

**BUREAU OF SUGAR EXPERIMENT STATIONS
QUEENSLAND, AUSTRALIA**

**ACID SULFATE SOILS IN CANEGROWING
REGIONS OF NORTHERN NEW SOUTH WALES**

by

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EXECUTIVE SUMMARY

The situation regarding acid sulfate soils of southern canelands was reviewed during a visit from 3-6 October 1994 to the northern New South Wales sugar region.

Acid sulfate subsoils contain iron pyrites (FeS_2). Pyrites is stable under anaerobic (saturated) conditions, but when oxidised forms sulfuric acid and releases mobile Fe^{2+} ions. Soil pH can be reduced to as low as 2 and aluminium (Al) is released into the soil solution. These conditions can be toxic for plants. Ground water from acid sulfate soils which finds its way to drains and streams, particularly after rainfall following extended dry periods, may kill aquatic life.

Periodic fish kills, attributed to the above cause, have occurred in rivers and streams of canegrowing regions of northern New South Wales. Generally the highest yielding cane in northern New South Wales is grown on soils with potential acid sulfate subsoils, but there are a few examples of acute acid sulfate toxicity, such as that described for coastal north Queensland.

Potential exists in the south, due to large areas of acid sulfate subsoils, for the products of pyrites oxidation to be carried from canelands, and other sources, into streams and rivers. In a region of increasing population, where recreational activities are becoming of greater economic importance, industries may be subject to legislation and restrictions because of the perception that they are damaging the environment.

Current activities by the sugar industry with respect to acid sulfate problems are to be commended. Farmer education programs and advice with regard to laser levelling, shallow drains, soil and drain water analysis and treatment of drainage spoil, will reduce the adverse environmental impact of farming acid sulfate soils. Despite the above activities, pressure from outside the industry will continue, particularly with each occurrence of fish death.

It is recommended that the sugar industry continues with its positive lead on this environmental issue, if it is to secure future survival and growth. Not only must the industry adopt best practices, but it must be seen to be adopting these practices. Research is required to obtain quantitative data on the relative contribution of drainage from canelands to overall acid sulfate problems in catchments of the region. Additional research is required to test techniques designed to reduce acid discharge from canelands, and this should be followed by promotion of techniques shown to be effective. A demonstrated reduction in acid discharge from canelands has potential to generate much positive publicity and forestall unfavourable public reactions.

Implementation of a rapid titration test for total sulfidic acidity of soil is proposed; however, research is required to establish criteria for critical levels, sampling intensity and sampling depth.

The effects of the following practices on acid discharge and cane yield need to be researched:

- Minimum soil disturbance
- Mounding
- Liming
- Improved surface drainage
- Water-table control
- Treatment of drainage water
- Treatment of drainage spoil (liming, capping, burial)

Not all suggestions made in this report will be appropriate in all situations. However, with increased communication between the various interest groups, increased technical expertise brought to bear on the problem will result in the minimisation of acid sulfate problems in the canegrowing areas of the region.

1.0 INTRODUCTION

The author was invited to inspect and comment on the situation regarding acid sulfate soils in the three most southern mill areas of the Australian sugar industry. A day was spent in each mill area inspecting and discussing the situation with officers of the New South Wales Sugar Milling Cooperative. Assistance provided to the NSW Sugar Milling Cooperative was provided under the terms of a contractual arrangement for BSES to provide extension and technical services to the NSW sugar industry.

A request for an in-house review of approaches to the management of acid sulfate soils was prompted by perceived community concerns regarding possible adverse environmental effects associated with farming these soils. Of particular concern is fish death blamed on the products of oxidised pyrites, flushed into streams and rivers following rainfall. In many cases, agriculture is at the receiving end of adverse publicity following fish death.

The purpose of the inspection was to critically review the current approach to acid sulfate soil problems and make recommendations regarding future actions.

2.0 BACKGROUND INFORMATION

2.1 The acid sulfate problem

Approximately 10 000 years ago, much of Australia's coastal lowlands was submerged by seawater. In tidal swamps and marshes, bacteria breaking down the abundant organic matter reduced sulphates (SO_4^{2-}) from the tidewaters and iron III oxides in the sediment, to form iron pyrites (FeS_2). Greatest concentration of pyrites formed under anaerobic conditions. As the sea receded, pyrites sediments were overlaid by alluvium. These alluvial soils were fertile and have been shown to be highly productive for agriculture. Pyrites in subsoils causes no problems, provided it remains buried and in an anaerobic condition. Problems arise when subsoils containing pyrites are exposed to the air during drain excavation or by a falling water-table. Pyrites is oxidised to sulfuric acid and mobile Fe^{2+} ions. This reduces soil pH to as low as 2 and releases aluminium into the soil solution.

Acidic ground water containing the products of oxidised pyrites, if carried into drains, streams and rivers, can result in conditions toxic to most forms of aquatic life. Streams can show a marked change in colour from muddy brown to brilliant blue and may become crystal clear as sediments settle. Severe acid sulfate effects occur infrequently (at a 30-year interval), generally following rainfall after extended dry periods, although localised occurrences may occur more frequently.

Death of fish in river systems is of concern not only because of damage to recreational and professional fishing industries, but also because of the disagreeable aesthetic nature of this occurrence. Of further concern to coastal agriculture are suggestions that farming activities may cause or contribute to fish death or sickness by increasing the rate of oxidation of pyrites.

2.2 Extent of the inspection

The Condong mill area was inspected with Tony Hayes. Peat soils which overlay a layer of pyrites were inspected in the Crabbes Creek area on the coast to the south of Murwillumbah and McLeods Creek to the north. McLeods creek is the location of a field trial with instrumentation established by CSIRO and the University of NSW as part of the coastal zone program.

New canelands located near Rocky Mouth and Tuckean Creeks in the Broadwater Mill area known to have acid sulfate subsoil problems were inspected with Peter Nielsen. Poor growth of cane thought to be due to nutritional problems was also inspected in the mill seed cane plot and a field in the Tuckean Creek area.

Results of soil tests in the Harwood mill area were made available by Don Parsons, and canelands known to have acid sulfate problems were inspected. These areas included the property of J Hirst (Maclean), J Moloney (Shark Ck) and A Baker (Lawrence).

2.3 Contrast between acid sulfate problems of the northern and southern sugar industries

Acid sulfate toxicity was identified in canelands of coastal north Queensland in the late 1980s (Reghenzani and Haysom, 1986). The problem was generally restricted to relatively small areas (patches less than 0.01 ha) showing acute symptoms in cane. Cane was killed where drainage spoil containing pyrites was spread in the field, particularly where spoil was used to fill hollows. Affected areas were brought back into production over time. The procedure recommended was to improve internal drainage by the use of mole drains and allow natural leaching of acid from the profile over one or two wet seasons. The application of heavy rates of lime (10-15 t ha⁻¹) and the adoption of shallow farming techniques were then used. Fish kills attributed to acid sulfate runoff are rare in northern canegrowing areas. It is likely that in north Queensland, tidal exchange and river flows are adequate to dilute products of pyrites oxidation to non-toxic concentrations.

The southern canegrowing region is characterised by large areas of low lying delta soils, much of which has potential acid sulfate subsoils. Generally cane growth is not adversely affected by acute acid sulfate toxicity unless drain spoil is spread in cane fields. Major fish kills, which occur in some streams of the southern region about every 30 years, are associated with heavy rainfall after an extended period of dry weather. Although there is little quantitative evidence to associate farming activities with damage to fish stocks, suggestions have been made that this link exists.

The southern sugar industry is now in a position where it must seriously consider off-farm effects of farming activities, if it is to safeguard long-term industry viability.

2.4 Overview of the acid sulfate soils situation in the southern sugar industry

The greatest area of concern is within the Condong Mill area because about half of the area overlays potential acid sulfate subsoils. The peat soils which overlay potential acid sulfate subsoils are the most productive of Condong canelands. Broadwater Mill is currently expanding into regions known to overlay potential acid sulfate subsoils. The pH of drainage water in these regions is being monitored and techniques such as lime application to drains and capping of drainage spoil are being implemented by innovative canegrowers. In Harwood Mill area both existing and new canelands are known to have acid sulfate problems. Frequently acid sulfate problems are associated with salinity in the Harwood Mill area.

Government authorities have an interest in the effects of agricultural activities on the acidity of drain discharge. An order placed by the Maclean Council and the Department of Conservation and Land Management which stopped work on a new cane assignment at Maclean early in 1994 is evidence of this interest. The order was placed when low pH water discharged from a drain servicing the development. Work was allowed to continue after drain water and levees at the site were treated with lime and evidence presented which showed a similar low pH for water entering the drain from a natural area.

An inaugural national conference on acid sulfate soils (Bush, 1993) brought together many organisations interested in acid sulfate problems. In my discussions while visiting southern canegrowing regions, I formed the opinion that while some potential agricultural solutions were suggested at the conference, there has been little evaluation, implementation or development of solutions for canegrowing lands, other than for work by the Cooperative.

3. CURRENT ACTIVITIES REGARDING ACID SULFATE PROBLEMS

In many respects the NSW industry is well advanced in its approach to acid sulfate problems. The circular, 'Guidelines for drain construction and maintenance in acid sulfate soil areas', issued by the NSW Sugar Milling Cooperative in September 1994 (Appendix A), is an example of positive steps to inform growers and promote management techniques which minimise the risk of farming potential acid sulfate soils.

Other activities which assist with identification and control of acid sulfate risk are:

1. subsidised soil analysis which helps identify problem areas and promotes the use of lime;
2. laser levelling of fields to improve surface drainage;
3. monitoring of drain water pH;
4. burial, liming and capping of drainage spoil;
5. identification and avoidance of acid sulfate 'hot spots' for new cane expansion.

4.0 SUGGESTIONS REGARDING THE FUTURE APPROACH TO ACID SULFATE PROBLEMS

The natural consequence of population growth, industry expansion and alienation of sugarcane lands is increased public scrutiny of the sugar industry's environmental record. Off-farm movement of products of acid sulfate oxidisation, fertiliser nutrients, pesticides and even the

ash from cane fires, have potential to become very emotive issues. The challenge for the sugar industry is to foresee and handle these issues appropriately.

When considering the appropriate approach to environmental issues, the legitimate aspiration of the sugar industry must be balanced with those of other resource users. This does not mean that the requirements of one group will have an adverse effect on another, rather that a process of communication and consultation is essential for the long-term prosperity of all. With regard to the acid sulfate issue, I recommend that the sugar industry takes a proactive stance, which takes cognisance of the sociological and physical aspects of the situation.

I suggest the following three-faceted approach:

1. **Positive communication.** The sugar industry already has a positive approach to finding solutions to acid sulfate problems, and it should communicate this fact directly to groups which may regard themselves as adversaries. The aspect of communication is listed first as I am of the opinion that public perceptions are probably more important than the next two topics which are more physically based.
2. **Sources of acidity.** The relative contribution of drainage from sugarcane lands to the overall acidity problem needs to be determined quickly. This will indicate how important the problem is to the sugar industry, the direction in which any research effort should go, and the likely impact of agricultural solutions on the overall problem.
3. **Methods of reducing acid discharge from canelands.** While it is suggested that practices listed in Section 3.2, and later in Section 4.3, may reduce acid discharge, there is a need to obtain quantitative data on the cost, effectiveness and effects on sugarcane productivity.

4.1 Positive communication

The NSW Sugar Milling Cooperative should give consideration to appointing a specialist in public relations.

Strong representation of sugar industry interests in active landcare or total catchment management (TCM) groups is another way of fostering community cooperation and generating positive communication. Mr Nielsen's involvement in the TCM water quality committee is to be commended. Early access to analytical data and input into interpretation will be positive benefits to flow from involvement in the TCM group. In addition, the TCM group has the potential to coordinate and support an increased research effort into monitoring and control of acid sulfate problems.

4.2 Sources of acidity

Although it is recognised that drainage from canelands is a source of acidity, there are little quantitative data on the contribution from caneland relative to that from other sources. Circumstantial historical evidence of fish kills before establishment of drainage systems, and even before clearing for agriculture, suggest substantial natural sources of acidity.

With data already available from sampling within catchments, it may be possible to carry out a catchment balance for sources of acidity. The basic data required for such an audit would be concentration and flow rate. Such a catchment-wide audit would best be performed by the TCM group. The purpose of an audit would be to identify the relative contribution to acidity from localities or land use activity (including natural land use).

Should existing data prove inadequate to identify sources and their relative contribution, consideration should be given to obtaining the data from a coordinated sampling program, or from colour changes in waterways using remote sensing. If entire catchment auditing does not meet with TCM approval, or is beyond available resources, an alternative may be to monitor a subcatchment, such as Rocky Mouth Creek, which contains a variety of land uses.

Monitoring of net fluxes at entry and exit of the creek, and from point sources (drains from sugarcane lands), would permit estimation of non-point sources by difference. Calculation of net fluxes in a tidal situation would require continuous measurement of chemical parameters, rate and direction of flow.

4.3 Methods of reducing acid discharge from canelands

There are a larger number of options for control of acidity available to canegrowers than can be implemented in the natural situation, or under less intensive agriculture. With greater control over factors which influence the generation of pyrites oxidation products, it is possible that use of land for canegrowing could reduce the release of acidity, or at least not make it worse.

There is little information available on the effectiveness of management options discussed in this section. While in all likelihood the options are indeed best practices, each should be evaluated in the field, before being promoted within the sugar industry. The methods outlined below are a compilation of my practical experience with rehabilitation of acid sulfate sites in north Queensland, published material (Naylor, 1993; White and Melville, 1993) and discussions with officers of the NSW Sugar Milling Cooperative. Broadly the techniques fall into four categories, listed in order of possible effectiveness; avoidance, prevention, control, and treatment.

4.3.1 Avoidance

Avoidance of soils with severe acid sulfate potential is preferable to trying to cure the problem after it has developed. The farm rating committee, which recommends the granting of new assignment in NSW, has the option to refuse assignment where acid sulfate risk is too great. Maps being produced by the Department of Conservation and Land Management (CALM) will assist in identification of regions of unacceptable risk. However, at 1:25 000, these maps will not show sufficient resolution at the farm scale. Soil sampling at an intensity as determined by regional risk may be required to determine suitability for farm development and as an aid to planning existing and new farms.

Farmers should be encouraged to take soil samples along the path of proposed drains. Alignment of drains to avoid areas of high acid sulfate risk, or construction to shallow depths to avoid acid sulfate layers are possible management options. Sampling intensity and depth

should be based on a knowledge of acid sulfate risk, variability of pyrites concentration and depth of the pyrites layer. In any case, the number of samples requiring analysis would be expected to be much greater than are being analysed now. The Cooperative may wish to investigate the provision of a simple, rapid, reliable and low-cost test for actual and potential acidity. The rapid titration technique developed by Konsten *et al* (1988) has been suggested as suitable by Dent and Bowman (1993). Electromagnetic induction instruments may also be suitable as low cost discriminators to locate acid sulfate subsoils.

4.3.2 Prevention

Avoidance will not be possible in all situations, because of large areas of caneland overlaying potential acid sulfate subsoils. Some techniques need to be available for application within existing fields. The following techniques are designed to reduce aeration and disturbance of subsoil layers, minimise formation of acidity, reduce water movement into the soil profile and reduce transport of acidity to drainage lines.

4.3.2.1 Minimum soil disturbance

Any soil disturbance such as that caused by deep ripping or ploughing, which inverts soil layers, brings subsoil to the surface or aerates subsoil will result in acidification of potential acid sulfate soil. The skill in farming soils with potential acid sulfate subsoils is to avoid this disturbance. Tines should be used for cultivation, rather than ploughs. Should it be necessary to rip deeply, for example to install mole drains, a Yeoman type leg which results in minimum soil disturbance should be used in preference to a standard ripper leg.

Minimum or zero tillage of ratoons associated with trash blanketing reduces soil disturbance and would be expected to reduce acid production. Although trash blanketing is not particularly popular in the southern sugar industry, zero tillage is common. Additional research is in progress which may overcome barriers to acceptance of green cane harvesting in the southern sugar industry, and this may result in further reduction of soil disturbance.

4.3.2.2 Mounding

Construction of higher than normal mounds in the row offers advantages in the management of acid sulfate problems. A higher row sheds more rainfall into the interspace, increasing surface runoff, decreasing subsurface flow and decreasing the transport of acidity to drains. There is greater depth of soil for plant growth above the water-table, and less need for deep cultivation. In north Queensland, larger mounds tend to keep the plant more erect and make it easier for the harvester to pick up lodged crops. In the south, however, there is a fear of increased losses should cane lodge badly along the row. Care has to be taken when harvesting fields which have been mounded, so as not to increase dirt sent to the mill. Recent studies on the automatic control of basecutter height may overcome this problem. Construction of mounds is very simple if sweeps are used before plant cane is out of hand.

4.3.2.3 Improved surface drainage

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4.3.2.3 Improved surface drainage

Rainfall removed by surface drainage does not enter the soil profile and will not carry acid sulfate products to drainage lines. Laser levelling will improve surface drainage, but care should be taken to minimise cuts, so as not to expose acid sulfate subsoil. Mounded rows and broad, flat, uncultivated and impervious interspaces will assist runoff. Headlands should be below the level of the interspace, to facilitate surface flow to drains (Figure 1).

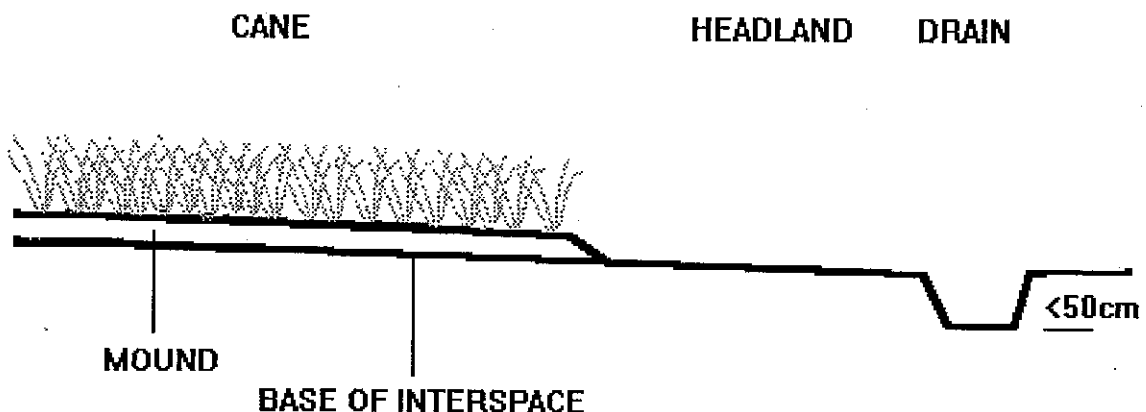


Fig. 1 General arrangement to improve surface runoff to drains.

An alternative arrangement such as shown in Figure 2 could be used if drainage spoil has been capped on headlands, raising headland height. Surface flow is collected in an invert in the field and runs to the drain through a pipe under the headland. The maximum depth of drains such as those shown in Figures 1 and 2 would depend on depth of the acid layer and hydrology of the field. A value of <50 cm is shown only for illustrative purposes to indicate a preference for shallow drains.

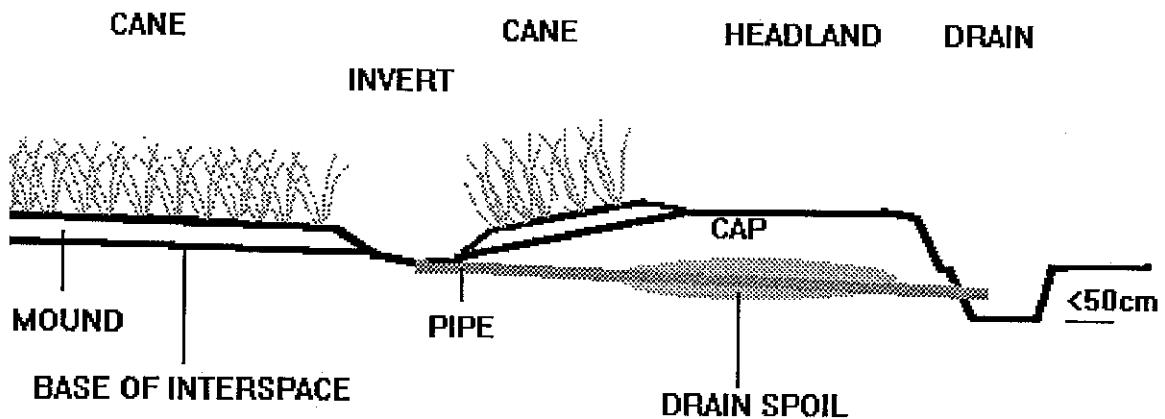


Fig. 2 Alternative arrangement to improve surface runoff where drainage spoil is capped under headlands.

4.3.3 Control

Low lying topography of southern canelands means that drainage is a necessity to minimise loss of productivity due to excess water. Many drains are floodgated to prevent ingress by tidal water and low lift pumps are common to lower the water-table in drains quickly.

There is some disagreement about the value of flood gates and some gates are being opened. The logic behind the opening of flood gates is to prevent the entrapment of fish, improve flushing and avoid the sudden release of acidity, all of which may reduce fish death. It should be possible to develop computer models to test if opening or partial opening of flood gates is having a desirable effect or otherwise. Data generated from the subcatchment study suggested in Section 4.2 would be particularly useful for the model suggested here.

Where topography is appropriate, the drainage system offers the opportunity to do much more than just remove excess water. It should be recalled that most severe fish kills occur following rainfall at the end of an extended period of dry weather. Closure of flood gates and reverse pumping offer the opportunity to control water table height during dry periods, and thus reduce the formation and subsequent flush of acidity.

A series of locks may be necessary to raise water to drains higher in the landscape. It should be noted that reverse pumping would not be suitable for some regions due to

4.3.4.3 Drainage waters

The application of lime to drains certainly raises the pH of static, acid drain water; however, I have some concerns regarding the effectiveness of this treatment in the long term. The concerns I have relate to the effective mixing of lime with water, the cost of lime required to treat all acid water discharged from drainage systems without any direct economic benefit to canegrowers, and possible toxic elements which may remain in drainage water, despite the change in pH.

During discussions with Mr Nielsen before the visit, it was decided to have some water samples analysed by BSES laboratory in Brisbane. Three samples were collected by Mr Nielsen, a sample each of ground water and drain water on the Hickey, Arndell and Burke property and a sample from Rocky Mouth Creek. All locations are within a known acid sulfate problem area. Titrateable acidity assay was requested in addition to standard water assay. The results presented in Table 1 show a large imbalance between anions and cations, suggesting interference possibly due to Al or cations. Assay results show that all waters were not suitable for irrigation. All waters were obviously from acid sulfate areas ($\text{Cl}:\text{SO}_4^{2-}$ ratio less than 8) and had very low pH values. Ground and drainage waters had appreciable salinity and were of lower quality than the creek.

Table 1
Water analysis - Broadwater

	Hickey Arndell & Burke		Rocky Mouth Creek
	Groundwater	Drain	
Conductivity (mmhos cm^{-1})	9.05	5.74	2.76
Na absorption ratio (SAR)	12.1	4.0	5.2
Chlorides (mg L^{-1})	1 952	892	672
NaCl (from Na) (mg L^{-1})	2 998	1 052	714
Total solids (mg L^{-1})	16 013	16 605	16 471
Total hardness as CaCO_3 (mg L^{-1})	1 791	1 983	552
Ca^{2+} (me L^{-1})	11.19	14.15	2.82
Mg^{2+} (me L^{-1})	24.63	25.50	8.22
Na^+ (me L^{-1})	51.24	17.99	12.20
K^+ (me L^{-1})	0.42	0.18	0.34
Cl^- (me L^{-1})	54.99	25.13	18.93
HCO_3^- (me L^{-1})	160	200	240
SO_4^{2-} (me L^{-1})	53.79	52.04	14.76
Titrateable acidity as $\text{mg L}^{-1} \text{CaCO}_3$	1 702	1 485	370
pH	2.67	2.78	3.46
$\text{Cl}:\text{SO}_4^{2-}$ ratio based on mM L^{-1}	2.05	0.97	2.57

Titrateable acidity of drainage and ground water samples averaged 1 594 mg CaCO₃ L⁻¹. For a drain 1.5 m wide and 0.5 m deep, 1.2 kg CaCO₃ per metre of drain would be required to neutralise acidity, assuming the lime dissolved completely. Application rate would be equivalent to 8 t of lime per hectare of drain surface area or 1.6 kg of lime per 1 000 L of drain water.

5.0 POOR GROWTH INSPECTION

Sections of poor growth in two fields suspected by Mr Nielsen of suffering from a nutritional problem were inspected during the visit to Broadwater. Both the mill seed plot and a Tuckean Creek site, in common with other sites apparently showing similar symptoms, were recently laser levelled. Laser levelling removed high sections of beds, formed when fields were first brought into production. Regular patterns of poor growth in fields correspond to high sections of the old beds.

Soil assay data (Table 2) indicate generally low levels of exchangeable potassium (K), but without an assay value for nitric K, I cannot say with certainty that K is limiting cane growth. In any case, values for exchangeable K < 0.2 me% indicate the need for K fertiliser in the range 80-120 kg K ha⁻¹. The poor area on Sawtell's property would benefit from the application of 2.5 t lime ha⁻¹ which will increase Ca, as well as reducing Na percent of cations. The latter value is in the range where yield could be adversely affected (10-15%). No other nutritional problems are indicated by the soil assays. None of the samples indicate an acid sulfate, salinity or sodicity problem.

Regular patterns of poor growth were very obvious in the varieties BN78-8031 and Q124 at the Tuckean Creek site. At both sites foliage showed chlorosis of leaves and necrosis of leaf margins, as has been described for K deficiency; however, dry weather may also be responsible for these symptoms. Chlorotic flecking similar to that described by Anderson and Bowen (1990) for silicon (Si) deficiency were observed on sections of leaves exposed to the sun (sunny side up). Some leaves showed freckling similar to those caused by magnesium (Mg) deficiency.

To assist in determining the cause of poor growth, I recommend the analysis of third leaf samples from healthy and poorly grown BN78-8031 and Q124 (four samples), to be collected from actively growing standover at the Tuckean Creek site. For each sample, select 20 leaves that are not damaged by insects or otherwise diseased. Cut away all but the middle 20 cm section of each leaf, remove and discard the midrib.

Place each leaf sample in a clean labelled paper bag and keep the sample cool and dry in an Esky with freezer bricks, for transport to drying facilities. Dry as soon as possible at 70°C and place the dried paper bags and samples in a sealed plastic bag. At all times care must be taken to avoid contamination of the sample. If leaves are dusty they may be wiped clean with lint-free tissue paper, soaked in distilled or double-distilled water. The sample should not be placed on dirty or metal surfaces, if necessary, work on a clean plastic sheet. In addition to standard assays for macro and trace elements, analysis for B and Si should be requested.

Table 2

Soil analysis - poor growth areas Broadwater Mill

Farmer	Sawtell		Boland & Milgate	NSW CoOp	
	Good	Poor	Poor	Poor	Poor
Depth	0-25	0-25	0-20	0-20	20-40
Date	13/4/94	13/4/94	20/6/94	27/6/94	27/6/94
Lab	BSES	BSES	Incitec	Incitec	Incitec
Colour			Brown	Black	Grey Brown
Texture	Peat-loam	Peat-loam	Clay loam	Loam	Loamy sand
pH(1:Water)	5.13	4.71	5.3	5.0	5.1
Buffer pH			5.3	5.0	5.8
Organic C %			1.2	3.6	1.1
Nitrate N mg kg ⁻¹			6.7	6.0	2.8
S "	18	20	15	13	5
P(BSES) "	118	148	46	>200	79
P(Colwell) "			26	260	50
K meq%	0.139	0.009	0.10	0.24	0.04
Ca "	5.46	1.26	4.04	3.09	0.54
Mg "	3.47	0.36	4.61	0.82	0.14
Al "			3.49	4.93	1.02
Na "	0.537	0.273	0.46	0.17	0.03
Cl mg kg ⁻¹			35	5	5
EC dS m ⁻¹	0.108	0.072	0.22	0.03	0.02
Cu mg kg ⁻¹			1.4	0.8	0.6
Zn "			0.2	3.3	1.6
Mn "			8	9	2
Fe "			88	150	51
B "			0.26	0.52	0.14
Zn(HCl) "			1.0	6.3	1.7
CEC meq%			12.70	9.25	1.77
Na% cations (ESP)	5.92	14.35	3.62	1.84	1.69

Pending results of the assay, there may be an opportunity to evaluate nutritional treatments applied to small plots located within poor growth areas. I suggest the following treatments with subsequent observation of cane growth and symptoms:

1. Control,
2. Potassium, 120 kg K ha⁻¹,
3. Cement, 2 t product ha⁻¹,
4. Magnesium sulfate, 150 kg Mg ha⁻¹.

6.0 CONCLUSIONS

In any region of increasing population and recreational activity, public perceptions of the effects of farming on the environment should be of concern to farming industries. In the specific case of farming lands with potential acid sulfate subsoils and where the death of fish may be linked to acid sulfate problems, immediate steps must begin to address the issue. If the issue is not addressed, occurrence of the next fish kill will surely focus adverse attention on the sugar industry because it is the major agricultural land user in northern New South Wales.

The sugar industry should foster community-based groups involved in landcare and total catchment management with the aim of identifying acid sulfate sources and solutions. Under the umbrella of the above groups, the sugar industry would be well served to encourage research into best practices which will address the acid sulfate problem. Many sound policies and practices are already in place, others are suggested in this report. Unfortunately there are limited data on the effectiveness of remedial steps at farm and catchment levels.

It was beyond the scope of this report to design experiments which would evaluate effectiveness of remedial measures; however, I am sure suitable sites can be found and experiments designed which would identify best practices for the sugar industry. It may be possible to reduce acid discharge from caneland to less than occurs from lands in their natural state. Such a finding would change public perception of the effects of cane farming on off-farm acid sulfate effects.

Poor growth following laser levelling of fields in Broadwater Mill area is thought to be due to a nutritional problem which should be identified by foliar assay.

7.0 REFERENCES

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APPENDIX A
GUIDELINES FOR DRAIN CONSTRUCTION AND MAINTENANCE
ISSUED BY THE NSW SUGAR MILLING COOPERATIVE.

Around the Paddocks



New South Wales Sugar Milling Co-operative Ltd

September 1994

GUIDELINES FOR DRAIN CONSTRUCTION AND MAINTENANCE IN ACID SULPHATE SOIL AREAS

Purpose of these Guidelines

In recent years there has been increased recognition of and concern about the impacts on fish and waterways from activities in areas of acid sulphate soils.

These guidelines have been prepared by the Co-operative in conjunction with the NSW Environment Protection Authority to alert and inform cane growers of the issue and to provide advice on how to minimise the impacts of drainage works in acid sulphate soil areas.

It is important that our industry acts responsibly to minimise any possible contribution by our drainage works to this problem.

What are "Acid Sulphate Soils"?

These are sediments laid down several thousand years ago when sea levels were higher than now. Iron from river sediments combined with sulphur from sea-water in the presence of large quantities of organic matter. In waterlogged conditions, these soils are stable. They decompose to release sulphuric acid when exposed to oxygen contained in air.

These soils are common on coastlines throughout the world, including the eastern coast line of Australia. There are numerous areas of these soils on the North Coast.

Where do they occur?

Acid sulphate soils are most likely to be encountered during drain construction in peat or swamp country. They typically occur in low-lying former estuarine areas within the flood plains and less than 1 metre above the high tide mark.

They are estimated to occur below approximately one half of Condong cane land and below a much smaller proportion of Broadwater and Harwood cane lands.

What does pH mean?

pH is the measure of acidity with 7 being neutral and a lower pH being more acid. Each unit of pH represents a 10 fold change in acidity, meaning pH5 is 10 times more acid than pH6.

How do you identify them?

Check for acid sulphate soils when:

- **drain spoil inhibits growth of cane and weeds**
- **acid water, with pH less than 4, occurs in drains**
- **drain water is a bluegreen milky colour**
- **drain water is very clear**
- **drain water contains no fish life**
- **there are extensive iron stains or iron deposits on drain surfaces, or iron-stained drain water**
- **very high sulphur levels occur in soil analysis**
- **soil acidity is below pH 4**
- **pale yellow deposits of jarosite are found along cracks and root channels in the soil.**
- **sulphurous gas or rotten-egg gas is present after soil disturbance.**

Need confirmation?

Contact your Agricultural Officer at:

HARWOOD MILL
CONDONG MILL
BROADWATER MILL

Don Parsons (066) 400 423
Tony Hayes (066) 722 244
Peter Nielsen (066) 208 257

What can you do to minimise the risk of acid drain water resulting from drain maintenance or construction in acid sulphate risk areas?

EXISTING CANE LAND

Shallow Drainage to avoid Acidic Sub-soil

Construct shallow drains to lower the water table 0.5 metres below the soil surface. Use width rather than depth for drain capacity.

Manage Drain Spoil

Bury acidic drain spoil or cap it with 300mm of non acidic material if it is to be used for construction of headlands. Apply lime to areas where drain spoil is placed and to the exposed profiles of newly constructed drains. Apply lime during or immediately following construction.

Acidic drain spoil can be spread over cane land and neutralised with applications of lime. A soil test *before* spreading of the spoil will indicate the amount of lime required. It may require 1.5 tonnes of lime per 10m³ of spoil.

Minimise Soil Disturbance

This includes excavation and depth of cultivation. Use lime on disturbed areas.

Use Herbicides

Control weeds in drains with herbicides registered for that purpose rather than mechanical removal which may expose acid sulphate soils.

NEW CANE LAND

Manage the Problem from the Start

The best way of minimising the effects on the environment of growing cane on acid sulphate soils is to use the management options for existing cane land from the beginning of development.

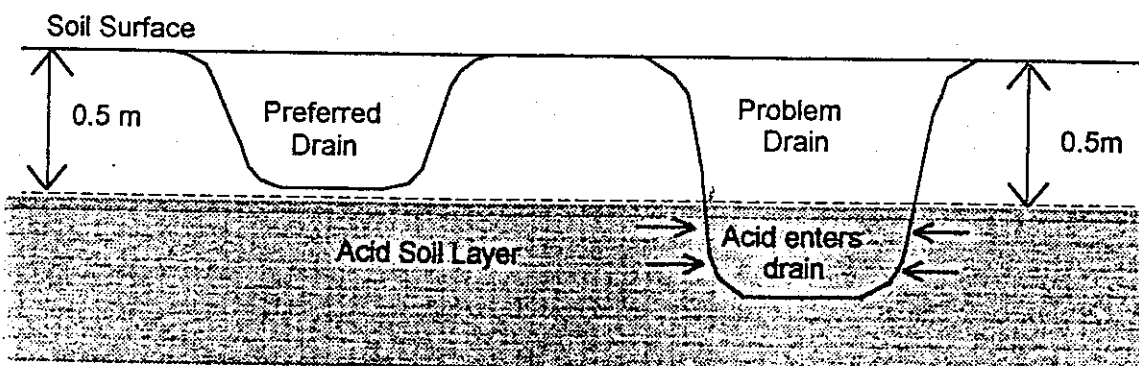
You can do this by:

- * avoiding highly acidic areas
- * using shallow drains
- * laser grading cane blocks
- * minimising soil disturbance
- * treating drain spoil
- * monitoring pH of drain water

New development also offers the opportunity to avoid highly acidic areas. A current mapping program by CALM will identify the depth of any acid sulphate soil layer which can then be verified by local soil sampling. It may be necessary to avoid areas where practical management options are not available for controlling acidic runoff.

Drains should be located away from these problem areas wherever possible.

TYPICAL SOIL PROFILE IN ACID SULPHATE AREAS



THE FUTURE

Some of our most easily worked and productive soils fall into the acid sulphate category. Acid flows, periodic river clearing and fish kill events may occur, irrespective of whether cane, or other crops or native vegetation, is grown on these soils. However, we must ensure that none of our activities worsen the situation. With careful and sensitive management we can minimise the off-farm effects of using these soils.

Your Agricultural Officer will be pleased to discuss these guidelines with you.