Ministry for Primary Industries
Manatū Ahu Matua

Import Risk Analysis

Inorganic Fertiliser

Prepared for Biosecurity Risk Analysis
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Growing and Protecting New Zealand

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1.1 SUMMARY

This risk analysis examines the biosecurity risks posed by the importation of fertiliser into New Zealand, and identifies factors for consideration in managing these risks. The risk analysis will contribute to the revision of current Import Health Standards.

The conclusions from the risk analysis are:

- Biosecurity risk depends on the form in which fertiliser is transported. Bulk products have greater likelihood of contamination throughout the supply chain, whereas bulk bags or smaller retail bags containing fertiliser are likely to have less direct contamination (and given the toxic nature of the product would likely devitalise any contaminant) but may have an association with hitchhikers.

- Machinery and equipment that is dedicated for processing and transportation, or machinery and equipment that is thoroughly cleaned and subsequently inspected would reduce the likelihood of contamination from prior use.

- Biosecurity hazards can be reduced by separating areas where fertiliser is stored and bagged from areas where other commodities are processed and stored in the country of origin

- Biosecurity hazards can be reduced if the environments surrounding processing and storage facilities in the country of origin are kept free of vegetation. This will reduce the likelihood of wind blown seeds or invertebrates contaminating the fertiliser.

1.2 PURPOSE

New Zealand imports a range of organic and inorganic fertilisers. As fertilisers are spread directly onto land, they provide a means by which unwanted organisms, for example exotic seeds or invertebrates, could establish in New Zealand. This document is a general risk analysis that can be used to inform the review of the relevant import health standards.

The Biosecurity Operational Systems and Standards Group are reviewing the import health standards for inorganic fertilisers. There are two relevant standards (Bulk fertiliser - 152-08-04i, and Guano based fertiliser from all countries - ferguaic.all), and a variety of different products are covered by these standards. The current standards are based on historical information about the risks, for example bulk shipments are considered likely to be contaminated from previous cargo in transport vessels. There is considerable experience in MAF with managing this pathway; however a formal risk analysis has not yet been developed.

Since the standards were last reviewed there have been a number of changes in the origins of fertilisers, the range of products and their processing and transportation processes. Up-to-date information on the risks associated with imported fertilisers is needed to inform a review of the import health standards

1.3 SCOPE

The commodities included in this assessment are inorganic fertilisers covered by the current import health standards. These include phosphate rock, potash, urea and other chemical fertiliser ingredients. Guano is fertiliser of organic origin but is included in this assessment since geological processes are involved in its genesis making it analogous to mineral substances (Nickel, 1995).

There is insufficient information available about the hazards associated with fertiliser to undertake a comprehensive import risk analysis. The approach adopted in this analysis is to identify examples of potential hazards associated with this pathway and risk factors that can be considered when developing and assessing risk management systems for specific products.

MAF does not currently inspect containerised consignments of imported fertiliser; however there are records from bulk consignments. This analysis has used data on border interceptions to identify hitchhikers, and information about other likely hitchhiker hazards has been sourced from risk analyses of other inanimate pathways.

General examples of the products and supply chains for fertiliser and broad groups of hazards associated with this pathway have been provided to illustrate the likely risks. Specific examples of potential hazards have been discussed where this information is available.

This analysis identifies risk factors which can be used to manage biosecurity risk but it does not address the practical implementation of risk management measures.

2 Commodity Description

Fertilisers are substances applied to soil to amend soil fertility and supply nutrients to increase plant growth. The main elements required for plant growth are nitrogen, phosphorus, potassium, calcium, sulphur and magnesium. Trace elements are also important, these include; boron, chlorine, copper, iron, manganese, molybdenum, selenium and zinc.

Fertilisers imported into New Zealand are either direct application fertilisers requiring no further processing prior to being used, or fertiliser for further processing. In the latter case the raw imported material is processed in such a way that a biological contaminant could be devitalised, generally accomplished by heating acidulation or grinding. If this fertiliser is processed by acidulation or heating contamination will be eliminated; however, if grinding is used then contamination, particularly by seeds, will only be eliminated if grinding sieves are fine enough.

2.1 ORIGIN

New Zealand imports fertiliser from many countries and in a variety of forms: manufactured and raw ingredients, bulk and bagged. Guano, phosphate rock, potash and urea are the most commonly imported fertilisers.

In the five years from January 2006 to December 2010 there were 1980 imports of fertiliser from 50 different countries. These consignments consisted of both bulk and bagged fertiliser. Around 50% of our imports came from six countries; 12% came from Canada, another 12% from Australia, 10% from Morocco and 6% each from China, Saudi Arabia and USA (QuanCargo, 2011). Main imports are detailed below:

Guano

- Indonesia – 18 consignments; 1,260 tonnes
- Philippines – 45 consignments; 1,269 tonnes

Phosphate rock

- Africa (Egypt, Morocco, Togo and Tunisia) – 280 consignments; 1,737,430 tonnes
- Asia (Indonesia and Vietnam) – 120 consignments; 705,089 tonnes
- Pacific (Christmas Island and Nauru) – 21 consignments; 76,119 tonnes

Potash (includes potassium chloride, potassium nitrate and potassium sulphate)

- Canada – 133 consignments; 543,364 tonnes
- Germany – 74 consignments; 45,149 tonnes

Urea

- Asia (China and Malaysia) – 33 consignments; 167,124 tonnes
- Middle East (Kuwait, Qatar, Saudi Arabia and United Arab Emirates) – 174 consignments; 1,104,657 tonnes

Other common imports included ammonium nitrate, ammonium phosphate, ammonium sulphate, magnesium chloride, magnesium sulphate and various branded fertilisers.

In the five years from 2006 to 2010 New Zealand imported around 5 billion tonnes of fertiliser in bulk and bagged form, 33% of this came from the six countries that made up 50% of imports. 79% of all fertiliser imported was classed as “manufactured-solid”. The “unmanufactured-solid” fertilisers were primarily, phosphate rock, sulphur and urea. However, in the import data there was significant overlap between the two classes (QuanCargo, 2011).

2.1.1 Origin and processing prior to shipping

Guano is a phosphate rock formed from the fossilised excrement of seabirds and is accumulated along coastal areas. Guano is mined and ground, and under the current import health standard is required to be heat treated at 100 °C for at least one minute.

Phosphate rock is a non-detrital sedimentary rock which contains high amounts of phosphate bearing minerals; limestones and mudstones are common phosphate bearing rocks. Phosphate rock is mined and transported in its raw state for processing at plants in New Zealand.

Potash is the common name for various mined salts that contain potassium in water-soluble form. Potash is mined and then processed by grinding and subsequent flotation to remove unwanted components before drying and sizing.

Urea is synthesised from liquid ammonia and gaseous carbon dioxide which is dehydrated and then granulated prior to shipping.

Other manufactured fertilisers are produced within processing plants by the combination of chemical ingredients. For example; ammonium nitrate, ammonium phosphate and ammonium sulphate are produced by the reaction of ammonia with nitric acid, phosphoric acid and sulphuric acid

2.2 PATHWAY DESCRIPTION

2.2.1 Transportation

Due to the number and variety of countries manufacturing and supplying fertiliser there is corresponding variety in the ways in which fertiliser is transported and handled. Information on the transportation of fertiliser is taken from discussions with Brent Falvey from Ravensdown in Christchurch.

Generally bulk fertilisers are transported from the manufacturer’s premises to ports by either truck or rail, in either open or covered trailers. This bulk fertiliser is then transferred directly to the ship or transported by barge to a ship at anchor.

Bagged fertiliser may be bagged at the manufacturer's premises or in some cases may be transported in bulk to a storage facility, or the port of export and bagged prior to shipping.

Larger manufacturers may have dedicated transportation, equipment and ports which will reduce the likelihood of contamination from prior use of equipment and proximity to other commodities. However, smaller suppliers may use equipment which has previously been used for transporting other commodities; and fertiliser, bulk or bagged, from these suppliers may be stored and bagged in close proximity to other commodities such as grain.

2.2.2 End use in New Zealand

- Guano is a direct application fertiliser.
- Phosphate rock is a primary ingredient of superphosphate. The manufacturing process involves grinding the raw material to a fine powder and then mixing it with sulphuric acid. This process should eliminate any hazard organisms associated with phosphate rock. However reactive phosphate rock is able to be dissolved by the acids in the soil so can be applied directly without any chemical processing.
- Potash is a direct application fertiliser but may also be blended with single superphosphate products
- Urea is a direct application fertiliser and requires no further processing.
- Other fertilisers are processed or blended into specific products.

3 Risk Assessment

3.1 HAZARD IDENTIFICATION

Imported fertilisers are largely derived from chemical processes and mined rock. As a result, they are not usually associated with live organisms. Guano is the direct product of a live organism; however it is mined in a solid, dry state and then heat treated prior to shipping to neutralise contaminants.

Imported fertiliser can be contaminated with biological material that could pose a biosecurity risk to New Zealand. The fertiliser pathway is similar to other inanimate pathways; potential hazard organisms are either organisms that have no biological host relationship with the fertiliser and are therefore termed "hitchhiker organisms" or are organisms that are associated with other contaminants such as soil or plant debris.

Fertilisers are imported into New Zealand in either bulk (loose in a container or ship's hold) or bagged form, and the potential for contamination will vary depending on the form in which it is imported.

Bulk fertilisers are potentially at risk of contamination and exposure to hitchhikers at all stages along the pathway. Bulk fertiliser may be contaminated by soiled equipment used for mining, production and transportation at the manufacturer's premises. Bulk fertiliser may also be contaminated during transportation to the ship if equipment has been used for other purposes or is not free of soil. Bulk fertiliser may be exposed to hitchhiker organisms at the manufacturers premises and during transportation to the ship and then again on board the ship during transport to New Zealand.

Bagged fertiliser may also be contaminated and be exposed to hitchhikers at the manufacturer's premises; however, once packaged the likelihood of direct contamination is greatly reduced. As with any other inanimate pathway bagged fertiliser may provide entry to New Zealand for hitchhiker organisms concealed between bags or in seams or elsewhere in crevices on bags, or associated packaging such as pallets and wrapping material.

There is anecdotal evidence of fertiliser being bagged on the wharf prior to transport (B. Falvey pers. comm.); a practice which would expose the fertiliser, and bags, to organisms present in the immediate area and on equipment as a result of previous activities. There is further anecdotal evidence of bagged fertiliser stored beneath conveyor belts carrying grain. Once this particular shipment was inspected within the ship it was contaminated not only with grain but also with mice (B. Falvey pers. comm.).

Both seeds and invertebrates have been found contaminating imported fertiliser. Of the 1,480,000 tonnes of fertiliser imported into New Zealand in the five years from 2006 to 2010 (a total of 1,984 consignments), 61 tonnes (11 consignments) was treated for contamination (QuanCargo, 2011). It is important to note that data is not available for the number of consignments contaminated just those consignments that were treated. Organisms present on those consignments that were treated were subsequently identified.

Four seed species were intercepted on one consignment of fertiliser (fertiliser type unrecorded) from Canada. They were; *Avena sativa* (oat); *Lupinus* sp. (lupin); *Rapistrum rugosum* (common giant mustard), and *Triticum aestivum* (wheat). All these species are present in New Zealand, and therefore do not pose a biosecurity risk in themselves. They could however, introduce bacteria, fungi and viruses which are absent from New Zealand and associated with seeds.

In addition to the known seed species contaminating consignments, unidentified seeds were present in consignments of fertiliser from Belarus, Belgium and China, (MAF interception database, 2011). These unidentified species could be species that are new to New Zealand, or of genetically modified origin, or species that could potentially harbour plant pathogens. These interceptions on a pathway that is not routinely inspected on arrival into New Zealand indicate that there are mechanisms for contamination by plant seeds.

In one shipment of Osmocote (a brand of prepared controlled release fertiliser containing potassium sulphate, calcium phosphate, ammonium phosphate and ammonium nitrate) from Israel a live adult moth, *Agrotis ipsilon* (black cutworm), a serious agricultural pest was intercepted; this species is not present in New Zealand. It is unclear from the interception record whether this was bulk or bagged fertiliser, and whether the animal was intercepted within the fertiliser and therefore where in the supply chain contamination could have occurred. In addition unidentified spiders were present in consignments of fertiliser from Australia (MAF interception database, 2011).

A consignment of bulk phosphate rock from Vietnam contained rooted corn seedlings with each hold containing 8 – 12 plants. Contamination is thought to have occurred via the barge that transported the phosphate rock from land to load the ship at anchor (MAF non-compliance report, 2011).

Bagged and loose containerised fertiliser was surveyed for hitchhiker contamination between 1 July and 31 August 2011. Of the 33 consignments surveyed three were found to have contaminants associated with the shrink wrap surrounding the bags or loose in the sea container. A total of eight organisms were found, these were; two spiders, one snail, two beetles and three flies, most organisms were dead on arrival in New Zealand with the exception of one spider and one fly. All organisms, except for one beetle, were species not currently present in New Zealand and none are considered agricultural pests. It is important to note that the number of consignments surveyed was small, the timeframe was limited, and while the fertiliser came from a range of countries there were generally only one or two consignments from each country. Given these limitations the results of this survey may not reflect the general prevalence of hitchhikers on the pathway.

Statistics on contamination of containerised fertiliser compiled by AQIS (2010) indicate that in 2010 4% of all containers transporting fertiliser into Australia were contaminated (192 of 4726 containers). This contamination consisted primarily of soil (0.91% of containers), bark (0.83% of containers) and grain (0.68% of containers).

Other contamination consisted of seeds, plant material, fungus and insects. Contamination within the fertiliser was less than that on the containers with 0.5% of containers contaminated (24 of 4726 containers). Contamination within the fertiliser consisted of seeds and plant material.

The available information for hazard identification gives an indication of the types of potential hazards associated with fertiliser, but there is insufficient detail available to identify specific hazards associated with commodities and countries. In the absence of detailed information for identifying hazards associated with the pathway or of risk analyses for similar bulk or bagged products, three risk analyses of hitchhiker organisms on other inanimate pathways have been used to inform this document. The "Import risk analysis for vehicles and machinery" (MAFBNZ 2007) defines hitchhiker organisms and outlines management measures for these organisms which have no biological association with the pathway. The "Pest risk analysis for six moth species: lessons for the biosecurity system on managing hitchhiker organisms" (MAFBNZ 2008) details incursions of moth species that may be associated with shipping containers and the risk analysis "Ants on Sawn Timber Imported from the South Pacific Region" (MAFBNZ 2003) provides detail on hitchhiking ant species and assesses their impact within New Zealand

Based on the recorded interceptions on imported fertiliser, survey results of bagged fertiliser, and risk analyses for hitchhiker organisms, likely groups of potential hazards associated with fertiliser have been identified:

- **Seed contamination** may arise from the prior use of vehicles and equipment used in transporting or processing the fertiliser in the country of origin. It may also occur by wind dispersal from environments surrounding places of production or storage. In addition to the risk of non native or unwanted genetically modified plant species entering New Zealand as seeds, plant viruses, bacterial and fungal diseases may also be transmitted by seeds.
- **Invertebrate contamination** may result from resident insect pests within vehicles or containers used to transport or store fertiliser or from habitats surrounding manufacture or storage facilities.
- **Feathers or animal faeces** which may carry disease causing organisms may be present as a result of the prior use of vehicles and equipment used in transporting or processing the fertiliser in the country of origin.
- **Soil and plant debris** may contaminate vehicles and containers used in the production, transport and storage of fertiliser. This contaminant may have associated microorganisms such as bacteria, fungi, viruses and nematodes which may be pathogenic and undetectable to the naked eye.

Interception records from QuanCargo and survey results have demonstrated that imported fertiliser has a wide variety of organisms associated with this pathway. However, these organisms are only likely to be a biosecurity risk if they have a mechanism for regular association with the fertiliser pathway and a means of exposure to the New Zealand environment.

3.1.1 Stages at which hazard organisms can be associated with fertiliser

Contamination can occur at many stages along the supply chain from the manufacturer in the country of origin, subsequent transportation to the port, and during shipping. Stages at which consignments may become contaminated and contaminants are exposed to the New Zealand environment are illustrated in figure 1.

Bulk fertiliser carries greater likelihood of direct contamination given that it is not contained at any point in the supply chain. There is reduced opportunity for contamination of bagged fertiliser and given the toxic nature of the product the likelihood of viable organisms being present within bags of fertiliser once the consignment reaches New Zealand is probably negligible. However, bagged fertiliser still carries risk from hitchhiker organisms present externally on the bags or wrapping.

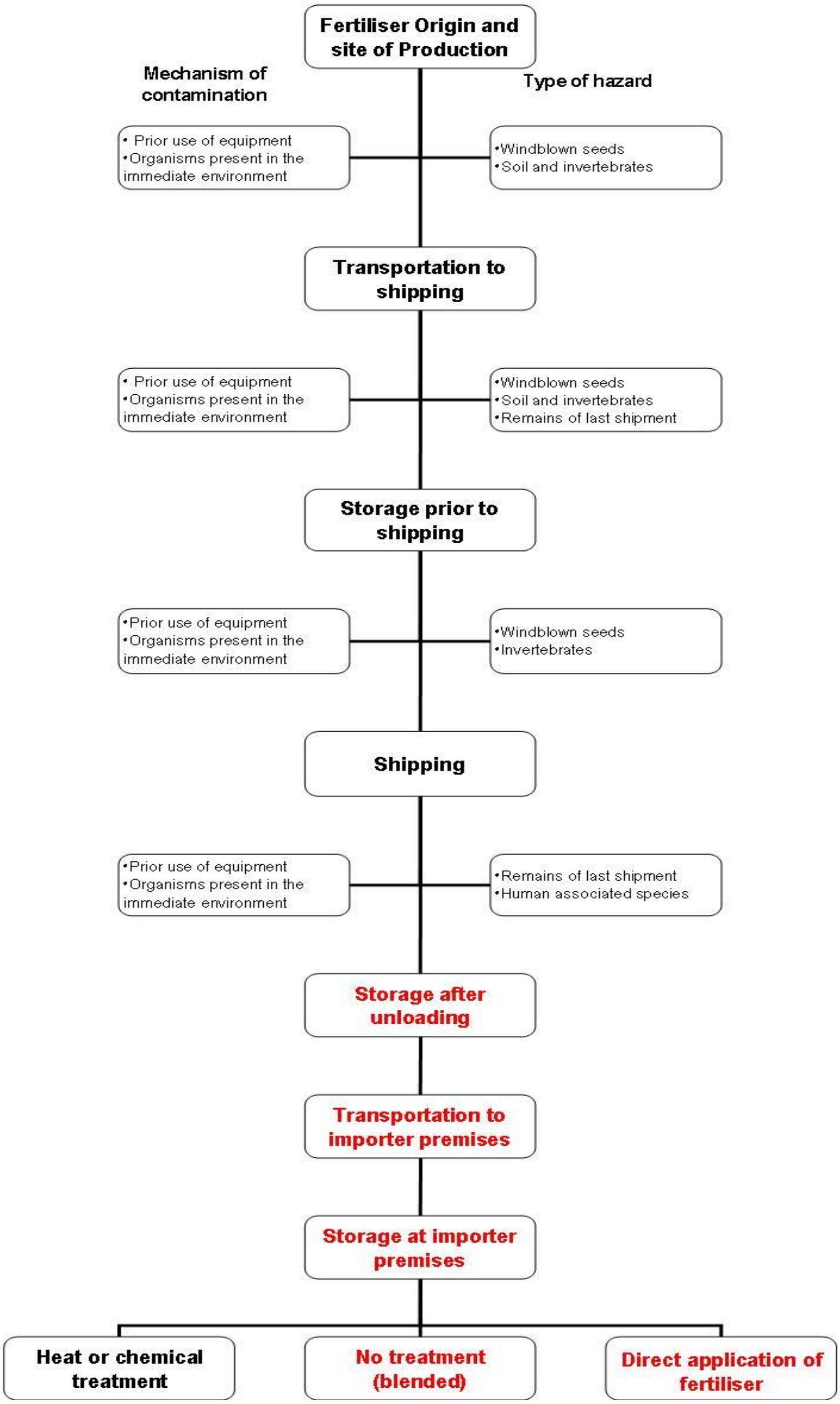

Fig. 1 Pathway diagram showing stages at which consignments may become contaminated and contaminants are exposed to the New Zealand environment.
The central portion of the diagram describes the fertiliser pathway from processing to application with branches indicating the mechanism of contamination and the types of potential hazard at each step. Pathway steps in red indicate those points at which potential hazards can be exposed to the New Zealand environment.

3.1.2 Conditions for hazard organisms to be considered risk organisms

In order for a hazard organism to be considered a risk, certain conditions need to be met. A formal risk analysis assesses the likelihoods of entry, exposure and establishment in New Zealand for a particular species and pathway combination. Additionally the impacts of establishment on the economy, environment, socio-cultural values, and human health need to be assessed (MAFBNZ 2006). It is only once this analysis has been conducted that the potential hazard organism is classed as a risk on the commodity or pathway.

Imported fertiliser is not routinely inspected and has not been subject to a detailed survey. There is therefore no list of potential hazards, and detailed risk assessment is not possible. However the consequences of hazard organisms on the fertiliser pathway can be assessed by consideration of example species for each group of potential hazards identified in section 3.1. Example organisms are selected on the basis of some recorded association with the pathway, and known impact. It is assumed that the consequences of unknown organisms in the same group of potential hazards will be similar.

For the purposes of this document the formal risk assessment procedure is replaced by a more general discussion of entry, exposure and establishment of these example organisms, and the potential consequences arising from establishment. Therefore, the organisms discussed below are not considered risk organisms, as a formal risk analysis was not conducted.

For practical purposes, when an organism is detected on a commodity at the border, but hasn't been specifically identified in the Import Health Standard, the status of that organism is determined using the BORIC database[1]. If that organism is not included in the BORIC database, an urgent assessment is done. If the same organisms are regularly intercepted on this pathway a formal risk assessment should be undertaken for those organisms.

3.2 ENTRY

Hazard organisms may enter New Zealand transported as hitchhikers on imported fertiliser. Records of live interceptions on fertiliser, and information in other hitchhiker risk analyses, indicate that hitchhiker organisms are capable of surviving transport to New Zealand by ship from countries exporting fertiliser (for example: MAF interceptions database; MAF non-compliance reports; Pest risk analysis for six moth species: lessons for the biosecurity system on managing hitchhiker organisms, 2008; Import risk analysis for vehicles and machinery, 2007; Ants on Sawn Timber Imported from the South Pacific Region, 2003).

The different forms in which fertiliser is transported affects the likelihood of hazard organisms entering New Zealand. Bulk products have greater likelihood of contamination throughout the supply chain and contamination may not be within the fertiliser and therefore is less impacted by fertiliser toxicity. Bulk bags or smaller retail bags containing fertiliser are less likely to be contaminated but have more likelihood of association with hitchhikers. Viable organisms are less likely to arrive in New Zealand within bagged fertiliser given the toxic nature of the product. However, bagged fertiliser still carries risk from hitchhiker organisms present externally on the bags and these organisms may be able to leave the consignment at any point along the supply chain.

[1] Available online at http://www.maf.govt.nz/biosecurity-animal-welfare/pests-diseases/boric.aspx

3.3 EXPOSURE

Hazard organisms may be exposed to the New Zealand environment during storage, transportation, and fertiliser application. Once the fertiliser enters the country and has been offloaded from the ship it may be stored before being transported to the importers premises. If this storage is not secure, hazard organisms may have to opportunity to leave the consignment. This is of particular concern if the consignment is contaminated with invertebrate pests or wind borne seeds.

Transport to the importer's premises presents another opportunity for organisms to leave the consignment if the method of transportation is not secure. Once at the importers premises chemical processing of the fertiliser should eliminate hazard organisms from the consignment. However if the fertiliser is a direct application product or simply blended with another product processing will not manage the risk. Further, if equipment used on contaminated fertiliser within the manufacturer's premises is subsequently used on another product, that contamination may be transferred. The initial product may be bound for further processing, which would manage that risk, but the subsequently contaminated product may be a direct application product.

Hazard organisms may be exposed to the New Zealand environment if hitchhikers are present on the outside of bags or wrapping and these are subsequently transported and disposed of at landfill sites.

Direct application fertiliser may be hand or machine spread in both commercial and home-garden environments or applied by aerial topdressing on commercial properties. If any hazard organisms were present, particularly seeds or soil, this would provide an ideal opportunity for introduction directly into a receptive environment.

3.4 ESTABLISHMENT AND SPREAD

The likelihood of establishment will depend on the organism. Thermal tolerances and reproductive biology will greatly influence the likelihood of establishment. Organisms adapted a climate warmer than New Zealand's may not be able to establish permanent widespread populations, and may be confined to limited regions of the country or protected areas such as greenhouses.

Some organisms such as seeds, nematodes or asexually reproducing invertebrates may be able to establish when present in small numbers. Organisms such as sexually reproducing invertebrates will have a much lower likelihood of establishment unless they are present in sufficient number to ensure that reproductive individuals can locate each other and establish a breeding population.

The frequency of interceptions does not necessarily predict the likelihood of establishment. Species such as fall webworm (*Hyphantria cunea*) have been detected as a hitchhiker at the border only three times (two dead larvae and one egg mass) and yet has been considered to have entered New Zealand on up to six separate occasions and has once been reported as temporarily established (MAF, 2008). Likewise crazy ants (*Paratrechina longicornis*) have managed to establish colonies at ports in Auckland and Tauranga despite limited interceptions. However, for most organisms the number of exposure events is significant and is likely to increase with an increase in volume imported from a particular country.

The resulting spread of an established organism will depend on that organism's biology. However, hitchhiker species may have a higher likelihood of spread given their association with inanimate pathways. Wind dispersed seeds could be expected to have opportunity to disperse easily to suitable habitats. Organisms such as nematodes and soil borne viruses could spread further than the point of establishment associated with contamination of farm machinery and equipment.

3.5 CONSEQUENCES

Hitchhiker organisms which manage to establish populations in New Zealand have the potential for adverse consequences, both economic and social. Fungal diseases, nematodes and soil borne viruses have the potential to negatively impact growers, both commercial and domestic, within New Zealand. This impact may be both a reduction in yield and an increase in the cost of in-field control. Invasive plant species could increase weed control costs, and species which establish in natural environments have the potential to disrupt native ecosystems reducing the cultural value of these environments.

Insect species have a wide range of potential consequences depending on the species. Phytophagous species can reduce crop yields and increase the cost of invertebrate control. Many ant species tend honeydew producing insects, such as aphids and scale insects, and can cause major disruption in crop systems and in native forests, additionally invasive ants have the potential to become significant pests of human environments.

3.5.1 Examples of the consequences of potential hazard organisms

Seeds

Oats have been intercepted in imported fertiliser (section 3.1). Fungal diseases of oats such as leaf spot of oats (caused by the fungal pathogen *Drechslera avenae*) can be seed borne and transmitted by infected plants (Carmona et al, 2004). *Drechslera avenae* destroys the leaf area causing considerable loss of yield (Agrios, 2005). If infected seeds were present in fertiliser and subsequently spread on oat crops this fungal pathogen could infect existing crops if the infected seeds were to germinate.

Fungal infestation of seeds of wheat is common. In one study by Duthie et al. (1986) fourteen different species of *Fusarium* were isolated from samples of seed with 26% of seeds infested by one or more species of *Fusarium*. These pathogens invade the xylem of roots and stems and interfere with the movement of water, resulting in the death of plants (Agrios, 2005).

Seeds of plant species present in direct application fertiliser have a variety of different risks associated which will depend on the species. Establishment of weed species may increase the direct cost of weed control within crops. They may be species which have a history of invasiveness in other countries and if spread beyond the field environment may have detrimental effects on native ecosystems. Additionally seeds have the potential to carry disease. The number of seeds entering on this pathway is potentially high depending on the conditions in which the fertiliser was processed, stored and shipped.

Soil contamination

Soil borne viruses such as *Soil-borne wheat mosaic virus* (SBWMV) which infects both wheat and rye is transmitted by plasmodiophorids (slime moulds) present in the soil. This virus enters the host plant as an obligate parasite of plasmodiophorids via root hairs and epidermal cells in periods of high soil moisture (Lebas et al, 2009). SBWMV reduces the size of root systems stunting the plants and dramatically reducing yields (Agrios, 2005). These viruses can reside within resting spores that remain viable for decades and therefore presents a risk if contaminated soil is present in fertiliser and subsequently spread on fields with suitable crops.

Nematodes are able to persist in the soil for many years in the absence of a host plant. They present a particular risk to New Zealand due to our reduced nematode diversity as compared to similar habitats in the northern Hemisphere (Watson, 2004). Nematodes cause root dysfunction which reduces water and nutrient uptake and can enhance secondary microbial infections. In a survey of soil contamination on shipping containers arriving in New Zealand 81% of samples contained live nematodes, of these samples 4% were plant parasitic nematodes (Gadgil et al, 2000). Nematode contamination of soil presents a risk to New Zealand agriculture if soil associated with fertiliser is spread on fields.

Invertebrate hitchhikers

The common name 'cutworm' refers to the feeding habits of larvae of various species in the Lepidoptera family Noctuidae. All crop and pasture plants are attacked by cutworms of various species. Plants are often attacked at or near ground level and fall to the ground; however, some species of cutworm attack reproductive parts of the plant such as the ears of corn or the pods of beans. Yield losses as a result of cutworm damage can be up to 40% in heavily infested fields (Appel et al, 1993). Insect contamination presents a hazard if several live insects are present in the same consignment of direct application fertiliser and are exposed to a suitable environment in which to establish a breeding population.

4 Risk Factors for Consideration in the Management of Risks Associated with Inorganic Fertilisers

A number of factors contributing to the biosecurity risk posed by imported fertilisers have been identified from the hazard identification process and analysis of the pathway. Consideration could be given to managing these factors to reduce the biosecurity risk.

The risk factors identified here can be used either in standard development, for profiling sub-pathways of increased risk under existing standards or to enable industry to manage their own risks.

4.1 BAGGED AND BULK PRODUCTS

Different degrees of risk are associated with the different forms in which fertiliser is transported. Bulk products have greater likelihood of contamination throughout the supply chain, whereas bulk bags or smaller retail bags containing fertiliser are likely to have less likelihood of direct contamination but may have an association with hitchhikers.

4.2 PRIOR USE OF EQUIPMENT

Equipment and machinery that has been used for another purpose prior to its use in fertiliser manufacturing and transport may be contaminated. Equipment may have soil present and transport containers and ships holds may have the remains of the previous cargo *e.g.* grain.

Dedicated equipment or equipment that is thoroughly cleaned and subsequently inspected would reduce the likelihood of contamination from prior use.

4.3 PROXIMITY TO OTHER COMMODITIES

Handling of other commodities, such as grain, in close proximity to fertiliser increases the potential for contamination.

Areas where fertiliser is stored and bagged should be at a distance from areas where other commodities are processed and stored.

4.4 SECURITY OF STORAGE AND TRANSPORT

Fertiliser processed or stored outdoors or transported in uncovered trucks or trains is more likely to become contaminated with windblown seeds and invertebrates than fertiliser stored indoors or covered.

The environment surrounding processing and storage facilities should be kept free of vegetation to lessen the chance of wind blown seeds contaminating the fertiliser. Fertiliser should be covered when transported. Additionally, areas surrounding processing facilities should be kept free of vegetation to reduce the available habitat for invertebrates.

4.5 END USE IN NEW ZEALAND

Distinction should be made between fertiliser that requires further processing and direct application products. While these products may be similarly contaminated with risk organisms, fertiliser for further processing presents much less opportunity for exposure. Direct application fertiliser, or fertiliser that is simply blended, may be hand or machine spread or applied by aerial topdressing. If any hazard organisms were present, particularly seeds or soil, this would provide an ideal opportunity for introduction directly into a receptive environment. Chemical processing of the fertiliser should eliminate hazard organisms from the consignment and therefore is of negligible risk once processed.

4.6 THRESHOLDS FOR BIOSECURITY CONTAMINATION

There is currently not enough information on species interceptions on the fertiliser pathway to suggest an acceptable threshold level of entry via this pathway below which establishment is unlikely to occur. However, as interceptions are an indication of some failure in pathway management these warrant further investigation. Many fertilisers are toxic and will quickly devitalise biological contaminants; therefore, contamination within bags will pose less risk than contamination on the outside of bags and contamination associated with bulk shipments.

While there is not enough information to suggest thresholds, the pathway properties of fertiliser (i.e. products that are directly applied in large quantities to the soil) indicate that thresholds should be set at a much lower level than those for other inanimate pathways (for example sea containers or vehicles). Additionally it may not be possible to set thresholds for the entire pathway. Higher thresholds may be required for material that requires further processing either by heating or acidulation than that which is a direct application product or simply blended.

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