NSW GOVERNMENT | Primary Industries

2011 Ricecheck recommendations

A management guide for improving rice yields, grain quality, profits and sustainability

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ALWAYS READ THE LABEL

Users of agricultural or veterinary chemical products must always read the label and any Permit, before using the product, and strictly comply with the directions on the label and the conditions of any Permit. Users are not absolved from compliance with the directions on the label or the conditions of the Permit by reason of any statement made or not made in this publication.

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The information contained in this publication is based on knowledge and understanding at the time of writing (July 2011). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of Department of Primary Industries or the user's independent adviser.

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Cover photo: John Lacy, Industry Leader – Rice Farming Systems, Department of Primary Industries, Yanco has retired after 40 years of service to the irrigated industries of southern NSW

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Contents

Important: Use of pesticides

Pesticides must only be used for the purpose for which they are registered and must not be used in any other situation or in any manner contrary to the directions on the label.

Some chemical products have more than one retail name. All retail products containing the same chemical may not be registered for use on the same crops. Registration may also vary between States. Check carefully that the label on the retail product carries information on the crop to be sprayed.

This publication is only a guide to the use of pesticides. The correct choice of chemical, selection of rate, and method of application is the responsibility of the user. Pesticides may contaminate the environment. When spraying, care must be taken to avoid spray drift onto adjoining land or waterways.

Pesticide residues may accumulate in animals treated with pesticides, or fed any crop product containing pesticides or their residues. In the absence of any specified grazing withholding period(s), grazing any treated crop is at the owner's risk. Withholding periods for stock treated with any pesticides or fed on any pesticide treated plant matter must also be observed.

Pesticide residues may also contaminate grains, oils and other plant products for human use and consumption. Growers should observe harvest withholding periods on the pesticide label and should not assume that in the absence of a withholding period or after the expiry of a withholding period that the plant products will be free of pesticide residues.

ALWAYS READ THE LABEL. Users of agricultural chemicals must always read the label, and any permit, before using pesticide products, and strictly comply with the directions on the label or permit.

SunRice regularly tests rice grain for chemical residues to ensure levels are below maximum residue limits.

Adopt more Key Checks and increase yield

Figure 1. Yield response to Ricecheck management 1994 to 2002

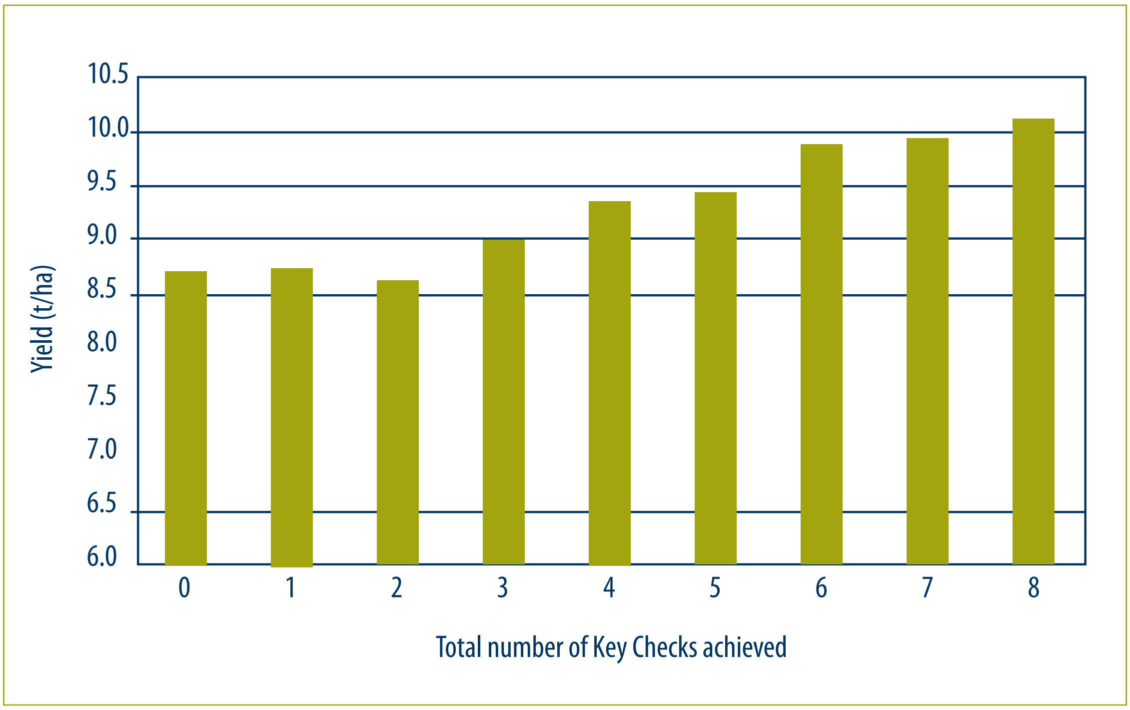

Figure 1 is taken from an average of nine years of data of Amaroo from Ricecheck records, illustrating the benefits of Ricecheck. It shows that as more of the Key Checks are adopted, the chances of obtaining a high yield are increased.

Summary of Ricecheck Recommendations

	PRODUCTIVITY	
	Field layout: the foundation stone of successful ricegrowing	
Key Check	• **Develop a good field layout with a landformed, even grade between banks and well-constructed banks of a minimum height of 40 cm (measured at the lowest point).**	Page 8
	• Supply an adequate head of water to allow a minimum of 20–25 cm water depth at microspore.	
	• Ensure clean and adequate capacity supply and drainage channels.	
	• In contour bay layouts a contour interval of 5 cm is ideal. Zero slope is ideal for terraced bays.	
	• Ensure culvert pipes, stop heights and widths allow adequate water flow.	
	• Supply and drain each individual bay through a side channel.	
	Sowing time: sowing on time gives maximum yield potential every year	
Key Check	• **Sow on time during the 'ideal' sowing window for each variety.**	Page 9
	Crop establishment: the first step on the yield ladder	
	• Undertake major field layout improvements (landforming and bank construction) prior to winter.	
	• Start ground preparation (vegetation control and/or cultivations) early enough to ensure sowing on time.	
	• Provide a level surface with enough roughness or cloddiness to suit the sowing method.	
	• Sow 125–150 kg seed/ha when aerial sowing and 135–170 kg seed/ha when drill sowing.	
Key Check	• **Achieve a uniform plant stand of 200 to 300 plants/m^2.**	Page 9
	Crop protection: weeds and pests reduce yields	
	• Prepare the field to minimise weed and snail numbers at sowing.	
Key Check	• **Apply only registered or approved pesticides to control weeds and insect pests to prevent economic yield loss.**	Page 11
	• Monitor herbicide resistance and implement recommended strategies.	
	Crop nutrition: the split nitrogen strategy: two steps important to high yields	
Key Check	• **Pre-permanent water nitrogen – apply sufficient nitrogen to achieve the target range nitrogen uptake at panicle initiation (PI).** **The PI topdressing rate should not exceed 60 kg N/ha.**	Page 14
Key Check	• **PI nitrogen – Use fresh weight and NIR analysis to determine topdressing nitrogen fertiliser requirements.**	Page 15
Key Check	• **Phosphorus – Before sowing, drill or incorporate 10–25 kg P/ha where the Colwell soil phosphorus level is below 20 mg/kg.**	Page 17

	Precision agriculture: manage soil and crop growth variation to improve profit	
Key Check	• **Use landforming cut/fill area maps, electromagnetic (EM) maps or aerial image maps to assess and manage soil and crop growth variability.**	Page 19
	• When landforming, topsoil 'new' cut areas or apply extra nitrogen and phosphorus and organic manures to 'old' cuts.	
	• Use EM maps to identify field zones with different soil characteristics. Obtain soil tests for each zone and use the tests as a basis for variable fertiliser and treatment application.	
	• Use aerial images to identify crop vigour zones at PI. Sample the zones for the NIR Tissue test and apply variable rate nitrogen based on the test results.	
	Panicle Initiation (PI) date: minimising risk of cold stress	
Key Check	• **Achieve PI before 10 January.**	Page 19
	Water management: the right depth at the right time	
	• Apply shallow water (3–5 cm on the high side of each bay) during establishment and tillering.	
	• Achieve 10–15 cm on the high side of each bay by panicle initiation.	
Key Check	• **Achieve a minimum water depth of 20–25 cm during the microspore stage.**	Page 19
	• Drain at the right time to ensure grains mature properly and prevent the crop haying off.	

	ENVIRONMENT	
	Land suitability: minimise effects to the environment	
Key Check	• **Minimise accessions to the watertable by using land of low permeability that is classified as suitable for rice growing, to ensure water use is within the seasonal limit set by the local irrigation company.**	Page 8
	Safe pesticide use:	
	• Prevent or minimise pesticide and nutrient residues in off-farm drainage water.	
Key Check	• **Do not drain rice water into regional drains within 21–28 days of pesticide application, as determined by the local irrigation company.**	Page 12

	GRAIN QUALITY	
	Harvest grain quality: management affects the result	
	• Manage the crop to ensure grain ripening, drainage and harvest occurs during milder autumn weather.	
Key Check	• **Maintain food safety and quality by preventing physical, chemical or biological contamination of the grain.**	Page 23
	• Clean headers, bins and trucks prior to harvest to prevent weed, insect and varietal contamination and prevent contamination from foreign objects such as glass.	
	• Adjust harvest machinery to minimise dockages.	
Key Check	• **Harvest the rice crop between 20 and 22% moisture content to maximise grain quality.**	Page 21

Steps to using Ricecheck

Ricecheck encourages you to manage your rice crop by comparing your practices with the practices producing the highest yielding crops.

It involves crop monitoring, measuring crop performance and analysing results. It helps you to learn from your experiences to improve your crop management in the future. Observing, measuring, recording, comparing and adopting best practices are the learning steps involved in identifying the strengths and weaknesses of your management.

1. Manage your crop using the recommendations.

This book *Ricecheck recommendations 2011* provides you with the latest recommendations. For achieving consistently high yielding rice crops the key checks are the most important and require particular attention. Read this book thoroughly, and refer to it throughout the season.

For additional details, refer to *Production of Quality Rice in South Eastern Australia.* Keep up-to-date with Department of Primary Industries Primefacts and consult your District Agronomist.

2. Check your crop – observe, measure and record crop growth and management performance.

- **Observe** your crop regularly and take a close look at it by walking into the crop (that is, 'check' it). Don't manage your crop from the road or bank. Get your boots wet. See what is actually happening in the crop. Don't assume everything is OK.
- **Measure** crop growth when walking through the crop. Measuring with a ruler or ring is better than guessing. Count the number of plants and weigh samples for the NIR tissue test. Measure the depth of water and the height of the banks. Carry out the key checks.
- **Record** your measurements. Recording is an important part of using Ricecheck to ensure that the information is available for later use. Relying on memory is not good enough. Use the Ricecheck Crop data form or your own field notebook or office file. The important thing is to write it down!

3. Compare and interpret results to identify problem areas.

How did you achieve your yield or grain quality target? Interpret and analyse your management activities, measurements and yield results to identify:

- practices that achieved key checks;
- management which may have limited yield and can be improved.

Your District Agronomist can help with this analysis, providing you have good records.

4. Determine the best practices.

How did your practices compare with the highest yielding crops? What practices do you need to change?

5. Implement improved management practices next season.

Overcome poor results, or repeat management which resulted in good yields. Learn from your experiences.

Ricecheck: Recommendations 2011

The Ricecheck recommendations are based on current rice technology developed from extensive field experience and rice research and development projects. They represent the current state of knowledge and the successful farm practices identified by experienced ricegrowers, research scientists and extension agronomists. Each year, the recommendations are reviewed and revised based on seasonal experiences, research, extension and farmer results.

Target yield

Yield potential varies between ricegrowing valleys, with the Murrumbidgee Valley experiencing higher minimum temperatures than the Murray Valley. These higher temperatures enable higher yield potential in the Murrumbidgee Valley than the Murray Valley. Farmers in each valley are challenged to achieve the target yields, which are set 10–15% above average yields but are achievable by using current technology and adopting the key checks. See Table 1 for variety and valley yield targets.

Table 1. Yield targets (t/ha) by variety and region

Variety	Target yields (t/ha)			
	MIA	CIA	EMV	WMV
Amaroo, Reiziq, Illabong, Quest, Opus, Sherpa	11.5	11.0	10.5	10.0
Langi	10.5	10.0	9.5	9.0
Doongara	10.0	10.0	–	–
Jarrah	9.0	9.0	8.5	8.0
Kyeema	8.5	8.5	–	–
Koshihikari	–	–	9.0	8.5

Target water productivity

Maximising grain yield per megalitre of water is important for efficient water use. Since yield potential and water use vary between the Murrumbidgee Valley and the Murray Valley and between varieties, water productivity targets are specific to valleys and varieties. Table 2 shows the water productivity targets (irrigation and rainfall) for Amaroo and Langi by region. These targets are set approximately 10% above the overall average for each region since 1998. Water productivity can be improved by increasing yield, reducing water use, or by both.

Table 2. Water productivity targets (t/ML) for Amaroo and Langi by valley

Variety	Target water productivity (t/ML)		
	MIA	CIA/EMV	WMV
Reiziq	0.80	0.75	0.70
Langi	0.75	0.70	0.65

Note: Reiziq water productivity targets follow those of Amaroo.

Planning

Consistent production of high yielding, high quality and profitable rice depends on forward planning and a high level of management in all aspects of operating the rice farm system. The performance of other crops and pastures in rice rotations will have an impact on the management and yield of the rice crop.

1. Land suitability

Key Check: Minimise accessions to the watertable by using land of low permeability that is classified as suitable for rice growing, to ensure water use is within the seasonal limit set by the local irrigation company.

It is important that land used for rice growing is of low permeability to stop water seeping through to the watertable. Total water use should normally be below 14–16 ML/ha for the season. Depending on seasonal conditions, irrigation companies will determine suitable levels of rice water use each year. All fields used for rice must be approved by the local irrigation company. Outside of irrigation company areas there is limited opportunity for new rice development because there are no longer suitable land criteria. EM31 and soil sodicity tests are the main tests for assessing rice land suitability. Gypsum applications may increase soil permeability, resulting in excessive water use for rice.

2. Field layout

Key Check: Develop a good field layout with a landformed, even grade between banks and well-constructed banks of a minimum height of 40 cm (measured at the lowest point).

Plan supply, drainage and recycling

Water management is important. The best way is to be able to supply and drain water to and from individual bays via channels down the side of each field. This allows quick achievement of target water depths at any time during the season. It also helps with the management of land preparation, crop establishment, excess water from rainfall and drainage at maturity.

Supply to each individual bay allows greater flexibility and easier management than a single outlet in the top bay which supplies lower bays.

Alternating bay outlets between one side of the field and the other (see Figure 2C, page 19) can improve water flow within and between bays. This will ensure fresh water supply to all parts of the field, which can help reduce slime and the build-up of salinity (see page 19). Toe furrows are part of the bay drainage system and should be linked to the stops and bay outlets. Drainage systems should include recycling pumps to save water and prevent pesticide or nutrient residues entering regional drains.

Laneways around fields are important for access and improved management, such as monitoring water levels and controlling ducks.

A level rice bay will improve uniformity of crop growth and weed control, and improve water use. It should be landformed, or the equivalent, and have a **5 cm contour interval** between banks (or no more than 7.5 cm) to allow an even water depth over the bay. Flat bays in terraced bay layouts are ideal. Prepare bays well in advance of sowing when landforming or grading which can affect soil structure, leading to muddy water and poor root anchorage.

An optimum bay size range of 3–6 ha will allow good water control and efficient use of machinery.

Supply channels should be cleaned and be large enough to handle 12 ML/day (10 revs) flow rates which are needed to increase water levels just after PI. Poor channel weed control can be a major obstacle to achieving adequate flow rates. Allow sufficient head between the supply and rice bays to achieve a minimum of 20–25 cm water depth on the high side of the bays during the microspore stage. If sufficient head is not possible, alter slopes or change paddocks or use extra stops in the channels and bays. Ensure that culvert pipes, stop heights and widths match channel flow capacities.

Aim for a minimum consolidated bank height from the bay surface of 40 cm. Higher banks (up to 60 cm), particularly on bottom bays, provide greater flexibility for coping with thunderstorms, wind, cracking clay soils and retaining pesticide residues on-farm within 21–28 days of application. A width of 4–5 m between toe furrows is usually required.

Disc bankers are ideal for increasing the height of old banks. New banks should have 3 months' consolidation to reduce leakage and subsidence. Banks on cracking soil types which easily leak should have additional compaction and 6 months' consolidation.

Bay stops should be situated appropriately and high enough to allow high water depths required at microspore. Care is required in pushing up ends consistent with bank height. Wide bay outlets (up to 1 m) located between upper bays will assist water flow to lower bays during periods of high demand.

3. Sowing time

Key Check: Sow on time during the 'ideal' sowing window for each variety.

This ensures optimum plant growth and development.

1. Establishment occurs during a period of favourable temperatures for germination and seedling survival.
2. The critical reproductive growth stage, in particular microspore, occurs from late January to mid February when temperatures are most favourable and the risk of low (< 17°C) night temperatures is least. Cold damage still occurs in 1–3 years out of 10 in this favourable period, therefore spread the risk by having multiple sowing dates in the recommended window to enable staggered microspore timings.
3. Grain ripening, maturity and moisture drydown for harvest occur when 'milder' autumn temperatures are more likely which favour grain quality.

The target sowing dates for aerial and drill sowing for each valley are shown in Table 3. For drill and sod-sown crops it is assumed that the crop is flushed within 5 days of sowing. Sowing more than 10 days after the latest date is not recommended.

4. Crop establishment

Key Check: Achieve a uniform plant stand of 200 to 300 plants/m^2.

Good, uniform crop establishment is important for high yields. Competitive crop growth will aid early weed control and may reduce the reliance on herbicides. In farmer crops, the area of poor or uneven establishment can vary from 5 to 20% depending on the season. This is a major barrier to lifting industry yields.

Ground preparation

Aim to create a well-aggregated, firm seedbed 5 to 7 cm deep with most clods in the 1 to 5 cm range.

Aerial and drill sowing

Start ground preparation in autumn or mid-winter to allow enough time for bank construction and to minimise plant material on the soil surface at sowing. Early preparation ensures sowing on time.

Grading may be necessary after disc cultivation to remove hills and hollows created by the discs.

Table 3. Target dates for aerial and drill sowing for each region and variety

Variety	Aerial		Drill/sodsowing	
	MIA/CIA	MV	MIA/CIA	MV
Amaroo	1–20 Oct	1–15 Oct	1–15 Oct	1–10 Oct
Reiziq	1–20 Oct	1–15 Oct	1–15 Oct	1–10 Oct
Quest[1]	15–31 Oct	15–25 Oct	10–25 Oct	10–20 Oct
Sherpa	20 Oct–5 Nov	20–31 Oct	15–31 Oct	15–25 Oct
Illabong	–	15–31 Oct	–	10–25 Oct
Opus	–	10–25 Oct	–	5–20 Oct
Jarrah	1–15 Nov	1–10 Nov	25 Oct–10 Nov	25 Oct–5 Nov
Koshihikari	–	5–25 Oct	–	1–20 Oct
Langi	5–31 Oct	5–25 Oct	1–25 Oct	1–20 Oct
Doongara	5–25 Oct	–	1–20 Oct	–
Kyeema	5–31 Oct	5–25 Oct	1–25 Oct	1–20 Oct

[1] Quest sowing date may be influenced by the SunRice seed pick-up date.

Where early crop growth is expected to be slow as a result of heavy soil, muddy water or late worked subclover, sowing can start 5 days earlier than recommended in the table, except for sowing before 1 October. Drill/sodsowing dates are first flush dates.

Dry aerial seeding

Dry aerial seeding (dry seed sown into permanent water) and dry broadcasting (dry seed sown onto dry soil, before permanent water) are techniques that have gained popularity in recent years but have increased risk of low levels of plant establishment. Savings in labour, sowing cost and improved establishment on difficult soils are some of the advantages claimed for these techniques. Emergence through the water is normally 2 or 3 days slower than for aerial sowing. Reduced seedling numbers may be compensated for by higher seeding rates. Standard aerial sowing of pre-germinated seed into permanent water can give more consistent results under cool and muddy water conditions.

Ridge rolling

As a final operation prior to permanent water, ridge rolling can achieve a good seedbed more quickly and more cheaply than conventional equipment on cloddy clay soils and rice stubbles. The seed lies in deep grooves, minimising seed drift and improving plant distribution. This is especially important in preventing seed burial when dry sowing. The roller also produces an even surface that improves water management and allows early rice emergence and effective weed control.

Ridge roll high scarifier ridges to avoid clumped rows of plants and uneven water depths. To reduce wind damage use smaller drill ridges. Avoid fine seed beds and contour banks running in a south-west/north-east direction. Maintain shallow water on grey clays which often slake (melt) when permanent water is applied.

Muddy water sites

On dispersive soils which can lead to excessive muddy water (i.e. visibility less than 3 to 4 cm), as in the Western Murray Valley, good crop establishment is more difficult to achieve. Plant numbers are reduced and maturity is delayed. Cultivate as little as possible to maintain soil structure and delay ploughing in dry plant residue until the end of winter. Although excessive pasture vegetation can decrease establishment, some residue can reduce slaking and dispersion.

On dispersive (muddy) soils, shallow water during establishment is essential and the use of ridge rollers will help achieve this result. These crops may have areas that need to be drained during establishment as the temperature of the muddy water can be 5°–8°C below clear water which greatly inhibits seedling growth. Refill with clear water. Bird control is essential during this process to prevent seed predation. Broadcasting gypsum at 1.25 to 2.0 t/ha immediately prior to filling up reduces muddy water. Use the higher rate on extreme muddy water problem sites such as the central Deniboota and Wakool Irrigation Districts.

Direct Drilling

Rice can be direct seeded (sodsown) after a rice stubble or after a pasture. A knockdown herbicide is recommended in the following situations:

- Subclover pasture has greater than 50% grass.
- Barnyard grass or silvertop is present.
- Pasture growth cannot be grazed below 5 cm.

Refer to *Rice crop protection guide 2011* for more information on herbicides.

Pasture control

Reduce the amount of pasture in late winter and early spring by heavy stocking and using knockdown herbicides or by avoiding watering. Incorporating large amounts of vegetation when cultivating for aerial or drill seeding can lead to excessive slime problems and poor seedling establishment. Pasture growth when direct drilling should be no more than 5 cm in height.

The required stocking rates will vary from 25 to 30 dse/ha in August to 40 dse/ha in September just to control the pasture growth.

Bay filling

For aerial sowing, fill bays as quickly as possible to 3–5 cm deep and sow within 5–7 days of initial permanent water. Quick fill-up in 5–7 days allows earlier application of herbicide treatments to young germinating weeds and easier preventative weed control. Delayed sowing can lead to reduced plant establishment due to slime build-up, low oxygen levels in water, soil clod meltdown, a build-up of fungal organisms and advanced weed growth.

Flushing or permanent water should occur within 12 hours of dry broadcasting to prevent birds from eating the seed on the soil surface.

Sowing rates

Sowing rates to achieve 200–300 plants/m^2 are in the range of 125–150 kg/ha for aerial sowing and 135–170 kg/ha for drill sowing. A 150 kg/ha sowing rate provides about 600 seeds/m^2. For dry aerial and broadcast sowing, increase rates by 10% as seedlings are slower to emerge or may have lower germination. Increase Illabong sowing rates by 15% to compensate for larger seed size and slightly lower vigour.

Yield potential can be reduced if plant numbers are less than 150 plants/m^2 (see Table 4) because the plants may not tiller sufficiently to achieve the required fresh weights at panicle initiation. Yield potential can also be reduced if plant numbers are greater than 300 plants/m^2 because this can lead to a high and excessive number of shoots and biomass, and an increased risk of sterility.

It is difficult to know when plant populations are low enough to warrant resowing, but the longer the decision is delayed, the less successful it will be. If plant populations are less than 80/m^2, consider resowing if this is patchy or over a large area. Uniform populations as low as 20 plants/m^2 have sometimes resulted in reasonable yields.

Table 4. Yield potential from plant numbers

Plants per m^2	Population rating
200–300	Excellent
150–200	Acceptable: less chance of high yields
80–150	Fair: high yields difficult to achieve
under 80	Poor: high yields unlikely. Consider resowing if establishment is patchy.

Seed preparation

The recommended method for aerial sown pre-germinated rice is to soak the seed in water for 24 hours and to remove the water and store the grain for 24–48 hours (drain period). Temperatures above 35°C when rice is aerating after soaking in soaker silos and trucks can severely reduce the germination or kill rice. Thus in hot weather monitor the temperature of aerating rice and if necessary take action to cool the rice.

Slime

Seedling establishment can be reduced by slime. Germination of seed is reduced due to the presence of a 'fuzzy' coating or the weight of the slime or bacteria which holds the plants down.

Green slime potential is reduced by minimising organic matter and phosphorus nutrients on the soil surface. Avoid slime by effective burning of stubble, hard grazing of subclover pasture and by drilling phosphorus fertiliser beneath the soil surface.

Green slime is an alga which can be treated with algacide or by lowering water levels.

Brown slime is more difficult to control. It is caused by iron-oxidising bacteria found in most rice growing soils. As they multiply, the bacteria produce sticky sugars which form slime. Organic matter, organisms and green slime attach to the slime. Brown slime tends to increase as urea rates increase. Control brown slime by lowering water levels and exposing the rice and slime to sunlight. This dehydrates the slime and assists rice growth.

5. Crop protection

Key Check: Apply only registered or approved pesticides to control weeds and insect pests to prevent economic yield loss. See the *Rice crop protection guide 2011*.

A. Weed control

Many factors are important for successful weed control.

1. **Know your rice field.** A good knowledge of the weed situation in each field is important. Observations of previous rice or other rotation crops will provide useful information on weed activity. This is particularly important with perennial or biennial weeds such as water couch, silvertop, cumbungi, alisma and umbrella sedge.
2. **Inspect the crop.** Look for weeds at sowing and inspect your crop every 4 to 5 days during the first 3–4 weeks.

Experience suggests that weed populations of 10–15 plants/m^2 barnyard grass, 30 plants/m^2 dirty dora, 10 plants/m^2 starfruit and 30 plants/m^2 of silvertop can lead to economic yield losses.
Attempt to control all alisma and water plantain infestations to avoid the build-up of seed.

3. **Apply herbicides at the appropriate time.** Herbicides should be applied at the correct stage of weed and rice growth, before the weeds become too large.
4. **Apply the correct rate of herbicide.** Apply the registered label rate to ensure adequate control and reduce the risk of herbicide resistance.
5. **Control water depth and herbicide.** Water depth and flow management after application are an important aspect of successful weed control. Some herbicides require no water movement for 5 days after application.
6. **Read the label.** The grass weeds barnyard grass and silvertop can be controlled by various herbicide application strategies. Knockdown herbicides can be applied pre-sowing or pre-rice emergence prior to flooding. Selective grass herbicides can be applied pre-permanent water (drill sowing), at permanent water (by drip or aerial application) or post-permanent water until the weeds reach maximum growth stage.

   New rice land that has never been irrigated or flooded before is not likely to have a significant weed problem, with the possible exception of cumbungi. Cumbungi often occurs on new paddocks that have been aerially sown, and can become a problem if rice is re-sown in the following season.

Prevent spread of new weeds such as alisma and water plantain to other farms by maintaining good hygiene of cultivation, sowing and harvesting equipment, and footwear and vehicles.

7. **Herbicide resistance.** In the 1992–93 season, resistance to the herbicide Londax® was confirmed in 3 aquatic broadleaf weeds of rice – dirty dora, starfruit and arrowhead. Resistance became more widespread with each subsequent growing season. In 1998–99, a survey found 50% of dirty dora and 40% of starfruit and arrowhead populations resistant to Londax. Integrated weed management strategies implemented to overcome herbicide resistance have been successful in achieving effective weed control.

   It is important to closely monitor and record weed burdens, herbicide usage patterns and spray results, as alternative herbicide options are extremely limited. Check crops for any weed escapes. Use the 'Bin Test' to test for resistance, and send seed samples to the Charles Sturt University seed testing service.

The main herbicide resistance strategies are:

a) Cultural management
   - Rotate paddocks to avoid build-up of resistant weeds;
   - Consider drill sowing as fewer aquatic weeds germinate compared to aerial sowing.

b) Herbicide management
   - Use each herbicide as directed on the label to achieve effective weed control;
   - It is recommended that two herbicides (i.e. two different modes of action) be used on each aquatic weed to ensure total control. Consider the use of MCPA+Basagran M60® or Gulliver® + MCPA in conjunction with all herbicide programs. If available, use a herbicide with a different mode of action in following rice crops;
   - Details of registered herbicides and alternative application strategies for resistance management are summarised in the *Rice crop protection guide 2011.*

B. Pest control

The most common pests of rice are bloodworms, snails, ducks, aquatic worms, leaf miner and armyworms.

Bloodworms attack most aerially sown rice crops. All aerially sown crops should be treated for bloodworms at or within 24 hours of sowing, with further treatment(s) up to 3 weeks after sowing. Control may also be necessary in drill-sown crops, particularly when rice is sod-seeded into pasture.

Snails can be a problem in aerially sown crops from sowing until mid-tillering. Numbers may increase following wet winters and are higher in paddocks which grew rice in the previous season. A year's break from rice significantly reduces snail numbers.

Ducks and ibis often affect late sown crops with weak establishment areas. Use strategic shooting, scare guns, lights and plastic bags on stakes to scare birds from rice crops. Aim to prevent any birds from settling, as they are likely to attract additional numbers.

Galahs, cockatoos and ants carrying away seed can be a problem in dry broadcast crops before flooding.

Aquatic worms can cause serious damage to aerial-sown rice crops. They attract ibis which trample seedlings and muddy the water. However, damage can occur even in the absence of ibis. Control options are limited to draining water, drying out bays and scaring away ibis.

Leaf miner larvae burrowing in rice leaves can delay emergence of rice through permanent water and reduce establishment. If rice emergence is slower than expected, inspect the rice leaves for leaf miner larvae. Control using insecticide.

Locusts can attack seedling rice between flushes of water for drill sown crops. Aerial sown damage is less than drill as the locusts will only eat to the waterline. If the growing point has been eaten the plant will not recover. Manipulation of permanent water timing and depth is the main control.

Armyworms can affect the crop from flowering until harvest. Experience suggests that damage causing loss of 15–20 grains in a 0.1 m^2 rice-ring warrants chemical control. To reduce the risk of possible chemical residues, paddy rice from any sprayed crop must be reported to SunRice for segregation.

Details of registered pesticides are summarised in the *Rice crop protection guide 2011.*

Pesticides in rice drainage water

Key Check: Do not drain rice water into regional drains within 21–28 days of pesticide application, as determined by the local irrigation company.

Water drained from rice fields after the application of pesticides for weed and pest control may contain residues which can affect humans, livestock, or other living organisms. Regulatory guidelines have been set for all agricultural chemicals used on farms to limit the amount of these chemicals entering drainage water delivered into public drains, swamps and watercourses. The concentrations in drainage are monitored by irrigation companies and the NSW Office of Water to prevent damage to the environment. Drainage water arising from heavy rainfall may be partly minimised by large rice banks which assist retention of water.

All rice growers must ensure that pesticides applied to rice fields do not have unintended effects on other organisms.

Suspicious pests and diseases

Australian rice areas are currently free of major overseas rice pests such as golden apple snail and diseases such as rice blast.

The National Rice Industry Biosecurity Plan launched in March 2005 aims to prevent and minimise the incursion and spread of any new pests or disease in rice crops. Refer to the Biosecurity Plan, 'maNage rice' CD and your District Agronomist for information and symptoms of these major pests and diseases.

Rice farmers and agronomists need to maintain constant vigilance of crops to enable early detection of any pests and diseases that are accidentally introduced. Be on the lookout for unusual plant symptoms**. If suspicious symptoms are evident, farmers should contact their local district agronomist or agribusiness agronomist so that samples can be submitted to Yanco Agricultural Institute for assessment. Alternatively ring the Emergency Plant Pest Hotline on 1800 084 881.**

Rice blast is considered the most important rice disease in the world. Although it is not yet present here, NSW has favourable climatic conditions for rice blast. The symptoms of rice blast are lesions which can be found in most parts of the shoot, including leaves, leaf collar, stem, nodes and panicles. Rice growers should be vigilant and report any unusual plant symptoms.

Stem rot is a fungal disease of rice which was observed in NSW in the 1990s but has not been observed on a large scale since. Although it did not cause major losses then, it has been known to cause significant losses in favourable seasons in the US. The most common form of spread is on infected rice straw. When rice is grown on a field infected from the previous year's rice crop, the disease can build up in subsequent crops, particularly if the infected straw is not destroyed immediately after harvest.

Rice growers should check their crops 2 to 3 times between PI and draining, and again after harvest. Symptoms of stem rot are small, dark lesions on rice leaf sheaths at the water level. Straw burning practices appear to be keeping this disease in check.

Aggregate sheath spot and sheath spot. A disease survey in NSW in 2001 confirmed the presence of both diseases in NSW rice fields. Field trials have shown that aggregate sheath spot and sheath spot have the potential to cause yield losses as high as 20% and 10% respectively. Symptoms appear near the water line as spots on the leaf sheaths. The disease cycle of these two diseases is very similar to stem rot so burning stubble is also recommended to keep these diseases under control.

6. Crop nutrition

Nutrient balance

In the long term, fertiliser strategies should ensure that the nutrients removed from the soil by crops are replaced. Maintaining a balance prevents the development of deficiencies which may alter the sustainability of yield and grain quality of rice and other crops or pastures in the rotation.

Table 5 shows the amount of some of the key nutrients removed by a 12 t/ha Amaroo crop. Nitrogen (N) and phosphorus (P) are the most important nutrients for rice.

Table 5. Nutrients removed by a 12 t/ha Amaroo crop

Nutrients removed	In grain (paddy)	In stubble	Total
Nitrogen (kg/ha)	125	83	208
Phosphorus (kg/ha)	30	8	38
Potassium (kg/ha)	38	275	318
Sulfur (kg/ha)	10	8	18
Zinc (g/ha)	215	407	622

Nitrogen

The split nitrogen strategy

There is no reliable method of quantifying the soil nitrogen level before sowing. There is also no accurate method of predicting whether the season will be 'cold', 'average' or 'warm', particularly at the cold sensitive microspore stage of rice growth. Very high nitrogen from either legume pasture or nitrogen fertilisers leads to excessive rice growth, making the rice plant more prone to cold damage and yield loss.

Because of these limitations, split nitrogen application is recommended so that the application can be finetuned to the plant and season. Aim to apply two thirds of the nitrogen at the pre-permanent water stage to achieve the target nitrogen uptake at PI (Table 6), then test the crop and apply additional nitrogen at PI as required. If no nitrogen is required at PI the pre-permanent water nitrogen has supplied all crop requirement. This strategy maximises yield potential and nitrogen efficiency and lowers greenhouse gas emissions and the risk of over-fertilisation and cold damage.

a) Pre-permanent water nitrogen
Applying nitrogen before permanent water provides sufficient vegetative growth and nitrogen uptake at PI to obtain potential high yields. The application of 125 kg urea pre-flood increases PI nitrogen uptake by 20–25 kg N/ha. The amount of N is related to previous paddock history and organic nitrogen from legume pasture which is a significant contributor. Temperatures prior to PI affect the release of organic nitrogen and uptake into rice plants. High temperatures can increase the release and nitrogen uptake by 30–40 kg N/ha.

b) PI nitrogen
This timing aims to finetune the nitrogen requirements to fulfil crop yield potential.

It is based on an assessment of fresh weight, tissue nitrogen and cold risk.

Key Check: Pre-permanent water nitrogen – apply sufficient nitrogen to achieve the target range nitrogen uptake at panicle initiation (PI). The PI topdressing rate should not exceed 60 kg N/ha.

Table 6. Target N uptakes by the crop at PI for all varieties

Variety	Fresh weight (g/m^2)	NIR tissue N% at PI	Target PI N uptake (kg N/ha)
Amaroo, Illabong, Langi, Reiziq, Quest, Jarrah, Opus, Sherpa	2500–3700	1.4–2.0	100–150
Koshihikari, Kyeema	2100–3300	1.0–1.6	60–120
Doongara	2100–3300	1.2–1.8	70–130

Target N uptake

Farmers in the MIA and CIA aiming for high yields (e.g. 12 t/ha for Amaroo) can target the high end of the PI nitrogen uptake range (e.g. 130–150 kg N/ha). Farmers in the Murray Valley should target 110–130 kg N/ha nitrogen uptake because of the higher cold risk and lower yield potential. Deep water at microspore becomes more important at the high end of the ranges because of increased sensitivity to cold temperatures. High nitrogen uptakes above the target range indicate excessive pre-permanent water nitrogen or organic nitrogen and increased risk of cold damage. Nitrogen uptakes below the target range indicate that the pre-permanent water nitrogen or organic nitrogen level was too low.

Paddock history

Paddock history plays a significant role in the nitrogen status of rice crops. Both low and high nitrogen fertility paddocks have the potential for high yields. However, high fertility subclover paddocks with high nitrogen uptakes give more variable yields as they are more likely to be sensitive to cold stress at microspore. In 'colder' years, lower yields are likely, especially if water depths at microspore are below the target of 20–25 cm. See Table 7.

Table 7. Suggested nitrogen fertiliser rates for medium grain rice varieties based on paddock history

Paddock fertility	Paddock history*	Total nitrogen fertiliser (kg N/ha)
Low	Continuous rice cropping	180–240
Fair	Rice after rice or cereals or poor grassy pasture	90–180
Moderate	1–2 years of fair subclover/grass pasture	60–120
High	2–4 years of good subclover	0–60

* For Langi: as for medium grains.
* For Koshihikari and Kyeema – apply 60 kg N/ha less than stated.
* For Doongara – apply 20 kg N/ha less than stated.

Pre-permanent water nitrogen

As the pre-permanent water N rate is difficult to determine, reduce the risk of over-fertilisation or sterility from low temperatures by using the split nitrogen strategy. If total N use is expected to be 200 kg N/ha, apply 150 kg N pre-permanent water and the remainder, based on a NIR tissue test, at PI.

In general, do not apply more than 120–180 kg N/ha (259–388 kg urea/ha) pre-flood for any variety. For heavily cropped rice rotations, apply 180 kg N/ha for semi-dwarf varieties, e.g. Amaroo, Reiziq. In most paddocks this is sufficient nitrogen to achieve 12 t/ha yields. However, some soil types, for example heavy grey clays, may respond to up to 240 kg N/ha.

Application and timing

For aerial sowing apply pre-permanent water nitrogen one to seven days prior to fill-up, preferably drilled in 7 cm deep. For drill sowing broadcast nitrogen onto dry soil then follow immediately with the application of permanent water. These practices reduce the potential for nitrogen loss and greenhouse gas emissions. The application of N shortly after drill sowing and subsequent wetting and drying of the soil during flush irrigation has the potential for significant loss of N. The rule of thumb is 10% loss per flush but it could result in an 80% loss of N.

In deep grooved ridge-rolled paddocks, where seed moves to the bottom of the grooves, ensure the nitrogen fertiliser placement is a minimum of 3 cm below the seed to avoid seed fertiliser contact and potential reductions in seed germination and plant establishment.

Crops sown after 7 November, particularly those with high nitrogen uptake, have a greater risk of cold damage. Therefore, use lower nitrogen rates to produce crops with nitrogen uptakes at the low end of the target range.

Semi-dwarfs, such as Amaroo, are the preferred varieties in high fertility situations.

When sod-seeding into subclover pasture, applying 30–60 kg N/ha pre-flood will help seedling development and early growth.

Starter fertilisers containing N and P are useful in assisting early seedling growth. Examples are DAP and Granulock 12.

Nitrogen fertiliser strips

Nitrogen fertiliser strips help to accurately determine N fertiliser requirements at panicle initiation. Use nil, commercial and double commercial rate fertiliser strips of 50-metre long drill or broadcast runs prior to permanent water

Post-flood to pre-PI nitrogen (mid-season topdressing)

Extensive research has shown that nitrogen fertiliser for rice is best applied at the pre-permanent water stage and at panicle initiation. This maximises the availability and uptake of nitrogen by the rice plant and minimises losses.

However, when vegetative growth prior to PI is obviously restricted by nitrogen deficiency (stunting, poor tillering and severe yellowing) and the predicted N uptake at PI is less than 80 kg N/ha, then immediate topdressing with 60 kg N/ha is advisable to stimulate normal crop growth until PI.

For bays which undergo midseason dry-down in early to mid December, application of nitrogen topdressing just before reapplication of permanent water is more efficient than when the nitrogen is topdressed at PI. However this method cannot be recommended until further investigations are carried out to find a method to evaluate nitrogen status of the crop at mid-season dry down and determine the appropriate nitrogen rates.

Panicle initiation nitrogen

Key Check: PI nitrogen – Use fresh weight and NIR analysis to determine topdressing nitrogen fertiliser requirements.

When to topdress

Both the timing and the rate of nitrogen topdressing application are critical for best results. The decision on when to topdress is influenced by the degree of nitrogen deficiency. The ideal time to topdress is at PI, which is where 3 out of 10 shoots have a panicle 1–2 mm long. The topdressing window ranges from a panicle

(continued one page 17)

Table 8. Nitrogen uptake at panicle initiation (PI)

Fresh weight grams/ m^2	**NIR tissue nitrogen %**									
	< 0.9	0.9 to 1.09	1.1 to 1.29	1.3 to 1.49	1.5 to 1.69	1.7 to 1.89	1.9 to 2.09	2.1 to 2.29	2.3 to 2.49	> 2.5
< 1300	27	30	36	42	48	54	60	66	72	75
1300–1699	31	35	41	48	55	62	69	76	83	86
1700–2099	39	44	52	61	70	79	87	96	105	109
2100–2499	47	53	63	74	85	95	106	116	127	132
2500–2899	55	62	75	87	99	112	124	137	149	155
2900–3299	63	71	86	100	114	128	143	157	171	178
3300–3699	72	81	97	113	129	145	161	177	193	201
3700–4099	80	90	108	126	144	161	179	197	215	224
4100–4499	88	99	119	138	158	178	198	218	237	247

The figures in Table 8 are the levels of nitrogen uptake by the crop at PI (panicle initiation) in kg N/ha as calculated from the fresh weight and NIR tissue nitrogen %.

These tables (Tables 8, 9 and 10) incorporate the nitrogen uptake calculation. The exact calculation for nitrogen uptake is:

$$\frac{\text{fresh weight (g/m}^2) \times 0.23 \times \text{NIR N\%}}{10} = \text{N uptake kg/ha}$$

(0.23 converts fresh weight to dry weight)

Example: A crop with fresh weight @ 3100 g/m^2 and NIR Tissue N @ 1.4% has a PI nitrogen uptake of 100 kg N/ha.

$$\frac{3100 \times 0.23 \times 1.4}{10} = 100 \text{ kg N/ha}$$

Table 9. Nitrogen topdressing recommendations

Variety group	Water depth @ microspore	PI nitrogen uptake (kg N/ha, from Table 8)					
		40–60	61–80	81–100	101–120	121–140	> 140
		Nitrogen PI topdressing recommendation (kg N/ha)					
Amaroo, Quest, Illabong, Jarrah, Langi, Opus, Reiziq, Sherpa	Deep	150	120	90	60	30	0
	Shallow	120	90	60	30	0	0
Kyeema, Doongara, Koshihikari	Deep	120	90	60	30	0	0
	Shallow	90	60	30	0	0	0

Table 9 provides the nitrogen topdressing rate based on the PI nitrogen uptake level (obtained from Table 8) for each variety and for deep and shallow water depth at microspore.

Example: For Amaroo with deep water @ microspore and a PI nitrogen uptake of 100 kg N/ha (in the table range of 81–100), the recommended nitrogen topdressing rate is 90 kg N/ha.

Note: The recommendations contained in these tables are expected to provide a positive yield response to the nitrogen fertiliser applied at PI in the majority of seasons. The profitability, that is, the extra return compared with the extra costs, will depend upon the costs of topdressing (fertiliser and application costs), the actual yield response in the particular season and the rice paddy returns. Table 10 provides an indication of the range of yield responses that may be expected for Amaroo.

Table 10. Yield response (t/ha) to nitrogen topdressed at PI
For Amaroo, Quest, Langi, Illabong, Reiziq and Sherpa, sown on time, with deep water (minimum 20–25 cm) at microspore

Crop nitrogen uptake at PI (kg N/ha)	Yield response to different rates of topdressed nitrogen at PI (kg N/ha)	
	90	150
40	1.6	2.6
60	1.4	2.3
80	1.2	1.8
100	0.9	1.4
120	0.5	0.9
140	0.3	0.5
160	0.1	0.2
180	0	0

These yield responses are based on the use of experimental data. The actual responses to topdressed nitrogen at PI may be different to those indicated. Yields represent the estimated yield increase, in tonnes/hectare, over no N application for Amaroo sown on time in an average season.

Example: Variety: Amaroo
PI nitrogen uptake: 100 kg/ha
PI topdressing rate: 90 kg N/ha
Expected extra yield response: 0.9 t/ha in an average season

The $ value of this extra yield (net of harvesting costs) can be compared with the costs of the topdressed fertiliser and aircraft application or using 'maNage rice'.

Note:

1. **Nitrogen topdressing tables:** Ricegrowers requiring more detail about yield responses to nitrogen topdressed at PI for most semi-dwarf varieties, the risk involved and an economic cost/benefit analysis should use the 'maNage rice' computer software program. This program simulates the effect of sowing date and PI, variable temperature conditions and changing costs and returns for topdressing, harvesting, cartage and paddy returns on yield responses to topdressing.
2. **Fresh weight:** Fresh weight (g/m^2) of rice samples at PI provides the most accurate indicator of crop dry matter, and, with NIR tissue nitrogen %, is used to calculate the nitrogen uptake at PI. The likely response to topdressed nitrogen can then be assessed from the nitrogen topdressing recommendation (Table 9) and the yield response (Table 10). **Use the sampling techniques recommended** in the Rice NIR Tissue Test instructions.
3. **Water depth at microspore:**
   Deep water: 20–25 cm
   Shallow water: less than 15 cm

length of 1 to 50 mm and usually occurs over a 10 to 12 day period, depending on weather conditions. Crops should be topdressed as soon as possible after the NIR tissue test result is obtained. This is more important for crops which are more deficient.

Rates

Nitrogen requirements at panicle initiation can be determined by the Rice NIR Tissue Test using fresh weight and NIR tissue nitrogen content. Sampling procedures are outlined in the SunRice protocol.

The test results provide a nitrogen topdressing recommendation. They also help to evaluate pre-flood N. As a general rule, aim to topdress no more than 60 kg N/ha. An NIR tissue test recommendation over 60 kg N/ha usually indicates that insufficient pre-permanent water fertiliser was applied, or that cold weather led to lower mineralisation rates and lower nitrogen uptake.

The NIR tissue test

The nitrogen topdressing tables (Tables 8, 9 and 10) recommend an optimum amount of nitrogen to apply at PI. It is expressed as kg nitrogen per hectare. As a 'rule of thumb', 60 kg N/ha is 130 kg urea/ha or approximately one 50 kg bag urea/acre (see Table 11).

Table 11. Urea conversion (approximate)

Nitrogen rate (kg N/ha)	30	45	60	75	90	105	120
Urea rate (kg/ha)	65	98	130	165	195	230	260
Urea rate (50 kg bags/acre)	0.5	0.75	1.0	1.25	1.5	1.75	2.0

Two topdressing recommendations are given, with the higher nitrogen rate applying to crops that:

- are sown at the recommended times;
- have a minimum microspore water depth of 20–25 cm;
- have panicle initiation dates up to 10 January;
- in the MIA/CIA and northern MV areas, have a slightly lower cold risk.

As well as the NIR test, consider paddock N history.

Good subclover paddocks containing high organic nitrogen and late cultivated or sod-seeded paddocks which may continue releasing nitrogen after panicle initiation may need a lower rate. Conversely, heavily cropped paddocks with very low levels of organic nitrogen may require a higher rate than recommended.

Accuracy of the NIR tissue test

The NIR tissue test recommendation assumes the crop was sampled at PI. However, if the crop sampling was carried out before or after PI, the PI nitrogen uptake should be adjusted. At PI, crops are accumulating nitrogen at 1–2 kg N/ha/day. If sampling was carried out too late, subtract 1–2 kg N/ha from the recommended topdressing rates for each day after PI. If sampling was carried out too early, add 1–2 kg N/ha for each day before PI.

The NIR tissue test is most accurate for uniform plant populations of 150 to 300 plants/m^2. The accuracy may decline at lower populations.

Targeted sampling using aerial imagery

Sampling rice for the NIR tissue test can be made easier and more accurate using aerial imagery. Images taken prior to PI are based on a normalised difference vegetation index (NDVI). The NDVI image is used to identify zones of crop vigour in the field to target sampling locations for the NIR tissue test. The NDVI image and the NIR test are tools best used in conjunction with each other which allow farmers to variable rate N topdress their crops. It is essential farmers check or ground truth their crops because the differences between the biomass zones might not be from nitrogen but from other causes such as weeds or poor establishment. Thus each zone needs 'checking' before making decisions on nitrogen application. Also read 'Precision agriculture nutrient management' on page 18.

'maNage Rice'

'maNage Rice' is a computer software program that calculates the potential response of rice crops to topdressed nitrogen fertiliser at panicle initiation. It requires crop sampling to obtain data on fresh weight and NIR N% at PI. However, it also allows input of varieties (most semi-dwarf varieties), time of sowing, date of PI and water depth at microspore. It simulates the yields that can occur for an average season using weather data from the last forty years, and indicates the potential impact of cold damage in the worst, best and specific past seasons.

It also indicates a cost benefit analysis of the likely yield responses from PI topdressing. The costs of fertilisers, aerial application, cartage, harvesting and the returns from rice can be varied to suit particular situations.

Phosphorus

Key Check: Phosphorus – Before sowing, drill or incorporate 10–25 kg P/ha where the Colwell soil phosphorus level is below 20 mg/kg.

When permanent water is applied to a rice paddock, chemical processes in the soil allow higher levels of P to become available for the crop. However, high-yielding crops remove substantial quantities of P from the soil.

Responses to phosphorus applications can occur in the following situations:

- cut areas in landformed fields;
- continuous rice crops, particularly after the second or third crop, where no phosphorus has been applied to the previous crops;
- irrigated pasture phases where there has been no phosphorus fertiliser applied for 2–3 years;
- native pastures with no history of phosphorus fertiliser application.

Phosphorus may improve plant vigour and yield. Jarrah tends to be more P responsive than other varieties. The phosphorus recommendation table (Table 12) indicates application rates. Phosphorus fertiliser may be applied from July onwards to reduce labour demands near rice sowing. Phosphorus fertiliser is best drilled into the soil, since surface application just prior to permanent water encourages green algae growth.

Table 12. Phosphorus recommendations

Soil phosphorus (mg/kg, Colwell Test)	Recommended rate (kg P/ha)
0–15	10–25
15–20	10
over 20	nil

Rates

Soil tests give a guide to the likely rice yield response from phosphorus. Undertake soil tests 2 to 3 months prior to sowing to ensure that the results are back before fertilising. Soil tests may be less accurate on grey clay soils. Test strips are the best way of confirming phosphorus responses.

- In rice rotations it is common practice to fertilise winter crops with 125–150 kg/ha DAP or MAP targeting 30–40 mg/kg soil phosphorus which satisfies the requirements for rice.
- Responses to P application for Colwell tests of 15–20 mg/kg may be variable. A response may be noticed in crop vigour and growth without any significant increase in grain yield.
- Farmers growing continuous rice should routinely apply 15–25 kg P/ha.
- Drill/sodsowing: apply phosphorus with the seed. (For example, to apply 20 kg P/ha, you would require 100 kg/ha DAP.)

Mid-season P application

Phosphorus fertiliser should preferably be applied prior to permanent water. If, however, a trial strip shows low phosphorus or the crop is showing P deficiency symptoms (e.g. dark green colour, stunting, poor tillering or unexpectedly high NIR nitrogen), then an aerial application of 10–25 kg/ha P (e.g. as DAP, Superfect®) into the water often gives useful responses.

Zinc

Zinc deficiencies are rare but may occur where pH_{Ca} is greater than 6.5 on grey clays, gilgai paddocks or cut areas. Zinc deficiency is seen early in the life of the crop, and hence may have an impact on rice seedling vigour and establishment. Zinc application benefits are observed when cold weather creates difficult establishment conditions.

Zinc needs to be applied in a readily available form to achieve maximum effectiveness. Apply zinc with superphosphate as a blended product or as either zinc sulfate or zinc oxide at 5–10 kg/ha zinc. The ideal way to test for a zinc response is with test strips.

Sulfur

Sulfur has a positive balance between soil and water supply and crop removal. This is largely related to the supply of 18 kg S/ha to each crop in the irrigation water hence deficiencies of sulfur are not common. However, deficiencies have been recorded in a few local rice crops on lighter soils where sulfur containing fertilisers have not been used in recent years, and where soil sulfur levels are below 5 mg/kg (KCl test).

Sulfur deficiencies have similar plant symptoms to nitrogen deficiencies and respond quickly to top dressed super (e.g. low rate of gypsum).

Other nutrients

Potassium is in negative balance but no deficiencies have been recorded because of high amounts of potassium in the soil. Magnesium, calcium and sodium are in positive balance due to the amount of these nutrients in the irrigation water supply.

Precision agriculture nutrient management

Considerable in-paddock variation in rice crop growth can occur due to differences in soil properties where landforming has been undertaken without topsoiling. Precision agriculture and variable rate technology enables different zones in landformed paddocks to be treated as required to achieve uniform growth and yield.

Aerially or satellite sourced technology can be used to produce NDVI (Normalised Difference Vegetation Index) images of rice crop growth (see 'Targeted sampling using aerial imagery', page 17). These images show variation in crop growth, often from cut and fill areas. NDVI images, EM soil surveys, cut and fill maps and zone nitrogen uptake results can be used to understand factors causing crop variation. These tools can be used to plan variable rate application at the pre-permanent water stage to the following crop. Monitoring crops is essential to ensure the variation is due to nutrients, and not to other factors such as weeds or uneven plant populations. It is important to note that NDVI is not a measure of plant N, and an NIR test is still required to enable proper calculation of N topdressing requirements.

Cut areas that are not topsoiled often need a doubling of nutrients but this depends on the amount of cut. As much as 150–300 kg N/ha and 40 kg P/ha may be needed each season to bring cut areas to the same nutrient level as undisturbed areas. Application of animal manures such as poultry waste can assist.

Key Check: Use landforming cut/fill area maps, electromagnetic (EM) maps or aerial image maps to assess and manage soil and crop growth variability.

- When landforming, topsoil 'new' cut areas or apply extra nitrogen and phosphorus and organic manures to 'old' cuts.
- Use EM maps to identify field zones with different soil characteristics. Obtain soil tests for each zone and use the tests as a basis for variable fertiliser and treatment application.
- Use aerial images to identify crop vigour zones at PI. Sample the zones for the NIR tissue test and apply variable rate nitrogen based on the test results.

7. Panicle initiation date

Key Check: Achieve PI before 10 January.

The Ricecheck database and research results show that crops which reach PI before 10 January achieve highest yields.

If panicle initiation occurs before 10 January, the risk of low temperatures at microspore and flowering is lower. Normally, sowing a variety in the recommended sowing window will ensure this growth stage check is achieved.

Often late sowing or poor weather conditions delay crop establishment to the extent that crop development and PI is delayed beyond 10 January.

8. Water management

Key Check: Achieve a minimum water depth of 20–25 cm during the microspore stage.

Ensure a water depth of 20–25cm is achieved on the high side of bays at the microspore growth stage. Water depth indicators marked from 0–30 cm located on the deep side of every bay near the bay stops will make it easy to assess your water depths and make necessary adjustments to water flows and levels. Problems of shallow or overdeep water depth can be easily detected and rectified early using the depth indicators.

The water management practices for the rice crop growth stages are shown in Table 13.

Water quality

1. The tolerance of rice to salinity varies considerably with its stage of growth. The most sensitive stages are the early seedling stage and the reproductive development stage between PI and flowering. Long grain varieties are more sensitive to salinity than medium grains.
2. The salinity of the water supply to the rice field should, ideally, not exceed 1 dS/m, particularly during the sensitive seedling and reproductive stages.
3. However, the key issue is the salinity level of floodwater in the rice bays which may arise as a result of evaporation or salinity contributions from the soil or groundwater. Groundwater usually has higher salinity than channel supply water. No yield loss should occur from salinity below 2 dS/m, but this depends on variety and the level of leaching in the particular field.
4. Where rice is grown on fields with known soil salinity problems, circulating the water within the field is important. The common practice of supplying water through the bays, with overflow checks down one side of the field, may encourage the build-up of saline water at the stagnant ends of long bays, particularly in the bays furthest from the supply source (Diagrams A and B, in Figure 2). This concentrating effect can be significant

Figure 2. Overflow stop patterns and salinity in bays

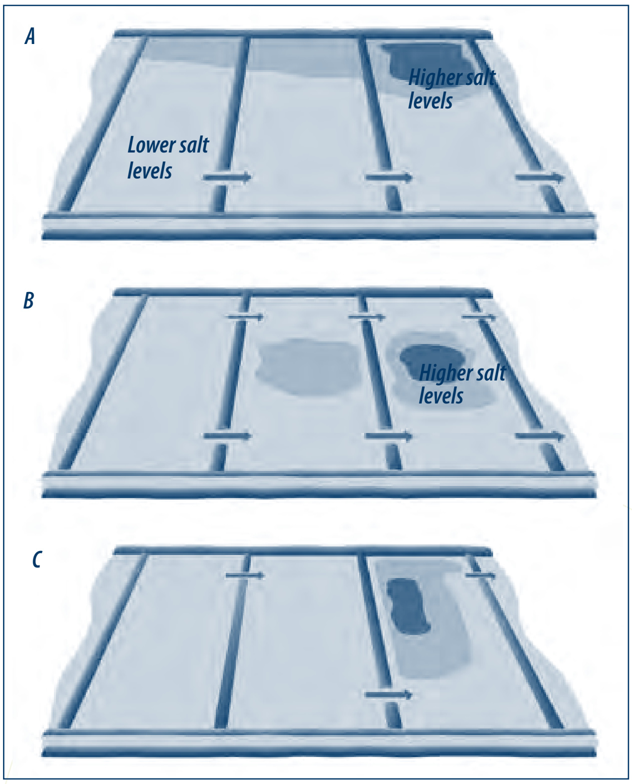

Table 13. Water management

Crop stage	Target water depth	Management practice	Comment
Establishment: permanent water	3–5 cm	This is the ideal water depth to encourage seedling establishment and early tillering. However, water levels may be higher at initial flooding or as required for herbicide management.	Drill sown rice (combine or direct drill): Seedlings at the 2 to 4 leaf stage should not be inundated for longer than 3 days as seedling death or retarded growth can result.
Mid tillering (3 shoots/plant)	5 cm	Shallow depth encourages tillering: very important if seedling number is low.	
Late tillering (mid Dec.)	5–10 cm	Tillering should almost be complete, so that water levels can be increased in readiness for the higher water demand weather of the summer and the greater depths required in January.	Restricted water flows: Water levels on well-tillered crops can be increased more rapidly to achieve 15 cm at panicle initiation if known channel supply water flows are restricted.
Panicle initiation (PI)	10–15 cm	Water levels are increased progressively to ensure that target water depths for EPM are achieved within 10 days of PI.	Deeper water at PI encourages elongation of the air space, increasing the height of the panicle above the soil surface. The water depth then required to protect the panicle at microspore will be deeper and more difficult to achieve. Water depth at these stages should not exceed 50% of the height of the crop.
Microspore	20–25 cm (Amaroo, Reiziq, Quest, Jarrah, Doongara, Illabong, Langi, Opus, Sherpa) 25 cm (Kyeema, Koshihikari)	The target water depths will help protect the developing panicle (12–20 cm above the soil surface) from the sterility effects of low temperatures during this critical reproductive growth stage. Aim to achieve the minimum depths 10 days after PI and maintain until the commencement of flowering, i.e. 25% panicles visible.	
Flowering	5 cm plus	Maintain sufficient water depth to ensure permanent water is kept even in very hot weather; deep water is not essential.	Deep water can be maintained to utilise rice bays as a storage, freeing up water supply to irrigate winter pastures and crops.
Lock-up	As required	Lock-up aims to allow surplus water on bays to be used up by the crop to minimise the amount of water to be removed from the field at draining time.	Allow 6–12 mm/day water use depending upon weather conditions and soil type to ensure adequate moisture until late dough stage.
Draining	—	Maintain permanent water until late dough stage, then drain quickly in 1–2 days via individual bay outlets. This reduces the chance of premature drainage and provides more even paddock ground conditions for harvest.	For more information refer to *Production of Quality Rice in South Eastern Australia.*

during periods of herbicide application that require water movement to be minimal. From mid-January to mid-February, high evaporative demand can cause salt to accumulate in these areas, and the salinity content of the water can increase to as high as 10 times that of the supply/bay water. Staggering the overflow stops (Diagram C of Figure 2), so that stops are on alternate sides of the field, will increase circulation of fresh water and minimise salinity build-up. Side supply delivery to each bay also helps circulation.

5. Water quality should be regularly checked during the season using a properly calibrated electrical conductivity meter, particularly in saline areas or when using groundwater as an irrigation supply (refer to DPI Primefact *Rice production using groundwater 2007).*

Midseason dry-down

Midseason dry-down involves draining and drying down of bays at the late tillering stage in early to mid December. The rice should remain without water for 70–80 mm of evaporation (5–8 days). Research results over four years indicated that this practice can increase yields, particularly on the poorer structured sodic soils. Midseason drainage has been used with success by Western Murray Valley farmers to alleviate 'straighthead' problems. Dry-down delays flowering by 4 days, which may or may not influence yield responses in cold years. It is suggested that farmers wishing to test mid season drydown should test the method in one or two bays rather than in a whole crop.

Delayed permanent water

Reduced water allocations from the drought has revived interest in this system for potential water saving, improved water productivity (t/ML) and improved profit/ML.

The practice of delaying the application of permanent water (DPW) to drill sown rice, from the normal 3-leaf stage until about two weeks prior to panicle initiation, has shown significant water savings. Research in the last two years has demonstrated **water savings of 16–20%** from the most moisture stressed treatments, resulting in a **10–15% increase in water productivity**.

The biggest issues to consider when delaying the application of permanent water to rice are weed control, nitrogen fertiliser management and the delaying of crop development. Weed control is more difficult when the crop is not ponded but new strategies are proving effective. Nitrogen management is different as large losses can occur when nitrogen applications are made early in the crops growth. The greater the moisture stress applied to the rice crop the greater the delay in the crops development, therefore DPW crops should be sown 7 to 10 days earlier than the planned sowing date of a conventionally irrigated drill sown crops of the same variety.

9. Grain quality

Harvest

Key Check: Harvest the rice crop between 20 and 22% moisture content to maximise grain quality.

Rice grain quality is an important factor affecting the value and marketability of the crop. Whilst variety is the major factor affecting quality (i.e. appearance, milling quality and cooking characteristics), grower management plays an important role.

Management by rice growers during the growing season and at harvest can greatly affect the milling quality, particularly the % whole grain (the percentage of whole grains in a sample after removing the hulls and bran layer). The higher percentage whole grain, the more valuable the grain: 60 to 65% whole grain is a good milling quality result for medium grains, with over 55% good for long grains. All medium grain crops start with the same high potential percentage whole grain.

The following are the main management factors influencing whole grain millout.

Varietal purity: grain samples must be free of other varieties e.g. medium grain in long grain. Long grains are not recommended for sowing on medium grain stubbles. Arborio grain types such as Illabong should only be planted after Illabong or on fresh ground.

Grain moisture decline: the rate grain dries during ripening determines how quickly the percent whole grain declines after reaching its peak. Weather conditions, time of sowing and drainage practices are major influences on grain moisture decline. A slower drying crop will peak in its whole grain, then decline slowly over time (Figure 3). A quick drying crop where the daily evaporation is greater than 2 mm (e.g. March evaporation averages 6 mm) may have the same high potential but the rate of decline is much faster. Under high evaporation and temperatures, grain moisture can fall at 0.5% per day for moist soils and at 1% per day for dry soils, so farmers need to closely monitor grain moisture under these conditions.

Time of sowing: sowing at the recommended time for each variety will help place the grain ripening stage and harvesting into the milder April period. April may experience spikes of hot weather and high daily evaporation, which will cause grain cracking and falls in % whole grain if harvest moisture is below 20%.

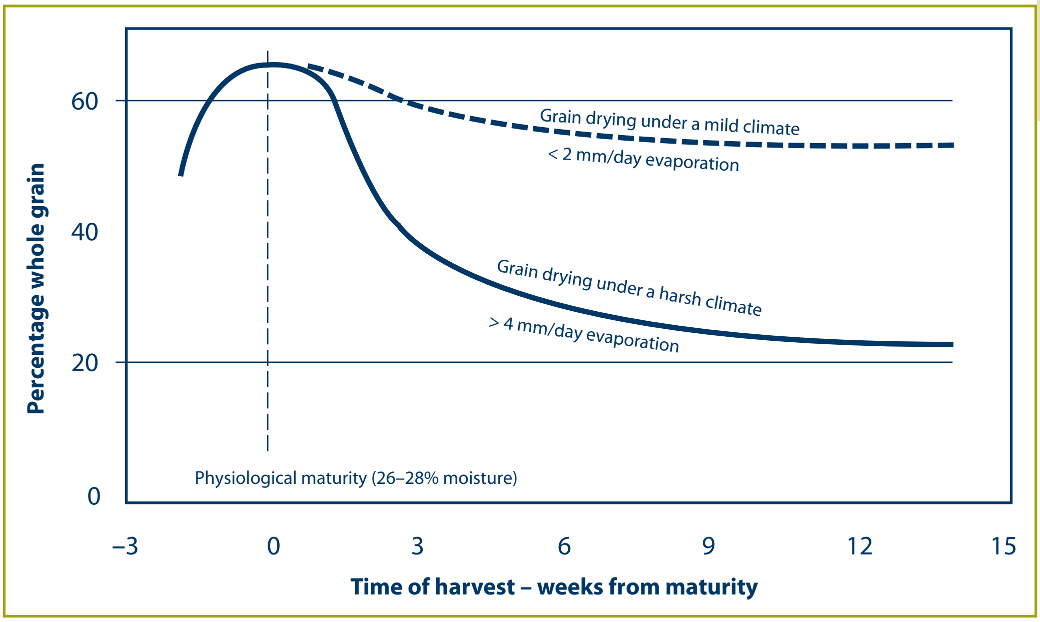

Figure 3. Effect of time of rice harvest on percentage whole grain

Shorter season varieties such as Quest, Jarrah and Illabong sown at the recommended times may mature and be ready for harvest in March when temperatures and evaporation are high. Sowing earlier than recommended may also result in the grain maturing under higher temperatures and evaporation. Moisture declines quickly in this period.

Varietal harvesting order: if at similar moisture contents, the medium grain varieties should be harvested before the long grain varieties, as the rate of decline in whole grain is faster in the medium grains. However, harvesting of Langi should not be delayed because of the risk of shedding. Jarrah and Illabong should be harvested first due to their faster whole grain yield decline. Delaying harvest may also lead to lodging problems with Jarrah.

Nitrogen management: growing rice at the optimum nitrogen levels will maximise whole grain millout because the crop will mature later in cooler conditions than a crop with low nitrogen.

Draining: draining at the right time is very important for achieving high grain quality. Draining too early may result in the grain drying down too quickly, increasing the risk of grains not maturing properly. Draining too late may leave the paddock in a boggy state and delay harvesting beyond the optimal moisture content for highest grain quality (See Table 14).

Table 14. Timing for management operations

Locking-up timing	**Normal conditions** Late February/early March	**Cooler conditions** Late March/early April
Draining timing	**Well-draining fields, e.g. red loam/clay loam soils**	**Slow draining fields, e.g. heavy grey-brown clay soils**
Late February to early March	No milky grains	No milky grains
Early/mid March	0–5% milky grains	5% milky grains
Late March/early April	5–10% milky grains	10–15% milky grains

Note: These criteria are to be used as guides only, as timing may vary depending on temperatures, soil type, irrigation infrastructure, variety etc.

Quality assurance

> **Key Check: Maintain food safety and quality by preventing physical, chemical or biological contamination of the grain.**

Consumers expect rice to be true to type, clean, and free from discolouration, off-flavours, chemical residues and foreign matter. Farmers have a responsibility to harvest and deliver paddy grain that can meet the new standards for food safety and quality.

Adjust harvesting machinery to minimise dockages. Clean headers, bins and trucks prior to harvest to prevent weed, insect and varietal contamination. Efficient harvest operations will deliver clean grain free of excess flatheads, glass, metal, plastic, straw, stones, dirt, weed seeds, other agricultural grains, and pearled and broken rice.

The consumers of rice products, supermarkets, processors and export markets are demanding increasingly stringent food safety and quality standards. Quality assurance programs in place with the NSW rice industry ensure that those standards are met.

Other resources

Rice crop protection guide 2011.
Production of quality rice in south-eastern Australia.
Rice production using groundwater 2007.
Rice cereal quality 2009.
Rice variety guide – 2011.

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