SUBSTITUTE CHEMICAL PROGRAM

INITIAL SCIENTIFIC AND MINIECONOMIC REVIEW OF ALDICARB

MAY 1975

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF PESTICIDE PROGRAMS
CRITERIA AND EVALUATION DIVISION
WASHINGTON, D.C. 20460

EPA-540/1-75-013

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This report has been compiled by the Criteria and Evaluation Division, Office of Pesticide Programs, EPA, in conjunction with other sources listed in the Preface. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

The Alternative (Substitute) Chemicals Program was initiated under Public Law 93-135 of October 24, 1973, to "provide research and testing of substitute chemicals." The legislative intent is to prevent using substitutes, which in essence are more deleterious to man and his environment, than a problem pesticide (one that has been suspended, cancelled, deregistered or in an "internal review" for suspected "unreasonable adverse effects to man or his environment"). The major objective of the program is to determine the suitability of substitute chemicals which now or in the future may act as replacements for those uses (major and minor) of pesticides that have been cancelled, suspended, or are in litigation or under internal review for potential unreasonable adverse effects on man and his environment.

The substitute chemical is reviewed for suitability considering all applicable scientific factors such as: chemistry, toxicology, pharmacology and environmental fate and movement; and socio-economic factors such as: use patterns and costs and benefits. EPA recognizes the fact that even though a compound is registered it still may not be a practical substitute for a particular use or uses of a problem pesticide. The utilitarian value of the "substitute" must be evaluated by reviewing its biological and economic data. The reviews of substitute chemicals are carried out in two phases. Phase I conducts these reviews based on data bases readily accessible at the present time. An Initial Scientific Review and Mini-economic Review are conducted simultaneously to determine if there is enough data to make a judgment with respect to the "safety and efficacy" of the substitute chemical. Phase II is only performed if the Phase I reviews identify certain questions of safety or lack of benefits. The Phase II reviews conduct in-depth studies of these questions of safety and cost/benefits and consider both present and projected future uses of the substitute chemicals.

The report summarizes rather than interprets scientific data reviewed during the course of the studies. Data is not correlated from different sources. Opinions are not given on contradictory findings.

This report contains the Phase I Initial Scientific and Minieconomic Review of Aldicarb [2-methyl-2-(methylthio) propionaldehyde O-(methylcarbamoyl)oxime]. Aldicarb was identified as a registered substitute chemical for certain cancelled and suspended uses of DDT. Where applicable, the review also identifies areas where technical data may be lacking so that appropriate studies may be initiated to develop desirable information.

The review covers all uses of aldicarb and is intended to be adaptable to future needs. Should aldicarb be identified as a substitute for a problem pesticide other than DDT, the review can be updated and made readily available for use. The data contained in this report was not intended to be complete in all areas. Data-searches ended in December, 1974. The review was coordinated by a team of EPA scientists in the Criteria and Evaluation Division of the Office of Pesticide Programs. The responsibility of the team leader was to provide guidance and direction and technically review information retrieved during the course of the study. The following EPA scientists were members of the review team: William Burnam (Pharmacology and Toxicology), team leader; George Bagley (Chemistry); Richard Claggett (Fate and Significance in the Environment); Richard Stevens (Fate and Significance in the Environment); Dr. E. David Thomas (Registered Uses); and Jeff Conopask (Economics).

Data research, abstracting and collection were primarily performed by Midwest Research Institute, Kansas City, Missouri (EPA Contract #68-01-2448). RvR Consultants, Shawnee Mission, Kansas, under a subcontract to Midwest Research, assisted in data collection. Union Carbide Corporation, a manufacturer of aldicarb, made certain comments and additions to this report. Recommendations of the EPA, Office of Research and Development, Gulf Breeze Environmental Research Laboratory, Gulf Breeze, Florida, have also been incorporated.

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PART I. SUMMARY

CONTENTS

This section contains a summary of the "Initial Scientific and Minieconomic Review" conducted on aldicarb. The section summarizes rather than interprets scientific data reviewed.

Production and Use

Aldicarb [2-methyl-2-(methylthio) propionaldehyde O-(methylcarbamoyl)oxime] is a pesticide with a broad spectrum of effectiveness against many species of insects, mites, and nematodes.

Technical aldicarb is manufactured under the trade name Temik®, a registered trademark of Union Carbide Corporation. The pesticide is currently registered for use on sugarcane and sweet potatoes (in Louisiana only), and on cotton, sugar beets, potatoes, peanuts, and commercially grown ornamentals; it is not registered for home use. Aldicarb is manufactured by the following synthesis process:

$$2(CH_3)_2C{=}CH_2 + 2NaNO_2 + 4HCl \longrightarrow 2NaCl + 2H_2O + [ClC(CH_3)_2CH_2NO]_2$$

2-Chloro-2-methyl-1-nitrosopropane dimer (I)

$$(I) \xrightarrow{2CH_3SNa} 2NaCl + CH_3SC(CH_3)_2CH{=}NOH$$

2-Methyl-2(methylthio)propionaldehyde oxime (II)

$$(II) \xrightarrow{CH_3NCO} CH_3SC(CH_3)_2CH{=}NOC(O)NHCH_3$$

Aldicarb

Hydrolysis of aldicarb to the oxime is reported to be complete after 1 min at 100°C in dilute alkali. Rapid, quantitative oxidation to aldicarb sulfone by peracetic acid is used in analytical gas-liquid chromatographic determinations.

An estimated 1.0 to 1.5 million pounds of aldicarb (as active ingredient) were produced in the United States in 1972; about 600,000 lb were used domestically. According to our estimates, about three-quarters of the total 1972 domestic usage was on cotton, about 100,000 lb on sugar beets, and about 60,000 lb on all other crops. On a regional basis, it is estimated that about 85% of the total 1972 domestic usage was in the Southern states, with the North Central and Northwest states accounting for essentially all of the remainder.

Toxicity and Physiological Effects

Technical aldicarb is extremely toxic to mammals.

Acute Oral Toxicity - The LD_{50} value for technical aldicarb was found to be 0.9 mg/kg and 1.0 mg/kg for male and female rats, respectively. The major metabolic products, aldicarb sulfoxide and aldicarb sulfone, have respective LD_{50} values of 0.88 mg/kg and 25 mg/kg. The LD50 for the 10% granular to rats is 7.07 mg/kg.

Dermal Toxicity - Rats were exposed for 4 hr to Temik 10G applied to the skin. Exposures of dry Temik 10G to dry skin produced an LD_{50} of 3,200 mg/kg; when wetted with saline, the LD_{50} was 400 mg/kg. In another 4 hr exposure with dry granules, the dermal LD_{50} was 4,580 mg/kg for the 10G and 6,320 mg/kg for the 15G. The LD_{50} of 10G to rabbits was 141 mg/kg in a 24 hr exposure.

Acute Inhalation Toxicity - Exposure of rats (as well as mice and guinea pigs) to 200 mg/M^3 of aldicarb dust for 5 min produced high toxicity. Rats survived an exposure to 6.7 mg/M^3 for 15 min, whereas five out of six animals died at this exposure for 30 min. Room air saturated with aldicarb vapor does not appear to be toxic to rats over an 8-hr exposure.

Subacute Toxicity (93-day study) - Eight out of 10 rats died when exposed to 0.5 mg/kg/day; no significant histopathological changes were observed. At 0.1 and 0.02 mg/kg day, experimental animals and controls had similar results in all parameters measured.

Chronic Oral Toxicity (2-years study) - There appeared to be no significant differences between the control rats and the test rats maintained on diets containing 0.005, 0.025, and 0.1 mg/kg aldicarb over a 2-year period. A 2-year study on rats gave the following no-adverse effect levels for aldicarb and certain metabolites:

1:1 mixture of aldicarb sulfone and sulfoxide	0.6 mg/kg/day
Aldicarb sulfone	2.4 mg/kg/day
Aldicarb sulfoxide	0.3 mg/kg/day
Aldicarb	0.3 mg/kg/day

Dogs maintained on a diet of 0.10 mg/kg/day of aldicarb for 2-years showed no statistically significant deleterious effects. The no-effect level for dogs in 90-day studies was also shown to be 0.1 mg/kg/day.

Aldicarb was non-carcinogenic in a lifetime skin painting study in mice.

Environmental Exposure - Rats were maintained on a soil treated 2-1/2 in deep with 500 lb of Temik® 10G per acre without any visible signs of toxicity.

Demyelination - A test of chickens on single and multiple doses of aldicarb did not produce symptoms of demyelination.

Teratology - No teratogenic effects were observed in young pregnant rats given 1 mg/kg of aldicarb in the diet.

Reproduction - Two separate three-generation reproductive studies in rats indicated no-adverse-effect levels of 0.1 and 0.7 mg/kg/day.

Mutagenic Effects - No mutagenic effects were noted in either of the three generation reproductive studies or in a dominant lethal study in rats.

Metabolism - Aldicarb is readily absorbed from the mammalian gastrointestinal tract. Distribution is passive with no tissue specificity. Metabolites of aldicarb are excreted in the urine and exhaled air. Of these metabolites, aldicarb sulfoxide is the most potent cholinesterase inhibitor. The sulfoxide and sulfone of aldicarb oxime are the major metabolites of aldicarb. Oxidative metabolism of aldicarb is by the mixed-function oxidases. Hydrolytic enzymes metabolize the carbamate moiety. There is apparently little or no accumulation of aldicarb or its metabolites in tissues.

Human Exposure - Data on humans indicated that up to a single oral dose of 0.1 mg/kg, aldicarb's effects were mild and transient. Information concerning manufacturing operations and accidents indicated that aldicarb, in coated granular form, has caused minimal adverse incidents.

Food Tolerances and Acceptable Intake

Aldicarb has not been reported by the Food and Drug Administration (FDA) as a significant residue in any class of food; nor is it routinely searched for in the FDA multiresidue analytical system which monitors pesticide residues in food. Adequate individual compound methods exist for measuring aldicarb residues. The apparent reason for the absence of aldicarb residue data is that the pesticide is not widely used on major food and feed items. The absence of aldicarb residue data does not necessarily mean it is not present in food.

Tolerances have been established for aldicarb residues on 15 food and feed commodities. These tolerances range from 0.01 ppm in meats and meat by-products to 1.0 ppm in potatoes and sugar beet tops.

An acceptable daily intake (ADI) has not been established for aldicarb.

Environmental Effects

Aldicarb is reported to be toxic to fish. Product labels carry a warning to this effect, and state that aldicarb should be kept out of any body of water. LD_{50} values (48 hr) for bluegill (*Lepomis macrochirus*), rainbow trout (*Salmo gairdneri*), and channel catfish (*Ictalurus punctatus*) have been reported as 150 µg/liter, 800 µg/liter, and 1,600 µg/liter, respectively.

Laboratory studies on the toxicity of aldicarb to wildlife have been limited to the mallard duck (*Anas Platyrhynchos*) and bobwhite quail (*Colinus Virginianus*). LD_{50} values (for approximately 8-day-old birds) are 3.6 and 240 mg/kg, respectively.

A number of field tests have been conducted to assess the hazard of aldicarb to wildlife. In one test, no evidence of mortality in animal and bird populations was observed in treated fields (1.5 lb aldicarb/acre) or in adjacent areas. Residues (0.07 ppm aldicarb and/or metabolites) were detected in only one of 14 birds sampled. Tests involving simulated spills of aldicarb indicate that neither wild deer, ring-necked pheasants, pigeons nor rabbits would be attracted to, or would feed on piles of aldicarb granules (the only formulation commercially available).

Aldicarb has been classified as highly toxic to bees. Populations of bumblebees, leafcutter bees, and alkali bees do not appear to be adversely affected by the use of aldicarb in accordance with label recommendations.

Available data indicates that, at rates of application recommended for control of target pests, aldicarb is toxic to a number of important predators and parasites, especially those preying on bollworms (*Heliothis* sp.). Those belonging to the order Hymenoptera are significantly affected. Spiders (order Araneida) and certain groups of hymenopterous insects (families Braconidae and Ichneumonidae) are apparently less affected.

The data on the effects of aldicarb on beneficial predators and parasites pertains primarily to cotton. Reports were not found on effects of aldicarb on predators and parasites in other crops for which the product is registered.

Laboratory tests show that the concentrations of aldicarb in soil that might result from normal use, for example those in accordance with label recommendations, are not toxic to a number of bacteria and fungi. However, the data is insufficient to determine whether or not the use of aldicarb, a pesticide recommended only for soil application, presents specific hazards to the soil microflora or microfauna under actual field conditions.

The dissipation of aldicarb and its metabolites has been studied in a number of water types. The half-life of aldicarb in pond water, lake water, and in a farm pond was found to be 5 days, 6 days, and 7 to 10 days, respectively.

Only limited data was found on the presence, fate, and persistence of aldicarb in the air. Monitoring of the air in uncovered, treated fields has failed to detect carbamate residues.

The persistence of aldicarb has been evaluated in a number of different soil types and under a range of pH values and moisture levels. The soil tests which were reviewed indicated a half-life range of 1 to 15 days. One investigator has stated that the half-life of aldicarb in soils varies from 1 to 4 weeks. More rapid degradation apparently occurs in mineral soils, while aldicarb residues are more persistent in soils of higher organic content. Replicated soil residue decline tests conducted on 12 different soil types indicate, according to the investigator, that aldicarb and its metabolites are not persistent.

Aldicarb is reported to be readily eluted with water from soil columns. Aldicarb had the highest leaching rate of several soil insecticides recently tested in three Egyptian soils; 47, 42, and 56% was leached from sand, loam, and sandy clay loam soils, respectively.

There is evidence of lateral movement of aldicarb, and aldicarb residues have been detected in nontarget vegetation. In one test, aldicarb and/or its metabolites were detected in 80% of the grass and weeds collected from the treated areas (dry land and irrigated cotton fields treated at the rate of 1.5 lb aldicarb/acre) and in 83% of the samples from untreated sections. Residues as high as 42.80 ppm were found in composite samples from treated areas of a dry land field 7 days after treatment, decreasing to 0.96 ppm 29 days after treatment. Residues were also detected in weeds growing in untreated sections (12 to 13 ft from the treated rows) ranging from 0.02 to 19.64 ppm. Similar residues were found in samples from irrigated fields.

Limited quantitative data were found on the aldicarb residues in specific plants. Volunteer crabgrass growing in fallow ground contained 1.15 ppm of ^{14}C-aldicarb equivalents 90 days after treatment at the rate of 3 lb aldicarb per acre. Sugar beet roots and potatoes contained 0.05 to 0.2 and 0.05 ppm aldicarb residue, respectively, when harvested 4 months after planting (and soil treatment with aldicarb 10% granules). Tests on a Pennsylvania tree farm have shown that aldicarb appears to be readily absorbed and translocated upward in the Scotch pine.

The propensity of aldicarb for bioaccumulation and biomagnification was recently studied in a laboratory model ecosystem consisting of a terrestrial-aquatic interface and a seven-element food chain. Thirty-three days after the introduction of radiolabeled aldicarb, the system was disassembled and its components were analyzed. The results of these analyses indicated that aldicarb had high persistence and low biodegradability. Aldicarb oxidation products (the sulfoxide and sulfone) were recovered in water and organisms in the ecosystem.

No significant lateral movement of aldicarb and its metabolites was caused by runoff, even during periods of heavy water flow. (Only samples of water taken 8 days after application, following 5 in of irrigation and 2 rainy days, contained analytically significant residue (0.14 ppm). Soil samples taken 7 days after application contained 5.5 ppm). By the time aldicarb reaches the 4-foot depth, the concentration of total toxic residue is no greater than 0.1 ppm.

Volatilization of aldicarb is apparently not a major factor in environmental transport.

Limitations in Available Scientific Data

The review of scientific literature was based on available sources, given limitations of time and resources. Data was not found in a number of pertinent areas:

1. Data on the effects (if any) of aldicarb residues in vegetation consumed by wildlife.

2. Field data of the effects on lower terrestrial organisms on crops other than cotton.

3. Laboratory or field data on effects (if any) on lower aquatic organisms.

Efficacy and Cost Effectiveness

Temik® has been used successfully in controlling several different types of insects (thrips, aphids, fleahoppers, and the Colorado potato beetle) and nematodes on potatoes, sweet potatoes, sugar beets and peanuts. There was no data found on at least eight other pest/crop combinations.

Good control of thrips and aphids was obtained in tests on cotton. Some reduction in boll weevil populations was also evidenced in selected tests. These experiments usually resulted in increased yield.

Infestations of the Colorado potato beetle, potato flea beetle and aphids were controlled well when Temik® was applied to potatoes. Yield increases generally followed the degree of pest control. Positive control of nematodes was also noted.

Temik® provided good thrip control, but variable yield differentials on peanuts. Nematode control and strong yield increases were demonstrated.

Some reduction in nematode damage on sweet potatoes was found, but yield changes were quite variable. On sugar beets, Temik® provided good control of nematodes as well as up to a 37% yield increase.

Based on these yield responses (compared to zero control) the following net benefit range has been estimated:

Crop	Least benefit ($/acre)	Greatest benefits ($/acre)
Cotton	-370.75	558.78
Potato	61.65	609.00
Sweet potato	-99.50	270.50
Sugar beet	-17.20	101.04
Peanut	-55.40	72.93

PART II. INITIAL SCIENTIFIC REVIEW

SUBPART A. CHEMISTRY

CONTENTS

This section reviews available data on aldicarb's chemistry and presence in foods. Eight subject areas have been examined: Synthesis and Production Technology; Physical Properties of Aldicarb; Composition and Formulation; Analytical Methods; Chemical Properties; Occurrence of Residues in Food and Feed Commodities; Acceptable Daily Intake; and Tolerances. The section summarizes rather than interprets scientific data reviewed.

Synthesis and Production Technology

Aldicarb is classed as an alkyl carbamate, and is manufactured in a three-step reaction. The reaction chemistry is as follows (Lawless et al., 1972[1]):

$$2(CH_3)_2C{=}CH + 2NaNO_2 + 4HCl \longrightarrow 2NaCl + 2H_2O + [ClC(CH_3)_2CH_2NO]_2$$

2-Chloro-2-methyl-1-nitrosopropane dimer (I)

$$(I) \xrightarrow{2CH_3SNa} 2NaCl + CH_3SC(CH_3)_2CH{=}NOH$$

2-Methyl-2-(methylthio)propionaldehyde oxime (II)

$$(II) \xrightarrow{CH_3NCO} CH_3SC(CH_3)_2CH{=}NOCONHCH_3$$

Aldicarb

Aldicarb and a series of related compounds have been patented for use as pesticides (Payne and Weiden, 1965).[2]

1/ Lawless, E. W., and T. L. Ferguson of Midwest Research Institute, and R. von Rümker of RvR Consultants, "The Pollution Potential in Pesticide Manufacturing," for the Environmental Protection Agency, Contract No. 68-01-0142 (1972).

2/ Payne, L. K., and M. H. J. Weiden, U.S. Patent No. 3,217,037 (to Union Carbide Corporation, November 9, 1965).

Only laboratory methods of preparation are discussed in the patent. This patent is assigned to Union Carbide Corporation, the only known manufacturer of aldicarb.

Inpurities listed by Union Carbide which are present in the manufacture of aldicarb and present in Temik® formulations are as follows: dimethylurea, 2-methyl-2-(methylthio) propionitrile: 2-methyl-2-(2)-methyl-2-methylthio-propylideneaminoxy) propionaldehyde O-(methylcarbamoyl) oxime; and 2-methyl-2-(methylthio) propionaldehyde oxime.

According to Union Carbide, the impurities are of no pharmacological significance.1/

A production schematic for aldicarb is shown in Figure 1.

Physical Properties of Aldicarb

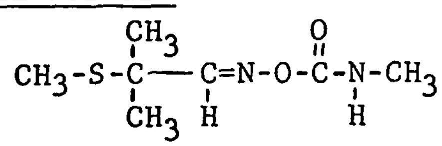
Chemical Name: 2-Methyl-2-(methylthio)propionaldehyde O-(methylcarbamoyl) oxime

Common Name: Aldicarb

Other Names: Temik®, UC-21149

Pesticide Class: Insecticide; carbamate

Structural Formula:



Empirical Formula: $C_7H_{14}N_2O_2S$

Molecular Weight: 190.2

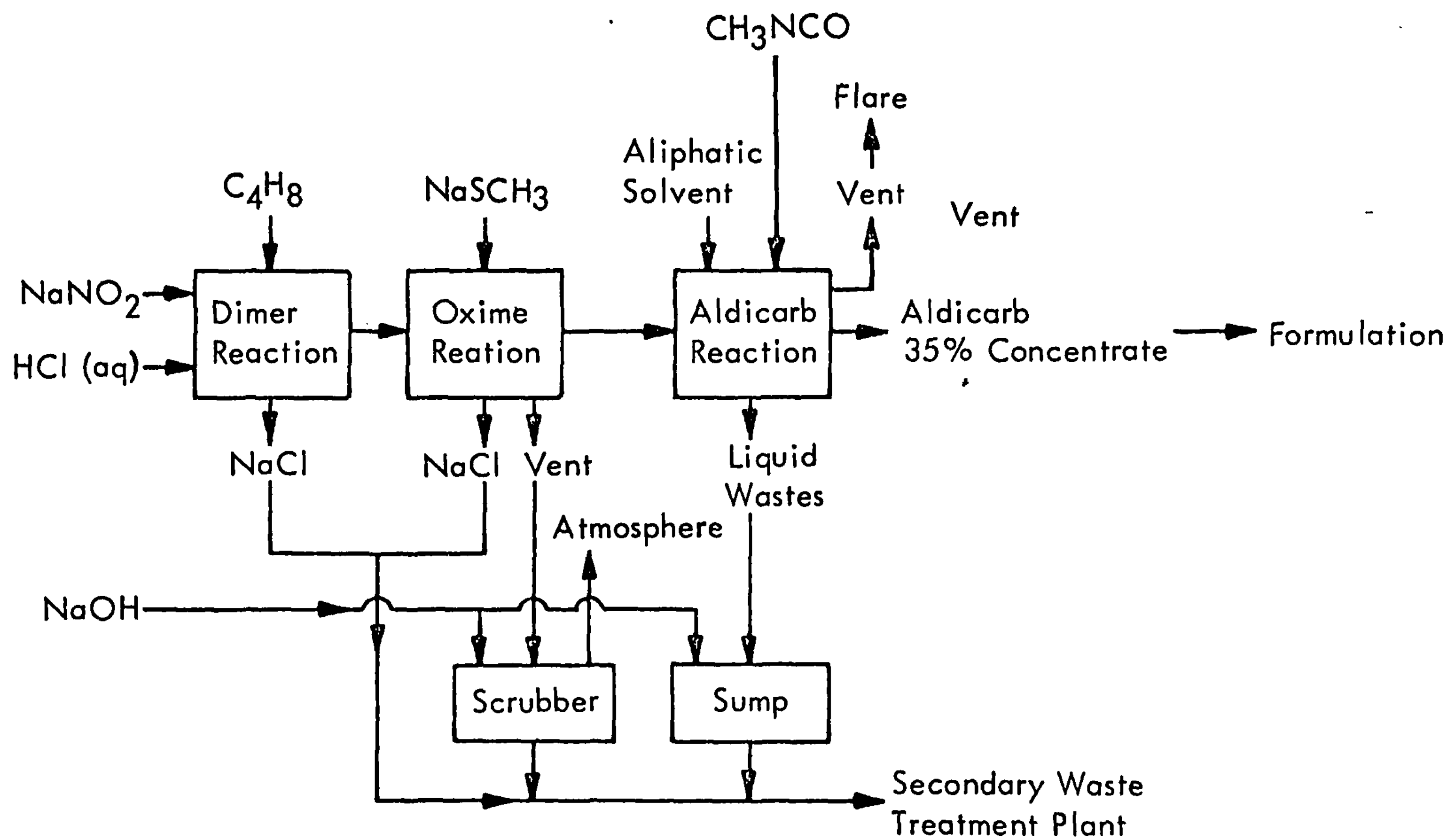
Percentage Composition: C, 44.2%; H, 7.4%; N, 14.7%; O, 16.8%; S, 16.9%

Physical State: White odorless crystals

Melting Point: 100°C

Vapor Pressure: 1×10^{-4} mm Hg at 25°C
7×10^{-4} mm Hg at 50°C
4×10^{-3} mm Hg at 75°C

1/ Union Carbide Corporation, Temik Technical Bulletin, Salinas, Calif. (1974).



Source: Lawless et al, <u>op. cit.</u> (1972).

Figure 1. Production schematic for aldicarb

Analytical Methods

This subsection reviews analytical methods for aldicarb. The review describes multi-residue methods, residue analysis principles, and formulation analysis principles. Information on the sensitivity and selectivity of these methods is also presented.

Multi-Residue Methods

Multi-residue methods for detecting aldicarb are not found in either the Association of Official Analytical Chemists methods manual[1/] or the Pesticide Analytical Manual, Vol. I (PAM, 1971)[2/]. Aldicarb has not been reported as a significant residue in any class of food nor is it routinely searched for in the FDA multi-residue analytical system which is used to monitor pesticide residues in food. Adequate individual compound methods exist for measuring aldicarb residues. The apparent reason for the absence of aldicarb residue data is that the pesticide is not widely used on major food items. The absence of aldicarb residue data does not necessarily mean that it is not present in food.

Residue Analysis Principles

PAM, Vol. II (1971)[3/] does not contain specific residue analysis method for aldicarb.

R. R. Romine[4/] describes two methods of residue analysis, the gas chromatographic method and the colorimetric method.

Gas Chromatographic Method - The toxic residue of aldicarb in biological substrates is composed of aldicarb and its sulfoxide and sulfone metabolites. All three of these components are determined as a total residue by first oxidizing aldicarb and aldicarb sulfoxide to aldicarb sulfone with peracetic acid and then determing total aldicarb sulfone by gas chromatography. The aldicarb sulfone is determined utilizing a flame-photometric detector incorporating a 394 nm filter specific for sulfur-containing compounds. Quantitative determination of aldicarb is achieved by reference of the peak height to a previously prepared calibration curve.

1/ Association of Official Analytical Chemists, Official Methods of Analysis of the Association of Official Analytical Chemists, 11th ed., Washington, D.C. (1970).

2/ U.S. Department of Health, Education, and Welfare, Food and Drug Administration, Pesticide Analytical Manual, Vol. I (1971).

3/ U.S. Department of Health, Education, and Welfare, Food and Drug Administration, Pesticide Analytical Manual, Vol. II (1971).

4/ Romine, R. R., "Aldicarb," Chap. 4 in Analytical Methods for Pesticides and Plant Growth Regulators, Vol. VII, Thin-Layer and Liquid Chromatography, J. Sherma and G. Zweig (eds.), Academic Press, Inc., New York (1973).

The components of the toxic residue may be separated by Florisil liquid-column chromatography prior to oxidation to the sulfone. The components can be separated quantitatively by procedures similar to those used for the total residues.

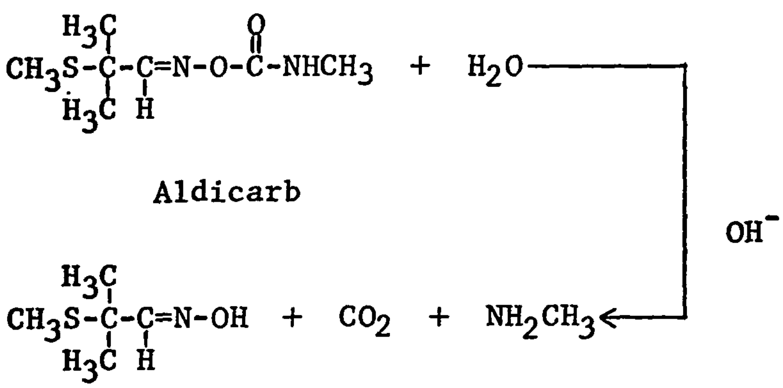
Studies have been made to determine if other sulfur-containing pesticides would interfere in the described method. Several aspects of the procedure, such as liquid-column chromatography, liquid-liquid partitioning, gas chromatography, and the sulfur-specific filter in the detector, afford considerable "built-in" specificity. Several currently registered pesticides as well as aldicarb metabolites have been tested through the procedure and do not interfere.

Recovery of aldicarb, aldicarb sulfoxide, and aldicarb sulfone is about 90% when crop or environmental samples are fortified prior to extraction. Sensitivity varies from 0.007 to 0.010 ppm depending on the nature of the biological substrate.

A wide variety of crops, both fruits and foilage, as well as soil, water, and animal tissues, have been routinely analyzed using the gas chromatographic method. Onions and other crops containing organic sulfur compounds have been successfully analyzed with minor clean up variations.

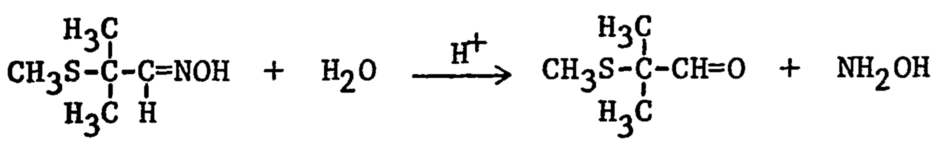
Colorimetric Method - The colorimetric method is based on the generation and quantitation of hydroxylamine. Since development of the gas chromatographic method, the colorimetric method is usually used as an alternative if instrumentation is not available or as a confirmatory procedure to further confirm the identity of the residues found by gas chromatography. In some cases the colorimetric end-point may be directly applied to the residue solution remaining after the small aliquot is withdrawn for gas chromatography. If sensitivity is not satisfactory, some further clean up of residue solutions may be necessary. Sensitivity is approximately 0.03 ppm.

The determination of total aldicarb residue is based on the carbamoyloxime group of the molecule. The carbamoyloxime, hydrolyzed with base to 2-methyl-2-(methylthio)propionaldehyde oxime, is illustrated as follows:



Aldicarb oxime

(1)



(2)

$$NH_2OH + 2\ I_2 + H_2O \longrightarrow HNO_2 + 4\ HI \qquad (3)$$

Hydrolysis of the oxime in acidic medium (2) forms the aldehyde 2-methyl-2-methylthiopropionaldehyde and hydroxylamine. The hydroxylamine is oxidized with iodine to nitrous acid (3) which is determined colorimetrically.

Chrysanthemum plants contain an interfering substance which causes a deep red color when the colorimetric method is applied. This is the only substrate known to exhibit this gross interference.

Formulation Analysis Principles - The infrared spectroscopic method is increasingly being used for formulation analysis. Under the method, as described by Romaine (1973), aldicarb is extracted from granules (the only registered aldicarb formulation) using methylene chloride solvent. The extract is diluted to a known volume with additional solvent and an aliquot is analyzed for aldicarb content by infrared spectroscopy utilizing the carbamate carbonyl absorbance at 5.75 µm. The absorbance of the sample at 5.75 µm is measured, and the aldicarb content is determined by comparison with the absorbance of a standard solution of analytical grade aldicarb treated in the same manner.

Composition and Formulation

Technical aldicarb [2-methyl-2(methylthio)propionaldehyde O-(methylcarbamoyl)oxime] is manufactured under the trade name Temik® a registered trademark of Union Carbide Corporation. Technical aldicarb is not isolated during manufacture. It is produced as a 30 to 35 percent solution in an organic solvent. The solution is used to impregnate ground corn cob grits in the 10/40 mesh range. The finished granulars contain 5 to 15 percent aldicarb on inert carriers.

The names under which pesticide products containing aldicarb are marketed in the United States are Temik®, 10% granular aldicarb pesticide and Temik®, 15% granular aldicarb pesticide. Common reference to the formulated products is "Temik 10G" (EPA Reg. No. 1016-69) or "Temik 15G" (EPA Reg. No. 1016-78).

Table 1. SOLUBILITY IN VARIOUS SOLVENTS

Solvent	Percent
Acetone	35[1/], 30[2/]
Benzene	15[1/]
Chlorobenzene	15[2/]
Chloroform	35[2/]
Ethanol	25[2/]
Methylene chloride	30[1/]
Toluene	10[2/]
Water	0.6[1/,2/]
Heptane	Practically insoluble[3/]

Adapted from Frear (1969)[1/], Kirk-Othmer (1966)[2/], and Martin (1971).[3/]

Chemical Properties

Most of the published information concerning the chemistry of aldicarb deals with metabolism and degradation in the environment. The chemistry of metabolism is discussed in the Pharmacology and Toxicology section, p. 21.

1/ Frear, D. E. H., Pesticide Index, 4th ed., College Science Publisher, State College, Pennsylvania (1969).

2/ Kirk-Othmer, Encyclopedia of Chemical Technology, 2nd ed., Vol. 11, Interscience Publishers, New York, New York (1966).

3/ Martin, H., Pesticide Manual, 2nd ed., British Crop Protection Council, Worchester, England (1971).

Hydrolysis - Aldicarb is hydrolyzed by alkali, as shown in the following equation:

$$\underset{\text{Aldicarb}}{CH_3SC(CH_3)_2CH{=}NOCONHCH_3} \xrightarrow{OH^-} \underset{\text{Oxime}}{CH_3SC(CH_3)_2CHNOH} + CO_2 + \underset{\text{Methylamine}}{NH_2CH_3}$$

According to an analytical procedure (Johnson and Stansbury, 1969[1/]), this reaction is complete in 1 min at 100°C in dilute alkali. Further hydrolysis of the oxime can be achieved by acid hydrolysis, as shown by the following equation:

$$\underset{\text{Oxime}}{CH_3SC(CH_3)_2CHNOH} \xrightarrow{H^+} \underset{\text{Aldehyde}}{CH_3SC(CH_3)_2CHO} + \underset{\text{Hydroxylamine}}{NH_2OH}$$

This second hydrolysis step is considerably more difficult, requiring 10 min digestion in strong acid.

Oxidation - Aldicarb is oxidized quantitatively to the sulfone by means of peracetic acid. This reaction is employed in analytical gas-liquid chromatographic determinations. The reaction is rapid, but proceeds through the sulfoxide which can be determined as an intermediate when the reaction is incomplete (Carey and Helrich, 1970[2/]):

$$\underset{\text{Aldicarb}}{CH_3SC(CH_3)_2CH{=}NOCONHCH_3} \xrightarrow{\text{Peracetic acid}} \underset{\text{Aldicarb Sulfoxide}}{CH_3\overset{O}{\overset{\|}{S}}C(CH_3)_2CH{=}NOCONHCH_3}$$

$$\downarrow \text{Peracetic Acid}$$

$$\underset{\text{Aldicarb Sulfone}}{CH_3\underset{O}{\underset{\|}{\overset{O}{\overset{\|}{S}}}}C(CH_3)_2CH{=}NOCONHCH_3}$$

1/ Johnson, D. P., and H. A. Stansbury, Jr., "Determination of Temik® Residues in Raw Fruits and Vegetables," J. Assoc. Off. Anal. Chem. 49(2):399 (1969).

2/ Carey, W. F., and K. Helrich, "Improved Quantitative Method for the Determination of Aldicarb and Its Oxidation Products in Plant Materials," J. Assoc. Off. Anal. Chem., 53(6):1296 (1970).

Acceptable Daily Intake

The acceptable daily intake (ADI) is established only by the FAO/WHO. It is defined as the daily intake which, during an entire lifetime, appears to be without appreciable risk on the basis of all known facts at the time of evaluation (Lu, 1973[1/]).

Although aldicarb is used on sugar beets and several other food crops, a majority of its use is on cotton. It is also a relatively new pesticide. Consequently, the FAO/WHO has not yet determined an ADI for aldicarb.

Tolerances

Section 408 of the Food, Drug and Cosmetic Act, as amended, gives procedures for establishing U.S. tolerances for pesticide chemicals on raw agricultural commodities. Section 409 applies to food additives, including pesticide chemicals on processed foods. Tolerances are published in the Code of Federal Regulations, Title 40, and in the *Federal Register*. A summary of current U.S. tolerances for aldicarb is presented in Table 2. No tolerances are pending on any other crops.

According to Lu (1973), U.S. tolerances which are established should not result in the maximum ADI being reached each day. He gives the following reasons:

1. The tolerance reflects the maximum level of residue resulting from good agricultural practice, but this level is often not reached.

2. The tolerance is based on the assumption that the particular pesticide is used on all food in the class in question, and this is rarely the case.

3. Much of the residue will be lost in storage, processing and cooking.

The tolerances are also based upon the entire product as purchased in the market. However, the product, as purchased, may not be entirely consumed.

1/ Lu, F. C., "Toxicological Evaluation of Food Additives and Pesticide Residues and Their 'Acceptable Daily Intakes' for Man: The Role of WHO in Conjunction with FAO" *Residue Rev.*, 45:81-93 (1973).

Table 2. U.S. TOLERANCES FOR ALDICARB

Commodities	Tolerance (ppm)
Cattle (meat, fat, meat by-products)	0.01
Cottonseed	0.1
Cottonseed hulls	0.3
Goats (meat, fat, meat by-products)	0.01
Hogs (meat, fat, meat by-products)	0.01
Horses (meat, fat, meat-by-products)	0.01
Milk	0.002
Potatoes	1.0
Peanut hulls	0.5
Peanuts	0.05
Sheep (meat, fat, meat by-products)	0.01
Sugar beets	0.05
Sugar beet tops	1.0
Sugarcane	0.02
Sugarcane fodder and forage	0.1
Sweet potatoes	0.02

Source: U.S. Environmental Protection Agency, EPA Compendium of of Registered Pesticides, Vol. III (1973).

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SUBPART II. B. PHARMACOLOGY AND TOXICOLOGY

CONTENTS

CONTENTS (Continued)

This section reviews pharmacological and toxicological data on aldicarb. The acute, subacute and chronic toxicity data for a number of species by various routes of administration is discussed. Data is presented on demyelination potential, metabolism, effects on reproduction, teratogenic, mutagenic and oncogenic effects. A review has also been made of aldicarb's effects on humans both in industrial and field environments. The section summarizes rather than interprets scientific data reviewed.

Acute, Subacute and Chronic Toxicity

Acute Oral Toxicity - Rats - The acute oral toxicity of aldicarb in rats was determined in a study by Gaines (1969)[1/] to be 0.8 mg/kg for males and 0.65 mg/kg for females. The compound used in these tests was technical grade and was suspended in peanut oil for dosing.

The LD_{50} value for aldicarb in rats was calculated to be 0.9 mg/kg for males and 1.0 mg/kg for females, when the vehicle was corn oil (Carpenter and Smyth, 1965; Weiden et al., 1965).[2-3/] Range finding tests determined (Striegel and Carpenter, 1963),[4/] that the LD_{50} for the male rat was 0.93 mg/kg (95% confidence limits, 0.67 to 1.3 mg/kg).

The acute oral LD_{50} of one of the two currently registered aldicarb formulations, Temik 10G, was 7.07 mg/kg administered as dry granules to rats (Weil, 1973).[5/]

To show that aldicarb could be extracted from Temik 10G, a gram of Temik 10G was mixed with 200 ml water for 8 hr. The oral LD_{50} to male rats was 6.2 mg/kg of Temik 10G formulation (Carpenter and Smyth, 1965). The LD_{50} values in rats for two metabolic products of aldicarb, the sulfoxide and sulfone were 0.88 mg/kg and 25.0 mg/kg, respectively (Weil, 1968).[6/]

Aldicarb is a carbamate insecticide which causes cholinesterase inhibition at very low doses. It has muscarinic effects at exocrine, excretory, cardiac and bronchial sites which are exhibited overtly by salivation, lacrimation, defecation, urination, slowing of the heart and trouble with breathing. It also has nicotinic effects evidenced by muscle fasiculations. Atropine has been shown to antagonize the muscarinic effects of most cholinesterase inhibitors. Aldicarb's chief metabolites, aldicarb sulfoxide and

1/ Gaines, T. B., "Acute Toxicity of Pesticides," Toxicol. Appl. Pharmacol., 14:515-534 (1969).

2/ Carpenter, C., and H. Smyth, Mellon Institute Report No. 28-78, EPA Pesticide Petition No. 9F0798 (1965).

3/ Weiden, M. H. J., H. H. Moorefield, and L. K. Payne, Jr., "O-(Methylcarbamoyl)oximes: A Class of Carbamate Insecticides-Acaricides," J. Econ. Entomol., 58:154-155 (1965).

4/ Striegel, J. A., and C. Carpenter, Mellon Institute Report No. 25-53, EPA Pesticide Petition No. 9F0798 (1963).

5/ Weil, C., Mellon Institute Report 35-41, EPA Pesticide Petition No. 3F1414 (1973).

6/ Weil, C., Mellon Institute Report No. 31-48, EPA Pesticide Petition No. 9F0798 (1968).

aldicarb sulfone are also potent cholinesterase inhibitors. Atropine was shown to be antidotal to the muscarinic and lethal effects of aldicarb and its metabolites when these compounds were given to rats at twice their LD_{50} (Johnson).[1]

Pyridine II aldoxime (2-PAM) in combination with atropine was no better than atropine alone and is not recommended as an antidote for aldicarb (Johnson). Atropine is the only antidote recommended on the Temik® labels; 2-PAM is not recommended and may be contraindicated.

Acute Oral Toxicity (repeated dose) - Rats - Groups of 10 rats (five females and five males) were tested starting at 45 days of age on repeated ingestion (7 days) of aldicarb, aldicarb sulfoxide, and aldicarb sulfone administered in the feed (Nycum and Carpenter, 1970).[2] Rats will tolerate > 0.4 mg/kg of aldicarb sulfoxide without effect on body weight, liver, and kidney weight and without depression of plasma, erythrocyte and brain cholinesterase. Aldicarb sulfone at 5.0 mg/kg of body weight depresses plasma erythrocyte and brain cholinesterase. When 2.5 mg/kg was administered, only brain cholinesterase of the females was depressed. This effect persisted at 1.0 mg/kg dose and did not lose statistical significance until 0.4 mg/kg was reached.

In a 93 day study, aldicarb was incorporated into the diet of CFE male and female rats at doses of 0.5, 0.1, 0.02 and 0 mg/kg/day. Mortality was significantly increased at the high dose and numerically but not significantly increased at 0.1 mg/kg. All survivors did not differ from controls with regard to pathology, organ weight or plasma erythrocyte or brain cholinesterase (Weil and Carpenter, 1969).[3] When aldicarb was fed at 3.2 mg/kg, the body weight of males and females was depressed. The liver and kidney weights were not depressed. Both males and females experienced depression of plasma cholinesterase activity, whereas only the males had a depression of erythrocyte cholinesterase.

Acute Toxicity by Other Routes Than Oral - Rats - The LD_{50} values for rats injected intraperitoneally with aldicarb carried in corn oil or propylene glycol was 0.44 mg/kg for males and females (Weil, 1970).[4]

Chronic Toxicity - Rats - A 2-yr study on the presence of aldicarb in the diet of the rat was conducted (Weil and Carpenter, 1965).[5] Forty rats (20 males and 20 females) were placed on each of the following diets: Group 1, control; Group 2, 0.1 mg/kg; Group 3, 0.05 mg/kg; Group 4, 0.025 mg/kg; and Group 5, 0.005 mg/kg.

1/ Johnson, H., Mellon Institute Report No. 31-139, EPA Pesticide Petition No. 9F0798.

2/ Nycum, J. S., and C. Carpenter, Summary with Respect to Guideline PR70-15, Mellon Institute Report No. 31-48, EPA Pesticide Petition No. 9F0798 (1970).

3/ Weil, C., and C. Carpenter, Mellon Institute Report 26-47, Section C, EPA Pesticide Petition No. 9F0798 (1969).

4/ Weil, C., Mellon Institute, Report No. 33-7, Amendments to EPA Pesticide Petition No. 9F0798 (1970).

5/ Weil, C., and C. Carpenter, Mellon Institute Report No. 28-123, EPA Pesticide Petition No. 9F0798 (1965).

Along with these test groups, 32 other rats (16 males and 16 females) were carried along on the diets simultaneously. At the end of the first 6 months, four animals of each sex from this second group were sacrificed and at the end of the first year, the remaining 12 animals of each sex were killed. The criteria of the test included food consumption, mortality and life span, incidence of infection, liver and kidney weight as percentages of body weights, body weight gain, maximum body weight gain, hematocrit, incidence of neoplasms, incidence of pathological lesions, and plasma, brain and erythrocyte cholinesterase levels. The aldicarb treated animals did not differ significantly from the controls for any of the above parameters.

Fifty-nine rats had microscopically verified neoplasms. During the first year there were seven occurrences. Eighty-three tumors were found; each tumor-bearing rat had an average of 1.4 tumors. More tumors were observed in the control group than in the treated group. Forty-seven percent of all females had tumors in the treated group while the incidence in the control group was 60%.

As reported by Weil,[1/] Greenacres Laboratory Controlled Flora rats (20 per sex) were fed the following aldicarb levels for a maximum of two years: 0.3 or 0.6 mg/kg/day of aldicarb sulfoxide (ASO); 0.6 or 2.4 mg/kg/day of aldicarb sulfone (ASO_2); 0.6 or 1.2 mg/kg/day of a 1:1 mixture of ASO: ASO_2, or 0.3 mg/kg/day aldicarb. No adverse effects were noted at 0.3 mg/kg aldicarb, but the high dose of the mixture of ASO:ASO_2 caused increased mortality in the first 30 days and, in the males, a decrease in plasma cholinesterase activity at two years and decreased weight gain. Some increased mortality was observed in females at the high close of ASO.

The investigators determined that the no-adverse effect levels for 2 years were as follows:

1:1 mixture of ASO:ASO_2-0.6 mg/kg	
ASO	0.3 mg/kg
ASO_2	2.4 mg/kg
Aldicarb	0.3 mg/kg

1/ Weil, C., Mellon Institute Report No. 35-72, Section C, EPA Pesticide Petition No. 3F1414.

Dermal Toxicity - Rats - Acute dermal toxicity (the LD_{50}) for aldicarb in rats was reported to be 3 mg for males and 2.5 mg for females (Gaines, 1969). These were 24 hr exposure periods.

Skin penetration tests (4-hr exposure) were conducted on male rats weighing 120 to 190 g (Carpenter and Smyth, 1965). Temik 10G (a 10% granular aldicarb formulation) in mixtures was applied to the skin as a dry formulation and with saline added. The test materials were retained under adhesive tape. The dry formulation was not as toxic as when the same mixture was wetted with saline.

The LD_{50} for Temik 10G was 400 mg/kg when wetted and 3,200 mg/kg when applied dry. Temik 10G wetted with saline is 1/40 as toxic to rats in terms of contained pesticide as is the unformulated material by mouth.

Dry granules of either Temik 10G or Temik 15G were applied for 4 hr to the clipped bellies of rats (Weil).[1/] The dermal LD_{50} of the 10G was 4.58 g/kg and the LD50 of the 15G was 6.32 g/kg.

Acute Toxicity - Inhalation - Inhalation studies were conducted with rats, mice and guinea pigs (Carpenter and Smyth, 1965).

A level of 200 mg/m^3 of aldicarb as a dust in a 5-min exposure is highly toxic to all three species. Guinea pigs are not quite as susceptible to inhalation of aldicarb dust as rats and mice (5-min exposure of mice and rats to 200 mg/m^3). Rats appear to be able to survive a dust concentration of 6.7 mg/m^3 for 15 min whereas five out of six are dead in 30 min at the same concentration. Rats are able to survive 8 hr in atmospheres of saturated vapors of aldicarb. Aldicarb appears to be less toxic in the form of an aerosol than as a dust: an 8-hr exposure of rats to an aerosol concentration of 7.6 mg/m^3 of aldicarb was toxic, but two out of six survived. When the aerosol concentration was raised to 15.8 mg/m^3 five out of six animals died in 4 hr.

Environmental Exposure - Rats - Groups of six female albino rats were subjected to top soil treated with Temik 10G for a 28-day exposure (Pozzani and Carpenter, 1966).[2/] The ventral surfaces of the rats were shaved free of hair. Temik 10G was incorporated into the top soil to a depth of 6 cm and the application rate was 100 and 500 lb/acre (one and five times the recommended usage, respectively). All the rats survived with no adverse effects. There were no fatalities or gross lesions produced and no adverse body weight changes.

1/ Weil, C., Mellon Institute Report No. 34-76, EPA Pesticide Petition No. 3F1414.

2/ Pozzani, U. C., and C. Carpenter, Mellon Institute Report No. 29-2, EPA Pesticide Petition No. 9F0798.

Rats were dosed orally with equiconcentration solutions of aldicarb and various cholinesterase inhibiting pesticides such as guthion, parathion, carbaryl, diazinon, methyl parathion, malathion, dipterex, EPN and trithion (West, and Carpenter, 1966).[1/] When the predicted LD_{50}s were compared to the observed LD_{50}s of these combinations, only simple additive effects were noted. No potentiation was observed.

Acute Oral Toxicity - Mouse - Black et al. (1973)[2/] reported that the acute oral toxic dose of technical aldicarb for the mouse was 0.3 to 0.5 mg/kg.

Acute Toxicity - Rabbits

Dermal - The results of a dermal toxicity evaluation with rabbits is shown in Table 3.

It has been determined that the LD_{50} (24 hr) for a single skin application (male rabbits) of 50% solution of aldicarb in water was 32 mg/kg of body weight. When the compound was applied in a 5% solution of propylene glycol, the LD_{50} was 5 mg/kg. If the carrier was changed to dimethyl phthalate the LD_{50} was 12.5 mg/kg. When the aldicarb was dispersed in a 5% solution of toluene, the LD_{50} for a 4-hr exposure was 3.5 mg/kg. (West and Carpenter, 1966,[3/] Wieden et al., 1965) In a 24 hr dermal test with dry Temik® 10G (a 10% granule formulation of aldicarb) under adhesive tape the LD_{50} was 141 mg/kg expressed as active aldicarb (Carpenter and Smyth, 1965).

A 15-day dermal toxicity study of aldicarb has been conducted with rabbits (Carpenter and Smyth, 1966). Three dosage levels of Temik® 10G (10.5% active granular formulation) 0.05, 0.10 and 0.2 g/kg were applied to abraded skin areas on male albino rabbits under wetted gauze for 6 hr a day for 15 consecutive days. The criteria of evaluation included total weight gain, food consumption, liver and kidney weight, along with histopathological examination of the liver, lung, kidney, heart, muscle, thyroid, and skin. In addition, a course of hematology was run along with kidney function (blood urea nitrogen) and liver function (serum glutamic oxalacetic and pyruvic transaminase) tests. The plasma and erythrocyte cholinesterase activity levels were assessed.

The only significant difference between controls and test animals was depressed weight gains for the groups in contact with 0.1 and 0.2 g/kg of Temik® 10G. Plasma cholinesterase was lowered in the 0.1 and 0.2 g/kg groups.

Eye Irritation - Aldicarb applied to the eye of the rabbit has a LD_{50} of 0.7 to 10 mg/kg (Striegel and Carpenter, 1963). No corneal irritation was noted.

1/ West, J., and C. Carpenter, Mellon Institute Report No. 29-98, EPA Pesticide Petition No. 9F0798 (1966).

2/ Black, A. L., Y. C. Chiu, M. A. H. Famy, and T. R. Fukuto, "Selective Toxicity of N-Sulfenylated Derivitaves of Insecticidal Methyl-Carbamate Esters," J. Agr. Food Chem., 21(5):747-751 (1973).

3/ West, J., and C. Carpenter, Mellon Institute Report No. 28-140, EPA Pesticide Petition No. 9F0798 (1966).

Table 3. DERMAL TOXICITY OF ALDICARB TO MALE RABBITS

Test compound	Active ingredient (%)	Weight range (g)	Time (hr)	Condition	Covering	LD_{50} and range or mortality containing Temik® (mg/kg)
Temik® 10G	10	2,600-3,500	24	Dry	Adhesive tape Vinylite sheeting	141
Temik® 10G C-15 Kobrite (corn cob granules)	10	2,400-2,900	4	Saline added	Adhesive tape	320 killed 2/2 160 killed 0/2
Temik® 10G C-6 Kobrite (corn cob granules)	10	2,200-2,700	4	Saline added	Adhesive tape	320 killed 2/2 160 killed 0/1
Aldicarb	100	2,200-3,000	4	Saline added	Vinylite sheeting	3.54 (in toluene)
Aldicarb	100	2,200-3,000	24	Saline added	Vinylite sheeting	4.96 (3.67-6.71) (in propylene glycol)
Aldicarb	50	2,300-3,300	24	Saline added	Vinylite sheeting	32 (24-43) in water
Aldicarb	100	2,300	24	Saline added	Vinylite sheeting	200 killed 2/2 50 killed 1/1 12.5 killed 1/2 6.25 killed 0/1 (in dimethyl phthalate)

Chronic Toxicity - Dogs - Long-term feeding studies (2 years) of aldicarb (99.9% pure) in the diet of beagle dogs have been conducted (Weil and Carpenter, 1966).1/ There were four groups of six dogs (three males and three females). The dosages were as follows:

Group 1 - control
Group 2 - 0.0003333% (0.1 mg/kg/day)
Group 3 - 0.0001667% (0.05 mg/kg/day)
Group 4 - 0.0000833% (0.025 mg/kg/day)

The criteria of evaluation included body weight changes, appetite, mortality, histophathology, hematology, biochemistry and terminal liver and kidney weights. The investigators reported that there were no statistically measurable deleterious effects even at the highest dosage.

The no-effect level for dogs and rats based on chronic studies was 0.1 mg/kg/day. The no-effect level was identical for the rats in the 2-year study and the 90-day dog studies (Smyth).2/

Subacute Toxicity - Cats - Cats were dosed with 0.5, 1.0 and 1.5 mg/kg of aldicarb with a 7-to-8-day interval between doses. There was no evidence of tolerance since third dose death was as prompt as death from the first dose (Carpenter and Smyth, 1965).

Acute Toxicity - Guinea Pigs - The LD_{50} for guinea pigs (and rabbits) falls in the same range as rats (Carpenter and Smyth, 1965).

Sensitization - Guinea Pigs - Aldicarb in saline exhibited no sensitizing properties when injected intradermally to guinea pigs in a modified Landsteiner sensitization protocol (Pozzani and Kinead).3/

Toxicity to Domestic Animals - Schlinke (1970)4/ evaluated the toxic effects of aldicarb in chickens (Table 4). White leghorn chickens 6 to 7 weeks old were treated for 10 days. The dosages were given in gelatin capsules or by oral drench. Aldicarb was administered to three groups (five birds per group) at a level of 1.0, 2.5 and 5 mg/kg/day. No ill effects were observed in the chickens that received 1 mg/kg/day. At the 2.5-mg/kg/day level, one bird died after the first dose and another after the third dose. All of the birds receiving 5 mg/kg/day died in a period of 3 days. One died after the first dose, one after the second dose, and the remaining three after the third dose.

1/ Weil, C., and C. Carpenter, Mellon Institute Report No. 29-5, EPA Pesticide Petition No. 9F0798 (1966).
2/ Smyth, H., EPA Pesticide Petition No. 8F0637, Vol. I.
3/ Pozzani, U. C., and E. R. Kinead, Mellon Institute Report 31-143, EPA Pesticide Petition No. 9F0798.
4/ Schlinke, J. C., "Toxicologic Effects of Five Soil Nematocides in Chickens," J. Am. Vet. Med. Assoc., 31:119-121 (1970).

Table 4. ACUTE ORAL TOXICITY OF ALDICARB TO CHICKENS (10-DAY TEST)

Dosage[a] (mg/kg/day)	Results	Body weight gain (%) Treated	Body weight gain (%) Control
5	1 died after first dose 1 died after second dose 3 died after third dose		
2.5	1 died after first dose 1 died after third dose	30	40
1.0	No ill effects	44	49

a/ Five per group (6 to 7 weeks old).

White Leghorn Cockerels were dosed orally with aldicarb; the LD_{50} was 9 mg/kg or ten times that for rats (West and Carpenter).[1]

Schlinke (1970) described the signs of aldicarb poisoning in chickens as excessive salivation, dyspnea, stiffness and twitching of leg, wing and pectoral muscles.

Demyelination Potential of Aldicarb in Chickens

Single oral doses 4.5 mg/kg (1/2 LD_{50}) or 30 daily doses of 4.5 mg/kg and 2.25 mg/kg caused no delayed ataxia or apparent limb paralysis during or 30 days after the last dose (Johnson and Carpenter, 1966).[2] At a high level (9.0 mg/kg), four of six birds died within 2 weeks at the beginning of the dosing without showing any overt ataxia or limb paralysis. A positive control was run (0.1 ml triorthocresyl phosphate) and produced symptoms associated with demyelination and caused death in 14 to 16 days.

1/ West, J., and C. Carpenter, Mellon Institute Report No. 28-30, EPA Pesticide Petition No. 9F0798.

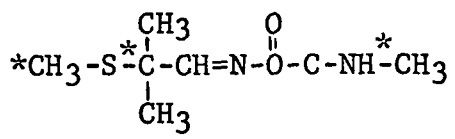
2/ Johnson, H., and C. Carpenter, Mellon Institute Report No. 29-90, EPA Petition No. 9F0798 (1966).

Metabolism

Absorption - Aldicarb is readily absorbed from the gastrointestinal tract of rats (Andrawes et al., 1967; Knaak et al., 1965; and Ryan, 1971[1-3/]), cows (Dorough et al., 1970 and Dorough and Ivie, 1968[4,5/]) and chickens (Hicks et al., 1972[6/]).

Distribution - Andrawes et al. (1967) found that aldicarb did not have a particular target tissue when given orally to rats. Hicks et al. (1972) found that labelled aldicarb or aldicarb sulfone given to laying hens reached a maximum concentration in muscle in 6 hr and declined during the next 10 days to 1/100 the highest concentration. Liver and kidney distribution was about twice as high as muscle.

Excretion - N. R. Andrawes et al. (1967) fed ^{35}S and ^{14}C aldicarb to rats and found 80% of radioactivity in the urine in 24 hr, and 1% in the feces. Only traces of unchanged aldicarb were found in the excreta. The 10 to 15% of the radioactivity in the animal after 24 hr was excreted more slowly. Knaak et al. (1965) fed aldicarb labelled at one of the three positions indicated below to rats:



1/ Andrawes, N. R., Jr., H. W. Dorough, Jr., and D. A. Lindquist, "Degradation and Elimination of Temik in Rats," J. Econ. Entomol. 60:979-987 (1967).

2/ Knaak, J. B., M. J. Tallant, and L. J. Sullivan, "The Metabolism of 2-Methyl-2-(Methylthio)propionaldehyde O-(Methylcarbamoyl)oxime in the Rat," J. Agr. Food Chem., 14:573-578 (1965).

3/ Ryan, A. J., "The Metabolism of Pesticidal Carbamates," CRC Critical Revs. Toxicol., 1(1):33-54 (1971).

4/ Dorough, H. W., Jr., R. B. Davis, and G. W. Ivie, "Fate of Temik-Carbon-14 in Lactating Cows During a 14-Day Feeding Period," J. Agr. Food Chem., 18(1):135-142 (1970).

5/ Dorough, H. W., Jr., and G. W. Ivie, "Temik-^{35}S Metabolism in a Lactating Cows," J. Agr. Food Chem., 16(3):460-464 (1968).

6/ Hicks, B. W., H. W. Dorough, Jr., and H. M. Mehendale, "Metabolism of Aldicarb Pesticide in Laying Hens," J. Agr. Food Chem., 20(1):151-156 (1972).

Aldicarb labelled at the S-methyl or tert-butyl positions was nearly all excreted in the urine and very little in the feces. The N-methyl labelled aldicarb was excreted about 35 to 40% in the urine and 20 to 25% in the expired air. Ryan (1971) gave a dose of aldicarb that was labelled with ^{14}C at the carbonyl carbon and found 62% excreted as $^{14}CO_2$ and 29% appeared in the urine. Dorough and Ivie (1968) fed aldicarb to a Jersey cow and found 90.2% in the urine, 3.0% in the milk and 2.9% in the feces. They also fed ^{35}S-aldicarb in milk to rats for 9 days. They found that 90% of each daily dose was excreted in the urine within 24 hr. Dorough et al. (1970) fed 0.12, 0.6, or 1.2 ppm aldicarb to a lactating cow for 14 days. Ninety-one to 94% was excreted in the urine, 3.0 to 3.5% in feces and about 1% in the milk. Hicks et al. (1972) fed laying hens 0.7 mg/kg aldicarb or aldicarb sulfone and found 75% in the feces in 24 hr.

Biotransformation -

Activation - In a recent review, Fukuto (1972)[1/] has pointed out that the aryl and alkyl carbamates are metabolized by oxidative pathways (by the mixed-function oxidases) or by cleavage of the carbamate moiety by direct enzymatic activity. Andrawes and Dorough (1970)[2/] found that aldicarb was oxidized to compounds which were also active cholinesterase inhibitors while hydrolysis inactivated them. Bull et al. (1967)[3/] found that the I_{50} for aldicarb was 1.8 x 10^{-5} M, for aldicarb sulfoxide, 8.1 x 10^{-7} M, and for aldicarb sulfone, 4.9 x 10^{-5} M using bovine red cell cholinesterase as the bioassay method. Shrivastava et al. (1971)[4/] found that mixed function oxidases of mosquitos oxidized aldicarb and that there was a requirement for $NADPH_2$.

Degradation - Andrawes et al. (1967) fed rats ^{35}S and ^{14}C aldicarb and identified seven metabolites in the urine. Half of the metabolites were not extracted into organic solvents and were not identified. Knaak

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1/ Fukuto, T. R., "Metabolism of Carbamate Insecticides," Drug Metab. Rev., 1(1):117-151 (1972).

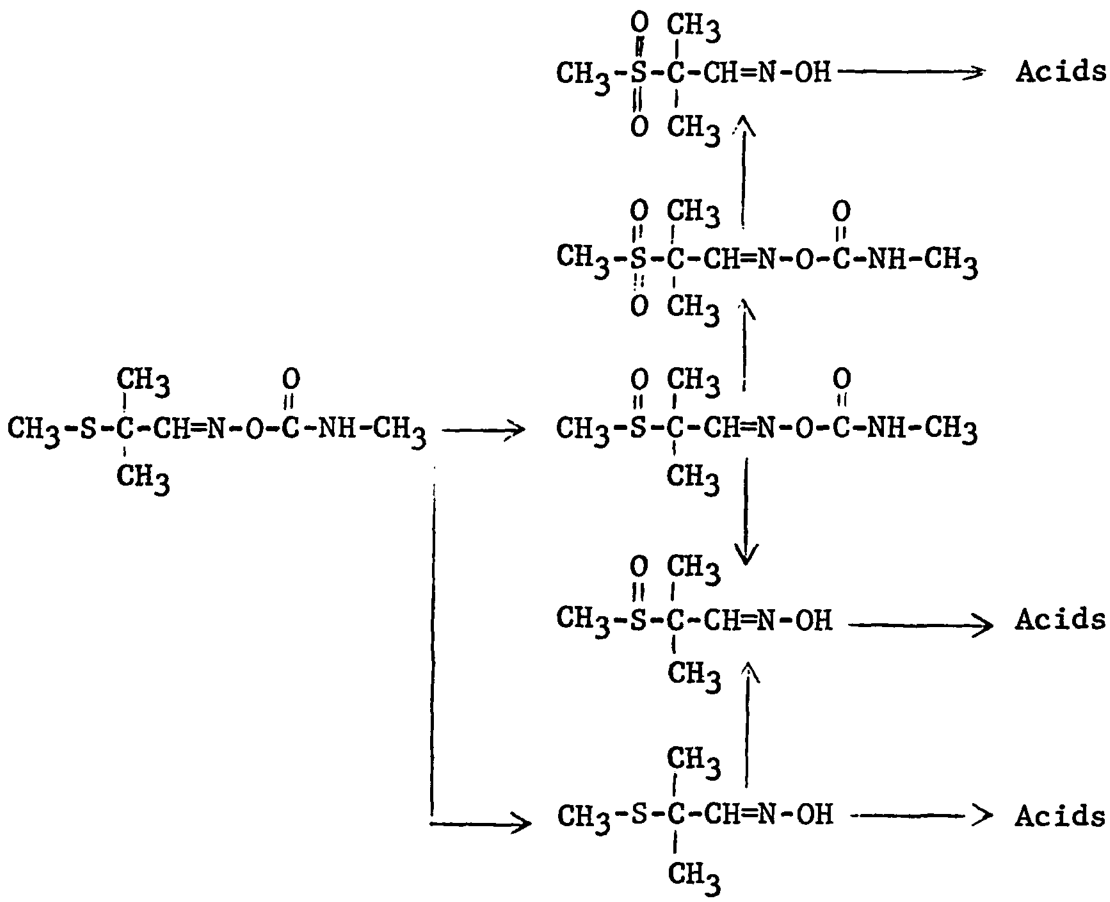
2/ Andrawes, N. R., Jr., and H. W. Dorough, Jr., "Metabolism of Temik in Boll Weevils and Houseflies," Texas Agricultural Experiment Station, Progress Report No. PR-2833 (1970).

3/ Bull, D. L., D. A. Lindquist, and J. R. Coppedge, "Metabolism of 2-Methyl-2-(Methylthio)propionaldehyde O-(Methylcarbamoyl)oxime (Temik, UC 21149) in Insects," J. Agr. Food Chem., 15(4):610-616 (1967).

4/ Shrivastava, S. P., G. P. Georghiou, and T. R. Fukuto, "Metabolism of N-Methylcarbamate Insecticides by Mosquito Larval Enzyme System Requiring NADPH," Entomol. Exp. Appl., 14(3):333-348 (1971).

et al. (1965) labelled the S-methyl-^{14}C, tert-butyl-^{14}C and N-methyl-^{14}C of aldicarb and found that rats metabolized it mainly to aldicarb oxime, aldicarb sulfoxide, sulfoxide oxime and sulfone oxime based on urinary recovery of these metabolites. The large amount of $^{14}CO_2$ excreted after dosing with N-methyl-^{14}C indicated an active N-demethylation while the $^{14}CH_3$-S-label did not yield any $^{14}CO_2$ indicating no thioether cleavage or demethylation of the sulfoxides or sulfones. Ryan (1971) also failed to find thioether metabolites. He suggested that thioethers are metabolized to sulfoxides and sulfones as the major metabolites *in vivo*.

Dorough et al. (1970) examined aldicarb metabolites in cows' milk and found aldicarb sulfoxide, aldicarb sulfone, oxime sulfoxide, oxime sulfone, nitrile sulfoxide, nitrile sulfone and five unidentified metabolites. No water soluble metabolites were found. Knaak (1971)1/ studied the metabolism of aldicarb in rats and proposed the following metabolic pathways:



Fukuto (1972) reported that the major organic-insoluble metabolite (80%) was a conjugate (glycoside) of 2-methyl-2-(methylsulfinyl) propanol. Others were the 2-methyl-2-(methylsulfinyl) derivatives of propionaldehyde, propinoamide and propionic acide. All were virtually nontoxic to rats.

Retention - Dorough et al. (1970) fed 0.12, 0.6 and 1.2 ppm aldicarb in feed to cows for 14 days. At the end of this period the livers contained

1/ Knaak, J. R., "Biological and Nonbiological Modifications of Carbamates," Bulletin of the World Health Organization, 44:121-131 (1971).

29, 123, and 164 ppb aldicarb equivalents, respectively. Other tissues had much less. Andrawes et al. (1967) fed ^{35}S and ^{14}C-labelled aldicarb to rats and found 10 to 15% excreted slowly over 1 to 10 days. Knaak et al. (1965) fed rats aldicarb labelled with ^{14}C at the S-methyl and tertbutyl carbon and found less than 0.1% in the carcass after 4 days. However, if the aldicarb was labelled at the N-methyl carbon, there was 8 to 10% of the carbon label in the carcass 11 days after treatment.

Dorough and Ivie (1968) fed a Jersey cow 0.1 mg/kg of aldicarb. Milk had 62 ppb at 3 hr, 10 ppb at 84 hr, 1 ppb at 276 hr and 0.1 ppb at 540 hr. Hicks et al. (1972) found that chickens that had a peak concentration of 0.2 to 0.3 ppm of aldicarb in muscle 6 hr after treatment had less than 0.01 ppm by the 10th day.

Effects on Reproduction

A three generation study was conducted in which aldicarb was incorporated into the diet of the parent generation of rats 84 days before mating occurred and into the diets of the subsequent generations at levels of 0.1 and 0.05 mg/kg/day. When the offspring were 112-days old, they were mated and their offspring collected and used as parents of F_3 pups. The presence of aldicarb at either dose in the diet did not appear to affect food acceptability in any generation.

Evaluation of the effect of aldicarb on reproduction performance was done by comparing indices for fertility, gestation, viability, lactation, mean weight of male pups, mean weight of female pups, micropathology on weanlings of the F_3 generation and micropathology of 90-day old adults of the F_3 generation. No statistical differences were found between the treated and control animals on any of the comparisons (Weil and Carpenter, 1964).1/

An abstract of a report on the study by Weil and Carpenter (1974)2/ indicated that up to 0.7 mg/kg/day aldicarb in the diet of rats for 3 generations had no adverse effect on fertility, gestation, gestation survival, 4-day, 14-day or 21-day survival. This dose caused no adverse effects in the dominant lethal mutagenicity test in rats.

Teratogenic Effects

The teratogenic potential of aldicarb in the diet of the rat has been reported (Weil and Carpenter, 1966). The dosages were 0.0, 0.04, 0.02 and 1.0 mg/kg.

1/ Weil, C., and C. Carpenter, Mellon Institute Report No. 27-158, EPA Pesticide Petition No. 0F1008 (1964).

2/ Weil, C., and C. Carpenter, Three Generation Reproductive and Dominant Lethal Study in Rats, unpublished report, No. 37-90, Carnegie-Mellon Institute, Pittsburgh, Pa. (1974).

Group 1 - Aldicarb was in the diet throughout pregnancy or up until the pups were weaned.

Group 2 - Aldicarb was available from the day the vaginal plug was present to the seventh day.

Group 3 - Aldicarb was given from day 5 to 15.

Five or six of the mothers per group were killed at the 20th day and a similar number were allowed to nurse and wean their young. Although the highest dosage level (1 mg/kg) approximated the oral LD_{50} value, no significant effects were found by any of the measurements associated with fertility, gestation, viability or lactation. There was no evidence of congenital malformation in the treated groups. Furthermore, the body weights of the mothers and the young were normal.

Behavioral Effects

Aldicarb (technical) was evaluated in comparative behavioral tests (Johnson and Carpenter, 1966)[1/] along with carbaryl and aldicarb sulfoxide. The chemicals were injected intraperitoneally into 10 rats (400 to 500 g) in each group. A discrete or noncontinuous avoidance behavior test was used employing a 10-compartment rat shock box.

The lowest behavioral effective dose in rats was found to be 0.266 mg/kg. This level was greater than the dosages of the other compounds such as eserine needed to produce disruptive behavioral effects on learned avoidance behavior.

Toxicity to Tissue Culture

Litterst et al. (1969)[2/] studied the effect of aldicarb on HeLa cells. The growth tubes were inoculated with 0.5 x 10^6 cells. The cells were incubated 48 hr and then the test compounds were added and incubation continued for another 48 hr. The LD_{50} (rats) for aldicarb was found to be 1 ppm. The ID_{50} (the concentration of insecticide in growth medium that causes a 50% reduction in cell number in 48 hr of incubation) in tissue culture was 750 ppm.

1/ Johnson, H. and C. Carpenter, Mellon Institute Report No. 29-89, EPA Pesticide Petition No. 9F0798, (1966).

2/ Litterst, C. L., E. P. Lichtenstein, and K. Kajiwara, "Effects of Insecticides on Growth of HeLa Cells," J. Agr. Food Chem., 17:1199-1203 (1969).

Mutagenic Effects

A dominant lethal test in rats showed no adverse effects at 0.7 mg/kg. See the preceding subsection, "Effects on Reproduction."

Oncogenic Effects

Investigators conducted an evaluation of aldicarb in relation to mouse skin carcinogenicity (Weil and Carpenter, 1966).1/ They used C3H/HeJ male mice since this strain has a high incidence of mammary tumors in breeding females. Also, there is a slightly lower incidence in virgin females. Hepatomas occur in the males. They painted 30 or 40 mice twice a week on hair-free skin of the back until death. As a negative control group, they utilized the statistics on the (C3H/HeJ mice) strain reported at a Gordon Conference in 1957: an incidence of 21% tumors occurred by the end of the life span of 184 males, three had skin tumors, and two were afflicted with lymphocyte leukemia. As a positive control, they painted another group of mice of the same strain with methyl cholanthrene. The results of the test are shown in Table 5. Aldicarb was non-carcinogenic to mice.

Effects on Humans

Three groups of four adult males were each given dose of an aldicarb solution corresponding to either 0.1, 0.05 or 0.025 mg/kg aldicarb.2/ Blood cholinesterase levels were monitored pre- and post-dosing and resulting symptoms were observed by physicians. All four men at the high dose developed mild cholinergic symptoms. While there was some variation in the blood cholinesterase values between different sampling periods due to aldicarb administration, the variation between values of controls taken 18 hr prior to ingestion and 1 hr prior, make statistical comparisons difficult. At 6 hr after dose, however, the means of all groups were statistically similar. Aldicarb's cholinesterase depression was rapidly reversible.

Symptoms of Aldicarb Poisoning - A case history of aldicarb poisoning experienced in a manufacturing plant has been reported (Sexton, 1966).3/

1/ Weil, C., and C. Carpenter, Mellon Institute Report No. 29-34, EPA Pesticide Petition No. 9F0798 (1966).

2/ Aldicarb Report, EPA Pesticide Petition No. 1F1008, Section C.

3/ Sexton, William F., Report on Aldicarb, EPA Pesticide Petition No. 9F0798, Section C (1966).

Table 5. INCIDENCE OF TUMOR OCCURRENCE IN MICE PAINTED WITH ALDICARB COMPARED TO METHYL CHOLANTHRENE PAINTED ANIMALS

	Aldicarb	Methyl cholanthrene
Concentration	0.125%	0.2%
Number of mice alive at 12 months	20	0
18 months	14	--
24 months	10	--
Appearance of first tumor		
Number of months of painting	17	3
Number of mice alive	16	25
Total number of mice with tumors	2	22
Carcinoma or sarcoma	1	21
Maximum number of months painted	28	11
Tumor index[a/]	18.2	95.6
Sarcoma or cancer index[b/]	9.1	91.3
Average latent period months[c/]		
Tumor	28	5.0
Cancer	28	6.1

a/ Tumor Index = $\frac{\text{No. of mice with tumors}}{\text{Effective group}} \times 100$

b/ Cancer Index = $\frac{\text{No. of mice with cancer}}{\text{Effective group}} \times 100$

c/ Average latent period = The length of time necessary to reach a 50% tumor (or cancer) index by a least squares calculation of tumor (or cancer) index versus time.

The subject was a foreman who ran a mechanical bagging machine for 1 day. The progress of his illness was as follows:

- 3:45 p.m. - No complaints.
- 5:00 p.m. - The subject experienced nausea, dizziness, depression, weakness, tightening of chest muscles.
- 8:00 p.m. - Plasma cholinesterase - 3.2 michel units. RBC cholinesterase - 1.47 michel units (a 57% depression of activity).
- 11:00 p.m. - Plasma cholinesterase - 2.96 michel units. RBC cholinesterase - 2.04 michel units. Still complained of tightness of chest.

He returned to work the next day without symptoms.

Occupational and Accidental Exposure Hazards

Manufacturing Operations - Studies were made in the 1960's on hazards connected with the manufacture of aldicarb in both plant and surrounding environment (Sexton, 1966). At the time manufacture started, observations were made on employees before, during and after an 8-hr shift. There were no observable physiological effects in the employees.

There was one obvious case of poisoning that occurred due to exposure to aldicarb which has been described in the symptoms section. There were no indications that concentrations as high as 0.05 mg/m^3 in the plant atmosphere produced a health hazard. Results obtained in the plant study (using midget impingers) indicated that the air in certain areas contained 0.01 to 0.52 mg/m^3 of aldicarb. Continuous sampling (Greenburg-Smith impingers) indicated an air-borne load of 0.006 to 0.333 mg/m^3. Samples (251) were also taken outside the plant north of the cooker. These were 38-min samples and only two exceeded 0.02 mg/m^3. None of the samples taken with the continuous samples exceeded 0.007 mg/m^3. Samples were taken at the vent of a caustic scrubber and the unneutralized aldicarb in the effluent ranged from 350 ug to 7,650 ug. Forty-six samples were taken at the perimeter of the plant and none of them were in excess of 4.3×10^{-4} mg/m^3.

Urine has been analyzed from employees working in the production and the formulation area of a plant (Ketchum, 1966).1/ These samples were analyzed for aldicarb sulfoxide, a known metabolite of aldicarb previously identified in rat urine. The results indicated little or no exposure to aldicarb.

An evaluation was made of air pollution around an aldicarb manufacturing plant and at a location where a formulation plant for aldicarb was operating (Peele, 1966).2/ During this evaluation 802 atmospheric samples were collected. It was stated that an atmospheric concentration of Temik® 10G in the range of 0.02 mg/m^3 was definitely not hazardous (apparently based on LD_{50} data).

Field Operations - A human exposure study was made during the field application of Temik® 10G on cotton (Williams, 1966).3/ The test took place on a 7-acre plot of ground. There were three plots in the area of about 2 acres. The treatment was as follows:

- Plot 1 - 0.5 lb active ingredient per acre.
- Plot 2 - 1.0 lb active ingredient per acre.
- Plot 3 - No treatment.

On six rows 450 ft long an application was made of 10 lb active ingredient per acre. The Temik® 10G was metered into the open furrow at the time of planting. The three participants in the test wore portable air sampling pumps which were operated continuously.

No appreciable amounts of Temik® 10G entered the atmosphere when the boxes and packages were opened and poured into the Gandy application hopper. One sampler operated for 5.5 hr inside the chemical storage building with an air flow of 7 liters/min and no appreciable amount of Temik® 10G was found in the air. The cholinesterase activity of the blood of the exposed personnel was checked at the start and the end of the day and no depression in activity was found. No indication was given that aldicarb sulfoxide, a metabolite of Temik®, existed in the urine of the men working in the field.

1/ Ketchum, N. H., Union Carbide Corp. Project No. 299A20, EPA Pesticide Petition No. 9F0798, (1966).
2/ Peele, R. E., Report on Aldicarb, EPA Pesticide Petition No. 9F0798, Section C., (1966).
3/ Williams, F., Report on Aldicarb, EPA Pesticide Petition No. 9F0798, Section C., (1966).

Accidents - Aldicarb has been cited in a small number of accidental exposure reports. The EPA Pesticide Accident Surveillance System (PASS) computerized data base lists a total of 11 episodes involving aldicarb. This data base includes most data reported for 1972 through January 1974. Eight of the 11 reported episodes took place in EPA Region IX. The available data, however, is not sufficient to establish any relationship between accident frequency and specific uses of aldicarb.

A report from Union Carbide[1/] regarding human exposure noted the following:

> An updating on experiences of overexposure to humans with TEMIK® 10G was submitted to EPA on May 10, 1972. In this summarization, all cases of alleged or actual illness due to handling or use of TEMIK® 10G were reported. At the formulation site (Thiokol Corp., Woodbine, Ga.) there were 10 cases of intoxication requiring medical attention in 1971. Three were hospitilized for one day or more; the others treated and released after 8 hours or less. With increased supervision to avoid preventable carelessness, there has been no recurrence of illnesses at this site. During 1971 and 1972, 9 cases were reported from commercial use. Five of these were subsequently found not to have been a result of exposure with TEMIK®. The confirmed cases resulted from almost total disregard of warning statements and safety precautions. One patient had an amazing concentration of 58 ppm aldicarb carbamates in the urine, indicative of an exposure of at least twice the rat oral LD_{50}. Despite indicated inadequate care and therapy at the hospital, eventually this individual recovered within 72 hours and returned to work within a week. Only one mild incident of poisoning has occurred in the field since this report. Recovery was complete in all cases.

1/ Union Carbide Corporation, Report on Aldicarb, EPA Pesticide Petition No. 3F141F, Section C.

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SUBPART II. C. FATE AND SIGNIFICANCE IN THE ENVIRONMENT

CONTENTS

This section contains data on the environmental effects of aldicarb on aquatic species, birds, beneficial insects, and non-target plants. Also considered are effects and residues in soil water and air and metabolic pathways in plants. The section summarizes rather than interprets scientific data reviewed.

Effects on Fish -

The toxic effects of aldicarb on fish were tested in laboratory studies on a number of species. Eighty bluegills weighing 5g each and divided equally into 16 two-liter jars, were exposed to a purified grade of aldicarb, aldicarb sulfoxide and aldicarb sulfone (Clarkson, 1968)[1/] The 96 hr-LC_{50} values were 0.1, 4, and 64 ppm, respectively.

The acute toxicity of Temik 10G in 130 rainbow trout (*Salmo gairdneri*) (10 per trial) has also been studied (Beliles et al., 1966)[2/]. On an active ingredient basis, the LC_{50} values and 95% confidence limits for a 48-hr exposure were 1.12 (0.78 to 1.60 ppm), for a 96-hr exposure they were 0.88 ppm (0.62 to 1.25 ppm). Signs of intoxication were observed in 6 hr at concentrations of 1.0 and 1.8 ppm. Other toxicity values obtained (Knott and Beliles, 1966)[3/] on bluegill (*Lepomis macrochirus*) were: LC_{50} (48 hr) 0.175 ppm (0.159 to 0.192 ppm) and LC_{50} (96 hr) 0.145 ppm (0.124 to 0.169 ppm).

It has been reported (Department of Interior, 1964)[4/] that the LC_{50} values for exposures of aldicarb to bluegill (*Lepomis macrochirus*) and rainbow trout (*Salmo gairdneri*) were 150 µg/liter (48 hr), 76 µg/liter (96 hr), 800 ug/liter (48 hr) and 560 ug/liter (96 hr), respectively. Carter (1971)[5/] working with channel catfish (*Ictalurus punctatus*) found the LC_{50} 24-hr exposure to aldicarb to be 1,600 µg/liter.

One study (Mulla, not dated)[6/] evaluated the toxicity of aldicarb under field conditions using mosquito fish (*Gambusia affinis*) and tadpoles of the western toad (*Bufo boreas*). Mulla considered the application of 1 lb of aldicarb per acre to be safe for mosquito fish. When 10 lb of aldicarb was applied per acre, there was no observed effect on tadpoles.

1/ Clarkson, Summary with Respect to Guidelines PR 70-15 Project No. 111B32, EPA Pesticide Petition File, (1968).

2/ Beliles et al., Report on Aldicarb, EPA Pesticide Petition No. 9F0798, Section C, Book III (1966).

3/ Knott and Beliles, Report on Aldicarb, EPA Pesticide Petition No. 9F0798, Section C, Book III (1966).

4/ U. S. Department of Interior Fish Pesticide Laboratory, Columbia, Mo., unpublished data, (1964).

5/ Carter, F. L., "In *vivo* Studies of Brain Acetylcholinesterase Inhibition by Organophosphate and Carbamate Insecticides in Fish," *Diss. Abstr.* 32(5): 27, 2-73 (1971).

6/ Mulla, Summary with Respect to Guideline, PR 70-15, EPA Pesticide Petition File.

Carter (1971) subjected channel catfish weighing about 8.5 grams to sublethal doses of aldicarb (1.6 ppm) to determine potency for brain cholinesterase inhibition and enzyme recovery rate. In static exposure tests it was found that 0.315 ppm of aldicarb caused a 50% inhibition of the enzyme. When brain cholinesterase was inhibited 80-to-90% by aldicarb, under static conditions, 6-to-10 days were required for 80% recovery of normal activity. Aldicarb produced scolinosis (a lateral curvature of the spine) with localized hemorrhaging at sublethal concentrations in channel catfish. Aldicarb also produced calcium deposition and fusion as long term effects.

The sequential toxicity symptoms and associated inhibition ranges were hyperactivity (35 to 75%), lethargy (65 to 86%), body paralysis (65 to 85%), scoliosis (62 to 89%), loss of equilibrium (78 to 92%) and opercular and mouth paralysis with ensuing death (50 to 95% maximum but the usual range was 65 to 85%) (Carter, 1971).

Effects on Birds

Hudson et al. (1972)[1/] studied the effect of age on the acute oral toxicity of a number of pesticides in mallard ducks (*Anas platyrhynchos*). Four groups were used in these tests. The age and weights (mean) were as follows:

36 ± 3 hr	-43
7 ± 1 day	-98 g
30 ± 3 days	-480 g
6 months ± 3 days	-1,254 g

The sex could not be determined in ducks less than 2 months old. At the older ages, three males and two females or two males and three females were used at each dose level. The dosage form was gelatin capsules. The toxicity response with aldicarb for the various age groups was as follows:

Age	LD_{50} mg/kg (95% confidence limits)
36 ± 3 hr	1.92 (1.55-2.37)
7 ± 1 day	3.60 (2.90-4.49)
30 ± 3 days	6.73 (5.29-8.55)
6 months ± 3 days	4.44 (3.49-5.65)

1/ Hudson, R. H., R. K. Tucker, and M. A. Haegele, "Effect of Age on Sensitivity: Acute Oral Toxicity of 14 Pesticides to Mallard Ducks of Several Ages," *Toxicol. Appl. Pharmacol.* 22:556-561 (1972).

A safety evaluation has been made of Temik 10G in the diet of bobwhite quail (Colinus virginianus) Beliles, 1966). Twenty quail (8 weeks old) were placed in a control group; each test group had 10 quail. The birds were fed Temik 10G and the dosages were; 560, 1,000, 1,800, 3,200, and 5,600 ppm. The quail were fed 7 days and returned to the basic diet for 3 days. During the 7-day feeding trial, there was no significant decrease in food consumption or the body weight of the survivors. Tremors and ataxia occurred in the quail that received 1,800, 3,200 and 5,600 ppm in the diet. There were no cases of tremor in the 1,000-ppm group. The quail that received 3,200 ppm of Temik 10G in the diet had pale livers at necropsy. The quail that received Temik G at lesser levels had no lesions. Denver Wildlife Research Center (1974)1/ evaluated the toxicity of aldicarb in mallard duck (Anas platyrhynchos) and California quail (Lophertix californicus). At the 95% confidence level, the LD_{50} in male mallard was 60.0 mg/kg, for female quail it was 2.58 mg/kg, and for male quail it was 4.67 (3.32-6.56) mg/kg.

Hill (1974)2/ evaluated the comparative toxicity of aldicarb to Japanese quail (Coturnix coturnix japenica) ring-necked pheasant (Phasianus colchirus) and mallard duck (Anas platyrhynchos). The 95% confidence limit was used. The LC_{50} for 14-day old quail was 381 ppm (317-453); for 10-day old pheasant there was no mortality at 300 ppm; for 5-day old mallard the LC_{50} was 594 ppm (507-695); and for 10-day old mallard the LC_{50} was less than 1,000 ppm (70% mortality at 1,000 ppm). Aldicarb 10% granular was applied at the rate of 1.5 lb AI per acre in dryland and irrigated fields. Aldicarb residues in wildlife were determined by a gas chromatographic-flame photometric analysis method. Samples of animals and birds were collected where found, usually within 1/2 mile of a treated field. Birds were killed as near a treated field as possible; coyotes were trapped around watermelon fields.

Throughout this test, no evidence of mortality in the animal or bird populations was observed in the treated or adjacent areas. Residues were detected in only one bird of 14 sampled; this was an oriole which contained 0.07 ppm of aldicarb and/or metabolites. No detectable aldicarb residues were found in any of eight (unspecified) terrestrial animals sampled.

1/ Denver Wildlife Research Center, "Toxicity of Aldicarb to Mallard and Quail," unpublished report, 1974.

2/ Hill, Elwood F. (U.S. Department of Interior, Patuxent Wildlife Research Station), Toxicity of Aldicarb to Wildlife, personal communication to Criteria and Evaluation Division, Office of Pesticide Programs, EPA (1974).

Evaluations on game birds were conducted initially in North Carolina. Three separate field trials using bobwhite quail (Colinus virginianus) were made to determine how placement and method of application of aldicarb might influence quail populations under simulated resident conditions. Six pairs of adult birds in small cages were randomly placed in a field of cotton that had been treated with aldicarb in-furrow at planting and side-dressed at squaring time. During a 2-week exposure period, observations were made on survival, symptoms, and weight gains of birds on treated and untreated areas. A single bird died in the treated zone.

A second quail trial involved different methods of application and treatment rates. Aldicarb was applied to noncropped land as an in-furrow treatment at depths of 1/2 and 2 in; and also broadcast on the soil surface and incorporated 4 to 6 in deep by rototilling. One plot was treated on the surface at 8.9 lb active ingredient per acre without incorporation. Duplicate plots were established with one group receiving sprinkler irrigation, while the other remained in "dryland" condition. Birds were caged over the treated areas and observations made during a 1-week period. Results showed that (1) aldicarb placed 2 in deep in-furrow caused no mortality of birds; (2) exaggerated dosages broadcast and incorporated did not create any appreciable hazards to hunger-stressed, captive quail; (3) treated land, promptly irrigated or receiving rainfall presented no hazard from completely exposed granules.

To eliminate the restrictions that small cages caused to birds' normal foraging habits, further field trials were conducted in North Carolina. Cotton plantings of 0.14 acre were treated with two formulations of aldicarb at 5.3 lb active ingredient per acre banded 12 in, in-row and incorporated 4 to 6 in deep by rototilling at seeding time. The entire plot was enclosed with wire fencing to prevent escape and predation. Twenty-four mature bobwhite quail which had been wing-clipped were released in each treated zone and supplied with cover, food and water. A similar untreated plot was established. None of the plots received supplemental water, and rainfall was about 0.4 in during the 16- to 20-day observation periods. One bird was found dead in the area treated with experimental granules.

Expanded evaluations with birds were made in California. Ring-necked pheasants (Phasianus colchicus) and California quail (Lophortyx californicus) were used in both caged and fenced field trials in sugar beet and cotton plantings. Rates and placements of aldicarb followed the label directions required for nematode control in both crops (see Table 9, p. 88). Results from these tests showed that (1) aldicarb was not hazardous to either species of upland game bird when used in accordance with label directions; (2) total consumption of emerging sugar beet seedlings by hunger-stressed birds did not result in mortality; seedlings contained up to 19 ppm of total toxic aldicarb carbamate residues; and (3) exposed spills of granules, were hazardous; quail seemed to be more apt to take up the grit product than the pheasants.

Extensive monitoring for effects on wildlife of sugar beet fields tested with aldicarb was carried out in 1970 and 1972 in England. The 1970 trials were conducted on two independent sites where a diversity of wildlife existed adjacent to commercial sugar beet fields that had been treated with aldicarb at rates up to 0.89 lb active ingredient per acre drilled in-furrow with the seed planting. Both sites were observed in the post treatment periods up to 32 days (Site A) and 43 days (Site B). The results are summarized in the following table:

Table 6. SUMMARY OF ANIMAL SPECIES RECORDED IN AND AROUND TWO SUGAR BEET FIELDS TREATED WITH ALDICARB AT 0.89 LB/ACRE[a]

Effect on animal species	Site A[c]	Site B[d]
Total species recorded[b]	57	51
Total species seen before treatment	44	31
Total species seen after treatment	41	44
Total species seen before and after treatment	38	24
Number of dead animals found	4[e]	6[f]

Source: Union Carbide Corporation.

a/ Commercial formulation applied in-furrow with sugar beet seed at planting, in Suffolk County, England, 1970.
b/ Includes eight species of mammals; remainder were birds.
c/ 6.25 Acres treated, solid block.
d/ 5.0 Acres treated, solid block.
e/ Ring-necked pheasants (*Phasianus colchicus*).
f/ Five wood pigeons (*Columba palumbus*) and one yellow hammer (*Emberiza citrinella*).

To explore the impact of aldicarb granular applications on natural wildlife populations, a second monitoring study was conducted in 1972 in the same general area used for the previous trials. About 25 acres of sugar beets were treated with aldicarb at 0.89 lb active ingredient per acre at planting time. Depth of drilling was about 0.8 in. The area selected had an abundance and diversity of wildlife. Very extensive assessments of the small mammal and bird populations were made in the 6-week period following application. The survey showed no change in diversity or numbers of birds after treatment, and many successfully reared young. Of four birds found dead in the area, only one linnet (*Acanthis cannabina*) was confirmed to contain residues of aldicarb.

Since spills of granular aldicarb can occur, a field study was conducted in New Jersey to determine the extent of hazard presented by exposed granules to Virginia white-tail (Odocuileus virginianus) deer and the common rabbit (Sylvilages Floridenus). Sufficient animals of both species were confined in enclosures expansive enough to permit normal grazing and active movement. The tests were conduced in 1969 under supervision of the New Jersey Fish and Game Commission. No adverse effects occurred from the simulated spills of aldicarb during an exposure period of 7 days. None of the animals sought out or fed on the granules in preference to their food. The quantity of spilled granules exceeded the maximum label dosage for crop use by at least sevenfold. Since there were obvious indications of feeding activity around the spills, it was concluded that neither wild deer nor rabbits were attracted to, or would feed on, piles of aldicarb granules.

Union Carbide (1971)[1/] reported a sugar beet-Temik 10G study in Greenfield, California, revealing that pheasant consumed nearly all foliage from beets treated with three applications of Temik 10G at 2 lb AI/acre (one at planting, two side-dress after emergence). Neither pheasant nor California quail (which ate less green tissue) were affected indirectly from plants containing 19 ppm total aldicarb carbamate residues.

A granule preference test with pheasants was conducted by the New Jersey Fish and Game Commission in 1970. Captive adult pheasant were fed cracked grains from a grain feeder. Half of one replenishment was substituted with Temik®. Only one mortality in nine adults occurred in a five-day observation period.

Another field study using a fenced area was conducted on cotton with the maximum Temik 10G side-dressing rate (3 lb AI/acre). The work was carried out in cooperation with the California Department of Fish and Game, Madera County, California. Neither California quail nor ring-necked pheasants consumed any cotton plant tissue which contained 19.5 ppm aldicarb carbamates. Some mortalities of birds did occur from spilled granules on one of the ends of treated row. The California Fish and Game Pesticide Wildlife Investigations group are reportedly satisfied with the proposed label uses on sugar beets and commercial usage of Temik 10G, provided the label specifies that spills on the turn-row are covered with soil immediately by discing or other mechanical means.

In a cooperative test in west Texas with the U.S. Department of Agriculture, Plant Projection Division, Texas State Department of Agriculture, and Union Carbide, over 300 acres of nearly isolated cotton was treated with Temik 10G at planting and side-dress. The fields were surveyed for bird activity. Three mourning doves (Zenaidura macroura) were found dead on the fringes of the field from the at-planting application. However, considerable dove activity was present in the area and the loss of birds was insignificant to the high number of birds observed.

1/ Union Carbide Corporation, "10G Aldicarb Pesticide Wildlife Reports," unpublished data, submitted in support of EPA Registration No. 1016-69, Salinas, California (1971).

In a Union Carbide Corporation Report (1970)[1/] the potential hazard of Temik® was tested on ten ring-necked pheasant (Phasiana colchicus) by the New Jersey Division of Fish, Game and Shell Fisheries. The pheasant (one year of age weighing from 3-5 lb) were placed in a 40' x 10' x 6' pen and exposed to six-8 oz spills then to 24 oz of Temik® (corn cob grit). Finally all feed was removed and replaced with 48 oz of Temik®, one pheasant was found dead. The pheasant were not readily attracted to Temik® and the danger from simulated spills seem to be minimal. However, mortality may occur in marginal pheasant range where natural feeds are at a minimum.

A further test in Madera County California (Union Carbide, 1971) evaluated the potential hazard of Temik® to California quail and ring-necked pheasant in a cotton planting. A large plot (125' x 150') of two-month old cotton was side dressed 6 to 8 in to each side and 2 to 4 in deep. This plot and a smaller untreated plot were enclosed with a 5' x 1" mesh fence. In the Temik® treated plot 21 adult quail, 10 immature pheasants, and 12 adult pheasants were introduced. Ten adult quail, 5 immature pheasants, and 5 adult pheasants were placed in the untreated plot. By the end of the 3rd day of observation 7 quail and 4 immature pheasants were dead in the Temik® plots; wild birds foraged in a similar treated area without effect. Neither pheasants nor quail fed on two-month old cotton plants. Therefore, there would be no hazard from indirect intoxication.

Effects on Beneficial Insects

Bees - Bailey and Swift (1968)[2/] classify aldicarb as "highly toxic" to honey bees, based on laboratory and field tests conducted in California on alfalfa, cotton, citrus, ladino clover, and sweet corn.

The comparative toxicity of aldicarb to honeybees (Apis mellifera) was evaluated in a laboratory test at 48 hr with 80°F temperature and a relative humidity of 65% (Atkins et al, 1973)[3/]. The LD_{50} was found to be 0.285 µg/bee with a slope value of 5.64 probits.

Moorefield (1974)[4/] reported that aldicarb was highly toxic to worker honeybees by topical application of technical active ingredient. However, when granular aldicarb is applied to the soil, direct exposure to bees is eliminated. In field studies with seed alfalfa in California, no mortality occurred to bees or their colonies from foraging on blooming alfalfa for 2 weeks after the crop had been side-dressed with aldicarb at the rate of 2.7 lb AI per acre.

1/ Union Carbide Corporation "Temik 10G Aldicarb Pesticide Wildlife Reports," unpublished data submitted in support of EPA Registration No. 1016-69, Salinas, Calif. (1970).

2/ Bailey, J.B., and J. E. Swift, "Honeybees and other Pollinating Insect Losses," Pesticide Information and Safety Manual, University of California, Division of Agricultural Sciences, pp. 7-10 (1968).

3/ Atkins, E. L., E. A. Greywood, and R. L. MacDonald, "Toxicity of Pesticide and Other Agricultural Chemicals to Honeybees," University of California Extension Laboratory Studies (1973).

4/ Moorefield, H. H. (Union Carbide Corporation), Data on Temik Aldicarb Pesticide Environmental Impact, personal communication (1974).

Mizuta and Johansen (1972)[1/] investigated the hazard of aldicarb and several other plant-systemic insecticides to nectar-collecting bees. In the greenhouse, alfalfa leaf cutting bees (Megachile rotundata) were exposed to white sweetclover (Melilotus) treated with aldicarb at the (unspecified) standard field dosage rate. In field tests, honeybees (Apis mellifera) were exposed to birdsfoot trefoil (Lotus sp.) treated with aldicarb at the recommended rate. There are no hazards to the bees from nectar of treated plants.

Moorefield (1974) reported that populations of other pollinators such as bumblebees, leafcutter bees, and alkali bees do not appear to be adversely affected by the use of aldicarb as recommended on labels.

Parasites and Predators - Ridgway et al. (1967)[2/] studied the effects of in-furrow applications of aldicarb (and several other systemic insecticides) to cotton on populations of the bollworm (Heliothis zea), the tobacco budworm (Heliothis virescens) and of arthropod bollworm predators. Aldicarb 10% granular was applied on four different plots varying from 0.3-2.0 acres at the rate of 1 lb AI per acre as an in-furrow application and, in another test, as a sidedress at the rates of 0.9 and 2.2 lb AI per acre. Results indicated that populations of certain beneficials, particularly those belonging to the order Hymenoptera were significantly reduced by aldicarb treatments. Spiders (order Araneida) and certain groups of hymenopterous insects (families Braconidae and Ichneumonidae) were less affected. In two experiments, the number of eggs and larvae of Heliothis spp, increased as the population of predators decreased. These results demonstrated the importance of natural populations of predators in suppressing populations of Heliothis spp. The mechanisms by which the beneficial arthropods are affected are not clear. They may feed on sap, pollen, or exudates from treated plants or on plant pests which feed on treated plants; and/or they may lack food because their hosts are destroyed by systemic insecticides.

Coppedge et al. (1969)[3/] applied aldicarb 10% granular as a side-dressing to 4- to 5-acre plots of cotton for the control of overwintered bool weevils (Anthonomus grandis). Rates of active ingredient application were 1 lb/acre; 2 lb/acre; 1 lb/acre + 2 lb/acre 10 days later; and 2 lb/acre + 2 lb/acre 9 to 10 days later. Treated plots were sampled for beneficial insects, including eight species of insect predators and spiders. Insect predators monitored in treated and untreated plots included the genera Notoxus, Hippodamia, Scymnus, Collops, Nabis, Geocoris, Orius, and Chrysopa. The average number of beneficial insects and spiders found per

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1/ Mizuta, H.M., and C. A. Johansen, "Hazard of Plant-Systemic Insecticides to Nectar-Collecting Bees," Wash. Agr. Exp. Sta. Tech.Bull. (72)(1972).

2/ Ridgway, R.L., P. D. Lingren, C. B. Cowan, Jr., and J. W. Davis, "Populations of Arthropod Predators and Heliothis spp. after Applications of Systemic Insecticides to Cotton," J. Econ. Entomol., 60(4):1012-1016 (1967).

3/ Coppedge, J.R., D. A. Lindquist, R. L. Ridgway, C. B. Cowan, and L. A. Bariola, "Sidedress Applications of Union Carbide UC-21149 for Control of Overwintered Boll Weevils," J. Econ. Entomol., 62(3):558-565 (1969).

400 ft of row in the treated plots was inversely related to the dosage of aldicarb used. An average of 13.4 beneficial insects and 3.4 spiders/400 ft of row were counted in the plot that received 2 + 2 lb aldicarb per acre, compared to 34.2 beneficial insects and 6.7 spiders in the untreated plots. More bollworms (Heliothis zea) and tobacco budworms (Heliothis virescens) were found in the treated than in the untreated plots.

Bariola et al. (1971)[1/] conducted large-scale field tests of four different farms varying from 10-40 acres with soil-applied aldicarb for suppression of the bollweevil (Anthonomus grandis) in northern Texas. Aldicarb 10% granular was applied at the active ingredient rate of 1 lb/acre in-furrow at planting time; 2 lb/acre sidedressed when cotton plants began to square; 2 lb/acre sidedressed when plants began to square + 2 lb/acre 10 to 14 days later. The aldicarb applications reduced populations of adult bollweevils 94 to 96% until late August when there is extensive seasonal movement, of bollweevils from untreated cotton. This would effect the results of the aldicarb treatment. Populations of bollworms (Heliothis spp.) increased in most aldicarb-treated plots. The in-furrow aldicarb treatment at planting resulted in an average increase of bollworm larvae of 17%; one sidedressing, 141%; two sidedressings, 126%. These increases in bollworm larvae appeared to be with reductions in the numbers of insect predators. There was also some reduction in the numbers of beneficial spiders.

Cate et al. (1972)[2/] studied the toxicity of aldicarb (and several other insecticides) applied topically and orally to an ichneumonid parasite (Campoletis perdistinctus). Eighty-eight trials using 10 adult C. perdistinctus per cage were placed in the greenhouse on individual flowering cotton plants treated with the pest insecticides. When aldicarb was applied to the stem of the cotton plants at the rate of 10 mg active ingredient per plant, the plants remained toxic to the parasite for more than 21 days. When adult C. perdistinctus were confined in petri dishes on leaves taken from cotton plants treated with aldicarb by soil application at the rate of 34 mg active ingredient per plant, there was 80% mortality 3 days after treatment, 42% after 7 days, and 9% after 14 days. Leaves taken from plants that had received a stem application of aldicarb at the rate of 10 mg active ingredient per plant resulted in 5% mortality 3 days after treatment; 6% mortality 7 days after the treatment (the latter two values not significantly different from parasite mortality in the untreated controls at the 5% level. Nectar collected from greenhouse grown cotton plants treated with aldicarb via the soil at 34 mg active ingredient per plant produced more than 50% mortality of adult C. perdistinctus for at least 7 days after treatment, while stem application of aldicarb at 10 mg active ingredient per plant produced 26 to 28% mortality 3, 7, and 14 days after treatment. In field tests, one aldicarb sidedress application of 2 lb AI per acre produced 18% mortality of adult C. perdistinctus cages on treated plants 3 days after treatment, and 100% mortality of adults offered nectar of treated plants 3 days after treatment.

1/ Bariola, L. A., R. L. Ridgway, and J. R. Coppedge, "Large-Scale Field Tests on Soil Applications of Aldicarb for Suppression of Populations of Boll Weevils," J. Econ. Entomol., 64(5):1280-1784 (1971).

2/ Cate, J. R., Jr., R. L. Ridgway, and P. D. Lingren, "Effects of Systemic Insecticides Applied to Cotton on Adults of an Ichneumonid Parasite, Campoletis perdistinctus," J. Econ. Entomol., 65(2):484-488 (1972).

Kinzer et al. (1974)[1/] studied the effects of aldicarb applications to cotton on populations of the bollworm (H. zea), the tobacco budworm (H. virescens) and eight arthropod predators, including largely the same species as monitored by Coppedge et al. (1969). Aldicarb 10% granular was applied in-furrow, or as one or two sidedressings; the total amount of active ingredient applied ranged from 1.7 to 2.2 lb/acre. In three field tests, the arthropod predator populations were reduced following these applications. However, at the time of the Heliothis infestations, the reduction in arthropod predator populations did not seem great enough to cause the Heliothis increases that occurred. Results of a field-cage test indicated that tobacco budworm moths, when given a choice between aldicarb-treated and untreated cotton plants, preferred to oviposit on the treated cotton. The authors concluded that reduced arthropod predator populations following aldicarb treatments do not appear to be the sole factor causing Heliothis increases. The increased Heliothis oviposition on aldicarb-treated cotton coupled with reduced arthropod predator populations could greatly increase Heliothis populations on cotton treated with aldicarb.

Further studies on the effects of aldicarb on beneficial insects have been reported (Moorefield 1974).

T. R. Pfrimmer, Stoneville, Mississippi, applied aldicarb granules with the seed at planting time to cotton at rates of 0.1 to 1.0 lb active ingredient per acre without diminishing beneficial insect populations. C. B. Cowan, Waco, Texas, applied aldicarb at 0.6 and 1.0 lb active ingredient per acre at planting, followed by 0.6 lb active ingredient per acre sidedressed at the four-leaf stage of cotton, 8 weeks after planting. The numbers of predators and parasites were not adversely affected. R. L. Hanns, at College Station, Texas, reported that more predaceous insects and spiders were in plots treated with aldicarb at the rates of 0.25 to 2.0 lb active ingredient per acre than in the checks which may have been due to the faster fruiting on the treated cotton. F. R. Gilliland reported that populations of beneficial insects on cotton in Auburn, Alabama, were depressed during early June in plots treated with aldicarb, but late in June and during July, little differences were observed between the populations of beneficials in treated versus untreated plots.

Predators that also feed on plant juices such as Geocoris, Nabis and Orius are reduced in numbers following aldicarb applications, but that the effect is transient, and that the predators frequently reestablish as the aldicarb residues dissipate to prey on insects against which aldicarb is ineffective, e.g., Heliothis and other lepidopterous genera. Coccinella, Collops, Chrysopa, and Coleomegilla genera; certain members of the Reduviidae and Carabidae families; spiders; and predatory mites appear to be less affected by aldicarb. Populations of these species may temporarily decrease in numbers simply from lack of food sources. Occasionally, increases in these species have been noted if a large number of prey abound following an aldicarb application. According to Moorefield (1974), aldicarb treatments have no apparent effect on parasitic insects of the Braconidae, Encyrtidae, Eulophidae, Ichneumonidae, Pteromalidae, Scelionidae, and Trichogrammatidae families.

Effects and Residues in the Soil

Biota - Spurr and Sousa (1974)[1/] studied potential interactions of aldicarb and several of its metabolites to nontarget organisms. The test bacteria and fungi were cultured in the laboratory on potato dextrose agar to which aldicarb and several of its metabolites and related chemicals were added at a final concentration of 100 ppm. The plates were inoculated with bacteria or fungi, incubated for 2 days at 30°C, and the growth of the test organism rated visually. In another test series, mycelial growth in the soil was studied in steam-pasteurized Norfolk sandy loam soil mixed with fungal inoculum grown on a cornmeal-sand medium in paper cups. Aldicarb, its metabolites and related chemicals were added to the soil at a final concentration equivalent to 50 lb active ingredient per acre, a fivefold exaggeration of the maximum use rate of aldicarb. The treated cups were incubated for 2 days at 21°C and 96% relative humidity, after which time surface growth was visually rated.

Organisms tested in this manner included eight species of bacteria and five species of fungi commonly found in different habitats, including saprophytes and parasites. Aldicarb and most of the related chemicals did not inhibit the growth of bacteria or fungi under these test conditions. The authors then investigated whether aldicarb would support the growth of microorganisms that might aid in its degradation and metabolism. Three soil fungi, i.e., *Rhizoctonia solani*, *Aspergillus niger*, and *Alternaria solani*, made only slight growth on inorganic salts or on aldicarb (1,000 ppm) plus inorganic salts. *Rhizoctonia solani* made a fair amount of growth on mannitol (1,000 ppm) plus inorganic salts. When both aldicarb and mannitol were present (1,000 ppm of each), the growth of *R. solani* was more than twice that with mannitol alone. By contrast, *A. niger* grew appreciably only on mannitol in the absence of aldicarb, while *A. solani* grew on manmitol with or without aldicarb present. *Agrobacterium tumefaciens*, a plant-pathogenic soil bacterium and a close relative of the nodule forming (beneficial) bacterium *Rhizobium*, had very little growth on aldicarb alone; its growth on aldicarb plus mannitol was half that observed on mannitol alone.

Spurr and Sousa imply from their observations that the growth of soil microorganisms should not be adversely affected by the concentrations of aldicarb applied for pest control purposes.

Lin et al. (1972)[2/] studied the effects of aldicarb and several other insecticides on the nitrification and growth rates of legume crops. Tested by the disc inhibition method, aldicarb was one of four (out of nine) insecticides which induced a high degree of growth inhibition of *Rhizobium.* Four different species of *Rhizobium* showed different degrees of sensitivity to the insecticides. At field use rates (5 ppm), aldicarb and the other

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1/ Spurr, H. W., Jr., and A. A. Sousa, "Potential Interactions of Aldicarb and its Metabolites on Nontarget Organisms in the Environment," *J. Environ. Quality*, 3(2):130-133 (1974).

2/ Lin, S., B. R. Funke, and J. T. Schulz, "Effects of Some Organophosphate Carbamate Insecticide on Nitrification and Legume Growth," *Plant Soil*, 37(3):489-496 (1972).

insecticides studied had little effect on the nitrification rate, or on the growth of alfalfa or sweet clover seedlings. At exaggerated rates (50 and 500 ppm), aldicarb and most of the other insecticides inhibited nitrification and seedling growth.

Gawaad et al. (1972)1/ studied the effects of aldicarb (and several other insecticides) on the nodulation of Rhizobium phaseoli and R. trifolii in broad beans and Egyptian clover. Aldicarb had no effect on the nodulation rate up to a concentration of 40 ppm. Several other insecticides tested in the same manner did not influence nodulation at rates of 10 ppm (approximate field use rates), but fewer nodules were found when these compounds were applied at 40 to 50 ppm. The Rhizobium species were more tolerant to aldicarb than to chlorinated hydrocarbon insecticides studies. Anderson (1971)2/ investigated the capacity of several fungi isolated from an agricultural loam soil to degrade DDT or dieldrin. In shake cultures, Mucor alternans partially degraded DDT in 2 to 4 days into two water-soluble metabolites. Aldicarb did not affect the growth rate of the fungus or its degradation of DDT. Heungens (1970)3/ investigated the effects of aldicarb and several other pesticides on the soil fauna in azaleas. The test plants were grown in pots in the greenhouse in a conifer litter substrate. Aldicarb (applied at the rate of 3 mg/liter) was among the pesticides most toxic to oribatids, while it was less toxic than several other materials to earthworms, enchytraeids, predatory mites, and collembola.

There were no additional reports found on the effects of aldicarb on lower terrestrial organisms. The few reports reviewed above indicate that at concentrations that might result from normal use in accordance with label recommendations, aldicarb was not toxic to the bacteria and fungi against which it was tested. However, this data is insufficient to determine whether or not the use of aldicarb, pesticide recommended only for soil application, presents specific hazards to the soil microflora or microfauna under field use conditions.

Residues in Soil/Laboratory Studies - Coppedge et al. (1967)4/ studied the fate of radio-labeled aldicarb in cotton plants and in three types of soil (Houston clay, Norwood silty clay loam, and Lakeland fine sand) in the laboratory. The three soil types varied considerably in organic matter content pH, water holding capacity, and sand, silt, and clay content. Two hundred µg of ^{35}S-aldicarb in 50 µl of water were added to 10-g samples of the different soils, mixed thoroughly, and

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1/ Gawaad, A.A.A., E. S. N. M. Ali, and A. Y. Shazli, "Leaching of Some Soil Insecticide in Three Egyptian Soils," Bull. Entomol. Soc., Egypt Econ. Ser., (5):23-26 (1971).

2/ Anderson, J.P.E., "Factors Influencing Insecticide Degradation by a Soil Fungus, Mucor alternans," Diss. Abstr. Int., 32(6):3114B-3115B (1971).

3/ Heungens, A., "The Influence of Some Pesticides in the Soil Fauna in Azalea Culture," Meded. Fac. Landbouwwet. Ryksuniv, Gent, 35(2):717-729 (1970).

4/ Coppedge, J.R., D. A. Lindquist, D. L. Bull, and H. W. Dorough, "Fate of 2-Methyl-2-(methylthio)propionaldehyde O-Methylcarbamoyl) Oxime (Temik) in Cotton Rlants and Soil," J. Agr. Food Chem., 15(5):902-910 (1967).

placed into tightly capped bottles which were held in the dark at 25 to 28°C. At intervals during a 12-week period, replicates of each soil type were removed from storage and analyzed. The approximate half-life of aldicarb in the three soils ranged from 9 to 12 days. Four weeks after treatment, the soils contained 0.3 to 27.2% of the applied dose of aldicarb. As in plants, the major metabolites recovered was aldicarb sulfoxide. Aldicarb was degraded more slowly in the soils than in cotton plants.

Bull et al. (1970)[1/] conducted further laboratory studies on the fate of radio-labeled aldicarb in sand, loam, clay and muck soils maintained at different moisture levels (0, 50, and 100% of field capacity) and at pH values of 6, 7, and 8. Samples of ^{14}C or ^{35}S-labeled aldicarb were added to the test soils. At various time after treatment, samples of the treated soils were analyzed radiometrically and/or by gas chromatography.

No important difference in results were attributable to pH within the range tested. Aldicarb was relatively stable in all dry soils, in sand at all moisture levels, and in loam at 50% moisture. The half-life of all toxic compounds exceeded 56 days. A moisture level of 50% was optimal for the oxidation of aldicarb to its sulfoxide and sulfone derivatives in loam, clay, and muck. A moisture level of 100% caused a substantially faster rate of decomposition to nontoxic products in the same soils. The volatilization of aldicarb and its derivatives was influenced greatly by soil moisture. As the rate of water evaporation from the soil increased, so did volatilization of radioactivity from the treated soil.

In an additional test series, 50-g samples of sand, Lufkin fine sandy loam and Woodward fine sandy loam were mixed thoroughly with 450 µg of ^{35}S-labeled aldicarb. Each sample was then enclosed in a flat, rectangular packet made of stainless steel screen and buried individually in a cotton field in holes that were each 19 cm (7.5 in) wide and 30 cm (12 in) deep. Each packet was placed in a horizontal position at a depth of about 15 cm (6 in) and surrounded by soil of the same type that was in the pocket. One set of samples was kept as dry as possible by covering the site with a plastic sheet during inclement weather. The other set of samples was saturated with water immediately after it was buried. The test was conducted in an unusually wet season. Under very wet conditions, all radioactivity was lost from the packets in a matter of hours. In the protected set of samples, the half-lives of aldicarb and its toxic metabolites was 1 day in sand and 4 to 7 days in the loams.

Quraishi (1972)[2/] studied the persistence of aldicarb and its metabolites in clay loam (pH 6.8 to 7.2) and in water collected from fields.

1/ Bull, D. L., R. A. Stokes, J. R. Coppedge, and R. L. Ridgway, "Further Studies of the Fate of Aldicarb in Soil," J. Econ. Entomol., 63(4):1283-1289 (August 1970).

2/ Quraishi, M. S., "Edaphic and Water Relationships of Aldicarb and its Metabolites," Can. Entomol., 104(:)·1191-1196 (1972).

Soil samples treated in the laboratory with aldicarb at 5 and 20 ppm did not contain detectable aldicarb residues after 8 and 12 weeks, respectively. At 50 ppm, chemically detectable amounts of aldicarb were present in the soil after 11 weeks. The soil samples were stored at 23 to 28° C, but the temperature at times reached 32°C. In field water treated in the laboratory with aldicarb at 100 ppm the parent compound and its metabolites were detectable at 0.4 ppm 11 months later. The water was stored at 16 to 20°C and exposed to 507.5 hr of sunlight. Aldicarb was readily eluted with water from soil columns.

Onsager and Rusk (1969)[1/] studied the residual toxicity of aldicarb and other insecticides to the sugar beet wireworm (Limonius californicus) in laboratory tests. Aldicarb 10% granular was applied at an initial concentration of 2.31 ppm, a rate suggested by the manufacturer. However, it was completely ineffective against the test insect immediately after treatment and was not further evaluated.

Campbell et al. (1971)[2/] studied the influence of organic matter content of soils on the control of the wireworm, Melanotus communis, by several insecticides, including aldicarb. These authors also found aldicarb to be ineffective against the test insect at 2 lb active ingredient per acre applied as 10% granular and therefore obtained no data on the influenced organic matter.

Supak (1972)[3/] investigated the volatilization, degradation, adsorption, and desorption characteristics of aldicarb in soils and clays. Volatilization of solid and dissolved aldicarb, and of aldicarb mixed with Houston black and Beaumont soils at the rate of 1 mg of toxicant per gram of soil was determined by GLC analysis of trapped vapors. The volatilization rate of aldicarb was generally depressed by the presence of water, and by elevated temperatures. For all systems, aldicarb volatilization losses ranged from 0.01 to 0.18% of the applied dose. At 23°C, the degradation of aldicarb exceeded 10% of the applied dose only in the Beaumont soil where 24 and 46% of the added toxicant were lost from the moist and dry soil, respectively. At 42°C, extensive degradation occurred in all systems; losses ranged from 38 to 82%. Adsorption experiments with radiolabeled aldicarb indicated apparent negative adsorption (exclusion) of the pesticide on Ca- and Al-saturated montmorillonite clays. There appeared to be two different bonding mechanisms responsible for retention of aldicarb near basic clay surfaces.

1/ Onsager, J. A., and H. W. Rusk, "Potency of the Residues of Some Nonpersistent Insecticides in Soil Against Wireworms," J. Econ. Entomol., 62(5):1060-1064 (1969).

2/ Campbell, W. V., D. A. Mount, and B. S. Heming, "Influence of Organic Matter Content of Soils on Insecticidal Control of the Wireworm," J. Econ. Entomol., 64(1):41-44 (1971)

3/ Supak, J. R., "The Volatilization, Degradation, Adsorption, and Desorption Characteristics of Aldicarb [2-Methyl-2-methylthio (propionaldehyde) O-(Methylcarbamoyl)Oxime] in Soils and Clays," Diss. Abstr. Int., 33(3):982B (1972).

Gawaad et al. (1971)[1/] studied the leaching characteristics of aldicarb and several other soil insecticides in three Egyptian soils; among the insecticides studied, aldicarb had the highest leaching rate; 47.12, 42.30, and 56.14% was leached from sand, loam, and sandy clay loam soils, respectively.

Residues in Soil/Field Studies - Kearby *et al.* (1970)[2/] studied the distribution and persistence of aldicarb residues in a Pennsylvania tree farm soil (and in the needles and branches of Scotch pine). Aldicarb 10% granular was applied broadcast at rates of 0.5, 1.0 and 2.0 lb/12 trees. Application was made on both sides of each 12-tree row in 3-ft bands. The 10-year old trees were spaced at 6-ft intervals and grew in fine, well mixed and mesic loam. Soil samples were taken, 1, 15, 36 and 63 days after application and analyzed colorimetrically. This analysis method did not differentiate between the parent compound and its degradation products. In the 0.5 and 1.0 lb/12 trees treatments, no apparent chemical residues were found in soil samples taken at depths of 6 and 12 in., 36 and 63 days after treatment. Only a trace amount, 0.07 ppm, was detected 63 days its major metabolites under the test conditions was estimated to be 15 days. Aldicarb appeared to be readily absorbed and translocated upwards in Scotch pine.

Andrawes, et al. (1971)[3/] studied the fate and persistence of aldicarb in soil under field conditions over two growing seasons. ^{14}C-aldicarb was applied at the rate of 3.0 lb active ingredient per acre in-furrow. This application resulted in ^{14}C-residues of 13.1 ppm in soil planted to potatoes, and 15.4 ppm in fallow ground. Ninety days after application, total ^{14}C-aldicarb equivalents had declined to 0.07 ppm in the cultivated soil, 0.05 ppm in the fallow ground. Maximum dissipation rates were associated with heavy rainfall at various times during the season. Aldicarb sulfoxide and sulfone and water-soluble metabolites were the principal transformation products of aldicarb remaining in the soil. Volunteer crabgrass growing in the treated fallow ground contained 1.15 ppm of total ^{14}C-aldicarb equivalents 90 days after the original treatment. When tomato plants were transplanted and grown for 7 days in the fallow ground 90 days after treatment, they contained from less than 0.01 to 0.06 ppm of total ^{14}C-residues.

In an additional test, ^{14}C-aldicarb was applied in-furrow at the rate of 1.0 lb active ingredient per acre. No crops were planted in this area, and the soil remained undisturbed. Soil samples taken after 14 days contained 0.59 ppm of total ^{14}C-aldicarb equivalents. Immediately after sampling, the treated area was disced to a depth of 15 to 20 cm (6 to 8 in.)

1/ Gawaad, A. A. A., E. S. N. M. Ali and A. Y. Shazli, "Leaching of Some Soil Insecticides in Three Egyptian Soils," Bull. Entomol. Soc., Egypt Econ. Ser., (5):23-26 (1971)

2/ Kearby, W. H., C. D. Ercegovich, and M. Bliss, Jr., "Residue Studies on Aldicarb in Soil and Scotch Pine," J. Econ. Entomol., 63(4): 1317-1318 (August 1970).

3/ Andrawes, N. R., W. P. Bagley, and R. A. Herrett, "Fate and Carryover Properties of Temik Aldicarb Pesticide,' J. Agr. Food Chem., 19(4):727-730 (1971).

and resampled. After discing, the residues found were 0.02 ppm of ^{14}C-aldicarb equivalents, an approximately 30-fold dilution. The residue level remaining after discing, was lower than that in the tomato transplant experiment. The authors conclude that residues of aldicarb and its transformation products do not persist in the soil after a 90-day growing season and that therefore, the likelihood of carryover of residues to subsequent crops is remote.

Woodham et al. (1973a)1/ investigated aldicarb residues remaining in soil, cottonseed, and cotton lint on the Texas high plains, following an in-furrow soil application of 10% granular formulation at the rate of 1.5 lb active ingredient per acre and use of a gas chromatographic-flame photometric analytical procedure. Aldicarb residues (measured as the sulfone) as high as 1.65 ppm were present in soil from dryland fields 3 days after application, decreasing to 0.24 ppm in 1 month, and completely disappearing in 4 months. Aldicarb residues in soil from irrigated fields averaged 0.7 ppm 13 days after treatment and had completely disappeared in 42 days. No significant aldicarb residues were detected in soil between treated rows or in adjacent untreated areas.

Quraishi (1972) reported on aldicarb residues in sugar beet roots and potatoes grown in soil treated with aldicarb 10% granules in the seed furrow at the time of planting at the rate of 1.6 lb active ingredient per acre. At harvest time 4 months later, aldicarb residues found in three samples of sugar beet roots ranged from 0.05 to 0.2 ppm. Potatoes harvested from fields treated in the same manner at 2 and 4 lb active ingredient per acre contained less than 0.05 ppm of aldicarb residues.

Moorefield (1974) reports that aldicarb is oxidized in the soil to aldicarb sulfoxide which is then largely hydrolyzed to nontoxic nitriles, oximes, etc. A small portion of the sulfoxide is oxidized further to sulfone which also degrades in soil to nontoxic nitriles, oximes, etc.

Replicated soil residue decline tests were carried out in a least 12 different soil types. According to Moorefield (1974), the results indicate that aldicarb and its carbamate metabolites in soil varies, depending upon several factors. Soil moisture is necessary to release aldicarb toxicant from the granule into the soil. Loss occurs by biological degradation by soil microorganisms, by chemical reaction catalyzed by clays, and by uptake into growing vegetation. Under very dry soil conditions, aldicarb diffuses slowly out of the granule and degrades more slowly.

According to Moorefield (1974), the half-life of aldicarb carbamate residues in soil varies from 1 to 4 weeks. More rapid degradation occurs in mineral soils, while aldicarb residues are more persistent in soils of higher organic content.

In a field test when aldicarb 10% granules were applied to bare Norfolk sandy loam at the rate of 10 lb active ingredient per acre, soil

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1/ Woodham, D. W., R. R. Edwards, R. G. Reeves, and R. L. Schutzmann, "Total Toxic Aldicarb Residues in Soil, Cottonseed, and Cotton Lint Following a Soil Treatment with the Insecticides on the Texas High Plains," J. Agr. Food Chem., 21(2):303-307 (1973a).

samples from the treated area contained 9.4 ppm of aldicarb residues at 0 days; 5.5 ppm at 7 days; 0.66 ppm at 14 days; and 0.19 ppm at 28 days.

Residues in Water

Moorefield (1974) reported that a laboratory study on the dissipation of aldicarb and its carbamate metabolites in various types of water has recently been completed. The disappearance of aldicarb was determined over a 30-day period in distilled water at pH 6,7, and 8, and in pond water and lake water, the latter two in the presence and absence of their respective bottom material. The initial concentration of aldicarb in all samples was 0.5 ppm. There was little or no degradation of aldicarb carbamates in the distilled water, or in the pond and lake water in the absence of bottom material. In the pond water with about 5% mud (percent by weight, dry basis) present, the aldicarb carbamate residue degraded to a concentration of 0.02 ppm in 20 days; the half-life being about 5 days. After 20 days, the bottom mud contained less than 0.01 ppm aldicarb carbamates. In lake water in the presence of bottom silt, aldicarb carbamates degraded to a concentration of 0.03 ppm in 25 days; half-life is about 6 days.

Moorefield (1974) further reported on a field study in which a farm pond was treated with aldicarb at an initial concentration of 3 ppm. Samples of water and bottom mud were taken periodically. Aldicarb carbamate residues in the pond water declined to 1.1 ppm after 2 weeks; 0.26 ppm after 4 weeks; 0.06 ppm (the limit of sensitivity of the method) after 6 weeks. The half-life was about 7 to 10 days. The maximum concentration of aldicarb carbamate residues in the bottom mud was 0.09 ppm at 4 weeks. The dissipation of aldicarb carbamate residues on this farm pond was rapid on a complete, without residue buildup in pond sediment.

Residues in Air

Bull et al. (1970) found that in some of their laboratory and field tests, aldicarb residues disappeared from different types of soil with unexpected rapidity. Aldicarb "losses" were correlated with soil moisture and type and consisted primarily of upward movement and subsequent volatilization. These and several other early laboratory experiments indicated that condensable volatiles consisted largely of oxime and nitrile products, with small amounts of aldicarb and its oxidation products. According to Moorefield (1974), more recent studies with refined trapping techniques suggest that extensive degradation of the aldicarb molecule occurs with resultant evolution of the methylthio function as carbon dioxide. Studies currently in progress to more completely account for the fate of aldicarb in soil, and to define the nature of the evolved products support the conclusion that most of the volatilized radioactivity is carbon dioxide liberated by extensive microbial degradation of the toxicant.

Nematologists, including Miller (1970)1/ and Brodie and Good (1973),2/ describe aldicarb as a "nonvolatile nematocide." Moorefield (1974) states

1/ Miller, P. M., "Failure of Several Non-Volatile and Contact Nematicides to Kill Eggs in Cysts of Heterodera tabacum," Plant Dis. Rep., 54(9): 781-783 (1970).

2/ Brodie, B. B., and J. M. Good, "Relative Efficacy of Selected Volatile and Nonvolatile Nematocides for Control of Meloidogyne incognita on Tobacco," J. Nematol., 5(1):14-18 (1973).

that aldicarb is not a volatile substance, as its low vapor pressure attests and that air monitoring samples in uncovered treated fields have failed to detect carbamate residues. Airborne particulate fines of aldicarb do present a hazard if inhaled. Special precautions are made to remove the dust from the granulated aldicarb product, Temik 10% granular aldicarb formulation and small hand applicators that severely abrade the granules are not recommended.

Effects on Nontarget Plants

Spurr and Sousa (1974) studied the effects of aldicarb and its metabolites on nontarget organisms in the environment, including a number of higher plants. In greenhouse tests, test plants were exposed to aldicarb applied at a rate equivalent to 50 lb/acre, a dosage five to 20 times greater than those permitted in the aldicarb registrations.

Under these conditions, aldicarb and its sulfone were nontoxic when applied postemergence to beans (*Phaseolus vulgaris* L.) corn (*Zea mays* L.) tomatoes (*Lycopersicon esculentum* mill), and cotton (*Gossyplum hirsutun* L.) or preemergence to perennial rye grass (*Solium perenne* L.) pearl millet (*Setaria italica* L.), red root pigweed (*Amaranthus retroflexus* L.) and mustard (*Brassica pincea* var. *foliosa*).

Woodham et al. (1973b)[1/] studied the total toxic residues of aldicarb in weeds, grasses, and wildlife following soil application of 10% granular to dryland and irrigated cotton fields in the Texas high plains. Aldicarb was applied at the rate of 1.5 lb/acre. Residues of aldicarb and/or its metabolites (measured as the sulfone by a gas chromatographicflame photometric analysis method) were detected in 80% of the grass and weeds collected from treated areas in dryland fields, and in 83% of the samples from untreated sections of these fields. Residues as high as 42.8 ppm were found in a composite sample of nightshade, ironweed, and careless weed collected from a treated area of a dryland field 7 days after treatment, decreasing to 0.96 ppm 29 days after treatment. Residues were also detected in weeds growing in untreated sections of dryland fields approximately 12 to 13 ft from the treated rows, ranging from 0.02 to 19.64 ppm. No detectable residues were found in weed samples from adjacent untreated, noncultivated areas outside of treated fields.

In irrigated fields, residues were detected in about 73% of the samples from treated areas, 38% of the samples from untreated sections of treated fields, and 31% of the samples from untreated sections of treated fields, and 31% of the samples from untreated, noncultivated areas adjacent to the treated irrigated fields. In this set of samples, the highest residues detected from treated areas were 2.09 ppm in a sample of careless seed 54 days after treatment; 2.94 ppm in a composite sample of Johnsongrass and ironweed 74 days after treatment; 1.85 ppm in a composite sample of careless weed, Johnsongrass, and Colorado grass; and 3.37 ppm in a composite sample of Johnsongrass and ironweed. Weed samples collected from untreated areas of the fields showed significant residues in only three samples, including 23.59 ppm in a composite sample of careless weed and Johnsongrass collected

1/ Woodham, D. W., R. G. Reeves, and R. R. Edwards, "Total Toxic Aldicarb Residues in Weeds, Grasses, and Wildlife from the Texas High Plains Following a Soil Treatment with the Insecticide," *J. Agr. Food Chem.*, 21(4):604-607 (1973b).

54 days after treatment (collected about 13 ft from treated areas). Small but detectable residues were found in three samples from untreated, non-cultivated areas adjacent to cultivated irrigated fields; they were: 0.03 0.02, and 0.01 ppm in material collected 51, 51, and 54 days, respectively, after treatment.

Metabolic Pathways in Plants

The metabolism of aldicarb in plants has been investigated extensively. Bull (1968)[1/] observed that aldicarb in cotton plants is completely metabolized within 2 days, primarily to the corresponding sulfoxide. Metcalf et al. (1966)[2/] noted that the sulfoxide is a more active cholinesterase inhibitor than aldicarb, and observed that the long-term persistence of the sulfoxide in the plant (cotton) and its slow oxidation to the sulfone is responsible for the persistent, systemic activity of aldicarb.

Bartley et al. (1970)[3/] have performed the most extensive work on the metabolism of aldicarb in cotton. They also studied previously unexamined water-soluble aldicarb metabolites, which become the predominant products of aldicarb metabolism in cotton.

The metabolic pathway of aldicarb in cotton plants, as delineated by Bartley et al. (1970) is presented in Figure 2. Bartley et al. (1970) noted that the initial metabolic attack on aldicarb is both oxidative and hydrolytic in nature, yielding organo-soluble products. These metabolites, for the most part, are transient in nature and are further converted to the water-soluble residues.

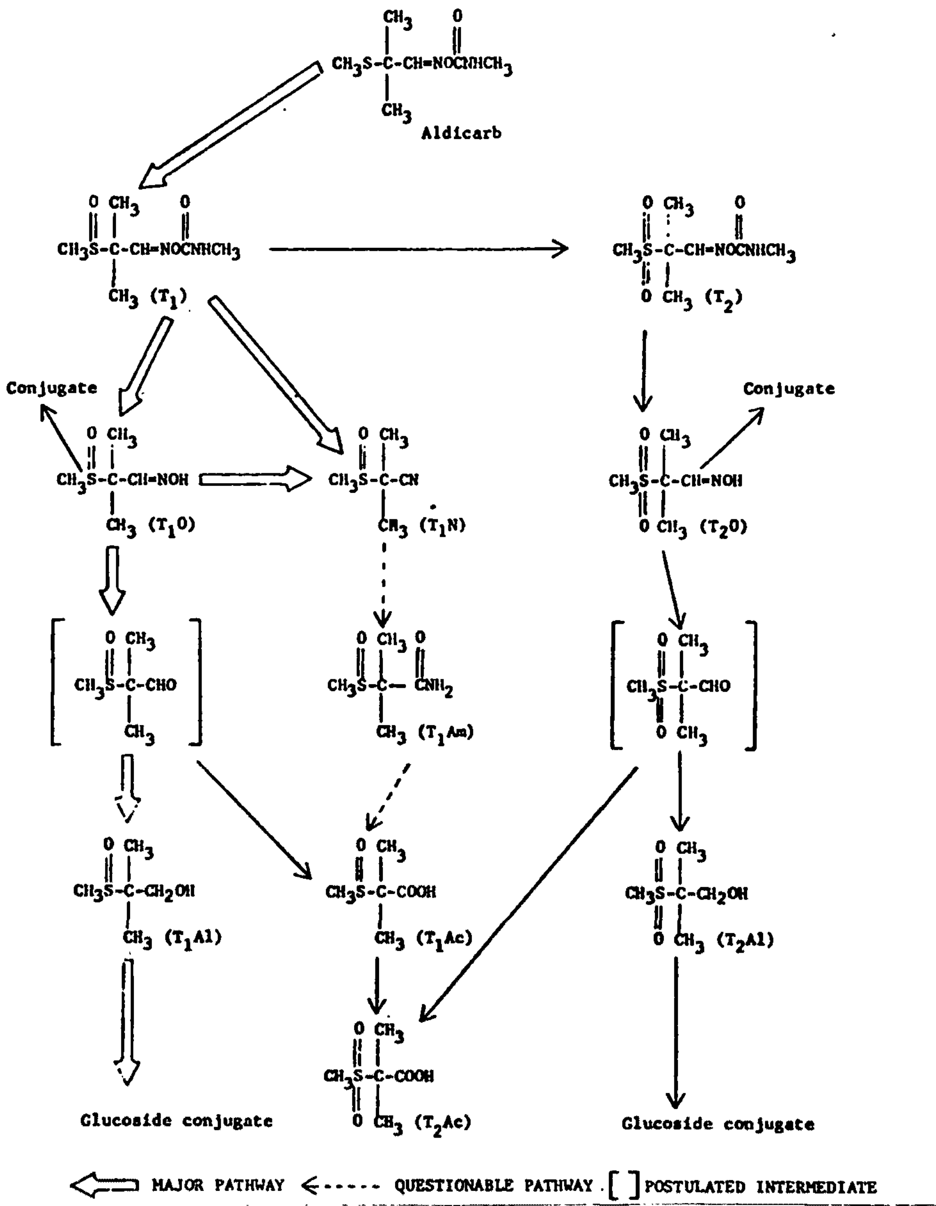
Surprisingly, the chief metabolic pathway in the formation of water-solubles is one of reduction, leading to the alcohol sulfoxide (T_1Al) (see Figure 2) in high conversion. Only minor quantities of this alcohol occur free in the aqueous and organic fractions, the bulk of the metabolite being in the form of a highly polar glycoside conjugate.

Apparently because of the resistance of the sulfoxide metabolites to oxidation, only minor quantities of the aldicarb sulfone metabolites, T_2O, T_2Al, and T_2Ac, were detected.

1/ Bull, D. L., "Metabolism of UC-21149 [2-Methyl-2-(methylthio)-propionaldehyde-O-(methylcarbamoyl)oxime] in Cotton Plants and Soil in the Field," J. Econ. Entomol., 61(6):1598-1602 (1968).

2/ Metcalf, L., T. R. Fukuto, C. Collins, K. Borck, J. Burk, H. T. Reynolds, and M. F. Osman, "Metabolism of 2-Methyl-2-(methylthio)-propionaldehyde-O-(methylcarbamoyl)oxime in Plant and Insect," J. Agr. Food Chem., 14(6):579-584 (1966).

3/ Bartley, W., N. Andrawes, E. Chancey, P. Bagley, and H. Spurr, "The Metabolism of Temik Aldicarb Pesticide [2-Methyl-2-(methylthio)-propionaldehyde)-O-(methylcarbamoyl)oxime] in the Cotton Plant," J. Agr. Food Chem., 18(3):446-453 (1970).

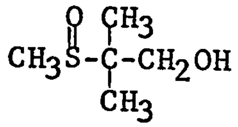
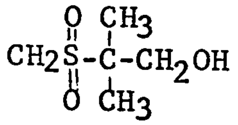
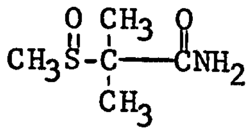
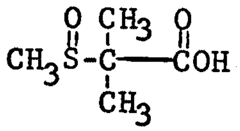
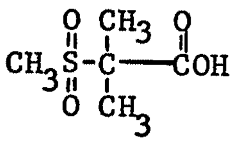


Compound	Abbreviation
2-Methyl-2(methylsulfinyl)propionaldehyde O-(methylcarbamoyl)oxime (Aldicarb sulfoxide)	T_1
2-Methyl-2-(methylsulfonyl)propionaldehyde O-(methylcarbamoyl)oxime (Aldicarb sulfone)	T_2
2-Methyl-2-(methylsulfinyl)propionaldehyde oxime (Oxime sulfoxide)	T_1O
2-Methyl-2-(methylsulfonyl)propionaldehyde oxime (Oxime sulfone)	T_2O
2-Methyl-2-(methylsulfinyl)propionitrile	T_1N
2-Methyl-2-(methylsulfinyl)propionamide	T_1Am
2-Methyl-2-(methylsulfinyl)propanol	T_1Al
2-Methyl-2-(methylsulfonyl)propanol	T_2Al
2-Methyl-2-(methylsulfinyl)propionic acid	T_1Ac
2-Methyl-2-(methylsulfonyl)propionic acid	T_2Ac

Source: Barlety et al., op. cit. (1970).

Figure 2. A metabolic pathway of aldicarb, in cotton plants.

All of the major plant metabolites of aldicarb have been found to be relatively nontoxic in acute studies (Bartley et al. 1970). The major metabolites, 2-methyl-2-(methylsulfinyl) propanol, (T_1Al), had no demonstrable effect on rats when included in their daily diet for 7 days at concentrations as high as 20,000 ppm. Acute oral LD_{50} values determined for aldicarb's water soluble metabolites are as follows:

Metabolite	Abbreviation	Acute Oral LD_{50} (mg/kg)
	T_1Al	11,300
	T_2Al	11,300
	T_1Am	16,000
	T_1Ac	7,500
	T_2Ac	5,700

Bioaccumulation, Biomagnification

The propensity of aldicarb for bioaccumulation and biomagnification was studied by Sangha (1972)[1]. The model ecosystem has a terrestrial-aquatic interface and a seven-element food chain. The design of the system simulates a farm pond surrounded by a water shed under cultivation in which a pesticide is applied to crop plants, and the eventual contamination of the resulting aquatic environment. Elements of the food chain include sorghum (Sorghum halepense) and larvae of the saltmarsh caterpillar (Estigmente acrea) in the terrestrail phase; and snails (Physa sp.), waterfleas (Daphnia magna), green filamentour algae (Oedogonium cardiacum), mosquito larvae (Culex sp.) and mosquito fish (Gambusia affinis) in the aquatic phase.

1/ Sangha, G. K., "Environmental Effects of Carbamate Insecticides as Assayed in the "Model Ecosystem," a Comparison with DDT," Diss. Abstr. Int. 32(8):4650-B (1972).

Radio-labeled aldicarb was applied to the system. At the end of 33 days, the system was taken apart, and the organisms and the water extracted and analyzed for radioactivity. In addition, extracts were spotted on thin-layer chromatographic plates, developed with appropriate solvents, and exposed to X-ray film to locate and identify the chemical composition of the residues in the different tissues. Metabolites were identified by cochromatography with hypothesized metabolites, as well as by infrared, nuclear magnetic resonance, and mass spectrometry techniques. Aldicarb had high persistence and low biodegradability in this test system when compared with other carbamates. Aldicarb oxidation products (sulfoxide and sulfone) were recovered in water (7.4 ppb) and other organisms in the system. Aldicarb was highly toxic to snails and mammals; its LC_{50} to Daphnia was 350 ppb.

Environmental Transport Mechanisms

Moorefield (1974) reported that the leaching characteristics of aldicarb have been evaluated in various soil types in in the laboratory and in the field. In laboratory studies, percolation experiments designed to simulate normal rainfall conditions, e.g., 1 in of precipitation per week, were conducted in plastic or metal columns. Under these conditions, downward migration of aldicarb and its metabolites was retarded to the extent that little or no radioactivity passed through clay, loam, or muck soil columns. Leaching was maximized in pure, course sand. However, even in this instance, a 6-in column was sufficient to prevent elution of 95% of the applied material. Evaporation of soil moisture encourages movement of aldicarb toward the soil surface. Therefore, evaporative losses between weekly applications of water may assist soil adsorption in opposing net downward movement of aldicarb. When evaporation was retarded with a perforated Saran wrap covering, a column length of 27 in of coarse sand still served as an efficient leaching barrier.

Moorefield (1974) also relayed the results of a field experiment conducted to determine the movement of aldicarb and its carbamate metabolites under conditions of heavy surface runoff. A bare Norfolk sandy loam field of 0.45 acre with a slope of approximately 1 ft/100 ft was treated broadcast at the exaggerated rate of 100 lb of Temik 10% granular aldicarb pesticide per acre, The field was disced to depth 6 in immediately after treatment. During a 28-day testing period, the field received a total of 8.3 acre-in of water, 5 in from sprinkler irrigation (1 in/hr) on the seventh day after application, and 3.3 in of rainfall at various times during the study. Runoff from the treated field drained into a farm pond 60 ft downslope. The untreated area between the pond and the treated field had been compacted and contoured to provide a surface for runoff water. Catchbasins for collecting runoff water in the untreated area were prepared by setting pails flush with the ground level 15, 30, and 45 ft downslope from the treated field. Samples of pond water, runoff water, and of soil from the untreated runoff area were taken after periods of runoff water flow, and soil and water were analyzed.

The only analytically significant residue, 0.14 ppm, was found in a runoff water sample taken 8 days after application, following 5 in of irrigation and rain during the preceding 2 days. No other samples of runoff water and none of the samples of soil from the runoff area or of pond water contained analytically significant concentrations of aldicarb residues.

The highest value obtained for any of these samples was 0.09 ppm. Soil samples from the treated area contained 0.4 ppm aldicarb residues at 0 days; 5.5 ppm at 7 days; 0.66 ppm at 14 days; and 0.19 ppm at 28 days.

A two acre plot of sandy loam soil (pH 7.8) was treated with Temik 10G in six-in bands at the rate of 54 lb/acre to a depth of three in. The plot was then subdivided into two one-acre blocks, one furrow irrigation to simulate normal moisture for sugar beets and the second sprinkler irrigation to simulate an extremely wet season. (Union Carbide Corp., 1972)[1/]

Soil core samples were taken to a depth of eight feet at 0, 4, 8, 16, 32, 64 & 132 days after treatment and to a depth of 12 feet 176 days after. Both the furrow and sprinkler-irrigated plots show downward movement of aldicarb residues. However, by the time the pesticide residue passes the 4-ft level, the concentration of total toxic residue is no greater than 0.1 ppm.

In addition, residue levels are reduced by degradation and dilution by groundwater. Therefore, the author points out that with the resulting low residue level, the movement of aldicarb by leaching should present no environmental hazard.

1/ Union Carbide Corporation, "Leaching of Aldicarb into Irrigated Sandy Loam Soil Following Treatment with Temik 10G Aldicarb Pesticide," report submitted to EPA, Pesticide Regulations Division, Chemistry Branch (June 1972).

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SUBPART II. D. PRODUCTION AND USE

CONTENTS

This section contains data on registration and on production and uses of aldicarb. The section summarizes rather than interprets scientific data reviewed.

Registered Uses of Aldicarb

Federally Registered Uses - Aldicarb is a pesticide with a broad spectrum of effectiveness against many species of insects, mites, and nematodes. It has pronounced systemic action. When applied to soil, the active ingredient is rapidly absorbed by plant roots and translocated throughout all parts of the plant. Aldicarb active ingredient is extremely toxic to mammals. Two granular aldicarb formulations are available for commercial use; they contain 10% and 15% stabilized aldicarb active ingredient. The aldicarb active ingredient is impregnated on organic granules with a small quantity of binding agent which prevents dustiness and reduces the oral, dermal, and inhalation toxicity hazard. In the formulation and packaging of aldicarb granules, special care is taken to remove any fines which might present an inhalation hazard.

Registered uses of aldicarb by crops, target pests, dosage rates, type of use, established tolerances, and use, timing, and pre-harvest interval limitations are summarized in Tables 7 and 8.

Warning and precautionary statements appearing on Temik 15G aldicarb pesticide carbon and package labels appear in Table 9.

Tolerances established for aldicarb residues on raw agricultural commodities are recorded in the Code of Federal Regulations (see Table 2, p. 19).

State Regulations - In many of the states that currently regulate the use of pesticides, aldicarb is subject to use restrictions. For instance, in California, aldicarb is one of 42 pesticides that have been designated as "injurious or restricted materials." The use of pesticides in this category is subject to special restrictions under regulations administered by the State Department of Agriculture. A permit from the County Agricultural Commissioner must be obtained for the use of aldicarb. The product may not be applied in any location where damage, illness, or injury appears likely to result through direct application, drift, or residue, to persons, other crops, or animals (including honeybees) other than the pest(s) which the application is intended to destroy. Before aldicarb is applied, the person responsible for the application must give warning to all persons known to be on the property to be treated.

Under the California requirement, it is unlawful to sell or to deliver aldicarb-containing pesticide products to any person who is required to have a permit, unless the person or his agent signs a statement that he has a valid permit to use the product.

Table 7. REGISTERED AGRICULTURAL USES OF ALDICARB

Crop & time of application	Pests controlled	Oz formulation/ 1,000 feet of row: 10%	Oz formulation/ 1,000 feet of row: 15%	Pounds active ingredient/acre (Range)	Tolerance, use and limitations
Cotton		40 - inch row spacing			0.1 ppm (cottonseed) 0.3 ppm (cottonseed hulls) 90 day preharvest interval Use high rate on heavy organic or clay soils. Do not make more than one application at planting and one side-dress application per crop. Granules should be worked into the soil to a depth of at least 2 inches or covered with soil to a depth of at least 2 inches to provide maximum performance and minimize hazard to birds. Do not allow livestock to graze in treated areas before harvest. Do not plant any crop not listed on label in treated soil within 100 days of last application. Do not use in homes or home gardens.
At - planting	Aphids, Thrips	4 to 6	2.5 to 4.5	0.3 to 0.5	Drill granules just below seed line or place in seed furrow and cover with soil. If seeds and granules are hill dropped, granule rates may be reduced by one-half.
	Fleahoppers, Leafminers, Mites, Overwintering boll weevils, Plant bugs including Lygus bugs	8 to 12	5.0 to 8.0	0.6 to 1.0	
	Nematodes	6 to 18 (Except Far West)	4.5 to 12	0.5 to 1.5	If rate does not exceed 1.0 lb active ingredient /acre drill granules just below seed line or place in seed furrow and cover with soil. For higher rates, apply granules in a 4- to 6-inch band and work into the soil or cover with soil; plant seed in or above the treated zone.
		24 to 48 (Far West only)	17 to 33	2.0 to 4.05	Apply granules in a 4- to 6-inch band 3 to 6 inches below the seed line or cover with 3 to 6 inches of soil. Plant seed above treated zone.
At - first squaring	Leafhoppers, Fleahoppers	12 to 24	8.5 to 17	1.0 to 2.1	Side-dress granules 8 to 16 inches to one side of the plant row and 2 to 6 inches deep(usually at or below bottom of water furrow).
	Mites, Boll weevils, Plant bugs, including Lygus bugs.	24 to 36	17 to 24.5	2.0 to 3.0	
From squaring through early bloom	Cotton leaf perforator	24	17	2.0 to 2.1	
	Whiteflies	24 to 36	17 to 24.5	2.0 to 3.0	

Table 7. REGISTERED AGRICULTURAL USES OF ALDICARB (continued)

Crop & time of application	Pests controlled	Oz formulation / 1,000 feet of row		Pounds active ingredient/acre (Range)	Tolerance, use and limitations
		10%	15%		
Peanuts		36 - inch row spacing			0.05 ppm (peanuts) 0.5 ppm (peanut hulls) 90 day preharvest interval. Use high rate on heavy organic or clay soils. Applied as soil application at planting. Granules should be worked into the soil to a depth of at least 2 inches or covered with soil to a depth of at least 2 inches to provide maximum performance and minimize the hazard to birds. Do not allow livestock to graze in treated areas before harvest. Do not allow hogs to root in treated fields. Do not feed peanut hay or vines to livestock. Do not plant any crop not listed on label in treated soil within 100 days of last application. Do not use in homes or home gardens.
At - planting	Thrips	11 to 22	7.5 to 15	1.0 to 2.1	Apply granules in seed furrow and cover with soil. In Southwest use high rate only.
	Nematodes (root-knot, ring, lesion, sting, stunt, spiral & stubby-root)	22 to 33	15 to 22	2.0 to 3.0	Apply granules in a 6-to 12-inch band and work into the soil or cover with soil to a depth of 2 to 4 inches. Plant seeds in the treated zone.
Potatoes		34 - inch row spacing			1.0 ppm 90 day preharvest interval for an at planting application. 50 day preharvest interval for post-emergence soil application. Use high rate on heavy organic or clay soils. Do not plant any crop not listed on label in treated soil within 100 days of the last application. Do not apply more than once per crop. Granules should be worked into the soil to a depth of at least 2 inches or covered with soil to a depth of at least 2 inches to provide maximum performance and minimize the hazard to birds. Do not allow livestock to graze in treated areas before harvest. Do not use in home or home gardens.
At - planting	Aphids	10.5	7 (Maine only)	1.0 to 1.05	Apply granules with seed pieces in the planting furrow and cover with soil.
	Flea beetles	31	21	3.0	
	Aphids	21	14.5	2.0 to 2.1	Apply as above <u>or</u>, drill granules 2 to 4 inches on both sides of seed row (split application) and 3 to 8 inches deep (usually 1 to 2 inches below the seed pieces).
	Colorado potato beetles, Leafhoppers	21 to 31	14.5 to 21	2.0 to 3.0	

Table 7. REGISTERED AGRICULTURAL USES OF ALDICARB (continued)

Crop & time of application	Pests controlled	Oz formulation/ 1,000 feet of row		Pounds active ingredient/acre (Range)	Tolerance, use and limitations
		10%	15%		
<u>Potatoes</u> (continued)		34 - inch row spacing			
At - planting	Nematodes (root-knot, lesion) (Golden nematode is suppressed. Verticillium wilt has been suppressed where nematode populations have been reduced).	31	21	3.0	Apply granules with seed pieces in the planting furrow and cover with soil. <u>or</u>, apply granules in an 8-inch band and work into the soil or cover with soil to a depth of 4 inches. Plant seed pieces in the treated zone.
Post-emergence (from 75% emergence up to 6 weeks after emergence)	Aphids, Colorado potato beetles	21 to 31	14.5 to 21	2.0 to 3.0	Side-dress granules 4 to 5 inches on both sides of plant row and 4 inches deep. Apply to early crop only. Do not apply if an at-planting treatment was made.
		(Washington only)			
<u>Sugar beets</u>		22 - inch row spacing			0.05 ppm (roots) 1.0 ppm (tops) 0.002 ppm in milk 0.01 ppm in meat, fat and meat by-products of goats, cattle, hogs, horses and sheep. 90 day preharvest interval 120 day preharvest interval if tops are to be fed to livestock. Do not use tops for human consumption. Do not exceed a total of 6.0 lb active ingredient/acre/crop. Do not make more than one at-planting application and two post-emergence applications per crop. Use high rate on heavy organic or clay soils. Granules should be worked into the soil to a depth of at least 2 inches or covered with soil to a depth of at least 2 inches to provide maximum performance and minimize the hazard to birds. Do not plant any crop not listed on the label in the treated soil within 100 days of the last application. Do not allow livestock to graze in treated areas before harvest. Do not use in home or home gardens.
At - planting or within one week before planting.	Nematodes (cyst and root-knot)	26 to 33	18 to 22	4.0 to 5.0	Apply granules in a 4 to 6-inch band and immediately work into the soil or cover with soil to a depth of 2 to 4 inches. Plant seed in or above the treated zone <u>or</u>, drill granules 1.5 to 3 inches to one side of the seed row and 2 to 4 inches deep.

Table 7. REGISTERED AGRICULTURAL USES OF ALDICARB (continued)

Crop & time of application	Pests controlled	Oz formulation/ 1,000 feet of row		Pounds active ingredient/acre (Range)	Tolerance, use and limitations
		10%	15%		
<u>Sugar</u> <u>beets</u> (continued)		22 - inch row spacing			Drill granules 1- to 3-inches below the seed line. Granules can be placed in the seed furrow if rate does not exceed 1.0 lb active ingredient/acre.
At - planting	Aphids	6.5 to 13	4.5 to 9.5	1.0 to 2.1	
	Leafminers, Leafhoppers	13 to 20	9.5 to 13.5	2.0 to 3.0	
	Sugar beet root maggot	10 to 13	6.5 to 9.5	1.5 to 2.1	Apply granules in a 2- to 4-inch band over the seed row and immediately work into the soil or cover with soil.
At - planting plus post-emergence(split application)	Nematodes (cyst and root-knot)	13	9.5	2.0 to 2.1	<u>At</u> - <u>planting:</u> Apply granules in a 4- to 6-inch band and immediately work into the soil or cover with soil to a depth of 2 to 4 inches. Plant seeds in or above the treated zone <u>or</u>, drill the granules 1.5 to 3 inches to one side of the seed row and 2 to 4 inches deep. <u>Post-emergence</u>: Side-dress granules 2 to 4 inches to one side of plant row and 3 to 6 inches deep (furrow depth). Apply 40 to 60 days after planting and before soil temperature at 6- inch depth reaches 55°F.
		At planting and			
		13	9.5	2.0 to 2.1	
		post-emergence			
Post-emergence (Do not make any post-emergence application if 4 to 5 lb active ingredient /acre were used for nematode control at planting or one week before planting)	Sugar beet root maggot	6.5 to 13	4.5 to 9.5	1.0 to 2.1	Apply granules to both sides of the plant row (split application) and immediately work into the soil or cover with soil.
	Aphids	6.5 to 13	4.5 to 9.5	1.0 to 2.1	Side-dress granules 2 to 8 inches to one side of the plant row and 2 to 6 inches deep. A repeat application may be required for continued protection against virus vectors (aphids, leafhoppers).
	Leafminers, Leafhoppers	13 to 20	9.5 to 13.5	2.0 to 3.0	
	Nematodes (cyst and root-knot)	26	18	4.0 to 4.05	Side-dress granules 2 to 4 inches to one side of plant row and 3 to 6 inches deep (furrow depth). Apply 40 to 60 days after planting and before the soil temperature at 6-inch depth reaches 55°F.

Table 7. REGISTERED AGRICULTURAL USES OF ALDICARB (continued)

Crop & time of application	Pests controlled	Oz formulation/ 1,000 feet of row		Pounds active ingredient/acre (Range)	Tolerance, use and limitations
		10%	15%		
<u>Sugar cane</u>		60 - inch row spacing			0.02 ppm sugar cane 0.1 ppm fodder or forage 120 day preharvest interval. Use high rate on heavy organic or clay soils. Make only one application per crop. Granules should be worked into the soil to a depth of at least 2 inches or covered with soil to a depth of at least 2 inches to provide maximum performance and minimum hazard to birds. Do not allow livestock to graze on the treated areas until the harvest has been completed. Do not plant any crop not listed on the label in the treated soil within 100 days of application. Do not use in homes or home gardens.
At - planting	Nematodes (lance, lesion, ring, root-knot, stubby-root and sting)	37 to 55	28 to 37 (Louisiana only)	2.0 to 3.0	Apply granules in opened row on top of the newly planted cane and cover immediately with at least 6 inches of soil.
<u>Sweet potato</u>		48 - inch row spacing			0.02 ppm 120 day preharvest interval. Use high rate on heavy organic or clay soils. Make only one application per crop. Granules should be worked into the soil to a depth of at least 2 inches or covered with soil to a depth of at least 2 inches to provide maximum performance and minimize the hazard to birds. Do not allow livestock to graze on the treated areas until the harvest has been completed. Do not plant any crop not listed on the label in the treated soil within 100 days of application. Do not use in homes or home gardens.
AT - planting	Nematodes (reniform and root-knot)	22 to 44	15 to 30 (Louisiana only)	1.5 to 2.0	Apply granules in a 12 inch band in the opened row. Cover immediately with soil by hilling up 8 to 10 inches. Plant in the center of the treated zone.

Source: Compiled from the EPA Compendium of Registered Pesticides and Union Carbide Corporation Temik 10G & 15G (aldicarb) Pesticide Labels 1016-69 & 1016-78.

Table 8. REGISTERED ORNAMENTAL USES OF ALDICARB

Crop	Pest controlled	10% formulation pounds/1,000 feet of row	Pounds active ingredient/acre	Limitations and use: Time of application	Limitations and use: Recommended application
				For use by trained personnel in commercial production of ornamental plants. Do not market potted plants within 4 weeks of last application. Granules should be worked into the soil to a depth of at least 2 inches or covered with soil to a depth of at least 2 inches to provide maximum performance and to minimize hazard to birds. Do not plant food crops in soil treated with aldicarb for at least 100 days after last application. Do not use in homes or home gardens. Do not use plant parts for food or feed purposes.	
FOR USE ON FIELD GROWN AND NURSERY PLANTINGS					
(Herbaceous plants and bulbs)					
Dahlias	Aphids Leaf hoppers Leafminers Spider mites	4 to 6 (42 - inch row spacing)	5.0 to 8.0	As pests begin to appear. Repeat if needed.	Apply granules as a side-dressing to both sides of the plant row; work into the soil to at least 2 to 4 inches.
Lilies (bulbs)	Nematodes (lesion)	4 to 6 (40 - inch row spacing)	5.0 to 7.0	At planting	Apply in furrow with bulblet. Cover with soil. Limit 7.0 lbs. active ingredient/acre at time of planting.
(Woody shrubs, trees and vines)					
Birch and Holly	Aphids Leafminers	4.5 to 9 (42 - inch row spacing) or 1 to 2 oz /one inch diameter of trunk at soil level	5.0 to 10	After spring growth begins and prior to occurrence of leafminer activity.	Apply granules as side-dressing 3 to 4 inches deep and 10 to 12 inches to one or both sides of the row. Cover with soil.
Roses	Spider mites	5 to 8 (42 - inch row spacing)	7.0 to 10	As pest begins to appear. Repeat if needed.	Apply granules as side-dressing to both sides of the plant row; work into the soil to at least 2 to 4 inches.

Table 8. REGISTERED ORNAMENTAL USES OF ALDICARB(continued)

Crop	Pest controlled	10% oz formulation/ sq. ft. of plant bed or closely packed pots	Pounds active ingredient/acre	Time of application	Recommended application
FOR USE ON POTTED PLANTS OR PLANT BEDS IN COMMERCIAL GREENHOUSES					
Chrysanthemum	Aphids Leafminers Thrips	20 to 30	5.0 to 7.5	3 to 5 weeks after transplanting cuttings or just after pinching. Repeat in 6 to 8 weeks if needed.	If beds are covered with leaf or compost type mulch, remove mulch, work into the soil and water thoroughly. Use the high rate on heavy organic or clay soils, or if pest populations become severe. Apply granules evenly around the base of plants. Wash off granules adhering to foliage.
	Spider mites Whiteflies	30 to 40	7.5 to 10		
Orchids (Cymbidiums)	Spider mites	30 to 40	7.5 to 10	Apply just prior to emergence of flower spikes. Repeat if needed.	
Easter lilies	Aphids	20 to 30	5.0 to 7.5	After plants are established and pests appear. Repeat in 6 to 8 weeks, if needed.	
Poinsettia	Spider mites Mealy bugs Whiteflies	30 to 40	7.5 to 10		
Gerbera	Aphids Leafminers	20 to 30	5.0 to 7.5		
	Spider mites Whiteflies	30 to 40	7.5 to 10		
Carnations Roses and Snapdragons	Aphids	20 to 30	5.0 to 7.5		On old well established roses, use maximum rate for spider mite control.
	Spider mites	30 to 40	7.5 to 10		

Source: Compiled from the EPA Compendium of Registered Pesticides and Union Carbide Corporation Temik 10G (aldicarb) Pesticide Label 1016-69.

Table 9. WARNING AND PRECAUTIONARY STATEMENTS APPEARING ON TEMIK® 15G (Aldicarb) LABELS.

UNION CARBIDE

TEMIK®

ALDICARB PESTICIDE

NET WT. 25 LBS.

FOR CONTROL OF CERTAIN INSECTS, MITES AND NEMATODES

15% GRANULAR

Active Ingredient: Aldicarb [2-methyl-2-(methylthio) propionaldehyde O-(methylcarbamoyl)oxime] 15%
Inert Ingredients: 85%

EPA REG. NO. 1016-78 EPA EST. 33761-GA-1

SEE DIRECTIONS FOR USE ON THE CARTON IN WHICH THIS BAG WAS PACKED.
THIS BAG NOT FOR DISTRIBUTION AND RESALE SEPARATELY.

DANGER POISON

KEEP OUT OF REACH OF CHILDREN AND ANIMALS

HARMFUL OR FATAL BY SKIN OR EYE CONTACT BY BREATHING DUST OR BY SWALLOWING GRANULES. RAPIDLY ABSORBED THROUGH SKIN AND EYES.

ANTIDOTE IS ATROPINE SULFATE. DO NOT USE 2-PAM. SEE ANTIDOTE STATEMENT, INFORMATION FOR PHYSICIAN AND OTHER DETAILED WARNINGS BELOW.

DO NOT STORE OR USE IN OR AROUND THE HOME OR HOME GARDEN

DO NOT GET IN SKIN OR EYES.
DO NOT BREATHE DUST.

Wear long-sleeved clothing and protective gloves when handling. Wash hands and face before eating or smoking. Bathe at the end of work day, washing entire body and hair with soap and water. Change contaminated clothing daily and wash in strong washing soda solution and rinse thoroughly before reusing.

SYMPTOMS OF POISONING

may be one or more of the following:

Weakness	Vomiting	Pinpoint Eye Pupils
Headache	Diarrhea	Abnormal Flow of Salive
Sweating	Tightness in Chest	Abdominal Cramps
Nausea	Blurred Vision	Unconsciousness

CONTACT A PHYSICIAN IMMEDIATELY IN ALL CASES OF SUSPECTED POISONING

ANTIDOTE is atropine sulfate. Consult a physician for antidote tablets and instructions before using this pesticide. DO NOT USE 2-PAM AS AN ANTIDOTE.

FIRST AID TREATMENT. If symptoms are apparent, give atropine sulfate tablets as directed by the physician. Do not give antidote unless symptoms of poisoning have occurred. Transport patient to a physician or hospital, whichever is faster. Keep patient warm and quiet. If breathing is difficult, give oxygen. Start artificial respiration immediately if breahting stops. SHOW A COPY OF THIS LABEL TO THE PHYSICIAN.

IN CASE OF SKIN OR EYE CONTACT, wash skin immediately and thoroughly with soap and water and rinse well; flush eyes with plenty of water for 15 minutes. Remove contaminated clothing and wash before reuse.

IN CASE OF SWALLOWING, induce vomiting immediately by putting finger down throat or drinking strong salty or soapy water. Then drink plain water and repeat until vomit is clear.

INFORMATION FOR PHYSICIAN. This product contains 2-methyl-2(methylthio) propionaldehyde 0-(methylcarbamoyl)oxime. It is a spontaneously reversible cholinesterase inhibitor causing parasympathetic nerve stimulation. Preferred treatment of poisoning in adults is atropine sulfate in 1.2 mg doses given intravenously every 10 or 12 minutes until patient is fully atropinized. Dosage for children is appropriately reduced. Atropinization should be maintained for 12 hours by intramuscular administration of atropine in lower doses given at appropriate time intervals. Do not administer 2-PAM, opiates and other cholinesterase inhibiting drugs. Artificial respiration or oxygen may be necessary. Observe patient continuously for at least 24 hours. Allow no further exposure to any cholinesterase inhibitors until cholintesterase level is normal by blood test.

TOXIC TO FISH, BIRDS, AND WILDLIFE. Birds feeding on treated areas may be killed. Keep out of any body of water. Do not contaminate water when cleaning equipment or disposing of wastes. Apply this product only as specified for use on the carton in which this bag was packed.

DISPOSAL OF SPILLED OR EXCESS TEMIK 15G ALDICARB PESTICIDE AND EMPTY CONTAINERS. If bag is broken, handle with rubber gloves. Do not get dust or granules on skin or in eyes. Do not breathe dust. Sweep up and bury any spilled or excess TEMIK at least 18 inches deep in soil isolated from water supplies and food crops. Never re-use bags or boxes. Burn empty bags and boxes immediately. Stay away from and do not breathe or contact smoke.

WARRANTY

1. The manufacturer guarantees and warrants (a) that the active ingredient content and the total net weight are as stated within lawful limits and (b) that the directions, warnings and other statements on the label are based upon responsible experts' evaluation of reasonable tests of effectiveness, of toxicity to laboratory animals and to plants, and of residues on food crops, and upon reports of field experience. Tests have not been made on all varieties or in all geographic areas.

2. The manufacturer further warrants that the material herein is reasonably fit for use under normal conditions as directed hereon. The manufacturer neither makes nor authorizes any agent or representative to make any other warranties of FITNESS OR OF MERCHANTABILITY, guarantee or representation, express or implied, concerning this material. This product is sold only on the basis that buyer assumes all risks of use or handling which may result in loss or damage and which are beyond manufacturer's control. No claim of any kind, and whether or not based on negligence, shall be greater in amount than the purchase price of the material in respect of which such claim is made. In no event shall manufacturer or seller be liable for special, indirect or consequential damages resulting from the use or handling of this material, whether or not based on negligence.

3. No modification of this warranty and disclaimer is authorized, except by specific reference to them in writing by an employee of the manufacturer.

UNION CARBIDE CORPORATION • AGRICULTURAL PRODUCTS

P.O. BOX 1906, SALINAS, CALIFORNIA 93901 USA

MADE IN USA

Active ingredient protected by U S Pat No 3,217,037

TEMIK is the registered trademark of Union Carbide Corporation for ALDICARB Pesticide

Table 9. WARNING AND PRECAUTIONARY STATEMENTS APPEARING ON TEMIK® 15G (aldicarb) LABELS (continued).

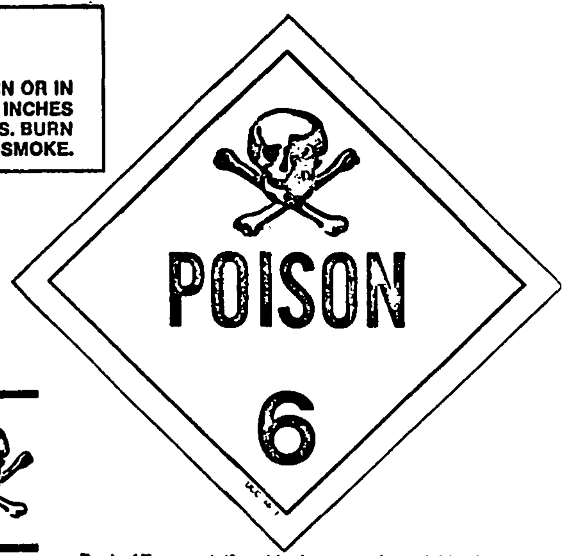
DISPOSAL OF SPILLED OR EXCESS TEMIK 15G ALDICARB PESTICIDE AND EMTPY CONTAINERS

IF CARTON IS BROKEN, HANDLE WITH RUBBER GLOVES. DO NOT GET DUST OR GRANULES ON SKIN OR IN EYES. DO NOT BREATHE DUST. SWEEP UP AND BURY ANY SPILLED OR EXCESS TEMIK AT LEAST 18 INCHES DEEP IN SOIL ISOLATED FROM WATER SUPPLIES AND FOOD CROPS. NEVER REUSE BAGS OR BOXES. BURN EMPTY BAGS AND BOXES IMMEDIATELY. STAY AWAY FROM AND DO NOT BREATHE OR CONTACT SMOKE.

KEEP DRY
Moisture can increase handling hazards

FOR DISTRIBUTION AND SALE ONLY IN THIS CARTON

DANGER POISON
KEEP OUT OF REACH OF CHILDREN AND ANIMALS



Dept. of Transportation shipping name: Insecticide, dry.

HARMFUL OR FATAL BY SKIN OR EYE CONTACT, BY BREATHING DUST OR BY SWALLOWING GRANULES. RAPIDLY ABSORBED THROUGH SKIN AND EYES. DO NOT GET ON SKIN OR IN EYES. DO NOT BREATHE DUST.

Wear long-sleeved clothing and protective gloves when handling. Wash hands and face before eating or smoking. Bathe at the end of work day, washing entire body and hair with soap and water. Change contaminated clothing daily and wash in strong washing soda solution and rinse thoroughly before reusing.

SYMPTOMS OF POISONING

may be one or more of the following:

Weakness	Vomiting	Pinpoint Eye Pupils
Headache	Diarrhea	Abnormal Flow of Saliva
Sweating	Tightness in Chest	Abdominal Cramps
Nausea	Blurred Vision	Unconsciousness

CONTACT A PHYSICIAN IMMEDIATELY IN ALL CASES OF SUSPECTED POISONING

ANTIDOTE

ANTIDOTE is atropine sulfate. Consult a physician for antidote tablets and instructions before using this pesticide. DO NOT USE 2-PAM AS AN ANTIDOTE.

FIRST AID TREATMENT

If symptoms are apparent, give atropine sulfate tablets as directed by the physician. Do not give antidote unless symptoms of poisoning have occurred. Transport patient to a physician or hospital, whichever is faster. Keep patient warm and quiet. If breathing is difficult, give oxygen. Start artificial respiration immediately if breathing stops. SHOW A COPY OF THIS LABEL TO THE PHYSICIAN.

IN CASE OF SKIN OR EYE CONTACT, wash skin immediately and thoroughly with soap and water and rinse well; flush eyes with plenty of water for 15 minutes. Remove contaminated clothing and wash before reuse.

IN CASE OF SWALLOWING, induce vomiting immediately by putting finger down throat or drinking strong salty or soapy water. Then drink plain water and repeat until vomit is clear.

INFORMATION FOR PHYSICIAN

This product contains 2-methyl-2(methylthio) propionaldehyde O-(methylcarbamoyl)oxime. It is a spontaneously reversible cholinesterase inhibitor causing parasympathetic nerve stimulation. Preferred treatment of poisoning in adults is atropine sulfate in 1.2 mg doses given intravenously every 10 to 12 minutes until patient is fully atropinized. Dosage for children is appropriately reduced. Atropinization should be maintained for 12 hours by intramuscular administration of atropine in lower doses given at appropriate time intervals. Do not administer 2-PAM, opiates and other cholinesterase inhibiting drugs. Artificial respiration or oxygen may be necessary. Observe patient continuously for at least 24 hours. Allow no further exposure to any cholinesterase inhibitors until cholinesterase level is normal by blood test.

TOXIC TO FISH, BIRDS, AND WILDLIFE

Birds feeding on treated areas may be killed. Keep out of any body of water. Do not contaminate water when cleaning equipment or disposing of wastes. Apply this product only as specified on this label.

UCC-2413C

Table 9. WARNING AND PRECAUTIONARY STATEMENTS APPEARING ON TEMIK® 15G (aldicarb) LABELS (continued).

UNION CARBIDE

TEMIK® 15% GRANULAR

ALDICARB PESTICIDE

GENERAL DIRECTIONS FOR USE

(See Back Panel For Crop Use Directions)

GENERAL INFORMATION

TEMIK 15G controls certain insects, mites and nematodes. When applied into moist soil at-planting and/or post-emergence the active ingredient is rapidly absorbed by roots and translocated throughout all parts of the plant. Control often lasts more than six weeks varying with growing conditions, rate of use and pests. Crop yields are usually increased with treatments of TEMIK.

GENERAL CAUTIONS

Use TEMIK 15G Aldicarb Pesticide only in accordance with label directions, warnings and cautions. Do not use on any crop not listed on this label, as any residues remaining may be illegal or harmful. DO NOT STORE OR USE IN OR AROUND THE HOME OR HOME GARDEN.

Use high rate on heavy organic or clay soils. Do not overapply. Treatments in excess of 6.5 pounds per acre made directly in the seed furrow of cotton or sugar beets may delay emergence and reduce plant stand.

Make side-dress applications close enough to plants to allow good uptake by the roots without injury to the plants from root pruning. In irrigated areas, follow application with irrigation within one week. If alternate furrows are irrigated after side-dress application, the TEMIK and water must be on the same side of the plant row.

Calibrate and adjust application equipment to insure proper rate and accurate placement. Clean application equipment thoroughly after use. Bury any excess material in soil (see instructions on TOP PANEL of this carton for DISPOSAL OF SPILLED OR EXCESS TEMIK and EMPTY CONTAINERS).

Deep disc any spills at row ends immediately to prevent birds from feeding on exposed granules.

COMPATABILITY

Pesticidal activity of TEMIK 15G Aldicarb Pesticide is not affected by normal applications of fertilizers or other pesticides. It may be reduced or lost if applied with alkaline materials such as lime.

PRE-HARVEST AND GRAZING USE INFORMATION AND LIMITATIONS

To avoid illegal residues in or on:

COTTONSEED

- Do not make more than one at-planting application and one post-emergence application per crop.
- Do not apply withing 90 days of harvest.

PEANUTS

- Do not make more than one application per crop.
- Do not harvest within 90 days of application.
- Do not hog off treated fields.
- Do not feed hay or vines to livestock.

POTATOES

- Do not make more than one application per crop.
- Do not harvest within 90 days of an at-planting application.
- Do not apply a post-emergence application within 50 days of harvest.

SUGAR BEETS

- Do not make more than one at-planting application and two post-emergence applications per crop.
- Do not exceed a total of 40 pounds per acre.
- Do not apply within 90 days of harvest.
- If tops are to be fed to livestock, do not apply within 120 days of harvest.
- Do not use tops as food for humans.

SUGARCANE AND SWEET POTATOES

- Do not make more than one application per crop.
- Do not harvest within 120 days of application.

OTHER CROPS

- Do not plant any crop not listed on this label in soil treated with TEMIK 15G within 100 days after last application.

MEAT AND MILK

- Do not allow livestock to graze in treated areas before harvest.

UCC-2413C

Besides California, a number of other states have imposed restrictions on pesticides. They are: Washington, Oregon, California, Illinois, Michigan, Massachusetts, Connecticut, New York, New Jersey, Delaware, North Carolina, and Florida.

In addition to restrictions on the use of aldicarb imposed by state statutes and regulations, many states amplify aldicarb product labels by making more specific use recommendations designed to accommodate local or regional requirements. These are usually issued jointly by the State Agricultural Experiment Station and Extension Service in cooperation with the U.S. Department of Agriculture. These state insecticide use recommendations are issued or revised annually.

Production and Domestic Supply

Volume of Production - According to the United States Tariff Commission, there has been only one basic producer of aldicarb in the United States up to and including 1972, i.e., Union Carbide Corporation. The production and sales volumes of aldicarb are not reported individually. In the most recent Tariff Commission reports (1972 and 1973)[1/], aldicarb is included in the category: "All other acyclic insecticides, rodenticides, soil conditioners and fumigants." This category includes, in addition to aldicarb, methomyl, chloropicrin, DBCP, other fumigants, soil conditioners, small quantities of rodenticides, and others. The reported production volume for this composite group was 104,295,000 lb of active ingredients in 1972; 111,288,000 lb in 1973.

Compared to several other pesticides in this category, the production and sales volume of aldicarb is so small that the Tariff Commission data are not very helpful in estimating aldicarb volumes. However, based on estimates in a previous study (Lawless et al., 1972)[2/] and on additional information received more recently, including the data on the domestic uses of aldicarb, Midwest Research Institute (MRI) estimates that between 1.0 and 1.5 million pounds of aldicarb active ingredient were moved in 1972 for domestic and export sales combined. It is assumed that this quantity is equivalent to the 1972 production of aldicarb, although it is possible that a part of it was produced prior to the 1972 calendar year.

Imports - A Tariff Commission report[3/] on benzenoid and non benzenoid chemical imports in 1972 shows an absence of aldicarb imports. The probability that there were no imports on aldicarb into the United States in 1972 is further supported by the fact that the product is the subject of a patent held by the basic U.S. producer, Union Carbide Corporation.

1/ U.S. Tariff Commission, Synthetic Organic Chemicals, U.S. Production and Sales, TC Publication 681 (1972, 1973).

2/ Lawless, E. W., and T. L. Ferguson of Midwest Research Institute, and R. von Rumker of RvR Consultants, The Pollution Potential in Pesticide Manufacturing, for the Environmental Protection Agency, Contract No. 68-01-0142 (January 1972).

3/ U.S. Tariff Commission, Imports of Benzenoid Chemicals and Products, TC Publication 601 (1973).

Exports - Technical or formulated aldicarb is not listed in Bureau of Census commodity descriptions on pesticide exports.1/ Based on other sources, including the Lawless study (1972), MRI estimates that the export volume of aldicarb in 1972 was on the order of 400 - 700,000 lb of active ingredient equivalent.

Domestic Supply - Based on the information presented in preceding subsections, MRI estimates that the domestic consumption of aldicarb in the United States in 1972 at about 600,000 lb of active ingredient.

Formulations - The only aldicarb formulation available for commercial use is a granular product containing 10% of stabilized active ingredient. According to Union Carbide Corporation, this formulation provides a uniform high-quality product with minimal handling hazards. The active ingredient is impregnated on organic granules with a small quantity of binding agent which prevents dustiness in shipment and reduces dermal toxicity. The final product is air-cleaned to remove any fines which might present an inhalation toxicity hazard.

Use Patterns of Aldicarb in the United States

General - Aldicarb is registered and used in the United States only on agricultural and commercially grown ornamental crops. The product is not registered or recommended for any industrial, commercial, or institutional pest control purposes, nor for use by amateur gardeners.

Aldicarb was first introduced for commercial use in agriculture in the U.S. in about 1970. In the U.S. Department of Agriculture's survey on the quantities of pesticides used by farmers in 19712/, aldicarb is not shown individually. However, in the group "carbamate insecticides," there is a category, "other," which, MRI believes to consist predominantly or entirely of aldicarb. According to this USDA report, 37,000 lb active ingredient of "other carbamate insecticides" were used in the U.S. in 1971, all on cotton. Of this total, 20,000 lb were used in the Southeastern and South Central states; 17,000 lb in the Pacific states.

In 1972, an estimated 600,000 lb of aldicarb active ingredient were used in the United States. About 75% of this total went on cotton; slightly more than 15% on sugar beets; the balance on ornamentals and a number of other crops, including some for which aldicarb is not registered. By geographic regions, about 40% of the total quantity of aldicarb was used in the Southwestern states; about 35% in the South Central states; slightly less than 10% each in the Northwestern and Southeastern states; the balance in the North Central states. More than 25% of the total quantity of aldicarb used in the U.S. in 1972 was used in the State of California on cotton, sugar beets and ornamentals.

1/ U.S. Bureau of the Census, U.S. Exports, Schedule B, Commodity by Country, Section 5, Chemistry, Report FT 410 (1973).

2/ U.S. Department of Agriculture, Survey on Quantities of Pesticides Used by Farmers in 1971, Agricultural Economic Report No. 252, in press.

MRI estimates that the quantity of aldicarb used on agricultural crops in the U.S. increased substantially (more than tenfold) between 1971 and 1972. Table 10 presents a breakdown of the estimated uses of aldicarb in the U.S. in 1972 by regions and major crops. The following information sources were used in arriving at these estimates:

1. The 1971 USDA survey of pesticide uses by farmers.

2. Results of a survey of the Federal/State cooperative extension services in all 50 states and in Puerto Rico conducted by RvR Consultants in 1973.

3. Analyses of State pesticide use recommendations.

4. Local and regional estimates on pesticide use volumes obtained from State research and extension personnel in personal communications.

5. Pesticide use reports from the states of Arizona, California, Illinois, Indiana, Michigan, Minnesota, and Wisconsin.

6. Data on pesticide uses supplied by the EPA Community Pesticide Studies Projects in Arizona, Hawaii, Idaho, Mississippi, South Carolina, Texas, and Utah.

7. Estimates and information obtained from the basic producers of aldicarb and of other pesticides, and from pesticide trade sources.

8. U.S. Bureau of the Census, Census of Agriculture, 1969, Vol. V, Special Reports.

9. Agricultural Statistics, an annual publication of the U.S. Department of Agriculture.

Data from these sources was carefully analyzed, correlated, cross-checked and cross-validated. The resulting estimates have the following limitations:

1. Aldicarb was not included among the 25 selected pesticides whose distribution, use, and environmental impact potential was recently studied jointly by Midwest Research Institute and RvR Consultants in a project sponsored by EPA and the Council on Environmental Quality (von Rumker et al., 1974).1/

1/ von Rumker, R., E. W. Lawless, and A. F. Meiners, Production, Distribution, Use, and Environmental Impact Potential of Selected Pesticides, for Council of Environmental Quality, Contract No. EQC-311 (15 March 1974).

Table 10. ESTIMATED USES OF ALDICARB (TEMIK®) IN THE U.S. BY REGIONS AND MAJOR CROPS AND OTHER USES (1972)

Region	Crop			
	Cotton	Sugar Beets	All Other Crops	Total All Crops
	(Thousands of pounds of active ingredient)			
Northeast[a]	-	-	Negligible	Negligible
Southeast[b]	40	-	10	50
North Central[c]	-	20	10	30
South Central[d]	200	Negligible	15	215
Northwest[e]	-	45	10	55
Southwest[f]	200	35	15	250
Total, all regions	440	100	60	600

a/ New England States, New York, New Jersey, Pennsylvania.
b/ Maryland, Delaware, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida.
c/ Ohio, Indiana, Illinois, Minnesota, Wisconsin, Michigan, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas.
d/ Kentucky, Tennessee, Arkansas, Louisiana, Mississippi, Alabama, Oklahoma, Texas.
e/ Montana, Idaho, Wyoming, Colorado, Utah, Washington, Oregon, Alaska.
f/ New Mexico, Nevada, Arizona, California, Hawaii.
Source: RvR estimates. See text.

2. Aldicarb has been in commercial use in the U.S. for only a few years. Its volume of use appears to be expanding rapidly, and it has been registered for use on additional crops since it first became available. The product has not as yet reached a "steady state" or steady growth trend.

3. Many pesticide use surveys (including the 1971 USDA survey) do not as yet list aldicarb individually.

Aldicarb Use Patterns by Regions - MRI estimates that about 85% of the total quantity of aldicarb used in the United States in 1972 (Table 10) was in the Southern states--an estimated 250,000 lb in the Southwest; 215,000 lb in the South Central states; and 50,000 lb in the Southeastern states. In all three areas, aldicarb was primarily used on cotton.

Few, if any, quantities of aldicarb were used in the Northeastern states. An estimated 30,000 lb were used in the North Central states, and 55,000 lb in the Northwest--the major use was on sugar beets.

Aldicarb Use Patterns by Crops - Almost three-quarters of the total estimated quantity of aldicarb used in 1972 was on cotton. An estimated 400,000 lb (90%) was equally divided on cotton in the Southwestern and South Central states; the balance of 40,000 lb (10%) was used in the Southeastern states.

About 100,000 lb of aldicarb active ingredients were used on sugar beets in the Northwestern, Southwestern, and North Central states.

An estimated 60,000 lb of aldicarb (10% of total U.S. consumption) were used on all other crops combined in 1972, consisting of about 15,000 lb each in the Southwestern and South Central states, and about 10,000 lb each in the remaining regions of the country, with the exception of the Northeast where the use of aldicarb was negligible.

Aldicarb Uses in California - The State keeps detailed records of pesticide uses by crops and commodities which are published quarterly and summarized annually. Table 11 summarizes the uses of aldicarb in California by major crops for the 4-yr period 1970 to 1973. The annual volume of aldicarb used in California increased from 14,000 lb in 1970 to 213,000 lb in 1973. According to this source, almost all of the aldicarb quantities used in California in 1970 and in 1971 went on cotton. In 1972, aldicarb use on cotton increased to 133,000 lb; 22,000 lb went on sugar beets; 3,000 lb on ornamentals; 5,000 lb on alfalfa; and 1,000 lb on a considerable variety of other crops. These California uses reflect State registration or experimental uses.

There was a further substantial increase in rate of use of aldicarb in California from 1972 to 1973. Use on cotton increased by more than 10% to 148,000 lb, while the quantities used on sugar beets and ornamentals, respectively, more than doubled. About 6,000 lb of aldicarb were again used on alfalfa and a variety of other crops, most of them not covered by the product's registered label.

Tables 12 and 13 present the aldicarb uses in California by crops and other uses, number of applications, pounds of active ingredient, and number of acres treated, for 1972 and 1973, the two most recent years for which such data are available. In 1972, aldicarb was applied to about 10, in 1973 to about 20 different crops in California, including those listed individually in Table 11. In addition, small quantities of aldicarb were used in both years by Federal agencies, county or city parks, the University of California and "other agencies." Some quantities were also used in greenhouses, on fallow (open ground), in or on nonagricultural areas, and for "soil fumigation."

There is a rapid increase in the use of aldicarb on cotton in California despite the fact that the California Agricultural Experiment Station and Extension Service do not recommend its use on this crop. A report[1/] on California's 1972 pest and disease control program for cotton contains the following statement on aldicarb in one section dealing with aldicarb's effects on various spider mites, Atlantic or Strawberry, Pacific, two-spotted, and carmine mites, on cotton.

> Use of aldicarb ... is very effective in reducing populations of spider mites, leafhoppers, lygus bugs, aphids and whiteflies on cotton. It is not effective on lepidopterous larvae with the exception of the cotton leaf perforator. Tests conducted in California indicate that in-furrow granular applications at planting or side-dressed applications to an established stand are effective, but the residual activity of in-furrow applications usually does not persist into late June and July. In-furrow applications at planting have frequently caused stand reduction; however, the reduction has not been serious enough to require replanting when germination conditions were adequate.
>
> The greatest potential of this material appears to be as a side-dressed application to established stands. Field tests indicate that the granules should be placed 6 to 8 in. from the plant row and deep enough to be in moisture (4 to 5 in.). Side-dressed applications should be made about mid-June just before the first irrigation but not after late June. Effective dosage rates range from 1.5 to 2.0 lb of active ingredient per acre, using the higher dosage on heavy soils and the lighter dosage on sandy or sandy-loam soils. The granules have been most effective on lighter soils.
>
> Poor reduction of spider mite populations has been observed in some cases where the granules were injected too shallow. Populations of beneficial damsel, big-eyed, and minute pirate bugs are reduced in Temik® treated areas. Lepidopterous insects

1/ University of California Division of Agriculture, California Agricultural Experiment Station Extension Service, 1972 Pest and Disease Control Program for Cotton, (1972).

Table 11. ALDICARB USES IN CALIFORNIA BY MAJOR CROPS AND OTHER USES (1970-1973)

Crop/Use	(Thousands of pounds of active ingredient) Year 1973	1972	1971	1970
Cotton	148	133	15	14
Sugar beets	52	22	1	Negligible
Ornamentals	7	3	Negligible	Negligible
Alfalfa[a/]	5	5	Negligible	Negligible
All other uses,[b/]	1	1	Negligible	Negligible
Total, all uses	213	164	16	14

a/ Aldicarb is not Federally registered or recommended for use on this crop.

b/ Includes small uses by Federal, State, and local government agencies and the University of California; and uses on (unspecified) non agricultural areas, in greenhouses, on fallow (open ground), and for "soil fumigation."

Source: California Department of Agriculture, Pesticide Use Reports for 1970, 1971, 1972, and 1973.

Table 12. USE OF ALDICARB (TEMIK®) IN CALIFORNIA IN 1972, BY CROPS AND OTHER USES, APPLICATIONS, QUANTITIES, AND ACRES TREATED

Commodity	Applications[a/]	Lb	Acres
Alfalfa	4	175.81	297.00
Alfalfa for seed	34	5,191.67	2,691.30
Beet	22	532.84	381.00
Cotton	1,144	132,237.89	107,714.65
Cottonseed	6	698.20	892.00
Federal agency		0.49	
Flowers	9	946.87	377.00
U -Flowers[b/]	2	5.00	15,000[c/]
Greenhouse	2	11.10	1.91
U -Nursery stock[b/]	1	5.00	4,560,000[c/]
Union/dry	1	20.40	17.00
Orange	1	25.00	50.00
Ornamentals	6	1,540.69	115.40
Ornamental bedding plants	51	299.69	60.59
U -Ornamental bedding plants[b/]	2	1.20	500,000[c/]
Other agencies		0.17	
Rice	1	104.00	52.00
Roses	7	684.87	75.80
Sugar beet	278	22,002.79	17,425.40
University of California		13.70	
Total	1,571	164,497.38	130,151.05

Source: State of California, Department of Agriculture, Pesticide Use Report for 1972.

a/ Only agricultural applications are tabulated in this column.

b/ U = Miscellaneous units.

c/ These appear to be order of magnitude errors, and do not significantly effect the total.

Table 13. USE OF ALDICARB (TEMIK®) IN CALIFORNIA IN 1973, BY CROPS AND OTHER USES, APPLICATIONS, QUANTITIES, AND ACRES TREATED

Commodity	Applications a/	Lb	Acres
Alfalfa	12	1,476.52	1,752.00
Alfalfa for seed	13	3,032.25	1,251.75
Beet	15	884.60	766.50
Bulb	1	20.00	4.00
Citrus	1	2.03	0.25
Corn, field	1	148.00	74.00
Corn, pop	1	60.00	30.00
Cotton	1,085	148,219.00	111,590.61
Cottonseed	4	163.65	372.00
County or city parks		0.11	
Deciduous ornamental trees	1	2.00	2.00
Federal agency		5.45	
Fallow (open ground)	2	220.00	220.00
Flowers	523	3,662.95	1,409.57
U -Flowers b/	115	373.79	650,212 c/
U -Flowering shrubs b/	1	1.00	4,000 c/
U -Foliage b/	2	7.42	9,000 c/
Grape	1	120.00	120.00
Greenhouse	6	128.18	32.94
U -Greenhouse b/	5	35.40	23
Nonagricultural areas	1	216.00	54.00
Nursery stock	2	3.28	2.16
U -Nursery stock b/	2	1.20	16,000 c/
Olive	2	25.60	32.00
Orchard	7	20.46	3.63
Ornamentals	20	358.57	79.90
U -Ornamentals b/	3	12.78	70,000 c/
Ornamental bedding plants	39	288.81	41.16
U -Ornamental bedding plants b/	4	7.50	50
Other agencies		312.00	
Roses	43	1,735.74	427.76
U -Roses b/	6	19.90	66,205 c/
Soil (fumigation only)	2	149.59	41.35
Sorghum	1	30.00	30.00
Sugar beet	433	51,509.39	40,873.10
Tomatillo/husk tomato	1	60.00	100.00
Tomato	1	80.00	80.00
University of California		19.15	
Total	2,356	213,412.32	159,390.68

Source: State of California, Department of Agriculture, Pesticide Use Report for 1973.

a/ Only agricultural applications are tabulated in this column.

b/ U = Miscellaneous units.

c/ These appear to be order of magnitude error, and do not significantly effect the total.

have not increased in Temik® treated areas under California conditions. Since this is largely a preventative insecticide use and because most applications of Temik ® in experimental field tests have not resulted in statistically significant increased cotton yields, a general recommendation for the use of Temik ® cannot be made. CAUTION: Temik ® is highly toxic. Read and follow label instructions if used.

The use record of aldicarb on cotton in California (Table 11) indicates that despite this statement, increasing numbers of California cotton growers apply the product.

PART III. MINIECONOMIC REVIEW

CONTENTS

This section contains a general assessment of the efficacy and cost effectiveness of aldicarb. Data on the production of aldicarb in the United States as well as an analysis of its use patterns at the regional level and major crop are found in Part II of the report. The section summarizes rather than interprets data reviewed.

Efficacy and Cost Effectiveness

The efficacy and cost effectiveness of a specific pesticide should be measurable in terms of the increased yield or improved quality of a treated crop which would result in a greater income or lower cost than would be achieved if the pesticide had not been used. Thus, one should be able to pick an isolated test plot of a selected crop, treat it with a pesticide, and compare its yield with that of a nearby untreated test plot. The difference in yield should be the increase due to the use of the pesticide. The increased income (i.e., the yield multiplied by the selling price of the commodity) less than additional costs (i.e., the pesticide, its application and the harvesting of the increased yield) is the economic benefit due to the use of the pesticide.

Unfortunately, this method has many limitations. The data derived is incomplete and should be looked on with caution. Midwest Research Institute's review of the literature and EPA pesticide registration files revealed that experimental tests comparing crops treated with specific pesticides to the same crop without treatment are conducted by many of the state agricultural experimental stations. Only a few of these, however, have attempted to measure increased yield and most of this effort has been directed toward just a few crops such as cotton, potatoes, and sorghum. Most other tests on crops measure the amount of reduction in pest levels which cannot be directly related to yield.

Even the test plot yield data are marginally reliable, since these tests are conducted under actual field conditions that may never be duplicated again and are often not representative of actual field use. Thus yield is affected by rainfall, fertilizer use, severe weather conditions, soil type, region of the country, pesticide infestation levels and the rate, frequency and method of pesticide application. Because of these factors, yield tests at different locations and in different years will show a wide variance ranging from a yield decline to significant increases. For example, in a year of heavy pest infestation frequent pesticidal use will result in a high yield increase because the crop from the untreated test plot is practically destroyed. Conversely, in a year of light infestation, the yield increase will be slight. The use of market price to estimate the value received by the producer also has its limitations. If the use of the pesticide increases the yield of a crop and the national production is increased, then the market price should decline. According to Headley and Lewis (1967),[1/] a 1% increase in quantity marketed has at times resulted in a greater than 1% decrease in price. Thus the marginal revenue from the increased yield would be a better measure of value received.

1/ Headley, J. C., and J. N. Lewis, The Pesticide Problem: An Economic Approach to Public Policy, Resources for the Future, Inc., Washington, D.C., pp. 39-40 (1967).

A third limitation to the quantification of the economic costs and benefits is the limited availability of data on the quantities of the pesticide used by crop or pest, the acres treated, and the number of applications. In most cases the amount of Temik® used on each crop or each pest is not available.

As a result of these limitations an overall economic benefit by crop or pest cannot be determined. This report presents a range of the potential economic benefits, based on 1972 cost data, derived from the use of Temik® to control a specific pest on a specific crop. This economic benefit or loss is measured in dollars per acre for the highest and lowest and average yield increases developed from experimental tests conducted by the pesticide producers and the State agricultural experimental stations. The yield increases are multiplied by the unit price of the crop applying Temik® (chemical plus variable application costs).

Temik® is a recently introduced pesticide that is applied to a wide variety of crops where it is used as a nematocide and as a control for small insects. Numerous tests have been conducted that compare Temik® and other insecticides and nematocides to untreated test plots to determine their effects on yield. These tests on cotton, potatoes, peanuts, sugar beets, and sweet potatoes are summarized in the following subsections.

Cotton

Approximately 440,000 lb AI of Temik® were used to treat cotton insects and nematodes in 1972. It has been shown to be effective in controlling thrips, aphids, boll weevils, leaf miners, desert spider mites and fleahoppers.

Efficacy Against Pest Infestation

Temik® has been evaluated for insect control on cotton by a number of researchers. These tests were conducted prior to registration and in noncommercial trials since registration. For this reason the results may not be representative of actual field conditions, but they have been included so that the review may be more complete. (See Table 14.)

Beckham (1970)[1/] evaluated Temik® and other insecticides for the control of thrips on cotton in Georgia. Results of tests conducted in 1967 and 1968 showed that Temik® was highly effective in thrips control. Davis and Cowan (1972)[2/] showed that Temik® applied in the seed furrow at planting gave effective control of thrips, the cotton aphid, and the cotton fleahoppers.

1/ Beckham, C. M., "Influence of Systemic Insecticides on Thrips Control and Yield of Cotton," J. Econ. Entomol., 63:936-938 (1970).

2/ Davis, J. W., and C. B. Cowan, Jr., "Field Evaluation of Three Formulations of Aldicarb for Control of Cotton Insects," J. Econ. Entomol., 65:231-232 (1972).

Davis and Cowan (1974)[1/] conducted tests with Temik® and concluded that effective control of thrips, cotton aphids and cotton fleahoppers was achieved. The director of the Cooperative Extension Service in Mississippi, W. M. Bost (1974)[2/], reporting on tests of Temik® at Verona, Mississippi, in 1971, found the pesticide gave excellent thrips control and reduced the number of boll weevils. Its effect on fleahoppers was inconclusive.

Fifty additional tests, conducted from 1965 to 1973, compared yields of Temik®-treated plots at Stoneville, Mississippi (Bost, 1974). Substantial yield information was also obtained from Union Carbide pesticide petitions registered with EPA.

In addition to the above test data, Union Carbide has submitted the results of 1974 efficacy and comparative yield tests for cotton. This data has been compiled and evaluated in the same manner as the published data and is presented in Table 15. These tests are results of commercial use and are likely to be more representative of actual field conditions than the experimental trials in Table 14. The tests were conducted in several states and, therefore, probably cover a wide spectrum of environmental conditions. Most of the yield increases are averages of several tests and in the cases where the number of tests was given, this number has also been presented. The average change in yield has been calculated as a weighted average based on the number of tests from which each yield change was derived. This supplementary data on cotton gave no indication of the efficacy of insect control but the tests did report increases in yield of from 0 to 390 lb/acre in South Carolina and Alabama respectively. The weighted average of all the tests indicated that the use of Temik® caused an average increase in cotton yield of 75.6 lb/acre.

<u>Cost Effectiveness of Pest Control</u>

The 1972 price received by farmers for cotton was 24.0¢/lb for lint. Additional income from cottonseed of 4.2¢/lb and government price supports of 12.5¢/lb brought the total income to 40.7¢/lb of cotton (<u>Agricultural Statistics</u>, 1973)[3/] Aldicarb costs amounted to $9.50/lb of active ingredient (Bost, 1974).

1/ Davis, J. W., and C. B. Cowan, Jr., "Early Season Insects on Cotton: Control with Two Systemic Insecticides," <u>J. Econ. Entomol.</u>, 67:130-131 (1974).

2/ Bost, W. M., Director, Cooperative Extension Service, Mississippi State University, State College, Miss., Personal letter to D. F. Hahlen (Midwest Research Institute, St. Louis, Mo.) (1974).

3/ U.S. Department of Agriculture, <u>Agricultural Statistics</u>, 1973.

Table 14. SUMMARY OF EFFICACY TESTS ON COTTON

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1964	0.6	8	3.26	5.70	(2.44)	a/
	1.0	37	15.06	9.50	5.56	
	2.0	73	29.71	19.00	10.71	
1964	2.0	(98)	(39.89)	19.00	(58.89)	
	4.0	65	26.46	38.00	(11.54)	
Unknown	1.06	(192)	(78.14)	10.07	(88.21)	
Unknown	0.5	328	133.50	4.75	128.75	b/
	1.0	277	112.74	9.50	103.24	
	0.6/100 lb seed	152	61.86	5.70	56.16	
	1.0/100 lb seed	87	35.41	9.50	25.91	
1965	2.0	(119)	(48.43)	19.00	(67.43)	
	1.0	(38)	(15.46)	9.50	(24.96)	
1965	3.0	851	346.36	28.50	317.86	
1965	1.0	83	33.78	9.50	24.28	
	2.0	523	212.86	19.00	193.86	
1965	0.6	396	161.17	5.70	155.47	
	1.0	917	373.22	9.50	363.72	
1965	3.0	395	160.77	28.50	132.27	
	3.0	130	52.91	28.50	24.41	
	3.1	300	122.10	29.45	92.65	
	3.1	(60)	(24.42)	29.45	(53.87)	
	3.7	820	333.74	35.15	298.59	
	3.7	600	(244.20)	35.15	(279.35)	

Table 14. (Continued)

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1966	0.98	892	363.04	9.31	353.73	b/
	1.94	839	341.47	18.43	323.04	
	3.68	586	238.50	34.96	203.54	
1966	1.1	230	93.61	10.45	83.16	
	2.5	365	148.56	23.75	124.81	
1965	1.0	(38)	(15.46)	9.50	(24.96)	
1965	3.0	851	346.36	28.50	317.86	
1966	3.0	1,253	509.97	28.50	481.47	
1966	3.0	1,281	521.37	28.50	492.87	
1966	1.0	(210)	(85.47)	9.50	(94.97)	
	2.0	360	146.52	19.00	127.52	
	3.0	(100)	(40.70)	28.50	(69.20)	
1966	1.0	320	130.24	9.50	120.74	
	2.0	250	101.75	19.00	82.75	
	3.0	350	142.45	28.50	113.95	
	0.55	558	227.11	5.23	221.88	
	1.25	661	269.03	11.88	257.15	
	1.72	1,413	575.09	16.34	558.75	
	2.56	1,224	498.17	24.32	473.85	
	0.60	300	122.10	5.70	116.40	
	1.38	230	93.61	13.11	80.50	
	1.90	60	24.42	18.05	6.37	
	2.68	(70)	(28.49)	25.46	(54.95)	
	1.0	(281)	(114.37)	9.50	(123.87)	
	1.0 + 1.0	(281)	(114.37)	19.00	(133.37)	
	1.0 + 2.0	150	61.05	28.50	32.55	
	1.0 + 3.0	207	84.25	38.00	46.25	

Table 14. (Continued)

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1966	0.1	614	249.90	0.95	248.95	b/
	0.25	937	381.36	2.38	378.98	
	0.5	970	394.79	4.75	390.04	
1967	1.0	54	21.98	9.50	12.48	c/
1968	1.0	152	61.86	9.50	52.36	
1970	0.6	296	120.47	5.70	114.77	d/
	2.1	384	156.29	19.95	136.34	
	0.9	351	142.86	8.55	134.31	
	1.8	394	160.36	17.10	143.26	
	1.0	381	155.07	9.50	145.57	
1972	0.8	309	125.76	7.60	118.16	e/
	1.2	443	180.30	11.40	168.90	
1970	1.0	307	124.95	9.50	115.45	f/
	2.0	164	66.75	19.00	47.75	
1972	1.0	11	4.48	9.50	(5.02)	g/
	1.125	231	94.02	10.69	83.33	
1972	1.0	433	176.23	9.50	166.73	h/
	0.5	221	89.95	4.75	85.20	
1972	0.33	907	369.15	3.14	366.01	i/
	0.67	898	365.49	6.37	359.12	
	1.0	701	285.31	9.50	275.81	
1972	0.5	595	242.17	4.75	237.42	g/
1972	2.0	632	257.22	19.00	238.22	j/
	2.0	846	344.32	19.00	325.32	k/

Table 14. (Continued)

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1971	0.25	300	122.10	2.38	119.72	k/
	0.5	197	80.18	4.75	75.43	
	1.0	50	20.35	9.50	10.85	
1965	1.0	83	33.78	9.50	24.28	
1965	2.0	523	212.86	19.00	193.86	
1965	0.5	(114)	(46.40)	4.75	(51.15)	
1965	1.0	157	63.90	9.50	54.40	
1965	2.0	538	218.97	19.00	199.97	
1966	0.5	1,258	512.01	4.75	507.26	
1966	0.1	614	249.90	0.95	248.95	
1966	0.25	937	381.36	2.38	378.98	
1966	0.5	970	394.79	4.75	390.04	
1966	1.0 + 2.0	150	61.05	28.50	32.55	
1966	1.0 + 4.0	206	83.84	47.50	36.34	
1967	0.5	310	126.17	4.75	121.42	
1967	0.75	542	220.59	7.13	213.46	
1967	0.25	585	238.10	2.38	235.72	
1967	0.1	10	4.07	0.95	3.12	
1967	0.25	321	130.65	2.38	128.27	
1967	0.5	134	54.54	4.75	49.79	
1968	0.25	277	112.74	2.38	110.36	
1968	1.0	207	84.30	9.50	74.80	
1968	0.25	280	113.96	2.38	111.58	
1968	0.5	81	32.97	4.75	28.22	
1969	0.25	363	147.74	2.38	145.36	
1969	0.1	675	274.73	0.95	273.78	
1969	0.25	293	119.25	2.38	116.17	
1969	0.5	266	108.26	4.75	103.51	

Table 14. (Continued)

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1970	0.25	545	221.82	2.38	219.44	k/
1970	0.5	536	218.15	4.75	213.40	
1970	0.1	207	84.25	0.95	83.30	
1971	0.1	232	94.42	0.95	93.47	
1971	0.25	260	105.82	2.38	103.44	
1971	0.5	223	90.76	4.75	86.01	
1971	1.0	330	134.31	9.50	124.81	
1971	0.25	117	47.62	2.38	45.24	
1971	0.5	308	125.35	4.75	120.60	
1971	1.0	366	148.96	9.50	139.46	
1971	0.25	155	63.09	2.38	60.71	
1972	0.25	657	267.40	2.38	265.02	
1972	0.25	137	55.76	2.38	53.38	
1972	0.25	195	79.37	2.38	76.99	
1972	0.5	198	80.58	4.75	75.83	
1972	0.25	49	19.94	2.38	17.56	
1972	0.25	53	21.57	2.38	19.19	
1972	0.5	171	69.60	4.75	64.85	

Table 14. (Continued)

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income* ($/acre at 40.7¢/lb)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1973	0.3	89	36.22	2.85	33.37	
1973	0.6	120	48.84	5.70	43.14	
1973	0.15	130	52.91	1.43	51.48	
1973	0.3	281	114.37	2.85	111.52	
1973	0.6	189	76.92	5.70	71.22	
1973	0.5	228	92.80	4.75	88.05	
1973	1.0	215	87.50	9.50	78.00	

* Data in parentheses indicate decreases in yield, income, and economic benefit.

a/ Union Carbide Corp., EPA Pesticide Petition Files, Section 11.

b/ Union Carbide Corp., EPA Pesticide Petition 8F0637.

c/ Beckham, op cit. (1970).

d/ Davis and Cowan, op cit. (1972).

e/ Davis and Cowan, op cit. (1974).

f/ Birchfield, W., "Cotton," Fungicide and Nematocide Test Results of 1970, Report No. 277, American Phytopathological Society, St. Paul, Minn. (1970).

g/ Blackman, op cit. (1972).

h/ Birchfield, op cit. (1972).

i/ Bird et al., op cit. (1972).

j/ Smith, F. H., "Cotton," Fungicide and Nematocide Test Results of 1972, Report No. 312, American Phytopathological Society, St. Paul, Minn. (1972).

k/ Bost, op cit. (1974).

Note: AI = active ingredient.

Table 15. 1974 RESULTS OF TEMIK® APPLICATION ON COTTON

Location	Application (lb AI/acre)	Yield Change (lb)	Value of Yield Change($) 1/	Temik® Cost 2/	Economic Benefit 3/	No. Tests
Calif.-Ariz.	.6	79	32.15	5.70	26.45	14
Calif.-Ariz.	2.0	144	58.61	19.00	39.61	N/S
Texas	.6	93	37.85	5.70	32.15	25
N.C.-S.C.	.6	11	4.78	5.70	-1.22	20
Ark.-Mo.	.6	73	29.71	5.70	24.01	5
Georgia	.6	274	111.52	5.70	105.82	10
Alabama	.6	390	158.73	5.70	153.03	2
Mississippi	.6	40	16.28	5.70	10.58	45
S.C	.6	0	0	5.70	-5.70	1
S.C.	.6	25	10.18	5.70	4.78	1
S.C.	.5	50	20.35	4.75	15.60	1
S.C.	.5	25	10.18	4.75	5.43	1
S.C.	.5	25	10.18	4.75	5.43	1
Average, All Tests -	.6	75.6	30.77	5.70	25.07	

1/ Change in cotton yield x $.407/lb (1972 average price).
2/ Lb AI/acre x $9.50/lb AI; since most Temik® is applied at planting, application cost (usually calculated with planting costs) is not evaluated.
3/ Value of Yield Change minus Temik® Cost equals Economic Benefit.
Note: N/S - pests not specified; AI = active ingredient.
Source: Comparative yield data submitted to EPA by Dr. Richard Back, Union Carbide Corporation, Washington, D.C.

For the data reviewed from non-commercial use situations the range of changes in cotton varied from a decline of 281 lb/acre to an increase of 1413 lb/acre. The economic benefit after subtracting the cost of Temik® ranged from a loss of $133.37/acre to an increase of $558.75/acre. The 1974 commercial use data indicates a range of economic benefits from a loss of $5.70/acre to an increase of $153.03/acre. The average economic benefit shown by this data is an increase of $25.07/acre. However, in typical farm situations this increase to farmer income would be reduced nominally by costs of insecticide application and costs of harvesting the additional output. The actual application cost was treated here as a joint cost with the planting operation; therefore, a rather nominally low figure resulted. Furthermore, there is no indication that this supplementary data is a statistically representative sample of all comparative yield tests conducted on cotton.

Potatoes

Temik® is registered for control of aphids, leafhoppers, flea beetles, Colorado potato beetle larvae and various nematodes. However, most of the literature reviewed consisted of evaluation of Temik® for nematode control.

Efficacy Against Pest Infestation

In experimental trials prior to 1974 registration of Temik® for use on potatoes, Hofmaster and Waterfield (1972)[1/] conducted yearly tests of various soil insecticides between 1967 and 1971 for control of the Colorado potato beetle in Virginia. They concluded that 2 lb AI/acre of Temik® gave the best results and provided almost complete protection from the potato beetle from plant emergence to harvest. Miller and Kring (1970)[2/] evaluated several insecticides for control of insects and nematodes on potatoes in Connecticut. They concluded that the use of Temik® lowered the tobacco stunt nematodes by 90%, reduced feeding by potato flea beetles 95% or more, decreased the Colorado potato beetle damage more than 80% and reduced aphid population by over 99.5%.

Cetas (1970, 1971, 1972, 1973)[3-6/] conducted yearly tests comparing several insecticides for control of root lesion nematodes at the Long Island Vegetable Research Farm. He concluded that good control of the nematode was achieved with in-furrow applications of Temik®.

1/ Hofmaster, R. N., and R. L. Waterfield, "Insecticides Applied to the Soil for Control of the Colorado Potato Beetle in Virginia," J. Econ. Entomol., 65:1672-1679 (1972).

2/ Miller, P. M., and J. B. Kring, "Reduction of Nematode and Insect Damage to Potatoes by Band Application of Systemic Insecticides and Soil Fumigation," J. Econ. Entomol., 63:186-189 (1970).

3/ Cetas, Robert C., "Potato," Fungicide and Nematocide Test Results of 1970, Report No. 293, American Phytopathological Society, St. Paul, Minn. (1970).

4/ Cetas, Robert C., "Potato," Fungicide and Nematocide Test Results of 1971, Report No. 315, American Phytopathological Society, St. Paul, Minn. (1971).

5/ Cetas, Robert C., "Potato," Fungicide and Nematocide Test Results of 1972, Report No. 323, American Phytopathological Society, St. Paul, Minn. (1972).

6/ Cetas, Robert C., "Potato," Fungicide and Nematocide Test Results of 1973, Report No. 260, American Phytopathological Society, St. Paul, Minn. (1973).

Cole et al. (1972, 1973)[1-2] evaluated Temik® for control of verticillium wilt on potatoes and concluded that there were no significant differences in wilting when compared to an untreated plot. Weingartner et. al. (1973)[3] and Weingartner and Dickson (1973)[4] evaluated Temik® for control of a variety of nematodes and found that it reduced some nematodes, increased tuber quality and yields. These tests are summarized in Table 16.

Additional comparative efficacy and yield data for Temik® use on potatoes has been provided by Union Carbide and is presented in Table 17. In addition to the yield and economic benefit data, brief remarks on efficacy have been added in those cases where the data presented assessment of efficacy. These remarks give the measure of efficacy used followed by the value for the plots treated with Temik® and the value for the untreated check plots. As the test results show, Temik® appears effective in reducing the numbers of insects and nematodes found in potatoes and in the soil, as well as in reducing the incidence of verticillium wilt on potatoes.

Cost Effectiveness of Pest Control

For the non-commercial tests conducted prior to registration (1964-1973) the range of yield changes varies from a loss of 13 cwt/acre to an increase of 250 cwt/acre. The 1972 average price of potatoes was $2.55 cwt and the cost of Temik® is $9.50/lb AI (Bost, 1974). The economic benefits indicated by these tests, therefore, range from a loss of $61.65/acre to an increase of $609.00/acre, exclusive of application and harvesting costs. The 1974 commercial yield data is sufficient for permitting some differentiation by region in which the tests were conducted. From the three state area of Oregon, Washington, and Idaho there were 23 reports covering at least 57 comparative yield tests. Yield changes varied from a loss of 8 cwt/acre to an increase of 301 cwt/acre with an average yield increase of 144 cwt/acre. The calculated economic benefits of Temik® in this area range from a loss of $39.40/acre to a gain of $739.05/acre. The average economic benefit of these tests indicated a gain of $338.70/acre. A number of tests were submitted from the New England area, including tests from Maine, Connecticut, and New York. Changes in potato yield ranged from a decline of 5 cwt/acre to an increase of 133 cwt/acre with an average increase of 62 cwt/acre. The economic benefits associated with Temik® use averaged an increase of $131.98/acre, while they varied from a loss of $22.25/acre to an increase of $310.65.

1/ Cole, H., C. W. Goldberg, W. R. Mills, and R. A. Krause, "Potato," Fungicide and Nematocide Test Results of 1972, Report No. 153, American Phytopathological Society, St. Paul, Minn. (1972).

2/ Cole, J., R. A. Krause, and J. P. Huether, "Potato," Fungicide and Nematocide Test Results of 1973, Report No. 127, American Phytopathological Society, St. Paul, Minn. (1973).

3/ Weingartner, D. P., J. R. Shumaker, and D. W. Dickson, "Potato," Fungicide and Nematocide Test Results of 1973, Report No. 302, American Phytopathological Society, St. Paul, Minn. (1973).

4/ Weingartner, D. P., and D. W. Dickson, "Potato," Fungicide and Namatocide Test Results of 1973, Report No. 301, American Phytopathological Society, St. Paul, Minn. (1973).

Table 16. SUMMARY OF EFFICACY TESTS ON POTATOES

Date	Application (lb AI/acre)	Yield increase* (cwt/acre)	Additional income at* $2.55/cwt ($/acre)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1964	3	221	563.55	28.50	535.05	a/
1964	3	250	637.50	28.50	609.00	
1964	1	137	349.35	9.50	339.85	
1965	3.0	228	581.40	28.50	552.90	b/
	1.5	198	504.90	14.25	490.65	
1965	3.0	143	364.65	28.50	336.15	
1965	3.0	152	387.60	28.50	359.10	
1965	2.0	89	226.95	19.00	207.95	
1965	1.0	108	275.40	9.50	265.90	
	2.0	132	336.60	19.00	317.60	
1965	3.0	69	175.95	28.50	147.45	
1965	3.0	(13)	(33.15)	28.50	(61.65)	
1965	2.0	152	387.60	19.00	368.60	
	1.0 + 1.0	142	362.10	19.00	343.10	
	2.0	131	334.05	19.00	315.05	
1965	1.0	26	66.30	9.50	56.80	
	3.0	28	71.40	28.50	42.90	
1967	2.0	177	451.35	19.00	432.35	
	3.0	170	433.50	28.50	405.00	
1969	2.0	234	596.70	19.00	577.70	
	3.0	246	627.30	28.50	598.80	
	2.0	231	589.05	19.00	570.05	
1970	2.0	148	377.40	19.00	358.40	

Table 16. (Continued)

Date	Application (lb AI/acre)	Yield increase* (cwt/acre)	Additional income at* $2.55/cwt ($/acre)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit (loss)* ($/acre)	Source
1971	2.0	176	448.80	19.00	429.80	
	2.0	153	390.15	19.00	371.15	
	2.0	149	379.95	19.00	360.95	
1970	3.0	80	204.00	28.50	175.50	e/
1971	3.0	72	183.60	28.50	158.10	f/
	3.0	65	165.75	28.50	137.25	
1972	3.0	7	17.85	28.50	(10.65)	h/
1973	2.25	23	58.65	21.38	37.27	j/
1973	3.0	26	66.30	28.50	37.80	k/
	3.0	23	58.65	28.50	30.15	
	3.0	43	109.65	28.50	81.15	
1973	3.0	65	165.75	28.50	137.25	l/
1973	3.0	25	63.75	28.50	35.25	m/

* Data in parentheses indicate decreases in yield, income, and economic benefit.
a/ Union Carbide Corp., EPA Petition File, Section 11.
b/ Union Carbide Corp., EPA Pesticide Petition 7F0573.
c/ Miller and Kring, op. cit. (1970).
d/ Hofmaster and Waterfield, op. cit. (1972).
e/ Cetas, op. cit. (1970).
f/ Cetas, op. cit. (1971).
g/ Cole et al., op. cit. (1972).
h/ Cetas, op. cit. (1972).
j/ Schultz, O. E., and J. C. Locke, "Potato," Fungicide and Nematocide Test Results of 1973, Report No. 299, American Phytopathological Society, St. Paul, Minn. (1973).
k/ Cetas, op. cit. (1973).
l/ Weingartner and Dickson, op. cit. (1973).
m/ Weingartner et. al., op. cit. (1973).
Note: AI = active ingredient.

Table 17. 1974 RESULTS OF TEMIK® APPLICATION ON POTATOES

Location	Pest[4/]	Application (lb AI/acre)*	Yield Change (cwt)	Value of [1/] Yield Change($)	Temik® [2/] Cost($)	Economic[3/] Benefit($)	No. Tests	Efficacy Remarks (T/U)**
U.S.[5/]	A,L,C,F	2.5	225	573.75	23.75	550.00	104	
U.S.[5/]	A,L,C,F	2.5	83	211.65	23.75	188.10	16	
U.S.[5/]	N	3.0	47	119.85	28.50	91.35	49	
Oregon	V,A	3.0	79	201.45	28.50	172.95	1	% leaves with aphids: 0/14
Washington	N	3.0	301	767.55	28.50	739.05	1	% root knot galls: 0.29/64.33
Washington	V	3.0	57	145.35	28.50	116.85	1	
Washington	V	3.0	301	767.55	28.50	739.05	1	incidence of wilt after 1 month: slight/severe
Washington	V	3.0	116	295.80	28.50	267.30	1	
Washington	V	3.0	32	81.60	28.50	53.10	1	
Washington	V	3.0	109	277.95	28.50	249.45	1	
Washington	V	3.0	108	275.40	28.50	246.90	1	
Washington	V	3.0	80	204.00	28.50	175.50	1	
Washington	V	3.0	15	38.25	28.50	9.75	1	
Ida.-Wash.-Ore.	N	3.0	297	757.35	28.50	728.85	19	
Ida.-Wash.-Ore.	I	2.5	43	109.65	23.75	86.15	17	
Washington	N	3.0	69	175.95	28.50	147.45	1	root knot index: 0.86/4.69
Washington	V,N	3.0	132	336.60	28.50	308.10	1	nematodes/250 ml soil:87/440
Washington	V	3.0	53	135.15	28.50	106.65	1	mean % wilt: 13%/15%
Washington	A,mites	3.0	-8	-20.40	19.00	-39.40	1	live mites/10 leaves:1965/6672
Washington	A,mites	3.0	55	140.25	28.50	111.75	1	live mites/10 leaves:1285/6672
Washington	V	3.0	4	10.20	28.50	-18.30	1	wilt rating: 1.8/2.8
Idaho	C	2.0	33	84.15	19.00	65.15	1	
Idaho	C	2.5	87	221.85	23.75	198.10	1	
Idaho	C	2.5	73	186.15	23.75	162.40	1	
Idaho	C,A	2.0	58	147.90	19.00	128.90	1	
Idaho	C,A	2.0	88	224.80	19.00	205.40	1	
Maine	C,A,L	1.0	-5	-12.75	9.50	-22.25	1	
Maine	C,A,L	2.6	15	38.25	24.70	13.55	1	
Maine	C,A,L	2.6	117	298.35	24.70	273.65	1	
Connecticut	N	3.0	133	339.15	28.50	310.65	1	#nematodes/100g soil:16/76
New York	L,A,F	2.5	65	165.75	23.75	142.00	1	aphids: 18.5/152.7
New York	N	3.0	33	84.15	28.50	55.65	1	#nematodes at harvest: 67/187
New York	N	3.0	72	183.60	28.50	155.10	1	#nematode/gm of root: 33/81
New York	N	3.0	65	165.75	28.50	137.25	1	#nematode/gm of root: 18/90
New York	N	3.0	80	204.00	28.50	175.50	1	#nematode/gm of root: 6.4/44.7
New England	N	3.0	46	117.30	28.50	88.80	22	
New England	I	2.5	97	247.35	23.75	223.60	10	
Michigan	N/S	3.0	110	280.50	28.50	252.00	1	
Michigan	N/S	3.0	182	464.10	28.50	435.60	1	
Michigan	L,F,A,PB	3.0	122	311.10	28.50	282.60	1	aphids/season: 105/395
Ohio	A,C	3.0	140	357.00	28.50	328.50	1	aphids/leaf, 78 days: 15.5/71.2

Table 17. (Continued)

Location	Pest[4/]	Application (lb AI/acre)*	Yield Change (cwt)	Value of [1/] Yield Change($)	Temik® [2/] Cost($)	Economic[3/] Benefit($)	No. Tests	Efficacy Remarks (T/U)**
Wisconsin	N/S	1.5	156	379.80	14.25	383.55	1	
Wisconsin	N/S	3.0	163	415.65	28.50	387.15	1	
Michigan	N/S	3.0	65	165.75	28.50	137.25	1	
Michigan	N/S	3.0	67	170.85	28.50	142.35	1	
Wisconsin	N/S	1.5	12	30.60	14.25	16.35	1	
Wisconsin	N/S	3.0	-8	-20.40	28.50	-48.90	1	
Wisconsin	N/S	1.5	111	283.05	14.25	268.80	1	
Wisconsin	N/S	3.0	146	372.30	28.50	343.80	1	
Wisconsin	N/S	1.5	28	71.40	14.25	57.15	1	
Wisconsin	N/S	3.0	18	45.90	28.50	17.40	1	
Wisconsin	N/S	1.5	33	84.15	14.25	69.90	1	
Wisconsin	N/S	3.0	31	79.05	28.50	50.55	1	
Michigan	N	3.0	36	91.80	28.50	63.30	4	
Ohio, Mich., Wisc.	I	2.5	104	265.20	23.75	241.45	32	
New Jersey	A,C	3.0	105	267.75	28.50	239.25	1	aphid control: excellent/poor
Virginia	C	2.0	176	448.80	19.00	429.80	1	#Colo. potato beetles/10 hills: 0/213
Virginia	C	2.0	176	448.80	19.00	429.80	1	#Colo. potato beetles/10 hills: 0/219
Virginia	C	2.0	148	377.40	19.00	358.40	1	#Colo. potato beetles/10 hills: 0/309
Virginia	C	4.0	151	385.05	38.00	347.05	1	#Colo. potato beetles/10 hills: 0/309
Va.,N.J.,Del.,Penn.	I	2.5	159	405.45	23.75	381.70	19	
Florida	N	3.0	43	109.65	28.50	81.15	1	#nematodes/100cc soil: 63.6/115
Florida	N	3.0	73	186.15	28.50	157.65	1	#nematodes/100cc soil: 145/2702
Florida	N	3.0	46	117.30	28.50	88.80	1	#nematodes/100cc soil: 165/942
Florida	N	3.0	31	79.05	28.50	50.55	3	
N.D.,Minn.	I	2.5	17	43.35	23.75	19.60	9	
Arizona	A	2.5	90	229.50	23.75	205.75	7	
Arizona	N/S	2.0	108	275.40	19.00	256.40	1	
Average, All Ore.,Wash.,Ida.		3.0	144	367.20	28.50	338.70	57	
Average, All New England		2.75	62	158.10	26.13	131.98	41	
Average, All Ohio,Mich.,Wisc.		2.5	93	237.15	23.75	213.40	52	
Average, All Va.,N.J.,Del.,Penn		2.5	157	400.35	23.75	376.60	24	
Grand Average		2.75	130	331.50	26.13	305.37		

* AI/acre = active ingredient/acre.

** T/U = treated/untreated.

1/ Change in potato yield x $2.55/cwt (1972 average price).

2/ Lb AI/acre x $9.50/lb AI, since most Temik® is applied at planting the application cost is considered a joint cost with planting cost and not considered here.

3/ Value of Yield Change minus Temik® Cost equals Economic Benefit.

4/ N=nematodes, L=Leafhoppers, C=Colo. potato beetle, A=aphids, F=flea beetles, V=verticillium wilt, I=insects, unspec., T=thrips, PB=plant bugs, N/S=not specified.

5/ Tests in various states not specified elsewhere.

Source: Comparative yield data submitted to EPA by Dr. Richard Back, Union Carbide Corporation, Washington,D.C.

Eighteen reports covering 32 yield comparisons from the Ohio, Michigan, and Wisconsin area were included in potato yield data. The lowest yield change was a loss of 8 cwt/acre, while the greatest change was an increase of 182 cwt/acre. The average change in yield was an increase in output of 93 cwt/acre. The economic benefits implied by these yield changes are: $48.90/acre, $435.60/acre, and $213.40/acre, respectively. Several tests from the Mid-Atlantic area showed an average yield increase of 157 cwt/acre, with an economic benefit of $376.60. The lowest yield change from this area was an increase of 104 cwt/acre and the highest was an increase of 126 cwt/acre. The economic benefits ranged from $239.25/acre to $429.80/acre.

Additional data submitted by Union Carbide on potatoes resulted in reports covering at least 366 comparative yield tests. Overall data on changes in yield varied from a loss of 8 cwt/acre to a gain of 301 cwt/acre, averaging an increase of 130 cwt/acre. Economic benefits ranged from a loss of $48.90/acre to an increase of $739.05. The average economic benefit for the 1974 potato yield data was an increase of $305.37/acre.

Sweet Potatoes

Temik® is registered for control of root knot, reniform and miscellaneous nematodes on sweet potatoes in Louisiana.

Efficacy Against Pest Infestation

Birchfield and Martin (1970, 1973)[1-2] and Averre et al. (1972)[3] evaluated aldicarb for root knot nematode and observed a reduction in the nematodes and an increase in No. 1 grade sweet potatoes. Birchfield and Martin (1973) tested various rates of Temik® for control of the reniform nematode and found that heavier dosages resulted in significantly reduced namatodes and greater yields. Martin and Birchfield (1970, 1973)[4-5] and Birchfield and Martin (1971, 1972, 1973)[6-7] tested Temik® for control of miscellaneous nematodes which are not known to cause sweet potato yield reduction. They found some nematode reduction but a wide yield variance.

1/ Birchfield, W., and W. J. Martin, "Sweet Potato," Fungicide and Nematocide Test Results of 1970, Report No. 303, American Phytopathological Society, St. Paul, Minn. (1970).

2/ Birchfield, W., and W. J. Martin, "Sweet Potato," Fungicide and Nematocide Test Results of 1973, Report Nos. 308 and 309, American Phytopathological Society, St. Paul, Minn. (1973).

3/ Averre, C. W., L. W. Nielson, and K. R. Baker, "Sweet Potato," Fungicide and Nematocide Test Results of 1972, Report No. 334, American Phytopathological Society, St. Paul, Minn. (1972).

4/ Martin, W. J., and W. Birchfield, "Sweet Potato," Fungicide and Nematocide Test Results of 1970, Report No. 305, American Phytopathological Society, St. Paul, Minn. (1970).

5/ Martin, W. J., and W. Birchfield, "Sweet Potato," Fungicide and Nematocide Test Results of 1973, Report Nos. 306 and 307, American Phytopathological Society, St. Paul, Minn. (1973).

6/ Birchfield, W., and W. J. Martin, "Sweet Potato," Fungicide and Nematocide Test Results of 1971, Report No. 318, American Phytopathological Society, St. Paul, Minn. (1971).

7/ Birchfield, W., and W. J. Martin, "Sweet Potato," Fungicide and Nematocide Test Results of 1972, Report No. 335, American Phytopathological Society, St. Paul, Minn. (1972).

Cost Effectiveness of Pest Control

The yield changes on test plots treated with Temik® varied from a loss of 68 bu/acre to an increase of 228 bu/acre based upon grading the potatoes according to U.S. standards into U.S. No. 1, jumbo and canners grades. Averre et al., (1972) used prices of $1.75/bu for U.S. No. 1 grade and $0.75/bu for canners and jumbo grades. At these prices and with the cost of aldicarb at $9.50/lb AI per acre (Bost, 1974), the economic benefit range would vary from a loss of $99.50/acre to a gain of $270.50/acre. The average benefit is an increase of $67.58/acre. The test results are summarized in Table 18.

Sugar Beets

Temik® is registered for control of the sugar beet root maggot, nematodes, leaf miners and aphids, with application rates varying from 1 to 3 lb/acre AI for insects and from 3 to 5 lb/acre AI for nematodes.

Efficacy Against Pest Infestation

Two references were found for non-commercial experimental trials which evaluated Temik® for control of the sugar beet nematode. Steele et al. (1972)1/ in two separate tests in Salinas, California, in 1972 compared aldicarb with several nematocides and an untreated check. They concluded that Temik® gave the best control of nematodes and that the highest yields were obtained when 4.0 lb AI/acre Temik® were applied.

Additional commercial yield data submitted by Union Carbide gave no indication of the efficacy of the insect or nematode control achieved, although performance data was presented.

Cost Effectiveness of Pest Control

Steele and Hodges (1972)2/ compared yields of sugar beets when Temik® was applied at various rates and placement methods. However, most of these test conditions were not those that are currently registered for nematode control, and they have been omitted from this review. In the one remaining test, the use of Temik® at 4.0 lb/acre AI in a 5-in band treatment increased sugar beet yield by 3.26 tons/acre over the untreated check plot. At the 1972 average price of $16/ton for sugar beets and $9.50/lb AI for Temik®, the economic benefit of this treatment is $14.16/acre. This data is presented in Table 19.

1/ Steele, A. E., L. R. Hodges, and G. W. Wheatley, "Sugar Beet," Fungicide and Nematocide Test Results of 1972, Report No. 332, American Phytopathological Society, St. Paul, Minn. (1972).
2/ Steele, A. E., and L. R. Hodges, "Sugar Beet," Fungicide and Nematocide Test Results of 1972, Report No. 333, American Phytopathological Society, St. Paul, Minn. (1972).

Table 18. SUMMARY OF EFFICACY TESTS ON SWEET POTATOES

Date	Application (lb AI/acre)	Yield increase* (bu/acre) No. 1	Yield increase* (bu/acre) Canner	Additional income* ($/acre)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit* ($/acre)	Source
1970	1.0	30	20	67.50	9.50	58.00	a/
1970	1.0	46	13	90.25	9.50	80.75	b/
	2.0	44	(18)	63.50	19.00	44.50	
1971	1.0	55	(23)	79.00	9.50	69.50	c/
1972	1.0	27.5	(57)	5.37	9.50	(4.13)	d/
1973	0.5	2.5	(34)	18.25	4.75	13.50	e/
	0.5	12	25	39.75	4.75	35.00	
	1.0	15	(1)	25.50	9.50	16.00	
	1.0	(39)	(29)	(90.00)	9.50	(99.50)	
	1.5	38	(23)	49.25	14.25	35.00	
	1.5	47	12	91.25	14.25	77.00	
	2.0	40	10	77.50	19.00	58.50	
	3.0	93	2	164.25	28.50	135.75	
1973	0.5	16	(12)	19.00	4.75	14.25	e/
	0.5	39	(30)	45.75	4.75	41.00	
	1.0	7	(28)	(8.75)	9.50	(18.25)	
	1.0	34	(13)	49.75	9.50	40.25	
	1.5	2	(27)	(16.75)	14.25	(31.00)	
	1.5	47	(20)	67.25	14.25	53.00	
	2.0	19	(42)	1.75	19.00	(17.25)	
	3.0	62	(25)	89.75	28.50	61.25	
1973	1.0	(33)	22	(57.75)	9.50	(67.25)	e/
1973	3.0	128	100	299.00	28.50	270.50	
	2.0	124	54	257.50	19.00	238.50	
1973	1.5	83	88	211.25	14.25	197.00	e/
	1.5	65	73	168.50	14.25	154.25	
	0.5	65	50	151.25	4.75	146.50	
	1.0	51	38	117.75	9.50	108.25	
	1.0	44	18	90.50	9.50	81.00	
	0.5	38	44	99.50	4.75	94.75	

* Data in parentheses indicate decreases in yield, income, and economic benefit.

a/ Birchfield and Martin, op. cit. (1970).

b/ Martin and Birchfield, op. cit. (1970).

c/ Birchfield and Martin, op. cit. (1971).

d/ Birchfield and Martin, op. cit. (1972).

e/ Martin and Birchfield, op. cit. (1973).

Note: AI = active ingredient.

Table 19. SUMMARY OF EFFICACY TESTS ON SUGAR BEETS

Date	Application (lb AI/acre)	Yield increase* (tons/acre)	Additional income at* $16/ton ($/acre)	Aldicarb cost at $9.50/lb ($/acre)	Economic benefit ($/acre)	Source
1972	2.0 - 1 in. band	0.39	6.24	19.00	(12.76)	a/
	4.0 - 1 in. band	7.32	117.12	38.00	79.12	
	2.0 -.5 in. band	0.19	3.04	19.00	(15.98)	
	4.0 - 5 in. band	3.26	52.16	38.00	14.16	
	4.0 - Sidedress	1.30	20.80	38.00	(17.20)	
	2.0 - Sidedress	4.64	74.24	19.00	55.24	
	4.0 - Sidedress	8.69	139.04	38.00	101.04	

* Data in parentheses indicate decreases in yield, income and economic benefit.
a/ Steele and Hodges, op. cit. (1972).
Note: AI = active ingredient.

The 1974 supplementary data contained 28 reports covering 1,080 field tests of Temik® for control of nematodes and insects. (See Table 20.) The reports were not differentiated by region of the country in which the tests were conducted. In all cases reported, the yield of sugar beets increased. The range of yield increases was from 1.6 to 6.2 tons/acre with an average of 3.6 tons/acre over all the tests. The economic benefits varied from a loss of $4.35/acre to a gain of $57.75/acre. The average economic benefit due to Temik® was an increase of $36.23/acre.

Peanuts

Temik® is registered for control of thrips and nematodes on peanuts.

Efficacy Against Pest Infestation

Morgan et al. (1970)[1/] showed that Temik® gave good control of thrips on peanuts in Georgia in 1965 and 1966 but slightly decreased yields over untreated plots. Smith (1972)[2/] tested Temik® on peanuts in Virginia in 1971 and found some control of thrips but little control of root-knot nematode although a slight yield increase was evidenced.

Sturgeon and Schackelford (1972)[3/] and Sturgeon and Jackson (1973)[4/] compared various insecticides for treatment of nematodes on peanuts in Oklahoma. Their papers usually do not specify the type of nematode controlled but do indicate that peanut yields increased in all but one test. (See Table 21.)

In the 1974 yield tests on peanuts shown in Table 22 a few indications of comparative efficacy are given. Use of Temik® greatly reduced the percent of thrip damage in all cases reported as well as reducing the number of nematodes per 100 ml of soil. In one case the nematode rating increased on the plot treated with Temik®. Unfortunately, the majority of test reports gave no indication of efficacy at all. (See Table 21.)

1/ Morgan, L.W., J. W. Snow, and M. J. Peach, "Chemical Thrips Control: Effects on Growth and Yield of Peanuts in Georgia," J. Econ. Entomol., 65:1253-1255 (August 1970).

2/ Smith, J.C., "Tobacco Thrips Nematode Control on Virginia Type Peanuts," J. Econ. Entomol., 65:1700-1703 (1972).

3/ Sturgeon, R. V., Jr., and C. Schackelford, "Peanut," Fungicide and Nematocide Test Results of 1972, Report No. 321, American Phytopathological Society, St. Paul, Minn. (1972).

4/ Sturgeon, R. V., Jr., and K. E. Jackson, "Peanut," Fungicide and Nematocide Test Results of 1973, Report No. 296, American Phytopathological Society, St. Paul, Minn. (1973).

Table 20. 1974 RESULTS OF TEMIK® APPLICATION ON SUGAR BEETS, UNIDENTIFIED U.S. REGIONS

Pest4/	Application (lb AI/acre)*	Yield Change (tons)	Value of 1/ Yield Change($)	Temik® 2/ Cost ($9.50/lb)	Economic 3/ Benefit	No. Tests
R	1.75	2.5	40.00	16.62	23.38	31
R	1.75	2.7	43.20	16.62	26.58	73
R	1.75	3.3	52.80	16.62	36.18	45
R	1.75	2.6	41.60	16.62	24.98	13
R	1.75	2.2	35.20	16.62	18.58	43
R	1.5	2.7	43.20	14.25	28.95	27
R	1.5	2.3	36.80	14.25	22.55	48
R	1.5	3.0	48.00	14.25	33.75	19
R	1.5	2.4	38.40	14.25	24.15	26
R	1.5	2.2	35.20	14.25	20.95	34
R	1.5	2.8	44.80	14.25	30.55	14
R	1.5	2.6	41.60	14.25	27.35	10
R	1.65	4.5	72.00	15.68	56.32	5
R	1.65	4.4	70.40	15.68	54.72	5
R	1.65	4.1	65.60	15.68	49.92	7
R	1.65	3.8	60.80	15.68	45.12	9
R	1.65	2.9	46.40	15.68	30.72	5
C	1.65	4.0	64.00	15.68	48.32	8
C	4.5	5.3	84.80	42.75	42.05	102
C	4.5	2.4	38.40	42.75	-4.35	107
C	4.5	6.2	99.20	42.75	56.45	58
C	4.5	4.5	72.00	42.75	29.25	69
C	4.5	5.4	86.40	42.75	43.65	28
C	4.5	3.7	59.20	42.75	16.45	290
A	1.5	1.6	25.60	14.25	11.35	N/S**
A	1.5	3.3	52.80	14.25	38.55	N/S
A	1.5	4.5	72.00	14.25	57.75	N/S
L	2.5	2.4	38.40	23.75	14.65	N/S
Average	2.25	3.6	57.60	21.38	36.23	

* AI/acre = active ingredient/acre.

** N/S = not specified.

1/ Change in sugar beet yield x $16/ton.

2/ Lb AI/acre x $0.50/lb AI, since most Temik® is applied at planting the application cost is considered a joint cost with planting cost and not considered here.

3/ Value of Yield Change minus Temik® Cost equals Economic Benefit.

4/ R = root maggot, C = cyst nematode, A = aphids, L = leafhoppers.

Source: Comparative yield data submitted to EPA by Dr. Richard Back, Union Carbide Corporation, Washington, D.C.

Table 21. SUMMARY OF EFFICACY TESTS ON PEANUTS

Date	Application (lb AI/acre)	Yield increase* (lb/acre)	Additional income at 14.5¢/lb* ($)	Aldicarb cost at $9.50/lb ($)	Economic benefit* (loss) ($)	Source
1965	1.0	(102)	(14.79)	9.50	(24.29)	a/
1966	1.0	(80)	(11.60)	9.50	(21.10)	
1971	1.0	124	17.98	9.50	8.48	b/
1970	3.0	(43)	(6.24)	28.50	(34.74)	c/
1970	3.0	(71)	(24.80)	28.50	(53.20)	d/
1970	3.0	369	53.50	28.50	25.00	e/
1972	0.6	192	27.84	5.70	22.14	f/
	0.3	174	25.23	2.85	22.38	
	1.0	156	22.62	9.50	13.12	
1972	2.0	188	27.26	19.00	8.26	g/
	2.0	(151)	(21.90)	19.00	(40.90)	
	2.0	371	53.80	19.00	34.80	
1972	2.0	634	91.93	19.00	72.93	h/
	1.0	284	41.18	9.50	31.68	

* Data in parentheses indicate decreases in yield, income, and economic benefit.
a/ Morgan et al., op. cit. (1970).
b/ Smith, J. C., op. cit. (1972).
c/ Minton and Morgan, op. cit. (1970).
d/ Minton et al., op. cit. (1970).
e/ Morgan, L. W., and N. A. Minton, "Peanut," Fungicide and Nematocide Test Results of 1970, Report No. 286, American Phytopathological Society, St. Paul, Minn. (1970).
f/ Minton and Morgan, op. cit., (1972).
g/ Sturgeon and Shackelford, op. cit. (1972)
h/ Sturgeon and Jackson, op. cit. (1973).
Note: AI = active ingredient.

Cost Effectiveness of Pest Control

In Table 21 the range of yield changes varied from a loss of 151 lb/acre to an increase of 634 lb/acre. At the 1972 average price for peanuts of $0.145/lb the economic benefits for these tests range from $40.90/acre loss to a gain of $72.93/acre. However, being non-commercial tests these results may not be representative of actual field experience.

The 1974 commercial trials in Table 22 were conducted in several areas of the peanut-growing region, but there are insufficient reports to attempt regional differentiation. The range of yield changes over all the reported tests varied from a loss of 102 lb/acre to an increase of 1,160 lb/acre. The average change in yield was an increase of 469 lb/acre. The economic benefits associated with these yield changes ranged from a loss of $24.30/acre to a gain of $149.20. The average economic benefit from the use of Temik® on peanuts was calculated to be an increase of $49.01/acre, exclusive of application and harvesting costs.

Table 22. 1974 RESULTS OF TEMIK® APPLICATION ON PEANUTS

Location	Pest[4/]	Application (lb/AI/acre)*	Yield Change (lb)	Value of [1/] Yield Change($)	Temik® [2/] Cost ($)	Econimic [3/] Benefit ($)	No. Tests	Efficacy Remarks (T/U)**
U.S.	N,I	2.0	573	83.09	19.00	64.09	73	
SE U.S.	N	2.5	678	98.31	23.75	74.56	38	
SE U.S.	I	1.5	112	16.24	14.25	1.99	20	
SE U.S.	N,I	2.0	569	82.51	19.00	63.51	16	
Tex. and Okla.	N	2.5	195	28.28	23.75	4.53	8	
Tex. and Okla.	I	2.0	117	16.97	19.00	-2.04	4	
Tex. and Okla.	N,I	2.25	128	18.56	21.38	-2.82	14	
Georgia	N,I	2.0	412	59.74	19.00	40.74	1	%thrip damage: 18.1/31.9
Georgia	N,I	2.0	109	15.81	19.00	-3.20	1	Nematode rating: 200/129
Georgia	N,I	2.0	450	65.25	19.00	46.25	1	%thrip damage: 5.8/48.8
Georgia	T	1.0	-102	-14.79	9.50	-24.29	1	%thrip damage: 2.5/67.0
Georgia	T	2.0	46	6.67	19.00	-12.33	1	%thrip damage: 0.5/67.0
Oklahoma	N	2.0	629	91.21	19.00	72.21	1	
Oklahoma	N	1.5	-14	-2.03	14.25	-16.28	1	#nematodes/100ml soil: 0/27
Oklahoma	N	3.0	346	50.17	28.50	21.67	1	#nematodes/100ml soil: 0/27
Oklahoma	N	3.0	395	57.28	28.50	28.78	1	Pod necrosis rating: 2.8/3.4
S.C.	T	0.5	275	40.02	5.70	34.32	1	Thrip damage rating: 0/2.5
N.C.	N	2.0	1160	168.20	19.00	149.20	1	
Florida	T,A,N	0.8	200	29.00	7.60	21.40	1	
Average U.S.		2.0	469	68.01	19.00	49.01		

* AI/acre = active ingredient/acre.

** T/U = treated/untreated.

1/ Change in peanut yield x $1.45/lb (1972 average price).

2/ Lb AI/acre x $9.50/lc AI, since most Temik® is applied at planting the application cost is considered a joint cost with planting cost and not considered here.

3/ Value of Yield Change minus Temik® Cost equals Economic Benefit.

4/ N = nematodes, I = insects, unspecified, T = thrips, A = aphids.

Source: Comparative yield data submitted to EPA by Dr. Richard Back, Union Carbide Corporation, Washington, D.C.

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