elegans. The hybrids differed from both parents in having strong basal, rather than apical, branching. The flower heads were round (as in *Z. elegans*) rather than elongated (as in *Z. peruviana*). The intercrossing of different F_1 hybrids and backcrossing to either parent failed to produce viable seed. One F_1 offspring, highly sterile and lacking in hybrid vigor, closely resembled *Z. peruviana* in all characteristics except flower color.

Examination of pollen mother cells of hybrid plants for all meiotic stages revealed that meiosis was irregular, and while differences were observed, they appeared to be in degree rather than in type. The metaphase I configurations were usually dense and sticky, making it difficult to study the nature of bivalent formation and chromosomal associations. From 7 to 17 percent of the pollen mother cells showed chromosomes that were off the metaphase I plates. From 1 to 3 percent of the cells showed bridges and fragments in anaphase I, and occasionally chromosomes off the spindle. A few chromosomes were also observed off the metaphase II plate. From 0 to 10 percent of the cells showed lagging chromosomes at the late anaphase II and early telephase II stages.

These studies on embryo culture with zinnia appear to support the hypothesis that an abnormally developed endosperm cannot nourish the developing embryo, which consequently degenerates. However, by using IAA and embryo culture techniques, mature plants were produced. Interspecific hybrids that originate in this manner produce greater variation in the germplasm and may prove useful in future plant breeding programs.

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Relative Survival of Seven Gladiolus Cultivars After Field Exposure to *Fusarium oxysporum* f. *gladioli*[1]

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Abstract. Seven cultivars of gladiolus were evaluated for survival in mixed and separate plots exposed to *Fusarium oxysporum* over a period of 6 years. In mixed plantings the most resistant cultivars became the dominant survivors within 5 years. Cultivars planted separately (A) showed highly significant differences for wt of corms and cormels, number of cormels, and the number of flower spikes produced each year. Survival and production of these cultivars under field conditions were correlated with resistance to *Fusarium oxysporum.* Mixed plots (B) showed a highly significant shift in flower spike production toward resistant cultivars.

Fusarium oxysporum Schlecht f. *gladioli* (Massey) Sny. and Han. is a major pathogen of gladiolus. In Florida alone, this disease causes an estimated annual loss of 1.5 million dollars (7). Numerous letters from amateur growers have described a change in flower color in their gladiolus plantings. Some have attributed the decrease of certain cultivars and subsequent increase of others in mixed plantings to sports and mutations. The changes are more likely related to the increase or decline of different cultivars in mixed plantings. It is the purpose of this report to provide data on the survival of gladiolus cultivars exposed to *Fusarium* infections under field conditions over a period of years.

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[3]Trade names used in this publication are only to provide specific information. Their use does not constitute a guarantee of the product named and does not signify that they are approved by the U.S. Department of Agriculture to the exclusion of others of suitable composition.

Materials and Methods

Seven cultivars of *Gladiolus* differing in flower colors were purchased in 1963 for use in this experiment. The cultivars were: 'Friendship', 'White Friendship', 'Black Phantom', 'Wild Rose', 'Purple Burma', 'Gold', and 'Lavender Petunia'. These corms were of the commercial grade #5, approximately 2 cm in diam and weighed about 453 g per 100 corms. These cultivars have been shown to possess different degrees of susceptibility to *Fusarium* and probably were infected as most commercial sources are (4, 5, 6). In the test plots where cultivars were kept separate (A), each of 3 replicates of each cultivar began with 5 corms. In test plots with mixed cultivars (B), each of 3 replications began with 5 each of 7 cultivars. The plots were established in fields known to be infested with *F. oxysporum* f. *gladioli.* A 2-year rotation was used to allow growth and elimination of corms and cormels missed in digging the crop. The usual commercial practice is to grow a gladiolus crop only once in a 4-year rotation to reduce the incidence of *F. oxysporum* (8). All plots were fertilized with a commercial 5-10-5 fertilizer at the rate of 500 lb. per acre at the time of planting. Other workers have reported that an application of fertilizer, especially N, resulted in an increase in the incidence of *Fusarium* (2, 1). Weeds were controlled by clean cultivation followed by application of a premergence herbicide, Isopropyl N(3-Chlorophenyl) carbamate (CIPC)[3]. At the end of each growing season, usually after the first heavy frost, the corms were harvested, cured, cleaned, and then stored at 45°F with controlled relative humidity of 60-65%. The corms and cormels were counted and weighed just before planting in the following year.

When possible, each season's test was kept to the same size at the time of planting. Any excess over the original number of corms or cormels was discarded. The 5 larger corms or cormels available were selected for replanting each season in the separate cultivar plots (A). The 35 larger and healthier corms or cormels, regardless of cultivar, were selected for each replication in the mixed plantings (B). In the mixed plantings (B), this method of selection reflected the natural survival of the cultivars. The cultivars in the mixed plantings (B) were identified by their flower characteristics and were evaluated only for the number of flower spikes produced. Those in separate plantings (A) were evaluated for total wt of corms and cormels, the wt of cormels separately, the no. of corms, the no of cormels, and the no of flower spikes produced each year. Data were subjected to analysis of variance.

Results and Discussion

The foliar symptoms resulting from *Fusarium* infection varied with time for each cultivar. By October 1, of each year, the *Fusarium* symptoms were widespread, and no cultivar was completely free of symptoms. By this time some plants were completely killed by *Fusarium.* The symptoms observed were similar to those described by McClellan, Palmer, and Pryor (3, 4, 6, 7). In this experiment the most susceptible cultivars (5, 6) were the first to show symptoms of *Fusarium* infections. By harvest time there was no evidence of appreciable infection by foliar pathogens or by nematodes. Each year, as the corms were cleaned, extensive *Fusarium* corm rot was observed.

During the 6-year test period, no sports or mutations were observed for color or other characteristics in the cultivars planted. In 1963, the cv. Wild Rose did not produce significantly more flowers than any of the other cultivars in the mixed plots; but by the end of 1968, it ranked first in flower spikes, outproducing any other cultivar by over 10 times. An explanation for this difference could be that 'Wild Rose', being resistant to *Fusarium,* produced the greatest number of large, healthy corms. Thus, when only 35 corms were selected for each new planting, it replaced the weaker, more susceptible cultivars in the mixed plots (B). The cv. Lavender Petunia accounted for 24% of all flower spikes produced in mixed plots (B) in 1963; but by 1966, it produced no flowers. The cv. Gold produced 11% of the total in 1963, but produced nothing in 1968. 'Purple Burma' produced 19% in 1963, and only 6% of the total in 1968. It is interesting that the only cultivar showing an increase in flower spike production in plot (B) was the oldest of the 7 cultivars in the commercial trade. Cultivars which possess some resistance or tolerance to *Fusarium* apparently survive longer.

Analysis of variance in the plots where cultivars were planted separately (A) showed significant differences in the number of cormels produced, 'Wild Rose' ourproducing all other cultivars. 'Wild Rose' also produced more corms than the other cultivars, but the differences were not significant, probably because the number of corms replanted was reduced to 5 each season. Mean wt in g of cormels produced by separate cultivars showed no significant differences. The wt of corms and cormels produced by 'Wild Rose' was significantly higher than that produced by any other cultivar.

Table 1. Mean no. of flower spikes per replicate produced by separate (A) gladiolus cultivars.[a]

Cultivar	1963	1964	1965	1966	1967	1968
Friendship	5.0	11.0	10.3	5.3	5.3	5.7
White Friendship	6.7	10.7	10.0	3.3	8.0	6.0
Black Phantom	1.3	6.7	11.0	0.7	5.0	5.7
Wild Rose	10.0	10.7	16.0	5.3	12.0	15.0
Purple Burma	7.0	5.3	2.7	0.7	2.7	2.0
Gold	9.7	9.0	9.3	3.0	4.3	5.3
Lavender Petunia	12.0	4.3	2.7	0.0	1.7	1.0

[a]Differences greater than 8.5 are significant at the 5% level, and differences greater than 11.1 are significant at the 1% level.

The importance of selecting and growing *Fusarium*-resistant cultivars for commercial flower spike production is shown by a comparison of flower spike yields in plots (B). The cv. Wild Rose for example, yielded a total of 467 flower spikes during the entire 6-year test period compared to 'Friendship', which produced a total no. of 116 flower spikes. The most susceptible cv. Lavender Petunia, yielded a total of 49 flower spikes. Making a similar comparison in the separate plots (A), 'Wild Rose' produced 207 flower spikes while 'White Friendship', its closest competitor, yielded a total of 134 flower spikes. 'Purple Burma' yielded 61 flower spikes. A similar comparison for the total wt of corms and cormels for the 6-year period showed that 'Wild Rose' produced 27.4 lb. and its nearest competitor, 'Black Phantom', produced 17.4 lb., while the least productive cultivar was 'Lavender Petunia' with only 3.0 lb., under similar growing conditions. Under commercial corm production practice, these differences would be much more pronounced.

Table 2. Mean no. of flower spikes per replicate produced by mixed (B) gladiolus cultivars.[a]

Cultivar	1963	1964	1965	1966	1967	1968
Friendship	4.3	11.3	7.0	6.0	5.0	5.0
White Friendship	5.7	9.7	6.0	1.0	2.7	1.7
Black Phantom	2.3	6.3	3.7	0.3	1.7	0.7
Wild Rose	3.7	15.7	27.0	14.0	44.3	50.7
Purple Burma	6.3	10.7	1.3	1.0	3.7	2.0
Gold	3.7	12.3	5.0	0.3	1.0	0.0
Lavender Petunia	8.0	6.3	2.0	0.0	0.0	0.0

[a]Differences greater than 9.0 are significant at the 5% level, and differences greater than 12 are significant at the 1% level.

The production of the resistant cultivars was severely reduced by the discarding of any excess of the original number of corms and all cormels. However, the susceptible cultivars had no excess, and their potential was not similarly reduced. It is suggested that the changes in color make-up of mixed plantings of gladiolus are due to the loss of susceptible cultivars, and to their replacement by resistant ones.

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Effect of Low Concentrations of Ozone and Sulfur Dioxide on Foliage, Growth and Yield of Radish[1]

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Abstract. The radish cv. Cherry Belle was exposed to 5 pphm ozone and/or 5 pphm sulfur dioxide for 40 hr per week for 5 weeks and compared with controls grown in charcoal filtered air. Ozone and/or sulfur dioxide significantly reduced the plant fresh wt, leaf fresh wt, root fresh and dry wt and root length and width. The effects of the combinations of the 2 gases were additive except for plant fresh wt, root length and root fresh and dry weights where the effects were significantly less than additive. Low concns of ozone and sulfur dioxide can be significant factors in the growth and yield of radishes.

Agricultural lands adjacent to urban areas are increasingly exposed to air pollutants of urban origin. The impact of the increasing levels of individual air pollutants on crop growth and yield is poorly understood. The interaction of 2 or more pollutants on plant growth and yield has not been published. Katz (6) found that crop yields were not significantly reduced by sulfur dioxide unless at least 5% of the leaf area was visually injured. Thomas and Hill (12) reported that 40 to 60 pphm sulfur dioxide[5] for 4 hr reduced carbon dioxide assimilation in alfalfa. Katz (5) found that carbon dioxide assimilation was reduced and dark respiration stimulated, when alfalfa was exposed to 10 pphm sulfur dioxide for 504 hr. Examination of the plants revealed a slight shrinkage both in leaf thickness and in individual leaf cells. In some leaves there appeared to be either slight coagulation of the protoplasm or a breakdown of some of the chloroplasts. Guderian and Stratmann (2) have demonstrated a suppression of plant growth by sulfur dioxide with no visible leaf necrosis. Photochemical oxidants, including ozone, have reduced the growth of plants with and without visible injury (10). Oxidants also increased leaf and fruit drop of citrus and thereby reduced the yields by as much as 50% in the Los Angeles area (11). Ozone injury to tobacco has also induced premature senescence which is related to reduced growth (8). Concentrations of ozone incapable of causing visible necrosis in Duckweed reduced frond and floral production (1). Hill and Littlefield (4) observed that 40 to 60 pphm ozone[6] for 0.5 to 1.5 hr reduced apparent photosynthesis 25 to 60% in various crops. In addition, they found that 10 pphm ozone for several hr caused partial stomatal closure of oats with some reduction in stomatal width evident within 0.5 hr after the start of fumigation. Menser and Heggestad (7) found that tobacco leaves were injured by mixtures of ozone and sulfur dioxide at concns that were subthreshold for each gas alone. This syndrome suggested an interaction between ozone and sulfur dioxide in the mixture, that decreased the plant injury threshold.

The objective of this study was to determine if the concns of ozone and sulfur dioxide acting alone or in combination, at concns corresponding to those found in rural areas adjacent to urban complexes, significantly reduced the growth and yield of radishes.

Materials and Methods

Twenty pots (15 cm diameter) containing 5 to 6 radish seeds (*Raphanus sativus,* L., cv. Cherry Belle) planted in a 1:1 mix of peat-perlite were placed in each greenhouse exposure chamber (3). The plants were grown under the following environmental conditions; 25°C day, 20°C night temperature, 80% relative humidity and daylight was supplemented with 1000 ft-c artificial light for 12 hr. The radishes were watered 3 to 4 times per week with a half-strength nutrient solution modified with an iron chelate. Twelve days after seeding, plants were randomly removed from each pot to leave 3 uniformly spaced plants in each pot.

The experimental procedure consisted of 4 exposure treatments of approximately 5 pphm ozone, 5 pphm sulfur dioxide, a mixture of the 2 gases at these concns and a control chamber. The concns of the gases were controlled to within ± 1.5 pphm of the average values shown in Table 1. Air in all chambers was first passed through a particulate and then an activated charcoal filter. The gas treatments were started 3 to 4 days after seeding and were maintained 8 hr per day, 5 days per week until harvest at 5 weeks. The experimental procedure was run twice. Plants in both runs were randomly rotated within chambers and moved between chambers every other day to minimize possible chamber and position effects.

At harvest (5 weeks from seeding) fresh weights of the leaves, roots and whole plants, dry weights of the leaves and roots, and root lengths and widths were determined. The data reported are the average of 3 plants per pot with 20 pots in each treatment. All experimental data were analyzed as a 2^3 factorial with 20 duplicates per treatment by an analysis of variance and significant differences between treatment means illustrated by the method of Least Significant Differences. A plant injury index was constructed for each pot of plants by visually estimating the percent of leaf area showing necrosis or chlorosis.

Ozone, produced by a silent electrical discharge in dry oxygen, and dilute tank sulfur dioxide were separately metered into the exposure chambers. A Davis[7] conductometric analyzer was used to measure sulfur dioxide. Ozone was measured with a

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[5]1 pphm SO_2 = 26.2 $\mu g/M^3$ at 760 mmHg and 25°C.

[6]1 pphm O_3 = 19.6 $\mu g/M^3$ at 760 mmHg and 25°C.

[7]Mention of product or company name does not constitute endorsement by the Environmental Protection Agency or the USDA.