

EFFECT OF SOME ANTITRANSPIRATION CHEMICALS ON  
PHOTOSYNTHESIS AND RESPIRATION OF CORN AND SOYBEAN SEEDLINGS

by 4589

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TABLE OF CONTENTS

INTRODUCTION .....	1
REVIEW OF LITERATURE .....	2
MATERIALS AND METHODS .....	4
Plant Culture .....	4
Plant Treatment with Antitranspirant Chemicals .....	5
Measurements .....	5
RESULTS .....	11
Results of Experiment I .....	11
Results of Experiment II .....	15
DISCUSSION .....	19
ACKNOWLEDGMENTS .....	22
LITERATURE CITED .....	23

## LIST OF FIGURES

FIGURE		PAGE
1.	Diagram of the apparatus used for measuring photosynthesis, respiration and transpiration of control and antitranspirant-treated plants .....	7
2.	Spectral characteristics of photosynthesis chamber light (PS), environment chamber lights and sunlight (Feb. 1, 1970, 1200 hr) .....	9
3.	Transpiration, respiration and photosynthesis in corn ( <u>Zea mays</u> L. var. 'United Hagie SX 158') as affected by antitranspirants .....	12
4.	Rates of transpiration, respiration, and photosynthesis in soybean ( <u>Glycine max</u> (L.) Merr. var. 'Wayne') as affected by antitranspirant chemicals .....	14
5.	Rates of transpiration, respiration, and photosynthesis in corn ( <u>Zea mays</u> L., var. 'United Hagie SX 158') as affected by antitranspirant chemicals .....	16
6.	Rates of transpiration, respiration and photosynthesis in soybean ( <u>Glycine max</u> (L.) Merr., var. 'Wayne') as affected by antitranspirant chemicals .....	18

## INTRODUCTION

Water is essential to life because of its role as matrix for cytoplasm, reactant in biochemical transformations, and climatic force in the environment. Almost 90 per cent of living cells of crop plants is water, which serves as a solvent as well as a component of proteins, nucleic acids and other organic compounds. In obtaining energy for the synthesis and utilization of carbohydrates and other compounds by green plants, water acts as a solvent and reactant. Heat from these reactions and from the surrounding environment, if not regulated, would increase the temperature of the plants. This regulation is provided by water.

The essentiality of water is exemplified in the practice of agriculture, particularly in the production of crops and pasturage. In the United States, about 70 per cent of overall precipitation is returned to the atmosphere through evapotranspiration from growing plants and through direct evaporation from moist soil, lakes, and streams (Walman, 1962; Wadleigh, 1964). Losses through evapotranspiration were subdivided by Walman (1962) as 23 per cent from farm crops and pasture, 16 per cent from forest and browse vegetation, and 32 per cent from non-economic vegetation. He also indicated that water for direct use in irrigation, industrial purposes, and municipal supply is drawn from the remaining 30 per cent of the precipitation. This portion is subsequently returned to streams.

Water deficiency frequently limits crop yields in Kansas and other parts of the world. Recently, considerable concern has been expressed

for conserving the water supply and using water more efficiently. Since agriculture is among the abusive users of water, decreasing transpiration of crops might increase production or decrease irrigation requirements. One way transpiration can be decreased is with chemicals having anti-transpirant effects on plants. Research reported here screened anti-transpirants chemicals for maximum effects on transpiration and minimum effects on photosynthesis and respiration.

#### REVIEW OF LITERATURE

Leaves are the principal plant organ through which water vapor is lost. Both stomates and the cuticular layer are involved. The rate of cuticular transpiration is low, however, compared to stomatal transpiration. Stomates are also the ports of gas exchange by plants with the outside atmosphere.

Stomatal openings are controlled more by light than by any other environmental factor (Ehrler and van Bavel, 1968; Willis and Balatubramania, 1968). The description given in most botany textbooks (Leopold, 1964; Devlin, 1966; Heath and Mansfield, 1969) suggests that light decreases carbon dioxide concentration and causes a rise in the pH in the guard cells. The higher pH supposedly stimulates conversion of starch to sugar; increased osmotic value of the guard cells causes water to be taken up and the stomates to open. This process is reversed in the dark to cause closure of the stomates. However, recent evidence may refute the concept that decreasing

carbon dioxide levels by photosynthesis is the major factor controlling stomatal openings (Hafez and Younis, 1969).

Zelitch (1963) exposed tobacco disks to various wavelengths of light and found that stomates failed to open in the far-red region, opened well in the red region, completely closed in green light, opened in the blue region, and remained closed as the ultraviolet region was approached. That response resembled the action spectrum of adenosine triphosphate synthesis in chloroplasts (Black et al., 1962).

Temperature and oxygen level (Walker and Zelitch, 1963; Hill and Littlefield, 1969) and water deficit (Yemm and Willis, 1954) in plants also cause stomatal movement in light. Some chemicals stimulate transpiration (Luke and Freeman, 1968), although the effect was more on the lower side of the leaf (Kotlyar and Lynbyskiy, 1969).

The first observations that chemicals reduce transpiration by affecting stomatal movement were those of Blandy (1957). He used phenylmercuric chloride on tomato and potato as a fungicide, but noted water use decreased. Zelitch (1963) recognized the importance of that observation and immediately tested several compounds, 13 of which were effective antitranspirants.

Davenport, Hagan, and Martin (1969) classified antitranspirants as emulsions of wax, latex or plastic; preventers of stomatal opening; and reflecting materials for radiant energy. Emulsions of wax, latex or plastic form a thin transparent film on the foliage that hinders escape of water vapor from the leaves (Possingham, Kerridge, and Bottrill, 1969). Chemical compounds that affected stomatal movement

acted on the guard cells around the stomatal pores and reduced loss of water vapor but not intake of carbon dioxide (Sivadjan, 1967; Mansfield, 1967). Reflective materials reduced leaf temperature and transpiration rates by reducing absorption of radiant energy (Gale and Hagan, 1967; Meidner and Mansfield, 1966; Kyne, 1968; Letey and Valora, 1965; Sivadkian and Ricardo, 1966).

It was also realized, as newer evidence was gathered (Davenport, 1967), that other processes besides transpiration were affected by antitranspirants. Photosynthesis (Klyuchnikov and Bogaeva, 1969), dry matter accumulation (Graham and Buchholtz, 1968) and even chlorophyll content of plants (Waisel, Borger, and Kozlowski, 1969) were all decreased by antitranspirant chemicals. The most efficient and desirable antitranspirants are those that specifically close stomates to transpiration but produce no phytotoxic effects to plants (Gale and Hagan, 1966). Most studies seem to single out phenylmercuric acetate as the one that answers the requirement best (Slayter and Bierhnizan, 1963; Shimshi, 1963; Gale and Poaljakoff-Mayber, 1967; Davenport et al., 1969).

#### MATERIALS AND METHODS

Plant Culture. Crops included in this study were corn (Zea mays L. var. 'United Hagie SX158') and soybeans (Glycine max (L.) Merr. var. 'Wayne'). Seeds of those crops were germinated in moist vermiculite and seedlings were transplanted to nutrients solutions one week after germination. The nutrient solution (Hoagland and Arnon, 1950) was in 2-liter containers and provided 5 mM  $\text{KNO}_3$ , 5 mM  $\text{Ca}(\text{NO}_3)_2$ , 2 mM  $\text{MgSO}_4$ , 1 mM  $\text{KH}_2\text{PO}_4$  and 10  $\mu\text{M}$  Fe-tartrate for corn and 10  $\mu\text{M}$   $\text{FeNa}_2\text{EDTA}$  for soybeans. Micronutrients were added at the levels suggested by

Johnson et al. (1957). The pH of the nutrient solution was maintained at 5.5 with HCl and NaOH. Six seedlings of each crop were held in each container.

Plants were grown in an environmental growth chamber for 12 days before treatment with antitranspirant chemicals (Table 1). The growth chamber had a  $25 \pm 1$  C and  $15 \pm 1$  C day-night temperature with a 16-hr light period and an 8-hr dark period. Lighting of about 1250 ft-candle at plant height was provided by sixteen 160-watt fluorescent lamps and six 300-watt incandescent lamps. Spectral characteristic of the lamps was determined with a spectroradiometer and compared with the spectral characteristic of sunlight. The rates of photosynthesis, respiration and transpiration were measured one day after treatment.

Plant Treatment with Antitranspirant Chemicals. To facilitate handling, the treatments were divided into two sets of manageable size. Plants are treated with the antitranspirant chemicals by applying chemicals in equal volumes as spray solutions to the aerial portions of the plants. Approximately 50 ml were applied to every 6 plants to thoroughly wet them. A surfactant, 19% polyoxyethylene sorbiton monolaurate in 1 ml per liter solution, was used whenever necessary. Other chemicals were added directly to the culture in aqueous form. Three replications of each treatment were randomized in complete blocks.

Measurements. Carbon dioxide assimilation (photosynthesis), respiration, and transpiration of control and treated plants were measured in a CO<sub>2</sub> assimilating chamber (Fig. 1). The chamber was a plexiglas cylinder 30 cm in diameter and 60 cm high with 1-cm-thick walls. The upper portion of the chamber was removable to facilitate



Table 1. Antitranspirant chemicals applied to corn and soybean seedlings for effects on transpiration, photosynthesis, and respiration.

Chemicals (active ingredients)	Concentration	Mode of action
<u>First Set</u>		
1. Control (distilled water)	-	Spray
2. 8-Quinololinol sulfate	$10^{-4}$ M	Spray-stomate closing
3. B-Naphthoxyacetic acid	0.005%	Acq. Sol. - Stomate closing
4. Phenylmercuric acetate	$10^{-5}$ M	Spray - stomate closing
5. 8-Hydroxyquinolinoline	$10^{-4}$ M	" " "
6. Cetyl alcohol	0.01%	Acq. Sol. - Stomate closing
7. Stearyl alcohol	0.01%	" " " "
8. Stearic acid	0.01%	" " " "
<u>Second Set</u> *		
9. Stoma Seal (PMA)	0.25%	Spray - stomate closing
10. Foli-gard (Acrylic copolymer)	4.0%	" " "
11. Keykote (Plastic wax)	5.0%	" - wax film cover
12. Folicote (Wax)	1.01%	" " " "
13. Mobile RD <sub>9</sub> (Plastic wax)	1.01%	" " " "
14. Spruce Seal (PMA)	2.5%	" stomate closing
15. Clear Spray (Latex)	5.0%	" wax film cover
16. Needle fast (Latex and PMA)	2.5%	" stomate closing

\* Concentration is expressed in per cent based on the manufacturers' dilution recommendations and not on the amount of the active ingredient present. The amount of active ingredient in the commercial products is information usually not provided by the manufacturers on the labels of the products.



#### EXPLANATION OF FIG. 1

Diagram of the apparatus used for measuring photosynthesis, respiration, and transpiration of control and antitranspirant-treated plants.

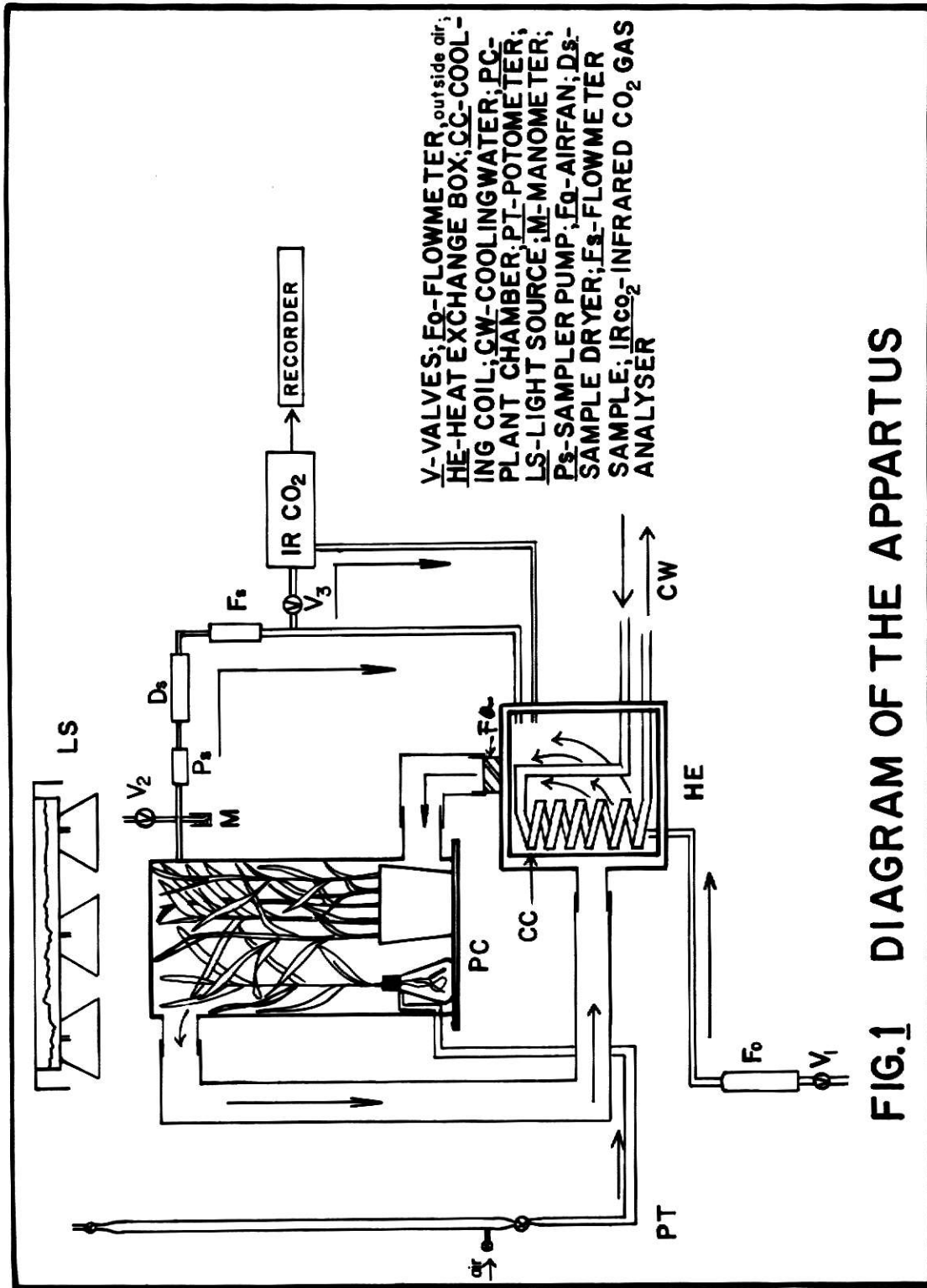


FIG.1 DIAGRAM OF THE APPARTUS

changing experimental plants. The upper portion was fastened air-tight to the base during operation. Air was recirculated by an electric fan in the heat exchanger through 7.6-cm diameter flexible hose into the chamber. The velocity of the air passing through the plant averaged  $10 \text{ km hr}^{-1}$ . That is near the average wind velocity under normal field conditions during the crop growing season. Temperature in the chamber was maintained at  $30 \pm 2 \text{ C}$  by pumping cold water through the coiled copper tubing that served as the cooling radiator inside the heat exchanger. The exchanger was an air-tight galvanized iron box with a volume of  $27 \times 10^3 \text{ cm}^3$ .

Light in the photosynthesis chamber was provided from three 300-watt cool bean, medium spot lamps combined with four 25-watt "grow lux" fluorescent lamps. The lamp base was suspended 15 cm above the chamber. The spectral characteristics of the lamp compared with those from the environmental growth chamber and with the sunlight are shown in Fig. 2.

Carbon dioxide content of the air inside the chamber was maintained at  $300 \pm 20 \text{ ppm}$  during the test by monitoring into the system outside air of known  $\text{CO}_2$  level. The volume of outside air added to maintain the standard  $\text{CO}_2$  level was measured through either of two rotometers. That estimated the  $\text{CO}_2$  taken in by the crop and was a measure of  $\text{CO}_2$  assimilation. Atmospheric pressure in the chamber was maintained at  $760 \pm 19.2 \text{ mm Hg}$  by a relief valve placed before the infra-red  $\text{CO}_2$  gas analyzer. Carbon dioxide level in the system was measured by moving aliquot air samples with a sealed pump continuously through the infra-red  $\text{CO}_2$  gas analyzer. The air aliquot samples were dried



EXPLANATION OF FIG. 2

Spectral characteristics of photosynthesis chamber lights (PS), environmental chamber lights and sunlight (Feb. 1, 1970, 1200 hr).

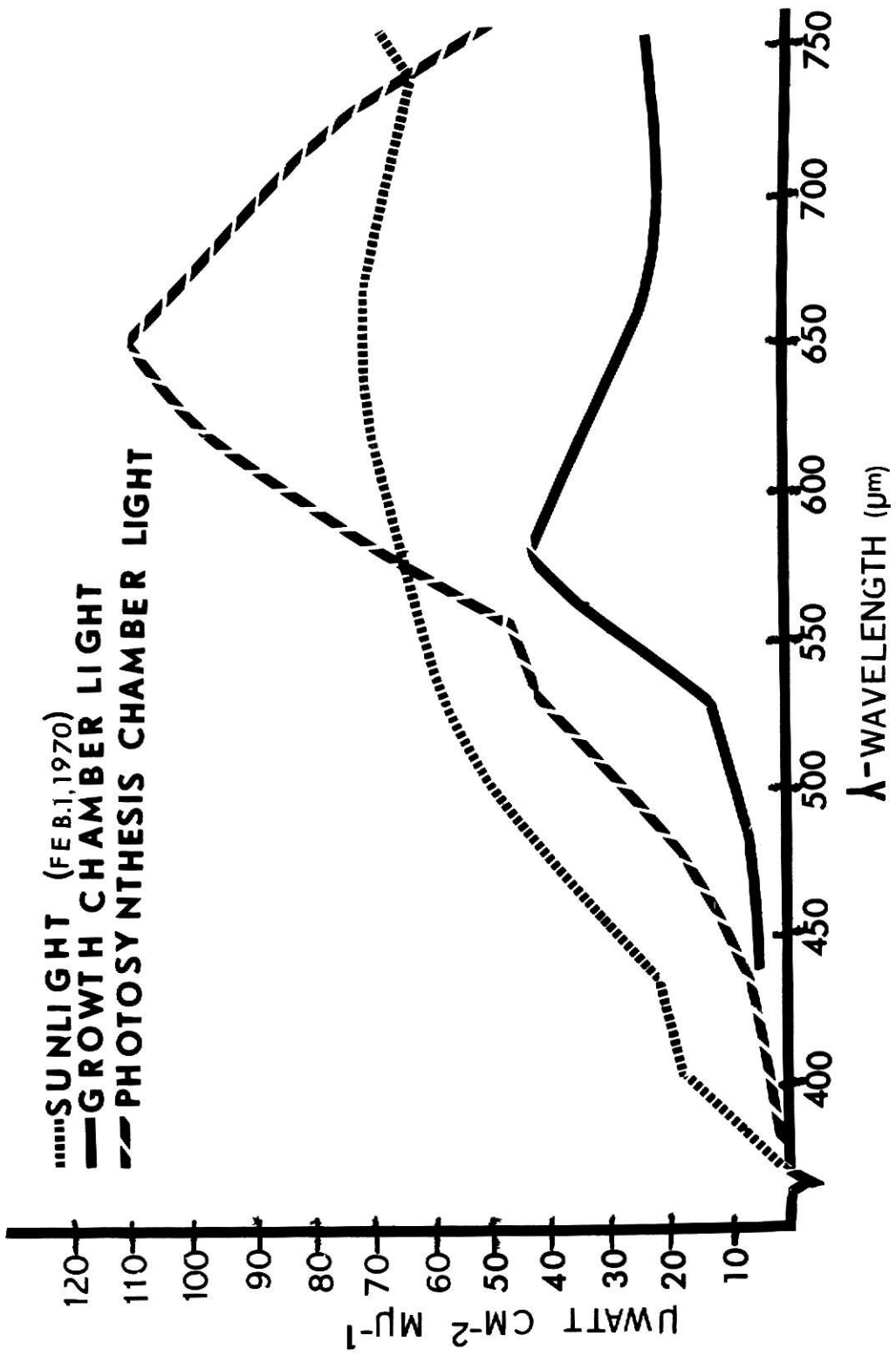


Fig. 2



by passing them through a cell containing  $\text{Mg}(\text{ClO}_4)_2$  before monitoring by the analyzer. The aliquot volume for the analyzer was maintained by a rotometer-valve combination. The air samples were channeled back to the system after measuring the  $\text{CO}_2$  level.  $\text{CO}_2$  levels were recorded by a recorder coupled with the gas analyzer. Net assimilation rate was calculated by the following formula (Hesketh and Musgrave, 1962):

$$\text{NAR} = kFAC\text{CO}_2(T/294)^{1/2}(29.92/p)^{1/2}/A$$

where NAR = net assimilation rate of  $\text{CO}_2$  ( $\text{mg CO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$ ).

$k = 1,000$  (mol wt of  $\text{CO}_2$ ) / 22.4 liters (273/294).

$F =$  liters of air flowing through the chamber per hour.

$AC\text{CO}_2 =$  differential reading of  $\text{CO}_2$  in ppm air volume as determined by the infra-red  $\text{CO}_2$  gas analyzer.

$(T/294)^{1/2}(29.92/p)^{1/2} =$  empirical gas law correction to convert air flow rate to standard condition of the rotometers used.

$A =$  leaf area of plants in  $\text{dm}^2$ .

Respiration was determined by the rate of  $\text{CO}_2$  buildup in the system during darkness with no outside air added. This was expressed as unit weight of  $\text{CO}_2$  increased per unit surface area of leaves.

Transpiration rate was determined by placing one of the test plants in a sealed 300-ml suction flask filled with nutrient solution. The plant was sealed carefully at the base. The flasks were connected to a 100-ml burette (modified potometer) outside the photosynthetic chamber by flexible tygon tubing. Volume of water displaced in the burette per 15 minutes was taken as the transpiration rate of the

plants in the flasks. Transpiration was calculated as:

$$T = (\text{ml H}_2\text{O}/\text{min}) (60 \text{ min/hr}) (1/A)$$

where

$$T = \text{transpiration in ml water dm}^{-2}\text{hr}^{-1}$$

$$A = \text{leaf area in dm}^2$$

## RESULTS

The spectral characteristics of the lights in the photosynthesis chamber (PS) and environmental chamber at the time of the studies were compared with that of sunlight (Fig. 2). These were expressed as microwatts per square centimeter per millimicron ( $\text{uwatt cm}^{-2} \text{mu}^{-1}$ ) at various wavelengths. That of sunlight was the average of two observations. In one, the sensing element of the instrument was perpendicular to the light source and in the other it was perpendicular to the ground and about  $60^\circ$  to the sun. Measurement of the spectral characteristics of the environmental chamber lights was the average of 5 observations and represented the light conditions to which plants were exposed during the growing period. Likewise, measurement of the photosynthesis chamber was the average of 5 observations of light to which plants were exposed during the measurement of photosynthesis and transpiration.

Results of Experiment I. The rates of respiration, transpiration and photosynthesis of corn for the first experiment are presented in Fig. 3. Transpiration rates differed significantly at the 0.05 level; however, differences in photosynthesis and respiration rates among treatments were not significant. That might be attributed to high



EXPLANATION OF FIG. 3

Transpiration, respiration, and photosynthesis  
in corn (Zea mays L. var. 'United Hagie SX 158') as  
affected by antitranspirants.

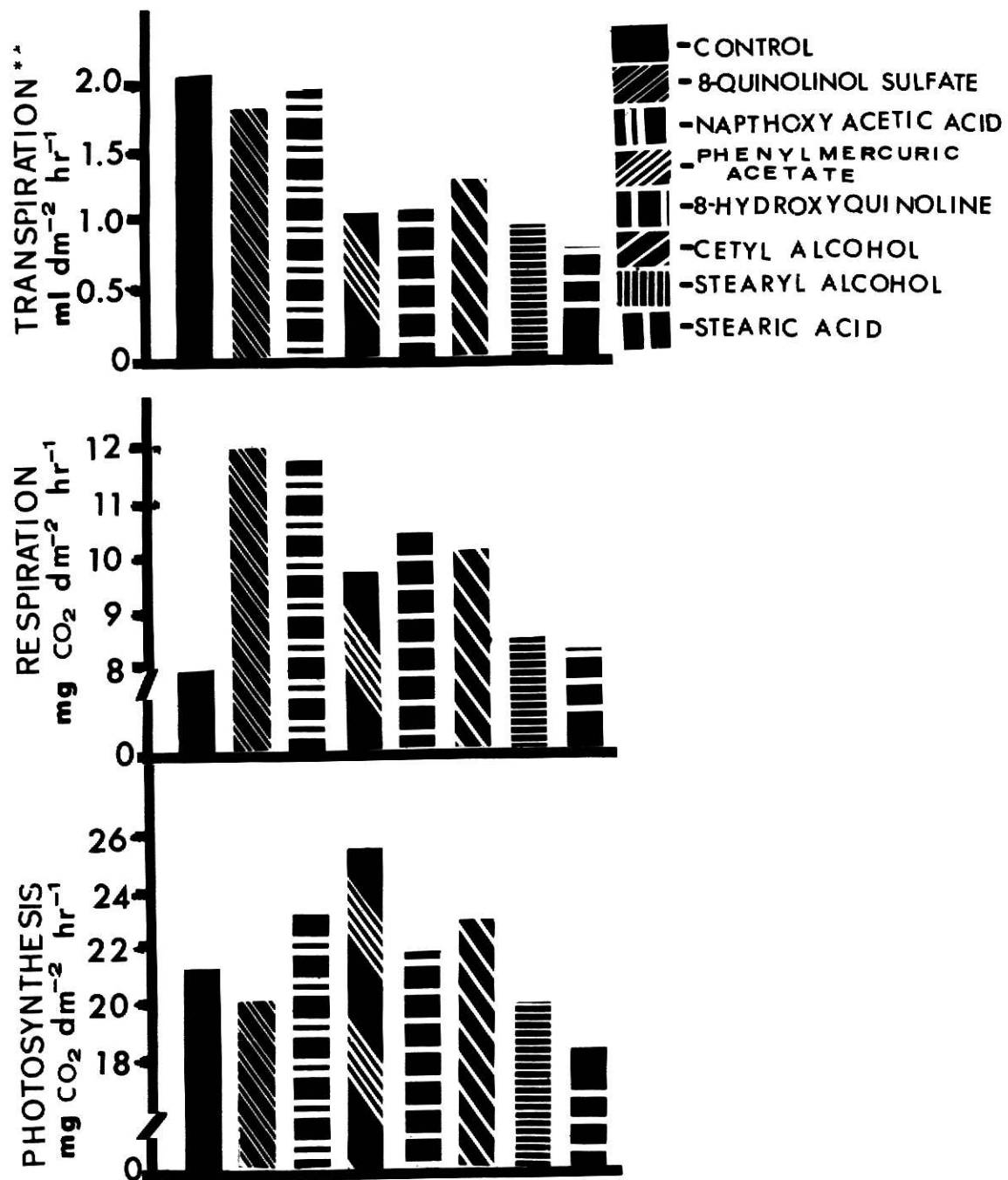


Fig. 3

error or variation between blocks in photosynthesis and respirations observations. Respiration ranged from  $7.94 \text{ mg CO}_2 \text{ hr}^{-1} \text{ dm}^{-2}$  of the control to  $12.18 \text{ mg CO}_2 \text{ hr}^{-1} \text{ dm}^{-2}$  for the 8-quinolinol sulfate treatment. Although the differences were not significant, respiration was frequently higher in plants treated with antitranspirants chemicals.

Applying antitranspirant chemicals significantly reduced transpiration by an average of nearly 30 per cent. Treated plants, however, frequently showed loss of vigor. The two treatments that did not differ from the control in transpiration rates were 8-quinolinol sulfate and B-naphthoxyacetic acid. The magnitude of respiration in this experiment was higher than that observed in the others.

Net assimilation rates differed insignificantly from  $17.86 \text{ mg CO}_2 \text{ hr}^{-1} \text{ dm}^{-2}$  to  $25.23 \text{ mg CO}_2 \text{ hr}^{-1} \text{ dm}^{-2}$ . Some antitranspirant chemicals seemed to increase assimilation rates.

Respiration, transpiration and photosynthesis rates of soybean for Experiment I are shown in Fig. 4. Mean differences in respiration rates among treatments were highly significant and differences in transpiration rates were significant. Mean differences of net assimilation rates among treatments were not significant, however.

Respiration rates of soybean plants treated with antitranspirants increased significantly. The rates ranged from  $2.34 \text{ mg CO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$  for the control to  $7.28 \text{ mg CO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$  for phenyl mercuric acetate was raised from  $10^{-5} \text{ M}$  to  $10^{-3.5} \text{ M}$ , the plants showed abnormal loss of turgor, especially on the younger leaves, and turned yellow. Respiration was high, but photosynthesis and transpiration ceased and the plants ultimately died. The  $10^{-5} \text{ M}$  concentration was used in the experiment but the plants exhibited conspicuous black spots on



EXPLANATION OF FIG. 4

Rates of transpiration, respiration and photosynthesis in soybean (Glycine max (L.) Merr. var. 'Wayne') as affected by antitranspirant chemicals.



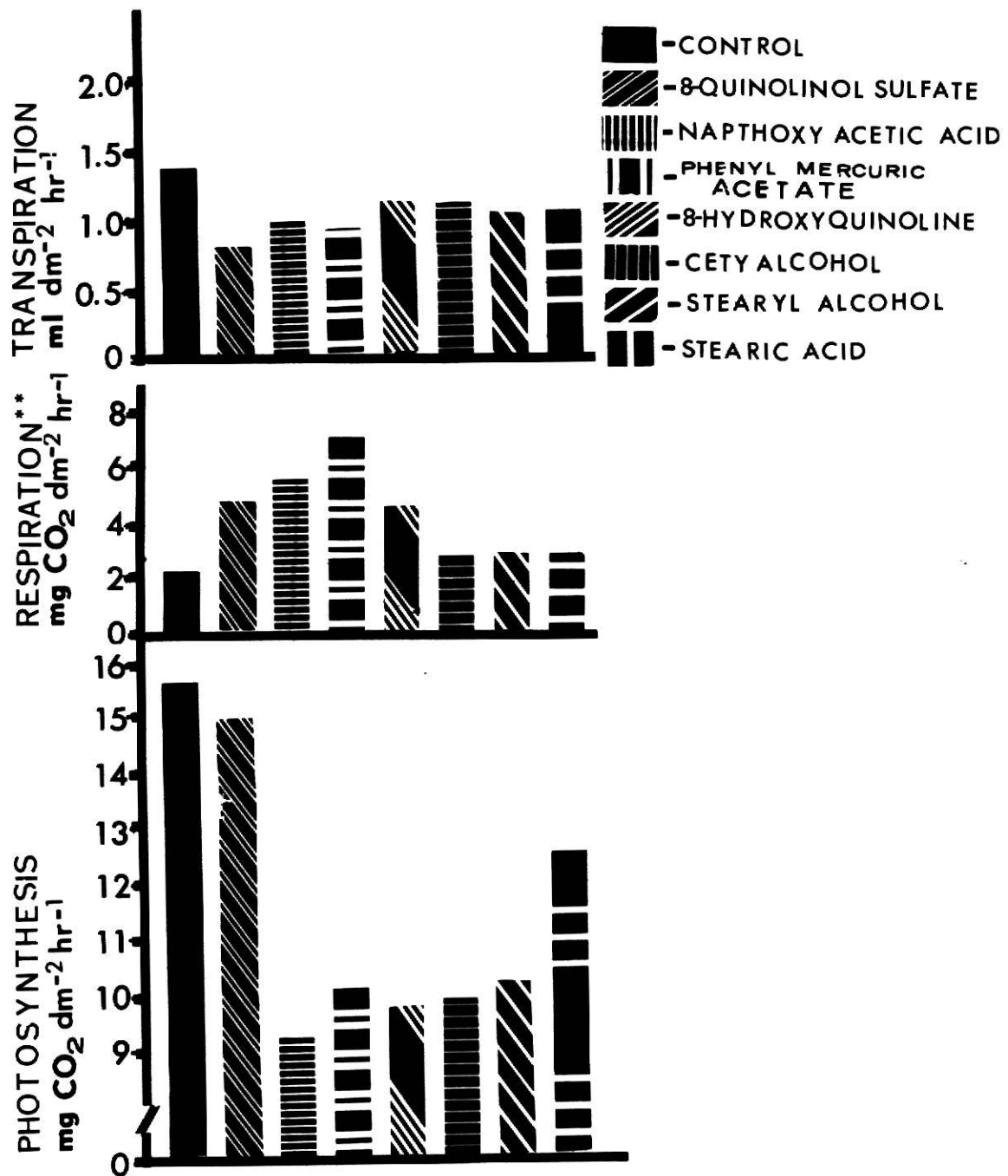


Fig. 4

some leaves. Apparently, those were caused by high concentrations of chemicals.

The antitranspirant chemicals decreased transpiration rates significantly by an average of 38% compared with the control. Obviously, the antitranspirant chemicals studied were nearly equal in their ability to control transpiration.

Although  $\text{CO}_2$  net assimilation rates by soybean plants were not affected significantly by antitranspirant chemicals, they appear to have been generally depressed. Net assimilation rates among the treatments ranged from  $9.27 \text{ mg CO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$  for B-naphthoxyacetic acid to  $15.63 \text{ mg CO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$  for the control. The depressing action of B-naphthoxyacetic acid on photosynthesis of soybean may be attributed to the compound's herbicidal properties.

Results of Experiment II. Figure 5 shows the rates of respiration, transpiration and  $\text{CO}_2$  net assimilation of corn treated with anti-transpirant chemicals. Common names of the chemicals are listed on the legend. Only the transpiration rates differed significantly among the treatments. Mean rates of photosynthesis and respiration did not differ significantly among the treatments. However, antitranspirant chemicals seem to have increased respiration. The rates of respiration ranged from  $4.82 \text{ mg CO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$  for the control to  $7.25 \text{ mg CO}_2 \text{ dm}^{-2} \text{ hr}^{-1}$  for Clear Spray.

Transpiration rates were reduced about 30% after applying anti-transpirant spray. The antitranspirant chemicals studied seemed to be equal in their ability to suppress transpiration. However,



EXPLANATION OF FIG. 5

Rates of respiration, transpiration, and photosynthesis in corn (Zea mays L., var. 'United Hagie SX 158') as affected by antitranspirant chemicals.

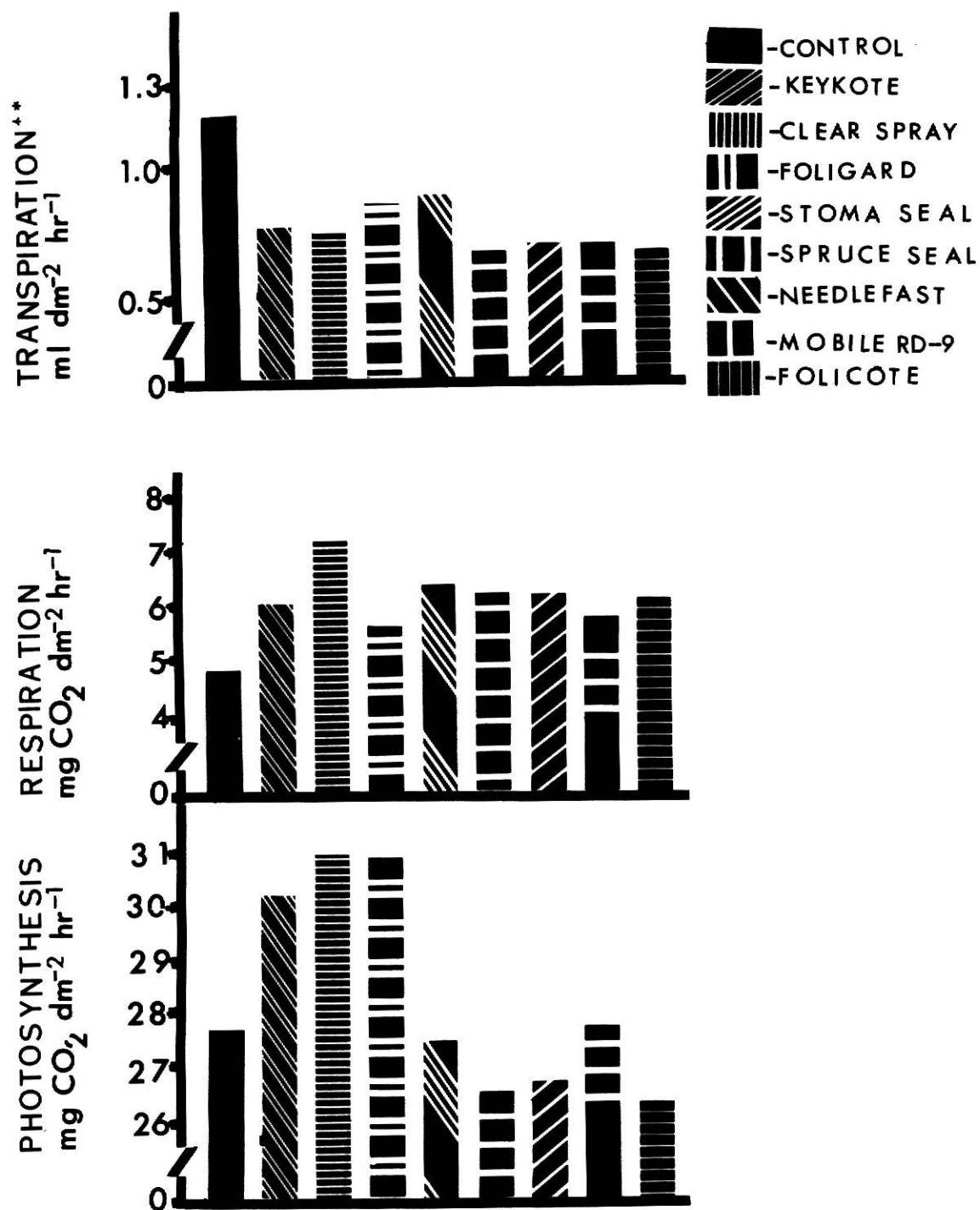


Fig. 5

transpiration rates of plants treated with Keykote, Clear Spray, Stoma Seal, Foli-gard, Needle Fast and Mobile RD<sub>9</sub> were apparently higher than the rest, but the chemicals were equally effective among themselves in antitranspirant ability. Transpiration rates ranged from 0.86 ml dm<sup>-2</sup> hr<sup>-1</sup> for Folicote and Spruce Seal to 1.18 ml dm<sup>-2</sup> hr<sup>-1</sup> for the control.

Net assimilation rates did not differ significantly among treatments in the corn plants. However, it was very obvious that three chemicals increased the photosynthetic rates by about 3% over the control. These chemicals were Keykote, Clear Spray and Foli-gard. Photosynthetic rates ranged from 26.33 mg CO<sub>2</sub> dm<sup>-2</sup> hr<sup>-1</sup> for Folicote to 30.97 mg CO<sub>2</sub> dm<sup>-2</sup> hr<sup>-1</sup> for Foli-gard.

The effects of antitranspirant chemicals in Experiment II on the rates of respiration, transpiration and photosynthesis of soybean are shown in Fig. 6. Means of respiration rates and transpiration rates differed highly significantly among treatments. However, differences in CO<sub>2</sub> net assimilation rates among treatments were not significant.

Antitranspirant chemicals significantly increased respiration. The rate of respiration ranged from 3.13 mg CO<sub>2</sub> dm<sup>-2</sup> hr<sup>-1</sup> for the control to 5.36 mg CO<sub>2</sub> dm<sup>-2</sup> hr<sup>-1</sup> for Foli-gard.

17A

#### EXPLANATION OF FIG. 6

Rates of transpiration, respiration and photosynthesis in soybean (Glycine max (L.) Merr var. 'Wayne') as affected by antitranspirant chemicals.



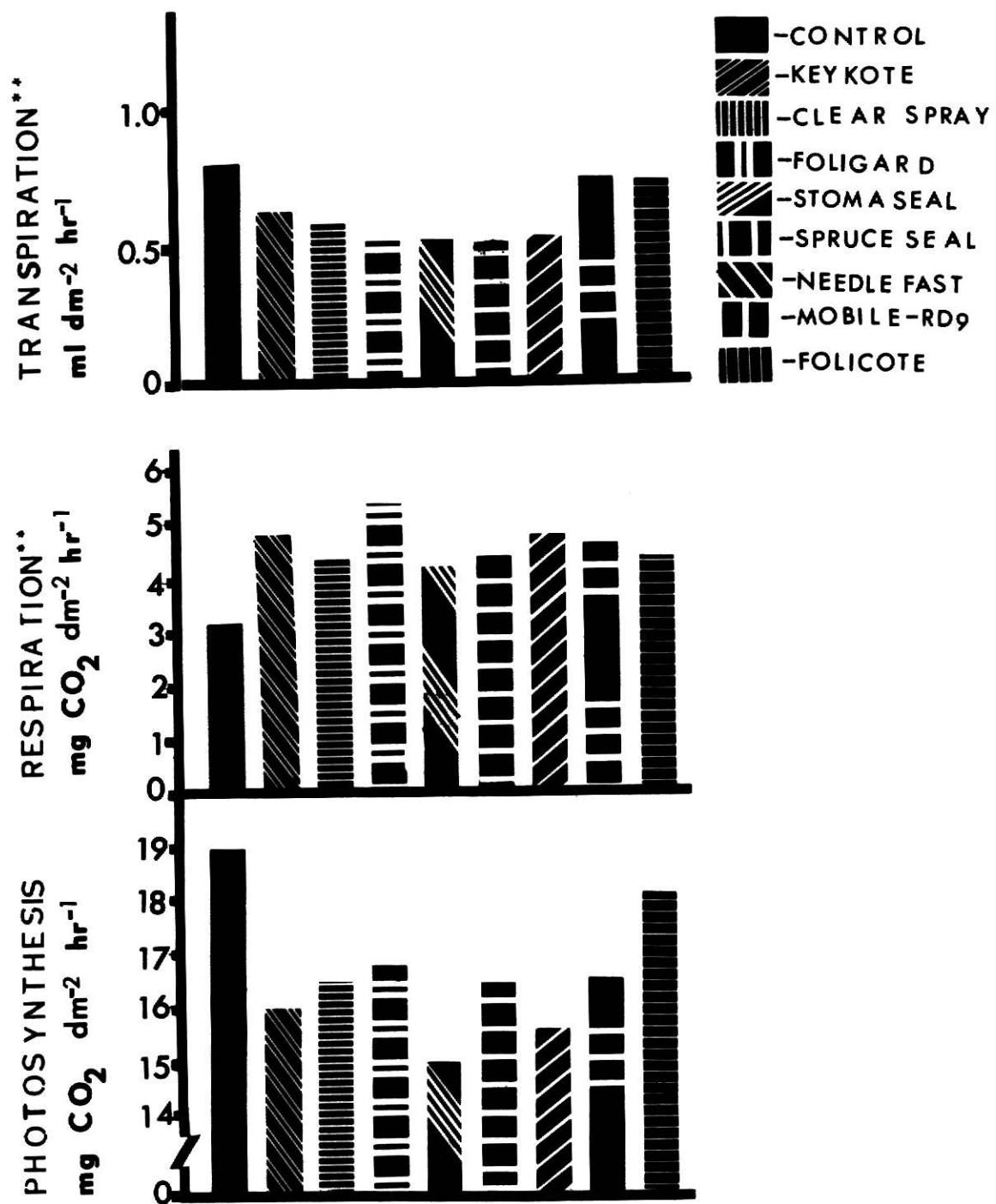


Fig. 6

## DISCUSSION

Antitranspirant chemicals appeared to be effective in decreasing transpiration in both crops studied. Water loss from plants treated with antitranspirant chemicals decreased from 30 to 50%. Those observations were slightly higher than those of Slayter and Bierhuizen (1964) and Davenport et al. (1969), but comparable to those of Miller (1968). Differences in techniques of measuring transpiration could account for differences in results among studies. The modified potometer used in this study might have detected minor differences between treatments and would tend to exaggerate differences, particularly after calculating results from raw data.

Except for 8-quinolinol sulfate, B-naphthoxyacetic acid, Foli-gard and Stoma Seal for corn and Mobile RDg and Folicote for soybean, the antitranspirant chemicals applied decreased transpiration significantly when compared with the control. Whether the active ingredient was phenylmercuric acetate for controlling stomatal movement or plastic and wax for forming a thin film cover on the leaf surface, the end effect seemed to be the same. One of the factors important for the effectiveness of an antitranspirant chemical is the thorough wetting of the foliage surfaces.

Chemicals studied appeared to increase respiration of the crops, particularly those chemicals with herbicidal properties. Except for 8-quinolinol sulfate and B-naphthoxyacetic acid in corn, chemicals with the greatest ability to decrease transpiration also increased respiration. That might be expected because transpirational cooling

is also suppressed. Supposedly, this would increase the foliar temperature compared with the surrounding air. The increased rates of respiration may be attributed to the rise in temperature of the plant. Observations (data not shown) indicated that the leaf temperature was increased by 0.5 to 1.5 C by the application of antitranspirant chemicals. Unfortunately, data collected were incomplete to support and ascertain this hypothesis.

Differences among treatment means of net carbon dioxide assimilation rate were not significant, but the application of antitranspirant chemicals appeared to decrease photosynthesis. Observation by Slayter and Bierhuizen (1964), Zelitch (1963) and Shimshi (1963) indicated that antitranspirant chemicals have a depressing effect on photosynthesis. Carbon dioxide net assimilation rates in soybeans and corn seedlings observed during this study suggested that the chemicals might depress photosynthesis. However, differences among the means of the treatments were not significant. It is highly possible that the technique of measurement employed may be the cause of this. The high water content of air fed from the outside may not have been totally eliminated by the drying agent when air was monitored to the analyzer. Measurements on respiration rates would not be affected similarly with net assimilation rate measurement because all parts of the system were closed in the case of respiration. The whole system should have been closed from the outside sources of air as soon as the carbon dioxide level inside the chamber reached 350 ppm. That is an alternative method of measuring net assimilation rate. The time lapse in decreasing carbon

dioxide level from 350 to 250 ppm inside the chamber with the potted plants while the lights are on could have been a better measure of net assimilation rate.

Graham and Buchholtz (1968) reported that dry matter accumulation is one of the processes in plants that were adversely affected by the application of antitranspirant chemicals. That observation agreed with those by Shimshi (1963) and Davenport (1969). Increased respiration rates with the application of antitranspirant chemicals and the insignificant effect of the chemicals on net assimilation rates may explain the decreased dry matter accumulation (Graham and Buchholtz, 1968).

Attention should be focused on those chemicals that showed greater promise. Those chemicals low in respiration effects, high in decreasing transpiration, and did not affect photosynthesis significantly. Some of these were Stoma Seal, Spruce Seal, Needle Fast, Mobile RD-9 and Folicote for corn, and Clear Spray, Foli-gard, Stoma Seal, Spruce Seal, Needle Fast, and Keykote for soybean.

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## LITERATURE CITED

- Black, C. C., J. F. Turner, M. Gibbs, D. W. Krogmann, and S. A. Gordon. 1962. Studies on the photosynthesis processes. II. Action spectra and quantum requirements of triphosphopyridine nucleotide reduction and formation of adenosine triphosphate by spinach chloroplasts. *J. Biol. Chem.* 237:580-584.
- Blandy, R. V. 1957. The effect of certain fungicides on transpiration rates and crop yields. *Internat'l Cong. Crop Protect. Proc.* 4:1513-1516.
- Davenport, D. C. 1967. Effects of chemical antitranspirants on transpiration and growth of grass. *J. Expt. Bot.* 18:332-347.
- \_\_\_\_\_, R. M. Hagan, and P. E. Martin. 1969. Antitranspirants-- Use and effects on plant life. *Calif. Agric.* 23(5):14-16.
- Devlin, R. M. 1966. Transpiration. *In* *Plant Physiology*. Reinold Pub. Corp., New York. pp. 60-86.
- Ehrler, W. L. and C. M. M. van Bavel. 1968. Leaf diffusion resistance, illumination, and transpiration. *Plant Physiol.* 43(2):208-214.
- Gale, J. and R. M. Hagan. 1966. Plant antitranspirants. *Ann. Rev. Plant Physiol.* 17:269-282.
- \_\_\_\_\_, and A. Poaljakoff-Mayber. 1967. Plastic film on plants as antitranspirants. *Science* 156(3775):650-652.
- \_\_\_\_\_. 1967. High alcohols as antitranspirants. *Water Resources Res.* 3(2):437-441.
- Graham, J. C. and K. P. Buchholtz. 1968. Alteration of transpiration and dry matter with atrazine. *Weed Sci.* 16(3):389-392.
- Hafez, M. G. A. and M. E. Younis. 1969. Studies in stomatal behaviour: The effects of moving normal and carbon dioxide-free air on the stomata of some plants. *Physiol. Plant.* 22(2):332-337.
- Heath, O. V. S. and T. A. Mansfield. 1969. The movements of stomata. *In* *Physiology of Plant Growth and Development*. M. B. Wilkins, ed. McGraw-Hill Pub. Ltd., England. pp. 301-332.
- Hesketh, J. D. and R. B. Musgrave. 1962. Photosynthesis under field condition. IV. Light studies with individual corn leaves. *Crop Sci.* 2:311-315.
- Hill, C. A. and N. Littlefield. 1969. Ozone-effect on apparent photosynthesis, rate of transpiration, and stomatal closure in plants. *Environ. Sci. Tech.* 3(1):52-56.

- Hoagland, O. R. and D. I. Arnon. 1950. The water culture method for growing plants without soils. California Agr. Exp. Sta. Cir. 347.
- Johnson, C. M., P. R. Stout, T. C. Boyer, and A. B. Carlson. 1947. Comparative chlorine requirements of different plants species. *Plt. and Soil* 8:337-353.
- Kijne, J. W. 1968. Influence of evaporation suppressants on water movements in soils. *Aust. Jour. Soil Res.* 6(1):67-73.
- Klyuchnikov, L. Yu, and M. V. Bogaeva. 1969. Physiological responses of conifers to 2,4-D treatment in mixed young trees. *Biol. Abs.* 50(23):128543.
- Kotlyar, V. Z. and M. A. Lynbyn'skyl. 1969. Transpiration of upper and lower leaf surface in light and dark in plants provided with different nutrition. *Biol. Abs.* 50(19):105685.
- Leopold, C. A. 1964. Water. *In* Plant Growth and Development. McGraw-Hill Book Co., New York. pp. 393-406.
- Letey, J. and N. Valora. 1965. Experiments on the use of fatty alcohol emulsion to modify plant transpiration. *Advancing Frontiers Plt. Sci.* 9:145-153.
- Luke, H. H. and T. E. Freeman. 1968. Stimulation of transpiration by cytokinins (aminopurines). *Nature* 217(5131):873-874.
- Mansfield, T. A. 1967. Stomatal behaviour following treatment with auxin-like substances and phenyl mercuric acetate. *New Phytol.* 66:325-330.
- Meidner, H. and T. A. Mansfield. 1966. Rates of photosynthesis and respiration in relation to stomatal movement in leaves treated with  $\alpha$ -hydroxysulfonates and glycolate. *J. Exp. Bot.* 17:503-509.
- Miller, N. A. 1968. The effects of several transpiration retardants on water balance, stomatal aperture, and leaf temperature of field corn leaves. *Disst. Abst.* 1969. 29(3640).
- Possingham, J. V., G. H. Kerridge, and D. E. Bottrill. 1969. Studies with antitranspirants on grapevines (*Vitis vinifera* cultivar sultana). *Aust. Jr. Agr. Res.* 20(1):57-64.
- Shimshi, D. 1963. Effect of soil moisture and phenyl mercuric acetate upon stomatal aperture, transpiration, and photosynthesis. *Plant Physiol.* 38:713-721.
- Sivadjian, M. J. 1967. Chemical inhibitors of plant transpiration. Phenyl mercuric acetate. *Bull. Soc. Bot. Fr.* 114(1-2):1-4.

- Sivadkian, J. and V. Ricardo. 1966. Action of long chain alcohols on the transpiration and growth of plants. Biol. Abst. 47:68915.
- Slatyer, R. O. and J. F. Bierhuizen. 1964. The influence of several transpiration suppressants on transpiration, photosynthesis, and water-use efficiency of cotton leaves. Aust. J. Biol. Sci. 17:131-46.
- Smith, D. and K. P. Buchholtz. 1962. Transpiration rate reduction in plants with atrazine. Science 136:263-265.
- Turner, N. C. 1969. Stomatal resistance to transpiration in three contrasting canopies. Crop Sci. 9:303-307.
- Wadleigh, C. H. 1964. We must fit farm to our water supply. Crop and Soil 16(4 & 5):8-9.
- Waisel, Y., G. A. Borger, and T. T. Kozlowski. 1969. Effect of phenyl mercuric acetate on stomatal movement and transpiration of excised Betula papyrifera marsh leaves. Plant Physiol. 44:685-690.
- Walker, D. A. and I. Zelitch. 1963. Some effects of metabolic inhibitors, temperature and anaerobic conditions on stomatal movement. Plant Physiol. 38:390-397.
- Willis, A. J. and S. Balasubramanian. 1968. Stomatal behaviour in relation to rates of photosynthesis and transpiration in Pelargonium. New Phytol. 62:265-285.
- Wolman, A. 1962. Water Resources. A report to the committee on National Resources of the Nat. Acad. of Sci. Nat. Res. Council. Washington, D. C.
- Yemm, E. W. and A. J. Willis. 1954. Stomatal movements and changes of carbohydrates in leaves of Chrysanthemum maximum. New Phytol. 53:373.
- Zelitch, I. 1963. The control and mechanism of stomatal movement. In Stomata and water relations in plants. Bull. Conn. Agric. Expt. Sta. 664:18.



EFFECT OF SOME ANTITRANSPIRATION CHEMICALS ON  
PHOTOSYNTHESIS AND RESPIRATION OF CORN AND SOYBEAN SEEDLINGS

by

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Fifteen antitranspirant chemicals were tested on seedlings of soybean (Glycine max (L.) Merr. var. 'Wayne') and corn (Zea mays L. var. 'United Hagie SX 158') for effects on transpiration, net assimilation, and respiration of the crops. The seedlings were grown in an environmental chamber for two weeks before applying the antitranspirant chemicals. The chemicals were applied as spray and/or as aqueous solution one day before measuring transpiration, photosynthesis and respiration rates. The concentration of the chemicals applied was based on the manufacturers' recommendations. A closed, light-transparent plexiglas chamber enclosed the crops and an aliquot sample of air was monitored to an infra-red CO<sub>2</sub> gas analyzer during the period when photosynthesis and respiration rates of the crops were measured. Net assimilation rate was expressed as mg CO<sub>2</sub> absorbed dm<sup>-2</sup> leaf area hr<sup>-1</sup> while respiration was expressed as mg CO<sub>2</sub> released dm<sup>-2</sup> leaf area hr<sup>-1</sup>.

The antitranspirant chemicals significantly reduced transpiration from 30 to 50% but appeared to increase respiration of the crops studied. Carbon dioxide assimilation rates were not affected significantly by the antitranspirant chemicals, although the data suggested that photosynthesis was depressed. Plant dry matter production was decreased by the antitranspirant chemicals because respiration rates increased while photosynthesis decreased or remained constant. Chemicals that were most promising decreased transpiration most and net assimilation least. Those were Stoma Seal, Spruce Seal, Needle Fast,

Mobile RD-9 and Folicote for corn, and Clear Spray, Foli-gard, Stoma Seal, Spruce Seal, Needle Fast and Keykote for soybean.