EDN™ Fumigas Introduction.
Biosecurity Treatments 2014
Methyl Bromide and Alternatives Conference.

Chris Dolman – Global Business Manager
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Fumigant Registration

Worker & Bystander Exposure

- TLV
  - Methyl bromide 1 ppm
  - Phosphine 0.3 ppm
  - Sulfuryl fluoride 1 ppm
  - Ethyl formate 100 ppm
  - EDN 10 ppm
  - Low human toxicity
  - Non-carcinogen/mutagen

Environmental Safety

- Non-ozone depleting
- Non-hazardous air pollutant
- Naturally occurring substances
- Degraded into earth friendly metabolites
- Qualify for organic status

Public Safety, Environmental Groups

- Broad-spectrum activity efficacy
- Satisfy bio-security requirements
- Ease of use
- Short hold time/short vent time/REI
- PPE
- Crop safety
- Bio-security approvals
- Non-corrosive
- No residues

Regulatory Authorities

Governmental Trade

Industry Trade Associations
A History of EDN Fumigas

- Thirty years ago, CSIRO, sought funding for Methyl Bromide replacements

- Candidates were selected based on chemistry (e.g. persistence) as well as toxicology

- The initial chemicals had limited ability to control fungi, bacteria, viruses and weeds

- This meant there were gaps in terms of Methyl Bromide replacements for both soil fumigation as well as timber and log exports

- And EDN Fumigas was born...
EDN Fumigas Key Features

EDN Fumigas is 100% ethanedinitrile
  • No known green house gas or ozone depleting properties
  • A “drop in” Methyl Bromide replacement

Timber Specific
  • Quicker fumigation (10 hours) for a range of timber pests
  • Higher toxicity to timber pests than methyl bromide - controls both surface and cryptic timber insects
  • Superior penetration - both across and along the timber grain (in wet and dry timber)
  • Scrubbing technology available to enhance user and bystander Safety

Soil Specific
  • Highly toxic to insect, nematodes, pathogens and weed
  • Pre-plant solution to manage risks and protect investments
  • Shorter plant-back period than methyl bromide for easier planning and greater productivity
Initially the focus of EDN FUMIGAS is exported (including inter-country) timber and pre-plant soil.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Pests</th>
<th>Rate</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries - Runners - Fruit</td>
<td>Pathogens, weeds and insects</td>
<td>150 - 500 kg/ ha for 24 hours varied by soil type</td>
<td>Data for further crops in development (tomato, cucurbits, cut flowers, melons, egg plant, etc). Focus on high value crops.</td>
</tr>
<tr>
<td>Timber and logs for export</td>
<td>Insect pests and pathogens</td>
<td>50g/ m3, 6 - 10 hours</td>
<td>Data for a range of insects including surrogate insects where high numbers are hard to find</td>
</tr>
</tbody>
</table>

Linde has achieved the timber and log registration in Australia with further registrations pending.
AT Linde safety is our number one priority and we recommend the following PPE

• Full face respirator with cartridge suitable for organic vapour

• Long sleeved, flameproof shirt & trousers or coveralls

• Safety gloves

• Safety shoes / boots
EDN Fumigas PPE (continued)

Personal Protective Equipment (PPE) is key for all fumigants

3M Mask Filters
• Filters with carbon impregnated with specific metal salts remove ethanedinitrile
• 3M “Multi-gas” and ABEK-type filters incorporate such carbon
• Three filters may be use successfully (6006, 6059, 6099)

Safety & Dosing Monitors
• Linde have worked with Spectros to creating a dosing monitor
• Monitors are also available for personal safety (depending on the ppm level required)
BOC have a product stewardship program for sensitive products such as fumigants.

A key element is ensuring our customers are set up to manage the product safety and effectively.

All new customers must complete risk assessments as well as be trained to use EDN Fumigas.
Training & Support

• Linde has experts situated around the world
• Support is available with trials
• Training is also available as part of our Product Stewardship Program
• Engineering support is available for application equipment
Timber Efficacy and Application
EDN Fumigas Application

- Unlike MeBr no vaporiser is required (boiling point: –21°C)

- Product fills the container uniformly when applied through natural drafts within the structure (a FLP fan may be used)

- Linde recommend the application line is purged with Nitrogen after application

- Some registrations will require a scrubber post fumigation
  - This is common for many fumigants and may be related to sensitive populations
  - We are working with Nordiko in Asia Pacific
EDN Fumigas Efficacy

- Trials have been conducted in China, South Korea, Malaysia, Australia & New Zealand
- More trials are expected throughout the Asia Pacific region
- Timber pests controlled to date include

Insects
- European house borer (Hylotrupes bajulus), Asian Long Horn Beetle (Anoplophora glabripennis), Japanese pine sawyer larvae (Monochamus alternatus), Termites (Coptotermes acinaciformis, Coptotermes brevis, Cryptotermes brevis, Mastotermes darwiniensis, Cryptotermes brevis), Bark-Borne Burnt Pine Longhorn (BPL) (Arhopalus ferus (Mulsant)), Reticulitermes speratus, Tomicus piniperda and Hyphanria cunea

Pathogens
- Ganoderma applanatum, Splitgill (Schizophyllum commune)

Nematode
- Pine wilt disease (Bursaphelenchus xylophilus)
Name: Comparison of EDN with MeBr as a biosecurity fumigant for timber and log

Background

- Developed by the Department of Agriculture (DoA) and Murdoch University
- Timber pests are difficult to obtain in large numbers
- Surrogate insects based on order groups allowing large numbers of insects (5-10,000)
- DAFF will be using this data to approve EDN Fumigas for imports and discuss exports with Australia's trading partners
3 Stage Testing process

1. Determine dose/response to establish kill concentration (Complete)
2. Assess cross grain penetration of EDN in parallel with MeBr (Complete)
3. Commercial testing of logs (50% loading factor) (end of May)

Insects & Relatives

- Selected pests provide broad coverage to beetle Order Coleoptera e.g. powder post beetle, Asian long horn beetle, European house borer and burnt pine long horn beetle
- Cigarette beetles, rust red flour beetle, warehouse beetles were selected because their adults or pupae or larvae or eggs have a high tolerance to methyl bromide
  - Lasioderma serricorne (Cigarette beetle)
  - Sitophilus oryzae (Rice weevil)
  - Trogoderma variable (Warehouse beetle)
  - Rhyzopertha dominica (Lesser grain borer)
  - Tribolium castaneum (Rust red flour beetle)
Name: Material damage assessment of EDN to apply cultural assets in Korea

<table>
<thead>
<tr>
<th>Material</th>
<th>25g/m³ for 6hr</th>
<th>50g/m³ for 6hr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Cotton</td>
<td><img src="cotton_before.png" alt="Image" /></td>
<td><img src="cotton_after.png" alt="Image" /></td>
</tr>
<tr>
<td>Copper</td>
<td><img src="copper_before.png" alt="Image" /></td>
<td><img src="copper_after.png" alt="Image" /></td>
</tr>
<tr>
<td>Silver</td>
<td><img src="silver_before.png" alt="Image" /></td>
<td><img src="silver_after.png" alt="Image" /></td>
</tr>
<tr>
<td>Lead</td>
<td><img src="lead_before.png" alt="Image" /></td>
<td><img src="lead_after.png" alt="Image" /></td>
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</tbody>
</table>

Damage Assessment
- Slight on copper, silver, copper, cotton

Insects Controlled
- Termite (Reticulitermes speratus) Pine shoot beetle (Tomicus piniperda) and Fall web worm (Hyphanria cunea)
Linde is working with STIMBR and Plant & Food Research in New Zealand to establish EDN Fumigas as a replacement for Methyl Bromide

1 a) Finding: Sorption has a greater relationship with the loading factor than moisture content in timber
1 b) In process: Sorption for a commercial fumigation of kiln dried timber
1 c) In process: Desorption study to establish accurate aeration standards
1 d) In process: Sorption for wet logs
2 a) In process: Efficacy data on all life stages of Arhopalus ferus
EDN Fumigas is in the registration process in Indonesia

Working with PT Biosecurity the following research protocol will be completed

The key pest is the Dry wood termite (*cynocephalus cryptotermes*) all life stages

The results will support the use of this fumigant in the timber export trade
Soil Efficacy and Application
EDN Fumigas Application

• The fumigant is into the soil pre-planting for disease and weed control

• This supports the intensive farming required for feeding a growing population

• There are two methods of application (Chemigation and Shank Injection)
Key Crops

Over 50 trials conducted in Israel, Turkey and Australia

Key Crops of interest

• High value crops are the focus: nursery stock, strawberry (runners & fruit), cut flowers, tomatoes, cucumber, water melons, egg plant, pepper, ginger
• Treatment must be under plastic for all crops (for efficacy and safety)
Trials on pests have been conducted in the lab and in the field

Key Pests of interest

• Includes some biosecurity pests – weed seeds, nematodes and pathogens

• Key weed seeds: Poa annua, Spergula arvensis, Agrostis tenuis, Raphanus raphanistrum Conyza Canadensis, Lolium sp. Solanum nigrum, Amaranthus retroflexus, Portulaca oleracea, Orobanche aegyptiaca, Cyperus rotundus

• Key pathogens: Pythium ultimum, Phytophthora cactorum, Fusarium oxysporum, Rhizoctonia fragariae, Schlerotium rolfsi, Pythium sulcatum, Rhizoctonia solani, Fusarium acuminatum, Phytophthora cactorum, Phytophthora cryptogea, Bipolaris soroikiniana

Key nematodes: Meloidogyne spp., Steinernema spp., Pratylenchus sp. Helicotylenchus dihystera, Rotylenchulus parvus, Criconemella sp
Shank Injection Worker Exposure trial
Future Developments

Trial work continues on new commodities and pests

Potential Markets

- Fresh Fruit disinfection e.g. Apples
- Fruit fly on a range of produce
- Grain and oil seed commodities
- Grain devitalisation
- Where do you think it fits????
Visit our Linde Crop Science Website (http://cropscience.linde-gas.com)

This site includes
• Product labels & registrations
• Product fact sheets
• Case studies
• Product stewardship information
• Contact details to request more information

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Questions?
Question 1

The active ingredient of EDN Fumigas is

a) Ethanedinitrile

b) Formic acid

c) Hydrogen Cyanide

d) Carbon Dioxide
Question 2

Which of the following PPE is recommended by Linde?

a) Full face respirator with cartridge suitable for organic vapour

b) Long sleeved, flameproof shirt & trousers or coveralls

c) Safety gloves

d) Safety shoes / boots

e) Safety Monitor

f) All of the above
Question 3

The TWA-TLV over 8 hours period for ethanedinitrile is

a) 10 ppm

b) 5 ppm

c) 50 ppm

d) 100 ppm