SOIL SCIENCE SOCIETY OF SOUTH AFRICA

NEWSLETTER

No. 111

May 2021

SSSSA COUNCIL: 2021-23

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Vice-President	**Prof J. van Tol** (UFS, Bloemfontein)
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The SSSSA does not necessarily agree with opinions expressed in this newsletter.

MESSAGE FROM THE PRESIDENT

At the last AGM held on 20 January 2021, a new council took over the running of the SSSSA under the new president Prof Jude Odhiambo for the period 2021-2023. The new council will have its first meeting on 19 May 2021.

Combined Congress 2022

Due to the strict lockdown regulations because of the Covid-19 pandemic, it was not possible to hold the Combined Congress in 2021. However, the SAPSSC committee is currently busy organizing the 2022 congress which will be held on a virtual platform from 24 to 26 January 2022. The theme of the congress is "*What is the new normal for agriculture to ensure sustainable livelihood in Africa?* The first announcement has already been made and the second announcement is expected sometime in May 2021. The societies have invited respected experts in their respective fields of specialization as keynote speakers and I would encourage members to register for the conference. This is the first time the Combined Congress is to be held virtually and it will truly be a new experience for all of us.

Journal

All paid-up members of the SSSSA have free access to the SA Journal of Plant and Soil. The Journal is hosted by Taylor & Francis and all previous issues are available electronically on the Taylor & Francis website www.tandfonline.com. To help improve the impact factor of our journal, please: cite articles in our Journal, download articles from our Journal and publish in our own Journal.

SACNASP

The SSSSA encourages its members to register with SACNASP as Natural Scientists in the field of Soil Science. According to law, it is compulsory for practising soil scientists to register with SACNASP. Also, points for Continuous Professional Development (CPD) must also be earned, namely 25 points per

cycle of five years. By attending the congress, you earn three of the annual five points. By being a paid-up member of the SSSSA, you earn yet another point annually, and by performing your job as a scientist, you may earn another two points each year.

Registration with SARS and PBO matter

There has unfortunately been no recent progress, so the statement from the previous Newsletter remains the status quo, namely "We are still awaiting registration as Public Benefit Organisation (PBO)". The process to get registered with SARS is incredibly slow. The council has been busy with this process for almost three years now. The society got registration as NPO last year and now awaits registration as PBO. The date this will be concluded depends on how fast SARS process the submission. So the situation is in the hands of SARS and the SSSSA Council continues to engage them to try and expedite the process.

SSSSA Web Page

The design of a new SSSSA web page by the contracted webmaster and designer has been slower than we had anticipated. There have been many challenges and unforeseen delays, but Council looks forward to the finalized (and hopefully much improved) web page with updated information.

Membership

New members continue to join the society and it is encouraging to see many young members joining. Registered members should encourage their colleagues who are not registered to do so and senior soil scientists and academic staff must please encourage juniors and students to join. I would also like to take this opportunity to request all members who have not renewed their membership for 2021 to do so as soon as possible.

International Union of Soil Sciences (IUSS)

The SSSSA is affiliated to the IUSS. Every paid-up member of the SSSSA is entitled to the privileges of the IUSS. A regular newsletter from IUSS is also circulated online to all registered members of the SSSSA.

In these difficult Covid-19 times, please let us all take the necessary precautions to stay safe and healthy.

Kind regards

Jude Odhiambo

(072 378 7716; **jude.adhiambo@univen.ac.za**)

EDITORIAL

We have a wide variety of news in this issue, despite the Covid-19 situation, which I know has caused disruptions to many of us. My thanks to those who have responded with items, and again, I invite anyone to submit something that you think would be of interest to SSSSA members. After all, it is your newsletter.

My special thanks go to Prof Giel Laker. He has been retired for a number of years, but still remains very active in soil science, and still corresponds regularly with colleagues. To this end, he has collated the presentations, discussions and conclusions from the Conservation Agriculture Workshop from the 2019 Combined Congress (see P17). Due to the electronic nature of this newsletter, it has been decided to include this document as an Appendix at the end. In addition, Prof Giel has almost completed a book about his life in Soil Science (see the article on P12 by Gerhard Nortje in this issue). I am sure many soil scientists and others cannot wait to read it.

Another book that has appeared is that by Cornie van Huyssteen on soil classification and the correlation between the SA and WRB systems. A review of the book by Johan van Tol is also included (P13).

Finally, look out for the announcement of the 2021 Photo Competition (P15) – get out your camera and get out and about!

Regards,

Garry Paterson
(012 310 2601; 083 556 2458; garry@arc.agric.za)

COUNCIL MATTERS

Council would like to remind members that nominations for SSSSA awards can be submitted at any time (normally presented at the next Congress). The three awards that are available are:

- **Honorary Membership** – for retired members that have contributed to the Society over a long period of time
- **Gold Medal** - awarded for excellence in Soil Science, either for a specific contribution or over a career
- **Silver Medal** – outstanding service to the Society and/or to Soil Science

All nominations need to be proposed and seconded by paid-up Full Members of SSSSA. Enquiries should be directed to Council Member Johan van Tol (vanTolJJ@ufs.ac.za).

IN MEMORIAM

Professor Bob Scholes, Professor of Systems Ecology at Wits University and Director of their Global Change Institute, passed away suddenly on 28th April 2021, while on a hike along the Cunene River in Namibia.

While not a soil scientist or SSSSA member, Bob was well known to many of us as a dedicated ecologist who always had the best interests of our ecosystem at heart, and who was involved in many aspects of research, both in South Africa and elsewhere. Bob was a Foreign Associate of the US National Academy of Sciences, a Fellow of the Royal Society of South Africa, a Member of the South African Academy and a winner of South Africa´s "National Science and Technology Forum Lifetime Contribution to Science" Award.

He is survived by his wife, Professor Mary Scholes, and their son.

CONGRESSES

COMBINED CONGRESS 2021 → 2022

As previously mentioned in the President's Message, the next **Combined Congress** that was due to be held in Cedara (KZN) in January 2021 was postponed until 2022, due to the Covid-19 situation. It will now be a virtual/online event taking place from 24 to 26 January 2022.

The first announcement has already been made and the second announcement is expected sometime in May 2021.

SYMPOSIUM SSSA - SALT LAKE CITY, NOVEMBER 2021

SYMPOSIUM SSSA, Div.5. Can Soil Taxonomy contribute towards a sustainable economy as a carrier of soil information?

SESSION DESCRIPTION:
Pedology has advanced in the last few decades through the application of spatial analysis and digital mapping. However, soil survey interpretations have not kept pace with these advances. This has been partly because soil survey interpretations have been historically general in nature. Compounding the problem, current efforts toward broadening assessments of soil health simplify soil classification amounting to a loss of soil information. This symposium aims at a new focus for soil survey interpretations: (i) soil contributions to multiple ecosystem services; (ii) systematic economic evaluations of soil potentials toward sustainable development , and (iii) Soil Taxonomy as a useful carriers of information.

Deadlines:

- June 22 (early abstract deadline)
- July 13 (final abstract deadline)
- November 1 (abstract refund deadline)

For more details, including the final date/s, contact the 2021Chair of the SSSA Pedology Division, Prof Daniel Hirmas (University of California - Riverside) at daniel.hirmas@ucr.edu

DEGREES AWARDED

UNISA

Mashapa Elvis Malobane, a PDP student at ARC-Soil, Climate and Water, has been awarded a PhD by UNISA for his thesis "*Conservation Agriculture effects on soil quality and greenhouse gas emission in a sweet Sorghum-based cropping system in South Africa*". Elvis has subsequently been appointed on a one-year post-doctoral contract at ARC-SCW.

Pierre Fourie received his MSc degree in Environmental Science from UNISA during the April 2021 virtual graduation ceremony, with research title: "*Digital soil mapping as a tool for improved road and game drive management within Phinda Private Game Reserve, KwaZulu-Natal*". This research is a first-time application of DSM in the conservation industry, for the purpose of making game drives more sustainable. A publication or two is in progress. *(Supervisor: Dr G.P. Nortjé, Co-supervisor: Dr G.M van Zijl).*

UFS

Two PhD degrees have been awarded by the University of the Free State:

1) **Isaac Gura** (2021): "*Quantifying soil fertility parameters with electromagnetic induction, infrared reflectance spectroscopy and conventional chemistry procedures for maize and wheat under irrigation in arid climate*". (Promotors: Profs CC du Preez, LD van Rensburg and Dr. JH Barnard).
2) **Oscar Chingongue** (2020): "*Comparison of crop management systems for smallholder farmers in Mozambique*". (Promotors: Profs JJ van Tol, CC du Preez and Dr. G Ceronio).

In addition, the following have been awarded an MSc degree:

Lethabo Tlomatsana, Daniel Jordaan, Khumo Jaola, Zikhona Gqalaqha, Mischke Bouwer, Natasja Combrink

APPOINTMENTS

The South African Sugarcane Research Institute (SASRI) is pleased to announce the appointment of **Dr Thandile Mdlambuzi** as a Soil Scientist within the Plant and Environment Resource Centre as from November 2020. Thandile joins SASRI from the Agriculture Research Council (ARC) - Infruitec-Nietvoorbij where he held the position of Researcher. Thandile holds a PhD degree in Soil Science obtained from the University of KwaZulu-Natal and has gained valuable knowledge in various disciplines within the soil science field and his primary focus has been in assisting small-scale farmers with dealing with the effects of climate change. In his capacity as a Soil Scientist at SASRI, he will continue helping small-scale growers within the sugarcane industry.

Dr Adornis Nciizah has been promoted from Researcher to Senior Researcher at the ARC, and he took up his new post, moving from ARC-Soil, Climate and Water (Pretoria) to ARC-Infruitec-Nietvoorbij (Stellenbosch) on 1st April 2021. Adornis has a PhD in Agronomy from the University of Fort Hare and was previously the leader of a project looking at the evaluation of climate change variables on performance of soybean grown under variable agronomic practices and agro-ecological zones.

MISCELLANEOUS

Soil Classification Working Group

The SCWG would like to congratulate the following members who were elected unanimously to the board:

- **Prof Cornie van Huyssteen** – Co-ordinator
- **Dr Cathy Clarke** – Vice Co-ordinator

Their term starts now, and the SCWG trusts they will lead us to serve soil classification and soil science well.

The Group would also would like to thank Martiens du Plessis and Garry Paterson who served on the board until now for their contributions. They will revert to being ordinary members of the SCWG.

The next SCWG board is therefore:

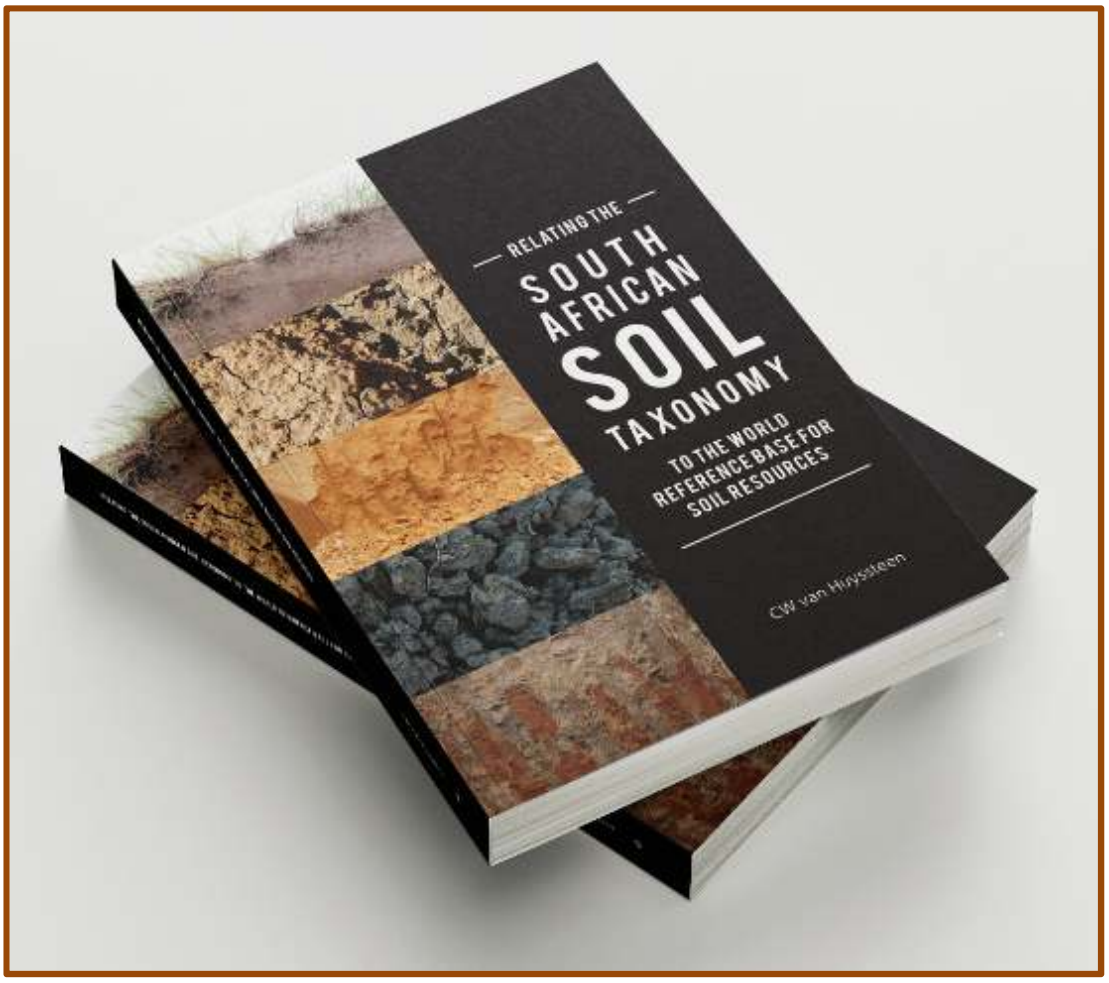
Co-ordinator: Cornie van Huyssteen
Vice Co-ordinator: Cathy Clarke
Past Co-ordinator: George van Zijl

The board will serve until 2023, when a new vice co-ordinator will be elected, Cornie will become past co-ordinator, Cathy co-ordinator and George will become an ordinary member of the SCWG again.

Any SSSSA member who is interested in soil classification, or who would like to make a contribution, can contact either Cornie (vanHuyssteenCW@ufs.ac.za) or Cathy (cdowding@sun.ac.za).

New Book (1)

Cornie van Huyssteen (UFS) has produced a new book in the field of soil classification, "Relating the South African Soil Taxonomy to the World Reference Base for Soil Resources".



The diagnostics and tacit knowledge presented in this publication are based on the South African soil classification system and the World Reference Base (WRB). When necessary, further substantiation was derived from the Land Type Survey of South Africa. The adopted procedure is effective in providing a reasonable classification based on the South African soil forms and families. Lastly, this publication also highlights some peculiarities, omissions and inconsistencies observed between the South African system and the WRB.

The book costs R280 (R224 for the e-book) and interested persons can contact Cornie directly (vanHuyssteenCW@ufs.ac.za).

New Book (2)

"Soil Science from the Heart" by Prof M.C. Laker almost ready for publication

Dr G.P. Nortjé

Professor Giel Laker has just completed writing his book "Soil Science from the Heart", and we foresee that final publication of this very important book should materialise between August-September 2021.

Professor Laker himself states the following about the book: "*This book is the result of relentless pressure exerted on me over a period of years by an increasing number of people to write such a book. The plea for the book was driven by a fear that the wealth of unwritten South African soil science information and insights stored in my brain would be forever lost if I should die or if my memory should give in before they are written up. These include unrecorded personal experience and observations, published and unpublished papers and reports by myself and others that I am the only one that can access freely and easily because of my good memory or even the only one that can access them at all".*

I am glad to say that I was the main person who applied pressure on him!

Prof Laker also says, "*The main aim of this book is to try to fill some of the vacuums in regard to accessible soil knowledge, information and practical insights, at least partially by means of rendering currently inaccessible knowledge, information and insights accessible. It is intended for users of soil information, both soil scientists and non-soil scientists. It is not intended to be a formal soil science handbook for use at any level. On the other hand, it is also not intended to be a popular style book that can be understood by non-scientists. The intention was to write an easy to read and easy to understand book in semi-popular scientific style, while retaining scientific integrity and factual correctness".*

"Several people believe that the story of my life could be an inspiration to others and requested that I should write something about it. So, I start the book with a section that can be described as a synoptic autobiography, dealing briefly with those aspects that are related to me as a soil scientist. Some of it may unfortunately give the impression of vain bragging. That is definitely not the intention. It is merely recording of actual true facts. I am very aware that I am not that good or any better than others. Hopefully readers will become aware that I believe that my whole life has been steered by the Grace of God, who gave me talents to use and created opportunities for me in which to use them".

This book is much needed and overdue for southern African soil scientists, farmers, natural scientists, environmentalists and everyone interested in soil science. It reads

like a story book, with much information specifically for farmers, and for the academically oriented includes more than 500 references. The book has 17 chapters, covering all fields of soil science, as well as land suitability evaluation, land use planning, agricultural development and land reform.

Thus far, several people have shown interest in buying the book. Please let me know if you would be interested in acquiring a copy. You may contact me on:

Dr Gerhard Nortjé (Cell: 083 501 8680, E-mail: nortjgp@unisa.ac.za)

Book review by Johan van Tol (UFS)

Relating the South African Soil Taxonomy to the World Reference Base for Soil Resources – CW van Huyssteen

Relating the South African Soil Taxonomy (SAST) to other internationally used classification systems such as World Reference Base of Soil Resources (WRB) or USDA Soil Taxonomy is a daunting task faced by many soil science scholars in South Africa. This is due to the inherent differences between the classification systems in their approach to classify soils (e.g. SAST relies mostly on morphological properties whereas the WRB and Soil Taxonomy rely strongly on supporting information from lab measurements). To establish successful correlations, one must be adequately acquainted with both classification systems. In his book *'Relating the South African Soil Taxonomy to the World Reference Base for Soil Resources'*, Prof Cornie van Huyssteen has made a significant contribution to national and international literature on soil classification. Prof van Huyssteen is ideally positioned to write this book, stemming from a long-term involvement in the SAST (he is currently convener – again), and serving for eight years as vice-chair of the IUSS working group for the WRB. His knowledge and understanding of both classification systems are clearly depicted in the book.

The book provides a detailed comparison between diagnostic horizons of the two classification systems. This was done through detailed interpretation of chemical and physical measurements of the modal profile database for different SAST diagnostic horizons and then identifying the similar horizon/s in the WRB. Prof van Huyssteen then unpacks the family differentiae and discusses how these relate to WRB qualifiers. In my opinion, the key contribution is in Chapter 5, where the SAST soil forms *and families* are related to WRB soil groups with relevant qualifiers. The book ends with important recommendations for future research in pedology as well as an insightful summary of how elegant the correlations between the classification systems are at soil form level.

Relating the South African Soil Taxonomy to the World Reference Base for Soil Resources should be on the shelf of every soil scientist in South Africa. The book will help scholars with preparing manuscripts and reports for publication internationally and it will also assist

considerably the interpretation of international literature on soil use and management. Never again will I wonder what is an *Albic Stagnic Petric Plinthosol* – it is a Wasbank soil form, of course.

NEWS FROM UNISA

A very interesting and important MSc study is currently underway at Dinokeng Game Reserve (DGR), to the north of Pretoria. The study is being carried out by Anelle Human (Supervisor: Dr G.P. Nortjé, Co-supervisor: Prof M.C. Laker) and addresses the problem of soil crusting, the origin (history) of the development of the extensive bare crusted areas, and looks at measures to rehabilitate the bare areas.

What makes this research site interesting is the fact that the soil became bare due to ploughing, which was abandoned because of a drought period. This was followed by overgrazing with cattle, aggravating the problem. Grasses could not re-establish because of the well-known effects of soil crusting, such as poor germination and poor seedling emergence. In addition, seeds have been washed away due to excessive runoff, the latter also leading to both sheet and gully erosion. Ripping of the soil and even a change from cattle to wildlife did not alleviate the problem. Rehabilitation of these soils is now a major challenge, especially since the affected soils are extremely unstable and it is an eco-tourism area where some measures which could be applied on a cattle ranch will, for aesthetic and other reasons, not be acceptable.

News from University of Venda

Merging of Department of Soil Science with Crop Science and Horticulture Departments:

Due to the restructuring of Schools to Faculties at the University of Venda, the Department of Soil Science has now been merged with the Departments of Crop Science and Horticulture and the new name for the merged departments is: "Department of Plant and Soil Sciences"

Photo Competition

The Soil Science Society of South Africa is again running the "Beauty of African Soil" photo competition this year. We received a cash sponsorship from **AGT Cover Crops & Forages** for prize money, and entries are open now. Send your best soil pictures to Corrie Swanepoel (SwanepoelC@arc.agric.za) from now until 1st December 2021. The following rules apply:

Competition details

The competition runs until 1st December 2021 and is open to all SSSSA members. If any winner is in arrears with membership fees, those outstanding fees will be subtracted from the prize amount.

Photos can be submitted to **Corrie Swanepoel** at SwanepoelC@arc.agric.za

Photo requirements:

- The entered photo **must feature African soil prominently**. It may also feature plants, animals or humans, but the focus should be on soil.
- The photo should have been captured by the person entering the competition.
- Each SSSSA member may enter up to four photos. *(Note: If sent via email, only one photo at a time, alternatively use WeTransfer).*
- Photos must be in digital .jpeg format and must not exceed 10 MB in size.
- High resolution photos are preferred (above 1.5 MP).
- Make sure that if you have any persons featured in the photograph, you have their permission to submit the photo to the competition. Likewise, if your photo is the property of your employer or company.
- No copyrighted photos should be submitted.

Categories:

1. **SOILS UP CLOSE**
2. **SOILS IN LANDSCAPES/AGRICULTURE**
3. **SOIL AND PEOPLE/ANIMALS**
4. **LIVING SOILS (WE ARE LOOKING FOR PICTURES ABOUT SOIL HEALTH, SOIL ORGANISMS OR SOIL CONSERVATION)**

Information required with your submission:

- The category for which you are submitting the photo
- A title for the photo
- The location where the photo was taken
- Optional – any background information regarding the photo

Judging:

- The SSSSA Council members, in consultation with a professional photographer, will judge the entries and select the winners in each category.
- Winners to be announced at the Combined Congress 2022.
- Winners in each category will receive their certificates at the SSSSA AGM, to be held during the Combined Congress in January 2022.
- Winners will receive cash prizes, sponsored by **AGT Cover Crops & Forages**.
- Top entries will be featured on the SSSSA website, newsletter and Facebook page, and displayed at the Combined Congress 2022.

NOTE: by submitting your photo, you grant the SSSSA 'copyright' to use the photo in SSSSA promotional material, adverts, fliers, brochures, posters, newsletters , websites and social media. The photographer reserves ownership of the photo but gives the SSSSA permission to use the photograph as mentioned above. The photographer's name will, wherever possible, be featured with the photograph.

PAPER ON OUTCOMES OF CONSERVATION FARMING WORKSHOP HELD DURING THE COMBINED CONGRESS IN JANUARY 2019

Prof Giel Laker has written up the outcomes of the Conservation Farming Workshop that was held during the Bloemfontein Combined Congress in January 2019 in the form of a paper. It is an objective summary of the five key papers which were presented at the workshop and the feedback from the different discussion sessions and final conclusions, without any interpretations or comments by the author.

Because of the nature of the paper, not being a research or review paper, it was not acceptable for publication in a journal. Ms Anneliza Collett from the Department of Agriculture, Land Reform and Rural Development has, however, arranged for publication of the paper on the Department's website. The direct link to the article is: https://www.dalrrd.gov.za/Portals/0/Scientific%20And%20Technical%20Information/CA%20Workshop%20outcomes%20article%20by%20Laker.pdf?timestamp=1620135827856

A search for the article can be made on the Department's website: www.dalrrd.gov.za. Click on the Resource Centre option, where under "Scientific and Technical Information" the article "CA Workshop outcomes article by Laker.pdf" will be found.

Editor's Note:
To save members time in downloading the document, as well as the fact that electronic distribution makes it easy to include various items, the paper is attached as an Appendix to this Newsletter.

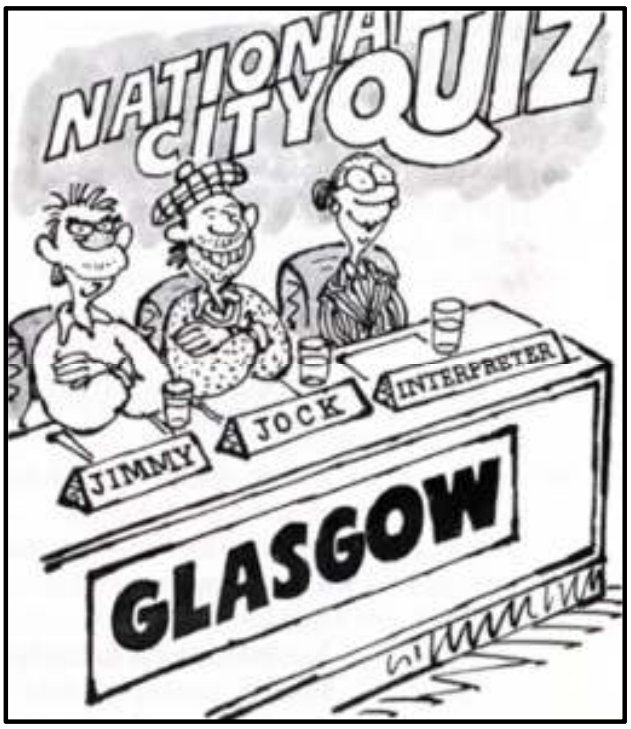
Anyone who wants a separate electronic copy can follow the steps outlined above.

HUMOUR

If a Society has a Scotsman as its editor (*al is hy tweetalig!!*), the opportunity is provided for some cultural education, as with this item below.

SCOTS WORDS

Continuing the occasional theme of trying to explain the way that the Scots language differs from the Sassenachs (sorry, English), here are a few words that have totally different meanings in Scotland, as in most other areas of the world!



Aboot - What it usually means: A form of footwear.
Meaning in Scotland: What's going on? (Whit's aboot?)
Baltic - What it usually means: Relating to the region surrounding the Baltic Sea. Meaning in Scotland: It's frozen.
Burn - What it usually means: to harm using fire.
Meaning in Scotland: A wee stream.
Close - What it usually means: Nearby.
Meaning in Scotland: The passageway leading into a tenement (apartment) building.

Coo - What it usually means: The noise a pigeon makes. Meaning in Scotland: A cow (normally a Highland Cow).
Cry - What it usually means: To sob.
Meaning in Scotland: Call (as in "What do you cry him?").
Coupon - What it usually means: a voucher to get discount on something.
Meaning in Scotland: A face.
Fit - What it usually means: healthy and energetic.
Meaning in Scotland: What? (as in "Fit ye saying?)
Flit - What it usually means: To move swiftly and lightly.
Meaning in Scotland: To move house.
Greeting - What it usually means: A polite welcome. Meaning in Scotland: Crying or weeping.
Honking - What it usually means: The noise a goose makes.
Meaning in Scotland: Stinking.
Ken - What it usually means: The male version of Barbie.
Meaning in Scotland: Know.
Messages - What it usually means: Verbal or written communications.
Meaning in Scotland: Your groceries.
Ned - What it usually means: A shortened version of Edward.
Meaning in Scotland: A troublemaker
Patch - What it usually means: A piece of cloth used to mend a torn piece of clothing. Meaning in Scotland: To ignore someone.
Patter - What it usually means: To make a repeated light tapping sound.
Meaning in Scotland: To be good with words, funny.
Piece - What it usually means: A part of something. Meaning in Scotland: A sandwich.
Steaming - What it usually means: Emitting water vapour (e.g. a kettle).
Meaning in Scotland: Very drunk.
Winch - What it usually means: A mechanism using rope that pulls or lifts things.
Meaning in Scotland: To kiss.

The Covid-19 pandemic has actually changed evolution! Don't believe me? The think about how we have changed from "Human beings" into "Zoom-an beings"!

SOIL SCIENCE SOCIETY OF SOUTH AFRICA: MISSION

The SSSSA is a scientific society, which, in the interest of its members, promotes the advancement of soil science and soil technology as well as the responsible practicing thereof by its members with the view to the long-term sustainable utilization of the environment in the interest of the community.

Aims

1. Promotion and protection of the professional status and prestige of soil science as a science and career.

2. Promotion and extension of the society.

3. Promotion of the standard of training of soil scientists and technologists.

4. Creation of opportunities for the free exchange of ideas on soil science and technology.

5. The obtaining and dissemination of knowledge, information and ideas having relevance to soil science by means of discussion and publication.

6. Promotion of contact between the society and other bodies with common or similar interests, both within South Africa and overseas.

GRONDKUNDEVERENIGING VAN SUID-AFRIKA: MISSIE

Die GVSA is 'n wetenskaplike vereniging wat in belang van sy lede verbind is tot die bevordering van grondkundige wetenskap en tegnologie, en die verantwoordelike beoefening daarvan deur sy lede met die oog op die lang termyn volhoubare benutting van die omgewing in belang van die gemeenskap.

Doelstellings

1. Bevordering en beskerming van die professionele status en aansien van grondkunde as 'n wetenskaplike beroep.

2. Bevordering en uitbouing van die vereniging.

3. Bevordering van die standaard van opleiding van grondkundige wetenskaplikes en -tegnoloë.

4. Skepping van geleenthede vir vrye gedagtewisseling oor grondkundige wetenskap en tegnologie.

5. Die verkryging en verspreiding van kennis, inligting en idees wat op grondkunde betrekking het by wyse van samesprekings en publikasies.

6. Bevordering van skakeling tussen die vereniging en ander liggame met gemeenskaplike of soortgelyke belange, beide in Suid-Afrika en in die buiteland.

APPENDIX

"PAPER ON OUTCOMES OF CONSERVATION FARMING WORKSHOP HELD DURING THE COMBINED CONGRESS IN JANUARY 2019"

CONSERVATION FARMING IN CROP PRODUCTION IN SOUTH AFRICA: OUTCOMES OF A WORKSHOP

M.C. Laker

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Abstract

In South Africa the term Conservation Agriculture (CA) is often used to describe any soil and water conservation action, rather than the narrow concept that CA encompasses a combination of three management principles, i.e. minimum soil disturbance, using a diversity of crops in rotation or association, and protecting the soil with an organic soil cover, that must all be implemented together. In January 2019 a workshop was held during the annual Combined Congress of the four South African crop related scientific societies, namely the Soil Science, Crop Science, Horticultural Science and Weed Science Societies of South Africa, to share and exchange CA research experiences and lessons, and to identify knowledge research gaps in the field of CA in South Africa. By collating the information from the workshop, the aim of this paper was to align CA among the different crops related and to identify the challenges with CA in South Africa. It was clear that CA management requirements are site- and context-specific. No blanket CA practice can be recommended everywhere. Adaptation and application of CA within different South African farming systems needs to be dealt with sensibly and realistically in a way that is based on practical rather than purely theoretical considerations. It was stressed that proponents of CA must not become unrealistic activists, but the all expressed views and recommendations must be based on scientifically proven facts and data.

Key words: Conservation agriculture, no-till, annual rainfed cropping, irrigation, soil fertility.

Introduction

In January 2019, a workshop to discuss various matters related to conservation farming in crop production was held in Bloemfontein during the Combined Congress of the Soil Science, Crop Science, Horticultural Science and Weed Science Societies of South Africa. It addressed all types of conservation farming with its three legs of minimum soil disturbance, mulching and crop rotation and not only no-till based so-called “Conservation Agriculture” (CA).

Prior to the workshop, the organising committee decided that the five key papers and the feedback from the discussion groups had to be summarised into a paper that would ensure that information would not be lost and that people interested in or involved with conservation farming could benefit from them. After the workshop several people have expressed the importance of having this information available in the form of a published paper. The purpose of this paper was thus to give synoptic summaries of the main points in the PowerPoint presentations that were made by the invited speakers at the workshop and of the feedback from the discussion groups. Unfortunately, the person who was designated to compile this paper could in the end not do it. So, the author had to step in at a very late stage. At that stage, he could find copies of the full feedback only for the discussion session on CA in rainfed agriculture other than no-till and the session on irrigated agriculture. For the sessions on no-till CA in annual rainfed cropping, CA in orchards and vineyards and soil fertility management in CA only parts of the original feedback reports could be found. A few main points from the final integrating session also receive some attention.

The paper does not contain any interpretations by the author, but is simply a recording of what was discussed. Except for the reference to DWAF (2004) and the papers that elaborate on the topics discussed, all references given in this paper are references extracted from the presentations that were made at the workshop.

Approach

The workshop had an opening session in which the aims and objectives of the workshop were explained. This was followed by eight introductory papers by invited speakers. Five breakaway sessions related to Topics 2 to 6 (Table 1) were arranged. Delegates were free to choose to attend any breakaway session. A rapporteur for each breakaway group had the responsibility to submit clear-cut conclusions and recommendations to a final session of the workshop.

Table 1: Presentations, presenters and breakaway groups at conservation farming workshop

	Topic	Invited presenter	Breakaway session
1	Introduction to CA	JA Strauss	*
2	No-till conservation agriculture in rainfed annual crop production in South Africa	H Smith	Facilitator: PA Swanepoel Rapporteur: JA Strauss
3	Conservation agriculture farming systems – other than no-till - in rainfed annual crop production	R van Antwerpen	Facilitator: L Lindeque Rapporteur: C Botha

4	CA in orchards and vineyards	P Raath	Facilitator: N Cook Rapporteur: N Taylor
5	CA in irrigated agriculture	W de Clerq	Facilitator: J Annandale Rapporteur: M van der Laan
6	Soil fertility management in CA	G Nortjé	Facilitator: A Mostert Rapporteur: J van Biljon
7	Importance of detailed soil surveys in CA	E Verster	*
8	Responsible weed control in CA	E Hugo	*

*No breakaway session

Four of the five key presentations on different aspects of conservation agriculture are elaborated on in the form of review papers in a special issue of the South African Journal of Plant and Soil.

Outcomes of key presentations and feedback from group discussions

No-till based Conservation Agriculture in rainfed annual field crop production in South Africa

This topic is elaborated in the article of Strauss *et al*. (In Press).

The ***presentation*** by H.J. Smith stressed that introduction of no-till practices was needed to curb the serious soil erosion (water an wind) that is taking place in South Africa's rainfed annual crop production areas. A map of the state of South Africa's biodiversity shows that the grain producing areas of the Western Cape are critically endangered. In the maize quadrangle, parts of Gauteng and the far western part of Northwest province are also critically endangered. The areas just east of the latter in Northwest province and the adjoining western part of Free State province are classified as endangered. Due to cultivation 46% of the soil organic carbon has been lost from these soils (Swanepoel et al., 2016). The areas in Northwest province and the western Free State are dominated by sandy soils combined with low and unreliable rainfall, making them highly vulnerable to wind erosion. The whole of the eastern part of the maize quadrangle on the Mpumalanga Highveld is classified as vulnerable, but not endangered. This area has higher and more reliable rainfall and more stable soils than the areas to the west. Some areas in the relatively high rainfall eastern Free State are also classified as vulnerable, with the rest of the eastern Free State classified as "least threatened".

The main principles of conservation agriculture were listed as:

- Minimum soil disturbance.

- Diversity, including plants/crops and animals.
- Permanent organic soil cover – mulching
- Maximise living roots.

Further principles include:

- Integrated soil fertility and acidity management.
- Integrated weed management.
- Integrated pest and disease management.
- Integration of animals.

Intensive cultivation leads to a downward spiral of soil degradation and therefore minimal disturbance of the soil is required.

Maintenance of a permanent grass cover is essential in order to

- Protect and improve the soil.
- Provide food for micro-organisms.
- Control soil temperature.
- Suppress weeds.
- Improve the soil water balance.

Diversified cropping is essential because it takes over the role of ploughing, fertilisers, pesticides and herbicides. These include crop rotations (at least three crops), intercropping and cover crops, as well as integration of the animal factor. The main functions of crop rotations and associations are

- Provide quantity and quality (diversity) of biomass for weed, pest and erosion control.
- Produce residual fertiliser for following cash crops.
- Provide food and shelter.
- Positive impact on biodiversity.
- Diversity of food sources for micro-organisms.

According to Blignaut et al. (2015) 80-90% of South Africa's grain farmers practice conventional tillage, minimum or reduced tillage, conventional no tillage or conventional zero tillage, all lacking adequate soil cover. The remaining 10-20% practice CA with high external inputs, while none is practising CA with low external inputs or organic CA.

Adoption of different CA practices differs a lot between different provinces (Findlater, 2015). Adoption of two crops in rotation or two crops + no-till are relatively high in Gauteng=KwaZulu-

Natal>Mpumalanga>Western Cape. Adoption of three crops in rotation or three crops + no-till is significant only in the Western Cape (the winter rainfall area). Adoption of CA practices is low in the Free State and Northwest province, which include substantial areas with very marginal rainfall (low) and soils (sandy) with serious limitations for rainfed crop production.

Development and adoption of CA is driven by innovative farmers and groups.

The conclusion regarding no-till CA in South Africa is that there is limited research on

- Soil cover
- Cover crops
- Soil biology
- Integrated soil fertility management
- Soil water
- Livestock integration
- Economics
- GHG emissions (C footprint)
- Value adding with regenerative/CA certification

Research and development is needed to accelerate mainstreaming and adoption of no-till CA

- In various agro-ecological regions, which needs to
- focus on immediate impacts, but with a long term view of
- continuous adoption of CA principles
- in local farming conditions
- through systems research approaches
- either through on-farm, or on-station trials.
- Creating an enabling environment, i.e. policies and incentives.
- Sensitive for different farmer categories.
- Using innovative scaling out and scaling up/down approaches.

Important aspects were highlighted in the partial report-back from the ***Group discussion*** that could be obtained. It was stressed that no-till based CA is important for rainfed cropping systems to survive. It is believed that it can work on all soils and in all agro-ecological regions. Specific technologies are, however, site/region specific and must be adapted to the requirements of different soils and regions to succeed. For no-till CA to be implemented successfully it is important to introduce all three legs of it (minimum soil disturbance, leaving a mulch cover and crop rotation) simultaneously and not only one or two of these. It important to integrate a livestock factor into no-till CA systems where possible.

The following research and development challenges were identified:

- Site/region specific research is needed.
- Research must concentrate on both large-scale mechanised commercial farming and small-scale farming, because they have different scenarios and require different approaches.
- Research is needed on the impacts of crop rotations on soil-borne diseases, both positive and negative.
- Research is needed on the impacts of no-till, mulching and crop rotations on insect diversity – both harmful insects and beneficial insects.
- Research is needed on elevation of herbicide resistance in crops under no-till, because there is concern about the trend to use more potent herbicides under no-till and at higher concentrations.
- Research is needed on liming of acid soils under no-till since lime is not incorporated into soil under the system and lime does not move in soil.
- More research is needed on the stratification of plant nutrients close to the soil surface under no-till and how it affects nutrient element uptake. Studies should be made of how widespread and serious the problem is.
- Research is needed on how soil analyses and fertiliser recommendations should be adapted for no-till systems.

Other challenges include

- There is a need for more well-trained agronomists to do research on no-till systems and assist with advisory services related to no-till.
- Improvement of dissemination of research findings and data obtained in no-till research.

Conservation agriculture farming systems – other than no-till - in rainfed annual crop production

This topic is further elaborated in the paper by Van Antwerpen *et al*. (In this issue).

The ***presentation*** by R. van Antwerpen stressed that the objective with conservation agriculture in rainfed annual crop production is to avoid losses of arable land while regenerating degraded land.

Soil erosion caused by human actions is the main form of soil/land degradation, as was identified already early in the 1900s (Cooper, 1996). The Soil Conservation Act No. 76 of 1969 was enacted to control soil erosion in South Africa. It specified that contour bunds had to be applied to all cultivated fields with slopes steeper than 2%, unless protected by perennial fodder crops (Cooper, 1996). These

were solely erosion correction measures and were not always successfully implemented. It was in 1983 replaced by the Conservation of Agricultural Resources Act No. 43 of 1983 (CARA). CARA involved government subsidies for varies types of soil conservation works. Its ability to curb soil erosion was disappointing, due to only 14 officials being appointed for the whole country and lack of efficient technical systems (Cook, 1996). In 2017 a new conservation act was drafted because CARA was deemed to be outdated and did not address the complexities of small-holder farming.

Soil erosion in cropland is aggravated by (i) bare soil; (ii) soil crusting/compaction; (iii) steep and/or long slopes. Bare soil areas can be reduced by keeping the soil surface permanently covered by a cover crop or mulch. In some areas a cover crop cannot be recommended, because it competes with the main crop for water. In annual cropping not enough material is produced for effective mulching. Standing stubble is more effective, but not adequate. In the sugar industry mulching is effective. Even where cane is burned about 7 tonnes of mulch is left per ha after harvesting, covering 70% of the area.

Soil crusting/compaction can be minimized by means of

- Reducing the mass (weight) of tractors and other vehicles that traverse fields.
- Controlled traffic.
- Reducing the number of tillage operations.
- Water harvesting.

The effects of steep and/or long slopes can be mitigated by means of water harvesting techniques and flow reducers. Flow reducers include

- Contour banks that have the correct width, depth, shape and slope to discharge excess water safely without causing erosion (Reinders et al., 2016).
- Strip cropping augments the efficiency of contour banks, for example on steep slopes in sugarcane fields. It also curbs wind erosion.
- Mulching.

Adoption of “Conservation Agriculture” (CA), consisting of the combination of no-till, soil cover and crop rotation is very poor in South Africa, with the following deemed to be the main reasons

- In small-scale farming areas there are competing uses for crop residues.
- Large-scale commercial farmers find it difficult to accept that crop farming can be done without cultivation.

Conclusions

- South Africa has the legislation and tools to combat soil erosion, but yet erosion is rife.

- CA (combination of no-till, soil cover and crop rotation) has been adopted by only a small number of farmers in South Africa. Do we understand what the problems are that prevent the others from adopting it?

Recommendations

- Create an umbrella CA organisation to promote CA among farmers from all enterprises. Maybe under umbrella of the Soil Science Society of South Africa.
- Publish CA outcomes in scientific papers ***and in popular media***. Take also into consideration that people are reading less and that other technologies, such as short video clips could be very effective.
- Train people who interact with farmers in regard to all aspects of CA.
- Make it clear that CA is not simply no-till linked to other cropping systems.
- Make it clear that no-till is important, but that it can be substituted with reduced tillage and rip on row.
- Take the circumstances and preferences of farmers into consideration when changes are promoted.

Feedback from the discussion group concentrated on how to improve on the slow adoption of conservation agriculture in South Africa, with special reference to CA (combination of no-till, soil cover and crop rotation). Farmers stick to what they know best since they cannot afford to take chances, because the risk is just too high. They will have to be convinced that it is economically viable to adopt CA practices. The problem is that the impacts of different CA practices are area (climate) and site (soil) specific and we do not know enough about their impacts in different agro-ecological regions of the country. We must know what works for us under our circumstances. More experiments and demonstrations are thus needed on different soils in different climatic areas to identify what works best in each case. Different CA systems must be compared so as to develop guidelines. There must then be knowledge flow to and exchange with farmers ***based on these area and site specific guidelines***. Further specific research recommendations are

- Research on runoff and erosion under no-till based CA practices and the need to combine it with contouring, rain water harvesting, etc.
- Research on how to change systematically from a system like contouring to full CA.
- Research on how to get enough organic matter in semi-arid areas. Cover crops are theoretically good sources, but how practical are they in such areas and how must they be managed? Keep in mind that fallow periods are required in such areas.

- Research on how to adapt existing farming implements to no-till practices in an inexpensive and easy way, since new specialised no-till implements are expensive and their cost may be prohibitive.

It is further recommended that so-called "permanent controlled traffic" should be implemented together with no-till where the latter is used in areas with high vulnerability to soil compaction. Attention should in all regards be given to both large-scale commercial farming and small-scale farming.

Conservation Agriculture in orchards and vineyards

In the ***presentation*** by P. Raath it was shown that conservation agriculture in orchards and vineyards in the Western Cape consists of the growing of winter cover crops.

The growing of a cover crop typically involves one mechanical cultivation for seedbed preparation in March/April, before the onset of the winter rains. This seedbed preparation is essential because of the thick mulch from the cover crop of the previous season. To maximise fibre production for the build-up of soil organic matter and biological weed control:

- A small amount of P is applied just before seedbed preparation.
- Seedbed preparation is done by cutting in the mulch from the previous season with a disc harrow. This is done about four weeks before the cover crop is sown, so as to avoid the development of a N negative period after the cover crop is sown.
- The cover crop is then sown with a planter.
- Small grain species need a top dressing of 28 kg N per ha at the two to six leaf stages.

Depending on the climate and the primary crop, the cover crop is controlled with post-emergence herbicides any time between late August and early October. Cover crops are rotated biennially to avoid build-up of pathogens for any specific species.

Cover crops were found to have several benefits, such as

- A large reduction in runoff and erosion. Total soil loss due to erosion during severe rainstorms from a Glenrosa soil at Nietvoorbij, Stellenbosch, was only 0.51 $t.ha^{-1}$ under a living cover crop and 0.026 $t.ha^{-1}$ under a 7.5 $t.ha^{-1}$ mulch, as opposed to 3.77 $t.ha^{-1}$ from the control. It, furthermore, prevented collapse of the topsoil structure.
- A large increase in the organic matter content of the top 30 cm of the soil. Under chemically controlled rye and Burr medics it more than doubled over a 10 year period (increases of 125

and 119% respectively). Under chemically controlled oats the increase was also high (65%). It was much less under chemically controlled weeds (27%) and almost nothing under mechanically controlled weeds (7%).

- Reduction in water consumption.
- Enhancing weed control. Five N-fixing broadleaf cover crops reduced the mass of winter weeds produced by the end of winter (August) over 10 years on average from 1.88 $t.ha^{-1}$ under the control to between 0.73 and 0.91 $t.ha^{-1}$. Small grain crops were ven more efficient, with rye reducing it to 0.45 $t.ha^{-1}$ and two types of oats to 0.06 and 0.13 $t.ha^{-1}$ respectively. Rye and oats with chemical control before bud break completely wiped out summer weeds in virtually all seasons. Chemical control in November was less effective.
- Bringing about very large increases the N content in grapevines.
- Increasing the yield of grapes and the quality of table grapes, giving higher incomes.

It is concluded that conservation agriculture is applied successfully in orchards and vineyards in the form of cover crops. Cover crops are most beneficial when grown as a full cover and controlled chemically before bud break.

Only partial ***Feedback*** from the discussion group was available. The main aims of CA in orchards and vineyards are

- To improve water use efficiency by preventing surface ponding of water subsurface waterlogging under irrigation. Emphasis on this was driven by the recent severe prolonged drought in the Western Cape.
- To improve weed control through cover crops.
- To increase the soil organic carbon content and improve soil quality through cover crops and thus increase profitability by increasing yields and improving fruit quality.

The question is whether minimum tillage should be part of the CA package or just cover crops, to some extent perhaps supported with mulching. Several aspects received attention around discussions on cover crops, including

- Should a cover crop be established as a full surface cover or just between the rows and not under the canopies also?
- In case of the latter, should crop residues or other organic materials, like wood chips, be brought in as mulch to cover the soil surface beneath the canopies?
- Should single species or multi-species cover crops be used? Which are the best species?

- Concern was expressed about the possibility that cover crops may produce too high soil organic matter contents that would lead to excessive nitrogen contents in the soil and that the latter could impact negatively on fruit quality. This would have to be studied.
- Disease and pest complexes in orchards under cover crops need to be studied. To what extent can cover crops help to combat certain pests or diseases and/or to what extent could cover crops enhance certain pests and / or diseases in fruit trees?
- It was noted that in some regions permanent perennial cover crops are grown in orchards or vineyards.

Attention was given to the role and impact of ridging in orchards and vineyards in relation to CA. Aspects that were highlighted, include

- Should ridging be done or not?
- Can ridging be matched with CA or does it counter CA?
- Concern was expressed about increased soil crusting, runoff and erosion due to ridging. The opinion was expressed that ridging makes it difficult to establish cover crops and that it makes mechanisation difficult.
- It was recommended that more integrated research regarding the interactions between ridging and CA should be conducted.

Conservation Agriculture in irrigated farming systems

This topic is further elaborated on in the article by De Clercq et al. (In Press).

The ***presentation*** by W. de Clercq highlighted the main problems confronting irrigated agriculture in South Africa. In most river catchments the largest problem is that the water demand is exceeding the water supply/availability. Thus, there is a need for improved water budgeting. The supply-demand imbalance is amplified by wasteful systems and lack of proper farm planning.

Deteriorating water quality is a concern. On the one hand, it is about the impact of poor quality irrigation water on crop productivity. On the other hand, it is about upstream pollution with human disease organisms and/or heavy metals, which impact negatively on the acceptability of export fruit on lucrative export markets. The latter is due to poor adherence to and enforcement of environmental and water laws.

The economic viability of irrigated agriculture is coming under increased pressure due to various reasons. High electricity costs are escalating pumping costs of irrigation water. Farm unrest is

enforcing introduction of expensive mechanised systems. It also escalates unemployment and consequential social and socio-economic problems.

Irrigated agriculture involves complex farming systems that are presently in stage of transition, iner alia due to government's small farmer development programmes. The question is whether the country has leaders who understand the total scope of the problems.

Understanding of conservation in irrigated agriculture requires understanding of the total system at farm, catchment and regional level. At farm level there is a need to match soil, slope and climate (the terroir concept in viticulture) and water with each crop. There is a need to match an irrigation system and soil in order to minimize soil degradation in the form of soil erosion and physical soil degradation (mainly crusting) in irrigated agriculture. Both these are increasing problems, especially in high value permanent crops. Over-irrigation and consequential waterlogging and salinization of soils are major problems. Pollution of soil from external sources is becoming an increasing serious problem in irrigated agriculture.

A strategy decision has to be made between a larger wetted soil volume or a smaller one (De Clercq et al., 2001). The former amounts to wetting the soil to greater depth with infrequent heavy irrigations. The latter involves wetting the soil to shallower depths with high frequency light irrigations. The former has the advantage of better (deeper) root development, which give better tree performance and survival during abnormally hot, dry spells, water restrictions or break down of irrigations systems. It is also easier to manage. It has the disadvantage of larger amounts of salts brought into the soil, less control over the salt load and bigger volumes of water needed during winter to leach out the salts. The latter has the advantage of less over-irrigation, smaller amounts of salts brought into the soil and better control over the salt load in the soil. It has the disadvantage of poor (shallow) roots systems, which make trees very vulnerable during abnormally hot, dry spells, water restrictions or break down of irrigation systems. It is especially a problem in the case of young trees, which have never developed decent root systems before such system was introduced and is especially a problem in mega-farms, where quick returns are needed. It requires more management inputs and is difficult to manage. A case study in the Breede River catchment showed that in precision irrigation there is heavy dependence on probes and that farmers are only interested in adopting a new technology if it is linked to a probe and not time-consuming.

Water quality guidelines are required for a large range of water quality factors (De Clercq et al., 2001).

Concluding remarks:

- Farmers are needed who will produce more with less water.

- The irrigation community will have to adapt or die.
- Soil scientists need to enhance the decision base for farmers – closing the gap between measurement and application.
- Systems with lower environmental impact have to be designed.

The ***feedback*** report from the group discussion showed that a wider field was covered during the deliberations than in the presentation.

Irrigated farms and irrigation farming are not cheap. Irrigation provides better opportunities to manage a farm than under rainfed conditions. Thus the economics of applying the CA concept in irrigated agriculture need to be considered relative to other systems.

Crop diversification and crop rotation is one of the three legs of CA. Irrigation provides opportunities for more crop diversification, because a wider variety of crops, such as onions, potatoes and groundnuts, can be grown. Quick rotations are often possible. Rotation of a cash crop with a cover crop is also possible. In the Western Cape three years of potatoes rotated with 3-4 years under a perennial pasture cover crop utilised for dairy production was found to be very profitable. However rotation of potatoes with other crops was limited by water restrictions that made it possible to utilise only one out of four fields, for example, at a time. In the Northern Cape 3-4 years under Lucerne was found to be a very good cover crop.

A residue cover is the second leg of CA. Irrigated agriculture is a very productive system that produces a large amount of crop residues under CA. The residues reduce non-beneficial water loss through evaporation form the surface soil. This could mean a reduction in the amount of water used for irrigation. The feedback asked the question: *"If irrigation used 60% of our blue water and we could reduce it by 20% it could have major implications?"* (Note by the author: The statement that agriculture uses 60% of the country's blue water is a commonly made misrepresentation of the statistics in the National Water Resource Strategy (DWAF, 2004). In NWRS it is stated that in 2000 all sectors together used 12 000 million m^3 of South Africa's 20 000 million m^3 blue water. Agriculture used 78 000 million m^3 of this, in other words 61% of the water that was used by all sectors in 2000, or 39.5% of the available blue water. Of course, a big saving in the amount of water used by agriculture would be highly beneficial to the country. Reduction in the amount of water used, will also mean a reduction in the use of electricity for pumping, which is a form of conservation. It will also mean lower input costs for the farmer.

On the other hand, the wetter topsoil conditions under a thick mulch can have negative impacts on the nitrogen balances in the soil through:

- Higher denitrification due to anaerobic conditions.
- Higher N volatilization from urea due to higher urease activity.
- Higher leaching losses of N due to more deep drainage of water.

Reduced tillage (no-till) is the third leg of CA. Soil compaction is one of the main problems under no-till, the severity of which depends on the soil type. Even under no-till there is a lot of in-field traffic. Some crops in a rotation may need intensive tillage. Movement towards precision agriculture, for example through controlled traffic, could be advantageous. Deep rip before no-till is essential.

Irrigation scheduling needs to be adapted where there is a big residue cover. In the sugar industry over-irrigation occurred where models were used. In the Northern Cape, infiltration was increased where maize was planted directly into wheat stubble. Satellite imagery could be used to improve irrigation.

The design and planning of irrigation systems depend on soil type, water quality and whether drainage is needed or not. In sugarcane the selected irrigation system interacts with farming systems and equipment used. It may require a big change in equipment, which can have huge capital input implications. It can interfere with controlled traffic. Furrow irrigation limits traffic mobility. Drip irrigation has implications for sugarcane transport rigs, which have wide turning circles. It has interactions with problems like weeds in the wetted zone and termites in the dry zone. In citrus drip irrigation allows fertigation and precision application of nutrients.

The following knowledge and research gaps regarding CA in irrigated agriculture were identified:

- What can the irrigator do to bring in CA? Taking into consideration that bringing in crop rotation could mean disturbing the soil more often. How to handle the large amount of infield traffic.
- Is CA in irrigated agriculture sustainable? Is intensification sustainable? Keep in mind that CA is one component of intensification.
- The uncertainties on how to better manage the CA system should be addressed.
- The problem of increased disease pressure, especially in wetter systems, should be addressed.
- Reducing the environmental footprint through increasing production should receive attention.
- The management of solutes should receive attention.
- Use of remote sensing and linking up of technologies should receive attention.
- The fact that there was no agricultural economist present was identified as a weakness, since the economics of CA in irrigated agriculture should receive attention.

- The extent of adoption of CA in irrigated agriculture in South Africa should be determined
- A ***good review*** of CA in irrigated agriculture is urgently needed.

Soil fertility management in Conservation Agriculture

This topic is further elaborated in the paper by Nortjé & Laker (In Press).

The ***presentation*** by G. Nortjé pointed out that in South Africa grain production systems based on continuous intensive soil tillage has caused extreme soil degradation, leading to a decline in soil fertility. This has led to excessive fertiliser applications that are biologically unnecessary, economically non-viable and environmentally harmful. One of the *"Good Agricultural Practices"* (GAP) associated with conservation agriculture (CA) is *"integrated soil fertility management"*, which essentially depends on locally adapted CA principles and practices to improve soil health, allowing producers to reduce the use of fertilisers, while sustaining good and stable yields and increasing profitability.

The basic objective of CA should be to prevent and resolve all forms of soil degradation, including degradation of soils' fertility status due to unsustainable management practices. It is important to bring the soil into an optimum chemical/fertility state and maintaining it. Determination of the optimum status for specific fertility factors should be based on experimental data obtained from field experiments ad backed up by science. Unfortunately there is not much experimental data under CA systems in South Africa.

According to GrainSA (2016) the focus of CA is soil biology, which drives soil chemistry and soil physics. Once soil biology functions properly, it positively influences and restores soil chemistry and soil physics over the medium to long term. Healthier soils release more nutrients and fertiliser applications could be reduced. In the short term, an integrated biological-chemical soil fertility strategy should be used. Beukes et al. (2011) found that CA practices increased soil organic C and N by 164% and 108% respectively, compared with conventional tillage.

On the other hand there is serious concern about the strong stratification of plant nutrients very close to the soil surface under no-till based CA, even as shallow as the top 2-3 cm (Thibaud, 2000). It has especially been found that P does not move in soils, not even in sandy soils (e.g. Laker, 1964). Since shallow soil layers dry out quickly uptake of nutrients from them is poor. This may mean that higher fertiliser applications may actually be needed under such system.

Cognizance should be taken of various perceptions versus actual facts, experiences and trends, as well as concerns regarding soil fertility in South Africa, so as to take these into consideration when CA practices are introduced. Main points regarding the three primary macronutrients include:

- There are concerns about possible excessive ***N*** recommendations, combined with too high planting densities, in marginal maize cropping areas. There are concerns that the N guidelines in the latest fertilizer guidelines of FERTASA (2016) are possibly too high, especially for maize. Thibaud found in KwaZulu-Natal and experiments in the USA that maize under no-till requires much higher N applications than are required for optimum yields under conventional tillage, reaching the same yield as under conventional tillage only at an N application of 180 $kg.ha^{-1}$.
- There seems to be a perception that ***P*** levels in South African croplands have generally been built up to adequate levels and that excessive P applications are done widespread. Surveys have shown that the latter is partially true, but does not represent the complete picture (Laker, 2008). In two areas in Northwest province quite high proportions of maize fields had Bray-1 P levels in the excessive (30-49 $mg.kg^{-1}$) and harmful (>50 $mg.kg^{-1}$) ranges, the combined proportions for the two being 17-18% in one region and 28% in the other. These remained the same after an 18 year period but there were significant shifts towards more samples in the harmful range. This indicates that farmers who were over fertilizing with P continued to do so, creating more problems, since it has been proven that yield reductions can be expected at Bray-1 P levels >50 $mg.kg^{-1}$. On the other hand, alarmingly high proportions of the maize fields had deficient Bray-1 P levels and these increased over the 18-year period – from 26% to 33% in one region and from 24% to 32% in the other. The increase was due to more samples dropping out of the adequate range (10-29 $mg.kg^{-1}$). This could be related to
- The finding that there was a general decline in fertilizer applications during that period due to a lack of cash to invest in soil as a result of a persistent drought (Van der Merwe et al., 2001).

  High soil P levels and/or heavy P applications, have serious negative impacts on the micro-nutrient nutrition of crops. This was in the early 1960s identified as one of the two main causes of the severe zinc deficiencies in maize in the Highveld, especially on the sandy soils of the northwestern Free State (Laker, 1964, 2008). More recently extremely high soil P levels and highly excessive P applications were identified as the main cause of the devastating iron deficiencies in macadamia nut orchards in Limpopo and Mpumalanga provinces. Whereas Bray-1 P levels of >50 $mg.kg^{-1}$ have been found to be harmful, the problem orchards have Bray-1 P levels of >100 $mg.kg^{-1}$ and up to as high as 400 $mg.kg^{-1}$. These high P levels are not caused by heavy application of chemical fertilisers, but by high applications of dairy manure or

compost with 50-70% of such manure in it. This was also proven in a field experiment where such compost was applied to improve the soil health of the soil, but the trees virtually died of Fe deficiencies where it was applied. This was also found to cause serious Fe deficiencies in avocados in the same provinces. Like dairy manure, chicken manure also contains high P levels. Serious problems due to highly excessive soil P levels as a result of heavy applications of chicken manure have been found in vegetables, e.g. in KwaZulu-Natal.

There is still uncertainty about what the best extraction procedure is for the determination of plant-available soil P. There are very big controversies regarding what the optimum soil P levels are for crops, especially maize. The latter has to be sorted out very urgently.

- Potassium (K) has received much less attention than N and P. It should receive more attention and the K levels in cropped soils should be monitored carefully (Laker, 2008).

Among the other macro-nutrients (Ca, Mg, S), there is concern about the increasing incidence in S deficiencies, especially in a crop like avocado.

Deficiencies of various micro-nutrients are found in various crops on various soils in different parts of South Africa, as reviewed by Van der Waals & Laker (2008). Most widespread of these is zinc deficiencies. Globally Zn is the plant nutrient with the second most widespread occurrence in virgin soils, after P. This is also the case in South Africa. It is in South Africa most widespread and serious (i) in maize, a crop that is very sensitive to zinc deficiencies, (ii) on sandy soils, (iii) in soils with high P levels or where high P applications are made and (iv) in soils with relatively high pH, both naturally or due to injudicious liming. Observations in maize fields on sandy soils in the north-western Free State revealed that Zn deficiencies are found where the pH (H_2O) is higher than 5.5, i.e. at pH (KCl) higher than 4.5. This was then confirmed in experiments (Laker, 1964). Zinc deficiency is also a problem in avocados, especially in calcareous and sandy soils (Crowley *et al*., 1994).

The very high sensitivity of macadamias to Fe deficiencies has been mentioned, as well as the impact of high soil P levels on it. pH is also an important factor in Fe deficiencies n macadamias. The pH (H_2O) of the soil should not be higher than 5.5-6.0, i.e. the pH (KCl) not higher than 4.5-5.0. It is commonly found that the problem orchards have been limed to a pH (KCl) of about 6.5, which is far too high. Serious Fe deficiencies have also been found in macadamia orchards in Mpumalanga where these have been established on soils with serious compaction that have been cropped to tobacco before. Fe deficiency problems in avocado, associated with high soil P levels, have been mentioned.

Soil pH is the most dominant factor in soil fertility, since it controls the plant-availability of nutrients, as seen in the previous discussions. It also controls other factors. Strongly acidic (low pH) soils have

problems like Al toxicity and low levels of basic cation nutrients (Ca, Mg, K). Al is toxic to plant roots, reducing their growth, activity and health, thus leading to poor nutrient and water uptake (Raath et al 2018). Accurate calculation of the lime requirement before and orchard is established, is for three reasons important:

- Healthy roots can develop only in a soil with optimum pH.
- Soil cannot be limed after an orchard has been established.
- The optimum pH for nutrient availability has a very narrow range.

Concluding remarks

- Clarity is needed regarding trends in soil P levels in different soils under different crops and farming systems and the reasons for these trends.
- Clarity is needed on soil P norms for different crops on different soils.
- Clear recommendations are needed regarding N fertilization guidelines.
- K should receive attention.
- Clarity is needed regarding the reasons for the increased incidence of S deficiencies, especially in avocado.
- A better understanding of Zn deficiencies and the factors controlling them is needed. The strong Zn-Cu antagonism that was identified long ago should receive renewed attention.
- The impacts of physical soil degradation (Crusting, compaction) should be determined for more nutrients.
- More clarity is required regarding the impacts of high soil acidity (low pH) and the reasons for the inadequate lime applications made in South Africa. Clarity is needed regarding the optimum pH, especially pH (KCl), for nutrient availability and uptake.

In this case, the full ***feedback*** document was also not available, only partial feedback. It was emphasized that the main objective is to prevent and solve all forms of soil degradation. These include degradation of soil fertility due to poor soil fertility management.

Soil organic matter builds up under CA and this makes contributions towards improving soil fertility. Increased soil microbial activity also enhances plant-availability of nutrients in the soil. These promote recycling of nutrients in the soil.

On the other hand, strong stratification of plant nutrients very close to the soil surface under no-till is a concern. Information on movement of plant nutrients in soils under no-till is required, especially for relatively clayey soils. Likewise, information on the movement of lime in soils under no-till is required, especially on how to apply lime to overcome subsoil acidity.

Fertilizer guidelines were developed under conventional tillage situations. Different guidelines and new norms may be required for no-till based CA. Where (on the row or between rows) and at what depths should soil samples be taken under no-till? Maybe new extraction methods are required. Analyses should include analyses of soil biology and not only chemical analyses.

Attention should be given to possible "toxicities" of certain nutrients at excessive levels. Problems of excessive soil P levels, leading to induced deficiencies of various micro-nutrients, are a concern. The P guidelines that were used were questioned. Micro-nutrient deficiencies and toxicities need attention.

Clear guidelines are required regarding which pH levels are considered to be too low or too high, especially for pH (KCl) values.

Concluding remarks from final plenary discussion session

Three very strong statements formed the concluding remarks for the workshop:

- People promoting Ca should not become activists that advocate things for which there is no ground. All expressed views and recommendations must be based on sound scientific principles and data obtained by good research.
- Blanket recommendations cannot work. CA is site/area/region specific and recommendations must be tailored to the requirements of a specific site.
- Good observation is good science. Good observation provides the background on which to plan good, useful research.

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