Department of Primary Industries

Rice field guide

to pests, diseases and weeds

in southern New South Wales

Pests

Diseases

Weeds

RURAL INDUSTRIES
Research & Development Corporation

This publication is designed as a diagnostic tool to assist rice growers, advisors, as well as the industry in south eastern Australia to identify relevant pest, disease and weed issues that are encountered in rice crops in the region. It also contains a quick guide to the potential industry threats.

It provides descriptions, photographs and basic information about pest status and management, as well as references to more detailed information. Further information can also be found in "*Production of quality rice in southern NSW*".

Acknowledgements

This field guide was produced by NSW DPI's rice extension and research team as part of the RIRDC funded project '*Research to Practice in Rice Farming Systems*'.

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Design and production by:
AnDi Communications
www.andicom.com.au

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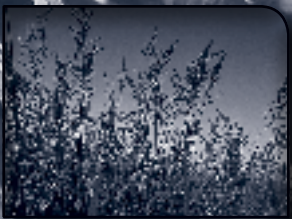


Weeds

Pests

Bloodworms

(Larvae of *Chironomus tepperi* and other species)

Bloodworms are the most consistent pest problem in aerially sown rice crops. Although various species of bloodworms are present in the crop throughout its development, damage is typically confined to the first three to five weeks after sowing.

Bloodworms can also be found in drill sown crops after permanent water is applied, however they rarely cause significant damage to established plants with well-developed secondary root systems. None of the species are obligate rice feeders, and they can be found in a range of other aquatic habitats.

Life cycle

The adults are small flies that superficially resemble mosquitoes, but do not bite. Eggs, often arranged in spirals, are laid in gelatinous masses into the water, and are often attached to twigs or straw. They hatch within two to three days and the bloodworms go through four larval stages, gradually increasing in size prior to pupating. The pupae, which do not feed, rise to the water surface and spit open to allow the adult midge to escape.

Mature bloodworm (top) and pupa of *Chironomus tepperi*, the main pest species in NSW. Bloodworm approximately 16 mm long.

Photo: G Warren, NSW DPI

Crop damage

Pruning/removal of seedling roots and hollowing out of newly sown seed.

Management

Bloodworms are unaffected by crop rotations and control in aerially sown crops is reliant on one or two applications of registered insecticides, the first of which should be applied on the day of sowing.

Drill sown crops should only be treated after permanent water and when there is clear evidence of recent plant damage.

Origin: Australian native, some species more widely distributed.

Key characteristics: up to 20 mm long. Damaging species predominantly red to dark red with a distinct head capsule.

Rice seed hollowed out by bloodworm after sowing.

Photo: G Warren, NSW DPI

Root damage to seedlings caused by bloodworms. The plant on the right has not been attacked.

Photo: M Stevens, NSW DPI

Water snails are a major pest of rice crops in southern NSW. Damage typically starts to occur within three weeks of:

- sowing in aerial sown crops; or
- application of permanent water in drill sown crops.

Origin: Australian native, widespread in the Murray and Murrumbidgee valleys and often found in billabongs and farm dams, as well as in rice crops.

Key characteristics: shell height up to 15 mm (*Isidorella*) or 18 mm (*Glyptophysa*); shell colour brown to reddish-brown; body dark grey to brown.

***Isidorella newcombi* adult. Shell height approximately 14 mm.**
Photo: M Stevens, NSW DPI

***Glyptophysa* sp. adult. Shell height approximately 12 mm. Note the more elongate shell relative to *Isidorella*.**
Photo: M Stevens, NSW DPI

Life cycle

Adult snails lay eggs in transparent masses usually attached to twigs or other debris.

Egg mass of *Isidorella newcombi* attached to a plant stem. Length approximately 7 mm.
Photo: M Stevens, NSW DPI

The young snails emerge as miniature versions of the adults and increase progressively in size. Adult snails are capable of burrowing beneath the soil surface and entering dormancy as water is drained from the crop. Over 40% of snails that enter dormancy will survive the winter period between repeat rice crops.

Crop damage

Snails attack the roots of rice plants at the exposed junction between the roots and shoots, either severing and killing the plant or retarding growth and delaying plant maturity. *Isidorella* is the main cause of crop damage, with damaging populations of *Glyptophysa* being fairly uncommon. Plant damage can occur up to the completion of tillering.

Management

Most snail problems can be avoided by having 12 (or more) months between rice crops–snails cannot survive without a period of inundation each year. Avoiding repeat crops may, however, compromise water use efficiency. Active snail populations in rice should be managed using a registered pesticide.

Severe snail damage to rice plants. Plants on the left are undamaged plants of the same age.
Photo: M Stevens, NSW DPI

Leafminers

(*Hydrellia michelae,* possibly other *Hydrellia* species)

Leafminers are the larval stages (maggots) of a small fly. They are a sporadic establishment pest of rice in south eastern Australia and elsewhere throughout the world. Damage is generally worse during cold seasons and in southern areas.

Late stage leafminer larva (4 mm long) removed from within a damaged leaf.

Photo: G Warren, NSW DPI

Leafminer damage. Affected leaves collapse and decay on the water surface.

Photo: M Stevens, NSW DPI

Origin: Australian native. *H.michelae* has been identified in crops in NSW, whilst *H.mareeba* is known from rice in Queensland.

Key characteristics: adult flies are approximately 2.5 mm long, relatively elongate, and seldom noticed in the field. The larvae are pale, translucent, approximately 4 mm in length when mature, and are found within discoloured areas of the leaves, often at or near the water level.

Life cycle

Female flies lay their eggs on the leaves of seedlings, and the newly hatched maggot initially feeds on the leaf surface before burrowing inside to feed on the internal tissue. The maggot moults several times before pupating within the leaf. The adult fly develops within the non-feeding pupa prior to emergence.

Crop damage

Leafminers create a characteristic 'mine' of pale tissue in the leaf, and destroy the vascular tissue within. This causes the leaf to collapse and lie flat on the water surface, and the leaf tip to decay. High levels of infestation can lead to plant death. Plants are most vulnerable prior to tillering.

Management

Crop rotations and sowing method have no impact on leafminer infestations, and management is through the use of registered insecticides. Crops should be assessed carefully before the decision to spray is made, as leafminer densities are always higher along the field margins. Shallow water and good land preparation that maximises seedling growth and density will help reduce the risk of significant leafminer problems.

A 'mine' within a rice leaf caused by leafminer feeding.

Photo: G Warren, NSW DPI

Whilst most earthworms are beneficial to crops, some species that can tolerate flooded conditions can cause indirect damage to rice by making the environment unsuitable for seedling growth. Aquatic earthworms can be a serious pest in aerially sown crops, but have little impact on drill sown crops provided the plants are not fully submerged when permanent water is applied.

Aquatic earthworm cocoons. Length 2 mm.
Photo: G Warren, NSW DPI

Aquatic earthworms. Length approximately 60 mm.
Photo: M Stevens, NSW DPI

Origin: believed to have originated in South America; known to have been present in Australia for over a century.

Key characteristics: thin, red earthworms up to 75 mm in length. Unlike bloodworms (which do not exceed 20 mm in length), aquatic earthworms do not have a head capsule.

Mature crop with areas of open water caused by poor seedling establishment due to high aquatic earthworm populations.
Photo: M Stevens, NSW DPI

Life cycle

Mature earthworms lay their eggs individually in 'cocoons' that protect the eggs from desiccation and physical damage. The newly hatched earthworm resembles a smaller version of the adult. Earthworms survive mainly in the egg stage during periods of low soil moisture.

Crop damage

Aquatic earthworms do not have chewing mouthparts and cannot attack growing rice plants. At high densities they destabilise the soil and move nutrients from the soil into the water column, leading to cold, dirty water and excessive algal growth, particularly over dispersive clay soils. This leads to plants not being able to anchor their root systems effectively, and in deep water seedlings can die and rot if they cannot get a shoot into the sunlight before they run out of seed energy reserves. Aquatic earthworms can also attract large numbers of ibis and other water birds that can trample young seedlings.

Management

There are no chemical management options available for aquatic earthworms. On vulnerable soils growers should avoid irrigated pastures immediately before rice, as these increase earthworm densities. Smaller field layouts with minimal slope combined with rapid flooding and sowing reduces the impact of aquatic earthworms, and scare guns should be used to deter ibis. Aquatic earthworm problems have largely been confined to the Murray Valley (due to soil-related factors), and the problem has declined in recent years as irrigated pasture production has fallen out of favour in many areas.

Common armyworm

(*Leucania convecta*)

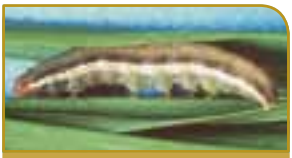
Armyworms can affect rice crops from tillering through to harvest. They also cause damage to a wide range of other summer and winter crops.

Life cycle

Adult moths fly into the crop and lay eggs on the leaves. The caterpillars that emerge go through six or sometimes seven larval stages, increasing gradually in size. The mature caterpillars normally pupate in the soil, however in a flooded rice crop some successfully pupate within the leaf sheaths. The complete life cycle (egg to adult emergence) takes around 45 days at 25°C. Development will be faster at higher temperatures.

Crop damage

Armyworm damage is dependent on crop stage. In younger crops damage will initially occur on the leaves, however as the crop matures and the armyworms increase in size they often attack the stems below the panicles, often severing the panicles completely.



Mature common armyworm caterpillar. Length approximately 40 mm.

Photo: NSW DPI Image Collection

Management

Controlling armyworms is currently dependent on the use of registered insecticides. In other crops such as maize, parasitoids are know to provide a high level of natural control, but the extent to which this occurs in rice is unknown. Anecdotal evidence suggests that crops that are drained mid-season may be more vulnerable to armyworm damage, but this has not been confirmed. Crops should be carefully evaluated before any decision to spray for armyworm since, as with leafminers, armyworm infestations are always heavier along the crop margins.

Origin: Australian native.

Key characteristics: relatively hairless caterpillars up to 40 mm long when mature, with variable longitudinal markings.

Common armyworm pupa. Length approximately 18 mm.

Photo: G Warren, NSW DPI

Adult common armyworm moth. Length approximately 20 mm (excluding antennae).

Photo: M Stevens, NSW DPI

Sugarcane and maize stemborer

(Bathytricha truncata)

Sugarcane and maize stemborers are commonly found in NSW rice crops, and although they are yet to cause serious economic damage, they produce characteristic symptoms that growers should be aware of. As their name suggests, they also cause damage to a range of other crops.

Origin: Australian native.

Key characteristics: pale, relatively hairless caterpillars up to 25 mm in length with darker head capsules. Generally only seen when stems are deliberately split open.

Life cycle

Adult moths lay eggs on the leaves. The newly hatched caterpillar burrows inside the stem and feeds internally, eventually pupating within the stem. The pupae may overwinter within rice stubble, with the adult moths emerging in spring.

Crop damage

There is often no evidence of stemborer infestation until tillers start to die as a consequence of internal feeding. This produces what are known as 'dead hearts'. If the stemborer damage occurs later in crop development, it can cut off the nutrient supply to the developing panicle, producing a characteristic 'white head' – a pale, empty panicle at the end of an apparently healthy stem.

Sugarcane and maize stemborer caterpillar removed from within a rice tiller. Length approximately 22 mm.

Photo: G Warren, NSW DPI

A 'white head' caused by stemborer damage lower within the rice tiller.

Photo: M Stevens, NSW DPI

Management

Sugarcane and maize stemborers have not yet required control, however the conspicuous nature of the 'white heads', which are more abundant along the crop edges, has led to this insect being a source of concern. Effective destruction of rice stubble will help reduce populations of overwintering pupae.

Tadpole shrimp

(*Triops australiensis australiensis*)

Tadpole shrimp are sporadic pests that can affect crops within the first five weeks after flooding. There is some evidence to suggest their infrequent occurrence is related to the non-target effects of some bloodworm control treatments.

Life cycle

Fertilised eggs are brooded for a short time before being deposited into the sediment. The eggs are very resistant to desiccation, remaining viable in dry soil for long periods. Hatching is triggered by flooding. The larvae rapidly moult and develop a carapace similar to the adult.

Crop damage

Tadpole shrimp attack the roots of young seedlings, producing damage similar to that caused by bloodworms. They have minimal impact on drill sown crops.

Management

The impact of tadpole shrimp can be minimised by sowing crops as soon as possible after the fields are flooded. This will ensure the plants are further through the establishment phase by the time tadpole shrimp are large enough to cause plant damage. There are currently no registered pesticides for tadpole shrimp control.

Origin: Australian native.

Key characteristics: aquatic crustaceans, brown to dark grey, with an oval carapace and forked 'tail', those found in rice bays are usually under 30 mm in length. When tadpole shrimp are present their cast skins can often be found along the downwind margins of bays.

Tadpole shrimp. Body length 20 mm.

Photo: G Warren, NSW DPI

Cast skins at downwind ends of bays are a sign of tadpole shrimp infestation. Length 18 mm.

Photo: M Stevens, NSW DPI

Unlike some American crayfish species, yabbies are not known to attack the rice crop. Their tunnelling activity can interfere with water-efficient rice production by causing banks to leak, and in some cases collapse.

Life cycle

After mating the eggs are retained by the female underneath its abdomen. There are three larval stages before the young leave the mother as independent juveniles which moult their shells as they increase progressively in size.

Crop damage

Yabbies burrow into the banks of fields, often leading to water leakage and in some cases bank collapses. When fields are drained yabbies seal off their burrows and can survive until the following season.

Management

Physical disruption through regular cultivation and reforming of banks every couple of seasons will keep yabby populations under control.

Origin: Australian native.

Key characteristics: small to medium-sized crayfish, dark brown in colour.

An adult yabby. Body length approximately 120 mm.

Photo: M Stevens, NSW DPI

Locusts and grasshoppers

(*Chortoicetes terminifera, Austroicetes cruciata*)

Locusts are sporadic pests of rice, and are only an issue in years when widespread regional outbreaks occur. Effective management of hopper bands in surrounding areas generally prevents significant damage to rice crops.

Life cycle

Eggs are laid into the soil and after hatching the nymphs ('hoppers') form mobile bands. After several nymphal stages the hoppers moult to the fully winged adults, which disperse in swarms.

Crop damage

Hopper bands have been known to cause significant damage to drill sown crops between flushes prior to permanent water. There have also been instances of adult swarms attacking flooded crops, however this is relatively uncommon.

Management

Control can be achieved using registered pesticides, and is most effective when targeted at hopper bands, which can be sprayed from the ground. Aerial spraying may be necessary if adult swarms invade flooded crops. Barrier treatments along crop margins may also be an option for preventing hopper infestation.

Origin: Australian native. Australian plague locust (*C.terminifera*) and small plague grasshopper (*A.cruciata*).

Key characteristics: medium to large grasshoppers (adult *C.terminifera* 25–42 mm, *A.cruciata* 15–35 mm), with conspicuous brown and sometimes green markings.

An adult Australian plague locust. Length 40 mm.

Photo: NSW DPI Image Collection

Golden apple snail
(*Pomacea canaliculata*)

Exotic threat

Southern Australia is relatively free from many of the rice pests that limit production in other countries. Whilst northern Australia is at risk from natural and human movement of tropical pests from South East Asia, many of these pests are unlikely to survive in the cooler conditions of southern NSW.

Some exotic pests do have the capacity to survive and flourish in southern Australia if they are introduced and become established. Two of these pose particularly severe threats: golden apple snail and rice water weevil.

Growers finding any unusual insects, snails, or symptoms of plant diseases should contact the **Biosecurity NSW Emergency Plant Pest Hotline on 1800 084 881**

The golden apple snail is native to South America, and was introduced into South East Asia as a human food source. It rapidly escaped from aquaculture facilities and established in the wild, and is now regarded as the most serious invertebrate pest of rice in the world. Although not established in Australia, it is frequently intercepted by quarantine officials at port facilities and other points of entry.

When mature, the golden apple snail is much larger than any of the native snails commonly found in rice fields and associated habitats. Unlike our native pest species, it has a hard operculum, carried on the back of its body, which can be used to seal off the shell opening. It lays its bright pink egg masses above the water on plants and other surfaces.

Golden apple snails. The operculum (pulled into the shell aperture) can be seen in the snail on the right. Scale intervals 10 mm.

Photo: R Cowie, University of Hawaii

Golden apple snail egg mass.

Photo: M Stevens, NSW DPI

Rice water weevil

(*Lissorhoptrus oryzophilus*)

Exotic threat

Native to North America, rice water weevil has now spread to almost every temperate rice growing area in the world other than southern Australia. It is the most serious pest affecting rice production in the USA.

The adult weevils are 3–4 mm in length and easily confused with harmless native weevil species. The adults produce longitudinal feeding scars on the leaves of rice plants, however the maggot-like larvae, which feed on the plant roots, are the main source of damage.

Adult rice water weevil. Length approximately 4 mm.

Photo: J Saichuk, LSU AgCenter

Feeding scars on rice leaves caused by adult rice water weevil.

Photo: J Saichuk, LSU AgCenter

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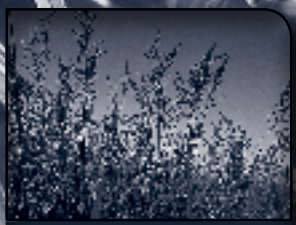


Weeds

Diseases

Damping off

(*Pythium* spp. and *Achlya* spp.)

Damping off diseases are the most significant diseases for rice growers in south eastern Australia. These fungal diseases are present every year and may cause seed and seedling losses. Depending on seasonal conditions, this may lead to poor seedling establishment, with a high potential for seedling death in cool seasons.

Biology

Damping off can be severe in aerial sown rice when sowing is followed by comparatively low temperatures early in the season. The disease is more prevalent on heavier soils.

Management

Good sowing techniques to optimise plant establishment, with particular emphasis on cultivation practices, sowing time and water depth control.

Symptoms

Seeds may fail to germinate and rot, or germinate and die before emergence. Death of the coleoptile may occur soon after aerial sowing or within a few days of emergence for drill sown crops. Unthrifty seedlings fail to survive permanent flood, exhibiting reduced leaf growth and short primary and secondary roots. Infected seeds and seedlings are sometimes covered with a whitish mycelium.

A seed (right) infected with Achlya showing fine mycelium growing out from the seed compared to a healthy germinating seed on the left.

Photo: G Warren, NSW DPI

Stem rot is a fungal disease that is considered a serious disease in many rice growing regions throughout the world, including California. Stem rot was found in rice in south eastern Australia in 1994-95. While the pathogen has been recorded occasionally since, it has not proven to be a virulent strain of the disease. Many rice cultivars are resistant to stem rot.

Biology

Disease can be expected to be greatest in the lower bays due to accumulation of sclerotia. Sclerotia are able to float to the surface and germinate to infect rice sheaths at the water level. The development of stem rot is favoured by excessive nitrogen application. Intensive rotation practices where stubble is not burnt also encourage the build-up of inoculum.

Stem rot forms a black lesion at water level around mid-tillering growth stage.

Photo: A Watson, NSW DPI

Symptoms

Irregular black lesions appear around mid-tillering stage.

The lesions are located at the water level on the leaves that surround the stem of each tiller, i.e., the leaf sheath.

The fungus penetrates the leaf sheath to finally reach and rot the culm or stem of the plant. Later, small black sclerotia are produced inside the infected culms. Infection can lead to lodging and poor grain development.

Damage ranges from unfilled grain to the death of the tiller. Yield losses in Australia are less than 10%, but overseas can be as high as 80%.

Management

- Avoid intensive rice crop rotations and susceptible cultivars, i.e., Kyeema, in continuously cropped fields.
- Avoid excessive nitrogen application.
- As infected stubble is the source of new infections, burn or incorporate the stubble after harvest.

Downy mildew

(*Sclerophthora macrospora*)

Downy mildew is a fungal disease very occasionally seen on the leaves of rice plants.

Biology

Downy mildew has a wide range of hosts including wheat, barley, oats, other cereals and many grasses. It is considered only a minor fungal disease of rice and other hosts. Although downy mildew has been recorded in south eastern Australia (first at Yanco in 1930), the hot dry climate does not generally favour its development. Downy mildew is favoured by cool temperatures (18–23°C) and high humidity.

The fungus survives as oospores in infected plant material. These oospores then become the primary inoculum for new infections.

Management

None required.

Symptoms

The rice seedling can be readily infected but symptoms generally are more noticeable near the flowering stage. Infected leaves have white to yellow spots and can be twisted if infection is severe.

Panicles are unable to completely emerge; they remain green and generally fail to produce grain.

Rice plant showing signs of infection with downy mildew (*Sclerophthora macrospora*).

William M Brown Jr., Bugwood.org

Cochliobolus leaf spot
(*Cochliobolus sativus*)

Cochliobolus leaf spot is a minor fungal disease of rice.

Biology
Cochliobolus leaf spot attacks are correlated with nutrient soil deficiency, with the disease rarely reported when rice is grown in situations of good fertility. The fungus can come from seed or can be carried over from other infected cereals and grasses.

Management
Grow rice in fertile soils and/or provide adequate nutrition to the crop. This disease is unlikely to occur purely as a result of the presence of the pathogen. The crop must be growing in a poor fertility situation for the pathogen to infect the plant. The disease is as much a nutritional problem as it is a pathological problem. There also may be some cultivar differences in susceptibility to the disease.

Symptoms
Dark brown spots found on leaves, ranging in size from minute flecks to elongated spots (2 x 1 mm).

Occasionally, larger spots and brown streaks may appear. Heavily infected seeds cause blight of seedlings. On older plants, the disease reduces the number of grains per panicle and also reduces kernel weight.

Leaf spots typical of Cochliobolus or brown leaf spot.
Photo: DE Groth, Louisiana State University

Sheath spot

(*Waitea circinata*)

Sheath spot was first reported in the southern New South Wales rice growing area during the 1994-95 season.

Biology

Sheath spot disease can cause lodging on very susceptible cultivars but it is generally considered of minor importance. Yield losses have been shown to be as high as 10%. It may become more serious under intensive rice crop rotations. The fungus survives the overwintering period as sclerotia or mycelium present in the soil or in rice crop debris. The causal organism can also be referred to as *Rhizoctonia oryzae*.

Management

- Straw removal, stubble burning and a longer rotation are control methods for sheath spot at the time of publication.
- Avoid intensive rice crop rotations.

Symptoms

The disease causes spot type lesions on the leaf sheath midway up the tiller. Typical lesions are oval, 5–30mm long.

The spot is generally grey-white surrounded with a reddish-brown border. In contrast to the very similar aggregate sheath spot disease, the lesions are usually separated and do not coalesce (join up).

Lesions are generally found near the water line, later progressing up the leaf sheaths.

Favourable conditions for the fungus can cause the death of the infected leaves.

Spot type lesions on a rice stem typical of sheath spot (*Waitea circinata*).

Photo: V Lanoiselet, formerly Charles Sturt University

Aggregate sheath spot
(*Rhizoctonia oryzae-sativae*)

Aggregate sheath spot was discovered in 2000-01 in several rice crops of southern New South Wales.

Biology

Aggregate sheath spot leads to grain sterility, reduced grain filling and grain yield loss. Semi-dwarf rice cultivars could be more susceptible than tall cultivars. Aggregate sheath spot has been shown to reduce yield by as high as 20%. The fungus survives the overwintering period as sclerotia or mycelium present in the soil or in rice crop debris.

Management

- Straw removal, stubble burning and a longer rotation are control methods for aggregate sheath spot at the time of publication.
- No rice cultivars that are resistant to the disease have been identified or developed in Australia.

Sheath spot lesions typical of aggregate sheath spot caused by *Rhizoctonia oryzae-sativae*.

Photo: V Lanoiselet, formerly Charles Sturt University

Symptoms

The first symptoms of aggregate sheath spot appear during the tillering stage as small black lesions on leaf sheaths near the water line. Lesions are oval and can be grey-green or yellowish coloured surrounded by a brown margin. Size ranges from 5–40 mm in length.

The disease then moves upwards and reaches the upper leaf sheaths.

Secondary infections progress up the stem and may spread to the flag leaf and panicle. Leaves of infected sheaths turn yellow and generally die. The culm may also be infected.

Young sclerotia appear whitish as they are covered with mycelium, becoming a dark-brown colour over time. The size of sclerotia can vary greatly.

Glume blotch

(*Pseudomonas syringae* pv. *syringae*)

Glume blotch is a bacterial disease, where the brown discoloration of the panicle sometimes causes great concern but is normally of little consequence.

Biology

Glume blotch is not considered to be a disease of economic importance. In severe cases, 75% of the panicle may be affected, although florets at the base of the panicle are rarely completely discoloured. Some florets may be sterile but this may be caused by factors other than the disease. Glume blotch is favoured by any factor causing stress to the plant before panicle emergence.

Symptoms

Small dark spots (1–2 mm) are found on the glumes or outer parts of the developing grain (also referred to as the husk). The spots are surrounded by green to light brown tissue.

Florets, the individual grain on the panicle (also called a spikelet) can be totally discoloured. Light to dark brown lesions without definite margins occur on the flag leaf sheath, and veins are darker than the interveinal tissue.

Management

None required.

Symptoms of glume blotch on the stem of the rice plant.

Photo: E Cother, formerly NSW DPI

Symptoms of glume blotch appearing on individual florets of the panicle.

Photo: E Cother, formerly NSW DPI

Sheath brown rot
(*Pseudomonas fuscovaginae*)

Sheath brown rot is a sporadic bacterial disease affecting stems and panicles. This newly discovered disease has not been studied thoroughly.

Biology
The bacteria can be seed borne but also can be epiphytic (live symptomless on the plant). The disease is more severe in cooler climates. Low temperatures at night during panicle extension (common in the Riverina) would be favourable to the pathogen. The disease appears to be more severe on some cultivars.

Management
At this stage the disease is minor but monitoring for its presence is important.

Symptoms
The main symptoms include browning or rotting of the leaf sheath and quite often the panicle, causing browning of the glumes.

The disease can cause grain sterility.

The characteristic brown lesions on the flag leaf sheath are elongated with an indefinite brown-black border.

In more severe cases the panicle may fail to emerge.

Typical browning of the rice stem associated with sheath brown rot on the stem (top) and panicle.

Photos: D Adorada

Sheath and glume rot

(*Pantoea ananus*)

This disease is of minor importance.

Biology

The bacteria may be epiphytic and may cause disease only under certain environmental conditions. When it was first reported in 2003, the suggested reason for the disease was the severe dust storms that crops experienced that year, these storms may have abraded tissue to allow disease entry.

Management

At this stage the disease is minor but monitoring for its presence is important.

Symptoms

The disease appears as browning of the neck region of the panicle.

The discoloration then may extend down the stem to the flag leaf and even down to the second node. The node may turn black often leading to a weakening of the stem compared to plants that are not affected.

Symptoms of sheath and glume rot showing browning of the stem and panicle.

Photo: E Cother, formerly NSW DPI

Symptoms of sheath and glume rot showing browning of the panicle.

Photo: E Cother, formerly NSW DPI

Exotic threat

Rice blast and kernel smut are two exotic diseases that present a significant risk to rice crops in south eastern Australia.

The threat is largely because the climatic conditions of the Australian rice growing region are similar to those where the diseases have caused serious problems overseas. The threat of diseases such as these highlights the importance of maintaining strict quarantine regulations.

Rice blast disease occurs in more than 84 countries. It is a fungal disease that affects many parts of the plant and can cause severe yield losses. Rice blast is arguably the most serious disease threat to rice growing in south eastern Australia.

Biology

Wind dispersal: Rice blast is usually distributed throughout rice growing areas by air currents picking up the conidia. The pathogen *P. grisea* has already been recorded in New South Wales infecting several different weeds.

Studies on *P. grisea* from rice and weeds indicate that cross infection would be unlikely. It is not known if virulent strains of *P. grisea* could be introduced to northern Australia by tropical

Leaf blast, one of the five symptoms of rice blast. Lesions 10–15 mm long.

Photo: V Lanoiselet, formerly Charles Sturt University

Symptoms

Lesions or spots can occur on leaves, leaf collar, stem, nodes, panicles and grain. Their shape, colour and size can vary.

Leaf blast: Spots are elliptical or diamond shaped with more or less pointed ends.

The lesions are 10–15 mm long and 3–5 mm wide with a grey or whitish centre and a brown or reddish-brown margin.

Collar rot: Symptoms occur when lesions develop at the junction of the leaf blade and sheath.

Infection can cause death of the flag or second to last leaf, significantly reducing the yield potential.

Panicle blast: The infected part of the panicles turns brown or sometimes black.

Neck rot: Early infections below the panicles cause neck rot and can result in the death of the entire panicle.

Node infection: Infected nodes appear brown-black and dry, resulting in tiller death.

Collar rot, caused by rice blast at the junction of the leaf blade and sheath.

Photo: DE Groth, Louisiana State University

Neck rot, rice blast infection below the panicle causing death of the entire panicle.

Photo: DE Groth, Louisiana State University

cyclones, as the maximum distance that conidia can travel is a controversial issue.

Transport of infected plant material: Under dry conditions at room temperature, conidia are able to survive for more than a year and mycelium for almost three years. Due to its lengthy survival, importation or transportation by travellers of contaminated seed, weeds or souvenirs made of rice straw could introduce rice blast to the rice growing area of south eastern Australia. Yield losses from rice blast can be extremely high especially in intensive, high input rice cultivation. Blast is favoured by moderate temperatures, high humidity and excessive nitrogen applications.

Management

- Maintain good flooding to avoid moisture stress.
- Burn straw to reduce the inoculum.
- Manage nitrogen to avoid excessive levels in the field.

Travellers: A study published in 1992 estimated the potential number of conidia of

Exotic threat

P. grisea introduced to Australia on the clothes of international travellers to be 240,000 million for 1988 alone. Conidia of *P. grisea* are already present in several Australian states, including New South Wales. The fungus has been recorded on a number of grasses within Australia but not on rice. Therefore domestic travellers could also involuntarily introduce conidia to the rice growing regions.

Neck rot, rice blast infection below the panicle causing death of the entire panicle.

Photo: DE Groth, Louisiana State University

Risk of establishment

The disease is favoured by high relative humidity but outbreaks have recently occurred in the hot and dry climate of California. A rice blast model developed at Charles Sturt University Wagga Wagga was run for the period 1988-99 with the meteorological data of four representative locations in the Australian rice growing regions. Out of a possible 11 years, the number of years favourable for outbreaks of rice blast ranged from two at Griffith to nine at Yanco. The model highlighted the potential threat of rice blast to the Australian rice industry.

Panicle blast results in infected parts of the panicle turning brown or black.

Photo: DE Groth, Louisiana State University

Total risk: The risk of rice blast establishing in the Australian rice regions appears quite high. In the event of *P. grisea* being introduced and causing an outbreak in Australian rice crops, it is useful for Australia to examine how North American rice growers manage the disease. The strict quarantine vigilance on the rice blast pathogen *P. grisea* and other exotic organisms should be maintained in order to protect the Australian rice industry.

Kernel smut

(*Tilletia barclayana*)

Exotic threat

Kernel smut is known to occur in most Asian countries, Central America and Western Africa. The disease is also widespread in California's rice growing areas.

Biology

Kernel smut only infects the florets of the rice plant, reducing both grain yield and quality. Even if yield losses are as high as 15%, kernel smut is generally not considered an economically important disease of rice. Excessive nitrogen application and excessive water depth favour the development of the disease.

Kernel smut was reported on rice at Mareeba (1980), when rice was grown in Queensland. Although widespread in California, the disease is considered as a minor disease of rice. Used farm equipment from overseas, transportation of rice material and farmers travelling to other rice growing areas pose the greatest threats of introducing kernel smut to Australia.

The climate of the Californian rice growing area is relatively similar to the climate of southern New South Wales and northern Victoria. The pathogen (*T. barclayana*) has never been reported in New South Wales or Victoria but an accidental introduction in the rice growing regions would probably lead to kernel smut outbreaks.

The risk of kernel smut to occur in the Australian rice growing regions is high.

Symptoms

The smutted grains are loaded with masses of black spores. The symptoms are more noticeable in the early morning when dew causes the infected grains to burst and release their loads of chlamydospores.

Kernel smut affected rice kernels (left) compared to normal healthy kernels.

Photo: DE Groth, Louisiana State University

Management

The use of tolerant cultivars is the only known method to control kernel smut. In the USA, surveys showed that long grain cultivars appear to be the most susceptible whereas short grain cultivars are the most resistant.

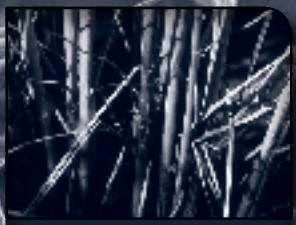
Department of Primary Industries

Rice field guide

to pests, diseases and weeds

in southern New South Wales

Pests



Diseases

Weeds

Weeds

Impact of sowing method
on rice weed spectrum

The weed spectrum in a rice field is strongly related to field preparation, sowing method and water management. If there are potential weed problems, management strategies can be used so that the weed population has little impact on the rice crop.

Aerial sowing

Aquatic broadleaf weeds are the main problem in aerial sown rice as they germinate at the same time as the rice. Early permanent water encourages aquatic weeds such as dirty Dora, starfruit, arrowhead, alisma and water plantain. Cumbungi, rushes and docks can also be a problem.

Semi-aquatic grasses such as barnyard grass and silvertop can be a problem if permanent water is delayed or water levels drop. This is because the soil becomes aerobic triggering their germination.

Aquatic broadleaf weeds are the main weed problem with aerial sown rice.
Photo: T Dunn, NSW DPI

Grass weeds are the key problem in sod sown rice.
Photo: B Dunn, NSW DPI

Sod sowing

Grass weeds are the main problem in sod sown crops. This is because they require wet but not flooded conditions to germinate, competing strongly with rice seedlings. Maintaining competitive pastures for at least four years before sod sowing aids their control, as it suppresses the barnyard grass. Heavy grazing before flooding controls smaller weeds, reducing the weeds ability to compete with the rice and weed seed production. Knockdown herbicides can be used if grass is present before sowing. Flushing allows the rice to grow and become competitive before permanent water is applied. If permanent water is delayed, grass weeds may become an issue and herbicides will be required.

Combine sowing

Cultivation and field preparation removes early weed competition. The wetting and drying that occurs with flushing also helps to reduce weed numbers. Permanent water reduces grass weeds but barnyard grass and silvertop can be a problem if permanent water is delayed. A dense, healthy rice crop offers good competition against weeds.

Drill sowing rice.
Photo B Dunn, NSW DPI

Planning
Know the field's weed history and provide a good layout to assist weed control, i.e., uniformity and water depth control.

Paddock hygiene
Avoid introduction of weed seeds by restricting access or thoroughly cleaning machinery, boots, etc.

Ensure supply and drainage channels are clean.

Pure seed
Use registered weed free seed from Sunrice each year.

Inspect crop regularly, especially during first three to four weeks.

Identify weeds accurately
Ensures correct management is applied.

Cultural methods
Rotation
Grow winter crops and use occasional summer fallows to avoid build up of weeds.

Cultivation
Can reduce some weeds before flooding but can spread weeds that reproduce from corms or stem/root segments.

Applying herbicides in aquatic situations is becoming more accurate and targeted with the use of helicopters.
Photo: Agropraisals Pty. Ltd.

Drill sowing
Limits aquatic weeds.

Ponding
Limits barnyard grass.

Adequate sowing rate
Competitive crop limits weeds.

Green manure/rice hay
In weedy crops before seed set.

Strategic burning of rice stubble
Destroys most weed seeds after harvest.

Herbicides
- Must be effective, safe and have minimum residues in the crop and drainage water.
- Ensure plant back periods are observed to avoid damage from herbicides used in previous crops.
- Ensure herbicides are registered for control of weeds in rice–see current rice crop protection guide.
- Use as directed on the label–correct timing, application rates, water depth and flow.
- Rotate herbicides and use two modes of action to ensure herbicide resistant weeds are killed.
- Consider knockdown herbicides before rice emerges.

Aerial pesticide application.
Photo: Field Air Finley

Barnyard grasses

(*Echinochloa* spp.)

A major grass weed in rice, other summer crops and pastures. Barnyard grass germinates with rice, grows quickly, is highly competitive and a prolific seeder. It causes yield loss, harvesting problems and contamination of rice seed.

As few as 10 plants/m^2 can cause economic losses, while heavy infestations can completely choke out the crop. Barnyard grass can use up to 50% of the soil nitrogen. Yield losses of more than 5 t/ha can occur.

Barnyard grass is always present after rice, especially drill sown crops, so growers often prefer not to drill sow repeat crops. It is less prolific but still a concern in aerial sown rice, as the early flooding suppresses its germination.

Biology

Barnyard grass can emerge just before sod sown rice and competes strongly for light and nutrients. Optimum germination temperature is 20°C. Massive populations can emerge in spring, with sequential germinations

Barnyard grass seedlings from an aerial sown rice crop. Note the round seed on the seedling that differentiates barnyard grass from rice and silvertop.

Photo: D McCaffery, NSW DPI

Identification

Origin: introduced and Australian native species.

Type: semi-aquatic annual.

Habit and height: erect, tufted grass up to 1.5 m, depending on species.

Seeding leaves: hairless, bright green to bluish green; often with distinctive red markings; no ligules or auricles present, distinguishing it from rice; leaves erect or prostrate, depending on species and surrounding canopy (more prostrate in drill sown, erect in aerial sown crops).

Mature plants: dull green and flat; tapering to a point.

Stems: slender, branching from lower nodes, flattened at the base.

Flowers: large panicle with up to 15 or more green to purple spikes; spikelets crowded in clusters along short branches. Shape and size varies with species.

Seed: 1–7 mm long, awned or awnless; white to brown, depending on species.

Similar species: rice (*Oryza sativa*), silvertop (*Leptochloa fusca*).

after periodic flooding (September to March). Barnyard grass prefers wet conditions but ponded water (e.g., aerial sown rice) limits its germination due to lack of oxygen. However, once established, it can survive flooding for the whole season. Flowers summer to autumn.

At maturity the seed head is held above the crop and the foliage can be quite dense, depending on the success of weed control. One plant can produce 7,000 seeds, so the seed bank can be substantial. Seed is spread in water, sowing seed and machinery, and can remain viable in dry soil for seven years.

There are four important species of barnyard grass in southern NSW

Common barnyard grass (*Echinochloa crus-galli*): up to 1.5 m tall; dull green hairless leaves, sometimes with red markings; seed head erect, lanceolate, ovate or pyramidal; awns on spikelets; brown grain; seeds shed at maturity.

Hairy millet (*E. oryzoides*): up to 1.5 m tall; pale green leaves; thick stems; drooping seed head; awns on spikelets; pale brown seed; matures later than common barnyard grass, just before harvest and retains seed on heads which may contaminate rice at harvest.

Awnless barnyard grass (*E. colona*): Australian native; 0.15–0.60 m tall; more spreading or prostrate; leaves dull green with conspicuous red or purple bands; compact seed head; small seed; no awns on spikelets; white grain; sheds seed readily.

Prickly barnyard grass (*E. muricata var. microstachya)*: up to 1.5 m tall; spreading branches; erect, pyramid-shaped seed head; awns or spikes on spikelets; yellowish-white grain; matures later than common barnyard grass.

Barnyard grass at the 3-leaf stage. In dense infestations, tiller production in rice can be more than halved and yield losses of over 5 t/ha may result.

Photo: Agropraisals Pty. Ltd.

Barnyard grass plants that survive seedbed preparation will rapidly dominate a crop.

Photo: Agropraisals Pty. Ltd.

Management

Farm hygiene

Manage weeds in surrounding areas and avoid introducing seed by thoroughly cleaning all off-farm machinery before entering the farm.

Crop rotation

Rotate with other crops and pastures. Growing vigorous pastures for four years will suppress barnyard grass populations in the following rice crop.

Mature barnyard grass in head above a tillering rice crop. Rapid development by weeds will provide a competitive advantage over crop plants.

Photo: Agropraisals Pty. Ltd.

Barnyard grass will germinate rapidly after the first flush irrigation is applied in drill seeded rice and typically emerges ahead of the crop. This is an ideal opportunity to combine non-selective knockdown and residual herbicides.

Photo: Agropraisals Pty. Ltd.

Pre-sowing management
Cultivation, grazing and knockdown herbicides can help reduce barnyard grass.

Sowing method
Aerial sowing plus early permanent water reduces barnyard grass problems in that year.

Herbicides
Both pre- and post-sowing selective herbicides offer effective control. Target the correct growth stage of both the rice and the weeds. Be aware of herbicide resistance and use strategies to reduce the risk of it developing.

Monitor regularly
Inspect every four or five days during first four weeks.

Barnyard grass in flower. Dense infestations can cause contamination and other difficulties at harvest.

Photo: M Lattimore, formerly NSW DPI

Silvertop grass

(*Leptochloa fusca* syn. *Diplachne fusca*)

Silvertop is a summer-growing grass weed found throughout the irrigation areas of south eastern Australia, often in roadside drains. Generally a minor rice weed, however dense, localised infestations can limit crop sowing options. Populations of 30 plants/m^2 can cause economic losses. Rice yield reductions of over 2 t/ha have been reported.

Biology

Seed germinates readily on the still water surface at 25°C then sinks and establishes on the flooded soil surface. Few seeds will germinate if buried deeper than 20 mm.

Seed is produced from mid-November to May and can easily spread through rice bays in water.

Silvertop seedlings. Silvertop seedlings have narrower leaves and stems than barnyard grass pictured at centre of photo.

Photo: Agropraisals Pty. Ltd.

Origin: Australian native.

Type: semi-aquatic annual or short-lived perennial.

Habit and height: erect, tussocky grass to 1 m high.

Leaves: narrow and often droopy, dull green with pronounced white mid-vein; membranous ligule but no auricles at the leaf-stem junction.

Stems: smooth, thick, hollow, soft, sometimes bent over.

Flowers: borne on upright panicles.

Seed: enclosed in a light, buoyant husk.

Roots: fibrous.

Similar species: rice (*Oryza sativa*) and barnyard grass (*Echinochloa* spp.).

Even a few uncontrolled silvertop plants on banks or in rice bays can produce a large number of seeds.

Landforming distributes seed uniformly across paddocks where it may germinate after autumn watering of annual pasture. In this situation the weed lies dormant in winter and assumes a perennial growth

habit, growing over the following summer, unless cultivated.

Management

Grazing
Silvertop is palatable and readily grazed by livestock. Heavy stock pressure may reduce the number of seedlings that over-winter in the pasture or stubble phase.

Cultivation
Silvertop is most easily controlled by cultivation close to filling-up before aerial sowing. Cultivation before combine sowing usually destroys existing over-wintering plants but may assist spread of seed.

Silvertop at flowering. Yield reductions of over 2 t/ha have been reported where localised silvertop infestations have become established.

Photo: D McCaffery, NSW DPI

Early permanent water
Following drill or aerial sowing applying early permanent water reduces silvertop germination.

Herbicides
Both pre- and post-sowing selective herbicides offer effective control. It is important to match the correct herbicide to the growth stage of the rice and the weeds.

Competition
Dense, vigorous rice crops compete well with silvertop seedlings.

Dirty Dora

(*Cyperus difformis*)

Dirty Dora is a sedge that is a major problem in aerial sown rice in south eastern Australia. Dirty Dora grows quickly, is very competitive with young rice and produces large amounts of seed. It occurs naturally in shallow swamps and depressions, along natural watercourses and in shallow channels but does not block waterways.

Populations of 30 plants/m^2 can cause economic losses. Left uncontrolled it can reduce rice yields by 3.5–4.0 t/ha or up to 50% and dense infestations can cause the maturing rice crop to lodge.

Many populations of dirty Dora have developed herbicide resistance. It is important to rotate herbicides with different modes of action. See the rice crop protection guide for more detailed information.

Biology

Seeds germinate quickly in shallow water and may float on the surface until the seedling can establish. Seedlings require moist or wet conditions to survive. Mature plants are extremely drought tolerant.

Origin: Australian native.

Type: semi-aquatic annual.

Height and habit: erect, tufted sedge to 0.5 m tall.

Stems: bright green, hairless and triangular; growing from base of plant.

Leaves: a few linear leaves growing from the base.

Flower head: small, dark brown, globular clusters of flattened spikelets on short stems at top of stem.

Seeds: extremely small (<1 mm), easily shed and cling to any surface; very easily dispersed.

Roots: fibrous, reddish brown.

Similar species: umbrella sedge (*Cyperus eragrostis*) and nut grass (*C. rotundus*) are perennials. They both have different sized and shaped seed heads.

Seedling stage dirty Dora. The field conditions associated with aerial sown crops are conducive to the establishment of dirty Dora.

Photo: D McCaffery, NSW DPI

Dirty Dora grows quickly and competes vigorously with young rice in thin or slow growing crops. Plant populations of over 5,000/m^2 have been recorded.

The life cycle usually takes about 15 weeks when rice is sown in October but can be shorter under ideal conditions.

Up to 50,000 seeds/plant have been recorded, with seed viability of up to 60%. Seeds may remain viable for more than seven years in fallow fields. Seed density has been measured up to 303,000/m^2 from land that has grown seven consecutive rice crops.

Mature dirty Dora. Dirty Dora is the most prolific semi-aquatic weed in rice in south eastern Australia. Each plant has the capacity to produce up to 50 000 seeds.

Photo: M Lattimore, formerly NSW DPI

Management

Herbicides

Herbicides are the most effective management option for aerial sown rice. However, many populations of dirty Dora are resistant to bensulfuron methyl (e.g., Londax®), so a herbicide program with several modes of action is required.

Drill sowing

Drill sowing does not altogether exclude dirty Dora but provides a practical alternative to managing it without herbicides.

Other cultural practices

Currently, there are no other cultural practices to manage dirty Dora that complement existing rice growing techniques. Rotation with other crops helps to reduce, but not eliminate, weed seed banks.

Starfruit

(*Damasonium minus*)

Starfruit is an important broadleaf weed of aerial sown and some sod sown rice. Although widespread across all rice growing districts, starfruit infestations appear more acute and difficult to manage in the western Murray Valley. It is also found in swamps, lagoons, shallow watercourses and channels but does not generally block waterways.

Starfruit is competitive in deep, stationary or slow moving water, particularly when rice crops are thin and slow growing as it suppresses rice tillering and yield.

Starfruit populations of 10 plants/m^2 can cause economic losses. Starfruit can remove as much as 40% of applied nitrogen.

It is generally only a minor problem in vigorous drill sown rice crops, as the aerobic conditions provided by flushing do not favour its germination.

Biology

Starfruit seedlings germinate on the soil surface after several days of continuous flooding in September-October in

Seedling stage of starfruit. Seedlings germinate on the surface of rice bays after several days of continuous flooding.

Photo: P Beale, NSW DPI

Origin: Australian native.

Type: aquatic annual or biennial.

Height and habit: emergent, broadleaf weed to 1 m tall, rooted in soil.

Seedling leaves: narrow and strap-like; radiating from the centre of the plant.

Mature leaves: ovate, cordate or oval; 50–100 mm long with three to five parallel veins; bright green, fleshy and hairless on a long stem; floating or emergent.

Stems: up to 0.3 m long.

Flower head: open panicle up to 0.5 m tall.

Flowers: small, white to pale pink; three petals; 3 mm long.

Fruit: star-shaped; olive to bright green; 10–12 mm; in groups of 6–10 along the stem.

Seed: small black capsule; 1–2 mm long.

Similar species: seedlings of alisma (*Alisma lanceolatum*) and swamp lily (*Ottelia ovalifolia*)

southern NSW. Growth is rapid and reproduction is possible within one month of germination.

Starfruit populations in aerial sown rice may be over 2,000 plants/m^2. Vast quantities of seed can be produced (up to 520,000 seeds/m^2) and the seed can remain viable for many years.

Management

Cultural practices and herbicide options

Management of this weed is similar to dirty Dora. Some populations have developed resistance to bensulfuron methyl (e.g., Londax®), so a rigorous herbicide management plan is needed.

Mid-vegetative stage of starfruit. This weed causes the most damage in thin, slow growing rice crops where it inhibits tillering and suppresses yield.

Photo: D McCaffery, NSW DPI

Star fruit flowering. Starfruit is usually a companion weed species to dirty Dora in aerial sown rice crops. Management options used for control of starfruit will be very similar to those for dirty Dora.

Photo: D McCaffery, NSW DPI

Arrowhead

(*Sagittaria montevidensis*)

Arrowhead is a significant broadleaf weed of aerial sown rice and channels in south eastern Australia. It is a declared noxious weed throughout NSW. Arrowhead is more prevalent in the Murrumbidgee Valley than the Murray Valley.

It is not as competitive as dirty Dora or starfruit, but dense arrowhead infestations can significantly reduce rice tillering and yield in small areas directly around an arrowhead plant. It occasionally obstructs drains.

Noxius weed status

Class 4. Must not be sold, propagated or distributed.

Biology

Arrowhead is spread by seed which can accumulate on the soil surface. One plant may produce up to 1,500 seeds which can remain viable for several years.

Seed germinates very quickly in spring in newly flooded bays and shallow channels or while floating in water. The juvenile leaves may form a dense cover over the entire bay before rice establishment in shallow water.

Origin: North and South America.

Type: aquatic perennial or annual.

Height and habit: tufted, erect, emergent, up to 1 m high.

Seedling leaves: similar to starfruit; narrow, straplike; 20–30 mm long; horizontal segments can be seen when held up to the light.

Mature leaves: large broad, arrow-shaped; 250–300 mm long; up to 20 mm wide; emergent or sometimes submerged or floating.

Stems: long, hollow and spongy, round in cross section, growing from the base of the plant.

Flowers: two to twelve whorls loosely clustered on stems up to 0.75 m long arising from plant base; male floweres have three white petals around a yellow centre and are 25 mm wide; female flowers are are in groups of three, round, green, with no petals and below the male flowers.

Fruit: bright to dull green to brown; up to cherry size.

Seed: about 20 per flower; shed when mature.

Roots: fibrous.

Similar species: *Sagittaria platyphylla*; water plantain (*Alisma plantago-aquatica*); alisma (*Alisma lanceolatum*); starfruit (*Damasonium minus*).

Seedling stage of arrowhead. Once a rice bay is wet, arrowhead can germinate within two to three days.

Photo: D McCaffery, NSW DPI

Noxious weed

Arrowhead seedlings may germinate and grow under mature plants.

Early spring and summer growth is rapid if there is no competition. It prefers bare areas where continuous deep water and anaerobic soil conditions favour its establishment and growth (e.g., unsown corners of bays and deeper borrow pits).

Flowers and fruit are produced in summer.

Mid-vegetative stage of arrowhead. Dense infestations of arrowhead can significantly reduce tillering and yield in small areas directly around the plant by up to 75%.

Photo: R Salvestro, NSW DPI

Mature arrowhead, a weed that is present in over 40% of rice crops in south eastern Australia, making it a weed of significance to the rice industry.

Photo: L Kealey

Management

Herbicides

Herbicides are the main control method. However, arrowhead has developed resistance to bensulfuron methyl (e.g., Londax®), so integrated herbicide management with several modes of action is critical.

Drill sowing

This may reduce the impact of the weed in known areas of infestation.

Arrowhead seed does not germinate if buried.

Water management

Depriving arrowhead of free water soon after germination but before plants are established may reduce plant numbers, but this practice can also promote barnyard grass establishment.

Water levels have little effect on growth and seed set once plants are well established.

Hand weeding

This is possible in small infestations but generally not viable.

Alisma

(*Alisma lanceolatum*)

Alisma is a prolific, competitive, broadleaf weed of aerial sown rice in south eastern Australia, particularly in the Murray Valley and Colleambally Irrigation Area.

Once established, it can survive dry conditions. It can also grow with only intermittent flooding such as roadside table drains, borrow pits of irrigation fields and poorly drained areas. Left unchecked, alisma can reduce rice yields by more than 50%. It is considered a serious weed because it is highly competitive and control options are limited.

Biology

Alisma is spread by seed and corms, mainly on agricultural machinery, but also by other means such as wildlife and muddy boots.

Seed will only germinate in flooded soil or under water. Open-ponded water in aerial sown rice crops allows early establishment of the weed before or during rice establishment. Leaves emerge and grow quickly above the water and crop.

Flowering occurs from January to March but can be earlier if plants have grown from corms. Seed heads extend above the crop at harvest and add to competition with the rice crop. Seed production is prolific with up to 25,000 seeds/plant. Seeds have a high level of dormancy and can remain viable for at least six years.

Seedling stage alisma. Alisma can produce between 10 000 and 25 000 seeds per plant. Left unchecked, alisma corm plants can reduce rice yields by more than 50%.

Photo: D McCaffery, NSW DPI

Origin: Europe, Asia and Africa.

Type: semi-quatic perennial.

Height and habit: erect, up to 1 m tall.

Seedling leaves: thin and linear or strap-like; similar to starfruit.

Mature leaves: narrow, flattened, ovate to lanceolate; 150–200 mm long and narrow (30 mm wide); grow very erect above the young crop.

Stems: long and fleshy.

Flowers: small, mauve, pink or cream with three petals; many flowers found in dense clusters on erect, open panicle; 500 mm long; 300 mm wide; two to three panicles per plant held above the leaves.

Seed: very fine and prolific.

Roots: corms; old plants may have several layers of corms.

Similar species: water plantain (*Alisma plantago-aquatica*); sagittaria (*Sagittaria platyphylla*); also related to starfruit (*Damasonium minus*); and arrowhead (*Saggitaria montevidensis*).

Corms overwinter in the soil, allowing the weed to survive dry periods and enabling spread by cultivation. They produce new growth the following season which can be very competitive with the rice crop.

Management

Aim to control alisma as seedlings as it is more difficult to control once corms have established.

Crop rotation

This is the best management practice for alisma, because most competition with rice results from corm plants. Corms cannot survive a hot dry summer fallow if exposed. Limited opportunities exist in spring to desiccate corms by repeated workings prior to flooding the rice field.

Herbicides

The main control tool for alisma in aerial sown rice.

Drill sowing

A possible control method if there are no corms present.

Farm hygiene

Attention to farm hygeine is critical to avoid introduction of alisma. Most weed spread can be traced to movements of machinery or contractor implements. Avoid moving any machinery (particularly headers) from infested to clean areas if possible, or thoroughly clean machinery.

Alisma plants produce corms after one year. Corm plants establish more quickly than those from seeds and have a much greater competitive effect on the rice crop.

Photo: W Clampett, formerly NSW DPI

Mature alisma. As most competition with the rice crop results from alisma plants establishing from corms, crop rotation is the best management practice for control.

Photo: A Storrie, formerly NSW DPI

Water plantain

(*Alisma plantago-aquatica*)

Water plantain is a sporadic broadleaf weed of rice, usually occurring as a few plants near the water inlet or on the crop margin. It can obstruct drains or compete with rice in patches. It is found naturally along the major river systems and in billabongs and creeks in south eastern Australia. In the 1990s, biotypes resistant to the herbicide bensulfuron methyl (e.g., Londax®) became a serious problem in aerial sown rice in the Murray Valley.

Biology

Water plantain reproduces from both seeds and corms.

Seeds are spread in irrigation water, on machinery, and by birds and livestock. They can survive in the soil for more than five years. Seeds germinate in flooded conditions and plants grow rapidly, flowering between January and March.

Corms are very hardy and plants can regrow before flooding if sufficient rainfall occurs. These plants compete strongly with the seedling rice crop.

Plants growing from seed do not grow as quickly as the corm plants but due to prolific seed production, large patches of water plantain can compete vigorously for space.

Origin: Australian native.

Type: aquatic perennial.

Height and habit: erect, emergent, growing to 1.5 m tall.

Leaves: closely related to alisma but has broader leaves (100–250 mm long and 70–100 mm wide) with seven prominent parallel veins, connected by numerous transverse veins; leaves attached to a long stem.

Stems: up to 0.8 m long.

Flowers: 10 mm in diameter; three white or pale pink petals; flower head an open panicle, similar to but larger than alisma (0.6 m long).

Seed: buoyant, aiding dispersal.

Roots: corms.

Similar species: sagittaria (*Sagittaria platyphylla*), alisma (*Alisma lanceolatum*) and starfruit (*Damasonium minus*).

Seedling stage alisma. Water plantain is closely related to alisma and the seedlings of each species appear the same.

Photo: Agropraisals Pty. Ltd.

Management

Water plantain is managed using similar strategies to alisma.

Herbicides

The main control tool in aerial sown rice. Herbicide resistance does occur in water plantain, so management should be planned carefully and include an integrated program using herbicides with several modes of action.

Cultural practices

Fallowing can be used to desiccate the corms. Drill sowing and crop rotation can also help minimise the impact of water plantain.

Farm hygiene

Farm hygiene is critical to avoid introduction of water plantain. Most spread can be traced to movements of machinery or contractor implements. Avoid moving any machinery (particularly headers) from infested to clean areas if possible, or thoroughly clean machinery.

Mid-vegetative stage of water plantain. Water plantain establishing from seed is slower growing than plants establishing from corms. However, due to large numbers of seeds produced by the parent plant, water plantain soon establishes significant populations if not controlled.

Photo: Agropraisals Pty. Ltd.

Mature water plantain and flower head. Strategies for the management of water plantain are very similar to those used for alisma. In aerial sown rice, herbicides are the main control tool.

Photo: M Lattimore, formerly NSW DPI

Sagittaria

(*Sagittaria platyphylla*)

Sagittaria is a broadleaf weed which grows and spreads rapidly. It is a declared noxious weed throughout NSW.

Sagitarria is not a major problem in rice but a significant problem of irrigation channels. It is more persistent than arrowhead due to its corms and tolerance of herbicides.

Noxious weed status

Class 4 and 5. Notifiable. Must be controlled.

Biology

Sagittaria is spread by seeds, stem and root fragments, and underground rhizomes/corms. Seed floats easily and is spread in water, and by birds and livestock.

Germination occurs in slow moving or static shallow water. Saggitaria is more tolerant of cold than arrowhead. It germinates in late winter to spring (earlier) and grows later (to June).

Origin: North America.

Type: aquatic perennial.

Height and habit: erect, emergent, growing to 1.5 m tall; may also be a submerged rosette.

Emergent leaves: oval, lance-shaped to linear; pointed tip; 250 mm long and 100 mm wide (narrow-leaved form also exists).

Submerged leaves: long, narrow strap-like, up to 0.5 m long.

Stems: triangular in cross-section, up to 0.8 m long.

Flowers: appear below the height of the leaves during spring to autumn in whorls or coils of four to six; male flowers have three white petals with yellow centre and are 30 mm wide; female flowers are flattened, green, berry-like with no petals.

Fruit: cluster of segments 5–10 mm across.

Seed: one seed per segment, flattened and winged, 1.5–3 mm long.

Roots: corms at the end of rhizomes.

Similar species: arrowhead (*Sagittaria motevidensis*); water plantain (*Alisma plantago-aquatica*); starfruit (*Damasonium minus*); and alisma (*Alisma lanceolatum*).

Sagittaria seedlings are grass-like and can develop into any of the three forms of the weed.

Photo: Goulburn-Murray Water

Mid-vegetative stage of sagittaria, a noxious weed which is a major problem in irrigation channels. It spreads rapidly and is more persistent than arrowhead.

Photo: Goulburn-Murray Water

Noxious weed

Sagittaria flowers produce up to 20,000 seeds.
Photo: Goulburn-Murray Water

Sagittaria seed floats easily helping it spread on water. It is also spread by livestock and birds.
Photo: Goulburn-Murray Water

Seedlings are grass-like and can develop into any of three forms:

- **Submerged rosette form:** arises from seed, plants can remain in this form in deeper water for several years, producing rhizomes and corms.
- **Broad-leaved form:** emergent leaves are produced from rhizomes if water height drops below 1 m. They can also develop from seed germinating in shallow, slow-moving water. These plants can flower and set seed.
- **Narrow-leafed form:** a grass-like form, arises from depleted rhizomes after grazing or herbicide treatment and will eventually produce broad-leaved plants.

Sagittaria seeds prolifically –each plant producing up to 20,000 seeds.

Corms are dormant in winter. They aid survival in dry periods and can remain viable for many years.

Early flowering stage of sagittaria.
Photo: Goulburn-Murray Water

Management

Herbicides

There are limited herbicide options. There are no registered herbicides for use in rice but some APVMA permits exist in some situations (see *www.apvma.gov.au*).

Physical removal

Excavation with machinery or by hand is possible for new small infestations but stem and root segments must be contained.

Hygiene

Ensure that root and stem segments are not brought onto the property by water or machinery. Avoid cultivation of infested areas which leads to weed spread.

Umbrella sedge

(*Cyperus Eragrostis*)

Umbrella sedge is widely distributed throughout the irrigation areas of south eastern Australia. It is often found in drains and roadside gutters, and is very hardy once established.

Umbrella sedge is not easily controlled in rice. It is mostly a problem in sod sown rice after irrigated pastures, but can be a problem if pasture is cultivated late for aerial sowing and plants remain. Dense infestations in channels can impede water flow.

Biology

Umbrella sedge is spread by rhizomes and seed. It grows mainly in summer in damp areas or shallow water. It flowers late summer-autumn and sheds seed when mature. It is very hardy once established, re-growing from rhizomes when watered after dry periods.

Management

In rice, cultivation to uproot plants combined with aerial sowing is the most successful management method.

In channels, renovation, cultivation and registered herbicides are used.

Seed head of umbrella sedge, a close relative of dirty Dora, umbrella sedge has green and brown spikelets compared to brown in dirty Dora.

Photo: M Lattimore, formerly NSW DPI

Origin: America.

Type: semi-aquatic perennial sedge.

Height and habit: tufted, up to 1 m tall.

Leaves: green, erect; 4–8 mm wide; as long as, or shorter than stems.

Stems: smooth, stout; 0.25–0.10 m tall; triangular with rounded edges; slightly swollen at the base.

Flowers: globular clusters; 10–50 mm diameter on branches; accompanied by leaf-like bracts up to 300 mm long; spikelets dull green or brown and flattened (5–15 mm long and 3 mm wide).

Fruit: dark nut with triangular cross section

Roots: short thick woody rhizomes.

Similar species: dirty Dora (*Cyperus difformis*)

Water couch is an aggressive stoloniferous grass weed of irrigated pastures and summer crops. It also grows on the banks of rivers, creeks and damp depressions. It is a persistent, tough perennial weed difficult to eradicate.

Water couch can become a significant weed in rice following pasture and in sod sown rice. It grows mainly in irrigation drainage channels and borrow pits where it can obstruct water flows. It creeps out from the banks of bays to form a dense mat which can choke out large patches of rice.

Biology

Water couch needs summer water to survive but can withstand long dry periods if not disturbed by cultivation. It can grow in still and moving water up to 1 m deep. It is dormant in winter and sensitive to frost. Established plants grow very quickly in spring once watered and temperatures reach 20°C.

Water couch is a prolific seeder, which is also spread by stolons (surface runners), stem segments and rhizomes, through cultivation, landforming, grazing animals and water flow.

Water couch with stolons. Water couch produces many seeds during summer and early autumn but its most obvious and aggressive means of spread is by stolons or rhizomes.

Photo: A Storrie, formerly NSW DPI

Management

Cultural practices

Channels, bank lines and borrow pits should be kept dry when not in use to minimise the incidence of water couch. Summer cultivation and periodic bank line renovation will expose and dry out rhizomes.

Heavy grazing and rotation with winter cereals

May reduce the severity.

Herbicides

Spot spraying infested banks before landforming will limit spread. There are no selective herbicides currently registered for its control in rice. Several non-selective herbicides are registered for control of water couch in non-crop situations.

Origin: Australian native.

Type: semi-aquatic perennial.

Height and habit: vigorous; stoloniferous habit; up to 0.5 m high; can form dense mats.

Leaves: bluish-green, 40–150 mm long; flat, tapered and hairless, except at their junction with the stem; membranous ligule.

Stems: branched with many-nodes and rooting stolons.

Flowers: mid to late summer; two V-shaped flattened spikes; 15–70 mm long; just above upper leaf sheath; on an erect stem; 100–250 mm long; spikelets form in two rows along one side of the spike.

Seed: prolific, maturing late summer to early autumn.

Roots: whitish or yellowish rhizomes.

Similar species: saltwater couch (*Paspalum vaginatum*); and spiny mudgrass (*Pseudoraphis sipnencens*)

Cumbungi (bulrush)

(*Typha* spp.)

Cumbungi is a major weed of water courses and irrigation channels in all rice growing districts. It often occurs in new aerial sown rice fields and can be a problem if rice is resown in the following year. It mainly infests channels, borrow pits and may be problematic in fields that have been continuously cropped for a long period.

In rice bays, most seedlings establish in borrow pits, corners of bays, and in combine sown crops where drill rows do not overlap. In slow growing aerial sown rice, cumbungi seedlings may be spread thinly throughout the crop.

Origin: Australian native.

Type: semi-aquatic, perennial.

Height and habit: emergent, 2.5 m tall or more.

Leaves: green to blue-green; flat; 1–2 m long; 10–25 mm wide; in two rows along the stem; overlapping at the base of the stem.

Stems: stiff and erect; cylindrical and pithy; up to 20 mm diameter.

Flowers: summer; male flowers form a very dense cylindrical, velvety-brown spike; female flowers form a similarly dense spike below the male flowers.

Seed: numerous; released with silky threads on lower spike.

Roots: extensive branched rhizomes; up to 25 mm diameter.

Plants that establish in borrow pits will encroach into rice bays rendering those areas unproductive. Infestations restrict water flow in farm supply channels and can interfere with bay drainage.

Cumbungi seedlings germinate readily from dormant seed, which lies over vast areas of dryland south eastern Australia, with the introduction of water for rice growing.

Photo: Agropraisals Pty. Ltd.

Biology

Cumbungi can produce over 200,000 viable seeds per panicle each season. Seed is easily spread by wind and water making it impossible to contain. Dormant cumbungi seed lies over vast areas of dryland south eastern Australia and germinates readily when water is introduced for rice growing. It can grow in water up to 2 m deep. Initial growth rates of cumbungi may be very slow.

Plants die back and become dormant in late autumn.

The plant develops an extensive system of rhizomes that enable

it to spread into rice bays and to over-winter. Rhizomes regrow from late September and throughout summer, and they allow plants to survive long periods without flooding.

First year cumbungi may produce a seed head if conditions are favourable. The seed head is generally much smaller than that on older plants.

Management

Cultural practices

Summer cultivation; periodic bank renovation; exclusion of irrigation water from unused channels, borrow pits and bays; and field rotation with pastures and winter cereals will help reduce the severity of cumbungi infestation. Burning can also reduce regrowth and seed.

Sowing method

In drill sown rice, seed should be sown as close as possible to contour banks to prevent cumbungi establishing. It is preferable to sow over gaps rather than leave gaps between drill rows and on the corners. The same approach should be taken for pre-drilling fertiliser in aerial sown fields, to ensure that crop growth is healthy and vigorous. High sowing rates will assist weed control.

Cumbungi in flower. Generally, cumbungi will not have sufficient leaf area to enable herbicide control before rice sowing. Where possible, delay spot spraying or wick wiping of non-selective herbicides until flowering, in mid- to late-summer.

Photo: M Lattimore, formerly NSW DPI

Herbicides

Changing herbicide options for the control of other weeds in rice can impact on the degree of infestation of cumbungi in rice crops. Some selective herbicides registered for rice will control seedling cumbungi but existing plants will generally not have adequate leaf area to enable herbicide control before sowing. It is preferable to delay spot spraying or wick-wiping of non-selective herbicides until flowering in mid to late summer, if possible.

Rushes

Several genera

Rushes can be found in poorly drained sites, including pastures and verges of channels, watercourses and rice fields. They tend to predominate in rice fields adjacent to natural watercourses and low lying depressions which become periodically inundated.

Common rush (pin rush) (*Juncus usitatus*)

Common rush is thought to be the most widespread of rushes throughout the irrigated areas of the Murray and Murrumbidgee valleys.

Historically regarded as an uncommon weed of rice, common rush like cumbungi may become more significant in rice crops as herbicide practices change.

Common rush is a nuisance in irrigated pastures and rice crops where it may occupy extensive areas of poorly drained bays. It may grow in shallow channels and drains, particularly where infrequently used, and block water flow. The conditions of sod sown rice crops encourage its continued growth.

Origin: Australian native.

Type: perennial.

Height: 0.35–1.20 m.

Leaves: no true leaf blades but some sterile stems often mistaken for leaves.

Stems: cylindrical stems; 1–2 mm across; reddish brown at the base; dull green in the middle; straw coloured at the tip; pithy and contain air spaces.

Flowers: spring and summer; clusters of old spent flowers may be present throughout winter.

Common rush (*Juncus usitatus*), also known as pin rush. Common rush can be controlled by thorough cultivation of the field with heavy offset discs before aerial or combine sowing.

Photo: D McCaffery, NSW DPI

Similar species: in addition to common rush, there are many species of rush found in south eastern Australia. These include rushes that belong to the same genus as common rush as well as species of other types of rushes: spike rushes (*Eleocharis* spp.); fringe rushes (*Fimbristylis* spp.); bog rushes (*Schoenus* spp.); club rushes (*Scirpus* spp. and *Bolboschoenus* spp.); and mat rushes (*Lomandra* spp.).

Rush identification is extremely complex and before implementing management programs, professional identification is recommended to ensure the correct management strategies are planned.

Biology

Studies on the germination of common rush have not been conducted in south eastern Australia. Young plants may be found in irrigated pastures in spring and autumn, in rice fields after the application of irrigation water and in stubble paddocks in July and August.

Once established, common rush plants may survive for several seasons.

Management

Cultural practices

Common rush can be controlled by thorough cultivation of the field with heavy offset discs before aerial or combine sowing. It is rarely grazed by livestock other than goats. Landforming will assist in controlling common rush by reducing the number of poorly drained sites that favour its development, particularly in pasture phases.

Herbicides

Various non-selective herbicides can be used to control common rush in the non-crop phase of the rotation.

Common spike rush

(*Eleocharis acuta*)

Common spike rush was a very rare weed in rice crops until the late 1990s. It is now found in aerial sown crops where herbicide practices have changed. Common spike rush is found in shallow water along streams, in swamps, gilgais, roadside table drains, waterlogged depressions and on the margins of irrigation supply channels.

Biology

Common spike rush grows throughout the year if sufficient moisture is available. At times of low moisture the stems dry off but rapid and vigorous growth is made from the rhizomes once moisture conditions improve.

Flowering occurs any time from spring through autumn.

Management

Cultural practices

Common spike rush is not normally a weed of rice crops and it is mainly a problem in supply and drainage channels where it can reduce water flows. Thorough cultivation is likely to provide the best control option within the rice field. Stock find the weed unpalatable.

The management strategies similar to those suggested for common rush would be appropriate for common spike rush.

Origin: Australian native.

Type: perennial.

Height and habit: rhizomatous perennial less than 1 m tall

Leaves: reduced to basal sheaths; purplish, blunt ended with a short projection.

Stems: cylindrical to flattened; triangular in cross section below the spikelet; 1–3 mm wide.

Flowers: flower head is usually dark-brown; 10–30 mm long; 3–7 mm wide; more or less tapering.

Seed: or nuts; 1.4–1.8 mm long; 1.0–1.4 mm wide; yellowish-brown, smooth or roughened.

Common spike rush (*Eleocharis* spp.) is related to common rush but belongs to a different species. There are many species of rush in south eastern Australia therefore accurate identification is recommended to ensure the correct management strategies are planned

Photo: D McCaffery, NSW DPI

While uncommon, bolboschoenus has been recorded in the western Murray Valley near Koraleigh, at Coleambally and near Griffith. It appears most often as small colonies of plants. Bolboschoenus (*B. caldwellii*) is often confused with a related species, *Bolboschoenus fluviatilis* (syn. *Scirpus fluviatilis*) that has the common names, marsh clubrush and river bulrush.

Bolboschoenus is usually found beside creeks and channels and on poorly drained land.

Biology

Bolboschoenus grows from both rhizomes and seeds but little is known about its biology. Flowering occurs over late summer and the plant senesces in winter. Seed production per plant does not appear to be high.

Spreading rhizomes and new shoots enable one bolboschoenus plant to extend its competitive effect over a wide area. Bolboschoenus has been observed competing vigorously with aerial sown rice over an area of about 1 hectare.

Management

Cultural practices

Crop rotation to avoid continuous rice growing is likely to be the most effective means of managing bolboschoenus.

Herbicides

There is no herbicide registered for control in rice crops.

Origin: Australian native.

Type: perennial.

Height and habit: perennial growing up to 1 m tall.

Leaves: grow to about 0.70 m long with longitudinal ridges and midribs, and sharp margins.

Stems: triangular.

Flowers: in terminal ovoid clusters to about 20 mm long with several clusters in an inflorescence.

Seed: top-shaped nuts, golden-yellow to deep golden-brown in colour. Six bristles arise below each nut and extend about half the length of the nut

Seed head of bolboschoenus (*Bolboschoenus caldwellii*). Flowering occurs over late summer and the plant senesces in winter. Seed production per plant does not appear to be high.

Photo: D McCaffery, NSW DPI

Alligator weed

(*Alternanthera philoxeroides*)

Alligator weed is an aggressive, stoloniferous plant which forms dense floating mats in water or grows on land. Unchecked, it may completely choke irrigation channels and water bodies. **A declared noxious weed for the whole of Australia.**

Alligator weed could be an extremely competitive weed if allowed to infest rice fields. Limited outbreaks have occurred in south eastern NSW. An eradication program has been underway since 1994 at Barren Box Swamp near Griffith. Care is needed to identify and control new infestations early.

Noxious weed status

Class 2 and 3. The plant must be eradicated and the land must be kept free of the plant.

Biology

Alligator weed grows in wet areas or in water during summer. Its leaves are killed by frost. New plants can arise from each node of the plant and can also grow from a small piece of root or stem. These can be spread by water, excavation equipment, machinery, boats, dredged sand and animals.

Alligator weed growing on land is more difficult to control than that growing in water due to its extremely dense

Alligator weed is a declared noxious weed and is capable of completely choking irrigation channels. It could also be an aggressive competitor of rice crops and therefore, rice growers should be familiar with its appearance.

Photo: J Whiteley, formerly NSW DPI

Origin: South America.

Type: aquatic perennial.

Height and habit: dense free-floating or rooted rafts of interwoven stems to 0.60 m high.

Leaves: glossy green, spear-shaped leaves, 20–70 mm long, 10–20 mm wide, in opposite pairs arising from the stem.

Stems: in water–hollow stolons up to 10 m long, rooting at the nodes; on land–shorter, less hollow and reddish brown.

Flowers: single, white, papery, ball-shaped flowers on a short stalk in the leaf axils, 10 mm diameter from November to March.

Seed: no viable seed

Roots: fine and short in water but in soil thicker, rhizome-like and extensive underground root systems up to 1 m deep may develop.

Similar species: water primrose (*Ludwegia* spp.); Mukunawanna (*Alternanthera sessilis*) –a culinary herb grown by Sri Lankins; slender knotweed (*Persicaria* sp.); dock (*Rumex* sp.).

Noxious weed

and extensive system of underground stems and roots. Root storage tissues can allow survival in long dry periods.

Alligator weed is tolerant of most herbicides.

Management

Quarantine
Introduction of this weed to the irrigation areas of south eastern Australia must be avoided. Rice growers should identify and report any suspected weed to the appropriate authority.

Physical control
Hand weeding and excavation effective for small, new, land infestations but not viable on a large scale.

Herbicides
Limited chemical control available.

The flower and stem of alligator weed. The weed normally grows from a small piece of stem and the plant can grow as a free floating raft or attached to the soil by roots.

Photo: J Whiteley, formerly NSW DPI

Alligator weed has been found in Barren Box Swamp near Griffith. Unchecked, it is capable of totally choking irrigation channels and rice crops. The weed can grow and spread in water and on land.

Photo: J Whiteley, formerly NSW DPI

Water primrose

(*Ludwigia peploides* subsp. *montevidensis*)

Water primrose can impede water flow in supply channels and could smother rice if it became established. It has been recorded in borrow pits of rice but its occurrence is rare. Usually found in stationary and slow moving water, on creek banks and in swamps. It can be confused with alligator weed.

Biology

Factors affecting germination are not known. Vegetative reproduction is important in its spread. Dense vigorous rice stands restrict growth of water primrose.

Management

Cultural practices

Periodic renovation and drainage when not in use will discourage its development in channels. Vigorous rice crop growth impedes its growth.

Water primrose (*Ludwigia peploides*) will impede water flow in supply channels and where established, could smother rice.

Photo: H Milvain, formerly NSW DPI

Origin: Australian native.

Type: herbaceous perennial.

Height and habit: floating or creeping, attached, emergent plant.

Leaves: oval, 2–6 mm long and attached to stem by a short petiole.

Stems: floating or creeping, up to several metres long.

Flowers: bright yellow, five petals, 20 mm across, produced in summer.

Roots: root-like structures of white spongy material may be present on floating stems.

Similar species: can be confused with alligator weed. Other introduced species of *Ludwegia* appear in rice from time to time including longleaf willow primrose (*L. longifolia*) a tall erect plant; and Peruvian primrose (*Ludwegia peruviana*). These species are not common in southwest NSW but are aggressive competitors and are declared noxious in some coastal areas.

Chara and nitella are plant-like algae that often form a dense mat on the floor of flooded rice bays, especially where rice stands are thin and in borrow pits. They do not seem to compete with the growing rice crop, though they may intercept some mid-season top dressed nitrogen. At the end of the season, the thick mats will impede rapid drainage of water, extend the soil drying period and delay harvest.

Origin: Australian native.

Type: stoneworts–fluffy plant-like algae which resemble flowering plants.

Height and habit: form a dense mat on bay floor, under the rice.

Chara is sometimes encrusted with lime and has a distinctive strong odour.

Nitella has is highly branched and has globules of mucus on the branches.

"Leaves": fernlike.

Stems: long whorled branches up to 1 m.

Similar species: hornwort (*Ceratophyllum* spp.); and milfoils (*Myriophyllum* spp.).

Biology

Little is known about the life cycle of the stoneworts.

Chara dominates where calcium is abundant in the water, while nitella thrives under more acid water conditions.

Management

Cultural

Mid-season (i.e., December) drying of aerially sown crops is the only cultural means of controlling stoneworts.

Herbicides

Registered algicides may be useful but are largely untested.

Chara (*Chara* spp.) does not have any significant effect on the growing crop but it can impede field drainage at the end of the season.

Photo: D McCaffery, NSW DPI

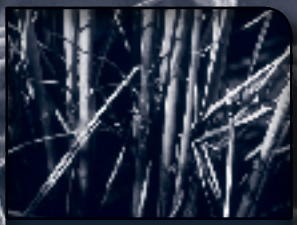
Department of Primary Industries

Rice field guide

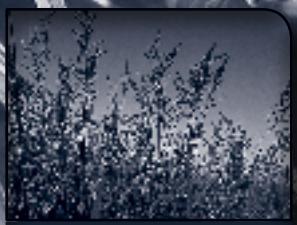
to pests, diseases and weeds

in southern New South Wales

Pests



Diseases



Weeds

Appendix

Glossary
of terms

Term	Description
aerial sown	Rice seed sown by aeroplane into permanent ponded water.
aerobic	Containing oxygen, e.g., wet soils following flushing.
anaerobic	Containing no oxygen, e.g., flooded soils.
annual	A plant which grows, blooms, and perhaps, sets seeds within a one year period.
aquatic plant	Plants that are naturally found growing in water at, or above, the surface of the soil.
auricle	A pair of claw-like projections or appendages at the base of a leaf blade in grasses and at the base of some other leaves.
awn	Bristle on end of spikelet.
biotype	All plants in a specific group, which resemble one another in some specific way.
blight (of seedlings)	Plant death, causing for example whole seedlings to die.
borrow pit	Deep ditch around rice bay.
bracts	Leaf-like structure under group of flower.
broadleaf (weed)	Dicotyledons, have two cotyledons and the leaves, unlike those of grass (or narrow leafed) weeds, do not have parallel veins.
capsule	A pod or seed vessel made of two or more cells, which becomes dry and splits open when mature to release its seeds.
chlamydospore	Thick walled survival structure of fungi.
collar (leaf)	The junction of the leaf blade and leaf sheath.
combine sowing	Rice seed sown into a dry, cultivated seedbed; permanent water is applied after rice plants have established.
conidia	Asexual reproductive spores of fungi.
cordate (shape)	Heart-shaped (leaf base).
corm	A short underground stem formed annually below a flowering stem and protected by surrounding leaf bases.
culm	The jointed and usually hollow stem of grasses.

Term	Description
drill sown	Rice seed sown into a dry seedbed, either cultivated (combine sown) or uncultivated (sod sown); permanent water is applied after rice plants have established.
emergent plant	A plant which grows in water, is rooted to the soil on the bottom but leaves and stems extend out of the water so that the plant is partially in the air.
epiphytic	Living on the surface of a plant, but not as a parasite and without causing infection.
floret	A single flower in a head of many flowers.
glume	The bract enclosing the flowers of grasses and sedges.
grass (weeds)	Monocotyledon, have one cotyledon or seed leaf, and the mature leaves are long and narrow, usually with parallel veins.
kernel	The inner portion of a seed, usually refers to an edible seed or the central part of a nut or fruit seed.
lanceolate (shape)	Long and thin and broadest below the middle, tapering to a point like a lance; lance-shaped.
larva	Immature stage of insects that ultimately pupate before emerging as an adult with a different body form (e.g., leafminer maggots, armyworm caterpillars).
leaf blade	The flat expanded portion (lamina) of a leaf.
leaf sheath	The tubular portion of a grass leaf that encloses the stem.
ligule	Membrane or row of hairs at junction of leaf sheath and leaf blade.
mid-season drying	The practice of draining irrigation water off crops in early December and drying the soil. Water is normally off the crop until the rice foliage shows obvious moisture stress symptoms, such as leaf curling and discolouration. The water needs to be reintroduced no later than 10 days before the crop reaches panicle initiation. The aim of the practice is to reduce the severity of physiologically induced sterility.
mycelium	Vegetative system of fungi made of microscopic filaments (hyphae).

Glossary
of terms

Term	Description
node	Points on a stem from which leaves, shoots, or flowers grow. A "joint" is another term for a node.
noxious weed	An invasive species of plant that has been designated by the controlling authority as one that is injurious to agriculture, horticulture, natural habitiats and ecosystems, humans and/or livestock. Most are introduced species. Typically they grow aggressively, multiply quickly and have adverse impacts on the environment in which they are a weed. Classification based on local government areas specifies how the weed must be treated/controlled.
nymph	Immature stage of insects that develop progressively towards an adult of similar body form without pupating (e.g., Australian plague locust).
oospores	Thick walled resting structure.
operculum	Hardened disc that can be retracted into the shell of some snail species (absent in common native snails in rice, present in golden apple snail).
oval (shape)	Having the general form, shape, or outline of an egg
ovate (shape)	Rounded, egg-shaped, broader at the base than the apex.
overwintering	Important stage for a pathogen on which it depends its survival from one year to another.
panicle	Branched flower/seed head.
parasitoid	A parasite that kills its host during development.
pathogen	A disease causing organism.
perennial	Living for more than two years.
permanent water	Ponded irrigation water (100–200 mm) applied to rice bays for the duration of crop growth.
prostrate	Lying flat on the ground.
pupa	Non-feeding stage of some insects (e.g., bloodworms, armyworm) intermediate between the larval and adult stages.
pyramidal, pyramid (shape)	Shape of grass inflorescence or flower head, wide at the base, leading to a pointed apex.
raceme	Single stem holding flowers/seeds.

Term	Description
rhizome	Underground stem, distinguished from root by its nodes, buds or scale-like leaves.
sclerotia	Resting bodies formed by the aggregation of mycelium into dense masses (survival structures).
secondary roots	Roots forming off the primary root, often called branch roots.
sedge	A grass-like plant with triangular stems and inconspicuous flowers.
seed borne	Carried on or within a seed.
semi-aquatic	Adapted for living or growing in or near water.
sod sown	Rice seed sown directly into uncultivated stubble or pasture using seed drills that minimise soil disturbance; permanent water applied after rice plants have established.
spike	The flowering head in a grassy plant made up of a stem/axis holding flowers along it.
spikelet	A small spike, the unit of a grass flower that contains one or more individual florets.
stolon	Lateral above ground stem (runner) which roots at the nodes.
stoloniferous	Producing stolons.
stonewort	Highly developed forms of algae resembling plants.
submerged plant	A plant which resides totally below the surface of the water.
tiller	The shoot of a grass, arising from buds at the nodes of a plant.
tillering	Vegetative growth stage of a grass, when side shoots are developing, in addition to the main stem.
veins (leaf)	A vascular structure in a leaf that provides supports for the leaf and transports both water and food. Used to identify some plants. Can be parallel or trasverse.
virulent	Able to infect a plant.
whorl	Three or more organs (flowers or seed pods) arising from one level on the axis.

Rice production

Ricecheck recommendations. Published annually by NSW DPI.

Rice crop protection guide. Primefact number 256. Published annually by NSW DPI. A guide to the pesticides that are approved for the control of weeds and invertebrate pests in rice.

Weeds information

Noxious and environmental weed control handbook. A guide to weed control in non-crop aquatic and bushland situations. NSW DPI (see current edition).

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NSW DPI Weed alert: Alligator weed. Available at: www.dpi.nsw.gov.au/factsheets

Alligator weed - Weed of National Significance. NSW DPI available at http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/profiles/alligator

Sagittaria. http://keyserver.lucidcentral.org/weeds/data/03030800-0b07-490a-8d04-0605030c0f01/media/Html/Sagittaria_platyphylla.htm

Weed Worries?

The Department of Primary Industries website provides the latest information on weed species, management advice and landholder obligations.

The site includes:

- The complete list of noxious weeds for every Local Control Area in NSW
- Requirements and obligations under the Noxious Weeds Act 1993
- Publications on a range of weeds species including control manual for Weeds of National Significance
- Information on weed management courses offered through PROfarm

NSW no space 4 weeds

Visit our website
www.dpi.nsw.gov.au/weeds

NSW Department of Primary Industries

Diseases of rice

Webster, R.K. and Gunnell, P.S. (ed.) (1992). *Compendium of rice diseases.* American Phytopathological Society, Davis, Ca, USA.

Ou, S.H. (1985). *Rice Diseases*. 2nd edn. Commonwealth Mycological Institute, Kew, England.

Exotic disease threats

Exotic pest alert: Kernel smut of rice. NSW DPI Primefact 1214

Exotic pest alert: Bacterial panicle blight. NSW DPI Primefact 1215

Exotic pest alert: Rice blast. NSW DPI Primefact 1211

Exotic pest alert: Bakanae. NSW DPI Primefact 1216

Exotic pest alerts are available at www.dpi.nsw.gov.au/biosecurity/plant/exotic-pest-alerts

Pests of rice

Stevens, M.M., Brickhill, J. and Brown, P. (2004). *Production of quality rice in south-eastern Australia. Chapter 10. Pests of rice crops – vertebrates and invertebrates*. RIRDC, NSW Agriculture.

Stevens, M. M. (1997). *Common invertebrates of New South Wales rice fields. Biology, pest status and control.* RIRDC, NSW Agriculture.

Stevens, M.M. (2005). *Pests of field crops and pastures. Identification and control*. Bailey, P. (Ed.) *Chapter 9. Rice*. CSIRO.

Exotic pest threats

Exotic pest alert: Rice water weevil. NSW DPI Primefact 1213

Exotic pest alert: Golden apple snail. NSW DPI Primefact 1212

Exotic pest alerts are available at www.dpi.nsw.gov.au/biosecurity/plant/exotic-pest-alerts