SASTA Soils Symposium 2011

The recent SASTA Soils Symposium on Sustainable Soil Use, held on 31 August 2011, attracted a large and varied audience. Tickets were sold out within two weeks of being advertised, and the KwaShukela auditorium at SASA was filled to capacity. There is no doubt that the highly respected speakers were a great drawcard to this event.

Gavin Smith, SASTA president, welcomed participants on behalf of SASTA to this, the first symposium arranged as part of the International Visitors' Grant, sponsored by SASTA. Funds for this grant were made available from the profit realised at the 2007 ISSCT conference held in Durban. Gavin, from the Sugar Milling Research Institute, left this message from the millers to the largely agricultural audience: 'Look after your soil, but keep it to yourself!'.

The first recipient of the SASTA International Visitors' Grant, and first speaker of the day, was due to be Professor Malcolm Sumner, from Georgia in the USA. Prof Sumner has a hugely impressive resumé. He currently holds the position of Regents' Professor of Environmental Soil Science Emeritus at the University of Georgia, Athens, USA – the highest recognition conferred on academics at this institution. He was born and bred South African, however, and received his B.Sc. and M.Sc. degrees at the University of Natal, Pietermaritzburg (UNP). After obtaining his PhD at Oxford University, he returned to UNP as a lecturer, rising through the ranks to become Professor and head of department (Soil Science and Agrometeorology). He emigrated to the USA in 1977. He has received multiple awards for his work, has published over 250 refereed journal papers, 40 book chapters and is the editor of 8 books. Prof. Sumner is indeed a force to be reckoned with in the world of soil science. Unfortunately, however, Prof Sumner had to cancel his trip at the last minute, due to medical reasons. SASTA and the audience alike wish Prof Sumner a speedy recovery. In the absence of Prof Sumner, Dr Neil Miles presented his talk. Dr Miles is a senior soil scientist at SASRI. He studied at UNP, and spent 28 years with the KZN Department of Agriculture as a research scientist and manager.

Prof. Sumner's presentation centred around management of soil for optimising yields, and drew on his experience working with growers in Central America. Small-scale vegetable growers in the region had begun to experience declining yields, and as a result had started to use expensive, specialist fertiliser products in an effort to improve their crops. Prof. Sumner, in association with the NORDIC programme, instituted changes to these growers' regimes, including regular soil and leaf sampling, 'regular' (rather than expensive specialist) fertilisers, and applications of lime and gypsum. Before the institution of this programme, growers had higher input costs, but less nutrients applied and lower income than after the programme. These growers benefited from a scientific approach based on soil and leaf samples; doing away with costly chemical fertilisers and 'snake oils'; and increased use of gypsum. Rapid uptake has been recorded in Guatemala, and the programme is expanding to other countries such as El Salvador and Nicaragua.

Large scale growers in the region had also begun to experience yield decline in crops such as coffee, sugarcane, bananas and citrus. A large number of stresses were identified, including severe acidity, high exchangeable aluminium, nematodes and fertiliser burn.

Solutions to these problems were found and implemented, with lime and gypsum being applied, nematodes being controlled and fertiliser being applied more appropriately.

Dr Miles drew a number of parallels between the central American growers and our own problems in sugarcane. These can be summarised as follows:

- Seek and use simple management interventions
- Avoid costly, specialised chemical solutions and 'snake oils' when 'regular' fertiliser will do.
- Use gypsum appropriately for the amelioration of subsoil acidity.
- Most importantly, look after the plants' **roots**! They are the key to success. Poor rooting has also been found to be a problem in South Africa's sugar industry: without a healthy root system, it is unreasonable to expect a good above-ground crop.

Questions / Discussion:

- **We have similar problems in SA, with subsoil acidity.** The gypsum source is important: some can be wet and difficult to handle. In sandy soils, the sulphur content can be low. Sugarcane is fairly acid tolerant, but we do find problems with poor rooting in very acid soils. With climate change and increased droughts a possibility, deep rooting is imperative; and gypsum contributes to this. Most of our soils do have enough calcium, but aluminium is a problem. Importantly, gypsum application should be based on soil tests.
- **Is fertiliser root burn a problem in SA?** Ammonium sulphate is often a cause of root burn, and this has been a problem in Australia; but it is not commonly used in sugarcane in SA. Australia has changed to MAP/DAP.

Dr Graham Kingston was next in the day's lineup of eminent speakers. Dr Kingston has recently retired from BSES in Australia after 42 years of research in sugarcane agronomy. His research interests have been many and varied, including sugarcane water requirements, irrigation scheduling, management of salinity and drainage, crop nutrition, chemical ripeners, green cane harvesting and the impacts of field practice on factory performance and sugar quality. Dr Kingston has travelled extensively and has a wide range of experience after consulting in Australia, South America, Africa and Pakistan.

Dr Kingston addressed the audience on nutrient management challenges in the Australian sugar industry. The Australian sugar industry's position in the north east of the country situates it in close proximity to the world-renowned Great Barrier Reef. It is in this context that growers need to fertilise their crops and monitor their environmental pollution. A Reef Rescue Programme aims to halt or reverse the decline in reef water quality and reduce detrimental impacts of water quality on the reef. Nitrogen, phosphorus and herbicide use is now regulated, and environmental management plans instituted for all cane farms larger than 70 ha in the central and northern cane-growing regions. Nitrogen and phosphorus use and management need to be carefully recorded; no audits have been imposed yet, but 'hot spots' could necessitate these audits. The 'Six Easy Steps' programme is used to calculate nitrogen and phosphorus application rates, taking into account soil sampling, nitrogen from legumes etc. Nitrogen and phosphorus application rates have decreased over the years, following increased environmental pressure.

Mill by-products also need to be managed carefully: filter mud application, for example, should minimise environmental harm, and records need to be maintained.

Silicon nutrition is another challenge in the Australian sugar industry – as in ours. Suitable products in large amounts, at economically justifiable prices, are difficult to find. Research into the various products is ongoing.

Questions / Discussion:

- **Do growers need to prove that they're irrigating responsibly; and does salt come into the equation?** No – no irrigation requirement. All areas except the Burdekin have supplementary irrigation. There is no real problem with salts.
- **What research is being done on nutrient management after the recent significant weather events (floods)?** Climate change research is being done; this will help to manage nutrients better during these events, coupled with long-term (climate change) and seasonal forecasts.
- **What are the implications of Dr Robertson's paper on sugarcane's affinity for ammonium nitrogen?** This paper re-examines what we know about nitrogen. Sugarcane does appear to favour the ammonium ion over nitrate ions. Sometimes only 30-50 % of applied N is taken up by the crop; the rest is lost. Questions still remain: How can we increase this efficiency? And are there genotypic differences in the CEC of roots?

Dr Peter Thorburn, a principal research scientist at the CSIRO in Brisbane, spoke next. Dr Thorburn's current work aims to determine management systems that can reduce detrimental environmental impacts while continuing to produce positive economic and social outcomes. Much of his work involves the development and application of simulation models. Dr Thorburn's research has led to significant developments in reducing the environmental impacts of farming on aquatic and marine environments, and through the mitigation of greenhouse gas emissions caused by agricultural production. His work has received international acclaim.

Dr Thorburn was saddled with the unenviable task of discussing the role of modelling in nutrient management. He explained some background to modelling philosophy, reminding the audience that "...a model is anything used in any way to represent anything else...", and that they are "...simplifications of the world." He described some very simple models of nutrient management, and how models could be plotted on two axes: becoming 'more useful' along the x axis, and 'more detailed' up the y axis. In this way, more detailed models might be more powerful, but they might be too complex to be easily used. He gave some examples of how models can be used to predict N reductions after legume crops, manage nutrient loads in water running into the Great Barrier Reef system, and explore nitrous oxide emissions from burnt and trashed cane harvesting systems. Dr Thorburn concluded that nutrient management revolves around models, and that it was sensible to model nutrients at a process level where feedbacks are complex and non-linear. He mentioned that at the Australian Society of Sugarcane Technologists' Congress, up to 75 % of all papers included a modelling component. Models aid our understanding of complex problems, and are currently under-utilised to explore optimum management. Finally, the audience was reminded that "...(all) models are wrong, but some are useful..."!

Questions / Discussion:

- **For optimising N rates, is there an assumed harvest age? Does N rate depend on harvest age?** The rate of N uptake is at a maximum from 3-6 months, and then decreases. So, the amount of N in the crop biomass is stable from 6-8 months onwards. The age effect is modelled, but probably isn't a large determinant of N rate. Systems which rely on attainable yield to predict N application rate can cause over-application, as growers are often too optimistic with their yield targets.
- **Has there been any modelling on the timing of N application vs N emissions?** Yes, though this is not a big factor. N15 labeling has illustrated some very low uptake values for N from fertiliser. A lot of N is immobilised in organic matter, but there is also ongoing mineralisation of organic matter. Modelling dampens the effect of this immobilisation and mineralisation.
- **Is there variation in atmospheric N, and is it taken into account in nutrition models?** Yes – there is big variation in atmospheric N across the world. It is high in Europe, and it is modelled there; in Australia, it is related to distance from the coast (it decreases exponentially with distance from the coast). It is very low, however – only a few kilograms – and so we don't worry about it. It may come into account in forest system, where it may be enough to 'top up' the system and keep it from declining.
- **The model shows sensitivity of the model to trash blankets: high moisture levels under trash blankets cause increased denitrification and therefore increased greenhouse gas (nitrous oxide) emissions under trashing. Wouldn't this be different under South African conditions, which are much drier?** This is probably correct – emissions are lower under Brazil than Australia. The model would probably show that SA conditions were drier, and therefore fewer N emissions. This would be a good project to implement in SA.

Dr Mart Farina, a specialist advisor, spoke next. Dr Farina obtained his B.Sc., M.Sc. and PhD in Agronomy at the University of Natal, Pietermaritzburg. He has worked for many years as a soil fertility researcher with the SA Department of Agriculture, and currently works as a soil fertility consultant. He has extensive experience with maize and grain legumes in KwaZulu-Natal, and has a special interest in soil acidity and technology transfer to farmers and advisors. Dr Farina has travelled and worked extensively around the world, spoken at numerous scientific congresses and published over 65 scientific papers. He has won numerous awards for his presentations and research, and is very well known by researchers and growers alike. Dr Farina combines the rare qualities of top-class research and highly effective technology transfer.

Dr Farina presented 'Soil Cover: why I'm a convert'. He used the results of a soil-borne disease investigation, funded by the Maize Trust, KZ Agriculture and Omnia Fertiliser, to illustrate his reasons for being a 'convert to cover'. Treatments in the trial, conducted in the KZN Midlands, included winter crop rotations (canola, crambe, oats, stooling rye, and maize and bare fallows), biocontrol agents, chemical biocides, tillage and extra cover – i.e. the addition of extra organic matter to the soil surface. Dr Farina saw clear evidence of why it is so important to keep the soil covered. Cover with living or dead mulch caused a significant increase in the soil moisture, and often maize yields. It was earthworm numbers and water infiltration rate, however, which were most improved

by retaining soil cover. In one example, 20 litres of water took 236 minutes (almost 4 hours) to soak into the soil after a bare fallow; whereas after a maize fallow with extra straw on the soil surface, the same amount of water took 39 minutes! In the same example, 3 earthworms per square metre were found in the bare fallow; maize plus straw gave 68 worms in the same area. Dr Farina also presented interesting aerial photos of a no-till maize field which had been partially burned during a runaway fire. The burned area, where the cover had been burned away, yielded 3.1 t/ha of maize (and took 52 minutes for 20 litres of water to infiltrate); while the unburned area directly adjacent to this yielded 9.4 t/ha (and 20 L took 11 minutes to soak away). Food for thought! Dr Farina concluded that in annual cropping systems, 30-40 % soil cover is not nearly enough; and he felt that this had relevance to the sugar industry too.

Questions / Discussion:

- **This trial was conducted on a good, red 'potato' soil – how much more would the effects have been shown on a poor, sandy soil?!** Very true. Fifty years ago, trashing was the norm in the sugar industry, as well as green manuring; now it is the norm to burn.
- **Remarkable what effect a single fire had on infiltration rate and yield of maize.** Yes. Burning of sugarcane tops leaves almost no cover on the surface, while using the tops for bioenergy might mean that the trash blanket is not as thick as it could be. Gerald Thompson's data have shown that a cold burn has a similar effect to a full trash blanket – so retain those tops!
- **A full trash blanket is a challenge in South Africa under moist conditions. How can we break our trash down faster?** The longer the trash lasts the better – one needs a mat of cover to protect the soil. This mat will have broken down by the end of the season anyway.
- **What is the impact of mulching on N dynamics? In Australia, researchers have noticed N immobilisation – has this been measured here?** In these trials, an extra 30 kg/ha N was added to make up for immobilisation.

Dr Brian Purchase has a BSc (Agric) from UNP and a PhD from London University. He spent 13 years as a university lecturer at the University of Rhodesia before joining the sugar industry, first working a sabbatical leave at SASRI before moving to the Sugar Milling Research Institute (SMRI). He has worked on nitrification in tropical grasslands, nitrogen fixation associated with sugarcane roots, and on a process for converting bagasse to ethanol. Most of his time in the sugar industry has been spent on the factory side where he was Director of the SMRI for 16 years. Dr Purchase is currently retired but works part-time as a Technology Associate with Bosch Projects and as a research mentor at the SMRI.

Dr Purchase's talk was titled 'Carbon legislation, carbon mitigation and sustainable agriculture – what does the future hold?'. He reminded the audience of the history of climate change legislation. The Kyoto protocol (2007) sought commitments from countries to reduce greenhouse gas (GHG) emissions to 5.2 % below 1990 levels by 2012. A follow-up convention at Copenhagen in 2009 sought mitigation commitments of about 40 % to keep temperatures rise below 2 ºC. Greenhouse gases could be reduced by countries' own mitigation projects, as well as trading offsets with other countries. Of the various trading mechanisms, the Clean Development Mechanism was most relevant to Africa, and Certified Emission Reduction certificates (CERs) would be issued based on carbon dioxide

equivalents mitigated by the project. Worldwide, a large number of CDMs were registered – mostly in the energy industries – with over 500 million CERs expected per year from these projects. Eighteen such projects were registered in South Africa; in agriculture, these were largely aimed at harvesting methane from manure for electricity production. Trade on the worldwide carbon market started off slowly, reached a peak in 2008, and then slowed substantially from 2009. From 2012 onwards, buying of foreign offsets by the EU will be severely restricted to 'least developed countries' (excluding South Africa, China and India). South Africa's commitment to a 34 % reduction in carbon output is contingent upon foreign funding, and Dr Purchase therefore deemed it unlikely to succeed.

Climate change mitigation via increased soil carbon can be seen as a 'triple win' – through development (better farming), climate change resilience (e.g. better water retention) and climate change mitigation (reduced GHGs). To this end, a Kenyan project involving small growers involves training in cropland management techniques (e.g. rotation, cover crops, compost management), leading to carbon sequestration. In South Africa's own sugar industry, projects such as that by Eustice et al. (SASTA 2011), on the assessment of GHG emissions by burning vs trashing is the type of work necessary to generate CERs for the sugar industry. Dr Purchase also mentioned biochar, a stable carbon product formed by burning organic matter at relatively low temperatures with limited oxygen, which has a large number of benefits (e.g. water and nutrient retention, suppression of GHG emissions etc) when retained in the soil. Does the sugar industry have the potential to make biochar from trash? Dr Purchase discussed his vision of sustainable farming into the future. He envisaged minimal reliance on CDMs, and instead a national paradigm shift with regard to farming. Farmers are, after all, more critical to human sustainability than doctors, engineers, lawyers and accountants! Dr Purchase discussed the somewhat humorous, but nonetheless eminently functional, urine diversion toilets – and impressed upon the audience the fact that 44 tons of nitrogen in urine is produced daily in Durban. There are currently 70 000 urine diversion toilets in the greater Durban area. Further to his vision of the future, Dr Purchase postulated that crops grown purely for energy had dubious long-term sustainability, but that photovoltaic and sun energy are the way forward.

Questions / Discussion:

- **How does one go about registering a project as a CDM?** The CDM system is very transparent – the process can be downloaded from the internet (UNFCC website).
- **Should we be looking at flyash, perhaps in lieu of biochar?** Flyash is not biochar; generally, an efficient factory shouldn't make biochar – all bagasse etc. should be burnt off in the furnace.

Dr Shaun Berry presented the last of the talks for the day. Dr Berry is a nematologist at SASRI, and has worked there since 2001. His research centres on managing nematode-related problems in sugarcane, and this covers a wide range of disciplines, including soil health, variety choice, chemical and biological control, nematode community management, and developing diagnostic methods.

Dr Berry's talk was titled 'Nematodes – a war lost?'. His war-themed presentation introduced us to the 'enemy' – plant-parasitic nematodes – and presented evidence of their destructive capacity. There are a number of different types of nematodes, including the benign bacterial and fungal feeders, predators and omnivores; the plant-parasitic species,

however, attack the root system of sugarcane, and cause up to R450 million in yield loss annually. The arsenal of 'weapons' used by this enemy includes strength in numbers – over 90 species in sugarcane – quick reproduction, and multiple effects on plant growth, resulting in reduced yields. Nematodes attack the sett and shoot roots of sugarcane, leading to delayed tillering, differences in the size of shoots, competition and thus reduced stalk number. Water uptake is also affected, reducing stalk length. Reduced yields year upon year lead to the need for more frequent replanting as yields become uneconomical. The weapons that we have at our disposal to vanquish this enemy include 'surveillance' (knowing the species suite and numbers of nematodes in the field) and nematicides, though the discontinuation of Temik production has left a gap in our arsenal. Other methods of nematode control include variety choice, the use of nematode-reducing green manures, organic amendments and planting at times of lower risk. More modern 'weapons of defence' include manipulation of nematode populations, to increase the beneficial species, and decrease the plant-parasitic species; and to help the plant to defend itself, by use of inducing resistance with various chemical elements. Dr Berry concluded his talk with the encouraging message that the war against nematodes is one that is in the process of being won.

Questions / Discussion:

- **Any prospects of a new (environmentally friendly) nematicide?** SASRI have tested some biological products, but the results weren't promising. Development of a new nematicide is not likely, as none have been developed for the past 30 years. There are 15-20 other nematicides on the market, but all are red-label products, which target enzymes in nematodes that are common to humans; in other words, if they kill nematodes, they are harmful to humans.
- **Will you look at semio-chemicals (to induce resistance)? Will they be cost-effective?** Some of these chemicals have been tested in pot trials; only Bion is commercially available at present, so we don't know the correct rates of the others. We have an MSc. student and a new project to study this. These would be useful for growers to apply with knapsacks.
- **Of the current suite of nematicides, which has the least effect on the (beneficial) predacious nematodes?** Most have an equal effect on predators, but the beneficial species tend to come back faster. Nematicides only slow the nematodes temporarily. Cropguard claims to be a 'smart' nematode killer, so that it allegedly does not affect the free-living nematodes.
- **What opportunities do we have for manipulating the balance of nematode species to our advantage?** The concept is good: increased *Helicotylenchus* nematodes generally leads to less damage from nematodes. We are not sure exactly how to do it, though we know that variety N12 increases *Helicotylenchus*, while N27 increases the plant-parasitic *Meloidogyne.* Velvet beans also increase *Helicotylenchus* numbers. Different bacteria could affect the nematode community composition; proof of concept is there, but it is not applicable yet.

This brought the formal presentations to a close, though the discussion continued well into the afternoon. Dirk McElligott, chair of the proceedings, thanked Gavin Smith and the SASTA council; Danile Macdonald, SASTA administrator; Neil Miles, Rian van Antwerpen,

Michael van der Laan and Carel Bezuidenhout for arranging the various speakers; the presenters themselves, and all of the attendees for making the day a success.

Article written by Ruth Rhodes