



RICE CRC

FINAL REPORT

Title of Project :	Investigating links between minerals in rice grain and Straighthead
Project Reference number :	2303
Research Organisation Name :	Cooperative Research Centre for Sustainable Rice Production
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RICE CRC

Final Report – Project Number : 2303

1. One page (A4 vertical format) non-technical summary of the Project

Straighthead or “Parrot Beaking” is a “physiological” disorder causing distortion and a high proportion of missing grains on the rice panicle. Crop losses range from 10 to 30% in medium grains and as high as 90% in short and long grains.

This Project reports:

- the current understanding of Straighthead, its symptoms and occurrence;
- crop surveys which were conducted in 1998/99 and 1999/2000; and
- mineral analyses of grains from plants affected by Straighthead.

The key findings of this project were:

- Straighthead was mainly observed in crops grown after pasture or other rice crops where the stubble was incorporated;
- Straighthead was more prevalent in the rice varieties Langi and Koshihikari;
- there are obvious symptoms of Straighthead in relatively few rice crops; but reductions in yield also occur across large areas without any visible symptoms of Straighthead appearing;
- the rice grains from crops visibly affected by Straighthead were found to have higher concentrations of mineral elements and possibly inferior mill-out; and
- the cost of Straighthead to the rice industry is estimated to exceed one million dollars per year”.

Recommendations

Further research is needed to gain an understanding of the causes of Straighthead. These studies should include:

1. Remote Sensing and yield mapping to gain better estimates of the extent of the problem.
2. The development of a stubble incorporation strategy which allows Straighthead to be induced “on demand”.
3. Studies to test the suggestion that copper deficiency is implicated in the problem.

RICE CRC

RESEARCH – FINAL REPORT

Final Report – Project Number : 2303

BACKGROUND TO THE PROJECT

Straighthead or “Parrot Beaking” is a “physiological” disorder causing distortion and a high proportion of missing grains on the rice panicle. Crop losses range from 10 to 30% in medium grains and as high as 90% in short and long grains.

Straighthead has been recorded in NSW rice crops since 1960s. It occurs in both the Murrumbidgee and Murray Valleys and the Coleambally Irrigation Area. Straighthead also occurs in Arkansas, Louisiana and Texas in the USA and in other countries who use other words to describe it.

There is no known cause of Straighthead although it can be induced in the glass house by addition of arsenic based compounds and straw or sugar to the soil. In Arkansas Straighthead is associated with the use of arsenic based herbicides used in cotton during rotation.

Straighthead is thought to be a relatively minor problem in the NSW rice area as a whole but can be devastating to individual growers who have the problem. However, its true extent is unknown because it is often confused with cold weather sterility and may occur at low levels unnoticed in many crops.

Straighthead is thought to be related to soil conditions and is not seed borne or transmitted around the farm.

The symptoms of Straighthead are upright panicles, with misshapen hulls of affected grains – often called “Parrot Beaking”. This effect is most pronounced in long grain. Medium grains tend to have some misshapen grain but not all “parrot beak” (Figure 1).

Figure 1:



Past Observations

1. Susceptible varieties such as long grains and Koshihikari tend to have the entire head sterile. Medium grains may have heads partially sterile or sterile heads beside affected plants.
2. Straighthead is less severe in high nitrogen areas, eg combine turns and double sowing of urea. Sterility is worse in low nitrogen areas eg. combine misses.
3. Straighthead occurs throughout the crop but also close to the bank whereas cold induced sterility is often reduced close to the bank.
4. Straighthead is often less severe near fresh water inlets into the bay.
5. Heads may be small and “caught in the boot” - this is mostly true of medium grain varieties. In the most affected areas, the head may be absent or just a single stalk.
6. Straighthead often occurs in the same area each rotation. It can affect a whole crop or just a few bays or only a few strips in the crop. Often there is no set pattern to its occurrence in a bay.
7. New shoots often emerge at the base of affected plants in response to the lack of demand for nutrients by the sterile panicle.
8. Straighthead typically affects small areas of a crop, from 1 to 5 ha, however each year one or two entire crops are reported to be affected.
9. Straighthead occurs over the entire rice growing area on a range of soil types from self mulching clays at Wakool to red loams in Finley. In Arkansas it is predominantly associated with the lighter textured soils. Every year crops are recorded with straighthead symptoms as growers become more aware of the problem.

Associations

Straighthead is often associated with paddock history and some management practices. However, these associations are not always able to be reproduced. Some of these associations are listed:

- *The same area in a rotation, however this is not always the case.*
- *Areas that have never grown rice, eg. a long term (over 5 years) pasture history, eg. a border check pasture layout converted to rice.*

- *Incorporation of large amounts of organic matter either from rice stubble incorporation or pasture and even oats stubble residues incorporated prior to sowing the rice crops.*

Control Strategies

The greatest problem with all control strategies is that there is no known way of predicting whether an area has Straighthead. Some paddocks have recurring problems, however this is not always the case.

A. Varietal Tolerance

Two variety trials at Wakool, one with Straighthead and one without, showed the impact of Straighthead on several varieties (Table 1). Glasshouse studies (L. Lewin *et al* unpublished) show similar rankings for medium and other varieties. Therefore, where Straighthead is expected growers are advised to grow medium grain varieties.

Table 1 – Straighthead Varietal Interaction 1998

Variety	Straighthead	Unaffected	% Yield Loss
Millin	8.5	12.3	30
Namaga	8.2	12.1	32
Amaroo	8.1	12.4	35
YRK4	5.7	12.8	55
Koshihikari	4.5	8.7	48
Langi	4.5	12.9	65
YRL 118	2.9	13.1	78
LSD (P=<0.05)	2.2	0.8	

- Source: *John Smith, unpublished*

B. High Nitrogen Rates

Straighthead can be reduced by applying higher nitrogen rates at sowing. Results from a field trial at Finley demonstrated the impact of applied N on Harvest Index (HI). Note: Harvest Index is the proportion of grain to grain + straw at harvest. It is a good measure of the degree of sterility. A rice crop with a high yield and little sterility or Straighthead will have a HI of 0.5 or higher. If the HI is less than 0.4 significant sterility it usually indicates high sterility.

This data indicates that nitrogen levels which reach PI N uptake of over 150kg N/ha will significantly reduce Straighthead. PI nitrogen levels over 150kg N/ha also place the crop at higher risk of cold damage and in Koshihikari severe lodging.

However, field experiments show some crops with very high nitrogen levels from old pasture can still suffer from Straighthead.

Table 2 – Straighthead response to Nitrogen 1997

N Applied Sowing Kg N/ha	N Applied PI kg N/ha	PI N Uptake kg N/ha	Yield t/ha	<u>Harvest Index</u>
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

- Source: R. Williams, et al - unpublished

Note: The low HI at low nitrogen rates this is the reverse trend to cold induced sterility. This data also shows that topdressing nitrogen at PI can significantly reduce the impacts of Straighthead.

In Straighthead areas it is recommended to fertilise medium grain varieties to the high end of the scale - aiming for over 130kg N/ha uptake at PI. It is also suggested to topdress crop with N uptake to 150 kg N/ha but not above 150 kg N/ha uptake. Early sowing and deepwater at microspore is essential to avoid cold damage.

C. Draining

Draining the rice for 10 to 14 days prior to reaching panicle initiation has been found to successfully control Straighthead. In Arkansas 30 to 40% of the crops are drained at this time for Straighthead control. To ensure that deep water is achieved at microspore, the draining of the crop should commence by 5th December and be completed by 20th December. The soil should actually dry and crack in this period to achieve the desired result. Where barnyard grass is present at this time, there is a threat that it will germinate causing a weed problem.

A trial conducted at Falkiner Field Station, Deniliquin in 1991 (Table 3) illustrates the benefit of mid season draining and nitrogen application for Straighthead control. The results are grain yield (tonnes/ha) and where plots were drained; they were re-watered before panicle initiation.

Table 3: Straighthead Draining and Nitrogen Trial

<u>Variety</u>	<u>Nitrogen Rate</u> (kg N/ha)	<u>Not Drained</u> Yield t/ha	<u>Drained</u> Yield 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

- Source: *L. Lewin, unpublished*

Note: *The interaction between nitrogen application and draining. Combining both practices improved the outcome significantly.*

D. Organic Matter Reduction

Sufficient anecdotal evidence exists to warn against incorporation of stubble residues of rice or winter cereals and large volumes of subclover. Removal by burning, heavy grazing or hay cutting is recommended. However, this will enhance nutrient removal. Table 4 reports the removal of nutrients for “average” rice crops.

Table 4. Nutrient balance sheet for a rice crop grown using industry average inputs of irrigation water (13.3 ML), and fertilizers to produce an industry average yield of 9.3 t/Ha. All nutrient figures are expressed as Kg element / Ha.

	N	S	P	K	Mg	Ca	Cu	Fe	Mn	Na	Zn
INPUTS											
Seed (150 Kg/Ha)	1.49	0.12	0.37	0.47	0.16	0.04	0.001	0.003	0.014	0.00	0.003
Fertilizer	120.00	3.50	4.60	0	0	3.60	0	0	0.000	0	0.015
Irrigation water (13.3ML)	4.60	18.00	0.67	3.86	15.30	24.50	*	*	*	42.40	*
Rainfall*	1	1		1	0.4	2				5	
Total Inputs	127.1	22.6	5.6	5.3	15.9	30.1	0.001	0.003	0.014	47.4	0.018
EXPORTS											
Grain (9.3 t/Ha)	93.1	7.7	23.1	29.1	9.7	2.2	0.033	0.233	0.891	0.664	0.166
Stubble burning	57.0	5.4	2.4	97.0	8.0	13.5	*	*	*	*	*
N not accounted for	42										
Stubble Removed	69.5	6.7	5.5	242.5	17.0	26.0	*	*	*	*	*
BALANCE											
Stubble incorporated	-8.0	14.9	-17.4	-23.7	6.1	27.9	-0.033	-0.229	-0.877	46.7	-0.149
Stubble burnt	-65.0	9.5	-19.8	-120.7	-1.9	14.4	*	*	*	*	*
Removed	-77.5	8.3	-22.9	-266.2	-10.9	2.0	*	*	*	*	*

*insufficient data

- Source: *Batten, Reuter, Kirkby, Unkovich*

2. Objectives

The aim of the project was to survey crops and find factors that cause Straighthead and determine its impact on grain quality and grain mineral composition.

3. Introductory technical information concerning the problem or research need.

The challenge for rice researchers is to identify the cause(s) of the disorder Straighthead and suggest management strategies for rice producers.

4. The Methodology - including a description and justification.

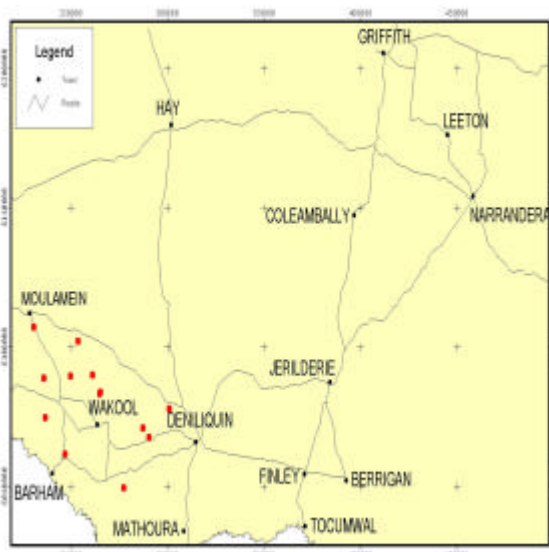
A. Survey of Crops Affected

Rice producers who observed symptoms of Straighthead in their crops were surveyed by mail and phone in 1998/1999 and 1999/2000 and asked a series of questions including paddock history, rice crop variety and management. Copies of the questionnaires are attached as Appendix 1.

From the two seasons a total of 35 crops were identified. Samples of soil and whole shoots were collected at crop maturity from paired areas of crop; those with visible Straighthead symptoms and nearby areas of crop with no visible Straighthead symptoms.

Soil samples were air dried prior to analysis. Shoot samples were dried at 70°C, weighed, thrashed through a standing small plot header and the grain collected and weighed. Mineral composition of soil and grain were determined by ICP analysis (Australian Government Analytical Laboratory, Sydney). The locations of crops sampled in 1998/99 are shown in Figure 2.

Figure 2: Distribution of crops affected by Straighthead 1998/99



B. Glasshouse studies

Glasshouse studies were conducted to develop a variety screening protocol. A range of commercial and advanced breeding lines were sown into soil in pots in a heated glasshouse at Yanco. At the 4-leaf stage arsenic, in the form of mono-sodium methyl arsenate (MSMA), was applied as a solution to the surface of the soil at rates ranging from nil to 56 mg As/pot.

Plants were observed daily and symptoms of Straighthead recorded using the Arkansas rating scale (Rasamivelona et al 1995; Appendix 2). At maturity plants were cut at soil level and grains removed and weighed. Some samples were analysed to determine the plant-essential mineral and arsenic composition.

5. Detailed results - including the statistical analysis of results.

A. Survey

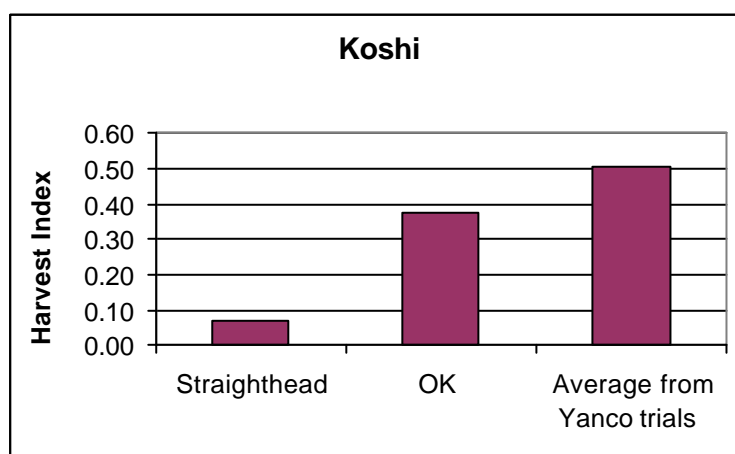
Data from the survey questionnaires are attached as Appendix 3. The impact of Straighthead on the growth and yield of Koshihikari, the variety most commonly affected by Straighthead is summarised in Table 5.

Table 5: Summary of Straighthead Patches in 10 Commercial Koshi Crops 1998/99

Patch of Crop	Control	Straighthead
Score 1-9 (1=no floret, 9 = panicle not emerged from boot)	2.9	6.5
Height (cm)	88	79
Harvest Index (%)	38	7
Grains/30 panicles	41	6
Grain Weight/Panicle	0.91	0.13
Panicles/m ²	832	913
Yield/m ²	390	135

The patches of rice affected by Straighthead had low harvest index ratios (grain weight:shoot weight) but the apparently unaffected areas of crop had lower harvest index ratios than expected for good rice crops (Figure 3).

Figure 3: Ratio of Grain Yield to Straw + grain yield (Harvest Index ratio) for samples from areas within 1998/99 crops visibly affected by Straighthead, from areas 30 to 50m from these which appeared normal (OK) and for samples from high yielding plots at Yanco Agricultural Institute



From these harvest indexes it is concluded that patches of Straighthead are a visible indication of a problem which is actually reducing the yield of the remainder, or at least large areas, of the crop. Grains from plants with visible Straighthead symptoms were found to have higher concentrations (mg/kg) and also higher amounts ($\mu\text{g}/\text{grain}$) of most minerals relative to grain from adjoining areas of crop (Tables 6 & 7).

Table 6: Grain mineral concentration samples from Straighthead and OK areas of 1998/99 rice crops

Element (mg/kg)	SH	OK	
	mean	mean	t Stat
Aluminium	3.16	2.69	0.71
Arsenic	1.49	0.80	4.14 **
Arsenic inorganic	0.20	0.14	3.45 **
Boron	1.67	1.17	3.61 **
Calcium	93.60	90.47	0.68
Cobalt	0.03	0.03	1.24
Copper	2.69	1.98	3.97 **
Iron	13.57	9.96	2.47 *
Magnesium	1472.67	1291.33	2.77 *
Manganese	33.53	33.33	0.06
Molybdate	0.80	0.81	-0.13
Nickel	0.45	0.23	2.79 *
Phosphorus	3464.67	2996.67	3.29 **
Potassium	2946.67	2888.00	0.42
Sodium	29.00	22.73	0.89
Sulphur	783.33	712.67	2.66 *
Zinc	23.53	16.63	5.18 **

>2.13 p=0.05 *

>2.95 p=0.01 **

Table 7: Amounts of minerals in samples from Straighthead and OK areas of 1998/99 Rice Crops

Element (ug/grain)	SH	OK	
	mean	mean	t Stat
Aluminium	0.112	0.064	1.320
Arsenic	0.016	0.009	2.628 *
Arsenic inorganic	0.001	0.000	1.468
Boron	0.039	0.025	4.091 **
Calcium	2.313	2.124	1.447
Cobalt	0.001	0.001	1.335
Copper	0.066	0.047	3.876 **
Iron	0.327	0.232	2.957 **
Magnesium	36.256	30.204	3.030 **
Manganese	0.850	0.793	0.616
Molybdate	0.020	0.020	0.089
Nickel	0.011	0.005	3.098 **
Phosphorus	85.492	70.220	3.489 **
Potassium	72.593	67.357	1.556
Sodium	0.684	0.515	1.157
Sulphur	19.392	16.670	3.028 **
Zinc	0.580	0.391	4.671 **

Grains from crops with Straighthead were compared to those of general rice mill samples provided by Ricegrowers' Co-operative Limited. The higher concentrations of minerals in grain from the "OK" areas in crops with Straighthead also suggests that the effects of Straighthead are not confined just to the areas of crop with visible symptoms. (Table 8).

Table 8:

Minerals in Rice Samples from areas of crop affected by Straighthead, near Straighthead and from general samples.				
	1999	1999	1998	1998
	Brown Rice	Brown Rice	General Samples	
	Straighthead	near Straighthead	Brown	Milled
No. samples	18	16	24	24
Al mg/kg	4.9	2.8	0.8	0.04
As (total) mg/kg	1.5	0.73	0.32	0.31
As (inorg) mg/kg	0.19	0.14	0.09	0.06
B mg/kg	1.7	1.2	0.9	0.4
Cd mg/kg	0.0	0.0	0.0	0.0
Ca mg/kg	94	94	91	46
Cr mg/kg	0.0	0.0	0.1	0.1
Cu mg/kg	2.0	2.0	2.7	2.1
Fe mg/kg	14	9.9	11	2.5
Mg mg/kg	1490	1290	1090	220
Mn mg/kg	35	35	38	12
Hg mg/kg	0.0	0.0	0.0	0.0
Mo mg/kg	0.75	0.83		
Ni mg/kg	0.47	0.22		
P mg/kg	3500	3010	2770	930
K mg/kg	3000	2920	2850	921
Se mg/kg	0.06	0.06	0.1	0.1
Na mg/kg	27	22	26	13
S mg/kg	790	720		
Zn mg/kg	25	17	17	12

Table 9: Soil mineral concentration samples from Straighthead and OK areas of 1998/99 rice crops

Element (mg/kg)	SH	OK	
	mean	mean	t Stat
Aluminium	21753	22200	-0.350
Arsenic	4.90	3.90	2.280 *
Arsenic inorganic			
Boron	3.90	3.60	0.990
Calcium	2297.0	2384.0	-0.700
Cobalt	10.000	10.000	0.930
Copper	22.0	23.0	-0.520
Iron	21520.0	21473.0	0.040
Magnesium	3819	3666	0.590
Manganese	505.0	534.0	-0.620
Molybdate			
Nickel	17.00	16.00	1.520
Phosphorus	138	159	-1.400
Potassium	3715	3877	-0.630
Sodium	567	585	-0.270
Sulphur	130	148	-2.310 *
Zinc	39.0	39.0	-0.130

>2.13 p=0.05 *

>2.95 p=0.01 **

B. Glasshouse Studies

The data from only one of the 5 studies are reported here (Table 10). The rate of arsenic which allowed rice genotypes to be separated according to their responses Straighthead symptoms varied between experiments.

The consistent pattern which emerged was that the long grain varieties Doongara, Langi, and Pelde and the advanced line YRL118, showed more symptoms of Straighthead at lower rates of arsenic than the medium grain genotypes such as Millin, Calrose, Namaga, and YRK4.

Table 10: Responses to arsenic by 13 genotypes.

Summary table for MSMA exp2	mean As				
	control	1ml MSMA	2ml MSMA	4ml MSMA	8ml MSMA
Number plants per pot	5	5	5	5	5
Mature tiller dry straw wt(g)	10.07	10.23	9.65	11.24	10.45
Mature tiller straight head score	3	2	4	4	4
Mature head number	11	11	10	10	8
late tiller dry straw dry wt (g)	2.11	2.45	2.86	3.27	3.42
late tillers grain dry wt(g)	0.66	0.59	0.23	0.02	0.05
late head number	4.7	4.77	4.27	0.73	1.12
Mature wt of full grains	6.1	5.63	5.2	4.89	1.78
Mature wt of empties	0.754	0.956	0.719	0.733	1.031
Mature empties number	201	259	180	207	318
Mature number of full grains	270.2	233	211.9	204.3	74.4
Dry wt of full grains (65/1hr)	6.14	5.56	5.03	4.76	1.74
HI	40.47	39.65	38.55	33.43	21.31
Average grain weight	23.47	23.99	24.77	26.27	17.54
% sterile	16.9	20.2	19.7	24.4	60.5

There is a significant effect of different rates of arsenic on % sterile grain (Figure 4) showing a large difference between cultivars Namaga, Millin, YRK4 and Calrose are not affected by event the highest rate of arsenic in MSMA Experiment 2, while the long grain cultivars, Langi and YRK118 have high rates of sterility with even the smallest amount of arsenic added.

Doongara had high levels of sterility before any arsenic was added in this trial.

Amaroo, Jarrah, Illabong, Koshi, Kyeema and Pelde were only affected by arsenic at the highest rate, leading us to believe that it has intermediate tolerance to arsenic.

Figure 4:

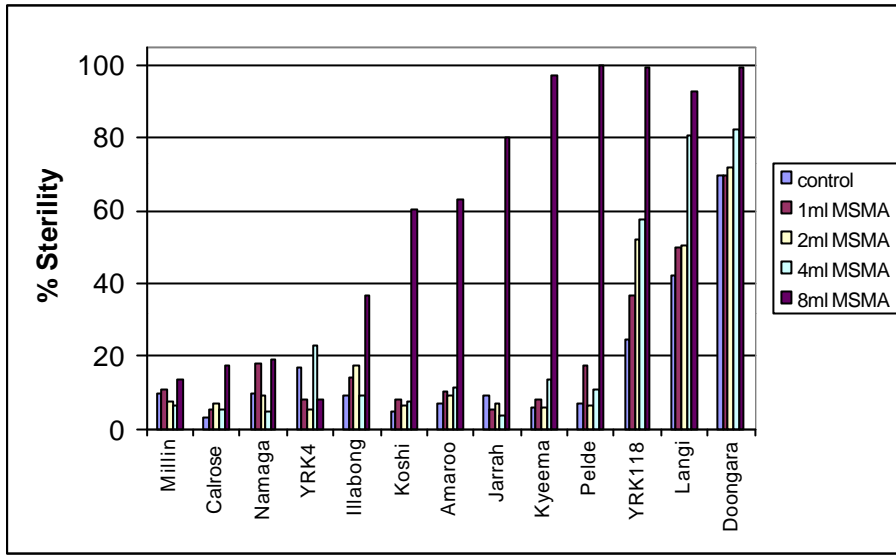


Figure 5:

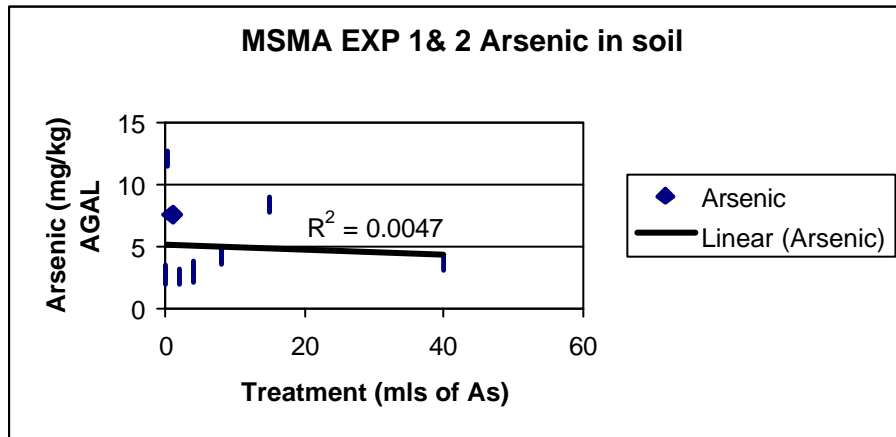


Figure 6:

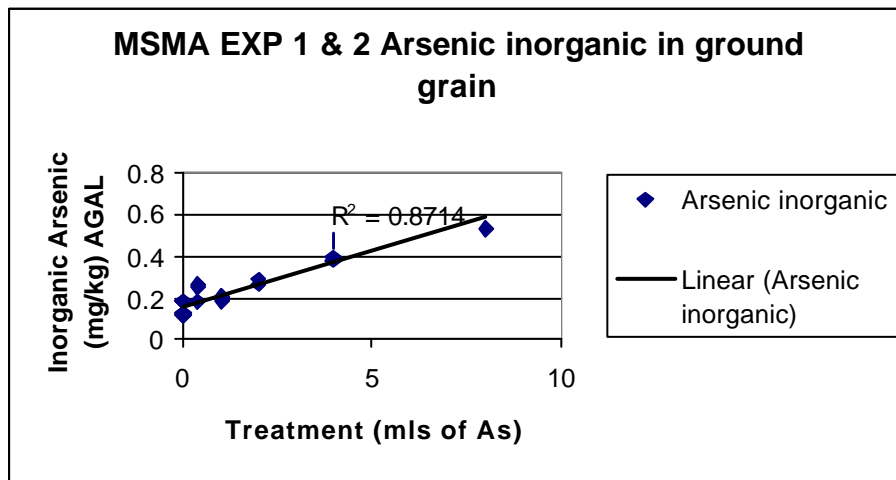
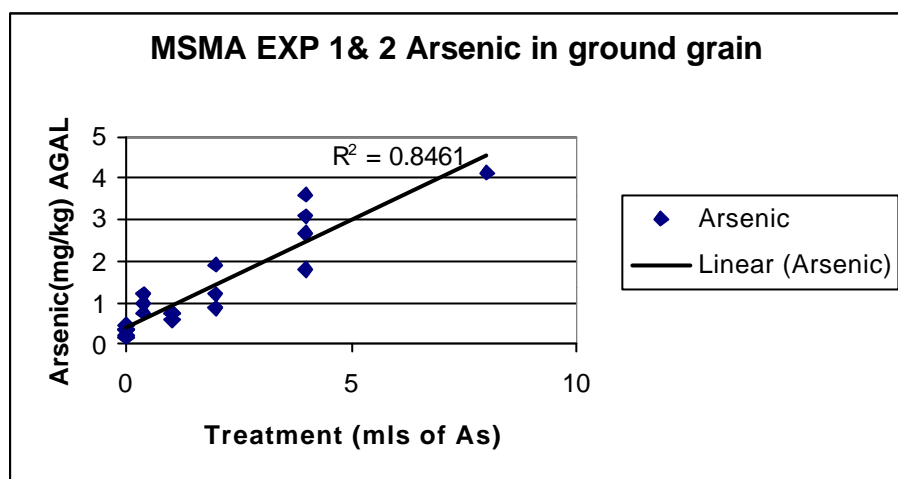


Figure 7:



6. Discussion of results including an analysis of research outcomes compared with the objectives.

The results from this project have confirmed earlier observations that Straighthead is an isolated problem, which can cause serious losses for individual rice producers.

Straighthead is mostly reported in crops of long grain varieties, such as Langi, and the short grain variety Koshihikari. Crops grown after pasture or where rice stubbles are incorporated are more likely to suffer from Straighthead.

Producers who find Straighthead can, and do, easily change to medium grain varieties. Currently, about 80% of rice stubbles are burnt so the carryover of organic matter is generally not a problem if rice is grown after rice. But rice after pasture is still of concern. In the future, more rice stubbles will be incorporated rather than burnt as rice producers come to appreciate that incorporation retains on average 56 kg N / ha (Table 4). Retaining the nitrogen in the soil reduces emissions of nitrous oxides to the atmosphere where they are 310 times more damaging than carbon dioxide in terms of greenhouse effects.

The major concern that emerged from this project, based on harvest index and grain mineral analyses, is that the Straighthead problem is not simply confined to the (usually) small patches of crop which give the disorder its name of Straighthead. Crop nearby with no visible symptoms of a disorder are also poor compared to average crops. A yield reduction of some 30% is suggested as the real impact of the disorder.

This finding makes Straighthead a problem with a greater economic impact than previously thought and underpins the recommendation that further research be conducted to define the cause of the problem and ultimately to define management practices which reduce its occurrence or severity.

The glasshouse studies were valuable in that they confirmed varietal differences in Straighthead symptoms. The disadvantage noted in the greenhouse studies was variation in response to MSMA between seasons, possibly a temperature of daylength interaction effect. Thus it was difficult to reproduce the effects at a given rate of applied arsenic. There is also the concern that arsenic, while it induces the symptoms, may not have a different mode of action to that caused by high organic matter in the field. Williams (2001) suggests that the redox potential of the soil is lowered by

additions of organic matter such as straw or sugar, and he used such additions to induce Straighthead in the glasshouse.

Grain quality

The analysis of grains from the field survey showed that most minerals were in higher concentrations in grain from straight head crops. The cause of this is suggested as a dilution effect due to lower yields and lower harvest index values (Batten 1986).

Of concern is the observation that the increases in mineral concentrations include increases in some of the heavy metals. It is possible that some elements in Straighthead-affected crops may exceed the maximum amounts allowed by overseas markets. On the basis of one comparison there is also concern that the grain from crops affected by Straighthead may have a very low millout percentage.

For these reasons there is concern that the grain of Straighthead crops could contaminate an otherwise sound shipment. Segregation is advised.

7. Implications and Recommendations – where possible, a statement of relevant costs and benefits to the Australian industry should be provided

These studies extend our understanding of the crop disorder Straighthead.

The impact of Straighthead is difficult to define. A suggested impact is over 1 million dollars per year. This is based on the assumption that 1% of the crop area (60 crops of 30 ha) is affected with a yield loss of 30% and rice is valued at \$200 per tonne. Individual growers suffer serious losses. One grower in 1999 had over 500 acres affected by Straighthead and believed it cost him \$70,000 in lost production.

The impact of stubble incorporation is known to enhance the incidence of Straighthead. But, to promote environmentally-friendly rice production and nitrogen economy stubble incorporation should be encouraged.

In addition, and potentially more devastating, is the risk to marketing of grain due to mixing poor quality grain with sound grain.

Further studies are highly desirable.

Recommendation 1. Develop a field screening system to aid in the selection of rice genotypes which have tolerance to the disorder known as Straighthead.

A field screening system used in Arkansas relies on the MSMA approach. This is deemed environmentally undesirable and may rely on a different mode of action to the 'natural' situation in Australian soils. In case the MSMA approach is misleading, it is recommended that a field system be developed which, building on the pot work of Williams (2001), uses straw to induce the disorder.

Recommendation 2. The screening system developed in Recommendation 1 be used to test theories as to the cause of the disorder.

Recommendation 3. Grain samples from crops affected by Straighthead be harvested and dried specifically to determine the impact of the disorder on the percent whole grain.

Recommendation 4. All rice producers be alerted to the problems associated with Straighthead and asked to advise Ricegrowers' Co-operative Limited of all crops which display symptoms of the disorder.

8. A description of the Project Intellectual Property and of any commercially significant developments arising from the Project.

The finding that some grains of rice may contain heavy metals which exceed the acceptable limits for some markets should be discussed by CRC Scientists and Rice Industry officials.

9. A dissemination strategy and communications or extension plan for the Project, including Publications.

Discussions will be held with the Rice industry to raise awareness of the issues.

Additional funding will be sought from the RIRDC to continue the routine and investigative studies on Straighthead.

10. A technical summary of all information developed as part of the Project, including discoveries in methodology and equipment design.

11. Relevant References

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12. Staff who contributed to this Project

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APPENDIX 1

RICE STRAIGHTHEAD SURVEY - 1998/99 - CROP DATA SHEET

GROWER NAME

ADDRESS

MOBILE () PHONE ()
 Best time to phone

SAMPLE IDENTIFICATION: FARM NO..... FIELD NAME.....

VARIETY:

DOES YOUR CROP HAVE THESE KEY STRAIGHTHEAD SYMPTOMS?

- Paddock history of straighthead
- Parrot Beaking /misshapen florets
- Worse sterility in low N areas
- Sterility right to the bank
- Less sterility near the water inlet

STRAIGHTHEAD

Have you seen straighthead in your rice before? YES NO

If yes, have you changed your management to reduce straighthead? YES NO

How?.....

How bad is the problem? A few heads
 Patchy occurrence eg. 10m²
 Large portion of cropacres/hectares (estimated)
 Whole crop

What is your estimated yield loss due to straighthead?.....

CROP DESCRIPTION: *(Please complete as accurately as possible)*

>10 cm surface soil
 >10 cm surface soil

Have you had a soil test done on this paddock? YES NO Do you still have the results ? YES NO

Has lime been applied to the soil? YES NO Rate and date of application

(b) PADDOCK HISTORY *(Please tick appropriate boxes or write in as specified)*

SEASON		RICE	VARIETY	WINTER CEREAL	CLOVER PASTURE	NATURAL PASTURE	OTHER CROP / COMMENT
1998	Winter						
1997/98	Summer						
1997	Winter						
1996/97	Summer						
1996	Winter						
1995/96	Summer			YES	<input type="checkbox"/>		

Was organic matter incorporated into the soil? YES NO

If yes, what was the type of organic matter incorporated? (eg. Oaten straw, sub clover)

What was the level of organic matter incorporated? High Medium Low

(c) SOWING

SOWING DATE Eg 15/10/98 (give first flush date for drill or combine sown crops)

SOWING METHOD

POTENTIAL YIELD LOSS DUE TO WEEDS NIL 201 - 250 >250

1 - 2 t/ha >2 t/ha

(d) FERTILISER APPLICATION (List: brand, type and rate of fertiliser applied at each stage. If none used, write "Nil")

	WITH SEED AT DRILL SOWING	PRE-FLOOD NITROGEN &/or PHOSPHORUS		POST FLOOD TO PI	PI
		FERTILISER 1	FERTILISER 2		
FERTILISER Type					
Rate					
<i>Example Type</i>	<i>Nil</i>	<i>Hi-Fert Goldphos 20</i>	<i>Pivot Urea</i>	<i>Nil</i>	<i>Greenleaf Urea</i>
<i>Rate</i>		<i>1 bag/acre</i>	<i>300 kg/hectare</i>		<i>1/2 bag/acre</i>

Was a NIR Rice Tissue Test done on this crop? YES NO Sample No

Any further information or comments

We hope that this survey will reveal the extent of the straighthead disorder and indicate what causes it.
 Thankyou for your time
 We would appreciate any comments on this topic via your local District Agronomist or by calling 02 69512713

Graeme Batten }
 Laurie Lewin } Yanco Agricultural Institute, PMB Yanco 2703
 Robyn Troidahl }
 Phillip Williams, Ricegrowers' Co operative Ltd., Leeton 2705

This work is being funded by the CRC for Sustainable Rice Production.



RICE STRAIGHTHEAD SURVEY - 1999/2000 - CROP DATA SHEET

GROWER NAME

ADDRESS

MOBILE () **PHONE** ()

Best time to phone

SAMPLE IDENTIFICATION: FARM NO..... FIELD NAME.....

VARIETY:

DOES YOUR CROP HAVE THESE KEY STRAIGHTHEAD SYMPTOMS?

- Paddock history of straighthead
- Parrot Beaking /misshapen florets
- Worse sterility in low N areas
- Sterility right to the bank
- Less sterility near the water inlet

STRAIGHTHEAD

Have you seen straighthead in your rice before?

If yes, have you changed your management to reduce straighthead
How?.....

How bad is the problem?

A few heads

Patchy occurrence eg. 10m²

Large portion of crop

.....acres/hectares (estimated)

Whole crop

What is your estimated yield loss due to straighthead?

CROP DESCRIPTION: *(Please complete as accurately as possible)*

Have you had a soil test done on this paddock?

Do you still have the results ?

Has lime been applied to the soil?

Rate and date of application

(b) PADDOCK HISTORY *(Please tick appropriate boxes or write in as specified)*

SEASON		RICE	VARIETY	WINTER CEREAL	CLOVER PASTURE	NATURAL PASTURE	Stubble or pasture residue??	Comments
1999	Winter							
1998/99	Summer							
1998	Winter							
1997/98	Summer							
1997	Winter							
1996/97	Summer							

Was organic matter incorporated into the soil prior to this crop?
 Do you usually incorporate stubble.....

If yes, what was the type of organic matter incorporated? (eg. Oaten straw, sub clover)

What was the level of organic matter incorporated? High Medium Low

(c) **SOWING DATE** / Eg 15/10/99 (give first flush date for drill or combine sown crops)

SOWING METHOD

POTENTIAL YIELD Nil up to 0.5 201 - 250 > 250 1 - 2 t/ha >2 t/ha
LOSS DUE TO WEEDS

(d) **FERTILISER APPLICATION** (List: brand, type and rate of fertiliser applied at each stage. If none used, write "Nil".)

	WITH SEED AT DRILL SOWING	PRE-FLOOD NITROGEN &/or PHOSPHORUS		POST FLOOD TO PI	PI
		FERTILISER 1	FERTILISER 2		
FERTILISER					
<i>Example Type</i>	<i>Nil</i>	<i>Hi-Fert Goldphos 20</i>	<i>Pivot Urea</i>	<i>Nil</i>	<i>Greenleaf Urea</i>
<i>Rate</i>		<i>1 bag/acre</i>	<i>300 kg/hectare</i>		<i>1/2 bag/acre</i>

Was a NIR Rice Tissue Test done on this crop? Sample No.....

Any further information or comments

.....

We hope that this survey will reveal the extent of the straighthead disorder and indicate what causes it.
 Thankyou for your time

We would appreciate any comments on this topic via your local District Agronomist or by calling 02 69512713

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APPENDIX 2

Straighthead rating scale used at Stuttgart, Arkansas, USA

At maturity, data were collected by visually rating the centre of each plot for floret sterility and panicle emergence from the boot.

The scale ranged from 1 to 9

where 1 = no floret sterility

2 = 1 to 20% floret sterility

3 = 21 to 40% floret sterility

4 = 41 to 60% floret sterility

5 = 61 to 80% floret sterility

6 = 81 to 100% floret sterility

7 = panicles emerged from boot but 100% floret sterility

8 = panicles partially emerged from the boot and 100% floret sterility

9 = panicles not emerged from the boot

REFERENCE:

Andre Rasamivelona, Kenneth A. Gravios and Robert H. Dilday. 1995.
Heritability and Genotype x Environment Interactions for Straighthead in Rice. *Crop Sci.* 35:1365-1368.

APPENDIX 3 Results from 1998/99 Straighthead Survey

Variety	Labelled	Dry Weight of Crop Affected with Severe Straighthead			GPS Location		Label	Dry Weight of Moderate Straighthead			GPS Location		Label	Dry Weight of Good Area Rice			GPS Location
		Site 1	Site 2	Site 3	Latitude	Longitude		Site 1	Site 2	Site 3	Latitude	Longitude		Site 1	Site 2	Site 3	
Koshi	L.Arthur Koshi SH 1,2,3				S 35°11'50.6"	E 144°17'41.1"							L. Arthur Koshi Good 1,2,3				
Koshi	I SH 123				S 35°08'42.8"	E 144°02'42.7"							Good 123				
	SH 123				S 35°18'27.5"	E 144°22'19.6"							OK 123				S 35°18'3"
Koshi	DM SH	1234	1556	1455	S 35°22'06.3"	E 144°24'41.9"							DM OK 1	1902	2152		
Koshi	DMartin Block 2 SH 1,2,3				S 35°21'53.1"	E 144°24'58.5"							D Martin Blk 2 Good 1,2,3				
	SH123				S 35°33'35.0"	E 144°12'32.7"							Good 123				
Millin	GM Mill	1765	1691	1856			GM Mill Mod 1	2299	1860	1880			GM Millin	2146	2150	2002	
Amaroo	SH123				S 35°26'20.5"	E 145°05'58.3"							OK 123				S 35°26'2"
Koshi	J Walter SH 1,2,3				S 35°40'34.5"	E 144°32'27.9"							J Walter Good 1,2,3				S 35°22'0"
	SH123				S 35°29'03.5"	E 144°39'21.8"							OK 123				S 35°29'0"
Koshi													Neil Chalmers Koshi Good 1,2,3				
Koshi	RC SH	1959	1968	1958			RC OK 1,2,3	1846	2179	1934			Rod C Koshi Good 1,2,3				
Koshi	Rod C No 2 SH 1,2,3				S 35°18'43.5"	E 144°05'48.7"							Rod C No 2 OK 1,2,3				
Namaga													OK 123				
Langi	SH123				S 35°18'30.6"	E 144°14'50.6"							OK 123				S 35°18'3"
	SH123												Good 123				
	A Wragge OK123				S 35°30'59.4"	E 144°41'22.9"							OK 123				S 35°31'16"
	Te Anau SH123				S 35°25'29.9"	E 144°48'25.9"							Te Anau Good 1,2,3				S 35°25'2"

APPENDIX 3(B)

Straighthead samples from 1999/2000 season results from CRC Straighthead Survey 1999 book
(pages 35-37)

Sample	Variety	SH score	Dry wt	Seed wt	HI	
RW SH1	Langi		2010	921	0.46	
RW SH2	Langi		2163	944	0.44	
RW SH3	Langi		1845	726	0.39	HI
RW OK1	Langi		2017	783	0.39	R. Williams
RW OK2	Langi		1736	485	0.28	Mean SH 0.43
RW OK3	Langi		1453	565	0.39	MeanOK 0.35
TH SH1			1819	519	0.29	
TH SH2			2108	302	0.14	
TH SH3			1993	300	0.15	HI
TH OK1			1889	371	0.20	T. Henman
TH OK2			2181	407	0.19	Mean SH 0.19
TH OK3			2248	474	0.21	MeanOK 0.20
FC SH 1			1626	279	0.17	
FC SH 2			1569	264	0.17	
FC SH 3			1846	354	0.19	HI
FC OK 1			1715	438	0.26	F. Cordor
FC OK 2			2108	630	0.30	Mean SH 0.18
FC OK 3			1669	518	0.31	MeanOK 0.29
BB SH1	Langi		1773	899	0.51	
BB SH2	Langi		1397	217	0.16	
BB SH3	Langi		1359	585	0.43	HI
BB OK 1	Langi		1394	725	0.52	B.Barnhill
BB OK 2	Langi		1724	832	0.48	Mean SH 0.36
BB OK 3	Langi		1646	902	0.55	MeanOK 0.52
LC SH1	Langi		1363	658	0.48	
LC SH2	Langi		1657	712	0.43	
LC SH3	Langi		1594	583	0.37	HI
LC OK1	Langi		2450	575	0.23	L. Chapman
LC OK2	Langi		1358	564	0.42	Mean SH 0.43
LC OK3	Langi		1352	561	0.41	Mean OK 0.35

RS SH1	Langi		2004	274	0.14	
RS SH2	Langi		2094	309	0.15	
RS SH3	Langi		1889	222	0.12	HI
RS OK1	Langi		1814	531	0.29	R. Scarf
RS OK2	Langi		1467	482	0.33	Mean SH 0.13
RS OK3	Langi		1652	567	0.34	MeanOK 0.32
RD SH1	Namaga		2061	198	0.10	
RD SH2	Namaga		2147	271	0.13	
RD SH3	Namaga		2146	413	0.19	HI
RD OK1	Namaga		1975	921	0.47	R. Dixon
RD OK2	Namaga		1581	700	0.44	Mean SH 0.14
RD OK3	Namaga		1919	807	0.42	Mean OK 0.44
JB SH1	Langi		874	327	0.37	
JB SH2	Langi		1584	524	0.33	
JB SH3	Langi		1536	429	0.28	HI
JB OK1	Langi		1515	653	0.43	J. Bradford
JB OK2	Langi		1585	705	0.44	Mean SH 0.33
JB OK3	Langi		1718	765	0.45	Mean OK 0.44
MR SH1	Langi		2022	879	0.43	
MR SH2	Langi		2774	997	0.36	
MR SH3	Langi		1950	905	0.46	
MR OK1	No samples found	No results in book				HI
MR OK2	No samples found	No results in book				M. Robinson
MR OK3	No samples found	No results in book				Mean SH 0.41
						Mean OK