03	7.62	6.34	6.24	5.89
	100	5.89	7.26	5.20	4.73	5.85	5.66
	200	7.98	7.44	3.77	3.10	5.10	4.72
(LSD-0.05=1.78)							
Inj. I (%)	0	0	0	0	0	0	0
	50	0	5	7	13	8	18
	100	3	8	23	25	22	23
	200	15	27	30	37	32	38
(LSD-0.05=5.12)							
Inj. II (%)	0	0	0	0	0	0	0
	50	5	5	5	12	7	7
	100	5	7	15	17	10	15
	200	12	12	20	23	15	25
(LSD-0.05=3.62)							

1/ Data came from an analysis of the final harvest in this design with Carolee Oat.

TABLE 14. DRY WEIGHTS OF TOPS AND ROOTS AT SEVERAL HARVEST AGES-OAT #5. 1/

Harvest Age (wks)	# Plant	TDW (gms)	RDW (gms)	TDW/RDW
3	3	0.25	0.15	1.5
4	6	0.90	0.75	1.1
5	3	2.34	2.22	1.1
9	6	12.20	5.95	2.0
10	12	14.70	6.31	2.3
11	6	18.50	6.07	3.0
12	18	23.65	6.88	3.4

1/ Data came from control plants and is given to show normal growth rates in the pots we used (15 cm).

TABLE 15. ANALYSIS OF VARIANCE - OAT #6. 1/ 2/

Source	DF	TDW		RDW		Tillers	
		Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob > F	LSD (0.05)
Conc.	2	0.98	0.21	0.30	0.18	0.01	1.03
Exp-Age	6	0.02	0.33	0.02	0.28	0.01	1.57
Har-Age	1	0.01	0.17	0.01	0.15	0.01	0.84
Conc *Har-Age	2	0.62	0.30	0.89	0.26	0.01	1.46
Conc.*Exp-Age	12	0.09	0.57	0.63	0.49	0.52	2.73

		INJ. I		INJ. II	
		Prob > F	LSD (0.05)	Prob > F	LSD (0.05)
Conc.	2	0.01	0.39	0.01	0.86
Exp-Age	6	0.01	0.59	0.01	1.32
Har-Age	1	1.00	0.32	0.01	0.71
Conc *Har-Age	2	0.99	0.55	0.15	1.22
Conc *Exp-Age	12	0.01	1.02	0.35	2.29

1/ Analysis using the 5 and 6 wk harvests only for Carolee oat exposed to four ozone concentrations at 7 exposure ages.

2/ Exp-Age (exposure-age), Conc. (concentration), Har-Age (harvest-age), TDW (top dry wt.), RDW (root dry wt.), Inj. (injury).

TABLE 16. CROSS PRODUCTS ANALYSIS - OAT #6. 1/

Variable	Correlation Coefficients (DF)		
	Conc. (2)	Residual (84)	Cor. Total (125)
TDW x RDW	-0.11	0.36	0.73
TDW x Inj. II	-0.62	0.12	0.53
RDW x Inj. II	0.85	0.20	0.51
Inj. I x Inj. II	0.97	0.34	0.11

1/ Data came from an analysis of the 5 and 6 wk harvests in this design with Carolee Oat exposed to O_3.

TABLE 17. EFFECTS OF OZONE CONCENTRATION AND HARVEST AGE ON SEVERAL PLANT RESPONSE - OAT #6. 1/ 2/

Treatment	Plant Responses				
	TDW (gm)	RDW (gm)	TILLERS (#)	INJ. I (%)	INJ. 2 (%)
Conc. (pphm)					
25	3.66	2.09	13.1	5	8
50	3.66	2.00	14.7	5	8
100	3.66	2.12	14.1	6	9
Harvest Age (wks)					
3	0.62	0.27	5.1	7	7
4	1.52	1.19	10.6	6	6
5	3.05	1.98	14.5	5	8
6	5.62	2.80	16.1	5	11

1/ Data came from the complete design using a regression analysis for Carolee Oat.

2/ Concentration effects were not significant but harvest age was except for Injury #1.

TABLE 18. EFFECTS OF OZONE CONCENTRATION, HARVEST AGE AND EXPOSURE AGE ON SEVERAL PLANT RESPONSES - OAT #6. 1/

Treatment	Plant Resonses				
	TDW (gms)	RDW (gms)	Tillers (#)	Inj. I (%)	Inj. 2 (%)
Harvest Age (wks)					
5	3.05	1.98	14.5	5	8
6	5.62	2.80	16.0	5	11
(LSD-0.05)	0.17	0.15	1.0	0.4	0.9
Exp-Age (wks)					
2	4.35	2.45	17.4	7	11
3	4.47	2.33	14.2	5	9
4	4.36	2.33	14.9	5	8
2+3	4.67	2.70	16.9	5	13
2+4	4.18	2.35	14.1	6	7
3+4	4.10	2.18	14.6	5	9
2+3+4	4.24	2.36	15.1	5	8
(LSD-0.05)	0.33	0.28	1.6	0.6	1.3
Conc. (pphm)					
25	4.35	2.41	14.1	5	9
50	4.34	2.31	16.3	5	9
100	4.33	2.45	15.6	6	10
(LSD-0.05)	0.21	0.18	0.8	0.3	0.7
Control 2/	4.43	2.06	16.8	5	10

1/ Data came from an analysis of the 5 and 6 wk harvest of Carolee Oat.

2/ The control values are shown but were not part of the analysis of variance.

TABLE 19. ANALYSIS OF VARIANCE - OAT #6. 1/

Source	DF	TDW		RDW		TILLERS		INJ. I		INJ.II	
		Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob>F	LSD (0.05)
Exp Age	6	0.06	0.57	0.51	0.43	0.02	3.48	0.01	1.82	0.01	2.89
Har Age	1	0.01	0.31	0.01	0.23	0.62	1.86	1.00	0.98	0.01	1.54
Exp Age x Har Age	6	0.72	0.81	0.32	0.61	0.32	4.92	0.74	2.58	0.02	4.08

1/ Analysis using the 5 and 6 wk harvests, and the 100 pphm O_3 for Carolee Oat.

TABLE 20. CROSS PRODUCTS ANALYSIS - OAT #6. 1/

Variables	Correlation Coefficient (DF)	
	Residual (28)	Cor. Total (41)
TDW x RDW	0.29	0.76
TDW x INJ. II	0.48	0.65
RDW x INJ. II	0.10	0.53
INJ. I x INJ. II	0.47	0.06

1/ Analysis using the 5 and 6 wk harvests, and the 100 pphm O_3 for Carolee Oat.

TABLE 21. EFFECTS OF EXPOSURE AGE AND HARVEST AGE ON SEVERAL PLANT RESPONSES - OAT #6. 1/

Variable		Plant Responses TDW	RDW	TILLERS	INJ. I	INJ. II
Har Age (wks)	5	3.08	2.01	15.19	6	8
	6	5.58	2.88	16.00	6	12
(LSD-0.05)		0.31	0.23	1.86	0.98	1.54
Ex. Age (wks)						
2		4.35	2.46	18.00	10	10
2+3		4.59	2.73	18.33	5	14
2+3+4		4.21	2.43	16.00	5	9
2+4		3.76	2.46	13.33	7	8
3		4.37	2.33	13.00	5	10
3+4		4.30	2.27	15.33	6	10
4		4.71	2.44	15.17	6	9
(LSD-0.05)		0.57	0.43	3.48	1.82	2.89
Control 2/		4.43	2.06	16.8	5	10

1/ Analysis using the 5 and 6 wk harvests, and the 100 pphm O_3 for Carolee Oat.

2/ The control values are shown but were not part of the analysis of variance.

TABLE 22. ANALYSIS OF VARIANCE - OAT #7. 1/ 2/

Source	DF	TDW Prob>F	TDW LSD (0.05)	RDW Prob>F	RDW LSD (0.05)	TILLERS Prob> F	TILLERS LSD (0.05)	INJURY I Prob> F	INJURY I LSD (0.05)	INJURY II Prob> F	INJURY II LSD (0.05)
Cham	1	0.01	0.20	0.01	0.18	0.01	0.97	0.01	0.39	0.01	0.93
Conc	3	0.28	0.28	0.20	0.25	0.35	1.37	0.01	0.56	0.01	1.31
Har-Age	2	0.01	0.24	0.01	0.21	0.01	1.19	0.23	0.48	0.01	1.13
Cham*Har-Age	2	0.01	0.34	0.62	0.30	0.01	1.68	0.23	0.68	0.07	1.60
Cham*Conc	3	0.39	0.40	0.15	0.35	0.29	1.94	0.01	0.79	0.01	1.85
Conc*Har-Age	6	0.56	0.49	0.24	0.43	0.27	2.37	0.20	0.97	0.01	2.27

1/ Design utilized four O_3 concentrations from 2 chambers over 3 harvest ages for Carolee Oat.

2/ Cham (chamber), Conc(concentration), Har-Age (harvest age), TDW (top dry wt.), and RDW (root dry wt.).

TABLE 23. CROSS PRODUCT ANALYSIS - OAT #7. 1/

Source	Correlation Coefficient (DF) Conc. (3)	Cham * Conc (3)	Har-Age (2)	Residual (48)	Cor.Total (71)
TDW x RDW	0.62	0.61	0.99	0.57	0.88
TDW x Till	-0.72	0.65	0.85	0.52	0.65
TDW x INJ. I	-0.94	-0.87	-0.99	-0.15	-0.19
TDW x INJ. II	-0.97	-0.77	0.97	0.20	0.45
RDW x Till	-0.66	-0.20	0.84	0.34	0.59
RDW x INJ. I	-0.54	-0.37	-0.99	-0.30	-0.21
RDW x INJ. II	-0.67	-0.07	0.97	0.12	0.44
INJ. I x INJ.II	0.98	0.95	-0.94	0.32	0.50

1/ Data came from an analysis of an exposure of Carolee Oat to ozone.

TABLE 24. EFFECTS OF OZONE CONCENTRATION, HARVEST AGE AND CHAMBER ON SEVERAL PLANT RESPONSES - OAT #7. 1/

		Plant Responses				
Variable		TDW (gm)	RDW (gm)	TILLER (#)	INJ. I (%)	INJ. II (%)
Harvest Age	4	1.38	1.09	10.7	4	0
(wks)	5	2.73	1.80	13.6	3	1
	6	4.53	2.79	13.8	3	8
(LSD-0.05)		0.24	0.21	1.2	0.5	1.1
Conc-	0	3.02	2.02	11.9	0	0
	25	2.86	1.95	13.1	2	2
	50	2.89	1.77	12.9	2	3
	100	2.74	1.83	12.8	10	7
(LSD-0.05)		0.28	0.25	1.4	0.6	1.3
Chamber	1	2.13	1.53	10.6	5	4
	2	3.63	2.25	14.8	2	2
(LSD-0.05)		0.20	0.18	1.0	0.4	0.9

1/ Data was obtained from a design using Carolee Oat.

TABLE 25. EFFECT OF OZONE CONCENTRATION BY CHAMBER ON SEVERAL RESPONSES OF CAROLEE OAT - OAT #7.

Plant Responses	Cham	Conc. (pphm) 0	25	50	100
TDW (gm)	1	2.39	2.15	2.10	1.88
	2	3.64	3.58	3.69	3.60
(LSD-0.05=0.40)					
RDW (gm)	1	1.83	1.49	1.37	1.45
	2	2.21	2.42	2.17	2.21
(LSD-0.05=0.35)					
Injury I (%)	1	0	5	5	20
	2	0	0	0	0
(LSD-0.05=0.8)					
Injury II (%)	1	0	2	3	10
	2	0	2	2	4
(LSD-0.05=1.9)					

TABLE 26. EFFECT OF HARVEST AGE BY CHAMBER ON SEVERAL PLANT RESPONSES OAT #7. 1/

Plant Responses	Cham	Harvest Age (wks) 4	5	6
TDW (gm)	1	1.17	2.13	3.08
	2	1.59	3.32	5.98
(LSD-0.05=0.34)				
Tillers (#)	1	9.8	10.3	11.6
	2	11.5	17.0	16.0
(LSD-0.05=1.7)				

1/ Data was obtained from a design using Carolee Oat exposed to O_3.

TABLE 27. ANALYSIS OF VARIANCE - OAT #7. 1/ 2/

		TDW		RDW		TILLERS		INJURY I		INJURY II	
Source	DF	Prob F>	LSD (0.05)	Prob>F	LSD (0.05)	Prob>F	LSD (0.05)	Prob>F	LSD (0.05)	Prob> F	LSD (0.05)
Cham	1	0.01	0.19	0.01	0.19	0.01	0.69	0.01	0.93	0.61	1.28
Conc	3	0.01	0.27	0.01	0.26	0.01	0.98	0.01	1.31	0.01	1.81
Har-Age	2	0.01	0.23	0.01	0.23	0.01	0.85	0.32	1.13	0.01	1.57
Cham *Har-Age	2	0.01	0.33	0.61	0.32	0.63	1.20	0.54	1.60	0.01	2.22
Cham*Conc	3	0.05	0.38	0.07	0.37	0.84	1.39	0.01	1.85	0.01	2.56
Conc*Har-Age	6	0.01	0.46	0.01	0.45	0.07	1.70	0.56	2.27	0.01	3.13
Cham*Conc *Har-Age	6	0.01	0.65	0.13	0.64	0.38	2.40	0.95	3.21	0.01	4.43

1/ Design utilized four SO_2 concentrations from 2 chambers over 3 harvest ages for Carolee Oat.

2/ Cham (chamber), Conc (concentration), Har-Age (harvest age), TDW (top dry wt.), and RDW (root dry wt.).

TABLE 28. CROSS PRODUCTS ANALYSIS - OAT #7. 1/

Source	Correlation Coefficient (DF)			
	Conc (3)	Har-Age (2)	Residual (48)	Cor.Tot.(71)
TDW x RDW	0.98	0.99	0.54	0.88
TDW x TILL	0.94	0.96	0.29	0.79
TDW x INJ. I	-0.91	0.92	0.03	-0.21
TDW x INJ. II	-0.90	0.99	0.25	0.19
RDW x TILL	0.88	0.97	0.04	0.75
RDW x INJ. I	-0.94	0.93	0.17	-0.26
RDW x INJ. II	-0.95	0.99	0.25	0.09
INJ I x INJ.II	0.99	0.94	0.30	0.77

1/ Data came from an analysis of an exposure of Carolee Oat to sulfur dioxide.

TABLE 29. EFFECTS OF SULFUR DIOXIDE CONCENTRATION, HARVEST AGE AND CHAMBER ON SEVERAL PLANT RESPONSES - OAT #7. 1/

Variable		Plant Responses TDW (gm)	RDW (gm)	TILLERS (#)	INJ. I (%)	INJ. II (%)
Conc.	0	2.94	2.06	12.2	0	0
(pphm)	75	3.11	2.06	13.1	0	2
	150	2.99	2.02	12.1	8	6
	300	2.36	1.52	11.0	20	14
(LSD-0.05)		0.27	0.26	1.0	1.3	1.8
Chamber	1	2.24	1.65	10.1	9	6
	2	3.46	2.18	14.1	5	5
(LSD-0.05)		0.19	0.19	0.7	0.9	1.3
Har-Age	4	1.36	1.02	9.6	6	2
(wks)	5	2.65	1.82	12.5	7	5
	6	4.54	2.90	14.1	7	9
(LSD-0.05)		0.23	0.23	0.9	1.1	1.6

1/ Data was obtained from a design using Carolee Oat.

TABLE 30. EFFECT OF SULFUR DIOXIDE CONCENTRATION BY HARVEST AGE ON SEVERAL RESPONSES OF CAROLEE OAT - OAT #7.

Plant Response Variance	Har-Age (wks)	Conc. (pphm) 0	75	150	300
TDW (gm)	4	1.49	1.42	1.39	1.15
	5	2.74	2.89	2.61	2.35
	6	4.59	5.03	4.96	3.58
(LSD-0.05=0.46)					
RDW (gm)	4	1.29	0.95	1.10	0.75
	5	1.97	2.17	1.55	1.61
	6	2.92	3.06	3.42	2.21
(LSD-0.05=0.45)					
Inj. II (%)	4	0	0	6	20
	5	0	1	6	9
	6	0	2	4	12
(LSD-0.05=3.1					

TABLE 31. EFFECT OF SULFUR DIOXIDE CONCENTRATION BY CHAMBER ON SEVERAL RESPONSES OF CAROLEE OAT - OAT #7.

Plant Response		Conc. (pphm)			
	Cham	0	75	150	300
TDW	1	2.53	2.56	2.25	1.62
(gm)	2	3.35	3.66	3.72	3.09
(LSD-0.05=0.38)					
RDW	1	1.94	1.84	1.77	1.06
(gm)	2	2.18	2.28	2.27	1.99
(LSD-0.05=0.37)					
Injury I	1	0	2	15	30
(%)	2	0	0	2	11
(LSD-0.05=1.9)					
Injury II	1	0	1	7	18
(%)	2	0	2	4	10
(LSD-0.05=2.6)					

TABLE 32. ANALYSIS OF VARIANCE - OAT #8. 1/ 2/

		Injury		Tillers	
Source	DF	Prob > F	LSD-0.05	Prob> F	LSD-0.05
Var	2	0.01	1.9	0.01	0.3
Cond	5	0.01	2.7	0.01	0.4
Pol-Exp	3	0.01	2.2	0.01	0.4
Var x Cond	10	0.01	4.7	0.01	0.8
Var x Pol-Exp	6	0.01	3.9	0.01	0.6
Cond x Pol-Exp	15	0.01	5.5	0.06	0.9
Var x Cond x Pol-Exp	30	0.01	9.5	0.01	1.6

1/ This design used 3 oat varieties exposed to 2 concentrations of ozone and 2 of sulfur dioxide over 6 growth conditions.

2/ Var (variety), Cond (condition), Pol-Exp (pollutant exposures).

TABLE 33. FOLIAR RESPONSE (% INJURY) OF THREE OAT VARIETIES GROWN UNDER SIX ENVIRONMENTAL CONDITIONS AND EXPOSED TO ACUTE DOSES OF SULFUR DIOXIDE OR OZONE.

Pollutant (pphm)	Variety	Conditions [Temp -°C(day/night); Day Length-Hrs] 26/22 9+3	26/22 12	26/22 1+18+1	26/22 9	22/18 9+3	22/18 9	Ave.
O_3 (50)	Carolee	16.67	28.33	11.67	33.33	11.67	25.00	21.11
	Salem	25.00	33.33	5.00	36.67	13.33	30.00	23.89
	Coker 227	35.00	35.00	16.67	33.33	23.33	35.00	29.72
	Ave	25.56	32.22	11.11	34.44	16.11	30.00	24.91
O_3 (75)	Carolee	20.00	38.33	13.33	40.00	31.67	35.00	29.72
	Salem	20.00	46.67	13.33	60.00	21.67	43.33	34.17
	Coker 227	40.00	40.00	68.33	60.00	36.67	41.67	47.78
	Ave	26.67	41.67	31.66	53.33	30.00	40.00	37.22
SO_2 (200)	Carolee	66.67	45.00	28.33	70.00	48.33	65.00	53.89
	Salem	66.67	60.00	28.33	71.67	58.33	70.00	59.17
	Coker 227	68.33	55.00	28.33	78.33	55.00	61.67	57.78
	Ave	67.22	53.33	28.33	73.33	53.89	65.56	56.94
SO_2 (300)	Carolee	78.33	68.33	38.33	66.67	40.00	63.33	59.17
	Salem	78,33	71.67	30.00	70.00	38.33	68.33	59.44
	Coker 227	75.00	71.67	68.33	81.67	63.33	70.00	71.67
	Ave	77.22	70.56	45.55	72.78	47.22	67.22	63.43
Over Pollutant	Carolee	45.42	45.00	22.92	52.50	32.92	47.08	40.97
	Salem	47.50	52.92	19.17	59.58	32.92	52.92	44.17
	Coker 227	54.58	50.42	45.42	63.33	44.58	52.08	51.74
	Ave	49.17	49.44	29.17	58.47	36.81	50.69	45.63

1/ This table shows the original data plus all possible combinations. See the Analysis of Variance table for significance and LSD values. (LSD for the 3 way interaction is 9.50). All exposures were run for 1.5 hrs.

TABLE 34. FOLIAR RESPONSE OF OAT AS AFFECTED BY ENVIRONMENTAL CONDITIONS, POLLUTANTS AND VARIETY - OAT #8.

Treatment	Response (% Injury)
Pollutant Exposures [1]	
O_3 - 50 pphm	25
O_3 - 75 pphm	37
SO_2 - 200 pphm	57
SO_2 - 300 pphm	63
(LSD-0.05)	2
Environmental Condition [2]	
26/22 9+3	49
26/22 12	49
26/22 1+18+1	29
26/22 9	59
22/18 9+3	37
22/18 9	51
(LSD-0.05)	3
Variety	
Carolee	41
Salem	44
Coker 227	52
(LSD-0.05)	2

1/ These were of 1.5 hr duration.

2/ The first values are day/night temperatures, the last are the length of the light periods. The 9+3 is 9 hrs. of full light plus a 3 hr. interrrupted night of incandescent light.

TABLE 35. FOLIAR RESPONSE OF THREE OAT VARITIES TO SIX ENVIRONMENTAL CONDITIONS OR FOUR POLLUTANT EXPOSURES - OAT #8.

Treatment	Variety		
	Carolee	Salem	Coker 227
Environmental Conditions 1/			
26/22 9+3	45	48	55
26/22 12	45	53	50
26/20 1+18+1	23	19	45
26/22 9	53	60	63
22/18 9+3	33	33	45
22/18 9	47	53	52
(LSD-0.05=5)			
Pollutant Exposures 2/			
O_3 - 50 pphm	21	24	30
O_3 - 75 pphm	30	34	48
SO_2 - 2 ppm	54	59	58
SO_2 - 3 ppm	59	59	72
(LSD-0.05=4)			

1/ The first 2 values are day/night (26/22°C) temperatures - the last are the length of the light (day) periods. The 9+3 is 9 hrs of full light plus a 3 hr interrrupted night of incandescent light.
2/ These were all 1.5 hr duration.

TABLE 36. FOLIAR RESPONSE OF OAT VARIETIES TO ENVIRONMENTAL CONDITIONS BY POLLUTANT EXPOSURES - OAT #8.

Environmental Conditions		Pollutant Exposures (1.5 Hr.)			
Temp °C (D/N)	Light (day length-hr)	O_3-50 pphm	O_3-75 pphm	SO_2-2 ppm	SO_2-3 ppm
26/22	9+3	26	27	67	77
26/22	12	32	42	53	71
26/22	1+18+1	11	32	28	46
26/22	9	34	53	73	73
22/18	9+3	16	30	54	47
22/18	9	30	40	66	67
(LSD-0.05=6)					

TABLE 37. ANALYSIS OF VARIANCE - OAT #9. 1/ 2/

Source	DF	TDW		RDW		INJURY		TILLERS	
		Prob> F	LSD (0.05)	Prob> F	LSD (0.05)	Prob> F	LSD (0.05)	Prob> F	LSD (0.05)
Rep	3	0.01	0.17	0.01	0.17	0.01	1.91	0.02	0.39
Sulfur	3	0.01	0.17	0.04	0.17	0.15	1.91	0.28	0.39
Conc.	3	0.01	0.17	0.01	0.17	0.01	1.91	0.01	0.39
Var.	2	0.01	<0.17	0.01	<0.17	0.01	1.91	0.01	<0.39
Rep * Conc	9	0.01	0.34	0.01	0.35	0.01	3.81	0.01	0.79
Sulfur * Conc	9	0.01	0.34	0.08	0.35	0.01	3.81	0.66	0.79
Var * Conc	6	0.01	0.30	0.01	0.30	0.01	3.30	0.14	0.68
Rep * Var	6	0.12	0.30	0.21	0.30	0.01	3.30	0.11	0.68

1/ Design used 3 oat varieties exposed to 4 concentrations of SO_2 and grown under 4 S-Levels.

2/ Rep (replication), Conc (concentration, Var (variety), TDW (top dry wt.), RDW (root dry wt.)

TABLE 38. CROSS PRODUCTS ANALYSIS - OAT #9.

	Correlation Coefficient (DF)		
Variable	Rep (3)	Conc (3)	Corr. Tot. (191)
RDW x RDW	0.98	0.97	0.71
TDW x INJ	-0.74	-0.99	-0.89
TDW x TILL	0.56	0.96	0.45
RDW x INJ	-0.65	-0.96	-0.82
RDW x TILL	0.57	0.88	0.57
INJ x TILL	-0.01	-0.97	-0.52

1/ Data came from an analysis of a SO_2 exposures.

TABLE 39. EFFECTS OF SULFUR DIOXIDE CONCENTRATION, S-LEVEL, VARIETY AND REPLICATION ON SEVERAL PLANT RESPONSES - OAT #9. 1/

Variable		Plant Responses TDW (gms)	RDW (gms)	Inj. (%)	Tillers (#)
Rep.	1	4.28	2.03	25	7.52
	2	4.11	1.95	32	7.40
	3	4.24	2.03	24	7.04
	4	3.89	1.73	30	6.98
(LSD-0.05)		0.17	0.17	1.91	0.39
Sulfur (ppm)	5	4.21	2.09	29	7.35
	15	4.10	1.87	27	7.38
	45	3.95	1.89	28	7.04
	135	4.26	1.90	27	7.17
(LSD-0.05)		0.17	0.17	1.91	0.39
Concentration (pphm)	0	5.43	3.19	0	7.69
	36	5.33	2.69	5	7.94
	75	3.89	1.42	29	7.42
	150	1.87	0.44	77	5.90
(LSD-0.05)					
Variety	Carolee	4.52	2.39	19	9.47
	Salem	3.51	2.15	29	6.58
	Coker 227	4.36	1.26	34	5.66
(LSD-0.05)		<0.17	<0.17	<1.91	<0.39

1/ Exposures were 3 hrs long, every other day, for 7 exposures.

TABLE 40. EFFECT OF SULFUR DIOXIDE CONCENTRATION BY REPLICATION AND BY SULFUR LEVEL ON GROWTH OF THREE OAT VARIETIES - OAT #9. 1/

Plant Responses	Treatment	Concentration (pphm)			
		0	36	75	150
TDW Replication	1	5.40	5.22	4.14	2.37
(gm)	2	5.77	5.40	3.70	1.55
	3	5.28	5.26	4.13	2.30
	4	5.28	5.43	3.60	1.27
(LSD-0.05=0.34)					
RDW Replication	1	3.16	3.00	1.40	0.57
	2	3.37	2.81	1.39	0.23
	3	3.06	2.62	1.68	0.75
	4	3.16	2.35	1.21	0.21
(LSD-0.05=0.35)					
TDW Sulfur Level (ppm)					
(gm)	5	5.62	5.60	3.71	1.89
	15	5.26	5.33	3.96	1.86
	45	5.51	4.89	3.71	1.70
	135	5.33	5.50	4.19	2.03
(LSD-0.05=0.34)					

1/ Exposure were 3 hrs long, every other day, for 7 exposures.

TABLE 41. EFFECT OF VARIETY BY SULFUR DIOXIDE CONCENTRATION AND BY REPLICATION ON GROWTH AND INJURY TO OAT - OAT #9. 1/

Plant Responses	Variety	Concentration (pphm)			
		0	36	75	150
TDW	Carolee	5.46	5.30	4.49	2.81
(gm)	Salem	4.63	4.26	3.60	1.57
	Coker 227	6.20	6.42	3.58	1.23
(LSD-0.05=0.30)					
RDW	Carolee	3.68	3.02	2.02	0.85
(gm)	Salem	3.62	3.06	1.64	0.28
	Coker 227	2.26	2.00	0.60	0.18
(LSD-0.05=0.30)					
Injury	Carolee	0	4	17	57
(%)	Salem	0	6	27	83
	Coker 227	0	5	42	90
(LSD-0.05=3.3)					
		Replication			
		1	2	3	4
Injury	Carolee	15	26	13	24
(%)	Salem	27	32	27	31
	Coker 227	34	37	33	35
(LSD-0.05=3.30)					

1/ Exposures were 3 hrs long, every other day, for 7 exposures.

TABLE 42. ANALYSIS OF VARIANCE - OAT #10. [1/] [2/]

Source	DF	TDW		RDW		INJURY		TILLERS	
		Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob F>	LSD (0.05)	Prob>F	LSD (0.05)
Rep	1	0.01	0.09	0.01	0.11	0.03	0.88	0.63	0.59
GT	3	0.01	0.13	0.01	0.16	0.01	1.24	0.01	0.83
ET	2	0.53	0.11	0.21	0.14	0.01	1.07	0.79	0.72
Conc	3	0.01	0.13	0.01	0.16	0.01	1.24	0.01	0.83
Rep * GT	2	0.12	0.19	0.82	0.22	0.01	1.75	0.01	1.18
Rep * ET x Conc	6	0.01	0.32	0.26	0.38	0.01	3.04	0.08	2.04
GT * ET x Conc	18	0.32	0.45	0.21	0.54	0.01	4.30	0.42	2.88
GT * Conc	9	0.63	0.26	0.02	0.31	0.01	2.48	0.56	1.66

1/ The design used 4 growth temperatures, 3 temperatures, 4 SO_2 concentrations and 2 replications on Carolee Oat.

2/ Rep (replication), GT (growth temperature), ET (exposure temperature), Conc (concentration), TDW (top dry wt), and RDW (root dry wt).

TABLE 43. CROSS PRODUCTS ANALYSIS - OAT #10. [1/]

Variable	Correlation Coefficients (DF)			
	Exp. T (2)	Conc (3)	Residual (96)	Cor. Tot (191)
TDW x RDW	0.99	0.91	0.31	0.58
TDW x INJ	-0.82	-0.99	0.06	-0.52
RDW x INJ	-0.77	-0.92	0.04	-0.42

1/ Data came from an analysis of a SO_2 exposure using Carolee Oat.

TABLE 44. EFFECTS OF SULFUR DIOXIDE CONCENTRATION, TEMPERATURE AND REPLICATION ON SEVERAL PLANT RESPONSES - OAT #10. 1/

Variable		Plant Responses			
		TDW (gm)	RDW (gm)	INJ. (%)	TILLERS (#)
Conc.	0	2.40	1.26	0	11.2
(pphm)	75	2.38	0.95	2	11.4
	150	2.12	0.86	10	10.9
	300	1.67	0.54	28	9.2
(LSD-0.05)		0.13	0.16	1.2	0.8
Growth Temp	18	2.05	0.72	9	11.3
(°C)	22	2.11	0.91	13	10.9
	26	2.32	1.08	9	10.5
	30	2.10	0.91	10	9.9
(LSD-0.05)		0.13	0.16	1.2	0.8
Exp Temp	18+30	2.13	0.88	13	10.5
(°C)	24+18	2.18	0.97	7	10.7
	30+24	2.12	0.86	10	10.7
(LSD-0.05)		0.11	0.14	1.1	0.7
Rep.	1	1.83	0.74	9.5	10.6
	2	2.46	1.07	10.5	10.7
(LSD-0.05)		0.09	0.11	0.9	0.6

1/ Data came from work with Carolee Oat.

TABLE 45. EFFECTS OF GROWTH TEMPERATURE BY SULFUR DIOXIDE CONCENTRATION AND BY REPLICATION ON THE GROWTH OF CAROLEE OAT - OAT #10.

Plant Response	Variable		Growth Temperature (°C)			
			18	22	26	30
RDW	Conc					
(gm)	(pphm)	0	0.86	1.31	1.74	1.13
		75	0.83	0.97	0.91	1.10
		150	0.74	0.78	1.03	0.90
		300	0.43	0.59	0.63	0.52
(LSD-0.05=0.31)						
Tillers	Rep					
(#)		1	10.46	10.63	10.96	10.25
		2	12.13	11.13	10.08	9.54
(LSD-0.05=1.18)						

TABLE 46. ANALYSIS OF VARIANCE - OAT #10. 1/ 2/

Source	DF	TDW		RDW		INJURY		TILLERS	
		Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob > F	LSD (0.05)	Prob>F	LSD (0.05)
GT	3	0.22	0.17	0.04	0.15	0.01	1.87	0.01	0.75
ET	2	0.35	0.15	0.05	0.13	0.01	1.62	0.05	0.65
Conc	3	0.01	0.17	0.01	0.15	0.01	1.87	0.01	0.75
ET x Conc	6	0.01	0.30	0.55	0.25	0.01	3.24	0.31	1.30
GT x ET	6	0.07	0.30	0.08	0.25	0.01	3.24	0.13	1.30

1/ Data came from a 3rd temperature replication conducted as part of Oat #11. This is from an SO_2 exposure of Carolee Oat.

2/ GT (growth temperature), ET(exposure temperature), Conc (concentration), TDW (top dry wt), RDW (root dry wt).

TABLE 47. CROSS PRODUCTS ANALYSIS - OAT #10. 1/

Variable	Correlation Coefficients (DF)			
	Growth Temp (3)	SO_2 (3)	Residual (48)	Cor. Tot. (95)
TDW x RDW	0.99	0.96	0.59	0.74
TDW x INJ.	-0.86	-0.99	0.06	-0.78
RDW x INJ.	-0.78	-0.92	-0.11	-0.60

1/ Data came from a 3rd temperature replication conducted as part of Oat #11. This is from an SO_2 exposure of Carolee Oat.

TABLE 48. EFFECT OF SULFUR DIOXIDE CONCENTRATION, EXPOSURE TEMPERATURE AND GROWTH TEMPERATURE ON SEVERAL PLANT RESPONSES - OAT #10. 1/

Variable		Plant Responses TDW (gm)	RDW (gm)	INJ. (%)	TILLER (#)
Conc.	0	2.41	0.86	0	11.96
(pphm)	75	2.34	0.78	2	11.58
	150	1.96	0.44	16	10.00
	300	1.40	0.29	49	8.42
(LSD-0.05)		0.17	0.15	1.87	0.75
Exp. Temp	18+18	1.97	0.55	20	10.06
(°C)	24+24	2.05	0.68	16	10.88
	30+30	2.07	0.54	15	10.53
(LSD-0.05)		0.15	0.13	1.62	0.65
Grow. Temp	18	2.00	0.57	19	12.13
(°C)	22	2.13	0.71	14	11.08
	26	2.03	0.58	15	9.79
	30	1.95	0.50	20	8.96
(LSD-0.05)		0.17	0.15	1.87	0.75

1/ Data came from work with Carolee Oat.

TABLE 49. EFFECTS OF EXPOSURE TEMPERATURE BY SULFUR DIOXIDE CONCENTRATION AND BY GROWTH TEMPERATURE ON TOP DRY WEIGHT AND INJURY TO CAROLEE OAT - OAT #10.

Plant Response	Exp Temp	Concentration (pphm)			
		0	75	150	300
TDW	18+18	2.64	2.23	1.68	1.33
(gm)	24+24	2.30	2.41	2.09	1.41
	30+30	2.30	2.39	2.13	1.47
(LSD-0.05=0.30)					
Injury	18+18	0	3	26	53
(%)	24+24	0	2	13	49
	30+30	0	3	11	44
(LSD-0.05=3.24)					

Injury (%)	Growth Temperature (°C)			
	18	22	26	30
18+18	19	14	21	27
24+24	18	15	14	17
30+30	19	14	9	15
(LSD-0.05=3.2)				

TABLE 50. ANAYLSIS OF VARIANCE - OAT #11. 1/ 2/

Source	DF	TDW		RDW		INJURY	
		Prob> F	LSD (0.05)	Prob> F	LSD (0.05)	Prob> F	LSD (0.05)
GH	3	0.01	0.20	0.01	0.43	0.02	1.35
EH	1	0.14	0.14	0.06	0.30	0.01	0.95
Conc	3	0.04	0.20	0.01	0.43	0.01	1.35
EH x Conc	3	0.01	0.29	0.02	0.60	0.01	1.91

1/ Design used 4 growth humidities, 2 exposure humidities and 4 SO_2 concentrations using Carolee Oat.

2/ GH (growth humidity), EH (exposure humidity), Conc (concentration), TDW (top dry wt). RDW (root dry wt).

TABLE 51. CROSS PRODUCTS ANALYSIS - OAT #11. 1/

	Correlation Coefficients (DF)			
	GH (3)	Conc. (3)	Residual (32)	Cor. Total (63)
TDW x RDW	0.99	0.76	0.41	-0.01
TDW x INJ.	0.22	-0.95	0.21	-0.21

1/ Data came from an exposure of Carolee Oat to SO_2.

TABLE 52. EFFECTS OF SULFUR DIOXIDE CONCENTRATION AND HUMIDITY ON SEVERAL PLANT RESPONSES - OAT #11. 1/

	Plant Responses		
Variable	TDW (gm)	RDW (gm)	Injury (%)
Concentration (pphm)			
0	2.42	1.89	0
75	2.43	1.56	0
150	2.37	1.93	7
300	2.17	1.25	13
(LSD-0.05)	0.20	0.43	1.4
Exp.Hum. (% RH)			
70	2.40	1.51	8
84	2.30	1.80	2
(LSD-0.05)	0.14	0.30	1.0
Gro. Hum. (% RH)			
48	2.04	1.20	5
56	2.45	1.80	6
63	2.31	1.62	4
65	2.59	2.01	5
(LSD-0.05)	0.20	0.43	1.4

1/ Data came from work with Carolee Oat, exposures were for 1.5 hrs.

TABLE 53. EFFECTS OF CONCENTRATION BY EXPOSURE HUMIDITY ON SEVERAL RESPONSES OF CAROLEE OAT TO SULFUR DIOXIDE - OAT #11.

Plant Responses	Exp Hum. (% RH)	Concentration (pphm)			
		0	75	150	300
TDW	70	2.62	2.47	2.50	2.01
(gm)	84	2.22	2.39	2.25	2.32
(LSD-0.05=-.29)					
RDW	70	2.05	1.59	1.61	0.81
(gm)	84	1.72	1.52	2.25	1.69
(LSD-0.05=0.60)					
Injury	70	0	0	10	21
(%)	84	0	0	3	6
(LSD-0.05=1.91)					

TABLE 54. ANALYSIS OF VARIANCE - OAT #12. 1/ 2/

Source	DF	TDW		RDW		INJURY		TILLERS	
		Prob> F	LSD (0.05)	Prob> F	LSD (0.05)	Prob> F	LSD (0.05)	Prob> F	LSD (0.05)
Rep	1	0.01	0.10	0.05	0.11	0.01	1.3	0.01	0.49
GL	3	0.01	0.14	0.01	0.15	0.01	1.8	0.01	0.69
EL	2	0.24	0.12	0.13	0.13	0.01	1.6	0.63	0.60
Conc	3	0.01	0.14	0.01	0.15	0.01	1.8	0.10	0.69
GL*Conc	9	0.03	0.29	0.01	0.30	0.01	3.7	0.73	1.38
EL*Conc	6	0.01	0.25	0.03	0.26	0.01	3.2	0.01	1.20

1/ Design used 4 growth lights, 3 exposure lights, 4 SO_2 concentrations and 2 replications using Carolee Oat.

2/ Rep (replication), GL (growth light), EL (exposure light), Conc (concentration), TDW (top dry wt), and RDW (root dry wt).

TABLE 55. CROSS PRODUCTS ANALYSIS - OAT #12. 1/

Variable	Correlation Coefficients (DF)				
	GL (3)	EL (2)	Conc. (3)	Residual (96)	Cor.Tot.(191)
TDW x RDW	0.98	0.99	0.98	0.48	0.78
TDW x INJ.	0.94	0.08	-0.92	0.04	-0.24
TDW x TILLERS	0.94	0.62	0.97	0.08	0.65
RDW x INJ.	0.87	0.22	-0.94	-0.08	-0.36
RDW x TILLERS	0.98	0.50	0.99	-0.02	0.55
INJ x TILLERS	0.76	-0.73	-0.95	-0.12	-0.13

1/ Data came from an analysis of a SO_2 exposure using Carolee Oat.

TABLE 56. EFFECTS OF SULFUR DIOXIDE CONCENTRATION, LIGHT INTENSITY AND REPLICATION ON SEVERAL PLANT RESPONSES - OAT #12. 1/

Variable		Plant Responses TDW (gm)	RDW (gm)	INJURY (%)	TILLERS (#)
Conc.	0	2.89	1.36	0	10.6
(pphm)	75	2.66	1.21	1	10.4
	150	2.61	1.01	6	10.1
	300	2.26	0.69	29	9.7
(LSD-0.05)		0.14	0.15	1.8	0.7
Growth Light					
(ft-c)	800	1.98	0.67	4	8.7
	1600	2.39	0.86	9	8.7
	2400	2.93	1.24	11	11.1
	3200	3.13	1.51	11	12.3
(LSD-0.05)		0.14	0.15	1.8	0.7
Exp. Light					
(ft-c)	700	2.55	0.99	7	10.2
	1400	2.65	1.12	7	10.4
	2100	2.62	1.09	11	10.1
(LSD-0.05)		0.12	0.13	1.6	0.6
Replication					
	1	2.49	1.02	10	9.8
	2	2.72	1.12	8	10.6
(LSD-0.05)		0.10	0.11	1.3	0.5

1/ Data came from work with Carolee Oat.

TABLE 57. EFFECTS OF SULFUR DIOXIDE CONCENTRATION BY GROWTH LIGHT AND BY EXPOSURE LIGHT ON THE GROWTH OF CAROLEE OAT - OAT #12.

Plant Responses	Concentration (pphm)	Growth Light (Ft-c)			
		800	1600	2400	3200
TDW	0	2.10	2.70	3.33	3.44
(gm)	75	1.99	2.55	2.80	3.29
	150	2.01	2.30	2.93	3.20
	300	1.82	2.02	2.55	2.57
(LSD-0.05=0.29)					
RDW	0	0.76	1.02	1.64	2.01
(gm)	75	0.69	1.03	1.31	1.82
	150	0.68	0.84	1.18	1.36
	300	0.56	0.55	0.84	0.83
(LSD-0.05=0.30)					

		Exposure Light (Ft-c)		
		700	1400	2100
TDW	0	2.83	2.84	3.01
(gm)	75	2.42	2.77	2.78
	150	2.46	2.67	2.70
	300	2.49	2.33	1.97
(LSD-0.05=0.25)				
RDW	0	1.31	1.46	1.31
(gm)	75	1.05	1.21	1.38
	150	0.84	1.04	1.16
	300	0.78	0.77	0.53
(LSD-0.05=0.26)				

TABLE 58. ANALYSIS OF VARIANCE - OAT #13. 1/ 2/

Source	DF	TDW		RDW		INJURY		TILLERS	
		Prob>F	LSD (0.05)	Prob>F	LSD (0.05)	Prob>F	LSD (0.05)	Prob>F	LSD (0.05)
Treat	29	0.01	0.65	0.01	0.77	0.01	2.33	0.01	1.57
Har Age	1	0.01	0.17	0.01	0.20	0.01	0.60	0.23	0.41
Treat*Har Age	29	0.01	0.91	0.01	1.09	0.01	3.30	0.06	2.22

1/ Design used 30 combinations of SO_2 and O_3 over 2 harvest ages for Carolee Oat.

2/ Treat (treatment), Har-Age (harvest age), TDW (top dry wt), RDW (root dry wt).

TABLE 59. CROSS PRODUCTS ANALYSIS - OAT #13. 1/

Source	Correlation Coefficients (DF)		
	Treatment (29)	Residual (120)	Corrected Total (179)
TDW x RDW	0.85	0.43	0.79
TDW x INJ.	-0.84	0.03	-0.32
TDW x TILLERS	0.67	0.54	0.42
RDW x INJ.	-0.80	0.08	-0.38
RDW x TILLERS	0.57	0.22	0.40

1/ Data came from an analysis of a SO_2 - O_3 exposure series using Carolee Oat.

TABLE 60. EFFECTS OF HARVEST AGE BY EXPOSURE TREATMENT ON GROWTH AND INJURY TO CAROLEE OATS FROM SULFUR DIOXIDE AND OZONE - OAT #13.

Time (hrs.)	SO_2 (pphm)	O_3 (pphm)	Plant Responses					
			TDW (gm)		RDW (gm)		INJURY (%)	
			42 days	49 days	42 days	49 days	42 days	49 days
.75	0	0	3.89	7.23	1.78	4.16	0	0
.75	0	20	3.89	6.32	1.62	3.27	0	0
.75	0	40	4.45	5.84	1.45	2.85	5	5
.75	0	80	3.24	5.75	0.70	2.59	15	13
.75	50	20	4.38	7.21	2.03	2.57	2	5
.75	5-	40	3.80	6.44	1.66	2.94	12	15
.75	100	0	3.73	7.25	1.11	3.88	5	5
.75	100	20	3.69	5.92	2.03	2.03	17	15
.75	100	40	3.58	6.09	1.05	1.86	27	30
.75	400	0	1.84	2.35	0.28	0.36	33	42
1.5	0	0	4.24	6.85	1.77	3.49	0	0
1.5	0	15	3.95	6.16	1.15	2.16	0	3
1.5	0	30	3.89	5.74	1.04	1.55	5	5
1.5	0	60	3.36	5.60	0.74	1.89	17	10
1.5	38	15	4.16	6.55	2.42	2.57	5	5
1.5	38	30	4.16	5.57	1.74	1.91	8	10
1.5	75	0	3.56	7.35	1.01	2.53	8	5
1.5	75	15	3.96	6.12	2.35	2.25	10	12
1.5	75	30	4.29	6.42	1.65	2.65	10	15
1.5	300	0	2.75	4.07	0.63	0.67	25	40
3.0	0	0	3.58	7.21	1.07	3.79	0	0
3.0	0	10	4.19	6.68	1.28	3.54	0	5
3.0	0	20	3.82	6.00	1.03	2.44	5	5
3.0	0	40	3.57	6.10	0.67	2.50	20	15
3.0	25	10	4.00	6.85	2.24	2.76	0	5
3.0	25	20	3.75	7.13	0.96	3.01	3	5
3.0	50	0	3.96	7.26	1.66	2.67	0	2
3.0	50	10	3.87	6.94	1.63	2.90	0	5
3.0	50	20	3.82	7.32	1.25	3.41	3	5
3.0	200	0	3.40	7.39	0.75	2.77	10	10
	(LSD-0.05)		0.91		1.09		3.3	

TABLE 61. ANALYSES OF VARIANCE - OAT #13. [1/]

Time (Hr) / Source	DF	TDW Prob>F	TDW LSD (0.05)	RDW Prob>F	RDW LSD (0.05)	INJURY Prob>F	INJURY LSD (0.05)	TILLERS Prob>F	TILLERS LSD (0.05)
0.75									
SO_2	1	0.24	0.39	0.10	0.64	0.01	0.81	0.01	0.85
Age O_3	2	0.03	0.47	0.07	0.79	0.01	0.99	0.57	1.04
SO_2*O_3	2	0.84	0.67	0.93	1.12	0.01	1.40	0.60	1.47
	1	0.01	0.39	0.01	0.64	0.51	0.81	0.89	0.85
O_3*Age	2	0.01	0.67	0.07	1.12	0.05	1.40	0.04	1.47
1.50									
SO_2	1	0.32	0.29	0.15	0.30	0.01	0.99		
O_3	2	0.02	0.35	0.04	0.36	0.01	1.22		
Age	1	0.01	0.29	0.01	0.30	0.03	0.99		
SO_2*O_3	2	0.15	0.50	0.01	0.51	0.12	1.72		
O_3*Age	2	0.01	0.50	0.01	0.51	0.01	1.72		
3.0									
SO_2	1	0.15	0.40	0.81	0.54	1.00	0.81		
O_3	2	0.54	0.49	0.60	0.67	0.01	0.99		
Age	1	0.01	0.40	0.01	0.54	0.01	0.81		
SO_2*O_3	2	0.34	0.69	0.37	0.94	0.24	1.40		
O_3 * Age	2	0.30	0.69	0.99	0.94	0.01	1.40		

1/ These tables represent separate ANDVA for 3 exposure times involving interactions of SO_2 * O_3 on Carolee Oat.

TABLE 62. CROSS PRODUCTS ANALYSIS - OAT #13. 1/

Time (hr.)	Variable	Correlation Coefficients (DF)				
		O_3 (2)	SO_2*O_3 (2)	O_3*H-Age(21)	Residual (24)	Cor.Tot.(25)
0.75						
	TDW x RDW	0.86	0.36		0.31	0.71
	TDW x INJ.	-0.76	-0.93		-0.10	-0.14
	RDW x INJ.	-0.98	-0.67		0.03	-0.32
1.50						
	TDW x RDW	0.81		0.92	0.45	0.72
	TDW x INJ.	-0.85		-0.99	0.14	0.05
	TDW xTILLERS	0.99		0.78	0.56	0.07
	RDW x INJ.	-0.99		-0.97	0.25	0.09
3.0						
	TDW x RDW	0.91	0.88		0.57	0.84
	TDW x INJ.	-0.98	-0.63		-0.09	0.34
	TDW x TILLERS	-0.20	0.48		0.48	0.40
	RDW x INJ.	-0.80	-0.92		0.14	0.27

1/ These tables represent separate analysis for 3 exposure times involving interactions of SO_2*O_3 on Carolee Oat.

TABLE 63. EFFECTS OF OZONE BY SULFUR DIOXIDE ON THE RESPONSE OF CAROLEE OAT-OAT #13. 1/

Time (hr.)	Plant Response	SO_2 Conc. (pphm)	Ozone Concentration (pphm) 2/ 0	20	40
0.75	TDW	0	5.56 (0)	5.14 (8)	4.81 (13)
		100	5.10 (8)	5.49 (1)	4.83 (13)
		(LSD-0.05=0.67) (12)			
	RDW	0	2.97 (6)	2.15 (28)	2.03 (22)
		100	2.44 (18)	2.50 (16)	1.46 (51)
		(LSD-0.05=1.12) (38)			
	Injury**	0	0	5	16
		100	0	5	28
		(LSD-0.05=1.40)			
	Tillers	0	9.50	9.67	10.67
		100	8.50	10.33	10.83
		(LSD-0.05=1.47)			
			0	15	30
1.50	TDW	0	5.55 (0)	5.06 (9)	4.81 (13)
		75	5.45 (2)	5.04 (9)	5.35 (4)
		(LSD-0.05=0.50) (9)			
	RDW**	0	2.63 (0)	1.66 (37)	1.30 (51)
		75	1.77 (33)	2.30 (13)	2.15 (18)
		(LSD-0.05=0.51) (19)			
	Injury	0	0	2	5
		75	7	11	13
		(LSD-0.05=1.72)			
			0	10	20
3.00	TDW	0	5.40 (0)	5.44 (0)	4.91 (9)
		50	5.61 (0)	5.40 (0)	5.57 (0)
		(LSD-0.05=0.69) (13)			
	RDW	0	2.43 (0)	2.41 (1)	1.74 (28)
		50	2.17 (11)	2.26 (7)	2.33 (4)
		(LSD-0.05=0.94) (39)			
	Injury	0	0	3	5
		50	1	3	4
		(LSD-0.05=1.40)			

1/ These tables represent separate ANOVA for 3 exposure times involving interactions of SO_2 and O_3.

2/ Values in ( ) are % reduction from control values.

** Significant at the 0.01 level.

TABLE 64. EFFECTS OF OZONE BY HARVEST AGE ON THE RESPONSE OF CAROLEE OAT - OAT #13. 1/

Time (hr.)	Plant Response	Harvest Age (days)	Ozone Concentration (pphm) 0	20	40
0.75	TDW	42	3.81	3.79	4.01
		49	7.24	6.12	5.96
	(LSD-0.05=0.67)				
	RDW	42	1.45	1.83	1.25
		49	4.02	2.65	2.36
	(LSD-0.05=1.12)				
	Injury*	42	3	8	16
		49	3	8	18
	(LSD-0.05=1.40)				
	Tillers*	42	9.17	10.17	10.50
		49	10.67	9.0	10.00
	(LSD-0.05=1.47)				
			0	15	30
1.50	TDW**	42	3.90	3.96	4.09
		49	7.10	6.14	6.08
	(LSD-0.05=0.50)				
	RDW**	42	1.39	1.75	1.35
		49	3.01	2.21	2.10
	(LSD-0.05=0.51)				
	Injury**	42	4	5	8
		49	3	8	10
	(LSD-0.051.72)				
3.0	TDW		0	10	20
		42	3.77	4.03	3.82
		49	7.23	6.81	6.66
	(LSD-0.05=0.69)				
	RDW	42	1.37	1.45	1.14
		49	3.23	3.22	2.93
	(LSD-0.05=0.94)				
	Injury**	42	0	0	4
		49	1	5	5
	(LSD-0.05=1.41)				

1/ These Tables Represent separate ANOVA for 3 exposure times involving interactions of SO_2 and O_3.

** Significant at the 0.01 level.

* Significant at the 0.05 level.

SECTION V

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16. ABSTRACT

Nine experimental designs were run to determine the effect of sulfur dioxide on the important Southeastern oat variety - Carolee. The designs were run under controlled conditions and looked at sulfur dioxide concentration (25-300 pphm), ozone interactions, growth and exposure temperatures, growth and exposure humidities, growth and exposure light intensities, nutrient sulfur levels, number of exposures and exposure ages, and a screen for growth conditions. Plants were grown to from 28 days to 84 days before final harvest. Top dry wt, root dry wt, number of tillers and injury were determined for all experimental designs except #5 and #8. The fifth design also included yield measurements and the eighth did not include the biomass data. The 75 pphm treatments for 1.5 hrs were close to a threshold dose. Growth environmental factors affected the response of the plants and in some cases exposure conditions caused an effect. Sulfur nutrition was a significant factor and showed an interaction with SO_2 concentration on several response measures. Foliar injury was highly correlated with growth reductions. Several designs studied the effects of ozone alone (#6, 7, 8) or in combination with sulfur dioxide (#13). Two designs utilized 2 additional oat varieties, Salem and Coker 227 (#8, 9).

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