DEPARTMENT OF
PLANT SCIENCES

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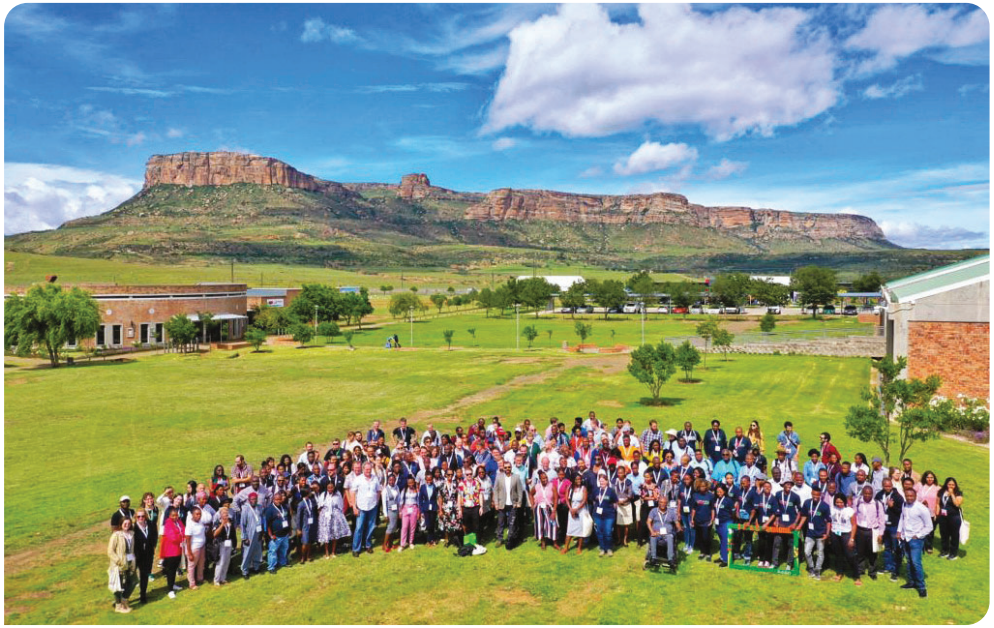
OVERVIEW OF 2020

The Department of Plant Sciences is a dynamic department contributing towards research, teaching and learning, community service and entrepreneurial development. The Department has three divisions – Botany (both Bloemfontein and Qwaqwa campuses), Plant Breeding and Plant Pathology. Due to COVID-19, 2020 was a difficult and challenging year for the Department, as surely is the case for all departments in the Faculty and the University. In spite of these challenging circumstances, Plant Sciences excelled in their teaching and learning approach and in the number of articles published and submitted during 2020. The Department also adapted to online meetings, postgraduate research proposals, and honours seminar days that included staff and students from both the Bloemfontein and Qwaqwa campuses. During 2020, 10 honours, 12 master's and 11 doctoral students obtained their degrees.

The Department of Plant Sciences on the Qwaqwa Campus started the year off on a high note by hosting the 46th Annual Conference of the South African Association of Botanists (SAAB 2020) from 7 to 10 January. Over 220 delegates representing 12 different nationalities attended. Delegates from the University of Pretoria commended the Local Organising Committee, saying that the "conference was very well organised and proved to be fantastic exposure for us to the excellent facilities and talented staff based on the Qwaqwa Campus", and that "it was one of the better SAAB meetings in recent years".



Delegates at the SAAB 2020 Conference, Qwaqwa Campus (7-10 January 2020)

ACHIEVEMENTS

Staff Achievements

The SARChI Research Chair in Disease Resistance and Quality in Field Crops, headed by Prof Maryke Labuschagne, has been renewed for another five years (2021-2025).

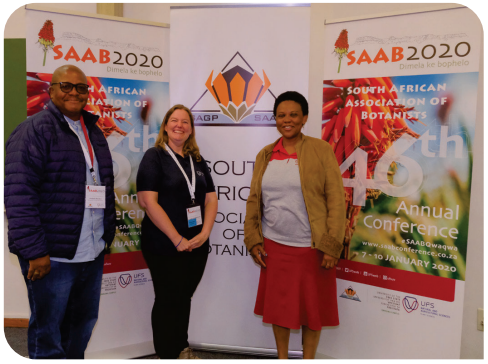
Dr Willem Boshoff, Prof Botma Visser and Prof Zakkie Pretorius won the prize for the best article, titled 'Hawerstamroes - Neem ingeligte besluite oor vatbaarheid van kultivars', in the January/February 2020 edition of *Wheat Focus*. The three researchers also won a prize for the best article '*Berberis* – 'n onbekende faktor in die stryd teen stam- en geelroes van koring in Suid-Afrika' in the March/April 2020 edition of *Wheat Focus*, and Dr Boshoff, Dr Cornel Bender and Prof Pretorius won the prize for the best article, titled 'Die voorkoms van roeswamme op rog, triticale en gars', in the May/June 2020 edition of *Wheat Focus*.

Prof Zakkie Pretorius, Research Fellow in the Department, was nominated for the 2019/2020 National Science and Technology Forum (NSTF)-South32 Awards. He was nominated in two categories, namely the 'Special Annual Theme Award: Research and Development (R&D) and Innovation in Plant Health', as well as in the 'Lifetime Category'. The Special Annual Theme Awards were made in recognition of the International Year of Plant Health (2020), declared by the United Nations (UN).

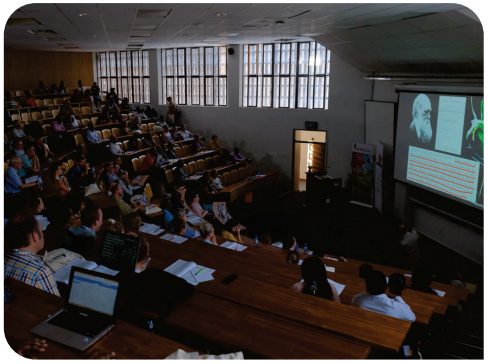
During the 13th Southern African Plant Breeders' Association (SAPBA) biennial conference held at the Future Africa Campus of the University of Pretoria from 8 to 11 March 2020, Prof Zakkie Pretorius received an Honorary Membership and Prof Liezel Herselman a Fellow Award in recognition of their services to and promotion of the objectives of the SAPBA and exceptional achievements / contributions to Plant Breeding. Dr Angeline van Biljon was elected to serve on the SAPBA executive committee for the next two years.

Prof Louis Scott was appointed as a member of the editorial board of the Elsevier journal *Quaternary Science Reviews*.

Dr Sandy-Lynn Steenhuisen served as chairperson for the local organising committee that successfully hosted the 46th Annual Conference of SAAB. Four exemplary plenary speakers were part of the conference programme – Prof Annah Moteetee (University of Johannesburg, South Africa), Prof Peter Linder (University of Zurich, Switzerland), Prof Felipe W Amorim (Institute of Biosciences, São Paulo State University [UNESP], Brazil), and the winner of the Best Young Botanist award at SAAB 2019, Mr Ryan Rattray (Genelethu, South Africa). The week culminated in a rather wet but enjoyable exploration of the Afromontane flora on the slopes of Sentinel Peak in the Maloti-Drakensberg.



Dr Martin Mandew, Qwaqwa Campus Principal, Dr Sandy Steenhuisen, Chairperson of the SAAB 2020 Local Organising Committee, and Prof Pearl Sithole, Qwaqwa Campus Vice-Principal: Academic and Research at SAAB 2020 (7 to 10 January)



Prof Felipe Amorim presenting the plenary lecture at SAAB 2020 (7 to 10 January)

Dr Steenhuisen was selected for the Department of Higher Education and Training (DHET) Future Professors Programme from the start of 2020. She was also appointed as an associate editor of the *American Journal of Botany* from August 2020.

Dr Cornél Bender, a Chief Officer: Professional Services in the Department, received her PhD in Plant Pathology.

Dr Lisa Rothmann (Lecturer – Units) was appointed as an Early Career Assistant Editor of *Phytopathology*.

Student Achievements

A number of students from Plant Breeding won prizes from SAPBA. Jenna Vos received the award for best second-year student in Plant Breeding, Charnè Viviers for best third-year student in Plant Breeding, and Robert Coertzen for the best fourth-year student in Plant Breeding, while Tondani Mishasha won the prize for best MSc student in Plant Breeding and Dr Ntombokulunga Mbuma won the prize for best PhD student in Plant Breeding.

Botany students who were awarded prizes at the Faculty's prize-giving function were Jo Cobbold, Carlo Visser and Emma Ferreira, who received Botanical Society of South Africa (Free State Branch) prizes for the best second-year, third-year and honours students in Botany, respectively.

Emma Ferreira conducting a vegetation survey in the Bokkeveld Plateau

In Plant Pathology, Lineo Maphobole received the incentive prize for Plant Pathology and Habofanoe Fosa received the award for the best final-year student in Plant Pathology.

Ms Sellwane Moloi, a PhD student of Dr Rudo Ngara, won the best poster prize in Plant Physiology at the SAAB Conference held at the Qwaqwa Campus in January 2020.

TEACHING AND LEARNING

Dr Boshoff presented an invited lecture titled 'Stem rust in wheat – the Southern African perspective' as part of an online seminar to MSc students taking the course Plant Breeding and Protection for Sustainable Production (BI1296) in the Department of Plant Protection Biology at the Swedish University of Agricultural Sciences. As part of the same online seminar, Dr Angeline van Biljon presented an invited lecture titled 'Nutritional improvement through biofortification'.

From 31 January to 7 February 2020 Dr Lize Joubert and Dr Andri van Aardt led the BTNY3712 excursion to Hogsback in the Eastern Cape. During the excursion, the third-year Botany students were trained in several vegetation survey, plant identification, research and specimen collection techniques.

Students surveying forest vegetation at Hogsback in February 2020, from the left, Justin Giddy, Jo Cobbold, Jaydon Dyers and Kirsten Nienaber

Students surveying fynbos vegetation at Hogsback in February 2020

After the practical fieldwork at Hogsback was completed, students were trained in scientific communication in the form of poster and oral presentations and written scientific reports. A total of 39 students successfully completed the module.

The new Zeiss Digital Classroom in Biology Lab 28, consisting of 60 iPads, 60 digital microscopes, 60 normal compound microscopes and a new audio-visual system, was used for the first time to train second-year Botany students in BTNY2616. The Digital Classroom promotes active student participation in class projects designed to teach skills in light microscopy, gathering, analysing and reporting data. The training using the Digital Classroom was very successful and more practicals will be designed around this system in future.

Amid the COVID-19 lockdown and restrictions, eco-physiology second-year students (BTNY2622) successfully completed a virtual online 'field excursion' under the supervision of Dr Gerhard Potgieter and Dr Makoena Moloi. Students were virtually introduced to the adaptations in different plants to grow and survive in the harsh Free State environment. Working interactively in online groups, they mastered the principles and data analyses of the techniques used to measure chlorophyll content and photosynthetic rate in plants under different environmental conditions.

Amid the COVID-19 pandemic, all lecturers successfully converted their lecturing material to support a blended approach to teaching. Everyone embraced new technologies to ensure the success of their students.

RESEARCH AND INNOVATION

SARChI Research Chair in Disease Resistance and Quality of Field Crops

The Research Chair completed a very successful first five-year cycle in 2020. The Chair has received funding for the next five-year cycle, and the team is excited about new projects commencing, and continued research on projects from the previous cycle.

In terms of research on quality in field crops, in 2020 three PhD students completed their degrees. One focused on possible yield reduction due to the presence of the quality protein maize (QPM) trait, which doubles the amount of the essential amino acids, lysine and tryptophan. A second thesis was on the introduction of foreign germplasm as a way to enhance wheat breeding in South Africa, and a third was on the improvement of acid soil tolerance in maize in Angola. Fourteen papers were published in accredited journals and four book chapters were published – three in crop quality and one in quantitative genetics as applied to drought resistance breeding in maize. Seven papers were presented at a national conference and one (a keynote presentation) at an international conference.

Research on quality of field crops was largely done in collaboration with the Consortium of International Agricultural Research Centres (CGIAR), specifically the International Maize and Wheat Improvement Centre (CIMMYT) in Kenya, Zimbabwe and Mexico, and the International Institute for Tropical Agriculture in Nigeria. The University of Cordoba in Spain was an important research partner on wheat quality. The main focus was on crop biofortification for iron, zinc, provitamin A, and lysine and tryptophan, especially under abiotic stress conditions, as well as gluten protein and quality of wheat under heat and drought stress.

In terms of research on disease resistance, two MSc students completed their dissertations on rust resistance breeding (both *cum laude*) and three PhD theses were completed on rust resistance breeding. Ten accredited papers were published on disease resistance in field crops, with a focus on wheat. Nine papers were published in the popular press, of which one (authored by Prof Boshoff) was awarded best paper in *Koring Fokus*.

As in the past, the disease resistance research was highly collaborative. International and local collaboration led to the following noteworthy achievements:

- The research of Dr Jianping Zhang at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Canberra, Australia resulted in the cloning of two broadly effective stem rust resistance genes, *Sr26* and *Sr61*. Dr

Zhang completed a significant part of her work at UFS where Prof Pretorius and Dr Boshoff helped with rust phenotyping. This research has been submitted to a high impact journal and has been accepted pending revision.

- Research by Dr Hongwei Li from the Institute of Genetics and Developmental Biology of the Chinese Academy of Sciences, resulted in the establishment of wheat-*Thinopyrum ponticum* translocation lines, carrying a new source of resistance to stem rust. A paper from this research has been submitted to a high impact journal.
- Prof Botma Visser, Dr Howard Castelyn and MSc student Mr Wilku Meyer attended the BHC-Bioinformatics-Wheat-Genomics-III workshop. The workshop was sponsored by the British High Commission and the United Kingdom (UK) Science and Innovation Network. It provided hands-on training in bioinformatics, wheat genomics and sequencing technologies and was presented by Dr Burkhard Steuernagel (John Innes Centre, UK), Dr Robert Davey (Earlham Institute, UK) and Dr Diane Saunders (John Innes Centre, UK).

Botany: Plant physiology/biochemistry and molecular biology

Dr Gerhard Potgieter was involved in the evaluation of the bio-stimulant properties of certain secondary molecules isolated from various plant and animal sources. The use of these bio-stimulants, in addition to traditional agricultural practices, is to improve yield and quality of crops in existing cultivation areas. The research collaboration between Dr Potgieter (Eco-physiology) and Introlab (SA) continued during 2020. The bio-stimulant properties of Xcell Boost on different crops under certain stress conditions were evaluated.

Dr Potgieter was also involved in developing new approaches in vegetation management, identification of alien plant species and management of crop health using drone technology. These include Normalised Difference Vegetation Index (NDVI) data for plant health monitoring and red-green-blue (RGB) photography in identifying plants through remote sensing. Dr Potgieter collaborated with Dr Andri van Aardt using the unique colour- and form signatures of plants to describe a protocol to identify different plants from drone aerial footage. This will aid in vegetation surveys and management of alien plant invasions, especially in areas that are difficult to access. An MSc dissertation by Mawethu Ndiki titled 'Evaluating colour and form signature to identify invasive alien plant species' was submitted during December 2020 (co-supervisor Dr Van Aardt).

Prof Botma Visser collaborated with Dr Boshoff from Plant Pathology to genotype cereal rust species. During 2020, leaf rust of oat, barley, and wheat were genotyped. Prof Visser is also investigating a new potential fungicide that could control stripe rust of wheat.

Dr Lintle Mohase and her research team continued their research on plant-defence mechanisms in wheat during aphid, *Duiraphis noxia*, (and rust), infestations. She collaborated with a pathologist (Dr Boshoff) from the UFS, an entomologist at the Agricultural Research Council Small Grain (ARC-SG), Bethlehem (Dr Astrid Jankielsohn) and the Lesotho Agricultural Research Unit (wheat germplasm in Lesotho). Her research concentrates on aphid distribution in wheat-producing regions of South Africa and Lesotho, the impact of aphid infestations on yield and quality, mechanisms of host resistance, the impact of drought stress on plant responses to aphids, as well as the effect of commercial plant activators on crop protection against the aphid.

Dr Makoena Moloi's research is on plant-environment interactions – particularly abiotic stress physiology and ecophysiology. The current research involves the physiological, biochemical and morphological responses of edamame and cowpea to drought and high temperature stress. The research team is in the process of running the first drought trial. Another project involves the use of biostimulants/biofertilisers to mitigate drought stress in plants. They discovered that kelp and fish protein hydrolysate-derived biostimulant (Xcell Boost) enhanced the photosynthetic capacity of edamame when applied at higher concentrations. They also found that application of selenium improved the biochemical responses of edamame under drought stress. Further tests on Xcell Boost will be undertaken in 2021 to establish the best application method, as well as the effect of biostimulants on the yield and nutritional content of edamame.

Dr Rudo Ngara concluded her Royal Society and National Research Foundation (NRF) Thuthuka grants in November and December 2020, respectively. She continued with her research on investigating the complex responses of cereal crops, such as sorghum, wheat and maize, to a range of abiotic stress factors.

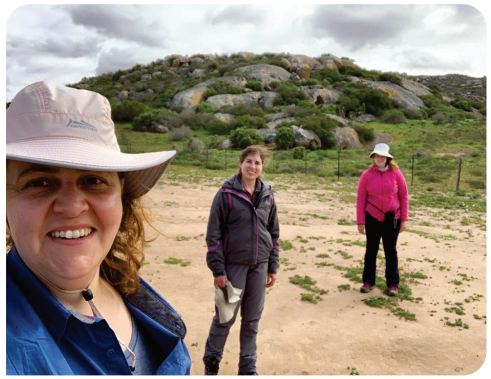
Dr Mpho Mafa's research is focused on plant cell-wall components, such as glycoside hydrolases (GHs), that are classified into different families based on their amino acid sequence and three-dimensional structural similarities in the Carbohydrate-Active Enzymes database (CAZymes: http://www.cazy.org). One of his research interests is to use these CAZymes to produce a value-added chemical that can be applied to induce plant immune responses against pathogens. They include oligosaccharides that are also known as Damage Associated Molecular Patterns (DAMPs). Dr Mafa also plans to investigate the defence role of the plant cell wall against South African biotypes of Russian wheat aphids. He is investigating whether there is a difference in the salivary proteins (with a specific focus to CAZymes) for the approximate five biotypes present in South Africa.

Botany: Phytomedicine and ethnobotany

Postgraduate students are working with Dr Pheello Mojau on the antimicrobial and antimycobacterial activities of *Populus x canescens* bark and leaves, *Acokanthera oblongifolia* stem and leaves, and *Dioscorea sylvatica* roots.

Botany: Plant taxonomy and molecular systematics

Dr Lize Joubert is leading a project titled 'The role of flower structure in the diversification of the genus *Nemesia* (Scrophulariaceae)' with Dr Mariëtte Jackson and Dr Andri van Aardt. This project explores the intersection between the fields of plant systematics, ecology, pollination biology, and evolutionary development to gain a better understanding of the origins of South Africa's most diverse plant groups. The study specifically focuses on the phylogenetic and taxonomic relationships between the ±77 *Nemesia* species that are endemic to southern Africa, and how a combination of ecological factors, floral key innovations, and interaction with pollinators has led to the diversification of the genus. Two MSc students and one BSc Honours student are being trained in this research project. Fieldwork was conducted in the Free State, Northern Cape and Western Cape, during which plant specimens, samples for molecular phylogenetic analysis, pollinator-, vegetation- and soil data were collected under the supervision of Dr Joubert and Dr Van Aardt.



Dr Andri van Aardt, Dr Lize Joubert and Ms Emma Ferreira collecting Nemesia in the Namaqualand klipkoppe

Pieter Bester, a collaborator on this project from the South African National Biodiversity Institute (SANBI), identified one of the collected specimens as a species new to science. The description of the new species will be published with a full taxonomic revision of the genus as part of the project outputs. All specimens collected were phylogenetically analysed under the supervision of Dr Jackson. With over half of the known species in the genus now included in the molecular phylogeny, this will form the basis for further expansion of the project to include detailed comparisons between closely related species.

The as yet undescribed Nemesia species from the Northern Cape

Dr Mariëtte Jackson leads the Molecular Systematics Research group. Various genera within the family Asteraceae are being studied to assess the phylogenetic relationships among these genera. A new field of research has begun which analyses fossil soil sediments from the fossil pollen collection of Prof Louis Scott, to obtain ancient DNA that can be used within phylogenetic studies.

Dr Jackson is also involved in a Plant Pathology MSc project in which fungi in sorghum kernels are being identified with molecular techniques. Dr Jackson also collaborates with Dr Joubert on the *Nemesia* project.

Botany: Palaeo-botany and ecology

Dr Andri van Aardt's research interest is in modern- and palaeoecology, studying sites such as Florisbad and Colbyn in terms of their palaeo-environments. This research is done in collaboration with several South African colleagues. In addition, she is working on a manuscript describing pollen morphology of *Acacia* species in collaboration with South African and International colleagues. A student is also investigating surface pollen and phytolith samples from transects in South Africa. Several of her students are busy with research on modern vegetation associations in the Golden Gate Highlands National Park (GGHNP), various national parks in the Eastern Cape, and areas surrounding Bloemfontein. She is also collaborating with Dr Joubert on the *Nemesia* project.

Prof Louis Scott collaborated in archaeological projects in Israel, from which two articles were published. He also submitted a manuscript for publication on the Pleistocene and Holocene past environmental research in the central interior, that appeared online during 2020 but will form part of a Special Issue of *Quaternary International*. This 2021 volume includes a paper in collaboration with Canadian colleagues on the environmental history at Kathu Pan in the Northern Cape. He also made progress with studies on fossil hyrax dung from Namibia and the environmental history of alluvial deposits in the Little Karoo.

Dr Sandy Steenhuisen on the Qwaqwa Campus undertook collaborative research on the use of sound recordings for assessing the biodiversity of birds in wetlands of the GGHNP in partnership with BirdLifeSA, the Afromontane Research Unit (ARU) and the Department of Zoology and Entomology on the Qwaqwa Campus. The Centre for Biological Control (CBC) at Rhodes University has again been an integral partner of the ARU and Dr Steenhuisen's research group, contributing supervision and expertise for research projects on the ecology of invasive species in the eastern Free Sate. For the first time for the ARU and Dr Steenhuisen's research group, SANBI was heavily involved in funding projects in the Department and training postgraduates in generating risk analysis reports of their study species, as part of the mandate of SANBI.

Plant Breeding: Molecular plant breeding

Prof Liezel Herselman's research continued to focus on marker-assisted disease resistance breeding, focusing specifically on rust resistance (stem, stripe, and leaf rust) and Fusarium head-blight (FHB) in wheat. A potential new source of stem rust resistance in two durum derived wheat lines was characterised and mapped in the same region as the stem rust resistance gene *Sr13*. Future work will focus on determining whether it is *Sr13* or another gene closely linked to *Sr13*. As part of the global efforts to develop wheat cultivars with durable wheat stem rust resistance, molecular marker analysis identified a considerable number of Ethiopian synthetic and elite wheat lines carrying economically important seedling and adult plant stem rust resistance genes. A genome-wide association study identified genetic regions linked to resistance against individual and multiple stem rust races, including novel regions associated with resistance to various

virulent stem rust races. These identified gene regions could play an important role in marker-assisted breeding for stem rust resistance.

Dr Adrè Minnaar-Ontong's research focused on breeding for resistance against fungal diseases across multiple crops with specialisation on resistance breeding against *Sclerotinia sclerotiorum* diseases in both sunflower and soybean. South African sunflower and soybean cultivars were evaluated for resistance to sclerotinia diseases to promote the improvement of disease control strategies. This research is funded by the NRF-Thuthuka (2019-2021) as well as GrainSA, and forms part of the South African Sclerotinia Research Network (SASRN) established in 2017. SASRN funds the maintenance of a *Sclerotinia sclerotiorum* culture collection, derived from a population genetics study on >1 000 isolates collected from eight of the nine South African provinces across multiple crops. This research was driven by Dr Minnaar-Ontong and her team (Dr Chrisna Steyn, postgraduate students and collaborators). A part of the population genetic study was completed as an MSc study in 2020, but will continue.

Another focal point in Dr Minnaar-Ontong's research includes the identification and characterisation of the *Fusarium* species responsible for sudden death syndrome (SDS) in South Africa, as well as the genetic analysis of soybean resistance against this pathogen. *Fusarium virguliforme* was identified and concluded as the causal species of SDS as part of an MSc study that was successfully completed in 2020. The outcome of this project contributed to the initiation of an SDS pre-breeding programme that started with the evaluation of commercial soybean cultivars for resistance. This research will contribute signficantly to soybean production of South Africa.

Dr Ansori Maré collaborated with Dr Boshoff (Plant Pathology) to identify new rust resistance sources in wheat using molecular markers and phenotypic evaluations to evaluate mapping populations. Selected wheat cultivars and lines from three different breeding backgrounds were identified to contain unknown rust resistance. The three breeding backgrounds included the CIMMYT rust resistance nursery, Morden Research and Development Centre – Agriculture and Agri-Food Canada and CM-82036/Avocet S. This research is funded by the NRF-Thuthuka and Winter Cereal Trust. Progress has also been made with cross breeding and molecular markers to enhance rust and FHB resistant wheat lines with additional resistance genes to ensure durable resistance in wheat.

Plant Breeding: Conventional breeding

Dr Rouxlene van der Merwe's research focused on breeding for resistance to pod dehiscence in vegetable type soybean. The research is being undertaken in collaboration with the Northeast Institute of Geography and Agroecology of the Chinese Academy of Sciences. This research continued to make progress towards the development of an improved South African vegetable type soybean cultivar that shows resistance to pod shattering. This project is undertaken in collaboration with Dr Minnaar-Ontong, who is responsible for marker-assisted selection.

Dr Van der Merwe also made progress with the development of an improved South African vegetable-type soybean cultivar that shows high yield potential and with improved nutritional value. Promising cultivars are being evaluated on agronomic performance and consumer acceptability in order to be promoted for production by small-scale farmers. This project is undertaken in collaboration with Dr Van Biljon, who assisted with sugar analysis, Prof Arno Hugo, who assisted with fatty acid analysis, and Dr Carina Bothma, who assisted with sensory tests.

Dr Van der Merwe continued her research on the characterisation of vegetable-type soybean cultivars in terms of drought stress tolerance. This project involves collaboration with Dr Van Biljon, who assisted with sugar analysis, Prof Hugo, who assisted with fatty acid analysis and Dr Moloi who assisted with physiological response analyses.

Plant Breeding: Wheat-quality and crop-nutritional value research

Prof Maryke Labuschagne and Dr Angeline van Biljon continued collaboration with Dr Carlos Guzman, of Cordoba University in Spain, and Dr Itria Ibba, of CIMMYT-Mexico, on bread and durum wheat quality, involving two PhD students. The collaboration is ongoing, with a focus on gluten proteins. Collaboration with CIMMYT in Harare and Kenya is also ongoing, involving Dr Thoko Ndhlela, Dr Jill Cairns, Dr Mike Olsen, Dr Cosmos Magorokosho and Dr Dagne Wegary. Four PhD projects on maize biofortification and stress tolerance breeding are included in the study.

Dr Van Biljon continued her research on the influence of abiotic stress on the nutritional profile and quality of various crops, as this information will contribute to the improvement of specific crops and lead to better food security. The research focuses on crops such as wheat, maize, vegetable-type soybeans, and butternut. The nutritional screening includes the study of storage protein through size exclusion- and reverse-phase high-performance liquid chromatography, as well as the determination of total starch, amylose, tryptophan, β-carotenoids, mineral content (especially iron and zinc), and the bioavailability of these minerals.

Dr Ntombokulunga Mbuma and Prof Labuschagne collaborated with researchers from the Agricultural Research Council (ARC). The research focuses on the development and improvement of high yielding cowpea genotypes/cultivars with improved protein content and mineral elements, in combination with good agronomic performances through bio-fortification breeding techniques. The research also involves understanding the adaptability and stability of cowpea varieties under South African conditions. Two peer-reviewed manuscripts were published during 2020 from this collaboration, which is ongoing and focuses on improving cowpea genotypes for nutritional value under abiotic stresses such as drought and heat.

Plant Pathology: Cereal rust diseases

Dr Willem Boshoff was involved in the Winter Cereal Trust project 'Evaluation of wheat cultivars and lines for genetic resistance to rust disease', carried out annually by the UFS rust pathologists. This research involves annual greenhouse and field screening with selected races of the three rust pathogens of wheat. During 2020 field trials were only possible in the Western Cape, with the support of Sensako staff; cereal varieties were rated with the assistance of Prof Pretorius. Data from these trials is annually included in the national wheat production guidelines of ARC-SG.

Plant Pathology: Soil microbial ecology

The soil microbial ecology group (SMEG) is run by Prof Wijnand Swart, and the focus of the group's research is on monitoring the rhizosphere microbiome as a bio-indicator of plant health. The group's research concentrates on adopting a 'total systems approach' to plant health management by utilising the functional diversity of fungi and bacteria, above- and below ground, as bio-indicators of soil and plant health. This involves understanding multi-trophic interactions that occur in agroecosystems, with particular focus on the rhizosphere microbiome. In so doing, innovative crop production and protection strategies are developed with specific emphasis on discovering beneficial microbes that can influence both plant and soil health.

Plant Pathology: Mycology

Despite the unusual challenges that COVID-19 placed on the travelling arrangements and access of students to the UFS Bloemfontein campus, the Pecan Research Group, under the leadership of Dr Gert Marais, managed to undertake a number of field trips. These included the Orange River (from Luckhof to Upington), Vaalharts, Schweizer-Reneke, Jacobsdal, as well as various other areas in Limpopo, Mpumalanga, Gauteng and KwaZulu-Natal. During these field trips, a total of six farmers' days were organised at which information on the latest findings from student projects were shared with pecan producers and other interested parties. This is part of a five-year research project between the South African Pecan Nut Producers Association (SAPPA) and the UFS. To support future pecan research at the UFS, a one-hectare pecan orchard was established on the Paradys Experimental Farm in Bloemfontein.

Four MSc studies were concluded during 2020, including studies on the screening of fungal candidates for the dry retting of kenaf, the use of essential oils to control crown and root rot of maize, confirming that the causative agent of pecan scab in South Africa is the fungus, *Cladosporium cladosporioides*, and that the fungus, *Neofusicoccum parvum*, causes dieback in pecans.

Plant Pathology: Epidemiology

The epidemiology programme was led by Dr Lisa Rothmann and supported by Prof Neal McLaren and Mrs. Marlese Meiring. The focus of the group is Sclerotinia stem and head rot of soybean and sunflower, as well as sorghum pathology. Prof McLaren, operating from the Western Cape, is a Research Fellow in the Department. He presented data science workshops at Stellenbosch University and the University of Pretoria and continued his research collaborations with the Agricultural Research Council-Grain Crops (ARC-GC), the Western Cape Department of Agriculture, and Sorghum Trust.

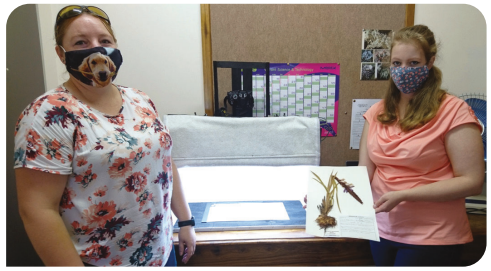
Sorghum research focused on grain-mold pathogens and mycotoxigenic fungi, as well as the effects of decortication on grain molds and mycotoxins. Applied epidemiology was used to identify grain mold and foliar disease driving variables and risk modelling. Ultimately, these studies aim at the identification and quantification of intervention technologies for the management of sorghum diseases. Field trials were conducted in collaboration with Dr Edson Ncube from the ARC-GC (Potchefstroom and Cedara). Research support from the Sorghum Trust continued during 2020.

Sclerotinia research focused on soybean and sunflower cultivar evaluations, with field trials in the eastern Free State and Mpumalanga. These trials aimed at identifying cultivars that can be included in pre-breeding programmes due to higher tolerance to Sclerotinia disease potential. This research was supported by the Sasol Trust, Oil and Protein Seeds Development Trust (OPDT) and Protein Research Foundation (PRF), under the initiative supported by GrainSA. A project in collaboration with Dr Derick van Staden, in Mpumalanga, investigated the potential of fungicide interventions for Sclerotinia stem rot of soybean under field conditions.

A study under the mentorship of Prof Emerson del Ponte, from the Plant Pathology Department from the Universidade Federal de Viçosa (Minas Gerais, Brazil) was completed in 2020. This study was aimed at analysing a ten-year Sclerotinia prevalence dataset from across South African soybean and sunflower production regions, using reproducible research practices and a statistical coding platform, R and R Studio.

ENGAGED SCHOLARSHIP

The Geo Potts Herbarium received a grant from the International Association of Plant Taxonomists to barcode and digitize the ±30 000 specimens held in its main collection. This project will lead to the more efficient management of the collection and make the digitised specimen records available online for use by the international scientific community.



Magdil Pienaar and Emma Ferreira digitizing specimens in the Geo Potts Herbarium

Dr Moloi was invited to be a Co-Guest Editor for the journal *Plants* (ISSN 2223-7747).

Prof Labuschagne served as Speciality Chief Editor for *Frontiers in Sustainable Food Systems*, and Associate Editor for both *Cereal Chemistry*, and *Journal of Cereal Science*.

As part of reviving the African Pollen database – a repository that was inactive during the last decade – Prof Scott started submitting modern pollen data from South Africa and began editing papers as Guest Editor for a special volume that will appear in the book series *Palaeoecology of Africa - African Palaeoenvironments and Geomorphic Landscape Evolution*, to be published by CRC Press.

Dr Joubert and Dr Van Aardt collaborated with the UFS Department of Otorhinolaryngology and the Lung Institute at the

University of Cape Town on pollen monitoring in the atmosphere. These counts are done on a weekly basis and posted on the website: https://pollencount.co.za/. This informs allergy sufferers about the current risk.

Dr Rothmann continued her role in the international multi-disciplinary organisation Open Plant Pathology as the Social Media and Blog Editor to encourage Open Science practices in Plant Pathology.

The South African Sclerotinia Research Network, led by Dr Rothmann, creates and communicates social media content on the fungal pathogen *Sclerotinia sclerotiorum*. As COVID-19 caused havoc in the agricultural sector, as it did in many other sectors, only one in-person farmers' day was held prior to lockdown. All further research communication and engagement with producers and industry was conducted on an online platform, which can be accessed at https://www.sclerotinia.co.za/.

Dr Steenhuisen was a panellist in an Academy of Science of South Africa (ASSAf) webinar on multidisciplinary research, in November 2020.

Dr Mbuma accepted an invitation as a senior reviewer for *African Journal of Food, Agriculture, Nutrition and Development* (AJFAND).

NATIONAL AND INTERNATIONAL COLLABORATION

Dr Willem Boshoff and Prof Zakkie Pretorius collaborated with researchers from the USA (University of Minnesota), the Kingdom of Saudi Arabia (King Abdullah University of Science and Technology), the United Kingdom (John Innes Centre), Australia (CSIRO Agriculture and Food), and China (Institute of Genetics and Developmental Biology, Chinese Academy of Sciences). Two peer-reviewed papers were published during 2020 from these collaborations and one is under review.

In collaboration with Dr Jim Kolmer from the Department of Plant Pathology at the University of Minnesota, Prof Pretorius and Prof Visser contributed to a publication in *Heredity,* describing the global *Puccinia triticina* population using next-generation sequencing.

Prof Visser also collaborated with Dr Sam Markell (North Dakota State University, USA), Dr Anthony Young (University of Queensland, Australia), Dr Gary Kong (University of Canberra, Australia), and Dr Sue Thompson (University of Southern Queensland, Australia), leading to the successful completion of the MSc study by Mr Wilku Meyer on sunflower rust in South Africa. In this study, the first in 25 years, three new sunflower races were described for the first time in almost three decades, bringing the total to seven. This study laid the groundwork for continued collaboration to describe the global sunflower rust population.

Prof Visser and Dr Les Szabo (of the University of Minnesota) collaborated on a study describing the development of genetic lineages within the global wheat stem rust population. Prof Visser also collaborated with researchers at the ARC-SG in Bethlehem.

Dr Minnaar-Ontong and Dr Van der Merwe collaborated with researchers from the Northeast Institute of Geography and Agroecology at the Chinese Academy of Sciences, on breeding for resistance to pod dehiscence in a vegetable-type soybean. Dr Minnaar-Ontogn also collaborated with Syngenta (together with Dr Rothman) on breeding for resistance to Sclerotinia headrot in sunflowers, and with breeding companies from industry, and researchers from the University of Manitoba, Canada and the University of Nebraska, USA.

Prof Swart collaborated with Prof Pedro Crous, Director of the Westerdijk Fungal Biodiversity Institute in the Netherlands and Secretary-General of the International Mycological Association. Prof Crous is an Affiliated Professor in the Department of Plant Sciences (Division of Plant Pathology) and collaborated closely with Prof Swart in describing seven new species of fungi, published in Fungal Planet Description Sheets of the prestigious international journal, *Persoonia*.

Dr Mafa collaborated with Prof Brett Pletschke, the principal investigator of the Enzyme Science Programme (ESP) in the Department of Biochemistry and Microbiology at Rhodes University, and with Prof Yasien Sayed, the director at Protein Structure-Function Research Unit (PSFRU) in the School of Molecular and Cell Biology at the University of the Witwatersrand.

Dr Mohase collaborated with Dr Jankielsohn from the ARC-SG in Bethlehem, on the aphid diversity in South Africa and Lesotho and the Lesotho Agricultural Research Unit (on wheat germplasm in Lesotho).

Dr Van der Merwe continued her national collaboration with the Edamame Development Programme (EDP). This collaboration includes germplasm maintenance of introduced varieties, base seed multiplication, research and training of students, pre-breeding and new cultivar development for South African growing conditions. She also continued collaboration with Prof Qiuying Zhang from the Northeast Institute of Geography and Agroecology of the Chinese Academy of Sciences. The project focuses on breeding for resistance to pod dehiscence in vegetable type soybean.

Dr Rothmann's research forms part of the the official Memorandum of Understanding (MoU) between GrainSA and the UFS which specifies that the Department of Plant Sciences "was signed for administrating the South African Sclerotinia Research Network, composed of a community of practice and a research consortium". The Network provides a platform for South African researchers, industry and producers to work together towards a management solution for Sclerotinia diseases in South Africa.

An official MoU between the UFS and the Universidade Federal de Viçosa, Minas Gerais, Brazil was signed. This MoU facilitates research collaboration and potential future exchange opportunities.

Dr Joubert collaborated with Mr Pieter Bester from SANBI, Prof Beverley Glover from the Department of Plant Sciences at the University of Cambridge, Dr Edwige Moyroud from the Sainsbury Laboratory in Cambridge, and Dr Mario Fernandes-Mazuecos from the Spanish National Research Council, on the project titled 'The role of flower structure in the diversification of the genus *Nemesia* (Scrophulariaceae)'. The collaborators provide expertise on the taxonomy of Scrophulariaceae, floral evolutionary development and molecular systematics respectively. Dr Fernandes-Mazuecos was due to visit to the UFS in 2020, but due to the international travel restrictions as a result of COVID-19, his visit has been postponed until September 2021, when Dr Glover is also scheduled to make her research visit to the UFS.

Dr Ngara continued her international collaboration with Dr Stephen Chivasa, Durham University, United Kingdom, on the Newton Advanced Fellowship-Royal Society grant, and nationally with Dr Nemera Shargie from ARC-GC in Potchefstroom, on a project funded by NRF-Thuthuka.

Prof Labuschagne continued research collaboration with the University of Cordoba in Spain, and CIMMYT (Mexico, Harare and Kenya) in 2020.

Dr Van Biljon's research was undertaken in collaboration with the ARC-SG, ARC-GC, Starke Ayres, and CIMMYT in Zimbabwe. She also collaborated with Dr Eric Alexandersson from the Swedish University of Agricultural Sciences in Alnarp, Sweden, who worked together on the South Africa – Sweden Bilateral Scientific Research Collaboration Programme 2018 -2020.

Dr Jackson continued her collaboration with Mrs Elmarie van Rensburg from the National Museum in Bloemfontein using molecular techniques to investigate the phylogenetic relationships of genera in the family Aizoaceae.

Prof Scott's and Dr Van Aardt's research and editorial work is undertaken in collaboration with several researchers from the USA, Canada, Spain, the UK, the Netherlands, France, Germany, Israel, and South Africa.

Dr Moloi collaborated with Dr Brigitta Tóth of the University of Debrecen in Hungary. They published two book chapters and research manuscripts in 2020.

Dr Marè collaborated with companies such as PANNAR, Sensako and the ARC-SG on various projects.

Dr Arun Gokul initiated a national collaboration between the Department of Plant Sciences and the Plant Sciences group of the Department of Biotechnology at the University of the Western Cape (UWC). This collaboration focuses on understanding the primary and secondary products produced by microorganisms associated with plants and the plants themselves. The research aims to test these compounds for plant growth promotion, bio-control of pathogens, and the bio-fortification of important agricultural crops.

Dr Mbuma and Prof Labuschagne collaborated with Dr Abe Gerrano and Dr Alina Mofokeng from the ARC on cowpea projects, and with Dr Sanesh Ramburan, from Bayer South Africa, on a maize project.

A research collaboration between Dr Potgieter (Eco-physiology) and Introlab (Pty) Ltd continued to evaluate the bio-stimulant properties of Xcell Boost on different crops under certain stress conditions.

Dr Marais collaborated with SAPPA and with Prof Bernard Slippers and Prof Wilhelm de Beer, from the Forestry and Agricultural Biotechnology Institute (FABI) at the University of Pretoria, to study diseases in the pecan industry in South Africa.

POSTGRADUATE STUDENTS

During 2020, 16 honours, 60 master's and 47 doctoral students were enrolled for postgraduate studies in the Department of Plant Sciences.

At the 2020 graduations, nine students graduated with the BSc Hons majoring in Botany (six on the Bloemfontein Campus and three on the Qwaqwa Campus), and one student graduated with the BSc Hons in Agriculture majoring in Plant Breeding.

Two students graduated with an MSc (Agriculture):
- Jolene Coertzen (Plant Pathology)
- Nicola Theron (Plant Pathology)

A further 10 students graduated with an MSc:
- Alec Edwards (Plant Pathology)
- Andani Mabirimisa (Plant Breeding – with distinction)
- Andrea Lessing (Plant Pathology)
- Diné Pretorius (Botany)
- Evandré Minnaar (Botany)
- Fanele Msani (Plant Breeding)
- Kholosa Maqolo (Plant Breeding – with distinction)
- Masefudi Pinkie Mojapelo (Plant Pathology)
- Raphael Banda (Plant Breeding – with distinction)
- Wilku Basie Meyer (Botany – with distinction)

Eleven candidates from the Department of Plant Sciences graduated with a PhD in 2020:

Amegbor, Isaac (Plant Breeding)
Thesis: Yield linkage drag in quality protein maize inbred lines and hybrids
Promoters: Prof MT Labuschagne and Dr A van Biljon

Anjejo, Mathewos (Plant Breeding)
Thesis: Genetics of stem rust resistance in selected wheat germplasm
Promoters: Prof L Herselman and Prof ZA Pretorius

Bender, Cornelia Magrietha (Plant Pathology)
Thesis: Stem rust resistance in South African wheat and triticale
Promoters: Prof ZA Pretorius and Dr WHP Boshoff

Chemonges, Martin (Plant Breeding)
Thesis: Genetics of stem rust resistance in South African winter wheat varieties
Promoters: Prof L Herselman, Prof ZA Pretorius and Dr WHP Boshoff

Chiipanthenga, Margaret (Plant Breeding)
Thesis: Drought tolerance in Malawian soybean germplasm
Promoters: Dr R van der Merwe and Prof MT Labuschagne

Du Toit, André (Plant Breeding)
Thesis: Introduction of foreign germplasm as a breeding strategy for the South African wheat industry
Promoter: Prof MT Labuschagne

Joubert, Sonia Mari (Plant Pathology)
Thesis: *Fusarium* spp. and associated mycotoxins in South African maize
Promoter: Prof NW McLaren

Masupha, Pitso Victor (Botany)
Thesis: Russian wheat biotypes in Lesotho: distribution, impact on wheat production and the role of phytohormones in host resistance
Promoter: Dr L Mohase

Nginamau, Dibanzilua (Plant Breeding)
Thesis: Development of maize hybrid varieties tolerant to acid soils for Angola
Promoters: Prof MT Labuschagne and Dr A van Biljon

Peprah, Bright Boakye (Plant Breeding)
Thesis: Genetic improvement of beta-carotene in cassava (*Manihot esculenta* Crantz)
Promoters: Prof MT Labuschagne and Dr A van Biljon

Rothmann, Lisa-Ann (Plant Pathology)
Thesis: The spatial quantification and hierarchy characterization of Sclerotinia prevalence from a decade of observations in soybean and sunflower
Promoter: Prof NW McLaren

POSTDOCTORAL RESEARCH FELLOWS

Dr Howard Castelyn (South Africa) was appointed as a postdoctoral fellow in the laboratory of Prof Visser to continue with the bio-informatic analysis of the adult wheat-stem rust interaction. He is currently in the second year of his term.

Dr Neila Abdi (Tunisia) was appointed as postdoctoral fellow in Plant Breeding in 2020, working on projects within the SARChI Chair.

Dr Nicholas Le Maitre (South Africa), under the supervision of Dr Steenhuisen, completed a year of his fellowship researching a variety of aspects of mountain flora, including the flowering phenology of *Rhodohypoxis* in collaboration with Dr Kelsey Glennon (University of Witwatersrand), introgression between indigenous and exotic *Celtis* species throughout South Africa, genetic diversity of *Protea* species populations, and the building and deployment of new AudioMoth sound recorders in the wetlands in GGHNP in order to determine seasonal changes in bird diversity using acoustics. The latter three projects are being undertaken in collaboration with the ARU.

STAFF MATTERS

Dr Lize Joubert and Dr Rudo Ngara were promoted to Senior Lecturers in the Department.

Dr Mpho Mafa was appointed as Lecturer in Botany on the Bloemfontein Campus.

Dr Arun Gokul was appointed as Senior Lecturer in Botany on the Qwaqwa Campus.

Ms Dipuo Mosea was appointed as Professional Officer in Botany on the Qwaqwa Campus. She was previously an Academic Facilitator in the Department.

Ms Orpah Taylor was appointed as Senior Assistant Officer in Plant Breeding and Ms Khetha Mbatha was appointed as Assistant Officer in Plant Pathology.

Ms Zelda van der Linde (Assistant Officer) resigned in February 2020.

Dr Gerhard Potgieter (Senior Lecturer) took early retirement at the end of November 2020, after 36 years of service and Mr Dirk Jansen took early retirement at the end of December 2020, after more than 40 years of service.

RESEARCH OUTPUTS

Research Articles

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Conference Contributions

Conference Papers/Posters

Adams, L.D., Martin, G.D., Clark, V.R., Downs, C.T., Thabethe, V., Raji, A. & Steenhuisen, S. 2020. *The effect of birds on seed dispersal and germination of invasive firethorn*. Paper delivered at the 46th Annual Conference of the South African Association of Botanists (SAAB), University of the Free State, Qwaqwa Campus, South Africa. 7-10 January 2020.

Amegbor, I.K., Van Biljon, A., Tarekegne, A., Shargie, N. & Labuschagne, M.T. 2020. *Genetic analysis for grain yield and quality traits of CIMMYT quality protein maize inbred lines.* Paper delivered at the 13th Southern African Plants Breeders' Association (SAPBA) Symposium, University of Pretoria, South Africa. 8-11 March 2020.

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Malepe, C.B.B., Gryzenhout, M. & Marais, G.J. 2020. *Fusarium species associated with pecan (Carya illinoinensis) in South Africa*. Paper delivered at the 46th Annual Conference of the South African Association of Botanists (SAAB), University of the Free State, Qwaqwa Campus, South Africa. 7-10 January 2020.

Mapaura, A., Canavan, K., Richardson, D.M., Clark, V.R. & Steenhuisen S. 2020. *Nassella tussock invasion in South Africa: an overview*. Paper delivered at the 46th Annual Conference of the South African Association of Botanists (SAAB), University of the Free State, Qwaqwa Campus, South Africa. 7-10 January 2020.

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Mbuma, N.W., Labuschagne, M.T. & Gerrano, A. 2020. *Assessment of genetic variability among cowpea genotypes for nutritional value*. Paper delivered at the 13th Southern African Plants Breeders' Association (SAPBA) Symposium, University of Pretoria, South Africa. 8-11 March 2020.

Miles, C., Van Biljon, A., Booyse, M. & Labuschagne, M. 2020. *The influence of different milling procedures on Mixsmart parameters and their relationships with primary wheat quality criteria.* Poster presented at the 13th Southern African Plants Breeders' Association (SAPBA) Symposium, University of Pretoria, South Africa. 8-11 March 2020.

Moloi, D. & Ngara, R. 2020. *Screening wheat varieties for drought tolerance using physiological and growth parameters.* Poster presented at the 46th Annual Conference of the South African Association of Botanists (SAAB), University of the Free State, Qwaqwa Campus, South Africa. 7-10 January 2020.

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Mosea, D. & Ngara, R. 2020. *Effects of polyethylene glycol-induced osmotic stress on the viability of sorghum cell suspension cultures.* Poster presented at the 46th Annual Conference of the South African Association of Botanists (SAAB), University of the Free State, Qwaqwa Campus, South Africa. 7-10 January 2020.

Msani, F., Zhou, M.M. & Van Der Merwe, R. 2020. *The effect of tramline and continuous row spacing on breeding and genetic parameters of sugarcane populations.* Paper delivered at the 13th Southern African Plants Breeders' Association (SAPBA) Symposium, University of Pretoria, South Africa. 8-11 March 2020.

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Phakela, K., Van Biljon, A., Wentzel, B., Guzmán, C. & Labuschagne, M. 2020. *Proteomic analysis of abiotic stress influence on durum wheat gluten composition*. Paper delivered at the 13th Southern African Plants Breeders' Association (SAPBA) Symposium, University of Pretoria, South Africa. 8-11 March 2020.

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Szabo, L.J., Johnson, J.L., Visser, B., Olivera, P.D. & Jin, Y. 2020. *Elucidating the evolutionary history of Puccinia graminis f. sp.* tritici *lineages through analysis of allelic variation of selected genes.* Paper delivered at the 2020 Borlaug Global Rust Initiative (BGRI) Technical Workshop. Online. 7-9 October 2020.

Van Biljon, A., Olckers, S-L., Osthoff, G. & Labuschagne, M.T. 2020. *The relationship between starch, amylose and zein protein fractions of quality protein maize grown under different nitrogen conditions.* Paper delivered at the 13th Southern African Plants Breeders' Association (SAPBA) Symposium, University of Pretoria, South Africa. 8-11 March.

Wentzel, B., Van Biljon, A., Miles, M., Booyse, M. & Labuschagne, M.T. 2020. *How useful is SDS-sedimentation as an indication of baking quality in a breeding programme?* Poster presented at the 13th Southern African Plants Breeders' Association (SAPBA) Symposium, University of Pretoria, South Africa. 8-11 March 2020.

STAFF (2020)

Head of Department: Prof L Herselman

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Associate Professors: Prof L Herselman and Prof B Visser
Senior Lecturers: Dr WHP Boshoff, Dr L Joubert, Dr GJ Marais, Dr A Minnaar-Ontong, Dr L Mohase, Dr MJ Moloi, Dr GP Potgieter, Dr A van Biljon and Dr R van der Merwe
Lecturers: Dr M Jackson, Dr MS Mafa, Dr NW Mbuma and Dr AC van Aardt
Lecturer (units): Dr LA Rothmann
Junior Lecturer: Dr A Maré
Affiliated Professor: Prof PW Crous
Affiliated Associate Professor: Prof M Zhou
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Mentor: Prof L Scott

Programme Director: Prof B Visser
Chief Officer - Professional Services: Dr CM Bender
Officers - Professional Services: Mr HP Pretorius and Ms M Pienaar
Senior Assistant Officers: Ms MP Mbingeleli, Dr C Steyn and Mrs OML Taylor
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Lecturers: Dr PJ Mojau and Mr TR Pitso
Research Associates: Dr LV Komoreng, Dr RJ McKenzie, Prof RO Moffett, Dr TM Mokotjomela, Dr T Ramakuwela and Dr JD Vidal Jr
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