# FRONTIERS
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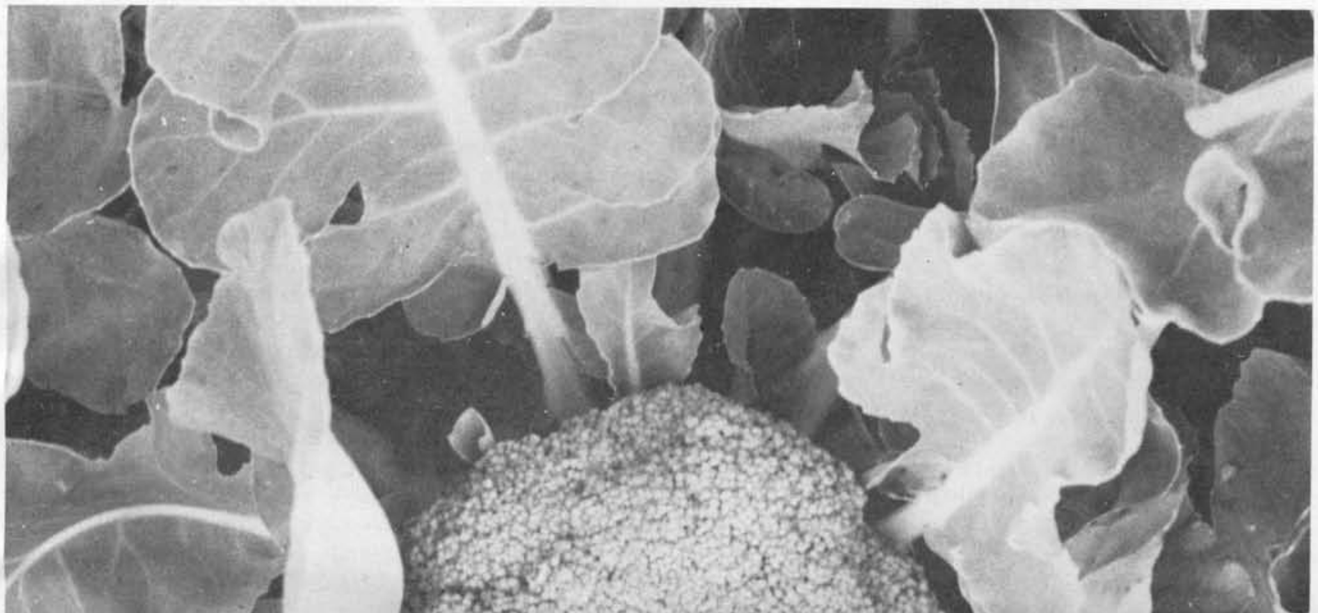

Growing broccoli in Connecticut. See page 3.

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION NEW HAVEN

# Finding new ways to reduce deer damage to crops

**By Michael R. Conover**

A dozen white-tailed deer, *Odocoileus virginianus*, feeding in a field at sunrise is a pleasing or disconcerting sight in Connecticut, depending upon whether you are a passerby or a farmer whose livelihood depends upon the crops in that field. Indeed, for farmers, damage to agricultural crops by deer is a major problem. This is especially true for nurserymen and apple growers in the winter, when natural foods for deer are scarce, and nursery plants and apple trees appear most inviting. Although farmers may obtain permits to kill deer that damage their crops, lethal control often does not substantially reduce damage and is controversial. Consequently I have been testing alternatives that will keep deer from the crops without taking their lives.

Among the alternatives under study at the Experiment Station are repellents that will keep the deer away or temper their appetite for a crop. Several repellents are available including: (1) Magic Circle® made from bone tar oil; (2) human hair collected from barbers and hung in nylon mesh bags; (3) thiram (tetramethylthiuram disulfide); (4) Big Game Repellent® (BGR) produced from putrified whole egg solids; (5) Hinder® containing soap-like materials; and (6) Miller Hot Sauce® containing capsaicin, an extract of hot peppers. Unfortunately, little was known about the ability of these products to repel deer.

Consequently, I tested repellents during the winter to see if they would keep free-ranging deer from eating one of their favorite foods, yews (*Taxus*), at several nurseries in Connecticut. I established several small plots (50 to 100 $m^2$) in each nursery during the fall and sprayed the various repellents on some plots while leaving others untreated. I found that a single treatment of any of these repellents provided some protection, but none prevented deer damage entirely. When compared to the untreated plots, damage was 15% less on plots treated with Miller Hot Sauce, 34% less on plots treated with hair, 43% less on plots treated with thiram or Hinder and 46% less on plots treated with BGR.

Because the plots were small, the data are useful in assessing relative effectiveness of the repellents, but may not predict the level of protection a farmer might expect if he treated all of his yews with any one of them. To evaluate efficacy on a larger scale, I set up a second experiment where 0.5-1.0 ha plots were treated once in the fall with BGR or Hinder, two of the most effective repellents in my earlier tests. By February, deer had eaten 41% of the new growth in untreated plots, but only 21% in the Hinder plots and 13% in the BGR plots. Although BGR looked more effective than Hinder in February, by late March, there was little difference between the two repellents. In BGR plots, 23% of the new growth had been eaten as had 24% in Hinder plots and 46% in untreated plots. The deer apparently fed extensively in the BGR plots during March. This suggests that two applications of BGR may be needed for winter-long protection.

A gallon of spray diluted and ready for use cost $12.00 for BGR and $0.75 for Hinder. The cost/acre to use these materials, of course, varied with the amount of vegetation to be sprayed. Since I used about 16 gallons to treat an acre the cost/acre was about $192 for BGR and $12 for Hinder.

Although my research indicated that the best repellents reduced damage by 50%, a properly built and maintained fence should eliminate deer damage entirely. Fences, of course, are not without installation costs ($0.25 to 0.50/ft) and must be maintained to remain effective.

Since there is no inexpensive and effective method to cure a deer problem once it has begun, if farmers and homeowners know which crops and nursery plants are unpalatable to deer, as well as know which sites are likely to experience damage, it may be possible to prevent deer problems from developing in the first place.

For several years I have observed some severe deer damage in a nursery that had a large variety of plants. This has allowed me to rank 61 ornamental plant species according to their relative vulnerability to deer damage. The value of this plant list is not in knowing the amount of damage each species sustained, for that will vary from site to site, but in their relative ranking. I found, for instance, that deer feed heavily on yews, spindle trees, and American arborvitae; moderately on rhododendrons, red cedar, and azaleas; and rarely on American holly, common boxwood, flowering dogwood, and some pines. Hence, homeowners, landscapers, and nurserymen might reduce damage at problem sites by selecting plant species that deer avoid.

This brings up the next question: how to predict if deer damage is likely at a particular site? To do this, I have studied approximately 20 commercial nurseries that were raising yews and had problems with deer. I looked at several characteristics of the nursery itself, such as its size and its nearness to houses and roads; at the number and extent of nearby woodlots where deer could live; and also at some characteristics of the local deer herd. Deer damage was best correlated with the number of deer in the woodlots adjacent to the nursery and not with the quality or quantity of natural food in the woods. This means that deer in Connecticut browse in nurseries not because they are forced to by the absence of available food, but because they are seeking the higher quality food found there. Fortunately, there is an easy way to estimate the number of deer around a nursery by checking adjacent woodlots during the spring for deer fecal pellets and then using a chart to convert the number of pellets to deer population. Hence this method helps farmers and landscapers estimate whether a deer problem is likely at a particular site before it begins and then allows them to take steps to avoid it.

The continuing search for non-lethal methods of repelling deer may one day help us all enjoy deer at sunrise without having to worry about what they ate for breakfast.

# Evaluating the king of the coles: broccoli in Connecticut

**By David E. Hill**

When I was a lad, my mother's exhortation, "Eat your broccoli, it's good for you!", was truly prophetic. Now, a few decades later, nutritionists and the American Medical Association extol the virtues of broccoli and other cole crops (*Brassica spp.*) including cabbage, cauliflower and brussel sprouts as important components of human diet. Compared to most vegetables, broccoli is rich in vitamins A, B, and C, minerals and fiber. Its popularity has grown as society has become more conscious of diet.

It is small wonder that a marketing survey by the Food Industry Institute at Michigan State University reported that among all common vegetables grown in the United States, broccoli leads with a 169% increase in per capita consumption in 10 years. Production increased from 200,000 tons in 1974 to 500,000 tons in 1984 in the major producing states of California, Texas, Oregon, and Arizona.

Despite increased consumption nationwide, Connecticut's production of broccoli remained relatively constant over the past decade with about 45 acres grown for sale at local roadside markets. Virtually none had been produced for supermarkets. In 1985, however, two supermarket chains developed keen interest in locally produced broccoli for fall consumption. Their interest stemmed from their policy of purchasing locally produced vegetables, which are fresher and have not gone through the rigors of expensive cross-country shipping.

If the number of acres on which broccoli is grown is to increase in Connecticut for an expanding market, it is important to examine the wealth of varieties, called cultivars, available to growers to determine those that are best for our soil and climate. From the 60 old and new cultivars that are available from domestic seed companies, I chose 28 for my 1985 trials. To this I added four experimental cultivars that had not been tested in Southern New England. The cultivars that I chose include hybrids with large uniform heads and "green sprouting" varieties with small primary heads and abundant small heads from sprouts that grow from the main stalk.

**Management:** Duplicate trials were conducted at the Valley Laboratory, Windsor on a sandy loam terrace soil with somewhat limited moisture holding capacity and at Lockwood Farm, Mt. Carmel on a fine sandy loam upland soil with a moderate moisture holding capacity. All cultivars were grown twice in each location for spring and fall harvest. The spring crop was started in a greenhouse on March 7, transferred to a cold frame April 8, and the seedlings transplanted in the field April 19 to 24. On June 12, the fall crop was started in an outdoor lath enclosure providing 50% shading and transplanted into the field July 23 to 29. The soil was fertilized with 10-10-10 at 1300 lb/acre or 4.5 lb/50 ft of row. Lime was added to raise the pH to 6.5. The transplants were set 18 inches apart in rows 3 feet apart. Each cultivar had 30 plants randomly set in five replications of six plants each. Root maggots were controlled by Lorsban (available only for commercial use — Diazinon is available for home gardeners) in the water added at transplanting. Cabbage loopers were controlled by malathion as needed. Seedlings were irrigated one or two times, but rainfall provided sufficient moisture throughout most of the growing season. Weeds were controlled by cultivation.

**Yield and quality:** As the cultivars were harvested, the yield was weighed, and the color, evenness and compactness of head were judged. Excessive stalkiness, leaves protruding from the head, and the premature heading called "buttoning" were also noted. The overall broccoli production at Windsor and Mt. Carmel was fairly uniform for both spring and fall crops. In the spring, the average yield per cultivar at Mt. Carmel was 6603 lb/A compared to 6355 lb/acre at Windsor. In the fall the average yield per cultivar at Windsor was 5909 lb/acre compared to 5705 lb/acre at Mt. Carmel. In the spring yield was 7-14% greater at both sites compared to yields in the fall and is probably due to cooler temperatures in the spring, which favor growth. Many of the cultivars listed in Table 1 had yields above the national average of 8000 lbs/acre.

With a wide diversity of cultivars, including both hybrids and open pollinated types, harvest of the spring crop began in early June and continued through July 10. The fall crop was harvested from September 9 through October 29. The cultivars that produced the most uniform, compact heads of dark green to bluish green color at Windsor and Mt. Carmel in spring and fall are listed in Table 1. The cultivars listed in the footnote to the table were not consistent at both sites and had small heads, defects in shape and color, or were not resistant to the downy mildew and bacterial soft rot that developed during August in Windsor.

The cultivar judged to have the best quality in the spring was Mercedes. The 6 to 8 inch heads were compact and weighed over 1 lb. In the fall, the growth of Mercedes was rampant and produced large loose heads that exceeded 2 lb. For the homeowner, however, this cultivar might be less appealing because few sprouts, called side cuts, formed after the primary head was severed. In spring, Paragon was judged second best with compact, deep green heads, 6 to 7 inches in diameter, weighing 0.8 lb. Also rated highly were Dandy Early, Green Dwarf and the experimental, XPH 5004. These cultivars performed well in both spring and fall. Dandy Early had large compact heads in the spring but medium in the fall. The heads of Green Dwarf are ball-shaped and are borne on short, compact stalks. The heads of Orion and Southern Comet were smaller compared to other listed cultivars and weighed about 0.75 lb. A virtue of these two cultivars is the excellent production of side cuts, which prolongs harvest.

Among the experimental varieties tested, XPH 5004 performed well in both spring and fall. Although the heads were slightly smaller in the fall crop, they were uniform,

**Table 1. Yield and maturity of broccoli cultivars that produced high quality heads in spring and fall. Averages of Mt. Carmel and Windsor.**

| Cultivar | Avg. Head 1b | First cut 1b/A | Side cuts over 3 in. diam. 1b/A | Avg. Maturity days | Harvest Span days |
|---|---|---|---|---|---|
| | | | **Spring Crop** | | |
| Dandy Early | 1.2 | 11340 | 2612 | 55 | 16 |
| Green Dwarf | 0.9 | 8398 | 3055 | 58 | 14 |
| Mercedes | 1.1 | 10725 | 520 | 57 | 6 |
| Orion | 0.7 | 5420 | 4480 | 50 | 23 |
| Paragon | 0.8 | 7220 | 2321 | 54 | 12 |
| Southern Comet | 0.8 | 6658 | 4498 | 54 | 20 |
| XPH 5004 | 0.9 | 7879 | — | 50 | 8 |
| | | | **Fall Crop** | | |
| Dandy Early | 0.9 | 8390 | — | 53 | 18 |
| Green Dwarf | 0.8 | 7101 | — | 58 | 11 |
| Prominence | 0.9 | 8256 | — | 54 | 6 |
| XPH 5003 | 1.0 | 9143 | — | 47 | 2 |
| XPH 5004 | 0.7 | 6568 | — | 48 | 4 |

Other cultivars tested: Atlantic, Bonanza, Bravo, Calabrese, Citation, Cleopatra, DeCicco, Early One, Futura, Galaxy, Gem, Goliath, Grande, Green Comet, Green Duke, Green Goliath, Green Hornet, Green Sprouting, Premium Crop, Spartan Early, Waltham 29, XPH 853, XPH 1127.

compact, and deep green. In fall, XPH 5003, Prominence, and Dandy Early had the largest heads, approaching 1 lb. Side cuts were not harvested in the fall because they formed late.

Several unlisted cultivars are worthy of note. Although Green Duke and Premium Crop, New England favorites, had large well-formed heads, they were susceptible to downy mildew and bacterial rot. There is, of course, less chance for this disease in the spring because harvest occurs before the heat of summer. The green sprouting varieties DeCicco, Calabrese, and Waltham 29 that are mainstays for home gardeners, produced abundant small, 1 to 2 inch shoots, but they were not harvested because they did not reach the 3-inch minimum diameter.

**Maturity:** An important characteristic of any vegetable crop is the time to maturity from seed or transplanting, which is required to estimate the time of harvest. In Table 1, the days to maturity were calculated from the day of transplanting to the day when half the heads were harvested. Among our listed cultivars, maturity ranged from 47 to 58 days. The earliest harvests were from the experimental cultivars XPH 5003 and XPH 5004. Green Dwarf and Mercedes had the longest maturities. Most unlisted green sprouting cultivars such as Calabrese, DeCicco, and Waltham 29 had maturities of 60 to 62 days in the spring planting and 68 to 75 days in the fall planting. Most hybrid cultivars had fairly constant maturities in spring or fall.

Another important facet of maturity is the span of harvest or days between harvest of the first and last marketable head. Short spans are highly desirable for machine harvest whereas long spans are favorable for harvesting by hand, especially by home gardeners. The harvest spans of our listed cultivars varied from 2 to 4 days for XPH 5003 and XPH 5004 in the fall to about 3 weeks for Orion and Southern Comet in the spring. Dandy Early and Green Dwarf were harvested over a 14 to 18 day span. The primary heads of the green sprouting cultivars were harvested over a 5 to 6 week span. In general, harvest spans tended to be longer in the fall than in spring.

**Planting Strategies:** The 1985 cultivar trials demonstrate that quality broccoli can be grown in Connecticut for harvest throughout June and from early September through late October. For the commercial grower, the use of only one or two cultivars may be risky, especially if those chosen are not resistant to downy mildew and bacterial rot. In 1985, these diseases developed in the upper Connecticut Valley and lowered anticipated yields of certain cultivars. The cultivars in Table 1 for which yields are listed were not affected by disease.

The spring harvest was shorter than the fall harvest because of hot weather in July. The reported production was accomplished with seedlings transplanted in a single planting about April 20 for the spring crop and around July 25 for the fall crop. Planting dates may need adjustment in Connecticut to allow for the normally colder air and soil at higher elevations in Litchfield, Tolland and Windham Counties.

If a long span of harvest is desirable, it may be accomplished in two ways: plant cultivars that mature over a broad span of time, or plant cultivars with short harvest spans in several plantings at weekly intervals.

The first plan might be accomplished with as few as two plantings, perhaps 3 weeks apart. For example, the spring planting of Dandy Early, Orion, and Southern Comet provided a 3 week harvest span from June 7 to June 23. But after June 21 the harvest diminished. A second planting late in April would have filled in the last 10 days in June, but, the harvest would diminish in early July with the onset of hot weather. The fall planting of Dandy Early, Green Dwarf and Paragon provided nearly a 3-week harvest span from September 10 to 29. A second planting 3 weeks after the first would be harvested in October.

Alternatively, cultivars with short harvest spans might be planted at intervals. For example, Mercedes with a harvest span of 7 days, was ready for harvest June 12. Three plantings, one week apart, starting April 20 would be required for a June harvest. For Green Dwarf with an 11-day harvest span, two plantings should suffice. For fall plantings Prominence, XPH 5003, and 5004 with short harvest spans were harvested September 9 to 14. Six plantings should be required, starting about July 20 to fill a harvest from early September through October. Dandy Early harvested September 11 to 29 should need a second planting 2 to 3 weeks after the first.

The first plan seems to offer a long harvest span with fewer plantings and provides diversity against the possible ravages of disease. The home gardener, however, may not need several plantings except to provide a spring and a fall crop. Harvest of side cuts during the summer should provide some broccoli for the table until the fall harvest commences in September. Full season production of broccoli is most welcome to the grower, but perhaps not for his children if they, like me as a child, had not yet learned the healthful benefits of broccoli.

# What is happening to EDB in ground water in Connecticut?

**By Joseph J. Pignatello**

Connecticut is one of several states where ground water has been found contaminated with EDB (see box). As of December 31, 1985, the Department of Health Services (DOHS), the Connecticut Department of Environmental Protection (DEP) and The Connecticut Agricultural Experiment Station found that 252 of 1550 private wells and 52 of 263 public wells tested contained at least 0.1 parts per billion (ppb) EDB, the tolerance level set by DOHS. As an emergency remedy, the state has ordered bottled drinking water supplied to the affected residents. Over one hundred other wells contain EDB between the tolerance level and the detection limit of 0.02 ppb. The affected area is clustered on both sides of the upper Connecticut River Valley where tobacco has been grown. DEP has also found a few more sites where EDB has originated from leaking gasoline storage tanks, since EDB is an additive in leaded gasoline.

A crucial problem is to estimate the retention time of EDB in ground water. Factors that can influence the retention of EDB include flushing and dilution by natural flow, natural chemical degradation, and degradation by subsurface soil microbes. My research touches all four topics, especially microbial degradation, which may ultimately determine the persistence of EDB in ground water in Connecticut.

Ethylene dibromide (EDB, or 1,2-dibromoethane) was used as a soil fumigant against nematodes and other soil-borne pests from the 1940s until 1983 when its registration was cancelled by the US Environmental Protection Agency (EPA). In Connecticut it was used mostly on tobacco, but in other states it was used on several vegetables, pineapple, citrus, soybeans, and cotton. EPA cancelled the registration because studies showed EDB causes cancer in laboratory rats and mice and reproductive problems in rats and because EDB used as a soil fumigant had leached to the ground water and was contaminating drinking water.

Figure 1 depicts an aquifer contaminated with EDB. An aquifer is the portion of the soil and bedrock where water occupies all the empty spaces within and around soil particles and in the cracks and fissures of rocks. The aquifer is recharged by precipitation. The flow lines in Fig. 1 show water moving vertically by gravity through the unsaturated soil zone (vadose zone) until it reaches the top of the aquifer (water table). Below the water table, water moves both horizontally and vertically until it discharges to the surface in nearby springs, lakes or streams. EDB is leached from the topsoil by rain forming a solution in water, which moves through the aquifer in a plume that eventually reaches surface water.

A committee of the Connecticut Academy of Science and Engineering chaired by Dr. Charles R. Frink of the Experiment Station, estimated that 1 to 1000 years may be required, depending on subsurface characteristics, before EDB-contaminated water reaches a zone of discharge to surface waters. These estimates ignored, for lack of reliable data, hydrodynamic dispersion and sorption on soil particles, which are probably important in Connecticut aquifers.

Hydrodynamic dispersion is the tendency for EDB-laden water to mix with surrounding cleaner water and is represented in Fig. 1 by the arrows beneath the plume. It is difficult to measure. Since dispersion expands the plume, it prolongs retention. Sorption, symbolized by the heavy circle surrounding the EDB molecule in Fig. 1, is the process whereby some EDB molecules are bound to soil particles instead of being dissolved in the water. Although largely reversible, sorption causes EDB to move more slowly than the water and, therefore, prolongs retention.

The major losses of EDB by degradation are also shown in Fig. 1. Chemical degradation includes reaction with water (hydrolysis) and other reactions catalyzed by soil particles. At normal ground water temperature of 10°C,

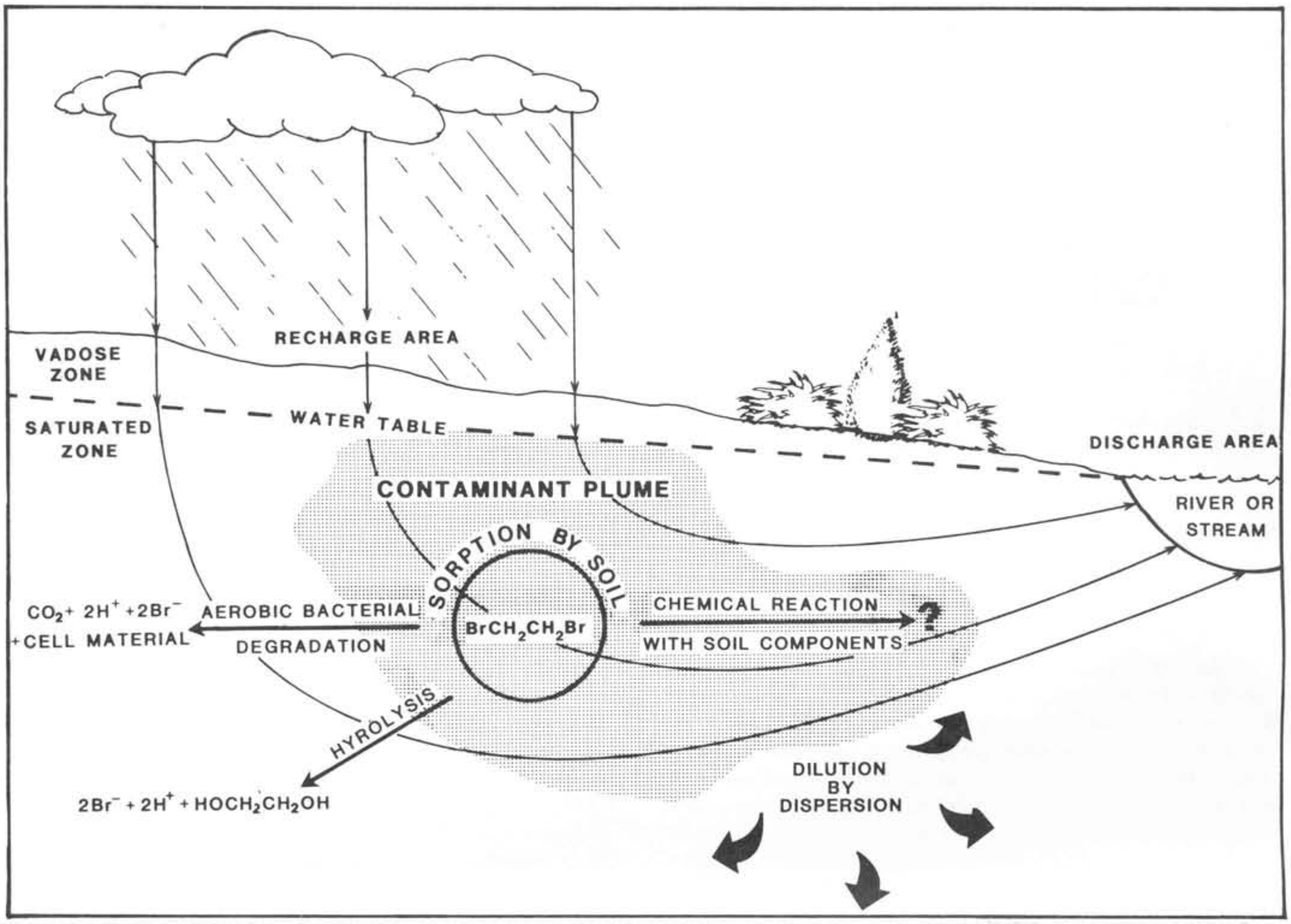


**Fig. 1 Diagram of an aquifer contaminated by EDB showing recharge by precipitation and eventual discharge into a body of water, and showing mechanisms that determine the fate and movement of EDB.**

hydrolysis occurs with a half life (time for 50% loss of EDB) of 4.4 years in one published study and 21 years in another study. My observations confirm the 21 years. Hydrolysis produces inorganic bromide ion and ethylene glycol, which are considered non-toxic to humans at ppb levels.

My chief objective is to determine the importance of microbial degradation of EDB in Connecticut aquifers. Surprisingly high numbers of bacteria are found attached to soil particles in aquifer soils, even at great depths. The important question is whether EDB can be attacked by the types of bacteria living in shallow, aerated aquifers that most commonly provide drinking water. Studies of shallow aquifers reveal that the dominant microbial forms are aerobic heterotrophic bacteria. These bacteria use organic compounds as a source of carbon for growth and energy (hence the term heterotrophic) only in the presence of oxygen (hence the term aerobic). Some of the carbon used by the bacteria is incorporated into their cells, and some is given off as carbon dioxide gas. These bacteria are adapted to grow on the small amounts of organic matter that trickle down from the surface in solution. Thus, they may be effective at using the low concentrations of EDB that are typically found in contaminated ground water.

The biodegradability of particular synthetic compounds is not easily predictable. Some compounds don't break down, some are used for growth and energy and some are merely transformed to other chemicals. EDB belongs to a class of synthetic compounds known as halogenated aliphatic hydrocarbons, many of which resist degradation by aerobic bacteria.

To assess microbial degradation of EDB, I am studying one location near Windsor Locks and another near West Simsbury. At the site near Windsor Locks several wells and a stream fed by natural ground water discharge are contaminated with 0.1 to 11 ppb EDB. The West Simsbury site is described later.

I collected samples of two surface soils from the Windsor Locks site that represent extremes of organic content and microbial activity and incubated them in the laboratory at 23°C at EDB concentrations from 6 to 18,000 ppb.

**Table 1. Products of microbial degradation of EDB in aerobic soils.**

| Microbial Degradation Products | % Yield |
|---|---|
| Bromide (based on 2 $Br^-$) | 90 ± 15 |
| $CO_2$ | 51 ± 4 |
| Cellular carbon | 36 ± 4 |
| Volatile organic compounds | 2 ± 3 |
| Non-volatile, water soluble compounds | 5 ± 2 |
| Products attributable to chemical degradation (as indicated by sterile controls) | 6 ± 2 |

At the lower concentrations, EDB decreased to near or below the detection limit of 0.02 ppb within hours to days, unless the soil was sterilized by heat or chemicals. EDB degraded either in the presence or absence of air.

The products of microbial degradation are listed in Table 1. Nearly all the bromine atoms in the EDB molecules were converted to inorganic bromide. I determined the fate of EDB carbon atoms with EDB made with carbon-14 ($^{14}C$), a radioactive isotope. EDB was metabolized almost completely by aerobic bacteria to radioactive carbon dioxide ($^{14}CO_2$) and bacterial cell materials containing $^{14}C$. These were not produced in sterile controls. Thus, at the ppb concentrations found in contaminated ground water, soil microbes can use EDB as a source of "food" for energy and cellular carbon.

If EDB were degraded as rapidly in the field as these experiments indicate, it should have disappeared in the topsoil shortly after application. At 15,000 to 18,000 ppb in the Windsor Locks soils, however, EDB was degraded much slower, with half-lives on the order of several weeks to several months. One explanation for the slower rates is that I have found high concentrations may be toxic to the bacteria that degrade EDB. These levels are at the lower end of the manufacturer's recommended application rate, which would range from 12,000 to 108,000 ppb if it were equally distributed in the top 6 inches of soil. This suggests that after application of EDB, degradation was slow enough to allow substantial amounts to leach to the ground water where microbial numbers and activity are lower and, hence, degradation is slower.

After determining that aerobic bacteria can degrade EDB in soil, I set out to determine whether aerobic microbes can do the same in ground water. Soil collected at Windsor Locks just below the water table was treated with EDB at 5 or 0.5 ppb. After 9 months at 10°C, these samples showed 94 and 96% reduction in EDB concentration, respectively (Table 2).

In 1985 scientists from DEP and I began studying the movement and fate of EDB in groundwater near Simsbury. Tobacco was grown on this site until the late 1960s and then houses were built. EDB was last applied in 1967. Despite the passage of two decades, domestic wells are contaminated with up to 1 ppb EDB. We are monitoring

**Table 2. Loss of EDB in soil taken from below the water table at Windsor Locks and incubated at 10°C.**

| | % Remaining | | |
|---|---|---|---|
| Time (days) | Initially 5 ppb | Initially 0.5 ppb | Sterile Controls (5 ppb Initial) |
| 0 | 100 | 100 | 100 |
| 14 | 76 | 99 | 97 |
| 49 | — | 73 | 85 |
| 104 | 29 | 58 | 88 |
| 133 | 35 | 43 | 86 |
| 201 | 20 | 36 | 83 |
| 280 | 6 | 4 | 78 |

EDB levels in domestic wells, which are 100 to 300 ft into the bedrock of the aquifer. In addition, we installed eleven monitoring wells that extend to the top of bedrock to analyze soil and water from the unconsolidated or soil zone of the aquifer. Results of this study will help decide how quickly EDB is degrading and will serve as a model for movement of other chemicals.

To complement the field study, I also collected samples of deep soil at some monitoring wells for laboratory incubation with $^{14}C$-EDB. I used a special sterilized sampler to prevent contamination from surface soil or airborne microbes. The samples are being incubated at 10°C under a variety of conditions: aerobic (high and low oxygen concentrations), anaerobic, and with and without periodic supplements of surface soil extracts, which may be needed to maintain the bacteria. Soil samples were treated with $^{14}C$-EDB at about 1 ppb and replicates are being analyzed periodically for production of $^{14}CO_2$. I am also studying bacterial numbers, types, and appearance by light and electron microscopy and by plating techniques.

To date $^{14}CO_2$ has been produced in all aerobic samples except those that were sterilized. This is proof of biological degradation because there is no plausible chemical route for production of $CO_2$ from EDB. This strongly suggests that biological degradation of EDB may play an important role in determining its persistence in ground water.

# Testing tomato products: paste, sauce, puree and catsup

**By Lester Hankin**

Most Americans eat processed tomatoes almost daily: catsup on hamburgers; taco sauce on burritos; relishes of various sorts; spaghetti sauce; and topping on pizza. They also drink tomato juice. We tested 59 processed tomato products for compliance with State and Federal Standards. The products were 16 pastes, 19 sauces, 9 purees, and 15 catsups (ketchups).

Although no standards are set for sauces, the Code of Federal Regulations sets standards for the tomato concentrates: pastes, purees, and catsup. The concentrates may be prepared directly from fresh tomatoes. They may also be prepared from tomato by-products like cores and peel remaining after canning tomatoes or pulp remaining after the juice has been extracted. Optional ingredients may include salt, lemon juice, organic acids, sodium bicarbonate, water, spices, and flavorings.

Tomato paste must contain at least 24% tomato solids. Tomato puree must contain at least 8% but less than 24%

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tomato solids. No standards are set for solids in catsup.

The samples were collected at food stores by inspectors of the Connecticut Department of Consumer Protection and tested in the laboratories of The Connecticut Agricultural Experiment Station. The samples were examined for compliance with regulations and for nutrients. Moisture, solids, salt, total carbohydrates, and calories were determined and are shown in Table 1.

*Pastes*: All tomato pastes contained more than the 24% tomato solids required. The range was from 24 to 28.6%; the average 25.3%. Salt averaged 0.43%. Samples claiming "no salt added" averaged 0.36% salt. Calories per 100 grams averaged 87. The carbohydrate and caloric content of the pastes are what would be expected from the concentration of tomatoes.

*Sauces:* The sauces contained about 9% tomato solids as compared with 25% in pastes. The solids content of sauces ranged from 8.1 to 10.7%. Sauces usually contained more optional ingredients to enhance flavor. Salt averaged 1.2%, which is about three times more than in pastes.

*Puree:* Tomato purees contained about 3% more solids than the sauces. Purees averaged 12.4% tomato solids; all were within the 8% minimum and 24% maximum allowed. The range was from 9.6 to 14.6%. The salt content of 0.21% was about half that in pastes.

*Catsup:* Catsups were the thickest products tested, averaging about 33% total solids. They averaged 2.8% salt, which is more than any other product examined. Calories averaged 126 per 100 grams, higher than all other products. The caloric and carbohydrate content of catsup is higher per unit of solids than the other products because sweeteners have been added.

All 59 tomato concentrates tested met specifications in the Code of Federal Regulations.

Values for individual samples by brand name and more detailed analyses are published in Bulletin 828, "Quality of Tomato Paste, Sauce, Puree, and Catsup," which is available free on request from Publications; The Connecticut Agricultural Experiment Station; P.O. Box 1106; New Haven, CT 06504.

**Table 1. Averages and ranges of constituents of tomato products.**

| Product | No. Tested | Solids, %[a] | Salt, %[b] | Total Carbohydrates, % | Calories per 100g |
|---|---|---|---|---|---|
| Paste | 16 | 25.3 (24.0-28.6) | 0.43 (0.31-0.60) | 17.7 (15.5-20.2) | 87 (79-101) |
| Sauce | 19 | 9.2 (8.1-10.7) | 1.20 (0.2-1.5) | 6.0 (4.7-7.6) | 31 (27-38) |
| Puree | 9 | 12.4 (9.6-14.6) | 0.21 (0.15-0.26) | 8.1 (6.3-10.0) | 42 (32-51) |
| Catsup | 15 | 32.7 (27.1-37.2) | 2.80 (0.2-3.5) | 27.2 (21.6-31.3) | 126 (106-200) |

(a) For paste, sauce, and puree, solids designates percent natural tomato soluble solids. For catsup, solids designates total solids.
(b) Values for salt include those claiming no salt added.

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