SOUTH AFRICAN SUGAR INDUSTRY

AGRONOMISTS' ASSOCIATION

PROGRAMME FOR THE MEETING ON 27 OCTOBER 1987

	8.45 - 9.00	Chairmans Report	
	9.00 - 9.50	Review Paper - Nematicides for Sugarcane	Mr RA Donaldson
	9.50 - 10.30	Plant Protection Chemicals and the Human Environment	Mr GJ Maritz
	10.30 - 11.00	**TEA**	
	11.00 - 11.45	By-products of the cane sugar industry	Dr J Bruijn
	11.45 - 12.15	Panela production in Colombia	Dr GD Thompson
	12.15 - 12.45	Progress with Cassava research in South Africa	Dr T Vorster
	12.45 - 2.15	**LUNCH**	
Slides	2.15 - 2.45	Floods: how to cope	Mr G Platford
Slides	2.45 - 3.15	Current research into improving poor quality soils derived from Dwyka Tillite and Middle Ecca sediment	Mr J Meyer Miss F Dewey
Slides	3.15 - 3.45	Progress in the biocontrol of Eldana	Mr DE Conlong & Dr AJM Carnegie

Attendance ± 57 - 60
Notices sent out too late (programme ?)

PETT/SN

SOUTH AFRICAN SUGAR INDUSTRY
AGRONOMISTS' ASSOCIATION

PLANT PROTECTION CHEMICALS AND THE HUMAN ENVIRONMENT

BY: G.J. MARITZ

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Man, more than any other organism, has altered his environment, whether rural or urban, to suit his own needs, particularly for food and fibre production.

Competition within all biological communities is intense and the crops grown by man are subject to attack by numerous competitors. These include fungi, bacteria, viruses, insects, nematodes, rodents, birds and increasingly important weeds. This competition is a natural part of the environment and plays a large part in agriculture.

Farmers and practical agriculturalists obviously try to minimise the crop losses that would inevitably result. Worldwide these are currently computed to be about two-thirds of the potential yield in developing countries and about one third in those countries with advanced agriculture. These figures include losses during storage.

To combat all these predators, many farmers still rely primarily on cultivations, timing of operations to avoid pests and pathogens and crop rotation. Sometimes they work and sometimes they don't! Plant breeders, too, have had some noticable successes in recent years in developing crop varieties which are not only higher-yielding but also tolerant to pests and pathogens. Better knowledge of plant physiology has also contributed to plant protection.

So why Plant Protection Chemicals?

The reason is that it is conservatively estimated that ninety percent of our current pest problems are dealt with effectively with chemicals. It is thus difficult to conceive how we could hope to develop alternative methods in the near future for controlling pests with equal effectiveness, dependability and cost.

At the present time agriculture has succeeded (except in certain areas of North Africa) in feeding the worlds population which doubled during the last forty years. This has largely been due to the ability to keep crop competitors under control with synthetic crop protection chemicals developed during that period. It has been calculated that the withdrawal of crop protection chemicals would result in yield reductions in major crops such as wheat and potatoes of 25% in the first year rising to 50% after three to four years.

The effect on our fruit exporting industries would be catastrophic. Plant protection chemicals remain essential if the still expanding human world population is to be fed from the earth's shrinking area of agricultural land.

As the Byzantine proverb says "Those who have enough to eat see many problems - those who go hungry see only one".

But while increased crop yields are desirable in terms of the world's burgeoning population and in terms of farm economics, what about the quality and safety of this "unnaturally" produced food.

The difference between those who use plant protection chemicals and those who worry about their effects are largely the result of misunderstanding. Nature itself is the worlds largest chemical factory!

Through tradition and custom man generally selects the parts of plants which he knows from experience to be edible, for example the potato tuber but not the poisonous berries. Also through tradition and custom we heat virtually all our food, although most of us no longer know the origin of this practice. Heating, especially baking and roasting, results in the formation of a large number of compounds with the structure of basic organic molecules such as benzene, pyridine and pyrrole. Man has been consuming all these compounds together with his food ever since food has been prepared by heating.

It is wrong to assume that unprocessed food is always physiologically more valuable and possesses greater nutritional value than processed food. Although this may be true in some cases, it is certainly not the rule. But it is also wrong to assume that all risks associated with food can be eliminated by processing, however modern the process used may be. The following examples serve to illustrate this:-

* Aflatoxins are "natural substances" but they are the most powerful carcinogens known to man, and they are extremely heat-resistant. This will be discussed further.

* Many fungi and mushrooms including some which appear very colourful and tempting (Amanita phalloides, A. muscaria) are extremely poisonous and retain their toxicity even after prolonged heating.

* Most food poisoning is caused by the enterotoxins produced by Staphylococcus bacteria and by endotoxins which are produced by Salmonella and Shigella bacteria. They are not only heat-resistant but also resistant to acids (stomach) and bases (duodenum). Only strict hygiene, sterile packaging, and the addition of preservatives keep the toxigenic organisms at bay. Once the toxins have been produced they can no longer be eliminated by culinary methods. Another substance which causes very serious food poisoning is the botulinus toxin which is produced by Clostridium botulinus (for example in canned beans!). While the toxin can be rendered harmless by boiling, the spores of this bacteria are very heat resistant.

The West German Federal Government's Nutrition Report (1984) on this subject states that alleged or hypothetical risks from agrochemicals or preservatives do not find corroboration in reality. On the contrary, infections and poisons transmitted by food are responsible not only for tens of thousands of cases of illness but also a large number of deaths. The vast majority of such cases are caused by failure to observe hygienic measures in the home and in large scale catering services. Between 1978 and 1982 there were 22,508 recorded cases of reportable illnesses in West Germany. A substantial proportion of these were connected with the consumption of foodstuffs. 372 of these cases resulted in death. In as many as 337 cases the illness was attributable to Salmonella infections. The Nutrition Report therefore made the following final criticism: "While the media and published books constantly complain about the alleged risks which are supposed to be attributable to the residues in food, the real dangers receive relatively little attention".

Every meal that we consume contains a large variety and an astonishing amount of carcinogenic or mutagenic substances or substances which are toxic in some other way. While the residues of crop protection agents are published and decried almost to the point of absurdity, what should be examined are these "natural" substances which are present in plants which form part of our diet.

Poisons are part of nature

All the food materials that we use today have been added to our diets the hard way, by a process of trial and error.

It is hardly surprising that a wide variety of the substances found in plant material are mutagenic and carcinogenic. Plants represent the beginning of the food chain. Over millions of years plants have evolved in order to protect themselves from hostile forces. There are not only herbivorous animals to guard themselves against but also viruses, fungi, bacteria and insects. Many plants have achieved survival by producing an amazing variety of sometimes highly toxic chemicals. Toxicologists have studied only a small percentage of these substances and still have very limited knowledge.

The earth contains and is surrounded by a vast number of substances which are simple and complex, which are of short and long life, and which are important to health and harmful to it. A chemical-free world is as impossible as non-biological agriculture. However, a completely biological world is frequently hostile to man.

A number of the strongest poisons ever known come from mother nature's kitchen.

Those who attempt to feed themselves from nature are at risk from toxic plants and fungi; even domestic gardens often contain poisonous plants which are not without danger to children. Although today we are aware of the danger of poisoning from rotten food, hardly anyone gives it any thought.

Several hundred years ago, the grain fields were from time to time heavily infested with a fungus with the botanical name Claviceps purpurea. These formed sclerotia (known as ergots) in the heads of grain. They contain several alkaloids producing various toxic effects, collectively known as ergotism, the most well-known of which is the inducement of premature labour in pregnant women resulting in miscarriages. Another effect consists in psychological disturbances which may be attributable to LSD-like substances. Because it is similar to cereal grain in size and shape, the ergot was difficult to eradicate mechanically. Consequently, due to the use of flour contaminated with ergot for bread baking, large numbers of stillbirths were a common occurrence in the age of "natural" agriculture. They were accepted in a fatalistic manner as the only alternative to hunger. Today the danger of contamination of grain with ergot has been completely eliminated by the use of modern agricultural and milling methods. In fact hardly anyone knows anything about the subject and therefore it is not surprising to learn that the current fashion for "natural" food and grinding one's own grain has once again resulted in cases of ergotism which have been reported in the medical literature.

The botulinus toxins are the strongest poisons known to man, - an average dose of only 0,0001 mg taken orally causes death. Potassium cyanide (KCN) (the gas chamber poison) and strychnine are fatal only in doses of 80mg and 60mg, respectively. In other words, "naturally" formed botulinus toxins are about 800,000 times more poisonous than potassium cyanide. Let us examine further examples of nature's toxicity.

Toxic fungal metabolic products in natural products

An unblemished apple has in all probability been treated with a fungicide during ripening. It is often claimed that this is only for cosmetic purposes and that an untreated fruit, while it is somewhat spotty and scabby, does not have a poorer taste. Although this is true, mycotoxin forming fungi can penetrate into the fruit through scabs and tears in the skin. A well-known example of this is the fungus Penicillium patulum which causes brown rot in fruit and vegetables and gray mould on various starch containing food. The fungus produces patulin, a powerful carcinogen, which in low concentrations is tasteless, odourless and colourless.

Aspergillus flavus produces aflatoxins including the well-known and very greatly feared aflatoxin B1. It is also a powerful carcinogen which mainly attacks the liver. Aspergillus flavus can occur in nuts (particularly ground nuts) and soyabeans, and in food which has not been protected with fungicides or preservatives.

We know of African tribes in which several forms of liver cancer were extremely common and whose diet consisted only of "natural" food, especially ground nuts. The introduction of industrially produced fungicides to crop farming and the protection of stored products had a dramatic effect; within one generation the cancer rate in these tribes dropped almost to a normal level.

Weeds as host plants for toxigenic fungi

The bearded darnel (Lolium temulentum) a grass weed which occurs worldwide, is infected by two fungi, Sclerotinia temulenta and S. secalincula. Both of these produce the mycotoxin temulin (an alkaloid) which can cause headaches, hallucinations, loss of the power of perception, and in rare cases death. If bearded darnel were not successfully controlled by modern herbicides malt barley for beer and other cereal products could be poisoned depending on the harvesting technique used. This would also be the case if the cereal were not freed from any infected seeds of grass weeds by thorough cleaning in the granary before milling.

The risk of damage to our health from fungicide residues, where these occur at all, is certainly infinitely smaller than the danger from mycotoxins whenever fungi have not been successfully controlled. For example, aflatoxin B1 in nuts, although they account for only a small part of the human diet, have a tolerance value of 5ppb (parts per billion) or 5 ug/kg (1 microgram = 1 millionth of a gram).

No crop protection agent with such a carcinogenic potential exists. It's manufacture would not be permitted.

Toxic Weeds

The seeds of Datura stramonium, the common thorn apple, contain atropine and scopolamine, two strong poisons well-known to every Agatha Christie fan. Today the risk of cereal and flour being poisoned by thorn apple has been eliminated by the use of herbicides and modern warehouse techniques.

The common ragwort (Senecio jacobaea) and the showy crotalaria (Crotalaria spectabilis), two weeds which are found worldwide, contain various alkaloids (e.g. retrorsin, isatidin) all of which may give rise to symptoms of:- degeneration and cirrhosis of the liver, deformities and pulmonary oedema. The toxins are present in the seeds and leaves of these plants and either become mixed with the cereal during harvesting or are consumed by grazing cattle.

Insect pests also leave toxins where they feed

The grain weevil (Calandra granaria) secretes quinone-like and benzoquinone-like substances which are known to be highly carcinogenic and are not degraded by the baking or boiling process.

Another pest is the flour mite (Tyroglyphus farinae). When contaminated flour is consumed, it results in severe diarrhea. Even workers who come into contact with infested flour sacks have shown signs of skin irritation. There is therefore good reason for treating warehouses with modern insecticides.

Diseased plants produce more toxins

In potatoes and tomatoes infestation by Synchytrium endobioticum or Phytophthora infestans results in an increase in the solanine content.

The alkaloid solanine can cause vomiting, headaches, diarrhea, hemolysis, cerebral oedemas, spasms and death. The toxic dose for man is 25mg, while about 400mg is fatal. In addition, experimental animals have exhibited birth defects.

When sweet potatoes are infested with Fusarium fungi, they produce the toxins ipomeanin and ipomeamaron which are highly toxic to the liver.

Some of the examples given show that in their food people probably consume several grams of "natural" crop protection agents every day, that is about ten thousand times the amount of residues or contaminants possible with synthetic products!

Professor B.N. Ames was formerly on the Board of Directors of the U.S. National Cancer Institute (National Cancer Advisory Board). He is a member of the National Academy of Sciences. He was the recipient of the most prestigious award for cancer research, the General Motors Cancer Research Foundation Prize (1983), and of the highest award in environmental achievement, the Tyler Prize (1985). He does no consulting for the chemical, drug or food industry, or for law firms.
He is the inventor of the Ames Test for genetic effect of chemicals.

In his testimony on the hazards involved with the contamination of drinking water wells in California, Ames wrote to Senator Torres, Chairman of the Senate Committee on Toxics and Public Safety:-
"The main current fallacy consists in thinking that carcinogens are rare and that they are mostly man-made chemicals. My own estimate is that over 99,99% of the carcinogens Californians ingest are natural (e.g., natural toxic chemicals in plants, mold carcinogens) or traditional (e.g. cooking food, smoking cigarettes, alcohol).

He goes on in his evidence to the committee to say that every meal and common drink is full of carcinogens. In fact drinking water from the most polluted wells in California - they contain up to 2800 parts per billion of trichloroethylene - is at least 1000 times less hazardous than an equal volume of cola, beer or wine.

His list of common carcinogens in drinks includes:-

- Coffee which contains about 1000 micrograms or 4000 parts per billion of hydrogen peroxide in each cup PLUS another 1000 micrograms of methylglyoxal, which has recently been found to be a carcinogen.

- Tap water which contains the carcinogen chloroform at 83 parts per billion, generated from chlorinating water to the US standards.

- Cola drinks which contain the alleged carcinogen, formaldehyde at 7900 parts per billion.

- Beer which contains nitrosamines PLUS 700 parts per billion of formaldehyde PLUS alcohol at 50 million parts per billion, all claimed to be carcinogens.

- Even organically produced fruit juices which contain various amounts of cancer-inducing moulds.

Pesticide Residues

On pesticide residues in food Professor Ames is equally as convinced. "Man-made pesticide residues in US food amount to about 150 micrograms a day on average; most of these residues are composed of non-carcinogenic compounds.

"The most significant man-made pesticide which can lead to carcinogenic residue in food is likely to be DDE, a metabolite of DDT. The risk of DDE in the average daily intake is equivalent in risk due to chloroform in one glass of tap water and thus it is insignificant compared to the high level of natural carcinogens in our diet".

"Even the occasional highly DDE contaminated fish - say 100 times the average level - would contribute a risk that is small compared to other very common minor risks such as a glass of beer or a peanut butter sandwich".

Nature's Pesticides

"We are ingesting natural pesticides in our diet in amounts at least 10,000 times higher than man-made pesticide residues. Natural pesticides are natural toxic chemicals, which are present in all plants, usually making up 5- 10% of a plant's weight. They have an enormous variety of chemical structures, though only a few are present in each plant species. Their function is protection against fungi, insects and animal predators; a major aspect of plant evolution is chemical warfare".

"Calculations on the carcinogenic risk of these compounds show that they completely overshadow the traces of man-made pollutants found in the daily diet".

Edible plants too contain poisons

Nature produces a larger number of substances than is generally recognized and far more than man is able to copy despite his modern laboratory techniques.

If we were to attempt to produce something like a raspberry and if we were successful in copying its chemical composition, it would be impossible to sell such a fruit under our consumer protection laws. The raspberry contains 14 different acids, 34 different alcohols, 34 aldehydes and ketones, 20 esters, 3 hydrocarbons and compounds of other classes including the hemotoxin coumarin. If we intended to bring this raspberry onto the market, we would have to demonstrate that each of these substances were harmless.

The gas chamber poison hydrogen cyanide (obtained from potassium cyanide, KCN) is a natural constituent of lima beans, bamboo shoots, young sorghum, peas, almonds and other crop plants. Six to ten bitter almonds are capable of killing a child, while for an adult sixty would be sufficient. The oxalic acid and anthraquinones in rhubarb, spinach, celery and beetroot damage the kidneys and reduce the blood calcium level.
Many pulses contain teratogens with high biological activity. An example of this is the lupin. It has been observed that cattle and goats which have consumed lupins while grazing frequently have given birth to offspring with severe deformities.

And what about common salt?

If common table salt were to be evaluated according to the same toxicological criteria as those used for classifying crop protection agents, a surprising result would be obtained; the ADI value (acceptable daily intake) for table salt would be 1mg/kg of body weight. According to this, the daily amount of table salt which the average man weighing 70 kg could consume over his entire life without damage would be 70 mg per day or less than 1/10 g!

However, the average man sprinkles salt generously over his meals. In addition, the amount of salt naturally present in food is in some cases even greater than the amount used in the preparation. Depending on our habits our daily salt consumption is between 5 and 25 grams or about 100 to 300 times the ADI.
Nevertheless, who has ever heard of a campaign to prohibit salt? This example can give us some idea of the extremely high safety factors which are built into the highest allowable amounts for chemical residues in food. The standards even take into account the rare cases in which allowable residual amounts or ADI values are exceeded.

The data that a manufacturer must submit before a crop protection chemical is approved for sale and distribution include the results of investigations into residues and their breakdown. The possible initiation of food poisoning, mammalian mutations, cancerous growths or birth defects are all examined. Internationally this data is studied by organisations such as the FAO, WHO, Scientific Committee for Pesticides of the EEC and in South Africa, by the Department of National Health and Population Development.

Maximum levels of residues are agreed for cereals, fruit, vegetables and other foodstuffs. The limits allowed in fresh foods are minute, a person might ingest them daily for many years without harmful effect and most residues are in any case inactivated during food preparation and cooking.

Adopt a fair attitude

Scientists and administrators often find it difficult to take seriously the opposition to plant protection chemicals of environmentally conscious groups. All too often the allegations of ill-effects are based on data which will not stand up to scientific or medical analysis.

It is self-evident that a better discussion can result only from the responsible use of scientific evidence by all concerned.

The agrochemical industry is highly responsive to allegations that it is poisoning the environment for it cannot afford to alienate the general public and the legislators. Responsible firms who are members of AVCASA have for many years co-operated with Government to ensure that commercial products registered in terms of Act 36 of 1947 are effective and safe when used according to the instructions on the label. Act 36 of 1947 requires evidence that the product is both effective and safe in use before registration of the product is granted.

Manufacturers have also responded to the environment lobby by testing their products on non-target organisms. Currently of the $ 29 - 30 million spent on developing a new crop protection chemical, at least $5 million is on average devoted to environmental studies. These include the persistence of the product and of the chemicals to which it breaks down in the soil.

The fear of poisoning by residual crop protection chemicals in our food is groundless. Monitoring through legislation is stringent and effective. Furthermore, there is a clear trend towards smaller and smaller residues and this will continue.

We as a responsible industry must however continue to strive to further improve the high standard which we have set. We must continue to act responsibly with due regard to the environment. We must continue to ensure that our staff are well-trained, kept aware of new developments and that they continue to provide the valued service to our farming community.

Equally important, however, is the need to inform, educate and influence the general public and hence the environmentalists and the media.
The sensible use of crop protection chemicals will remain essential for the foreseeable future if agricultural production is to be sustained and our increasing population fed.

In summary

Nature is never "good" or "bad" or "cruel". These are terms in the human scheme of evaluation. Nature has always ruthlessly obeyed its own laws. It was not and is not concerned with man's well-being. Man has learned to use it and to resist it while adapting and subjecting himself to it. We can study natural laws, draw conclusions from them and apply them but we will never be able to alter them.

Modern agriculture and the agrochemical industry can look back with pride on a period of development which has saved the lives of millions of people and improved the lives of millions more.
When the facts do not fit the preconceived opinion, it is better to alter the opinion than to twist the facts. The fact that "natural" foods are not free of toxic substances is by no means new: Pythagoras recognized that favism was caused by beans and therefore forbade his students to eat raw beans.

Paracelsus, a famous Swiss doctor about 400 years ago, had more common sense than many members of our enlightened age "All things are poisons and nothing is without toxicity" he said "It is the dose alone which makes something a poison". This statement is still true today.

SOUTH AFRICAN SUGAR INDUSTRY AGRONOMIST ASSOCIATION

BY-PRODUCTS OF THE CANE SUGAR INDUSTRY

by

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The raw sugar price on the world market has been below the cost price for a number of years and will remain so for the foreseeable future. For this reason by-products of the industry might become increasingly important for the survival of many sugar cane industries.

Patureau has stated that for a by-product industry to be successful two requirements have to be fulfilled: the market has to be sufficiently developed and there must be a sufficiently developed industrial base. To judge the first, he used the total Gross Domestic Product of the country and for the second the electrical energy consumed per inhabitant. These data are shown in Figure 1 and South Africa is in the favourable quarter of the graph, a position which it shares with other countries already producing a fair number of by-products, e.g. Cuba, Brazil and Taiwan.

Various by-products are listed in Figure 2. This listing is not exhaustive and only the more common ones are included. The list shows that South Africa already produces a fair amount of by-products. These products can be made from all parts of the cane plant, i.e. the fibre, juice and molasses.

1. PRODUCTS FROM FIBRE

(a) Electricity

This is the most common product and is made by nearly all sugar factories. Most of the excess of electricity generated is used for irrigation. With increasing demand for electricity and for fibre in general, it becomes important for sugar factories to increase their thermal efficiency and a considerable amount of excess fibre could be generated if there was a demand for it. At present increasing the thermal efficiency of factories would create a problem of surplus bagasse. Unfortunately Escom is not interested in buying power. A problem is that it cannot be available during the whole year. However, in other countries electricity can be sold to the national grid and sugar industries generate additional income in this way.

(b) Paper

Paper made from bagasse has been marketed for many years, indeed since 1850. The major difference in composition between bagasse and wood is a much higher pentosan content in the former as compared with hardwood or softwood. Fibre length is about the same as for hardwood, but it is slightly thinner. Softwood fibre is considerably thicker and longer. For this reason bagasse pulp is blended with recirculated waste paper or softwood pulp for the production of an acceptable quality paper.

South Africa manufactures packing paper at Ngoye paper mill in Felixton and fine paper at the SAPPI paper factory in Stanger. Before the fibrous material is chemically treated the longer fibre is separated from other cellular material (the pith) by mechanical separation in a depither, which is a type of hammer mill. Chemically there is not much difference between pith and fibre. The pith is usually returned to the sugar factory as fuel.

After this mechanical treatment the fibre is treated chemically to remove unwanted products, mainly lignin and pentosans. For bagasse treatment only an alkaline process is suitable. Digestion is normally carried out in continuous equipment with sodium hydroxide at a specific temperature and time. Today short retention times of around 10 - 15 minutes are applied. Various modifications of this basic treatment exist and in addition multistage processes are applied.

The digestion is followed by washing, screening, bleeching (for fine paper), washing, neutralising, dewatering and blending with other pulp material. Finally, the pulp is mixed with additives used in the paper industry to improve strength, appearance and printing properties. Conventional additives are alum, rosin and clay. The water slurry is subsequently felted and dried on a paper making machine.

The black liquor (soda plus lignin and hemicellulose) is not recovered in small factories. In larger factories the liquor is concentrated and burned in a recovery furnace. The sodium hydroxide is recovered, after combustion of the lignin, as sodium carbonate. This is converted into sodium hydroxide by treatment with lime.

Newsprint has not yet been successfully made from bagasse although research into this subject is being carried out in Cuba. Traditionally newsprint has been made from softwood, after mechanical treatment, mixed with 25% long fibre chemical pulp. Paper for newsprint has to be cheap, have a sufficient strength to resist the high speed of modern printing machines and have the correct absorbing characteristics for ink in high speed printing. The experimental plant in Cuba is equipped to investigate various combinations of mechanical and chemical treatments.

(c) Sugars and alcohol from bagasse

As a participant of the Co-operative Scientific Programmes (CSP), which are administered by the CSIR, the SMRI took part in the programme investigating the conversion of bagasse into liquid fuel.

The basis of the process is the enzymic conversion of cellulose, which is a glucose polymer, into glucose. The enzyme is produced by a fungus Trichoderma reesei. The enzyme attacks free cellulose, but is not very active on whole bagasse. The cellulose is embedded in lignin and hemicellulose which prevents enzymic attack. The bagasse has to be pretreated for which various methods are available. Steam explosion has been used and for this reason the residue of furfural production is a good starting material. Treatment with dilute acid under pressure has been applied at the SMRI. This decomposes the hemicellulose (pentosan) into xylose. The resulting xylose solution after washing and adjustment of pH can be fermented by various micro-organisms into ethanol. Up to now the final alcohol concentration has still been fairly low and some inhibitors have to be removed. The solid residue after the acid treatment is mechanically treated in an attritor mill to make it digestible by the <u>Trichoderma</u> enzyme. Before the enzymic treatment some inhibitors have to be neutralised after which the cellulose can be converted into glucose. The glucose can be used as a basis for cattle feed or further converted into ethanol.

The residual lignin can be returned as fuel to the furnace after drying. However, recently there has been some interest in the use of lignin from bagasse as a raw material for adhesives.

(d) <u>Chipboard</u>

Chipboard manufactured from bagasse is similar to the product made from woodfibre. The depithed fibre is mixed with resin and treated in a plate press at an elevated temperature. Urea-formaldehyde and phenol-formaldehyde are used as the resins. The latter is more expensive but water resistant. A fungicide is added to bagasse board to make it more durable.

A disadvantage of bagasse board as compared with woodfibre board is the presence of sand, which presents problems in sawing. In addition, the presence of residual sugars in bagasse make it more prone to fungal attack.

Chipboard was made in South Africa at a factory in Amatikulu between 1972 and 1977. The operation, however, was not profitable and the factory closed down. The only particle board factory at present operating in South Africa is at Malelane. This factory produces an endless sheet in the same way as paper is manufactured. This can only be done for small thicknesses of up to about 10 mm.

(e) <u>Furfural</u>

Furfural can be produced from any plant material containing pentosans, e.g. oat hulls, mealie cobs or straw. On acid hydrolysis the xylan forms xylose which subsequently condenses to furfural by losing three molecules of water.

The main use of furfural is in the extraction of aromatics from lubricating oil and refining of other products. By catalytic hydrogenation furfural is converted into furfuryl alcohol, the basic material for some resins used in reinforced glass cloth and resinous cements. Originally furfural was produced by heating bagasse with sulphuric acid. At present there are about five factories in the world making furfural from bagasse. The present method is based on a technique developed by the Finnish company Rosenlew and is carried out in a continuous reactor at 150 kPa with steam injection. The acid required for the reaction is formed in situ by the hydrolysis of acetal groups in hemicellulose. Sezela recovers this acid and also produces furfuryl alcohol.

(f) Animal feed

In the production of cattle feed the bagasse, of which only the finer particles (bagacillo) are used, acts as a carrier for molasses. By mixing molasses with about 25% fibrous material a reasonably manageable material is obtained, which is marketed in bags. The animal feed can be enriched by nitrogen containing material. It is made at present by Tongaat and Malelane.

2. PRODUCTS FROM MOLASSES

(a) Potable alcohol

A well known product is rum, not yet made in South Africa. The main producers are in the West Indies and in Puerto Rico where almost the total amount of molasses produced is converted into rum. Apart from the West Indies, rum is made in various other sugar cane growing countries like Reunion and Australia.

In South Africa potable alcohol is made by National Chemical Products and Natal Cane By-Products. These factories also produce a number of alcohol derivatives.

(b) Ethanol for motor fuel

Various countries have started to produce ethanol for motor fuel from sugar cane. Brazil has developed the largest project and present production is about 11 billion litres. Comparing possible production of ethanol with the liquid fuel consumption it is clear that ethanol from agricultural products is not a solution for a motor fuel problem when crude oil supplies start to decrease. However under local circumstances it can reduce the amount of foreign exchange necessary for oil imports, keep an agricultural enterprise economical and provide labour opportunities.

In most cases the ethanol is blended with petrol but in Brazil there are, in addition, specially built motor cars using pure ethanol only. For blending, the ethanol has to be waterfree, so called absolute, because upon mixing of 96% ethanol and petrol the water separates as a second phase. However, a spark ignition engine can tolerate a certain amount of water in the fuel provided it is homogeneously mixed with the fuel and where engines use alcohol only this can be in the form of 96% ethanol.

The addition of ethanol to petrol has the added advantage of raising the octane number. From the early twenties the traditional additive for increasing octane rating has been a mixture of tetraethyl lead or tetramethyl lead and an alkyl bromide to discharge the lead as lead bromide. However with the increased number of motor cars now in use the lead emission has become so large that it is a health hazard. In Natal the annual lead emission is presently 1600 tons and soon the use of leaded petrol will be banned in most countries. Although ethanol is not the only or the best alternative, where available it will assist in reducing lead emission.

The production of ethanol has been carried out in the past by fermentation until the process was superseded by a synthetic one. This fermentation was invariably carried out as a batch process, but since its return to use, more continuous processes are applied. A further refinement is the recycling of yeast, which increases its efficiency as a certain quantity of sugars is required for the production of the yeast. However, the ethanol plants in Zimbabwe and Malawi operate batch fermentation without yeast recirculation as it was decided to keep the plant as simple as possible. Fairly expensive centrifuges are necessary for yeast recirculation and these also require some maintenance.

Where absolute alcohol is required for blending, the distillation is slightly more complex. As alcohol and water form a minimum boiling azeotrope of 96% ethanol, the residual water has to be removed by a so called entrainer in a subsequent distillation. The entrainer forms another azeotrope with water and pure ethanol is recovered as the bottom product. Common entrainers are benzene or a mixture of petrol and benzene.

Where energy supply from bagasse is limited, the steam requirements for distillation can be reduced by heating the distillation columns in series in the same way as multiple effect evaporation is applied in sugar factories.

Effluent disposal forms a major problem. In the traditional ethanol production process, one litre of ethanol results in eleven litres of vinasse. This has to be disposed of on land or in the sea (where this is allowed), or concentrated and either sold as an additive for animal feed or completely burnt in a furnace. More modern fermentation methods, however, can considerably reduce the amount of effluent.

(c) Yeast

Various companies produce yeast for bakeries from molasses. While alcohol is formed by yeast under anaerobic conditions an aerobic process is used if yeast is the main product. Under aerobic conditions yeast grows fast and produces little or no alcohol.

3. PRODUCTION FROM JUICE

Cane juice can be used in exactly the same way as the molasses as a raw material for the preparation of ethanol or yeast, depending on whether one wishes to make sugar as well or not.

CONCLUSIONS

In conclusion, it can be seen that sugar cane is a very versatile plant - the fibre also yielding valuable by-products. The cane milling economy can indeed benefit from the support of subsidiary industries based on mill by-products.

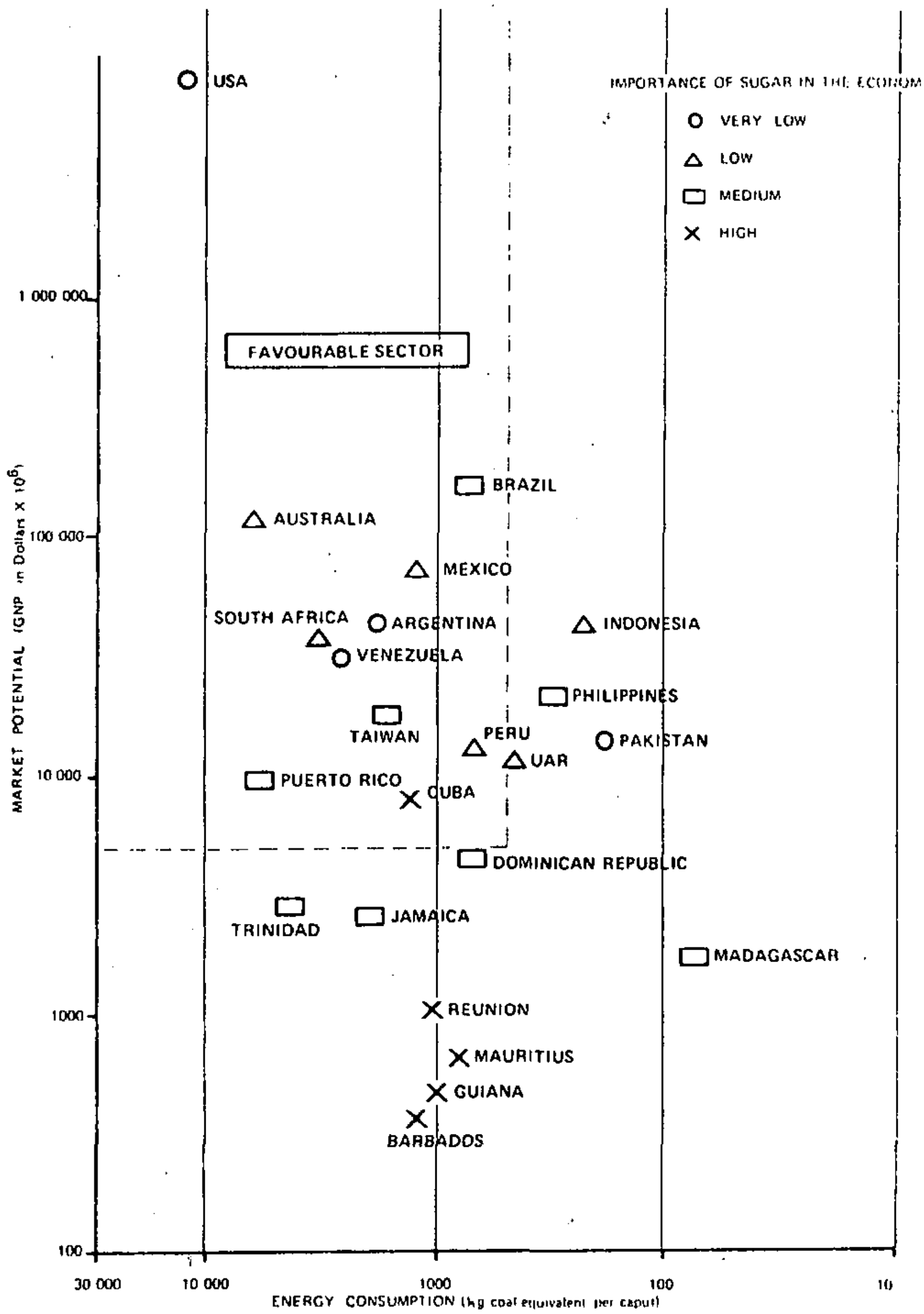


Fig. 1. By-products development prospects

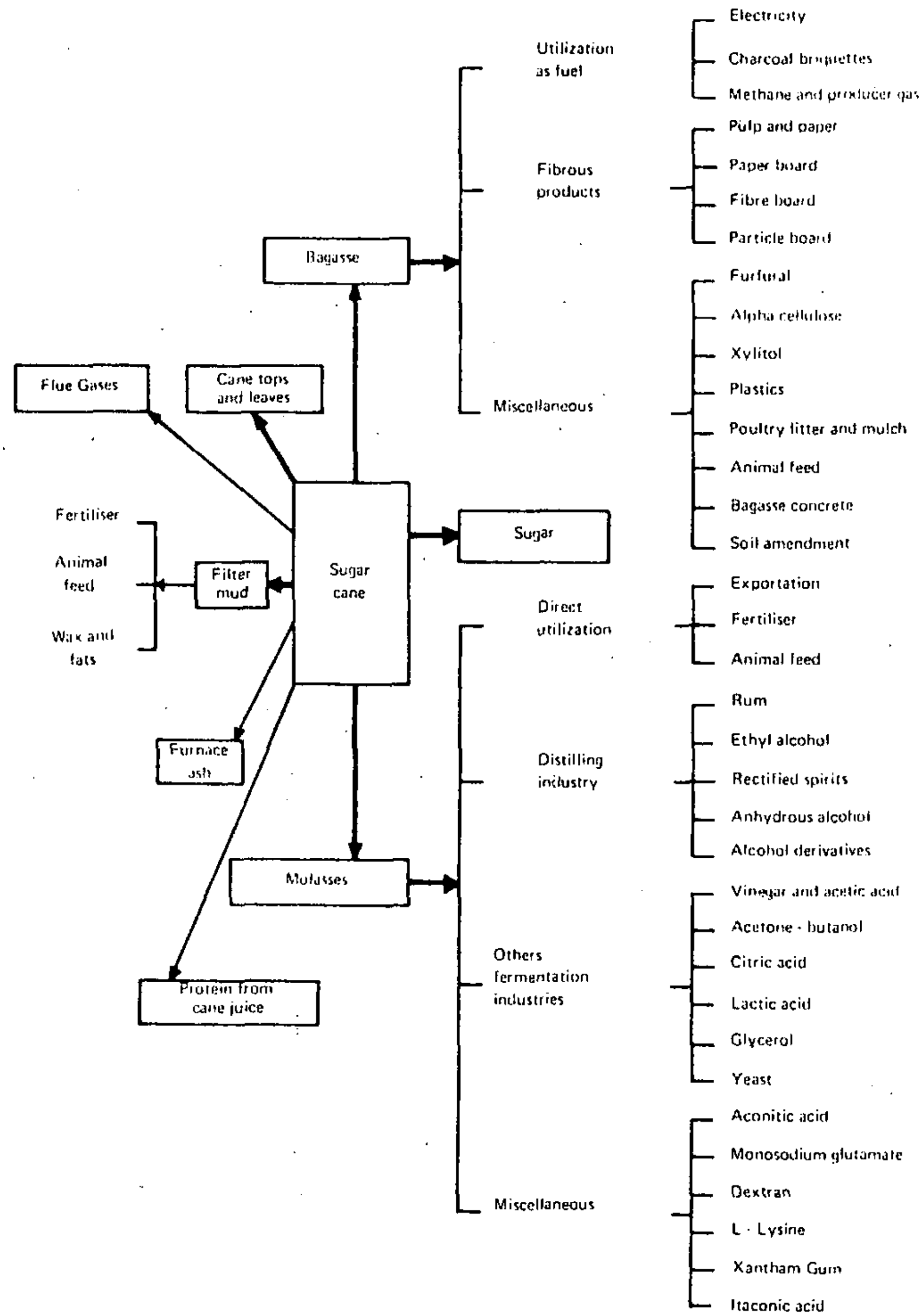


Fig. 2. By-products of the cane sugar industry

SOUTH AFRICAN SUGAR INDUSTRY

AGRONOMISTS' ASSOCIATION

PANELA PRODUCTION IN COLOMBIA

by GD Thompson

Panela is the Spanish name for gur or jaggery, which may have been produced in India as long ago as 300 BC. In contrast centrifugal sugar was not manufactured until 1844 in Europe. Colombia is the world's second largest producer of panela type sugar, India being by far the largest. As much as 1 million tons of panela may be produced per annum in Colombia, but the exact amount is never known. Production takes place in literally hundreds of small panela mills all over the country.

Colombia produces more than 1 million tons of centrifugal sugar each year. At times, depending on supply and demand, the price of panela may exceed that of centrifugal sugar by a significant amount. On such occasions centrifugal sugar may be fed into the panela process to the financial advantage of the producer.

Panela is produced traditionally from sugarcane grown by small planters whose fields vary in slope from mild to incredible. POJ 2878 is still by far the most common variety grown and some fields reputedly have not been replanted for more than 50 years. In the more 'progressive' areas, whole fields will be harvested green by hand and a trash blanket retained. In other places (and particularly on very steep slopes) the mature stalks are plucked by hand and the immature stalks left standing.

Harvested stalks are cut into lengths of approximately 1m and bundled. The bundles are loaded onto racks which hang on both sides of the saddle on mules (and sometimes horses). No weighing takes place. Most often there is an agreement between the grower and the miller that says the grower will receive half of the panela produced from his cane. In these circumstances the panela may never reach the market, being consumed directly by the farmer and his family. Panela will keep for only 3 or 4 months, but this is not a severe problem since the mills operate almost continuously through the year. The latitude of the industry stretches from the equator to 10°N. In some cases the grower may 'hire' the panela factory to process his own cane, the whole family suddenly becoming factory workers.

The cane is crushed in a 3-roller mill, usually belt-driven from a diesel engine, but in at least one mill by a water wheel. Extraction is unlikely to exceed 60%. The bagasse is stacked, usually under cover, to dry before using as fuel to evaporate the water from the juice. The furnaces are invariably inefficient so that supplementary wood fuel may be needed, and sump oil is often used to keep the fire alive, witnessed by much black smoke belching from the stack!

The juice is heated in the first and largest of a series of open pans. To the hot juice is added a coagulant which diffuses from a plant (similar in appearance to the leek) that is grown for this purpose. Impurities form a scum on the surface of the hot juice and this is removed periodically with a long handled scoop. The discarded scum or 'cachaza' is used as a fertilizer, being the equivalent of filtercake.

The partially evaporated juice is transferred into a succeeding open pan with the same scoop. The hot gases from the furnace flow beneath a succession of about six pans, the raw juice pan always being closest to the furnace. Heating and evaporation continue in the succession of pans, the 'massecuite' gradually assuming a rich brown colour. In the last or penultimate pan a colouring agent may be added, depending on local traditions and preferences, but this is illegal and the miller usually denies that anything has been added.

Men stand all day long moving the concentrating juice from pan to pan, wreathed in clouds of steam. The hardship is relieved only by the delectable aroma of molasses and, it is said, frequent injections of aguardiente (cane spirits), which can apparently keep a man going for 23 hours per day.

The critical point is reached in the last pan when a decision has to be made that the massecuite is ready to set. The decision reached, the boiling mass is scooped into a basin and stirred vigorously by hand as it cools. Before it becomes too viscous it is poured into moulds, usually rectangular in shape. Sometimes the panela is poured into a bun-shaped mould and immediately removed and placed upside down, retaining its shape whilst cooling and setting.

The flavour of panela has to be tasted to be believed. Its survival in third world countries should not be surprising since it is used to sweeten anything, and can be dissolved to make a delicious cool drink, or even a thick syrup, which with cheese and preserved figs is a favourite Colombian dessert. Every panela factory is the workplace of swarms of placid bees, and the hallmark of real panela is the inclusion of a few dead bees.

In September the price of panela was so favourable that five of the large centrifugal sugar factories in the Cauca Valley started producing panela themselves. This is accomplished simply by allowing conventional massecuites to cool and set. Panela producers threatened to go on strike if the government did not intervene to avoid flooding of the panela market. One's sympathy can easily be in their favour, but striking would seem to offer the big guys even better control of the market!

20 October 1987

Congratulations on a very comprehensive.

[~~local starch from cassava~~]

Mention findings of local cane growers/on crop rotation.

By products of starch production

PROGRESS WITH CASSAVA RESEARCH IN SOUTH AFRICA

BY DR T VORSTER

INTRODUCTION:

Cassava (Manihot esculenta Crantz), also commonly known as manioc, mandioca and tapioca, is a shrubby, perennial plant whose swollen carbohydrate-rich roots have been used for centuries in tropical lowlands as a subsistence crop. It was first cultivated more than 4 000 years ago, probably in Brazil or Mexico; it was introduced into Africa only in the 17th century and reached Asia about 150 years ago. Yet today, about 40 percent of global output comes from Africa, the rest being produced almost equally by Asia and Latin America; total world cassava production is approximately 110 million tonne per annum.

The reason why a crop that is so widespread in its distribution and such a major kilojoule (calorie) source for so many people was neglected by research workers for so long are many and varied. Cassava always has been consumed mainly by low-income tropical communities; it is a bulky, energy-rich, low-protein food which is not particularly appealing to more sophisticated palates; it is not frost tolerant and grows only in the tropics and sub-tropics between latitudes 30°N and 30°S;and it deteriorates rapidly after harvesting. It therefore has not been a traditional export crop and few people in temperate regions are familiar with it.

The position changed in the early 1970's when two new international agricultural research establishments, the International Centre for Tropical Agriculture(CIAT) in Colombia and the International Institute for Tropical Agriculture (IITA) in Nigeria, began large-scale, well-financed investigations on cassava. Both centres have made enormous strides not only in their own research but also in training scientists from other national research programmes; several developing countries have now followed their lead in establishing multi-disciplinary commodity research teams to study cassava, using the technology and the breeding material developed at CIAT and IITA. That the upsurge of interest that has led to such strong support for these two centres and to the adoption of parallel research elsewhere can be ascribed to a clearer recognition of the need for better understanding of what is now the world's seventh or eighth most important energy crop; the rise of cassava in the last 20 years as an important element in the international feed trade; and finally, the plant's potential, now being actively exploited, as a substrate for providing alcohol for fuel or as a raw material for the chemical industry.

The most important product from cassava is its starch, the low-amylose, high-amylopectin content of which gives it unusual viscosity characteristics and great dimensional strength. These are the characteristics of great value to the food, textile and paper industries and also as a parent material from which to hydrolise dextrins for forming adhesives. The world starch industry is involved not only with the production of starch but also with producing other products and by-products involving complex technology and marketing systems.

Cassava's potential for ethanol production, its superior starch characteristics and its potential to possibly suplement a shortage of basic energy foods in rural areas, served as a trigger for the agricultural division of the Anglo American Corp. of S.A. Ltd to take a decision to carry out a feasibility study of the potential of cassava as a major crop under sub-tropical conditions and to establish, during 1974, a cassava project for that purpose.

During the period 1977 to 1978, five cultivars that were collected from Mosambican and South African rural areas, were planted in replicated yield trials in a wide range of environments and with as many combinations of temperature, rainfall and soil types as possible. The programme covered 21 research sites, dotted troughout the sub-tropical areas of the Transvaal and Natal.

Based on results obtained with this work, it was felt that there is indeed potential for cassava cultivation on a large scale in the hotter areas of South Africa and a decision was taken during 1979 to establish the Centre for Cassava Research and with a more scientific input try to improve cassava as a commercial crop.

WORK OF THE CENTRE FOR CASSAVA RESEARCH

BREEDING

Initially work of the centre for Cassava Research was consentrated on importation of cultivars from other research centres across the globe to enrich the local germplasm. The breeding programme had two main objectives i.e.:

a. Evaluation of imported cultivars for favourable characteristics but especially yield.
b. To improve favourable characteristics by using selected imported and local cultivars as a base.

To date, none of the imported cultivars significantly outyield the production cultivar (MSaf2) on a continuous basis.

The development of new cultivars are however progressing very well. To date, a few cultivars outyield the test cultivar with a very great margin.

Attention was given to the selection of other desirable characteristics such as: starch content, plant morfology, disease and pest resistance, etc.

PHYSIOLOGY

The main emphasis was placed on:

a. Importation of germplasm from other research centres via tissue culture.
b. Micro propagation
c. Disease eradication
d. Germplasm conservation
e. Mistbed propagation

PATHOLOGY

Two major diseases threaten the cassava industry in South Africa presently i.e.: Cassava Bacterial Blight an African Mosaic Disease.

Pathological work was consentrated on:

a. Phytosanitation
b. Indentification of resistant cultivars
c. Methods of controlling pests and diseases

AGRONOMY

Through the years it was possible to iron out the most important parameters for the growing of cassava in South Africa.
This information, in combination with overseas research, made it possible to draw up a very comprehensive Cassava Recommendations booklet that is handed out to the growers.

Fertilize
Herbicide practice

Weeds in burnt fields

Uitkeurgang: Things can be done

Comment on stage of replant.

1. Andre - suggests aerial photos of blendale.
2.

SOUTH AFRICAN SUGAR INDUSTRY

AGRONOMISTS' ASSOCIATION

FLOODS : HOW TO COPE

by

GG Platford

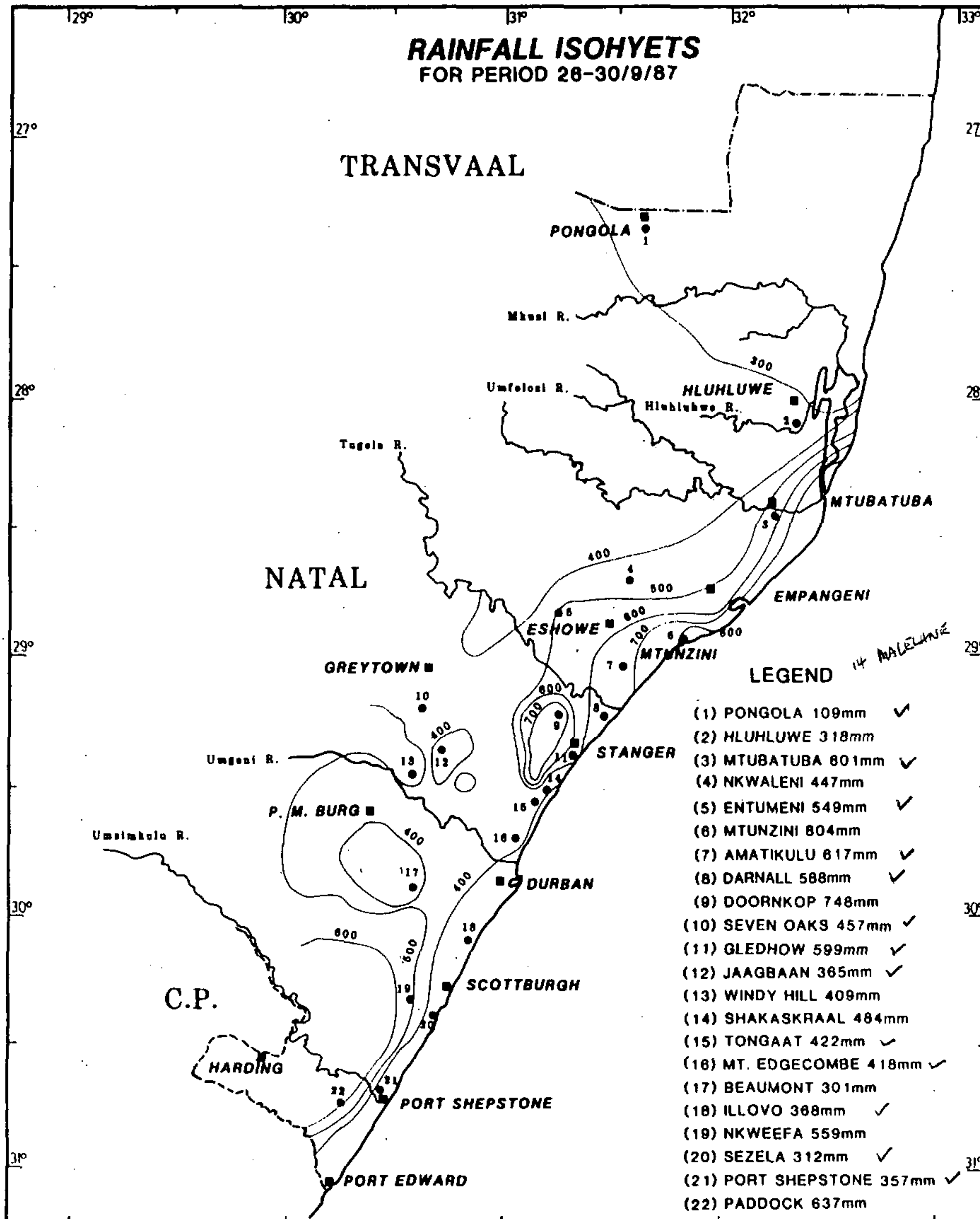
After every major storm or flood has caused enormous losses to property and life, the inevitable question is asked whether anything could have been done to prevent or minimise the damage. In this region it is quite widely believed that rainfalls of the magnitude of the recent storms over Natal happen only once in a lifetime. But how long ago was Demoina? How long ago was Lainsberg? Maybe they were not as wide spread as the recent rains but for each of the areas concerned they were disastrous and within the last six years. Despite the fact that the statistical probability of a comparative storm occurring again shortly is remote, extremely heavy rainfall can be expected in any portion of the province. Although this might not constitute a national emergency, immense damage can still be caused to the property of those unfortunately situated underneath the storm. The cost of rectifying the results of the excessive run-off can be very large.

As an agricultural based industry the wise and non-destructive use of the ground is of prime importance for sugarcane producers. The losses of precious topsoil from areas which generally are not well endowed with good soils, cannot be tolerated. The losses of thousands of tons of soil and millions of litres of water are often critical from farms where the potential yields are not high even in the best years. Leaching of fertilizers and other chemicals also takes place so that additional money is needed to replace the lost chemicals if yields are to be maintained.

Repairing the damage is another very high cost which is incurred, whether it be in reclaimation or in stabilization. Gabion weirs or barriers made of other materials found on the farm can be used but still incurr high costs. The pollution of down stream water sources by sediment as well as fertilizers and herbicides causes additional problems after these catastrophies.

The map below shows the extent of the rain for the five day period from 26th September to 30th September. Rainfalls of over 800 mm were recorded. To absorb this amount of water a moderately dry sandy loam would have had to be well over two and a half metres deep! It was inevitable that massive amounts of run-off water would be generated. The problem was how to cope with that run-off.

Figure 1. Rainfall distribution over the Natal coastal areas.



A quick flight around the industry after the recent floods revealed some very interesting observations. Major damage to stream banks and flood plains had occurred. Massive soil losses, collapsed banks and deposited sand and silt were evident in all the main streams and rivers. Cane fields in the low lying areas had been swept away or now lay buried under mud and debris. Where fields had been tilled by conventional ploughing, ready to replant, large soil losses were seen. However, on the steeper ground along the south coast where large losses could well be expected surprisingly little damage could be seen. This was undoubtably due to the change in practices which have seen minimum tillage and strip planting becoming much more widely used on these steeper fields. Flying up the north coast across the Umdloti and then turning inland towards the Upper Tongaat area and over the flatter lands, showed that where fields had not been planned and conventional tillage had been used to kill the old crop the saturated ground had literally just flowed away. The shallow erodible soils around Shakaskraal seemed particularly hard hit with huge holes and dongas. Further north near Mtunzini and Amatikulu the same pattern was repeated and looking at the amount of rain that fell in that region it was no surprise that the ground looked like porridge. The heavy sand deposits on the Umhlatuzi flats showed how this area had also suffered. Although the rain decreased to the north up towards the Umfolozi there was still sufficient rain to again flood the flats. Luckily a lot of the flooding took place over the area inundated by the Demoina floods.

The damage that took place could probably be put into four classes:

1. Riverine - Damage to stream banks and flood plains both by deposition and by scouring.

2. Waterway damage - Scouring caused by massive flows and poorly prepared grass channels.

3. Infield damage - Wash aways, rills, gullies in bare fallow land, newly planted areas, burnt harvested lands.

4. Land slippage - Land slides major and minor due to rock layers, E horizons etc.

The control of all of these types of erosion is not always possible. With such massive flows of water in the natural stream lines the bottom land areas are bound to be inundated whatever protective measures are taken. The same goes for the fourth class where the profile just becomes too saturated and literally flows down the hillside. However, the control of water flow by correct management practices and protective works on the hillside is feasible even in the big storms just experienced.

So what can be done to be better prepared for the floods? It has been established without doubt that on the farm the more ground which is being tilled or disturbed the greater will be the soil and water loss. Any technique which cuts down on the amount of tillage will improve the protection afforded to the ground. The use of minimum tillage by chemicals to kill the crop before planting radically reduces the soil disturbance. Even hand chipping out the old crop will reduce soil disturbance and aid in the preservation of the soil. Strip planting is the next practice to employ as this reduces the area of any disturbed soil by confining the replanting area to panels across the hillside.

Terrace banks placed across the slope also play a part in the general protection pattern by removing excess run-off water and directing it into prepared grassed waterways. These must be suitably designed and most importantly have a horizontal base and gently sloping sides which are completely covered with a strongly rooted grass.

The use of a trash mulch is also beneficial for it not only acts as a shield breaking up high intensity rain drops and preventing splash erosion but also as a sponge soaking up water and allowing a reservoir to form above the ground surface which can slowly infiltrate into the soil.

For the time when heavy rains occur of lesser magnitude than the storms just passed, a good measure of protection to stream banks can also be achieved. Either the use of natural vegetation along the water-course banks or banks which have been sloped back at an angle of 45 degrees or less planted to a grass with a creeping growth habit and sugarcane removed from a three metre strip along each side of the top shoulder can be used. These strips must also be planted to grass. What lessons then can be learned from the floods?

While very little can be done in floods of this size in the valley regions and hillside areas which have a high slippage potential, there are many good management practices which can and should be applied to control run-off water. The sooner minimun tillage,strip planting and terrace banks become standard practice the less the damage that will be caused by extra heavy rains.

GGP/SN
20 October 1987

SOUTH AFRICAN SUGAR INDUSTRY
AGRONOMISTS' ASSOCIATION

CURRENT RESEARCH INTO IMPROVING POOR QUALITY SOILS DERIVED FROM DWYKA AND MIDDLE ECCA SEDIMENTS

by JH Meyer, FJ Dewey and RA Wood

INTRODUCTION

Soils derived from Middle Ecca and Dwyka sediments have a reputation in the sugar industry for having limited productivity and requiring special management. This applies particularly to soil forms such as the Longlands, Westleigh, Kroonstad, Katspruit, Glenrosa, and Swartland, which collectively comprise about 15% of the area under cane. Physical factors which limit rainfall efficiency in these soils include:

- low intake rates (less than 5 mm/h)
- low total available moisture capacity (TAM less than 60 mm)
- surface crusting and a high erosion hazard
- slow internal drainage and poor aeration at depth
- high compaction hazard.

The Middle Ecca and Dwyka soil project was established to investigate practices which would minimise the adverse effects of the above limiting factors. To date, the effects of infield compaction on cane growth have been studied and the results of a trial conducted on a Longlands form soil at La Mercy were reported in a SASTA paper presented in 1984 by Swinford and Boevey. The merits of mole drainage as a means of minimising the waterlogging hazard have also been examined in two trials conducted at Mtunzini, and the findings were reported in a SASTA paper presented in 1986 (Dewey, Meyer and George).

Attempts at improving cane growth on these soils have continued and investigations that are currently in progress include the following:

- improving intake and movement of water through the soil profile by vertical mulching with filtercake or sand
- minimising crust formation and runoff potential by testing ameliorants such as phosphogypsum, polyvinyl alcohol, molasses meal, and filtercake
- improving surface drainage and increasing effective rooting depth by ridging-up.

Some of the more important results obtained to date are presented in this report.

VERTICAL MULCHING INVESTIGATIONS

It was shown by Gardner (1968) that infiltration and the advance of the wetting front in a soil is more rapid where deep vertical channels filled with chopped organic material are cut through the soil layers. This practice has been referred to as 'vertical mulching' and in view of the presence of a layered Westleigh/Longlands form soil at our Mtunzini farm, the first trial was established there in April 1986.

Procedure

The trial has four treatments and each is replicated three times:

i) control - hand-planting after minimum tillage
ii) vertical mulching (VM) with topsoil fed down the soil profile
iii) VM with coarse Umgeni sand at 150 t ha^{-1} fed down the profile
iv) VM with filtercake at 100 t ha^{-1} fed down the profile.

Sand and filtercake treatments were initially banded in the interrow and rotavated into the topsoil. Vertical mulching was then carried out using an Alubuster which allows surface material to drop into the subsoil behind a tine to a depth of approximately 500 mm. Cane setts of variety N12 were planted in the resulting furrow just above the top of the vertical mulch layer.

Results

- **Germination and growth**

The trial germinated well and visual differences were soon evident between the various treatments.

These differences were subsequently confirmed by measurements of stalk height and population taken when the cane was 9 and 12 months old, and shown in Table 1.

Table 1: Growth measurements - 9 and 12 month-old cane (mean of three replicates)

Treatment	Age (mths)	Mean stalk height (cm)	Mean No of stalks (10 cm of row)
Control (no mulching)	9	81	168
VM with topsoil		87	171
VM with sand		88	175
VM with filtercake		89	158
Control (no mulching)	12	171	252
VM with topsoil		181	258
VM with sand		184	247
VM with filtercake		189	263

Compared with control, all the vertical mulching treatments had a beneficial effect on stalk height while, as the crop approached harvest, vertical mulching with filtercake appeared to be the most successful treatment both in terms of height measurement and population count.

- **Plant crop yield data**

The trial was harvested in June 1987 when the plant crop was 14 months old. The mean yields obtained for the different mulching treatments are shown in Table 2.

Table 2: Yield data from the vertical mulching trial (plant crop - mean of three replicates)

Treatment	tc ha^{-1}	ts ha^{-1}	t ers ha^{-1}
Control (no mulching)	67,9	7,5	6,4
VM with topsoil	78,9	8,5	7,2
VM with sand	82,0	9,0	7,7
VM with filtercake	84,1	9,2	7,8
Mean	78,2	8,5	7,3
LSD (0,05)	7,9	1,4	1,3
LSD (0,01)	12,0	2,1	2,0

All vertical mulching treatments showed a significant (VM with topsoil) or highly significant response (VM with sand or filtercake) in terms of cane yield (11 to 16 tc ha^{-1}), when compared with that of the control treatment (no mulching). There was also a significant response (5% level) to vertical mulching either with sand or filtercake of about 1,5 ts ha^{-1}, when compared with control.

- **Soil results**

Following the application of the vertical mulching treatments, soil samples were taken from selected plots to compare the effects of vertical mulching on particle size distribution with increasing soil depth. Samples were taken to two depths with an Eyklkamp auger (0-15, 15-30 cm), at 5, 10 and 15 m intervals along the middle cane row of plots 5, 6, 7 and 8, representing VM with sand, VM with topsoil, VM with filtercake, and control treatments respectively. A comparison of the results of vertical mulching with sand and the control treatment is given in Table 3.

Table 3: The effect of vertical mulching with sand on the texture of the topsoil

Treatment	Plot	Depth (cm)	Sampling distance from waterway									Mean		
			5 m			10 m			15 m					
			% clay	% silt	% sand	% clay	% silt	% sand	% clay	% silt	% sand	% clay	% silt	% sand
VM Sand	5	0-15	8	7	85	8	8	84	10	9	81	9	8	83
	5	15-30	10	8	82	10	7	83	11	10	79	10	8	81
		Mean	9	8	84	9	8	84	121	10	80	10	8	82
Control	8	0-15	9	7	84	12	10	78	13	10	77	11	9	80
	8	15-30	10	7	83	13	10	77	13	9	78	12	9	79
		Mean	10	7	84	13	10	78	13	10	78	12	9	80

Undisturbed core samples were also taken to a depth of 15 cm at the 20 cm position within the middle row of the VM with sand treatment and the control treatment (Plots 5 and 8) to determine any changes in moisture release. The results of duplicate samples are given in Table 4. It would appear that the VM with sand treatment increased the available moisture capacity of the topsoil by about 18% when compared with that of the control treatment.

Table 4: The effect of vertical mulching with sand on moisture release

Treatment	Plot	Depth (cm)	Moisture %		Bulk density (kg m^{-3})	AMC (mm m^{-1})	Total porosity (% by vol)	Air-filled porosity (% by vol)
			Field capacity	Wilting point				
VM sand	5	0-15	9,23	4,94	1 705	73	35,7	19,9
VM sand	5	15-30	9,42	4,50	1 666	82	37,1	21,4
		Mean	9,33	4,72	1 686	78	36,4	20,6
	8	0-15	9,38	5,43	1 708	68	35,5	19,5
Control	8	15-30	9,32	5,49	1 645	63	37,9	22,5
		Mean	9,35	5,46	1 677	66	36,7	21,0

Preliminary intake measurements based on the use of the 'double ring' infiltrometer suggest more effective wetting up of the soil profile where the vertical mulching has been carried out with filtercake (Figure 1).

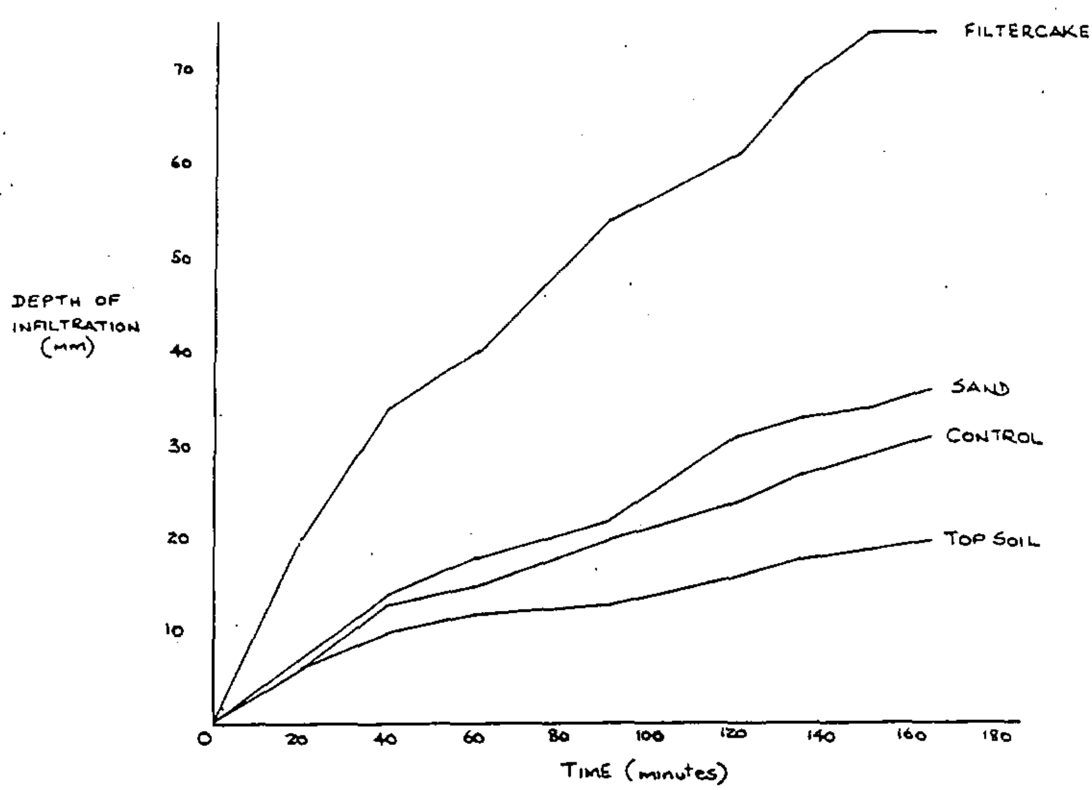


Figure 1: Infiltration rate (Mtunzini vertical mulching trial)

Comments

- While further soil measurements are necessary, it seems likely that an improved intake and movement of water through the root zone, coupled with an improved available moisture capacity, are reasons for the better performance of cane under the vertical mulching treatments.
- Gypsum blocks and access tubes for neutron probe measurements have been installed to compared the effects of soil moisture utilisation under various mulching conditions.
- Preliminary root washing has been carried out and the indications are that root proliferation in the vertical mulching treatments is deeper than that in the control treatments. Roots washed from the soil cores will be used to measure root length and mass at different depths.
- Further soil samples will be taken to a depth of 60 cm to determine more reliably the effect of vertical mulching in modifying the gleyed subsoil horizon. Undisturbed soil cores will also be taken to verify any improved effects in moisture release.
- A second trial was established in February 1987 on a shallow Glenrosa/Westleigh form soil on a site at Mount Elias using the same treatment design as the first trial. No results are as yet available for this trial.

SOIL AMELIORANTS

Exploratory tray site experiment

Preliminary soil permeability and clay dispersion studies conducted in the laboratory during 1985 indicated that soil aggregates may be stablised by using either phosphogypsum, molasses meal or polyvinyl alcohol. These result led to the initiation of a tray experiment in which topsoil with a history of crusting problems was weighed into trays, saturated with water, and treated with ameliorants applied at rates equivalent to the following:

Gypsum (G)	5 t ha^{-1}
Phosphogypsum (PG)	5 t ha^{-1}
Filtercake (FC)	50 t ha^{-1}
Polyvinyl alcohol (PVA)	10 g m^{-2}
Reverseal 9/85 (REV)	20 l ha^{-1} (diluted 50 times)
Molasses meal (MM)	25 t ha^{-1}
Trash blanket (TB)	10 t ha^{-1}

The two controls consisted of the 'undisturbed' soil and trays with disturbed soil which received no ameliorant. Each treatment was replicated three times. The trays were left in the open for six months, then sampled to a depth of 10 mm, and the samples analysed for various physical properties. The results are given in Table 5.

Table 5: A summary of the test results for the tray amelioration experiment (mean of three replicates)

Treatments	EC ($mS\ m^{-1}$)	SAR	CEC (meq %)	AWR	Linear shrinkage (%)	Dispersion ratio (%)
Original soil	55	1,1	-	4,9	1,0	49
Control	59	0,7	2,8	4,2	0,7	61
Gypsum	76	0,9	3,7	6,5	1,0	60
Filtercake	59	0,6	5,7	5,5	0,4	67
Polyvinyl alcohol	114	1,7	2,1	5,4	0,8	39
Reverseal 9/85	67	0,9	2,8	5,1	0,3	56
Molasses meal	117	1,6	2,9	7,9	1,2	43
Phosphogypsum	60	0,7	2,5	5,4	1,1	60
Sugarcane trash	67	0,9	3,6	5,8	0,5	60
Undisturbed soil	76	1,1	3,5	5,5	0,8	80
Mean	75	1,0	3,3	5,6	0,8	58

The two ameliorants that were most successful in reducing soil dispersion were PVA and MM. Filtercake increased intake rate, but the soils tended to be more dispersed where filtercake was applied.

RAINFALL SIMULATOR TRIALS

In a joint investigation with the Farm Planning department, the effects of phosphogypsum in reducing soil loss were assessed in a pilot study using a rainfall simulator.

The experiment was situated on a Longlands form soil prone to crusting and with a highly erodible topsoil. There were four treatments:

i) minimum tillage + 5 t ha^{-1} phosphogypsum (PG)
ii) minimum tillage - no PG
iii) conventional planting + 5 t ha^{-1} PG
iv) conventional planting - no PG

Rainfall was applied on two consecutive days in storms of 63 mm/h intensity. Results are given in Table 13.

Table 6: Soil loss and runoff from phosphogypsum treatment at La Mercy

Treatment	Storm 1		Storm 2	
	Soil loss (t/ha)	Runoff (%)	Soil loss (t/ha)	Runoff (%)
Min tillage + PG	0,28	27,1	0,77	67,1
Min tillage - no PG	1,38	45,0	3,43	69,4
Conventional + PG	2,52	56,5	4,38	88,6
Conventional - no PG	3,33	51,5	8,61	87,9
Mean min tillage	0,83	36,0	2,10	68,2
Mean conventional	2,92	54,0	6,49	88,2
Mean - PG	1,60	41,8	2,57	77,8
Mean - no PG	2,35	48,2	6,02	78,6

Soil loss and runoff losses were both reduced under minimum tillage treatments for both the first and second storms. Where PG was applied intake rates were apparently improved, perhaps due to reduced crusting effects, and this led to lower runoff as well as smaller soil losses from these plots. From this study, gypsum appeared to improve stability in the upper 50 mm of soil thus reducing initiation of runoff and subsequent erosion. This beneficial effect is enhanced if combined with minimum tillage on a soil with inherently poor physical characteristics.

In view of these promising results, a second experiment was carried out in which a wider range of ameliorants were tested under both rainfed and simulated rainfall conditions. Three replicates of the following treatments were established at La Mercy:

i) control
ii) molasses meal (25 t ha^{-1})
iii) phosphogypsum (5 t ha^{-1})
iv) polyvinyl alcohol (100 kg ha^{-1})
v) filtercake ((50 t ha^{-1})
vi) trash blanket (10 t ha^{-1}).

As in the previous rainfall simulator trial, two storms were applied to all treatments. A comparison of preliminary measured soil losses for the various treatments is shown in Figure 2. The trash blanket was the most effective treatment in reducing soil loss, followed in order by the molasses meal, phosphogypsum, polyvinyl alcohol , and filtercake treatments. The phosphogypsum results are particularly encouraging in view of the 60% reduction in soil loss compared with the control treatment. Penetrometer measurements have also confirmed that polyvinyl alcohol , phosphogypsym, and trash are the most effective treatments in reducing crust formation.

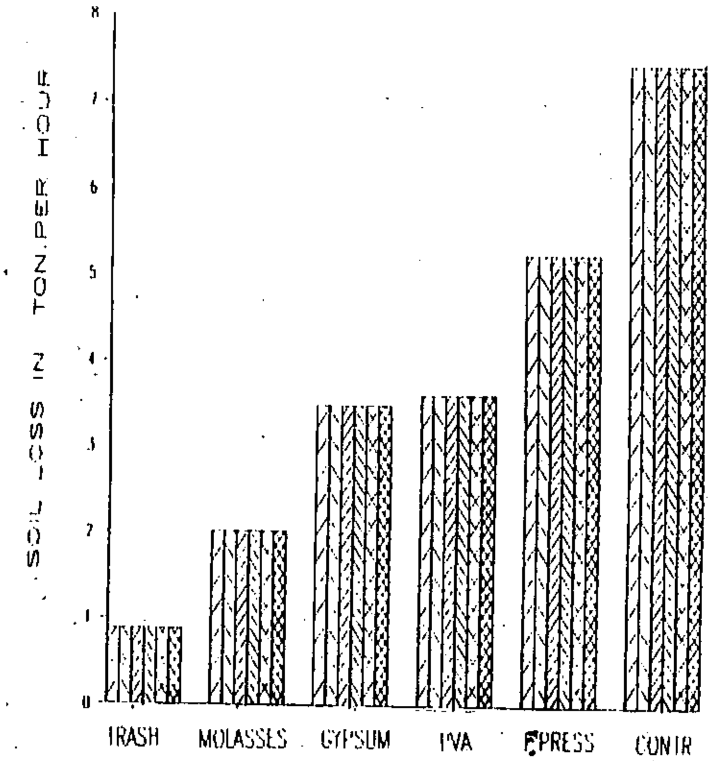


Figure 2: Soil loss per treatment, La Mercy

Ridging-up trials

Where shallow, poorly drained soils are detrimental to cane germination and growth it is thought that if cane is grown on a ridge, excess surface water will be more rapidly dispersed and aeration of the roots improved. Responses to ridging-up of the cane row were obtained in an experiment at Pongola under irrigated conditions on a well-drained soil. To determine whether or not ridging-up would improve cane growth on poorly drained shallow soils, trials at La Mercy and Nkwaleni have been established in order to compare ridge planting with conventional planting. A third trial has been superimposed on ratoon cane from a former mole drainage trial at Mtunzini.

- **La Mercy**

The trial established in March 1985 on a Longlands form soil under rainfed conditions has three treatments:

i) minimum tillage (control) (C)
ii) minimum tillage - ridging-up three months later (C + R)
iii) ridge palnting (R)

Each treatment was replicated eight times. The trial was planted with variety NCo376 but germination was retarded by the very dry conditions. Ridged plots were re-ridged mechanically when the cane was 8 months old following subsidence. Prior to harvesting at 15 months, height and count measurements were taken, at which stage eldana damage was evident throughout the trial. Stalk populations showed no improvement from ridging, but mean stalk heights of the ridged treatments increased on average by 120 mm. A summary of yield data is given in Table 7.

Table 7: Yield data - La Mercy ridging-up trial

Treatment	Plant			1st ratoon		
	tc ha^{-1}	ts ha^{-1}	ers t ha^{-1}	tc ha^{-1}	ts ha^{-1}	ers t ha^{-1}
Min tillage (Control)	54	6,3	5,4	69	9,0	8,0
Min till + ridging-up	56	6,9	6,0	75	9,3	8,2
Ridge planting	53	6,2	5,4	82	10,0	9,7

Although the plant crop indicated no response to ridging, the first ratoon crop showed a significant yield increase of 17% compared with the control treatment. It is likely that the response to ridging-up in the first ratoon is associated with the more effective removal of surface water during wetter conditions (1 092 mm rainfall, first ratoon crop versus 897 mm rainfall, plant crop).

- **Mtunzini**

This trial on a Longlands form soil was superimposed on another originally designed to test mole drainage with and without various ameliorants. At the beginning of the third ratoon (October 1984), half the plots were ridged-up while on the remainder, burnt tops were scattered to compare the two practices. The yield data for these treatments and for the seven cane varieties planted at this site are summarised in Tables 8 and 9 respectively for both the third and fourth ratoon crops.

Table 8: Yield data - Mtunzini ridging-up versus scattered tops trial

Treatment	3rd ratoon		4th ratoon	
	tc/ha/a	ts/ha/a	tc/ha/a	ts/ha/a
Tops scattered	56,3	7,2	64,0	8,5
Ridged-up	50,5	6,2	68,0	9,0

Table 9: Yield data for various cane varieties Mtunzini ridging-up trial

Crop	Yield	NCo 376	N7	N8	N11	N12	N13	N14
3R	tc/ha	56,1	51,6	50,5	35,5	66,2	49,7	63,9
	ts/ha	6,8	6,5	6,6	4,3	8,8	6,0	7,9
4R	tc/ha	57,3	61,4	67,3	64,3	73,8	66,0	72,6
	ts/ha	7,2	7,8	9,1	9,2	10,8	8,2	9,5

During the drier conditions experienced during the third ratoon crop the scattered tops treatment gave a somewhat better yield than the ridged-up treatment, but the situation was reversed in the fourth ratoon crop where rainfall conditions were more favourable and ridging-up tended to be better than the scattered tops treatment. N12 and N14 outyielded all other varieties, N12 appearing less severely stressed during the dry winter months. N8 suffered less stalk damage due to eldana (6%) compared with variety N13 which was severely affected (40%).

- **Nkwaleni**

The trial was established in April 1986 on a Katspruit form soil under irrigated conditions and treatments were similar to those at La Mercy. Prior to planting, a cut-off drain was installed to intercept seepage water. Each treatment was replicated six times and the trial was planted with variety NCo376. Dipwells were installed to monitor watertable heights, and bulk density and moisture measurements were also taken. The trial was harvested in June 1987 and the yield data are shown in Table 10.

Table 10: Yield data - Ridging-up trial, Nkwaleni

Treatment	tc ha^{-1}	ts ha^{-1}
T1 Conventional planting	92	10,0
T2 Ridging at 3 months	102	11,2
T3 Planting on ridge	99	9,8

Variability in this trial was high and the responses obtained to ridging-up or planting on the ridge were not statistically significant. Early subsidence of the ridges suggested that this practice is not likely to be successful under irrigation as these weakly aggregated soils break down easily, leading to surface crusting and reduced infiltration.

CONCLUSIONS

No firm recommendations can be made at this stage but it does appear that practices such as vertical mulching, amelioration with phosphogypsum, and possibly ridging-up may usefully complement established systems based on minimum tillage and strip planting.

REFERENCES

Swinford, JM and Boevey, TMC (1984). The effect of soil compaction due to infield transport on ratoon cane yields and soil physical characteristics. Proc S Afr Sug Technol Assoc 58: 198-203.

Dewey, FJ; Meyer, JH and George, JA (1987). An evaluation of the suitability of soils for mole drainage in the South African sugar industry. Proc S Afr Sug Technol Assoc 61: 133-139.

Gardner, WH (1968). How water moves in the soil. Crops and Soils.

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SOUTH AFRICAN SUGAR INDUSTRY
AGRONOMISTS' ASSOCIATION

ELDANA BORER AND BIOLOGICAL CONTROL

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Introduction

The African stalk borer Eldana saccharina Walker is a problem in many sugarcane growing countries in Africa and, since 1970, has caused serious losses in South Africa. It is especially serious in coastal rainfed areas, where there is no regular irrigation and where cane cannot be harvested every 12 months. Many other phytophagous insects occur in the cane fields, but few cause measurable crop losses. There is a reluctance to use insecticides against the borer, partly for fear that some quiescent insect might be encouraged to assume pest status, and partly because none of the many insecticides tested against E. saccharina has proved practicable as a control measure. Prospects for biological control have therefore been investigated.

Biological control programme

The biological control programme has involved surveys and studies of indigenous predators, parasites and pathogens, and an investigation of exotic biological agents which might warrant testing under local conditions.

Exotic parasitoids which have been tested, and in some cases released, are listed in Table 1. Initially the programme was aimed at natural parasitoids of E. saccharina which were known to occur in other parts of Africa, but which are not recorded from South Africa. For example, in West Africa, where the borer attacks both sugarcane and maize, both larval and egg parasitoids have been recorded. On several occasions the tachinid Descampsina sesamiae was introduced into South Africa, but a strong culture was never established, the developing maggots becoming encapsulated by the E. saccharina larva. Small-scale releases were made but, not surprisingly, the tachinid never became established. The tachinid Sturmiopsis inferens from India was equally unsuccessful.

A number of naturally occurring egg parasitoids of E. saccharina from West Africa were introduced in the early 1980's. These all showed promise in the laboratory, and the trichogrammatids were easily reared on the laboratory hosts Sitotroga cereallela and Anagasta kuhniella. Extensive field releases were conducted (up to 1,5 million per month) over a period of several years, and occasional recoveries were made in the vicinity of release points; but the parasitoids did not appear to become established.

In addition, other egg parasitoids were tested, some of which did very well under laboratory conditions. Trichogramma australicum, from Taiwan, was reared and released at a rate of 50 000 to over one million each week for a year. There was no sign of any egg parasitoid having become established, and work on egg parasitoids was shelved.

Recently, work has been concentrated on potentially useful larval parasitoids. Several species, which attack similar borers in other industries, have been imported and tested (Table 1), and some attack E. saccharina readily in the laboratory. Others (eg the tachinid Metagonistylum minense) will not do so; in which case they are tested no further.

Table 1: Parasitoids imported into South Africa for testing against the stalk borer Eldana saccharina Walker

Species	Source	Year
Egg parasitoids		
Trichogramma pretiosum*	USA	1977
Trichogrammatoidea armigera	India	1978
Trichogramma braziliensis	Colombia	1980
Trichogramma semifumatum	Colombia	1980
Trichogramma perkinsi*	Colombia	1980
Trichogramma australicum*	Colombia, Taiwan	1980 1983 1986
Trichogrammatoidea eldanae*	Ivory Coast	1980 1981 1984
Trichogramma spp.*	Ivory Coast	1980
Telenomus applanatus*	Ivory Coast	1980 1981 1982
Telenomus sp.	Bolivia	1984
Trichogramma evanescens*	Germany, Switzerland	1984
Larval parasitoids		
Descampsina sesamiae*	Ghana, Nigeria	1975 1981 1983 1984
Sturmiopsis inferens	India	1977
Paratheresia claripalpis*	Brazil, Colombia	1978 1985 1986
Metagonistylum minense*	Brazil, Colombia	1978 1985 1986
Cotesia flavipes	Brazil, Pakistan, USA	1978 1983 1985
Allorhogas pyralophagus*	Trinidad, USA	1984 1985
Iphiaulax kimballi	USA	1985
Rhaconotus rosliniensis	USA	1985
Macrocentrus prolificus	USA	1985
Palpozenilla diatraeae	Bolivia	1986
Pupal parasitoids		
Xanthopimpla stemmator	Mauritius	1986

* Field releases have been made

At present, exotic parasitoids which are being released in the field are the New World tachinid Paratheresia claripalpis and the oriental ichneumonid Xanthopimpla stemmator. Releases began only recently and no measure of success can yet be made.

Investigations among indigenous host plants of E. saccharina revealed a new species of bethylid, Goniozus natalensis, which is common in Cyperus papyrus but which had not been recorded from sugarcane. In papyrus it attacks its host larva in the inflorescence, but it was found in the laboratory that it would attack the host readily in cane pieces also. A pilot project of releases into one cane field indicated the parasitoid's ability to survive and reproduce there, and an expanded project is now in progress to release this bethylid extensively throughout the industry.

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