A Compact Automatic System for Measuring CO₂ and C₂H₄ Evolution by Harvested Horticultural Crops

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Abstract. A compact automatic system was developed for sampling, analyzing, calculating, and recording rates of carbon dioxide and ethylene production by up to 54 samples. The system consists of rotary stepping valves, microcomputer with printer, cassette tape recorder, and a gas chromatograph.

Carbon dioxide and ethylene are commonly measured to observe the physiological activities of harvested horticultural products. Some scientists have automatic gas samplers to minimize the man-hours required for collecting and analyzing the effluent gas. These automatic gas samplers are convenient and highly desirable, but they have some limitations. Generally, solenoid valves are used for the selection of samples, and a system that can accommodate a large number of samples will require a considerable amount of space for the valves (1,2). Most commercial units are limited to handling a maximum of 10 to 12 samples, and the sequence of sample selection is restricted. Automatic samplers generally are connected to an instrument for analysis of either carbon dioxide or ethylene or to 2 instruments in series for analyses of both carbon dioxide and ethylene. In all of these systems, the detector response, which may be on a chart paper, printer paper, or magnetic tape, needs to be transferred to another system for calculation of the rate of activity. These limitations can be minimized by modification and expansion of the system.

We have developed a system that automatically determines the rate of CO₂ and C₂H₄ produced by up to 54 samples and records the data on paper tape and cassette tape. The system consists of rotary stepping valves, a gas chromatograph, gas chromatograph controller, microcomputer, and a cassette tape recorder. Air is metered into the sample containers, and the outlets of the container are connected to the stepping valves.

Five Scanivalve ScanCon Model S64 large volume sample valves (rotary stepping valves), purchased from Scanivalve Corp., P.O. Box 2005, San Diego, California, were incorporated to handle a maximum of 54 samples. Each sample valve has 12 input ports, 1 output port for the selected sample, and 12 output ports for the 11 unsampled streams (Fig. 1). The output ports of selected sample from each of the 4 sample valves are connected to input ports of the 5th sample valve. The remaining 8 input ports of the 5th sample valve are used for 6 additional samples and 2 standard gases. The total space needed for the 5 sample valves and their electronic circuitry is about 45 cm high, 30 cm wide, and 25 cm deep, which is much less than the space needed for the gas chromatograph (Fig. 2).

A Bendix Model 2300 gas chromatograph was used to analyze carbon dioxide and ethylene. The selected output port of the 5th sample valve is connected to 2 sample loop valves in series, which are activated independently. Each sample loop valve is connected to a 3.2 mm x 244 cm stainless steel column packed with Porapak Q 50/80. The outlets of both columns are united together and connected to the flame ionization detector. Carbon dioxide is reduced to methane in Bendix Model 2300 catalytic converter at 400°C, which is located between the Porapak column and the flame ionization detector.

The Bendix 7000 gas chromatographic controller has several line functions. It is used to select the time at which the valves are activated, duration of sample loop purging, duration of cycle between samples, and sensitivity and attenuation of detector response and to control a few other items on the gas chromatograph. The total time for sample purging and analyses of gases is about 3 minutes. The cycle time between samples is maintained at a minimum of 5 min and can be extended to a maximum of 15 min. The sensitivity of the electrometer is adjusted for ethylene production with the different commodities.

A Rockwell AIM-65 microcomputer controls the sample valves and monitors the gas chromatograph controller, responds to the detector, and calculates the rate of activity. The computer contains a keyboard, printer, digital display, cassette recorder interface, and a 20 mA current loop interface. It has 20 lines of digital input and output which are used to interface the computer to the gas chromatograph controller, valve controller, and...
Fig. 2. Automatic system for sampling, analyzing, calculating, and recording rates of carbon dioxide and ethylene production. The 5 sets of stepping valves on the left of the gas chromatograph require only a limited space. The AIM-65 microcomputer is the small unit with keyboard placed on the top of the gas chromatograph control module.

a 12-bit analog to digital converter.

The program, written in BASIC, is about 75 lines long, and is divided into a main program and a group of subroutines. Subroutines are determined by the main program, which monitors for changes in the logic level of the lines from the gas chromatograph controller. Some sections of the program were set up for parameters needed in the calculations and operations, such as standard gas concentration, fruit weight, flow rate of air, and sampling sequence.

The sequence of port selection was indicated (in program) by identifying the port number in an array. A zero was used in the array to bypass specific port, and a negative value was used in the port number position to jump to positions in the array. Array positions 1 and 2 were assigned port numbers 55 and 56, which was connected to the standard ethylene (1 or 20 ppm) and carbon dioxide (0.517%) gases. In the example shown in Table 1, array positions 3 through 9, 15 through 21, and 27 through 33 were assigned port numbers 1 through 7, 13 through 19, and 25 through 31, respectively, which were connected to the 21 samples (Table 1). The negative value in array positions 10, 22, and 34 identified the array position to be selected next for the analysis. For example, -15 indicated that port assigned to port array position 15 would be selected next for the analysis and bypassing samples assigned to array positions 10 through 14.

The program responds to 4 functions:

1) Identifies the current port and prints the port number, prints the time, and adds the time interval to the time.

2) Advances to the next port in the sequence.

3) Does an analog to digital conversion for carbon dioxide. If the port is equal to 55, the reading is used as the standard; otherwise, it calculates the amount of carbon dioxide produced and prints the rate of production.

4) Does an analog to digital conversion for ethylene. If the port is equal to 56, the reading is used as the standard; otherwise, it calculates the amount of ethylene produced and prints the rate of production.

The BASIC program handles all of the communications with the interface with the user. Each rate is tabulated in sequence of analysis, with each rate identified numerically and by the day of the year and the time of analysis. Fig. 4 shows the data plotted directly from the cassette tape by a computer. The plot shows the typical curve of the rate of CO₂ production for tomato fruit as it decreased with maturation and exhibited a climacteric pattern with ripening. The plot of ethylene data shows the beginning of the climacteric peak on day 60.5, about 1.5 days after the preclimacteric minimum of CO₂ production. The sharp drop in the rate of CO₂ production on the 53rd day of the year is not a true change, but an error caused by failure to turn on the carrier gas after a full cylinder of carrier gas was installed.
Inhibition of Regrowth and Yield of Mature Lemon Trees with Ammonium Ethyl Carbamoylphosphonate¹

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Abstract. Sprays of ammonium ethyl carbamoyl-phosphonate (Krenite), applied to the tops of mature Lisbon lemon trees (Citrus limon (L.) Burm.) resulted in significant inhibition of regrowth for over 3 years. One spray increased yield over the control trees (hand topped annually), while 2 sprays reduced yield. The sprays did not effect the N concentration in the leaves.

Several methods have been tried to control top regrowth of mature lemon trees, including hand, mechanical, and chemical pruning. Hand pruning is expensive, and with both hand and mechanical pruning there is the expense of brush shredding (1, 9). Chemical pruning has many drawbacks such as undesirable rind thickness (6, 7), chemicals not available

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Handling of data with the cassette tape is convenient and efficient and minimizes errors that result with manual transfer of data.

The cost of each stepping valve was about $350 (1978) which is comparable to the cost of 12 solenoid valves, but the stepping valve is compact. The cost of the microcomputer was about $500. The total cost of automating the system, excluding the gas chromatograph and gas chromatograph controller, was about $2500. This cost is relatively small when compared to the cost for the labor needed in manual analysis and calculation. A supplement containing the wiring diagram, BASIC Program, and source of equipment is available from the authors.

Literature Cited


However, even with annual N rates up to 500 kg per ha, typical leaf N values are only 2.1 to 2.2%. Common, most economic, N rates range from 200 to 300 kg N per ha annually. A reduction in N from the 300 to the 200 kg rate has a greater effect on fruit yield than on vegetative growth. Thus, to sustain high fruit yields, high N rates are applied and these are associated with nitrate pollution of groundwater (5) and conditions favorable for vigorous vegetative growth and regrowth after pruning, particularly in the tops of trees. We theorized that an effective growth retardant applied to the tops of the trees could result in increased leaf N at a given N rate, and thus make for more efficient use of applied N. Our experiment explored this theory.

A field trial to evaluate the effectiveness of Krenite on production, leaf N concentration and retardation of lemon top regrowth was initiated in September 1975, at the University of California South Coast Field Station in Orange County. The 16-year-old ‘Frost’ nucellar Lisbon trees on Koethen sweet orange rootstock were mechanically flat topped to a height of 4.6 m in September 1975 and the treatments were applied by a power sprayer with a pressure of 7 kg/cm² (11 psi) in April, 1976 when regrowth obtained a mean length of 0.3 m on all trees. Top growth was sprayed at low volume to minimize run-off, using a water solution of 0.25% Krenite with 0.02% X-77³ added as a wetting agent. Control

³Colloidal Products of Sausalito, Calif. produces X-77. The principal active ingredients of X-77 are alkylpolyoxyethylene glycols, free fatty acids and isopropanol.