Straighthead in Australian rice crops

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in a nutshell

- Straighthead is a disorder which distorts panicles and florets and causes grain sterility
- Estimated yield loss in Australia exceeds $1 million each year
- It occurs mostly on old pasture country and where stubble is incorporated
- Some rice varieties are more tolerant of straighthead than others
- Techniques have been developed to study straighthead in the field and further research will lead to an understanding of the cause of the problem

Straighthead or 'parrot beaking' is a disorder of rice with symptoms which are only obvious at panicle emergence. Crop losses can range from 10 to 30% in medium-grain varieties and as high as 90% in long grains (such as Langi and Doongara) and short grains (such as Koshihikari).

This paper summarises the history of studies on straighthead in Australia. Straighthead has been recorded in NSW rice crops since the 1960s. It occurs in both the Murrumbidgee and Murray valleys and although often thought to be a relatively minor problem it costs an estimated $1–2 million per year in lost yield. Across the whole industry this may not seem much but straighthead can be a devastating problem to an individual grower. However, its true extent is unknown because the disorder is often confused with cold weather sterility and it may occur at low levels unnoticed in many crops.

The disorder also occurs in Arkansas, Louisiana and Texas in the USA, and in other rice producing countries but is known by other names in these places. Although there is no known cause of straighthead it is thought to be related to soil conditions. It is not seed borne or transmitted around the farm.

Straighthead can be induced in the glasshouse by the application of arsenical compounds to the soil. In Arkansas, straighthead is associated with the use of arsenic-based pesticides used in cotton during a rotation.

Occurrence

Straighthead occurs throughout the rice growing area but is more prevalent in the Murray Valley. It occurs on a range of soil types from self-mulching clays at Wakool to red loams at Finley. In Arkansas it is predominantly associated with the lighter textured soils.

Typically small areas of a crop from 1 to 5 ha are affected, however each year one or two entire crops are reported to be affected by straighthead, with yield losses as high as 90% in long-grain varieties and Koshihikari. In medium-grain varieties, losses of 30 to 40% are reported.

Straighthead is linked to the incorporation of large amounts of organic matter – the stubble from the previous crop or pasture, and even oat stubble residues incorporated prior to sowing the rice crop. It most often occurs in areas that have never grown rice, eg a long-term (over five years) pasture or a border check pasture layout converted to rice.

There is no set pattern to its occurrence – it can affect a whole crop, just a few bays or only a few strips in the crop. It can be a recurring problem in some paddocks.

Figure 1: A panicle of rice severely affected by straighthead

Symptoms of straighthead

- Sterile heads with deformed florets – often called parrot beaking – are characteristic of straighthead. This effect is most pronounced in long-grain varieties. Medium grains tend to have some deformed florets but parrot beaking is not as obvious.
- Affected heads may be small and 'caught in the boot'. This is mostly true of medium-grain varieties. In the most severely affected areas, the head may be absent or just a single stalk.
- Sterility due to straighthead is lower in high nitrogen areas, eg combine turns and double sowing of urea. Sterility is higher in low nitrogen areas, eg combine misses. *This is opposite to cold induced sterility.*
- Affected plants remain greener and upright compared with plants producing grains. New shoots often emerge at the base of affected plants in response to higher than normal shoot nutrient concentrations.

Research in Australia to date

Varietal tolerance

Dr Don McDonald became aware of a varietal difference in 1970–71 when his new variety Kulu suffered from straighthead, while Calrose, the standard variety at the time, was more resistant. In 1976–77 he found early maturing varieties were more tolerant.

A routine variety trial at Wakool in 1998 (Table 1) demonstrated the impact of straighthead on eight varieties. The results illustrated that long-grain varieties are more susceptible to straighthead than medium-grain varieties.

Glasshouse studies conducted at Yanco in 1998 and 1999 showed that straighthead symptoms which mimic those observed in the field could be induced with the use of arsenate.

These studies were discontinued because:

- the amount of arsenate needed to induce straighthead symptoms in some 'susceptible' varieties, without causing straighthead in all varieties, was unpredictable
- we could not be sure that the action of the arsenate was the same as occurs in the field
- arsenates are very toxic.

Nitrogen rate effect

Straighthead was unexpectedly found in a crop where an experiment designed to assess the response of Amaroo to nitrogen applied at pre-permanent flood and panicle initiation was being conducted. The results revealed that straighthead was reduced where higher nitrogen rates were applied at sowing (Table 2).

Results from this and other experiments have shown that when sufficient nitrogen is applied (both pre-flood and at panicle initiation) targeting a crop yield of 10 t/ha or better, the effect of straighthead is often greatly reduced. To add to the mystery of the cause of straighthead, there are observations that some crops grown with very high nitrogen levels from old pastures can still suffer from straighthead.

In fields that have a history of straighthead we now recommend the fertilisation of medium-grain varieties to the high end of the Ricecheck scale aiming for over 130 kg N/ha uptake at panicle initiation. It is also suggested to topdress crops with nitrogen uptake to 150 kg N/ha but not above 150 kg N/ha uptake. Early sowing and deep water at microspore are essential to minimise cold damage.

Mid-season draining

Draining the rice paddy prior to the crop reaching panicle initiation can sometimes control straighthead. In Arkansas 30–40% of the crops are drained at this time for straighthead control. Draining should commence early enough to ensure water is reapplied no later than ten days prior to panicle initiation and also ensure that deep water is achieved at microspore. The soil should be allowed to dry sufficiently for cracks to develop to achieve the desired result, but water must also be reapplied very quickly after this is achieved.

The possible benefits from mid-season draining and

Table 1: Straighthead varietal interaction 1998

Variety	Straighthead affected grain yield (t/ha)	Unaffected grain yield (t/ha)	Yield loss (%)
Millin	8.5	12.2	30
Namaga	8.2	12.1	32
Amaroo	8.1	12.4	35
Koshihikari	4.5	8.7	48
YRK4	5.7	12.8	55
Langi	4.5	12.9	65
YRL118	2.9	13.1	78
lsd(p<0.05)	2.2	0.8	

Table 2: Straighthead response to nitrogen at Mayrung in 1993–94 (Dunn et al 2006)

Preflood N (kg N/ha)	PI N (kg N/ha)	PI N uptake kg N/ha	Grain yield (t/ha)	Harvest index
0	0	42	4.1	0.29
0	75	42	6.7	0.35
0	150	42	8.7	0.37
75	0	70	7.9	0.35
75	75	70	12.1	0.49
250	0	157	12.6	0.44
250	75	157	12.5	0.45
250	150	157	12.5	0.43

Note the low harvest index at low nitrogen rates. This is the reverse trend to cold induced sterility.

nitrogen application can be substantial for plots drained, then re-watered before panicle initiation (Table 3). Note the interaction between nitrogen application and draining. Combining both practices can improve the outcome.

Organic matter reduction

Sufficient anecdotal evidence exists to warn against incorporation of stubble residues of rice or winter cereals or large volumes of sub clover residues. Removal by burning, heavy grazing or hay cutting is recommended.

Development of safe method to induce straighthead

Studies designed to induce straighthead in the field were funded by the Rice CRC and undertaken in the 2003–04 and 2004–05 rice seasons. Two field experiments at Yanco Agricultural Institute and a third on a different soil type at Leeton Field Station, demonstrated that straighthead can be induced by growing rice with nil or minimal additions of nitrogen and the incorporation of about 20 t/ha of straw. This method has the added benefit of being environmentally friendly and will enable further investigation into the causes of straighthead. The straighthead-inducing system is being used to screen Australian and overseas rice varieties for straighthead tolerance with the aim of incorporating this information into the rice breeding program.

Soil redox potential

The response of rice varieties grown in pots with the addition of straw and sugar were evaluated by Rob Williams et al. The results suggested that changes in the soil oxygen levels (redox potential) were involved in inducing straighthead.

Table 3: Grain yields from treatments with draining and nitrogen applications at Falkiner Field Station, Deniliquin in 1991

Variety	Nitrogen rate (kg N/ha)	Not drained (t/ha)	Drained (t/ha)
Calrose	0	1.6	5.6
Calrose	75	5.6	8.9
Pelde	0	0.3	7.6
Pelde	75	3.0	10.3

Since that work, electrodes to measure soil redox potential have been used in field studies.

The incorporation of rice straw in the 2003–04 and 2004–05 experiments led to a very rapid reduction in soil redox potential, (ie the soil rapidly became very oxygen deficient), compared to where no straw was incorporated.

The incorporation with straw also produced straighthead symptoms in the rice crop.

Micronutrient effect on straighthead

Analyses of shoot samples taken at several growth stages from field studies in the region indicated that the micronutrients copper and zinc were lower in plants suffering straighthead. This confirmed a suggested explanation, based on the symptoms, by Professor Ross Welsh from Cornell University/ USDA-ARS.

Foliar applications of zinc and copper were applied to the 2004–05 experiments at Yanco and Leeton. The nutrient applications increased the content of both zinc and copper in the plant but had no effect on the severity of straighthead or floret sterility. This result needs to be confirmed.

Control strategies

It is difficult to predict if straighthead will occur, or how extensive or severe it will be, making control of the disorder difficult. Varietal resistance to straighthead is often regarded as one of the most effective means of control.

If you have seen straighthead symptoms in fields in the past the best management options at the moment are:

- grow only medium-grain varieties
- ensure nitrogen levels in the crop are adequate
- do not incorporate stubble or pasture
- drain the field mid-season.

The future

There is still much to learn about straighthead. However, we now have an environmentally-friendly field technique for screening promising genotypes in the breeding program and to test theories about the basic cause of the disorder.

Figure 2: Affected plants remain greener and upright compared with unaffected plants

Figure 3: Straighthead can be induced by incorporating 20 t/ha of stubble, providing a safe method to study the effects of the disorder

Further information

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Further reading

Most of the early field and glasshouse studies on straighthead were not published in journals because the findings were inconclusive. Some results are only reported in annual reports which had a limited circulation. Reports of recent studies can be found in more widely circulated annual and final project reports and even in peer-reviewed journals. It is hoped that these publications will lead to renewed interest in solving the problem known as straighthead.

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Figure 4: Researcher Graeme Batten with straighthead affected rice plants