

Current Status of Insecticide Recommendations for Managing Stored Grain in Canada and the United States

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Current Status of Insecticide Recommendations for Managing Stored Grain in Canada and the United States

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A small number of fumigants and contact insecticides are registered for use on or near stored grain in the United States and Canada. However, the recommended use of these materials to manage stored grain insects varies between the individual states and provinces. Some of the apparent reasons for these differences include: economics (value of the crop, cost of treatment and losses resulting from infestation), attitudes (complacency and lack of knowledge), regulations (state and federal), weather and climate, location, grain handling, and storage facilities. Whatever the reasons, generally no more than 10 percent of the grain is treated with any insecticide or fumigant for insect pest management.

The incidence of infestation of stored-grain insects at the farm level in the United States and Canada has been questioned in recent years. A four-year survey of grain on farms in 27 states within the major grain growing areas indicated that 20-26% of the wheat, 78-82% of the corn, and 56-66% of the oats stored on the farm were infested with insects (Storey et al. 1983). A previous survey of grain exported from the United States from 1977 to 1978 (Storey et al. 1982) indicated that 17.9% of the wheat samples and 22.4% of the corn samples contained live stored-grain insects. Infestation of grain stored on farms in the main grain growing regions of Manitoba, Saskatchewan, and Alberta occurs at irregular intervals. A survey of 2919 primary grain elevators in Western Canada in 1969-1971 indicated that 15% of the elevators had stored-grain insect infestations (Sinha 1972). At the same time and in the same area, 42% of the farms also had infested stored grain. Federal government inspection reports from 1969-1981 for primary, transfer, and terminal elevators in Canada often indicated detection of insects (Sinha and Watters 1984); based on 1095 reports, 52% of these elevators were infested.

The extent of insecticide use on stored grain is also difficult to determine. Storey et al. (1983) reported that 14.6% of the wheat and 8.2% of the corn in farm storage was treated with malathion. Comparable malathion-treated export grain was 28% for wheat and 8.4% for corn (Storey 1982). In 1970-1971, 34% of the farms and 12% of the primary elevators in Canada used insecticides to manage stored-grain insects. Of the fumigants, phosphine was used most often, followed by malathion (Sinha 1972). Canadian reports from seven terminal elevators for 1980 indicated that the elevators used malathion 29 times, phosphine 10 times, and unspecified treatments 32 times. The unspecified treatments included fumigants such as ethylene dibromide and methyl bromide and pyrethrins or dichlorvos (Sinha and Watters 1984).

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Recent public awareness of the alleged dangers of certain fumigant residues in food has drawn additional attention to the more general problems of environmental contamination. For instance, the fumigant ethylene dibromide (EDB), which has been detected in cereal products, was recently reported to be a carcinogen (Sun 1984). As a result EDB was withdrawn from use as a grain fumigant in both the United States and Canada. The controversy arising from high EDB levels in food in the United States has also led to the suspension of registration of additional fumigants such as carbon tetrachloride, carbon disulfide, and ethylene dichloride in Canada. Other fumigants that are currently under review in Canada and that are also important to the future insect pest management program for the food and fiber industry include aluminum phosphide, chloropicrin, ethylene oxide, hydrogen cyanide, and methyl bromide (Anonymous 1984).

The Environmental Protection Agency (EPA) in the United State has set tolerance levels for EDB of 900 parts per billion (ppb) in raw grain, 150 ppb in cereal products requiring cooking, and 30 ppb in ready-to-eat cereal products. Individual states may establish even lower tolerance levels.

As of this writing carbon disulfide is being removed from U.S. markets and carbon tetrachloride is likely to follow. Response to these sudden and drastic regulation changes has been slow and uncoordinated by entomologists and regulatory authorities in both countries. There are many reasons for this serious situation, including the following:

1. Insecticide recommendations are developed and disseminated individually by each state or province, subject to federal registration specifications.
2. Stored-grain problems in many areas are not given sufficient attention unless a crisis occurs. Crises are not annual; consequently, many insecticide recommendations are not updated until another severe stored-grain insect infestation occurs or there are significant changes in the availability of pertinent insecticides.
3. Surveys of stored grain problems, which could provide warning, are rarely conducted.
4. There are few stored-grain entomologists in individual states or provinces. Such individuals could evaluate problems and make timely insect management recommendations.

Consequently, a comprehensive effort to meet the present challenge of insect management in stored grain is not likely to be developed in the United States or Canada even though the two countries have several similar insect problems in stored grain. This report is an attempt to collate official recommendations from the states and provinces as well as those of the federal governments of both countries.

In the event of a future stored-grain insect crisis, we hope that a collection of these recommendations from official sources will provide background information on the diversity and frequency of the guidelines provided. The data, reference source, and publication date are summarized in the tables that follow.

CHEMICALS USED FOR INSECT CONTROL IN STORED GRAIN
Summary of Extension pamphlets received in 1983-84

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Agriculture Canada	<ul style="list-style-type: none"> - Malathion 1% spray from 50%, 83.6% EC or 25% WP at 5 $\frac{1}{100m^2}$ (1.3 gal/1076 ft²) - Synergized pyrethrins (0.1:1.0%) (label) 	<ul style="list-style-type: none"> - Malathion (83.6%EC) 1% spray at 0.8 $\frac{1}{tonne}$ (1.7 pt/37 bu) - Malathion (0.5:1% dust) .5% dust: 1.6 kg/tonne (3.5 lb/37 bu) 1% dust 0.8 kg/tonne (1.8 lb/37 bu) 		<ul style="list-style-type: none"> - Aluminum phosphide 2-6 tablets/tonne 3-11 pellets/tonne (2-6 tablets/37 bu) (3-11 pellets/37 bu) 	Agr. Can. Publ. 1595 (1981-82) insert
Alberta	<ul style="list-style-type: none"> - Malathion (50% EC) 200 ml/l of H₂O at 5 $\frac{1}{100m^2}$ (.4 pt/1.1 qt at) (5.3 qt/1076 ft²) 	<ul style="list-style-type: none"> - Malathion (83.6%EC) 10-17 ml/10-20 $\frac{1}{tonne}$ of H₂O per tonne (.3-.6 oz/2.8-5.5 gal. of H₂O) - Malathion (2% dust) 415-735 g/tonne (.9-1.6 lb/37 bu) 	<ul style="list-style-type: none"> - Malathion (83.6%EC) 10-17 ml/5-10 l of H₂O (.3-.6 oz/1.4-2.8 gal of H₂O) 	<ul style="list-style-type: none"> - Aluminum phosphide 4-6 tablets/m³ 5-10 pellets/m³ (4-6 tablets/35 ft³) (5-10 pellets/35 ft³) 	F. Beier Guide to Crop Protection (part 1) (1984)
Manitoba	<ul style="list-style-type: none"> - Malathion (50% EC) 60 ml/l at 5 $\frac{1}{100m^2}$ (2 oz/1.1 qt at 5.3 qt/1076 ft²) 			<ul style="list-style-type: none"> - Aluminum phosphide 180 tablets/35m³ 300 pellets/35m³ (180 tablets/1225 ft³) (300 pellets/1225 ft³) 	Man-Insect Control Guide (1983)
Ontario	<ul style="list-style-type: none"> - Malathion (50% EC) 1.14 $\frac{1}{18.2}$ l of H₂O at 5 $\frac{1}{100m^2}$ (1.2 qt/4.8 gal of H₂O at 5.3 qt/1076 ft²) - Commercial "mill sprays" (synergized pyrethrins) to runoff 	<ul style="list-style-type: none"> - Malathion (83.6%EC) .6 $\frac{1}{9-22}$ l of H₂O for 35m³ (1.3 pt/2.4-5.9 gal of H₂O for 1225 ft³) - Malathion (0.5% dust) .45 Kg/35m³ (1 lb/1225 ft³) - Synergized pyrethrins (label) 		<ul style="list-style-type: none"> - Aluminum phosphide 500 tablets/100m³ 825 pellets/100m³ (500 tablets/3500 ft³) (825 pellets/3500 ft³) - Methyl bromide - Carbon tetrachloride + carbon disulfide (83:16) 	K. Bereza O.M.A.F. publ. 229 (1980)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Canadian Grain Commission	<ul style="list-style-type: none"> - Malathion 1% solution at 5 $\frac{1}{100m^2}$ (1% solution at 5.3 qt/1076 ft²) - Synergized pyrethrins 0.1:1% spray at 5 $\frac{1}{100m^2}$ (0.1:1% spray at 5.3 qt/1076 ft²) - Dichlorvos (EC) 2 ml/m³ (.07 oz/35 ft³) 	<ul style="list-style-type: none"> - Malathion 1% spray to achieve 8 ppm 	<ul style="list-style-type: none"> - Synergized pyrethrins 0.2:2% EC at 5-10 $\frac{1}{100m^2}$ (0.2:2% EC at 1.3-2.6 gal/1076 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide 4-5 tablets/m³ (35 ft³) 8-10 pellets/m³ (35 ft³) - Methyl bromide (label) - Commercial mixtures of ethylene dibromide, ethylene dichloride, carbon tetrachloride, carbon disulfide, .4-.8 $\frac{1}{m^3}$ (35 ft³) 	<p>J. VanLoon Stored Grain Pests Can. Grain Comm. (1983)</p>
Canadian Dept. National Defence	<ul style="list-style-type: none"> - Malathion (50% EC) .9 $\frac{1}{15}$ $\frac{1}{1}$ of H₂O at 5 $\frac{1}{100m^2}$ (1 qt/4 gal of H₂O at 5.3 qt/1076 ft²) - Malathion (50% WP) 1.1 kg/15 $\frac{1}{1}$ of H₂O at 5 $\frac{1}{100m^2}$ (2.5 lb/4 gal of H₂O at 5.3 qt/1076 ft²) - Synergized pyrethrins 0.1-0.3:0.25-2.0% EC 0.2:1.0% dust - Bromophos (25% WP) 112 g/3.8 $\frac{1}{1}$ of H₂O at 5 $\frac{1}{100m^2}$ (4 oz/gal of H₂O at 5.3 qt/1076 ft²) - Dichlorvos (spray) 8g/1 of H₂O per 500m³ (4.7 oz/1.1 qt of H₂O per 17500 ft³) - Dried peas and beans 	<ul style="list-style-type: none"> - Malathion (0.5% dust) .45 kg/0.35 m³ (1 lb/10 bu) - Synergized pyrethrins 0.2:2% EC at 5-10 $\frac{1}{100m^2}$ (0.2:2% EC at 1.3-2.6 gal/1076 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide 159 tablets/100m³ (3500 ft³) 583 pellets/100m³ (3500 ft³) - Methyl bromide 1.3-6.5 Kg/100/m³ (2.9-14.3 lb/3500 ft³) 	<p>Manual of Pest Control (5th ed) (1983)</p>	

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
U.S.D.A.	<ul style="list-style-type: none"> - Malathion (57% EC) .47/11.3 $\frac{1}{1}$ of H₂O at 3.8 $\frac{1}{46m^2}$ (1 pt/3 gal of H₂O at 1 gal/500 ft²) - Methoxychlor (50% WP) .45 kg/9.5 $\frac{1}{1}$ of H₂O at 3.8 $\frac{1}{46m^2}$ (1lb/2.5 gal of H₂O at 1 gal/500 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47/7.6-18.9$\frac{1}{1}$ of H₂O for 35m³ (1 pt/2-5 gal of H₂O for 1000 bu) - Malathion (dust) - Synergized pyrethrins (dust) 	<ul style="list-style-type: none"> - Malathion (57%EC) .24$\frac{1}{3.8-7.6 \frac{1}{1}}$ of H₂O for 93 m² ($\frac{1}{2}$ pt/1-2 gal of H₂O for 1000 ft²) 	<ul style="list-style-type: none"> - Commercially available formulations (liquids; methyl bromide; aluminum phosphide) 	<ul style="list-style-type: none"> USDA Bull. 2269 (1979) Leaflet 345 (1962)
Alabama	<ul style="list-style-type: none"> - Malathion (57%EC) .94 $\frac{1}{22.7 \frac{1}{1}}$ of H₂O at 7.6 $\frac{1}{92.9m^2}$ (1 qt/6 gal of H₂O at 2 gal/1000 ft²) - Methoxychlor (25%EC) .94 $\frac{1}{11.3 \frac{1}{1}}$ of H₂O at 7.6 $\frac{1}{92.9 m^2}$ (1 qt/3 gal at 2 gal/1000 ft²) - Methoxychlor (50% WP) .45 kg/11.3 $\frac{1}{1}$ of H₂O at 7.6 $\frac{1}{92.9 m^2}$ (1 lb/3 gal at 2 gal/1000 ft²) - Synergized pyrethrins (6:60%EC) .63 $\frac{1}{11.3 \frac{1}{1}}$ of H₂O at 7.6 $\frac{1}{92.9m^2}$ (1.3 pt/3 gal of H₂O at 2 gal/1000 ft²) - Lindane (20%EC) 1.9 $\frac{1}{75.6 \frac{1}{1}}$ of H₂O at 7.6 $\frac{1}{92.9m^2}$ (2 qt/20 gal of H₂O at 2 gal/1000 ft²) - Lindane (25% WP) 1.5 kg/75.6 $\frac{1}{1}$ of H₂O at 7.6 $\frac{1}{92.9m^2}$ (3.3 lb/20 gal of H₂O at 2 gal/1000 ft²) 	<ul style="list-style-type: none"> - Malathion (50%EC) .47 $\frac{1}{7.6-18.9 \frac{1}{1}}$ of H₂O per 27 tonnes (1 pt/2-5 gal of H₂O per 1000 bu) - Malathion (1% dust) 27.2 kg/27 tonnes (60 lb/1000 bus) - Synergized pyrethrins (0.3:3%) 18.9 $\frac{1}{27}$ tonnes (5 gal/1000 bu) 	<ul style="list-style-type: none"> - Malathion (50%EC) .24 $\frac{1}{3.8-7.6 \frac{1}{1}}$ of H₂O at 92.9m² ($\frac{1}{2}$ pt/1-2 gal of H₂O per 1000 ft²) - <u>Bacillus thuringiensis</u> (prepared) .45 kg/37.8 $\frac{1}{1}$ of H₂O per 465 m² (1 lb/10 gal/5000 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide - Methyl bromide - Carbon tetrachloride + carbon disulfide (80:20) - Ethylene dichloride + carbon tetrachloride (75:25) - Carbon tetrachloride + - Carbon disulfide + sulfur dioxide + normal pentene (82:16.5:1:5) - Carbon tetrachloride + carbon disulfide (84:16) 	<ul style="list-style-type: none"> J. French circular AV3-330 (1982)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Arkansas	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{7.6}$-18.9 $\frac{1}{1}$ of H₂O applied to runoff (1 pt/2-5 gal of H₂O) - Methoxychlor (50%WP) (for use on concrete) .45 kg/9.5 $\frac{1}{1}$ of H₂O applied to runoff (1 lb/2.5 gal of H₂O) - Methoxychlor (25% EC) .94 $\frac{1}{9.5}$ $\frac{1}{1}$ of H₂O applied to runoff (1 qt/2.5 gal. of H₂O) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{9.5}$ $\frac{1}{1}$ of H₂O per 27 tonnes (1 pt/2.5 gal of H₂O per 1000 bu) 	<ul style="list-style-type: none"> - Malathion (57%EC) .24 $\frac{1}{7.6}$ $\frac{1}{1}$ of H₂O for 92.9 m² (1/2 pt/2 gal for 1000 ft²) <u>Bacillus thuringiensis</u> 	<ul style="list-style-type: none"> - Aluminum phosphide 60-80 tablets/27 tonnes (1000 bu) 120-300 pellets/27 tonnes - Carbon tetrachloride + carbon disulfide + sulfur dioxide (82.3:16.3:1) - Carbon tetrachloride + ethylene dichloride (30:70) 	D. Johnson pamphlet EL 412 (1983)
California	<ul style="list-style-type: none"> - Malathion (57% EC) 3.78 $\frac{1}{94.5}$ $\frac{1}{1}$ of H₂O applied to runoff (1 gal/25 gal of H₂O) - Methoxychlor 2 1/2% spray to runoff - Synergized pyrethrins (label) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{7.6}$ $\frac{1}{1}$-18.9 $\frac{1}{1}$ of H₂O/ 27 tonnes (1 pt/2-5 gal/1000 bu) - Malathion (dusts) (label) 	<ul style="list-style-type: none"> - Malathion (57%EC) .24 $\frac{1}{3.8}$-7.6 $\frac{1}{1}$ of H₂O/ 92-9m² (1/2 pt/1-2 gal of H₂O/ 1000 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide - Methyl bromide - Carbon tetrachloride + carbon disulfide (80:20) - Ethylene dichloride + carbon tetrachloride (75:25) 	V. Burton Leaflet 2378 (1981)
Colorado	<ul style="list-style-type: none"> - Malathion - Methoxychlor - Synergized pyrethrins 	<ul style="list-style-type: none"> - Malathion - Synergized pyrethrins 	<ul style="list-style-type: none"> - <u>Bacillus thuringiensis</u> - Dichlorvos 	<ul style="list-style-type: none"> - Aluminum phosphide - Commercially available formulations 	F. Peairs Leaflet 5.545 (1984)
Delaware	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{11.3}$ $\frac{1}{1}$ of H₂O at 3.8 $\frac{1}{46.5}$m² (1 pt/3 gal of H₂O at 1 gal/500 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{7.6}$-18.9 $\frac{1}{1}$ of H₂O/ 27 tonnes (1 pt/2-5 gal of H₂O/ 1000 bu) 	<ul style="list-style-type: none"> - Malathion (57%EC) .24 $\frac{1}{3.8}$-7.6 $\frac{1}{1}$ of H₂O/ 92.9 m² (.5 pt/1-2 gal of H₂O/ 1000ft²) - Synergized pyrethrins (6:60%) 	<ul style="list-style-type: none"> - Aluminum phosphide 90 tablets/27 tonnes (1000 bu) 300 pellets/27 tonnes (1000 bu) - Methyl bromide .9 kg/28.3 m³ 	M. Granstein Insect Control in Fam Stored Grain

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Delaware (cont'd)	<ul style="list-style-type: none"> - Methoxychlor (50%WP) .45 Kg/11.3 l of H₂O at 3.8 l/46.5m² (1 lb/3 gal of H₂O at 1 gal/ 500 ft²) - Methoxychlor (25%EC) .9 l/11.3 l of H₂O at 3.8 l/46.5m² (1 qt/3 gal of H₂O at 1 gal/500 ft²) Synergized pyrethrins (6:60%EC) .47 l/26.5 l of H₂O at 3.8 l/65m² (1 pt/7 gal of H₂O at 1 gal/700 ft²) 	<ul style="list-style-type: none"> - Malathion (dust) - Synergized pyrethrins .94 l/7.6-18.9 l of H₂O per 27 tonnes (1 qt/2-5 gal of H₂O/ 1000 bu) 	<ul style="list-style-type: none"> .25l/3.8-7.6l of H₂O/92.9m² (8.8 oz/1-2 gal of H₂O/ 1000 ft²) - Dichlorvos 1 strip/28.3m³ (1000 ft³) - <i>Bacillus thuringiensis</i> .45 Kg/37.8 l of H₂O/46.5m² (1 lb/10 gal of H₂O/500 ft²) 	<ul style="list-style-type: none"> (2 lb/1000 ft³) - Carbon tetrachloride + Carbon disulfide (4:1) up to 22.7 l/27 tonnes (6 gal/1000 bu) - Carbon tetrachloride + ethylene dichloride (1:3) up to 30.2 l/27 tonnes (8 gal/1000 bu) 	
Georgia	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/11.3 l of H₂O for 139m² (1pt/3 gal of H₂O for 1500ft²) - Malathion (25%WP) .9 Kg/11.3 l of H₂O for 139m² (2 lb/3 gal of H₂O for 1500ft²) - Methoxychlor (50%WP) .45 Kg/11.3 l of H₂O for 139m² (1 lb/3 gal of H₂O for 1500 ft²) - Methoxychlor (25%EC) .9 Kg/11.3 l of H₂O for 139m² (2 lb/3 gal of H₂O for 1500 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/7.6-18.9 l of H₂O/ 27 tonnes (1 pt/2-5 gal of H₂O/ 1000 bu) - Malathion (1% dust) 27 Kg/27 tonnes (60 lb/1000 bu) - Synergized pyrethrins 0.3:3%:18.9 l/27 tonnes (5 gal/1000 bu) .06:1% dust: 45 Kg/27 tonnes (100 lb/1000 bu) 	<ul style="list-style-type: none"> - Malathion (57%EC) 60 ml/2.4 l of H₂O at .9 l/9.3m² (2 oz/2-5 qt at 1 qt/100 ft²) - Synergized pyrethrins 0.3:3% spray at .9 l/9.3m² (1 qt/100 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide - Methyl bromide - Carbon tetrachloride + carbon disulfide (4:1) - Ethylene dichloride + carbon tetrachloride (70:30) 	H Womack leaflet #11 (1983)
Idaho	<ul style="list-style-type: none"> - Malathion (57%EC) .38 l/9.5 l of H₂O for 116m² (.8 pt/2.5 gal of H₂O for 1250 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .35 l/7.6-18.9 l of H₂O/ 27 tonnes (.75 pt/2-5 gal of H₂O/ 	<ul style="list-style-type: none"> - Malathion (57%EC) .35 l/7.6-18.9 l of H₂O at .94 l/9.3m² (.75 pt/2-5 gal H₂O at 	<ul style="list-style-type: none"> - Aluminum phosphide - Methyl bromide - Ethylene dibromide + carbon tetrachloride 	H. Homan Inf. series #312

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Idaho (cont'd)	<ul style="list-style-type: none"> - Methoxychlor (50%WP) .45 Kg/9.5 l of H₂O for 116m² (1 lb/2.5 gal of H₂O for 1250 ft²) - Methoxychlor (25%EC) .94 l/9.5 l of H₂O for 116m² (1 qt/2.5 gal of H₂O for 1250 ft²) 	<ul style="list-style-type: none"> 1000 bu) - Malathion (dusts) 2% : 13.6 Kg/27 tonnes (30 lb/1000 bu) 4% : 6.8 Kg/27 tonnes (15 lb/1000 bu) 6% : 2.7 Kg/27 tonnes (6 lb/1000 bu) - Synergized pyrethrins (label) 	<ul style="list-style-type: none"> 1 qt/100 ft²) - Malathion (dusts) extra .45 Kg (lb) per 9.3m² (100 ft²) - Synergized pyrethrins extra .94 l (qt)/9.3m² (100 ft²) 	<ul style="list-style-type: none"> - Carbon disulfide + carbon tetrachloride 	
Illinois	<ul style="list-style-type: none"> - Malathion (57%EC) 2% spray to runoff 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/7.6-18.9 l of H₂O per 27 tonnes (1 pt/2-5 gal of H₂O/1000 bu) 6% dust: 4.5 Kg/2 tonnes (10 lb/1000 bu) 4% dust: 6-8 Kg/27 tonnes (15 lb/1000 bu) 2% dust: 13.6 Kg/27 tonnes (30 lb/1000 bu) - <u>Bacillus thuringiensis</u> (dust, WP) 	<ul style="list-style-type: none"> - Malathion 7.6 l/92.9 m² (2 gal/1000 ft²) 2.3 Kg/92.9m² (5 lb/1000 ft²) 3.4 Kg/92.9m² (7.5 lb/1000 ft²) 6.8 Kg/92.9m² (15 lb/1000 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide 180 tablets/27 tonnes (1000 bu) 300 pellets/27 tonnes (1000 bu) - Liquid fumigants 11.3-18.9 l/27 tonnes (3-5 gal/1000 bu) 	Circular 899 (1984)
Indiana	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/11.3 l of H₂O for 92.9m² (1 pt/3 gal of H₂O for 1000 ft²) - Methoxychlor (25%EC) 2 l/18.9 l of H₂O for 92.9m² (2 qt/5 gal of H₂O for 1000 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/7.6-18.9 l of H₂O for 27 tonnes (1 pt./2-5 gal of H₂O for 1000 bu) 	<ul style="list-style-type: none"> - Malathion (57%EC) .24 l/7.6 l of H₂O/92.9m² (.5 pt/2 gal of H₂O/1000ft²) - Synergized pyrethrins - Dichlorvos 1 strip/28.3m³ (1000 ft³) - <u>Bacillus thuringiensis</u> .9 Kg/75.6 l of H₂O/92.9m² (2 lb/20 gal of H₂O/1000 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide - Carbon tetrachloride - Ethylene dichloride - Ethylene dibromide - Carbon disulfide 	D. Mathew NP. E-66

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Iowa	<ul style="list-style-type: none"> - Malathion .47 $\frac{1}{11.3}$ $\frac{1}{1}$ of H₂O applied to runoff (1 pt/3 gal of H₂O) - Methoxychlor (25%EC) 1.1 $\frac{1}{11.3}$ $\frac{1}{1}$ of H₂O applied to runoff (1 qt 4 oz/3 gal of H₂O) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{11.3}$-18.9 $\frac{1}{1}$ of H₂O for 27 tonnes (1 pt/3-5 gal of H₂O for 1000 bu) - Malathion (dust) 2%: 13.5 Kg/27 tonnes (30 lb/1000 bu) 6%: 4.5 Kg/27 tonnes (10 lb/1000 bu) 	<ul style="list-style-type: none"> - Malathion (57%EC) 24 $\frac{1}{3.8}$-7.6 $\frac{1}{1}$ of H₂O/92.9m² (1/2 pt/1-2 gal of H₂O/1000 ft²) - Malathion (dusts) 2%: 6.8 Kg/92.9m² (15 lb/1000 ft²) 6%: 2.3 Kg/92.9m² (5 lb/1000 ft²) - Dichlorvos (20% strip) 1 strip/28m³ (1000 ft³) - <u>Bacillus thuringiensis</u> (WP₂ dust) .45 Kg/37.8 $\frac{1}{1}$ of H₂O/46.5m² (1 lb/10 gal of H₂O/500 ft²) .45 Kg/46.5m² (1 lb/500 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide empty bin: 60 tablets/81 tonne (3000 bu) - Chloropicrin. empty bin: .96 $\frac{1}{81}$ tonne (32 oz/3000 bu) - Commercial liquid fumigants 	D. Foster PM-205 (1983)
Kansas	<ul style="list-style-type: none"> - Malathion (57% EC) .24 $\frac{1}{7.6}$ $\frac{1}{1}$ of H₂O at 3.8 $\frac{1}{46m^2}$ (.5 pt/2 gal of H₂O at 1 gal/500 ft²) - Methoxychlor (25%EC) .9 $\frac{1}{7.6}$ $\frac{1}{1}$ of H₂O at 3.8 $\frac{1}{46m^2}$ (1 qt/2 gal of H₂O at 1 gal/500m²) - Synergized pyrethrins 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{3.8}$-18.9 of H₂O for 27 tonnes (1 pt/2-5 gal of H₂O for 1000 bu) - Malathion (dusts) 	<ul style="list-style-type: none"> - Dichlorvos (strip) - <u>Bacillus thuringiensis</u> 	<ul style="list-style-type: none"> - Carbon tetrachloride + carbon disulfide (80:20) - Ethylene dichloride + carbon tetrachloride (75:25) - Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5:35:60) 	pamphlet L-30 (1981)
Kentucky	<ul style="list-style-type: none"> - Malathion (57%EC) .24 $\frac{1}{7.6}$ $\frac{1}{1}$ of H₂O for 92.9m² (.5 pt/2 gal of H₂O for 1000 ft²) - Methoxychlor (50%WP) .34 Kg/7.6 $\frac{1}{1}$ of H₂O for/92.9m² (12 oz/2 gal of H₂O for 1000 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 ml/7.6-18.9 $\frac{1}{1}$ of H₂O/27 tonnes (1 pt/2-5 gal of H₂O/1000 bu) - Malathion (1% dust) 27 Kg/27 tonnes (60 lb/1000 bu) - Synergized pyrethrins 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 ml/7.6-11.3 $\frac{1}{1}$ of H₂O/92.9m² (.5 pt/2-3 gal of H₂O/1000 ft²) - Synergized pyrethrins (6:60%EC) .26 $\frac{1}{92.9m^2}$ (8.75 oz/1000 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide 90 tablets/27 tonnes (1000 bu) 300 pellets/27 tonnes (1000 bu) - Chloropicrin 1.1-2.3 Kg/27 tonnes (2.5-5 lb/1000 bu) - Ethylene dibromide 	D. Johnson Ent-19 (1982)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Kentucky (cont'd)	- Synergized pyrethrins (6:60%) .7 $\frac{1}{7.6}$ l of H ₂ O for 92.9m ² (1.5 pt/2 gal of H ₂ O for 1000 ft ²)	(6:60%EC) .9 $\frac{1}{7.8-18.9}$ l of H ₂ O/ 27 tonnes (1 qt/2-5 gal of water/1000 bu) - Synergized pyrethrins (.06:1% dust) 45 Kg/27 tonnes (100 lb/1000 bu)	- <u>Bacillus thuringiensis</u>	+ methyl bromide (30:20) .5-1.8 Kg/27 tonnes (1.1-4lb/1000 bu) - Methyl bromide .9-2.3 Kg/27 tonnes (2-5 lb/1000 bu)	
Michigan	- Malathion (50%EC) .15 $\frac{1}{3.8}$ l of H ₂ O for 46.5m ² (5.2 oz/gal for 500 ft ²) - Methoxychlor (20%EC) .38 $\frac{1}{3.8}$ l of H ₂ O for 46.5m ² (12.8 oz/gal of H ₂ O for 500 ft ²) - Synergized pyrethrins (6:60%EC) 64 ml/3.8 l of H ₂ O for 69.7m ² (2.2 oz/gal of H ₂ O for 750 ft ²) - Dichlorvos 1 strip/28.3m ³ (1000 ft ³)	- Malathion (50%EC) .47 $\frac{1}{7.6-18.9}$ l of H ₂ O/ 27 tonnes (1 pt/2-5 gal/1000 bu) - Malathion (2% dust) 13.6 Kg/27 tonnes (30 lb/1000 bu) - Malathion (6% dust) 4.53 Kg/27 tonnes (10 lb/1000 bu) - Synergized pyrethrins (6:60%EC) .65 $\frac{1}{18.9}$ l of H ₂ O/ 27 tonnes (22 oz/5 gal of H ₂ O/1000 bu)	- Malathion (50%EC) .24 $\frac{1}{3.8-7.6}$ l of H ₂ O/ 92.9m ² (.5 pt/1-2 gal of H ₂ O/ 1000 ft ²) - Malathion (2% dust) 6.8 Kg/92.9m ² (15 lb/1000 ft ²) - Malathion (6% dust) 2.3 Kg/92.9m ² (5 lb/1000 ft ²) - Synergized pyrethrins (6:60%EC) 69 ml/3.8 l of H ₂ O/92.9m ² (2.3 oz/gal of H ₂ O/1000 ft ²) - <u>Bacillus thuringiensis</u> - Allethrin	- Aluminum phosphide - Methyl bromide - Chloropicrin - Carbon disulfide + carbon tetrachloride (80:20)	R. Ruppel Ent. Bull. (1984)
Minnesota	- Malathion (57%EC) .47 $\frac{1}{11.3}$ l of H ₂ O at 3.8 $\frac{1}{46.5m^2}$ (1 pt/3 gal of H ₂ O at 1 gal/500 ft ²) - Methoxychlor 50% WP: .45 Kg/9.5 l of H ₂ O at 3-8 $\frac{1}{46.5m^2}$ (1 lb/2.5 gal of H ₂ O)	- Malathion (57%EC) .47 $\frac{1}{7.6-18.9}$ l of H ₂ O/ 27 tonnes (1 pt/2-5 gal of H ₂ O/ 1000 bu) - Malathion (1,2,4,6% dusts) 1% dust: 27 Kg/27 tonnes (60 lb/1000 bu)	- Malathion (57%EC) .24 $\frac{1}{7.6}$ l of H ₂ O/ 92.9m ² (.5 pt/2 gal of H ₂ O/ 1000 ft ²) - Malathion (1% dust) 13.5 Kg/92.9m ² (30 lb/1000 ft ²) - Dichlorvos	- Aluminum phosphide - Mixtures of carbon tetrachloride, carbon disulfide, ethylene dichloride; - chloropicrin	P. Harein Ent. fact sheet 8(1980), 9, 50 (1983)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Minnesota (cont'd)	at 1 gal/500 ft ² 25%EC: .9 1/9.5 l of H ₂ O at 3.8 1/46.5m ² (1 qt/2.5 gal of H ₂ O) at 1 gal/500 ft ²)		1 strip/28.3m ³ (1000 ft ³) - Synergized pyrethrins (6:60%EC) .24 1/3.8-7.6 l of H ₂ O/92.9m ² (8 oz/1-2 gal of H ₂ O/1000 ft ²) <u>Bacillus thuringiensis</u>		
Mississippi	- Malathion (57%EC) .38 1/9.45 l of H ₂ O for 116m ² (13 oz/2.5 gal of H ₂ O for 1250 ft ²) - Methoxychlor (25%EC) .94 1/9.4 l of H ₂ O for 116m ² (1 qt/2.5 gal of H ₂ O for 1250 ft ²) - Methoxychlor (50%WP) .45 Kg/9.4 l of H ₂ O for 116m ² (1 lb/2.5 gal of H ₂ O for 1250 ft ²)	- Malathion (50%EC) .47 1/9.4 l of H ₂ O/ 27 tonnes (1 pt/2.5 gal of H ₂ O/ 1000 bu)	- Malathion (50%EC) .23 1/3.8-7.6 l of H ₂ O for 92.9m ² (.5 pt/1-2 gal of H ₂ O for 1000 ft ²)	- Aluminum phosphide 60-180 tablets/27 tonnes 1000 bu) 120-300 pellets/27 tonne 1000 bu) - Commercial liquid formulations	J. Carpenter Ent. publ. 913 (1983)
Missouri	- Malathion (57%EC) .16 1/3.8 l of H ₂ O for 92.9m ² (.3 pt/gal for 100 ft ²) - Methoxychlor (25%EC) .36 1/3.8 l of H ₂ O for 92.9m ² (.75 pt/gal/1000 ft ²) - Chloropicrin (empty bin fumigation)	- Malathion (57%EC) .47 1/7.6-18.9 l of H ₂ O/ 27 tonnes (1 pt/2-5 gal of H ₂ O/ 1000 bu) - Malathion (2% dust) 13.6 Kg/27 tonnes (30 lb/1000 bu)	- Malathion (57%EC) 3.8 l of 2.5% spray/92.9m ² (1 gal of 2.5% spray/ 1000 ft ²) - Malathion (2% dust) 13.6 Kg/92.9m ² (30 lb/1000 ft ²) - <u>Bacillus thuringiensis</u> - Dichlorvos 1 strip/28.3m ³ (1000 ft ³)	- Aluminum phosphide - Methyl bromide - Chloropicrin - Commercial liquid fumigants	R. Munson Management of Stored Grain & Insect Control (1983)
Nebraska & Tennessee	- Malathion (57%EC) .16 1/3.8 l of H ₂ O for 69.7-92.9m ² (.3 pt/gal of H ₂ O for 750-1000 ft ²) - Methoxychlor (25%EC) .35 1/3.8 l of H ₂ O for	- Malathion (57%EC) .47 1/7.6-18.9 l of H ₂ O/ 27 tonnes (1 pt/2-5 gal of H ₂ O/ 1000 bu) - Malathion (1% dust) 22.7 Kg/27 tonnes	- Malathion (57%EC) .24 1/3.8-7.6 l/92.9m ² (1/2 pt/1-2 gal/1000 ft ²) - Malathion (dusts) 1%: 13.6 Kg/27 tonnes (30 lb/1000 ft ²) 6%: 2.3 Kg/27 tonnes	- Aluminum phosphide 90-180 tablets/27 tonnes (1000 bu) 200-400 pellets/27 tonnes (1000 bu) - Carbon disulfide - Carbon tetrachloride	L. Peters Nebraska EC80- 1534 (1980)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Nebraska & Tennessee (cont'd)	69.7-92.9m ² (.75 pt/gal of H ₂ O for 750-1000 ft ²)	(50 lb/1000 bu) - Malathion (6% dust) 4.5 Kg/27 tonnes (10 lb/1000 bu)	(5 lb/1000 ft ²) - Dichlorvos (strip) 1 strip/28.3m ³ (1000 ft ³) - Bacillus thuringiensis WP: .45 Kg/37.8 l of H ₂ O/46.5m ² (1 lb/10 gal/500 ft ²) Dust: 1.8 Kg/46.5m ² (4 lb/500 ft ²)	- Ethylene dibromide - Ethylene dichloride - Chloropicrin - Sulfur dioxide - Methyl bromide	E. Burgess Tenn. S.C. 956 (1980)
New Jersey	- Malathion (57%EC) .9 l/22.7 l of H ₂ O at 3.8 l/46.5m ² (1 qt/6 gal of H ₂ O at 1 gal/500 ft ²) - Methoxychlor (25%EC) 3.8 l/38 l of H ₂ O at 3.8 l/46.5m ² (1 gal/10 gal of H ₂ O at 1 gal/500 ft ²)	- Malathion (57%EC) .47 l/7.6-18.9 l of H ₂ O for 27 tonnes (1 pt/2-5 gal of H ₂ O at 5 gal/1000 bu)	- Malathion (57% EC) .24 l/7.6 l of H ₂ O for 92.9m ² (.5 pt/2 gal of H ₂ O for 1000 ft ²) - Bacillus thuringiensis .45 Kg/37.8 l of H ₂ O for 46.5m ² (1 lb/10 gal of H ₂ O for 500 ft ²)	- Carbon tetrachloride + carbon disulfide (80:20) - Ethylene dichloride + carbon tetrachloride (75:25)	S. Race Ext. Bull.E-003 (1984)
New York	- Malathion (57%EC) .47 l/11.3 l of H ₂ O at 3.8 l/46.5m ² (1 pt/3 gal of H ₂ O at 1 gal/500 ft ²) - Methoxychlor (25%EC) .9 l/11.3 l of H ₂ O at 3.8 l/46.5m ² (1 qt/3 gal of H ₂ O at 1 gal/500 ft ²) - Methoxychlor (50%WP) .45 Kg/11.3 l of H ₂ O at 3.8 l/46.5m ² (1 lb/3 gal of H ₂ O at 1 gal/500 ft ²) - Synergized pyrethrins (6:60%EC) .47/28 l of H ₂ O at 3.8 l/69.7m ² (1 pt/7 gal, 3 pt of H ₂ O at 1 gal/750 ft ²)	- Malathion (57%EC) .47 l/7.6-18.9 l of H ₂ O/27 tonnes (1 pt/2-5 gal of H ₂ O/1000 bu) - Synergized pyrethrins (6:60%EC) .71 l/18.9 l of H ₂ O/27 tonnes (1.5 pt/5 gal of H ₂ O/1000 bu)	- Malathion - Synergized pyrethrins - Dichlorvos (strip)	- Aluminum phosphide - Carbon tetrachloride + carbon disulfide + ethylene dichloride + ethylene dibromide (76.5:10:10:35) - Carbon tetrachloride + ethylene dichloride + ethylene dibromide (64:29:7) - Carbon tetrachloride + ethylene dibromide + ethylene dichloride + sulfur dioxide - Carbon tetrachloride + carbon disulfide + sulfur dioxide (83:16:1) - Ethylene dibromide + methyl bromide (70:30)	H. Willson (1981)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
North Dakota	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/11.3 l of H₂O/92.9m² (1 pt/3 gal of H₂O/1000 ft²) - Methoxychlor (50%WP) .45 Kg/5.7 l of H₂O/92.9m² (1 lb/1.5 gal of H₂O/1000 ft²) - Synergized pyrethrins (label) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/7.6-18.9 l of H₂O/ 27 tonnes (1 pt/2-5 gal of H₂O/1000 bu) - Malathion (dusts) 2,4,6% - labels - Synergized pyrethrins (label) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/7.6-18.9 l of H₂O/ 92.9m² (1 pt/2-5 gal of H₂O/ 1000 ft²) - Synergized pyrethrins - <u>Bacillus thuringiensis</u> 1.8 Kg/46.5m² (4 lb/500 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide max. 180 tablets/27 tonnes - Chloropicrin - Carbon tetrachloride + carbon disulfide (80:20) - Ethylene dichloride + carbon tetrachloride (75:25) - Carbon tetrachloride + carbon disulfide + sulfur dioxide (80:15:5) - Carbon tetrachloride 	D. McBride Insect Control (1984)
Ohio	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/11.3 l of H₂O at 3.8 l/46m² (1 pt/3 gal of H₂O at 1 gal/ 500 ft²) - Methoxychlor (25%EC) .9 l/11.3 l of H₂O at 3.8 l/ 46m² (1 qt/3 gal of H₂O at 1 gal/ 500 ft²) - Methoxychlor (50%WP) .45 Kg/11.3 l of H₂O at 3.8 l/46m² (1 lb/3 gal of H₂O at 1 gal/500 ft²) - Synergized pyrethrins (6:60%EC) .47 l/29.3 l of H₂O at 3.8 l/70m² (1 pt/7 gal, 3 pt of H₂O at 1 gal/750 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 l/7.6-18.9 l of H₂O/ 27 tonnes (1 pt/2-5 gal/1000 bu) - Synergized pyrethrins (6:60%EC) .71 l/18.9 l of H₂O/ 27 tonnes (1.5 pt/5 gal of H₂O/ 1000 bu) 	<ul style="list-style-type: none"> - Malathion - Synergized pyrethrins - Dichlorvos - <u>Bacillus thuringiensis</u> .45 Kg/37.8 l of H₂O/ 46.5m² (1 lb/10 gal of H₂O/ 500 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide - Mixtures of: carbon disulfide carbon tetrachloride chloropicrin Dichlorvos Ethylene dichloride Methyl bromide 	H. Willson L-153 Agdex 100/623 (1984)
Oklahoma	<ul style="list-style-type: none"> - Malathion (57%EC) 1.2 l/18.9 l of H₂O applied to runoff (2.5 pt/5 gal of H₂O) - Methoxychlor (2.5%EC) 1.8 l/18.9 l of H₂O applied to runoff (3.75 pt/5 gal of H₂O) 	<ul style="list-style-type: none"> - Malathion (57%EC) .24 l/7.6 of H₂O/ 13.5 tonnes (.5 pt/2 gal of H₂O/500 bu) - Malathion (2% dust) 9.1 Kg/27 tonnes 20 lb/1000 bu 	<ul style="list-style-type: none"> - Malathion (57%EC) - <u>Bacillus thuringiensis</u> - <u>Dichlorvos (strip)</u> 	<ul style="list-style-type: none"> - Carbon tetrachloride - Carbon disulfide - Ethylene dichloride - Sulfur dioxide - Chloropicrin - Ethylene dibromide 	factsheet No. 7180

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
South Carolina	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{11.3}$ $\frac{1}{1}$ of H₂O for 92.9m² (1 p\bar{c}/3 gal of H₂O for 1000ft²) - Methoxychlor (50%WP) .45 Kg/7.6-11.3 $\frac{1}{1}$ of H₂O for 92.9m² (1 lb/2-3 gal of H₂O for 1000 ft²) - Methoxychlor (25%EC) .94 $\frac{1}{11.3}$ $\frac{1}{1}$ of H₂O for 92.9m² (1 qt/3 gal of H₂O for 1000 ft²) - Synergized pyrethrins (6:60%EC) .63 $\frac{1}{11.3}$ $\frac{1}{1}$ of H₂O for 92.9m² (1.3 pt/3 gal of H₂O/1000 ft²) - <u>Bacillus thuringiensis</u> (tobacco storage) 57 g/18.9 $\frac{1}{1}$ of H₂O at 1.9 $\frac{1}{1}$/ 92.9m² (2 oz/5 gal of H₂O at .5 gal/1000 ft²) 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{7.6-18.9}$ $\frac{1}{1}$ of H₂O/ 27 tonnes (1 pt/2-5 gal of H₂O/ 1000 bu) - Malathion (1% dust) 27 Kg/27 tonnes (60 lb/1000 bu) - Synergized pyrethrins (6:60%EC) .94 $\frac{1}{7.6-18.9}$ $\frac{1}{1}$ of H₂O/1000 bu) 27 tonnes (1 qt/2-5 gal of H₂O/ 1000 bu) - Synergized pyrethrins (.08:1.1% dust) 27 Kg/27 tonnes (60 lb/1000 bu) 	<ul style="list-style-type: none"> - <u>Bacillus thuringiensis</u> (WP) .45 g/3.8 $\frac{1}{1}$ of H₂O (.1 lb/gal of H₂O) - <u>Bacillus thuringiensis</u> (dust) 1.8 Kg/46.5m² (4 lb/500 ft²) - Dichlorvos 1 strip/28.3m³ (1 strip/1000 ft³) 	<ul style="list-style-type: none"> - Aluminum phosphide 150 tablets/27 tonnes (1000 bu) 300 pellets/27 tonnes (1000 bu) - Methyl bromide .9 Kg/28.3m³ (2 lb/1000 ft³) 	P. Horton Agr. Chem. Handbook (1984)
South Carolina (unshelled peanuts)		<ul style="list-style-type: none"> - Malathion (57%EC) 1.2 $\frac{1}{18.9}$ $\frac{1}{1}$ of H₂O for 13.6 tonnes (2.5 pt/5 gal of H₂O for 15 tons) - Synergized pyrethrins (6:60%EC) 1.4 $\frac{1}{18.9}$ $\frac{1}{1}$ of H₂O for 13.6 tonnes (3 p\bar{c}/5 gal of H₂O for 15 tons) 	<ul style="list-style-type: none"> - Malathion (25%WP) .79 kg/7.6 $\frac{1}{1}$ of H₂O for 92.9m² (1.75 lb/2 gal of H₂O for 1000 ft²) 	<ul style="list-style-type: none"> - Aluminum phosphide 125 tablets/28.3m³ (1000 ft³) 165-200 pellets/28.3m³ (1000 ft³) - Methyl bromide .23 Kg/28.3m³/24h (.5 lb/1000 ft³/24h) 	
Texas	<ul style="list-style-type: none"> - Malathion (57%EC) .16 $\frac{1}{3.8}$ $\frac{1}{1}$ of H₂O applied to runoff (.3 pt/gal of H₂O) - Methoxychlor (25%EC) .35 $\frac{1}{3.8}$ $\frac{1}{1}$ of H₂O 	<ul style="list-style-type: none"> - Malathion (57%EC) .47 $\frac{1}{3.8-7.6}$ $\frac{1}{1}$ of H₂O for 27 tonnes (1 pt/2-5 gal of H₂O for 1000 bu) - Malathion (1% dust) 	<ul style="list-style-type: none"> - Malathion (57%EC) .24 $\frac{1}{3.8-7.6}$ $\frac{1}{1}$ of H₂O/ 92.9m² (.5 pt/1-2 gal of H₂O/ 1000 ft²) - Malathion (dust) 	<ul style="list-style-type: none"> - Aluminum phosphide 180 tablets/27 tonnes (1000 bu) 300 pellets/27 tonnes (1000 bu) - Methyl bromide 	P. Hamman B1410 (1982)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Texas (cont'd)	applied to runoff (.75 pt/gal of H ₂ O) - Synergized pyrethrins (.1:1%)	22.6 Kg/27 tonnes (50 lb/1000 bu) - Malathion (6% dust) 4.5 Kg/27 tonnes (10 lb/1000 bu)	1%: 13.6 Kg/92.9m ² (30 lb/1000 ft ²) 6%: 2.3 Kg/92.9m ² (5 lb/1000 ft ²) - Synergized pyrethrins (.3:3%) 3.8-7.6 l for 92.9m ² (1-2 gal for 1000 ft ²) - Dichlorvos (strip) - <u>Bacillus thuringiensis</u>	- Carbon tetrachloride + carbon disulfide (80:20) - Carbon tetrachloride + ethylene dichloride (25:75) - Ethylene dibromide + ethylene dichloride + carbon tetrachloride (5:35:60)	
Virginia	- Malathion (57%EC) .24 l/9.5 l of H ₂ O for 116m ² (.5 pt/2.5 gal of H ₂ O for 1250 ft ²) - Methoxychlor (25%EC) .74 l/9.5 l of H ₂ O for 116m ² (25 oz/2.5 gal of H ₂ O for 1250 ft ²) - Methoxychlor (50%WP) 4.5 Kg/9.5 l of H ₂ O for 116m ² (1 lb/2.5 gal of H ₂ O for 1250 ft ²) - Synergized pyrethrins (6:60%EC) .16 l/9.5 l of H ₂ O for 116m ² (5.3 oz/2.5 gal of H ₂ O for 1250 ft ²)	- Malathion (57%EC) .47 l/18.9 l of H ₂ O/27 tonnes (1 pt/5 gal of H ₂ O/1000 bu) - Malathion (6% dust) 4.5 g/27 tonnes (1 all/1000 bu) - Synergized pyrethrins (6:60%EC) .62 l/18.9 l of H ₂ O/27 tonnes (21 oz/5 gal of H ₂ O/1000 bu)	- Malathion (57%EC) .24 l/3.8-7.6 l of H ₂ O/92.9m ² (.5 pt/1-2 gal of H ₂ O/1000 ft ²) - Dichlorvos (20% strip) 1 strip/28.3m ³ - <u>Bacillus thuringiensis</u> .05 Kg(WP)/3.8 l of H ₂ O at .28 l/.035m ³ (.1 lb (WP)/gal of H ₂ O at .6 pt/bu) 1.8 Kg (dust)/46.5m ² (4 lb (dust)/500 ft ²)	- Aluminum phosphide - Ethylene dichloride + carbon tetrachloride (70:30) 18.9-37.8 l/27 tonnes flat storage - Carbon tetrachloride + carbon disulfide (80:20) 11.3-30.2 l/27 tonnes flat storage (3.8 gal/1000 bu flat storage)	J. Roberts Sr. Publ. 444-682 (1982)
Washington	- Malathion (57%EC) 3.8 l/94.5 l of H ₂ O applied to runoff (1 gal/25 gal of H ₂ O) - Methoxychlor (25%EC) 3.8 l/34.2 l of H ₂ O applied to runoff (1 gal/9 gal of H ₂ O) - Methoxychlor (50%WP) 1.8 Kg/34.2 l of H ₂ O	- Malathion (57%EC) .47 l/7.6-18.9 l of H ₂ O/27 tonnes (1 pt/2-5 gal of H ₂ O/1000 bu) - Malathion (1% dust) 27 Kg/27 tonnes (60 lb/1000 bu) - Synergized pyrethrins (label)		- Aluminum phosphide 90-180 tablets/27 tonnes (1000 bu) 200-400 pellets/27 tonnes (1000 bu) - Methyl bromide .9 Kg/28.3m ³ (2 lb/1000 ft ³) - Chloropicrin 1.4 Kg/27 tonnes (3 lb/1000 bu)	EM3314 (1980)

Province, state or organization	Bin treatment	Grain Protectant	Surface dressing (top 10-15 cm) or headspace	Fumigants	Information source and Reference
Washington (cont'd)	applied to runoff (4 lb/9 gal of H ₂ O)			- Carbon tetrachloride + carbon disulfide (80:20) 7.6-15.1 l/27 tonnes (2-4 gal/1000 bu) - Carbon tetrachloride + ethylene dichloride (25:75) 15.1-30.2 l/27 tonnes - Chloropicrin + carbon tetrachloride (20:80) 5.7 l/27 tonnes (1.5 gal/1000 bu) - Ethylene dibromide + ethylene dibromide + carbon tetrachloride (7:30:63)	
West Virginia	- Malathion (57%EC) .47 l/11.3 l of H ₂ O at 3.78 l/46.5m ² (1 pt/3 gal of H ₂ O at 1 gal/500 ft ²) - Methoxychlor (25%EC) .94 l/11.3 l of H ₂ O at 3.78 l/46.5m ² (1 qt/3 gal of H ₂ O at 1 gal/500 ft ²) - Methoxychlor (50%WP) .45 Kg/11.3 l of H ₂ O at 3.78 l/46.5m ² (1 lb/3 gal of H ₂ O at 1 gal/500 ft ²) - Synergized pyrethrins (6:60EC) .47 l/26.5 l of H ₂ O at 3.78 l/69.7m ² (1 pt/7 gal of H ₂ O at 1 gal/750 ft ²)	- Malathion (57%EC) .47 l/7.6-18.9 l of H ₂ O/27 tonnes (1 pt/2-5 gal of H ₂ O/1000 bu) - Synergized pyrethrins (6:60%EC) .7 l/18.9 l of H ₂ O/27 tonnes (1.5 pt/5 gal of H ₂ O/1000 bu)	- Malathion (57%EC) - Synergized pyrethrins (6:60%EC) - Bacillus thuringiensis .45 Kg/37.8 l of H ₂ O/46.5m ² (1 lb/10 gal of H ₂ O/500 ft ²) - Dichlorvos 1 strip/28.3m ³ (1 strip/1000 ft ³)	- Aluminum phosphide - Methyl bromide - Carbon disulfide - Carbon tetrachloride - Chloropicrin - Ethylene dichloride	J. Baniechi Pest Inf. Series 80 (1984)

- Notes: a) All malathion formulations are premium grade (deodorized)
b) Synergized pyrethrins contain the synergist piperonyl butoxide (pyrethrins: piperonyl butoxide)
c) Fumigant application rates vary with temperature, structure type, and grain type.
d) Treatment limitations are not presented in this table.
e) Requests sent for extension information on control of stored-product insects in grain to 50 states and 10 provinces. (Many rely on federal recommendations).
f) The fumigant ethylene dibromide (and any mixture containing this chemical) was de-registered in the U.S. and Canada in 1984.

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