Dynamics of Aldicarb Soil Residues Associated with *Pratylenchus penetrans* Control in Dry Bean Production

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ABSTRACT

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Aldicarb at 0.86, 1.72, 2.31, 2.88, and 4.62 kg a.i./ha was used to control *Pratylenchus penetrans* on navy bean (*Phaseolus vulgaris*) in Michigan. All treatments significantly reduced population densities of *P. penetrans*. Soil residues of aldicarb were directly related to the rate of application, and the residues decreased throughout the growing season. Eighty days after application, aldicarb soil residues were detectable only at application rates of 2.88 and 4.62 kg a.i./ha.

Additional key words: root-lesion nematode

The root-lesion nematode (*Pratylenchus penetrans* (Cobb) Filipjev & Schurmanns-Stekhoven) can reduce dry bean (*Phaseolus vulgaris* L.) yields in Michigan (3). Crop rotations, nematode-tolerant cultivars, and nematicides control this nematode (4). Aldicarb (Temik 15G) is currently the only nonfumigant nematicide registered for *P. penetrans* control.

Aldicarb has a broad spectrum of biological activity as an insecticide, acaricide, and nematicide (2,4,8,9). Aldicarb contains a thioether functional group. In soil, the thioether moiety is readily oxidized to sulfoxide. The sulfoxide is then slowly oxidized to sulfone. The oxidized forms are toxicologically similar. Degradation beyond these forms is dependent on soil composition and moisture (10) but generally involves normal carbamate hydrolysis (5). This pesticide has caused environmental concern as a groundwater contaminant and it is subject to restricted use. The objective of this study was to determine the level of aldicarb soil residues associated with *P. penetrans* in a dry bean production system in Michigan.

MATERIALS AND METHODS

A field experiment involving five levels of aldicarb (0.00, 0.86, 1.72, 2.31, 2.88, and 4.62 kg a.i./ha) was conducted on a McBride sandy loam at the Michigan State University Montcalm Experiment Farm in Entrican. Each treatment was replicated five times in a completely randomized block design. Each experimental unit consisted of four rows 6.1 m long and 0.9 m apart of the nematode-susceptible navy bean, *P. vulgaris* 'Sanilac.' Aldicarb was applied in a 0.2-m band and lightly incorporated into the soil with the planter press wheel at planting on 11 June 1980 (Julian date 163).

Soil and root samples to a soil depth of 30 cm were collected for nematode analysis immediately before planting and three times (Julian dates 190, 239, and 282) during the growing season (Fig. 1). Centrifuge flotation and shaker techniques were used for nematode extraction (1,6). The two center rows of each plot were harvested at maturity on 8 October 1980 (Julian date 282) and dry bean yields recorded. SURFACE II, a three-dimensional software package, was used to illustrate the population dynamics of *P. penetrans* in relation to aldicarb dosage (12).

Soil samples were collected to a depth of 30 cm six times during the growing season (Julian dates 163, 173, 193, 201, 218, 238, and 243) and analyzed for aldicarb residues by gas chromatography (GC) procedures. Peracetic acid was used to oxidize aldicarb and aldicarb sulfoxide to the common moiety, aldicarb sulfone (11). Quantification was based on aldicarb sulfone standards provided by the Environmental Protection Agency. Conversion to equivalent aldicarb was accomplished by using the formula: aldicarb (ppm) = (aldicarb sulfone, ppm) (aldicarb (mol wt)/aldicarb sulfone (mol wt)). Soil samples (10 g) were shaken for 15 min on a wrist-action shaker with 50 ml of glass-distilled acetonitrile and 0.5 ml of peracetic acid. After vacuum-filtration, the acetonitrile was removed by rotoevaporation, leaving several milliliters of water. Fifty milliliters of distilled water was added and the pH adjusted to 1.5 using 5 M HCl. The solution was shaken for 5 min each of three times with 50 ml of glass-distilled chloroform, placed in a separatory funnel, and the chloroform drained through anhydrous sodium sulfate into a 250-ml round-bottom flask. The chloroform was removed by rotoevaporation and the sample taken up in acetone for GC analysis.

Analysis was made using a Tracor 560 GC equipped with a flame photometric detector (sulfur mode) and a glass column (180 cm × 1 mm i.d.) containing 15% OV-1 on 80/100-mesh Gas Chrom Q support. With a column temperature of 180 C, detector and injector at 200 C, and an 80-cm^3/min flow rate of nitrogen carrier gas, the elution time for aldicarb sulfone was 2 min. Peak areas and retention times were determined by a PDP 8/e computer using a PAMILA software package (7). Aldicarb values were corrected for soil moisture content. Residue data were illustrated with SURFACE II (12).

RESULTS AND DISCUSSION

Soil and root population densities of *P. penetrans* were significantly reduced on Julian date 239 ($P = 0.05$) by all levels of aldicarb except 0.86 kg a.i./ha and by all rates on Julian date 282 (Fig. 1). The initial population density ($P_i = 25$ *P. penetrans*/100 cm^3 soil) was below the damage threshold (4), and the aldicarb treatments had no significant ($P = 0.05$) influence on dry bean yield.

Aldicarb residues in the soil were not detected until after the 11 June 1980 sampling date (Fig. 2). Soil concentrations were highest on 30 June 1980, then decreased throughout the growing season. In general, soil residues of aldicarb increased with increasing initial rates of aldicarb applied at planting. Eighty days after application of aldicarb, residues were detected only in soil treated with the two highest rates, 2.88 and 4.62 kg a.i./ha.

At aldicarb rates registered for nematode control in dry bean production, 1.68 and 2.42 kg a.i./ha, soil residues of aldicarb sulfone were relatively low. The effect of initial aldicarb concentrations

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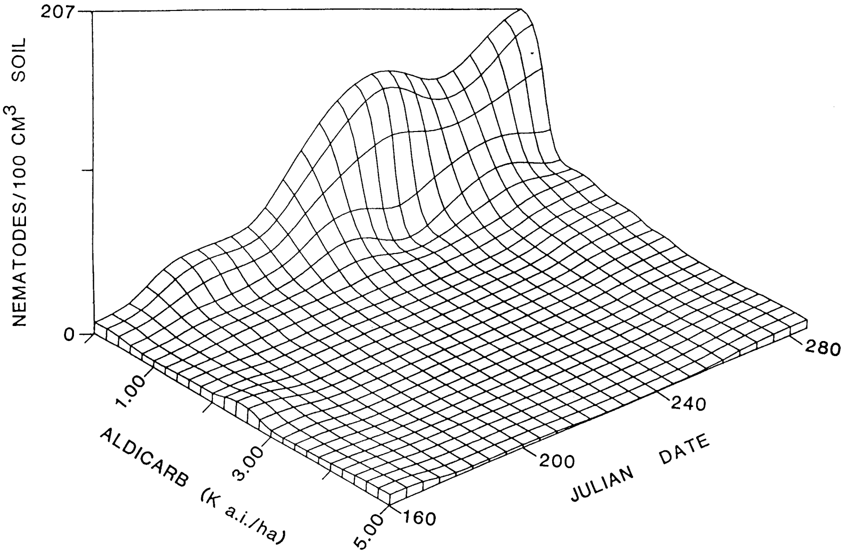

Fig. 1. Influence of five rates of aldicarb 15G (0.00, 0.86, 1.72, 2.31, 2.88, and 4.62 kg a.i./ha) on *Pratylenchus penetrans* population dynamics.

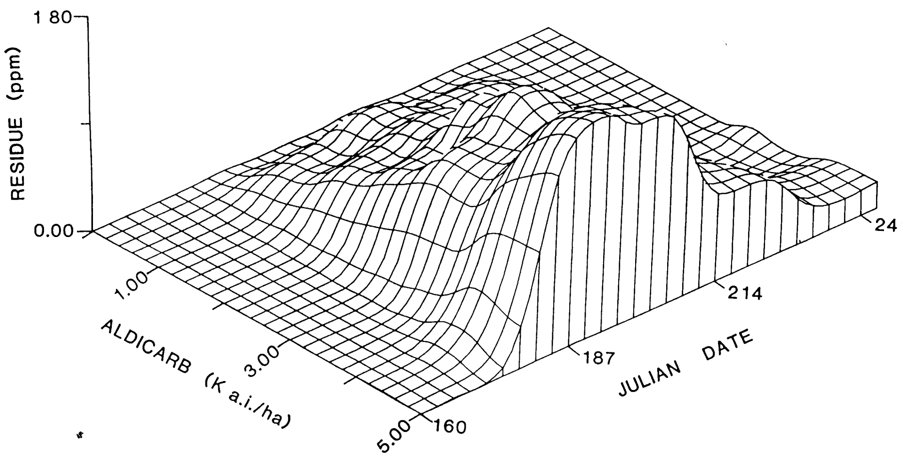

Fig. 2. Dynamics of aldicarb residues associated with different initial concentrations of aldicarb 15G.

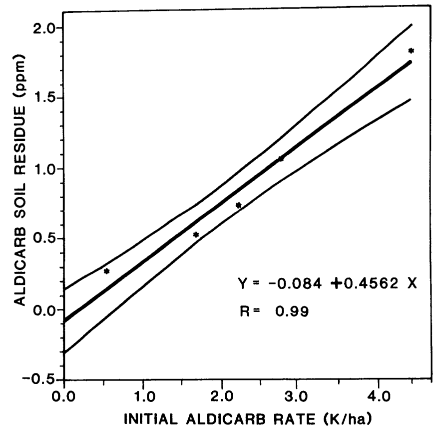

Fig. 3. Relation between initial aldicarb 15G concentrations and soil residues 30 days after treatment application.

on final aldicarb residues were expressed according to the following linear regression equation (Fig. 3):

$$Y = -0.084 + 0.4562X$$
$$R = 0.99.$$

Results indicated that degradation of aldicarb increased with time, and residues in the 30 cm of soil were at low or nondetectable levels by the end of the season for initial application rates of 0.86–4.62 kg a.i./ha. In the Michigan dry bean production system on sandy loam, use of aldicarb did not result in accumulation of significant aldicarb residues in the soil profile sampled. Aldicarb residue monitoring was not evaluated after multiple applications or in relation to movement of the chemical in soil. With repeated use of this nematicide, it may be necessary to maintain a long-term soil residue monitoring program. Information relating to downward movement in soil is also essential for protection of ground water.

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