INDUSTRY BIOSECURITY PLAN

FOR THE GRAINS INDUSTRY

Threat Specific Contingency Plan

Wheat aphid

Sitobion avenae

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and

Plant Health Australia

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Plant Health AUSTRALIA

GRDC Grains Research & Development Corporation

CRC PLANT biosecurity

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1 Purpose of this contingency plan

This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of wheat aphid (*Sitibion avenae*). It provides guidelines for steps to be undertaken and considered when developing a Response Plan to this pest. Any Response Plan developed using information in whole or in part from this contingency plan must follow procedures as set out in PLANTPLAN (Plant Health Australia, 2008) and be endorsed by the National Management Group prior to implementation.

2 Pest information/status

2.1 Pest Details

Sitobion avenae (Fabricius, 1775)

Other Names: *Macrosiphum avenae* (Fabricius) Markkula, 1963, *Amphorophora avenae* (F.), *Aphis cerealis* Kaltenbach, 1843, *Aphis granaria* Kirby, 1798, *Macrosiphum allii* Jackson, 1918, *Macrosiphum cerealis* (Kaltenbach), *Macrosiphum granarium* (Kirby), *Nectarophora cerealis* (Kaltenbach), *Siphonophora cerealis* (Kaltenbach), *Sitobion cerealis* (Kaltenbach), *Sitobion granarium* (Kirby, 1798) Mordvilko, 1914, *Macrosiphon avenae* (F.), *Sitobium avenae* (F.), *Aphis avenae* Fabricius, 1775

Common Names: wheat aphid, English grain aphid, grain aphid, puceron des céréales [French]

2.1.1 General information

Taxonomic position – Phylum: Arthropoda; Class: Insecta; Order: Hemiptera; Family: Aphididae

The wheat aphid, *Sitobion avenae* (F.), is an important pest in agricultural systems, especially in temperate climates of the northern and southern hemispheres. *S. avenae* apterae are 1.3-3.3 mm long and the alates 1.6-2.9 mm long. Body colour of *S. avenae* apterae depends on the clone and ranges from yellow to green, red, purple, and brown. Colour in *S. avenae* is determined both genetically and in response to environmental factors, including nutrition, with green and brown clones predominating (Jenkins *et al.,* 1999). The dorsal cuticle is distinctly and uniformly sclerotic. Siphunculi and antennae blackish; cauda pale; legs yellow; tip of femora, tarsi and tibiae smoky; siphunculi twice as long as cauda. A form of *S. avenae* with paler bases to siphunculi occurs in the Mediterranean region and in the Indian Peninsula (Blackman *et al.,* 1990). Alatae are similarly coloured but with more distinct intersegmental markings. Four larval instars occur and each having roughly the same coloration as the adults. First and second instar larvae have 5-segmented antennae while third and fourth instars have 6-segmented antennae. Males are generally red or reddish-brown.

2.1.2 Life cycle

The wheat aphid is monoecious, completing its life cycle on members of the Poaceae family and can complete all forms of life cycle known in aphids (Reimer, 2004). It has been shown that potentialities for sexual morph production differ among *S. avenae* clones (Hand and Wratten, 1985; Wegorek and Dedryver, 1987; Newton and Dixon, 1988) with evidence of four types of clones: pure holocyclic clones producing only males and egg laying females in autumn, intermediate clones producing both sexual morphs and parthenogenetic females, androcyclic clones producing only males and parthenogenetic females, and anholocyclic which produce only parthenogenetic females regardless of the environmental conditions. Such a polymorphism in reproductive strategies for overwintering, mainly observed in temperate regions, could be considered as a way for the species to maximize its fitness facing winter climate uncertainty.

The holocycle was described by Müller (1977) in Germany: eggs hatch at the end of winter (March) and winged individuals could be produced at the next generation and as a result populations can disperse early in the season. Numerous generations of parthenogenetic wingless and winged females follow. Winged red males and egg laying females appear in autumn (October). Eggs are laid on various Poaceae including straw in autumn and winter.

Similar to other aphid species, *S. avenae* produces in alternating cycles wingless morphs mainly adapted to host plant exploitation *in situ*, and winged ones for dispersal of the species over longer distances. Electrophoretic studies have shown that there is a substantial gene flow in Europe, due to winged migration (Loxdale *et al.,* 1985).

S. avenae lives on the leaves of Poaceae before heading, after which it lives preferentially on the ears. Its rate of increase on wheat is strongly affected by the growth stage of the host plant, with the highest rate of increase when feeding on ears at the milky-ripe stage (Vereijken, 1979).

2.2 Affected Hosts

2.2.1 Host range

S. avenae occurs on all cereal species including rice and maize and can develop on most cultivated or wild Poaceae, as well as on some Juncaeae and Cyperaceae. *S. avenae* clones show differences in host range and preferences.

2.2.2 Geographic distribution

S. avenae is widespread throughout the world, with a preference for temperate climates. It occurs widely in Europe, North Africa, the Middle East and Asia. It is rare to find *S. avenae* in tropical climates, and is believed to be absent from Australia.

Wheat aphid has been confirmed in countries listed in Table 1 (information obtained (August, 2008) from the Crop Protection Compendium – **www.cabicompendium.org**).

Table 1. *Current distribution of S. avenae*

Europe	Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Former Czechoslovakia, Denmark, Finland, Former Yugoslavia, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxemburg, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Serbia and Montenegro, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom
Africa	Algeria, Burundi, Egypt, Ethiopia, Kenya, Libya, Morocco, Mozambique, South Africa, Tunisia, Zimbabwe
Asia	Afghanistan, China, Georgia, India, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, Lebanon, Myanmar, Pakistan, Saudi Arabia, Syria, Tajikistan, Thailand, Turkey, Turkmenistan, Uzbekistan, Yemen
North America	Canada, Mexico, USA
Central America	Cuba
South America	Argentina, Brazil, Chile, Colombia, Ecuador, Peru, Uruguay

2.2.3 Symptoms

There are no specific symptoms for *S. avenae* that can differentiate attack from other aphid species. Early yellowing of upper leaves and ears occurs under heavy infestation along with the presence of the sticky excretion known as honeydew.

Symptoms by affected plant parts are as follows:

- Inflorescence: abnormal colour
- Leaves: abnormal colours

2.3 Entry, establishment and spread

Entry potential: Medium

The entry potential of *S. avenae* is Medium for the following reasons:

- No live host material for this pest is legally imported into Australia without Post Entry Quarantine
- Adult insects could hitchhike on clothing or other personal effects. Given the wide distribution of the pest in countries with direct flights to Australia it is possible for entry to occur
- Long distance aerial dispersal is a possibility as the pest gets established in countries nearer Australia

Establishment potential: High

The establishment potential of *S. avenae* in Australia is High for the following reasons:

- The hosts of *S. avenae* are widespread in Australia
- The climate in many cereal growing regions of Australia is similar to regions where the pest is already established

Spread potential: High

The spread potential of *S. avenae* in Australia is High due to its dispersal abilities and the widespread availability of hosts throughout the country.

Economic impact: Medium

The economic impact of *S. avenae* is likely to be Medium. *S. avenae* is found on numerous species of Poaceae worldwide, and is a pest of cereal crops in temperate regions. It is a major pest of wheat in Europe, North America, South America, Central Asia and China, but is relatively easily managed. It is considered a secondary pest on rice, maize, barley, and certain other cereals.

S. avenae causes direct damage by feeding on leaves, stalks and ears, and indirect damage by excreting honeydew and the transmission of viruses. The main impacts are reduced yields caused by the removal of plant nutrients and reduced photosynthesis as caused by honeydew accumulations. Other damage to *S. avenae* can also cause reduced number of heads, reduced number of grains per head, and reduced grain or seed weight (Rautapää, 1966; Kolbe and Linke, 1974; Hinz and Daebeler, 1976).

Wheat yields can be reduced by around 20-30% during outbreaks (Kolbe and Linke, 1974). Yield reductions of 11.5-43.4% were reported in a 3 year German field study, for a range of different wheat cultivars. *S. avenae* causes maximum yield loss on wheat between ear emergence and flowering. Infestations occurring later (during grain ripening) generally do not cause significant yield losses, but can reduce the quality of the flour for bread making (Wratten *et al.,* 1979).

The effect of *S. avenae* damage on yield therefore depends on the size and duration of infestation, the phenological stage of the crop when infested, pesticide applications, cultural practices, use of resistant cultivars, natural enemy abundance, weather conditions, and on other factors, such as foliar disease and dryness, that are likely to increase with aphid damage.

Damage on barley, rice, maize and other cereals has not been extensively studied. However yield loss on barley due to *S. avenae*, in one study, was manifested as a reduction in 1000-grain weight.

Honeydew, a sugar-rich aphid secretion, can cause physiological changes and chlorotic symptoms in leaves, and affects net carbon dioxide assimilation in wheat (Rossing and van de Wiel 1990; Rossing, 1991). Honeydew probably also causes an early senescence of leaves (Vereijken, 1979). Honeydew from *S. avenae* appears to be particularly disruptive to photosynthesis of cereals in laboratory and field studies (Rabbinge *et al.,* 1981). Honeydew production and its effect in encouraging the growth of secondary fungal pathogens may account for more than 60% of total yield loss (Rabbinge and Vereyken, 1980).

S. avenae is an important vector of barley yellow dwarf luteovirus (BYDV), which it transmits in a persistent manner. BYDV is a major pest of barley, and a secondary pest of wheat. *S. avenae* is also a minor vector of maize dwarf mosaic virus (MDMV), bean yellow mosaic potyvirus (BYMV) and pea

mosaic potyvirus, all transmitted in a non-persistent manner; and beet western yellows luteovirus, which is transmitted in a persistent manner (Brunt *et al.,* 1996; Blackman *et al*., 1990).

Environmental impact: Negligible

There is negligible potential to degrade the environment or otherwise alter the ecosystem by affecting species composition or reducing the longevity or competitiveness of wild hosts.

Overall risk: Medium

The overall rating is considered Medium given the likelihood of establishment and spread given the volume of susceptible crops grown in Australia.

2.4 Diagnostic information

2.4.1 Diagnostic protocol

Sitobion spp. can be distinguished from other aphids occurring on cereals by their tapering black siphunculi, bearing an apical band of polygonal reticulation visible through a binocular microscope, and by their partly black legs. *Sitobion fragariae* and *S. miscanthi* are known to occur in Australia. *S. avenae* can be distinguished from *S. fragariae* by the ratio between length of cornicles to length of cauda, which is close to a ratio of 1.5 for the former and a ratio of close to 2 for the latter. In areas where *S. avenae* and *S. miscanthi* coexist confusion could arise as the above ratio is closer. Diagnostic images of *S. miscanthi* are present in the Pest and Disease Image Library – (PaDIL **www.padil.gov.au**). Molecular markers can also be used to distinguish *S. avenae* from *S. fragariae* (Figueroa *et al.,* 1999). Suspected aphids should be sent for expert verification.

2.5 Response checklist

2.5.1 Checklist

Guidelines for Response Checklists are still to be endorsed. The following checklist provides a summary of generic requirements to be identified and implemented within a Response Plan:

- Destruction methods for plant material, soil and disposable items
- Disposal procedures
- Quarantine restrictions and movement controls
- Decontamination and farm cleanup procedures
- Diagnostic protocols and laboratories
- Trace back and trace forward procedures
- Protocols for delimiting, intensive and ongoing surveillance
- Zoning
- Reporting and communication strategy

Additional information is provided by Merriman and McKirdy (2005) in the Technical Guidelines for Development of Pest Specific Response Plans.

2.6 Delimiting survey and epidemiology study

Delimiting surveys should comprise local surveys around the area of initial detection concentrating on areas of poor growth. Surrounding crops would then be surveyed. The extent of the survey beyond the initial infested crop should be guided by the test results from surrounding crops. Farmers should be encouraged to scout their crops and report aphid detections which could then be followed up with collections and diagnosis. Laboratory diagnosis will be required to confirm detection.

2.6.1 Sampling method

2.6.1.1 HOW TO COLLECT

Susceptible crops such as wheat should be sampled during spring around the time of flowering. Summer crops and volunteer plants could also be monitored through autumn. Paddocks should be monitored by walking in a diagonal or zigzag pattern inwards from the upwind edge of the field, stopping 10 times at a minimum of 20m intervals and carefully checking at least 10 tillers at each stop for the presence of aphids. Areas where there is yellowing on otherwise vigorous plants should be targeted for potential aphid activity. Aphids should be brushed or aspirated from tillers and placed into vials of 95% alcohol. Vials should be labeled with the location, date, and crop sampled. An alternative collecting method is to use sweep nets or vacuum samplers at each of the 10 sites per paddock.

Winged aphid trapping using yellow trays placed in the field at crop canopy level (Robert *et al.,* 1988) or, on a regional scale, by suction trapping (French and Taylor, 1965) could be used to detect presence.

General protocols for collecting and dispatching samples are available within PLANTPLAN, Appendix 3 (Plant Health Australia, 2008).

2.6.1.2 NUMBER OF SPECIMENS TO BE COLLECTED

A minimum of 25 aphids should be collected from each site with more required if variation exists. Where possible collect aphids from multiple tillers. It is advisable to collect a large number of specimens of all life stages to assist in diagnosis. Collect a number of specimens of varying size and colour depicting variation in the morphology of the species. Collect specimens that are clean and in good condition (i.e. that are complete with appendages such as antennae, wings and legs). Kill specimens by placing directly into vials of alcohol.

2.6.1.3 HOW TO PRESERVE INSECT SAMPLES

Adults and larvae can be preserved by placing in 70% ethanol and stored indefinitely, although their colour fades gradually with time. Specimens required for molecular diagnostic work should be killed and preserved in 95-100% ethanol or frozen (-80˚C).

2.6.1.4 HOW TO TRANSPORT INSECT SAMPLES

For detailed information on transport and packaging requirements for suspect emergency plant pests refer to PLANTPLAN (Plant Health Australia, 2008).

Aphids can be transported in vials of ethanol taking care to prevent breakage. Label each sample clearly using an alcohol-proof marker. If possible retain and store a duplicate sample in a secure location.

2.6.1.5 HOW TO COLLECT PLANT SAMPLES IF REQUIRED

Plant samples need not be collected as part of the delimiting survey.

2.6.2 Epidemiological study

Temperature affects the rate of increase of *S. avenae* numbers (Dean, 1974; Kieckhefer *et al.,* 1989). *S. avenae* can develop and reproduce at 5-30°C; with the optimal rate of increase between 20 to 22.5°C (clonal variation may exist). Parthenogenetic morphs could withstand cold exposures to -10°C (Williams, 1980), however survival at these low temperatures would only be for approximately 8 h (Powell and Bale, 2005).

There is no evidence of the existence of true biotypes in *S. avenae*, but studies showed that some clones of this species have a better rate of population increase on certain cereals (Weber, 1985).

S. avenae, like most aphids, can experience rapid population growth, particularly in the absence of natural enemies. Alate (winged) immigrants were important until the end of flowering of winter wheat in the Netherlands. Their offspring were apterous (wingless) and became the driving force in local population growth. Subsequently, produced alates usually left the field (Rabbinge *et al.,* 1979). This pattern of population development could lead to significant spread of the pest within a single season.

2.6.3 Models of spread potential

- Winged aphids can travel great distances on wind currents. For example, 530 live aphids of around 25 species were caught in traps 25 km out at sea on a single day (Yoshimoto, 1964). *Rhopalosiphum maidis* aphids have been caught in the United States at heights of 2000 meters and the duration of time aloft was estimated to be as high as 25 hours (Irwin, 1988). The grain aphid, *Sitobion miscanthi,* is reported to have crossed the Tasman sea from Australia to the south island of New Zealand in 1967 (Close and Tomlinson, 1975)
- *S. avenae* is highly migratory and in the UK there was no clear genetic evidence for isolation by distance (Llewellyn, 2003)
- Wind and rain can initiate dispersal of apterous *S. avenae* within a field (Mann *et al.,* 1995). Sunderland *et al.,* (1986) have shown that up to 90% of the aphid population on a shoot fall to the ground each day, although their subsequent dispersal is poorly understood

2.6.4 Pest Free Area guidelines

Pest Free Area (PFA) guidelines relevant to this pest. Points to consider are:

- Due to the distances winged aphids are known to travel PFAs would need to be a considerable distance from the areas where *S. avenae* is detected
- The widespread availability of host plants throughout grain growing regions makes the ongoing maintenance and certification of PFAs unlikely and potentially very costly
- If a PFA is to be established it should be done in accordance with ISPM no. 4 *Requirements for the Establishment of Pest Free Areas* or current international standards

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).

2.7 Availability of control methods

2.7.1 General procedures for control

- Conserve natural enemies. Many parasitoids and generalist predators that attack aphids occur in Australia and control most species of aphids. It is likely they would also feed on *S. avenae*
- Insecticides are generally effective against aphids and could be used where *S. avenae* populations are at high levels. Some effective insecticides such as pirimicarb are relatively soft on the natural enemies and should be used in preference to broad-spectrum insecticides
- An action threshold of 3–5 aphids per shoot has been suggested in Germany (Pflanzenschutzamt Hannover, 2002)

2.7.2 Control if small areas are affected

If only a small area is found to be infested (i.e. research plots, etc.) immediate crop destruction should be undertaken.

2.7.3 Control if large areas are affected

If large areas are infested and eradication is the goal, insecticides that target aphids should be considered. Imidacloprid would likely give the longest lasting control. If eradication is no longer a possibility the focus should switch to integrated pest management relying on natural enemies as the primary means of control. Cultural controls and prevention should be included with selective pesticides being used only as a last resort when *S. avenae* levels are very high.

2.7.4 Cultural control

In temperate zones early sowing enables aphids to invade early in the autumn, thus enhancing the spread of barley yellow dwarf luteovirus, a major disease of barley. Early-sown fields may also have larger overwintering *S. avenae* populations than late-sown fields, and subsequently earlier and higher aphid populations in spring (Dedryver and Tanguy, 1984). When compatible with other agricultural practices, late sowing in autumn may therefore lead to a reduction in *S. avenae* infestations.

Some practices such as increasing seed rate and undersowing (the sowing of beneficial plants in and around the crops) could benefit natural enemies (Powell, 1983). High levels of nitrogen fertilization, often applied in split doses, retard winged formation but increase *S. avenae* fecundity as the flag leaf remains green during grain-filling.

2.7.5 Host plant resistance

Different levels of infestation by *S. avenae* among wheat varieties have been observed throughout the world. Resistance has been attributed to non-preference, but mainly the ability of a variety to reduce survival and growth (e.g. Chen *et al.,* 1997; Niraz *et al.,* 1996). However, the impact of infestation on yield is not obvious and no strong resistance genes were found in hexaploid commercial varieties. Most differences in resistance could be due to differences in development or maturity, to some morphological differences (e.g. awned ears are less favourable to *S. avenae* than awnless ones) and to differences in hydroxamic acid content (mainly at young stages of plant development) (Nicol *et al.,* 1993).

2.7.6 Chemical control

For autumn barley and wheat in the northern hemisphere, chemical control has to be applied during the period of overlap between aphid flight and seedling emergence and repeated immediately afterwards. In spring it is usually done on wheat between ear emergence and flowering; delayed sprays are ineffective or uneconomical. Many insecticides are effective on aphids, for example, carbamates and pyrethroids (Wiles and Jepson, 1992), but most of them are also harmful to parasitoids and predators. Imidacloprid is very effective on aphids and gives long lasting control, but is not currently registered with the Australian Pesticides and Veterinary Medicines Authority (APVMA: **www.apvma.gov.au**) for use in cereals. Effective insecticides that are softer on natural enemies such as pymetrozine and pirimicarb are available in Australia. Pirimicarb is registered for use on winter cereals, but pymetrozine is not currently registered for any broad-acre crops.

S. avenae has been reported to be resistant to commonly used insecticides in China. A bioassay revealed that the resistant strain showed high resistance to pirimicarb (resistance ratio [RR] of 161.8), moderate resistance to omethoate (RR: 32.5) and monocrotophos (RR: 33.5), and low resistance to deltamethrin (RR: 6.3) and thiodicarb (RR: 5.5) (Chen *et. al.,* 2007).

Seed treatments with systemic insecticides (e.g. imidacloprid) were efficient at preventing autumn infestations within Europe and consequently BYDV spread (Knaust and Poehling, 1992). This effect was because of the insecticides prolonged persistence in the plants. The long-term consequences on the aphid and its natural enemy populations are not known.

At flowering time in Europe, farmers often mix an aphicide with a fungicide that has to be applied at the same time. This fungicide could affect the development of the fungal pathogen Entomophthorales in areas where it controls aphid populations, but this point remains unclear.

S. avenae is not regularly sprayed during spring or summer on cereals other than wheat in countries where it is already established.

2.7.7 Mechanical control

- Crop destruction may be of use during eradication attempts
- Mechanical control is not likely to be of use in an IPM program

2.7.8 Biological control

The role of natural enemies in preventing cereal aphid outbreaks is emphasized in several studies (Wratten and Powell, 1991; Levie *et al.,* 2000; Kindlmann and Dixon, 2001; Sigsgaard, 2002; Schmidt *et al.,* 2003). *Aphidius rhopalosiphi* is one of the most prevalent parasitoids attacking *S. avenae* (Stary, 1981; Krespi *et al*., 1987; Legrand *et al*., 2001; Sigsgaard, 2002), and is already present in New South Wales, Tasmania, and Victoria. Many aphid parasitoids are polyphagous and it is likely that other cereal aphid parasitoids and predators would likely attack *S. avenae*.

An IPM programme was initiated in 1975 in Chile for the control of the cereal aphids *S. avenae* and *Metopolophium dirhodum*. The program involved the breeding and release of nine species of parasitoids and five coccinellid predators imported from Europe, Israel, North America and South Africa. Four of the parasitoids and one predator, *Hippodamia variegata*, became established. Satisfactory control of the two aphids was obtained. Three of the parasitoids, *Aphidius uzbekistanicus*, *A. rhopalosiphi* and *Praon volucre*, aided by native predators, maintained control of *S. avenae* (Zúñiga *et al.,* 1986). In 1978, cultures of the natural enemies were sent to Brazil and in 1981 were sent from there to Argentina (Altieri and Klein-Koch, 1989). Satisfactory results were subsequently obtained in both these countries.

The obligate Entomophthorales pathogen *Pandora neoaphidis* is known to cause epizootics in aphid populations (Feng, 1991; Feng, 1992; Hatting, 2000; Steinkraus *et al.,* 2002). Alate aphids can transmit *P. neoaphidis* to progeny colonies which allows the dispersal of aphid epizootics by migratory alates over a wide geographical range (Chena and Feng, 2004).

3 Course of action – eradication methods

Additional information is provided by the IPPC (1998) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a pest free area) or a measure to eliminate an established pest (establish a pest free area). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

Note: Eradication is unlikely unless the pest is detected while still contained within a small or isolated area, given the dispersal capabilities of the pest and the widespread availability of host plants in agricultural, natural, and populated areas.

3.1 Destruction strategy

3.1.1 Destruction protocols

- Disposable equipment, infested plant material or soil should be disposed of by autoclaving, high temperature incineration or deep burial
- Any equipment removed from the site for disposal should be double-bagged
- Insecticides should be used to destroy the pest
- Farm machinery used in destruction processes need to be thoroughly washed, preferably using a detergent

3.1.2 Decontamination protocols

Machinery, equipment, vehicles in contact with infested plant material within the Quarantine Area, should be washed to remove soil and plant material using high pressure water or scrubbing with products such as a farm degreaser or a 1% bleach (available chlorine) solution in a designated wash down area. General guidelines for wash down areas are as follows:

- Located away from crops or sensitive vegetation
- Readily accessible with clear signage
- Access to fresh water and power
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting)
- Gently sloped to drain effluent away
- Effluent must not enter water courses or water bodies
- Allow adequate space to move larger vehicles
- Away from hazards such as power lines
- Waste water, soil or plant residues should be contained (see PLANTPLAN, Appendix 18; Plant Health Australia, 2008)
- Disposable overalls and rubber boots should be worn when handling infested soil or plant material in the field. Boots, clothes and shoes in contact with infested soil or plant material should be disinfested at the site or double-bagged to remove for cleaning
- Skin and hair in contact with infested plant material or soil should be washed

3.1.3 Priorities

Specific priorities for eradication or containment:

- Confirm the presence of the pest.
- Prevent movement of vehicles and equipment through affected areas

- Eradication/decontamination of infested host material
- Determine the extent of infection through survey
- Inform all groups within the industry

3.1.4 Plants, by-products and waste processing

Infested plant material should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial (in a non-cropping area).

3.1.5 Disposal issues

Particular care must be taken to minimize the transfer of infested plant material from the area.

3.2 Quarantine and movement controls

3.2.1 Quarantine priorities

- Plant material at the site of infestation to be subject to movement restrictions
- Machinery, equipment, vehicles and disposable equipment in contact with infested plant material to be subject to movement restrictions

3.2.2 Movement control for people, plant material and machinery

Once established wheat aphid will be difficult to eradicate. Therefore, any zoning, quarantine or movement controls will usually pertain to containment and management unless detection occurs soon after establishment.

If Restricted or Quarantine Areas are practical, movement of equipment or machinery should be restricted and movement into the Area only occurs by permit. The industry affected will need to be informed of the location and extent of the pest occurrence.

Movement of people, vehicles and machinery, from and to affected farms, must be controlled to ensure that infested plant debris are not moved off-farm on clothing, footwear, vehicles or machinery. This can be achieved through:

- Signage to indicate quarantine area and/or restricted movement in these zones
- Fenced, barricaded or locked entry to quarantine areas
- Movement of equipment, machinery, plant material by permit only
- Clothing and footwear worn at the infested site should either be double-bagged prior to removal for decontamination or should not leave the farm until thoroughly disinfested, washed and cleaned.
- Hay, stubble or trash must not be removed from the site

- All machinery and equipment should be thoroughly cleaned down with a pressure cleaner prior to leaving the affected farm. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area (refer to section 3.1.2)

3.3 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties.

3.3.1 Destruction zone

The entire crop or pasture should be destroyed after the level of infestation has been established. The delimiting survey will determine whether or not neighbouring host crops are infested and need to be destroyed. The Destruction Zone may be defined as contiguous areas associated with the same management practices as the infested area (i.e. the entire trial, paddock or farm if spread could have occurred prior to the infestation being identified).

3.3.2 Quarantine zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, soil or contaminated equipment from an infested property.

3.3.3 Buffer zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

3.3.4 Restricted Area

The Restricted Area is defined as the zone immediately around the infested premises and suspected infested premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

3.3.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infested premises and all suspected infested premises and will be defined as the

minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

3.4 Decontamination and farm clean up

Decontaminant practices are aimed at eliminating the pest thus preventing its spread to other areas.

3.4.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia, 2008) for further information
- Keep traffic out of affected area and minimize it in adjacent areas
- Adopt best-practice farm hygiene procedures to retard the spread of the pest between fields and adjacent farms
- Machinery, equipment, vehicles in contact with infested plant material or soil or present within the Quarantine Area, should be washed to remove soil and plant material using high pressure water or scrubbing with products such as a detergent, farm degreaser or a 1% bleach solution in a designated wash down area as described in 3.1.2
- Plant material should be destroyed using herbicide. Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label. Killed plants should be ploughed in to eliminate the possibility of eggs being laid on residues or stubble in autumn

3.4.2 Decontamination if pest is identified in small or large areas

Destruction of plant material by herbicide as described. The infested area would need to be monitored in the following season for self sown plants for the presence of the pest and then destroyed.

3.4.3 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

3.5 Surveillance and tracing

3.5.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, including whether winged or wingless forms are present, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties in the pest quarantine area
- Surveying all properties identified in trace-forward or trace-back analysis as being at risk
- Surveying all host growing properties that are reliant on trade with interstate or international markets which may be sensitive to *S. avenae* presence
- Surveying commercial nurseries selling at risk host plants
- Surveying other host growing properties and backyards

3.5.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 3.3), and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out.

Steps outlined in Table 2 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

Table 2. *Phases to be covered in a survey plan*

Phase 1	• Identify properties that fall within the buffer zone around the infested premise • Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)
Phase 2	• Preliminary survey of host crops in properties in buffer zone establishing points of pest detection
Phase 3	• Surveillance of an intensive nature, to support control and containment activities around points of pest detection
Phase 4	• Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or infested plants. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the pest. Pathways to be considered are: ○ Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment ○ The producer and retailer of infected material if this is suspected to be the source of the outbreak ○ Labour and other personnel that have moved from infested, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers) ○ Movement of plant material and soil from controlled and restricted areas ○ Storm and rain events and the direction of prevailing winds that result in air-borne dispersal of the pathogen during these weather events
Phase 5	• Surveillance of nurseries, gardens and public land where plants known to be hosts of pest are being grown

Phase 6	• Agreed area freedom maintenance, pest control and containment

3.5.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including cropping conditions, the previous level of infestation and the control measures applied. As a guide, the following activities should be carried out following the eradication of the pest:

- Establishment of sentinel plants at the site of infestation (see Section 2.2.1)
- Maintain good sanitation and hygiene practices throughout the year
- Sentinel plants should remain in place and inspected on a fortnightly basis for a further 6 weeks and then on a monthly basis for a minimum of 12 months
- Surveys comprising plant sampling for and testing for *S. avenae* to be undertaken for a minimum of 12 months after eradication has been achieved

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4.1 Websites

CAB Compendium (**www.cabicompendium.org/cpc/home.asp**)

PLANTPLAN (**www.planthealthaustralia.com.au/plantplan**)

5 Appendices

5.1 Appendix 1. Standard diagnostic protocols

For a range of specifically designed procedures for the emergency response to a pest incursion refer to PLANTPLAN (Plant Health Australia, 2008), Appendices 2 and 3.

5.2 Appendix 2. Experts, resources and facilities

The following tables provide lists of experts (Table 3) and diagnostic facilities (Table 4) for use in professional diagnosis and advisory services in case of an incursion.

Table 3. *Experts who can be contacted for professional diagnostic and advisory services*

Expert	State	Details
Dr. Paul De Barro	QLD	CSIRO Entomology – Indooroopilly 120 Meiers Road Indooroopilly QLD 4068 Phone: 07 3214 2811 Fax: 07 3214 2885
Dr. Debbie Thackray	WA	Department of Agriculture and Food WA 3 Baron-Hay Court South Perth WA 6151 Phone: (08) 9368 3333 Fax: (08) 9474 2405
Dr. Owain Edwards	WA	CSIRO Entomology – Centre for Environment and Life Sciences Underwood Avenue Floreat WA 6014 Phone: (08) 9333 6000

Expert	State	Details
Francis Berlandier	WA	Department of Agriculture and Food WA 3 Baron-Hay Court South Perth WA 6151 Phone: (08) 9368 3249
Dr. Mallik Malipatil	Vic	DPI Victoria Knoxfield Centre 621 Burwood Highway Knoxfield VIC 3684 Ph: (03) 9210 9224; Fax: (03) 9800 3521

Table 4. *Diagnostic service facilities in Australia*

Facility	State	Details
DPI Victoria Knoxfield Centre	Vic	621 Burwood Highway Knoxfield VIC 3684 Ph: (03) 9210 9222; Fax: (03) 9800 3521
DPI Victoria Horsham Centre	Vic	Natimuk Rd Horsham VIC 3400 Ph: (03) 5362 2111; Fax: (03) 5362 2187
DPI New South Wales Elizabeth Macarthur Agricultural Institute	NSW	Woodbridge Road Menangle NSW 2568 PMB 8 Camden NSW 2570 Ph: (02) 4640 6327; Fax: (02) 4640 6428
DPI New South Wales Tamworth Agricultural Institute	NSW	4 Marsden Park Road Calala NSW 2340 Ph: (02) 6763 1100; Fax: (02) 6763 1222
DPI New South Wales Wagga Wagga Agricultural Institute	NSW	PMB Wagga Wagga NSW 2650 Ph: (02) 6938 1999; Fax: (02) 6938 1809
SARDI Plant Research Centre - Waite Main Building, Waite Research Precinct	SA	Hartley Grove Urrbrae SA 5064 Ph: (08) 8303 9400; Fax: (08) 8303 9403
Grow Help Australia	QLD	Entomology Building 80 Meiers Road Indooroopilly QLD 4068 Ph: (07) 3896 9668; Fax: (07) 3896 9446
Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories	WA	3 Baron-Hay Court South Perth WA 6151 Ph: (08) 9368 3721; Fax: (08) 9474 2658

5.3 Appendix 3. Communications strategy

A general Communications Strategy is provided in PLANTPLAN (Plant Health Australia, 2008)

5.4 Appendix 4. Market access impacts

Within the AQIS PHYTO database, no countries appear to have a specific statement regarding area freedom from *S. avenae* (April 2009). Should *S. avenae* be detected or become established in Australia, some countries may require specific declaration. Latest information can be found within PHYTO, using an Advanced search —Search all text" for *Sitobion avenae.*