PRESENT AND POTENTIAL DAMAGE TO ALFALFA IN THE SAN JOAQUIN VALLEY
A PROGRESS REPORT

Robert F. Brewer
Associate Horticulturist
University of California, Parlier

Alfalfa has long been considered one of the more sensitive agronomic crops as regards air pollution damage. Hill and Thomas (1933) carried out some of their classical air pollution experiments with alfalfa nearly 50 years ago. More recently Thompson and Kats (1976) and Oshima and his coworkers (1976), both groups working at Riverside, have studied the effects of oxidant-type air pollution on alfalfa. Thompson found that the two alfalfa varieties Hayden, considered smog sensitive, and Eldorado, considered tolerant, were both severely reduced in stand and in yields by air pollution in the Riverside area. Chemical analyses indicated lower crude fiber, beta-carotene and Vitamin C in both varieties when grown in ambient as compared with filtered, smog-free air. Oshima's investgations used Moapa 69 alfalfa plants growing in 5 gallon cans at 13 different southern California locations with varying ambient ozone levels to establish a crop loss-ozone dose durve which presumable could be used to assess losses anywhere one knew the ozone dose. Oshima's response curves, based on ozone dose in excess of 10 pphm, would predict approximately 2.5% reduction in Moapa 69 yields at most eastside San Joaquin Valley locations.

Kearney Experiments

In May of 1979 an experiment was established at the University of California Kearney Field Station near Parlier to determine the effects of ambient and enhanced ozone concentrations, with and without the presence of SO_2, on the growth and feeding quality of Moapa 60 and WL-512 alfalfa. Twelve foot square, open top, plastic covered chambers kept under positive pressure with motorized blowers, were used for these studies. These facilities, previously used in similar studies with sugar beets and cotton, permitted the introduction of filtered or non-filtered air with or without additions of extra ozone (O_3) or sulfur dioxide (SO_2) gas. Electronic ozone and sulfur dioxide analyzers continuously monitored the air in each of the twelve chambers and two non-enclosed or outside plots. Each 12 foot by 12 foot plot was subdivided into six 4 foot by 6 foot subplots. Three of the subplots in each plot were planted to Moapa 69, the other three to WL-512. The treatments used in this experiment, which is expected to be continued at least three seasons, are as follows:

1. Filtered Air - Air pulled through activated carbon filters which removes essentially all oxidant-type pollutants.

2. Filtered Air plus SO_2 - Four six-hour fumigations with a mean SO_2 content of 10 pphm (.1 ppm).

3. Filtered Air plus $1AO_3$ - Electric discharge generated ozone added to filtered air insufficient quantities to equal the ambient ozone dose.

4. Filtered Air plus $1.5AO_3$ - Ozone added to produce one and one half times the ambient level of ozone whenever that exceeds .05 ppm.

5. Ambient Air - No filtration or additions to air existing in the area.

6. Ambient Air plus SO_2 - Same SO_2 fumigation as in Treatment 2 combined with existing or ambient levels of ozone.

7. Outside Plot - Non-enclosed plots without air ducts or enclosures, used principally as a test of the "chamber" effect on the crop being grown.

Yields. Yield data for two varieties for 1979 and 1980 are presented in Table 1. In 1979 there were four cuttings, the last three of which are totaled. In 1980 the last seven of the eight cuttings are included in the total. The first cutting in both cases did not have the differential air treatments and was, therefore, excluded.

Table 1. Relative yield responses for Moapa and WL-512 for the 1979 and 1980 seasons.

Treatment	Moapa 1979 Yield*	Moapa 1979 % Ambient	Moapa 1980 Yield**	Moapa 1980 % Ambient	WL-512 1979 Yield*	WL-512 1979 % Ambient	WL-512 1980 Yield**	WL-512 1980 % Ambient
Filtered Air	6.03 kg	115	19.57 kg	104	6.47 kg	103	19.29 kg	103
Filtered Air+SO_2	4.72	90	17.79	94	5.66	90	16.79	89
Filtered Air+1AO_3	5.57	107	17.75	94	6.14	98	17.65	94
Filtered Air+1.5AO_3	4.73	91	14.91	79	5.53	88	17.24	92
Ambient Air	5.22	100	18.86	100	6.26	100	18.75	100
Ambient Air+SO_2	5.79	111	16.57	88	5.79	92	15.82	84
Outside Plot	5.92	113	21.53	114	5.92	95	20.25	108

* Treatment mean per plot, cuttings II through IV.
** Treatment mean per plot, cuttings II through VIII.

These data indicate reduced alfalfa yields associated with increasing air pollution. The apparent effect of ambient levels of ozone on the Moapa variety seems to be less in 1980 than in 1979. The Moapa variety appears more sensitive than WL-512 to ozone, but the order seems reversed as regards their sensitivity to SO_2 in the atmosphere.

Hay Quality. Results of analyses of 1979 alfalfa samples taken August 25 and September 27 (second and third cuttings, respectively) are presented in Tables 2 and 3.

Table 2. Results of quality determinations made on alfalfa samples harvested August 25, 1979

Treatment	Moapa Variety Protein	Moapa Variety ADF[1/]	Moapa Variety TDN[2/]	WL-512 Variety Protein	WL-512 Variety ADF[1/]	WL-512 Variety TDN[2/]
Filtered Air	26.7%	17.2%	49.4%	25.8%	17.3%	49.8%
Filtered Air+SO_2	25.4	17.2	50.7	25.7	18.1	49.7
Filtered Air+1AO_3	22.1	18.7	49.4	24.8	16.7	50.8
Filtered Air+1.5AO_3	23.8	17.3	50.6	25.4	16.9	51.5
Ambient Air	23.1	18.7	48.9	24.1	18.0	49.3
Ambient Air+SO_2	23.9	18.0	49.3	25.2	18.3	50.3
Outside	24.8	16.8	50.6	24.6	17.2	51.7

1/ ADF = Acid Detergent Fiber
2/ TDN = Total Digestible Nutrients

Table 3. Results of quality determinations made on alfalfa samples harvested September 27, 1979

Treatment	Moapa Variety Protein	Moapa Variety ADF[1/]	Moapa Variety TDN[2/]	WL-512 Variety Protein	WL-512 Variety ADF[1/]	WL-512 Variety TDN[2/]
Filtered Air	23.5%	14.0%	52.2%	23.7%	14.9%	53.2%
Filtered Air+SO_2	24.9	13.8	54.5	24.4	14.1	53.0
Filtered Air+1AO_3	25.4	14.5	54.9	24.5	15.3	53.2
Filtered Air+1.5AO_3	25.1	13.9	54.6	24.5	14.0	54.5
Ambient Air	25.8	13.8	54.6	24.5	14.1	53.2
Ambient Air+SO_2	25.9	14.2	54.6	24.8	14.2	54.6
Outside Plot	22.8	15.2	53.3	22.7	15.6	52.4

1/ ADF = Acid Detergent Fiber
2/ TDN = Total Digestible Nutrients

In the August 25th sampling, protein seems inversely related to pollutant level (directly proportional to yeidl) but his relationship was not apparent in the later smapling. When all of the 1980 and 1981 samplings have been analyzed, there should be a much clearer picture of the quality response. As mentioned previously, this was planned as a minimum of three years experiment. It is to be expected with a perennial such as alfalfa that subtle effects will become more pronounced with time.

References Cited

1. Hill, G. R. and Thomas, M. D. 1933. Influence of leaf destruction by sulfur dioxide and by clipping on yield of alfalfa. Plant Physiol. 8:223-45.

2. Thompson, C. R. and G. Kats. 1976. Effect of photochemical air pollution on two varieties of alfalfa. Environmental Science and Technology 10:1237-1241.

3. Oshima, R. J., M. P. Poe, P. K. Baegelmann, D. W. Baldwin, and V. VanWay. 1976. Ozone dosage-crop loss function for alfalfa: A standardized method for assessing crop osses from air pollutants. A.P.C.A. Journal 26(9):861-865.