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A Simple and Reliable Device for Monitoring Fumigant Residues in Soil

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Soil fumigation is commonly used to control soil pests such as nematodes and other soil-borne pathogens. Most fumigants are phytotoxic, however, and farmers must delay subsequent planting until the danger has subsided. The ability to measure phytotoxic levels of fumigant residues could minimize the waiting time, but no accurate and practical method of measurement is available. Bioassay methods such as the cress test (5) and the onion test (2) are difficult to apply and their application remains experimental.

In trying to develop a simple detection method, we found that a ceramic gas sensor (3) developed for gas alarms (1) could be modified into a device for rapid and accurate monitoring of fumigant residues in field soil. A TGS-813 gas sensor (Figaro Inc., Japan) was purchased and incorporated into an electrical circuit. The device was calibrated based on the cress (*Lepidium sativum* L.) test for measuring phytotoxoic residue levels of Di-Trapex (20% methyl isothiocyanate + 80% DD). To test the sensitivity of TGS-813 to the fumigants, the sensor was hung in a glass jar (Fig. 1) and specific quantities of fumigant were injected into the jar with a micro syringe. Changes in the resistance value of the sensor were recorded as voltage shifts.

The cress test was carried out simultaneously. Fifteen cress seeds were placed on a 10-mm-d wet cotton ball which was then hung in a glass jar (Fig. 1). Fumigants, diluted with suitable solvent, were injected into the jar as controls. After 24 hours at

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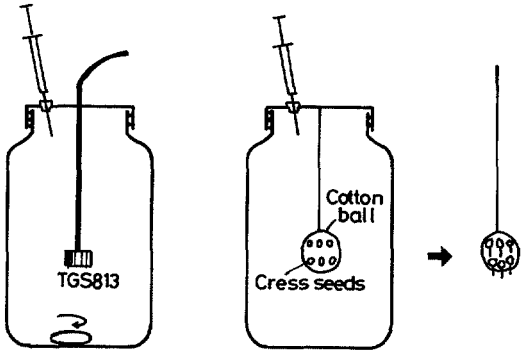

FIG. 1. Scheme for calibration of the TGS-813 gas sensor with fumigants (A) and the cress test (B).

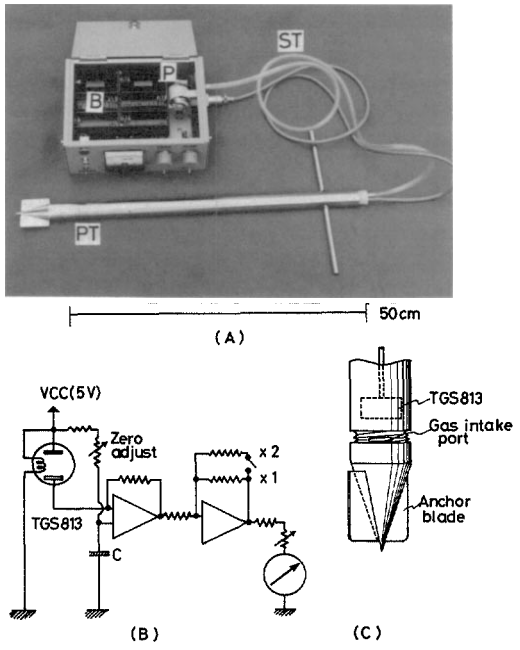

FIG. 2. Field version of the fumigant monitor (A), circuit diagram (B) and probe head (C). B: Battery holder, P: Vacuum pump, PT: Probe tube, ST: Suction tube.

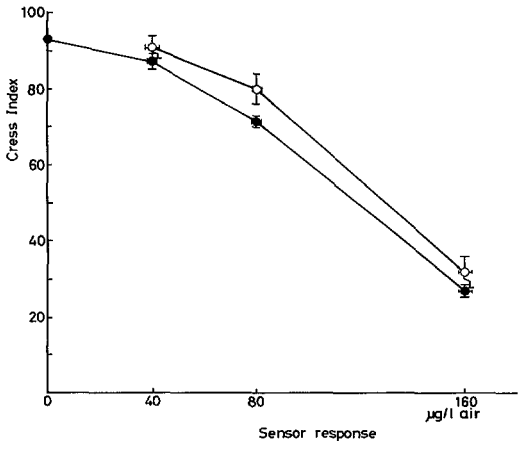

FIG. 3. Relationship between the cress index and gas concentration of methylisothiocyanate (●——●) and Di-Trapex (○——○) indicated by the fumigant monitoring device.

25 C, the seeds were visually inspected for germination and classified as follows: class 0 = no germination, class 1 = visible germination, class 2 = root length not exceeding 2 mm, class 3 = root length of 2–5 mm, class 4 = root length over 5 mm. The cress index (CI) was calculated as the gall index (4): CI = (sum of category numbers/4 × no. of seeds) × 100.

For field use, the device was constructed with a dry battery drive (Fig. 2A). A small vacuum pump facilitates the response of the sensor when it is inserted into the soil and purges excess gas in the probe tube to prepare for the next detection. The response of the sensor to the gas concentration is displayed on an ammeter as micrograms per liter of air; the circuit diagram and scheme of probe head appears in Figure 2B, C. The relationship between the cress index and the gas concentration expressed by this device is shown in Figure 3.

In practice, the probe tube is inserted to the desired depth in the soil after the sensor has been warmed to stable by power supply. Next, the handle is turned right to open the gas intake port by the action of the anchor blade and screw (Fig. 2C). The vacuum pump is started, and when the ammeter stabilizes, the value of the meter scale is read. After the intake port is closed, the probe tube is removed. Reading of many points is possible within a short time with this device. Thus, the residual gas can be measured accurately to indicate when aeration is necessary. Table 1 compares the results of our fumigant monitoring device with those of the cress test and ramification of Japanese radish roots, which is caused by residual methyl isothiocyanate in the early stages of growth and renders the crop unmarketable. Our simple monitoring device can be used to find the residual fumigant levels and avoid such problems.

TABLE 1. Residual gas level found by two fumigant monitoring methods at 1 week after treatment and root ramification index of Japanese radish at harvest.

	Plot	Gas level at sowing*	Cress index†	Ramification index‡
Fumigated	A	59 a	73.3 b	38.6 a
	B	106 b	38.3 a	62.2 b
Nonfumigated	C		89.8 b	18.3 a

Numbers within a column followed by the same letter were not significantly different ($P = 0.05$) according to Duncan's new multiple-range test.

* Micrograms per liter of air.

† Cress tests under field conditions were conducted as follows: ca. 200 ml soil was removed from 10–20 cm deep with a 50-mm-d core sampler and put immediately into a 1,000 ml glass jar. A 10-mm-d wet cotton ball detached with 15 cress seed was hung in the mid portion of the jar which was capped and kept at 22 C for 24 hours. Germination of the seeds was inspected and the cress index calculated.

‡ Japanese radishes with a ramification index (RI) exceeding 50 are unmarketable. RI based on a scale 0–4, 0 = no ramification and 4 = 76–100% of root ramification.

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