COMBINED CONGRESS 2023

23 – 26 January

Future Africa campus

University of Pretoria

Combined Congress 2023 – Participating Societies

South African Society of Crop Production

E-mail: admin@sascp.org.za
Website: www.sascp.org.za

Southern African Society for Horticultural Sciences

E-mail: admin@SASHS.co.za.za
Website: www.sashs.co.za

Soil Science Society of South Africa

E-mail: admin@soils.co.za
Website: www.soils.org.za

Acknowledgements

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Mrs Nwabisa Budaza

Mrs Nancy Nortje

Editors:

SASCP: Prof Martin Steyn

SSSSA: Prof Johan van Tol

SASHS: Prof Riana Kleynhans

Reviewers:

Our sincerest gratitude to all the editors and reviewers.

General support:

Staff and students of the Department of Plant and Soil Sciences, University of Pretoria

Venue

Future Africa campus, University of Pretoria, Pretoria (25°45’5’’S; 28°15’39E)

GENERAL INFORMATION

Registration

Registration will take place at the Future Africa campus (25°45’5’’S; 28°15’39E) from Monday the 23 January from 15:00 – 18:00 and on Tuesday morning from 07:00 – 07:50. The usual welcome cocktail has been moved to Wednesday to coincide with a poster session.

Opening and keynote addresses

The main opening will take place in the Future Africa main Auditorium on Tuesday 24 January at 08:00. The Keynote presentations will also take place in the main Auditorium on Tuesday morning 08:40 (SASCP – Petru Fourie from GrainSA), Tuesday afternoon 13:30 (SSSSA – Prof Roland Schulze) and Wednesday morning 08:00 (SASHS – Dr. Graham Barry).

Parallel sessions

Three parallel sessions will take place in the Future Africa auditorium and Annex 1 and 2

Refreshments and functions

Refreshments and lunch will be served at the Future Africa cafeteria and dining room. A glass bottle will be given to you on registration that you can refill during the conference at water dispensers.

The braai will be hosted at the Uitspan grounds on the LC De Villiers sports grounds of the University of Pretoria on Tuesday evening

A cocktail function that will coincide with the poster session will be held at the Future Africa Campus on Wednesday evening after the oral presentations

The gala dinner will be hosted at the CSIR International Convention center on Thursday evening after the excursions.

Important information for oral presenters

All presenters must take note of the date, venue and time of their presentations. You have 15 minutes for an oral presentation and an additional 5 minutes for questions. Time allocated for questions may also be used for you to move to another venue.

Please upload your presentations at the dedicated room (situated behind the main Auditorium) at least in the break before your session.

		Monday 23 January		
11:00:00	13:00:00	SAPSSC meeting		
13:00:00	14:00:00	Lunch		
14:00:00	16:00:00	SASCP Board meeting	SASHS Board Meeting	SSSSA Board Meeting
15:00:00	18:00:00	Combinded Congress Resgistration open Future Africa campus		
		Tuesday 24 January		
07:00:00	07:20:00	Registration		
07:20:00	07:40:00			
07:40:00	08:00:00			
08:00:00	08:20:00	Opening: **Prof Barend Erasmus**		
08:20:00	08:40:00	Dean Natural and Agricultural Sciences, University of Pretoria		
08:40:00	09:00:00	Keynote: **Petru Fourie**, Grain SA		
09:00:00	09:20:00	Perspectives of the grain and oilseed industry: Research and economic outlook		
09:20:00	09:40:00	Reinhard Kuscke, MD AgriSeker		
09:40:00	10:00:00	Morning tea		
10:00:00	10:20:00			
		Concurrent session 1		
		Auditorium **Crop prodution and quality** Chair: Pieter Swanepoel	Conference Room 1 **Post harvest technology** Chair: Mark Penter	Conference Room 2 **Soil Biology** Chair: Elmarie Kotze
10:20:00	10:40:00	**Abidemi Ruth Adebayo** Growth and yield of Water Efficient maize (WEMA) in response to nitrogen fertilizer and plant density in dryland of South Africa	**Ebrahiema Arendse** Effects of long-term storage potential on the physiological response and quality attributes of pomegranate (punica granatum l.) fruit	**Cowan Mc Lean** Can plants and microbial activity be used to indicate soil degradation of alpine soils situated in the northern drakensberg, South Africa?
10:40:00	11:00:00	**Nosipho Minenhle Phungula** Integration of potato cultivar selection, mulch, and fungicide application as an affordable, easy-to-apply yield improvement strategy for dryland smallholder producers	**Isa Bertling** The effect of CO2 on phytochemical alterations of sweetcorn (*Zea mays* l. Var. Saccharata) cobs	**Gerhard du Preez** Transitioning to sustainable food production: What can nematodes tell us about soil ecosystem health?
		Concurrent session 1 Continued		

		Auditorium **Crop prodution and quality** Chair: Pieter Swanepoel	Conference Room 1 **Post harvest technology** Chair: Mark Penter	Conference Room 2 **Soil Biology** Chair: Elmarie Kotze
11:20:00	11:40:00	**Rens Smit** Cropping systems as a sustainable alternative for fertilizers to improve wheat protein.	**Badubule Kolisi** Effect of smoke-water from different plant sources on the germination of agronomic and horticultural crops	**Itumileng Kekana** Bioremediation of non-essential metals using indigenous microbes following irrigation with treated wastewater
11:40:00	12:00:00	**Sandra Clarke** Evaluating pre-harvest sprouting of South African wheat (Triticum aestivum L.) cultivars in the Eastern Cape Province	**Nhlanhla Mathaba** Effect of postharvest calcium chloride dips on the improvement of 'classic round' tomatoes (*Solanum lycopersicum*) fruit quality attributes and shelf-life	**Ayabulela Madikana** 42 years of fire frequency levels effect on soil invertebrate community in the Savanna biomes, South Africa
12:00:00	12:20:00	**Marylyn Christian** Qualitative analysis of wheat genotypes under drought using near Infrared reflectance (NIR)	**Marli Kleyn** The impact of de-greening on lemon fruit quality	**Michael Kidson** Carbon losses and gains in agricultural soils: A baseline study of the microbial community of two soils under two cultivation practices
12:20:00	12:40:00	Lunch		
12:40:00	13:00:00			
13:00:00	13:20:00			
13:20:00	13:30:00			
13:30:00	14:00:00	Auditorium Keynote: **Prof Roland Schulze** UKZN A jourey as a hydrological modeller into the soils of South Africa		
14:00:00	14:10:00			
		10 minutes to change venues		
		Concurrent session 2		

		Auditorium **Modelling, water and nutrition** Chair: Linus Franke	Conference Room 1 **Hort Production and Cultivation** Chair: Karin Hannweg	Conference Room 2 **Genesis, Classification & Mapping** Chair: Johan van Tol
14:20:00	14:30:00	**Michael van der Laan** The water research observatory: a cloud-based platform for agrohydrological modelling and big data applications	**Siyabonga Dlamini** Enhancing the nutritional and physiological quality of sweet pepper fruit through incorporating biostimulants, organic, and inorganic fertilizers into the growing medium	**Molebaleng Sehlapelo** Investigating the accuracy of digitized soil data in digital soil mapping
14:40:00	15:00:00	**Lesego Madiseng** Prospects for mine water Irrigation in the Upper Olifants Catchment	**Heinrich Geldenhuys** The effect of tree windbreaks on fruit quality and yield of bearing 'Tango' mandarin (*Citrus reticulata*) trees in the Western Cape, South Africa	**Edward Smit** Towards a hydrological soil map of South Africa: Downscaling legacy soil information for machine learning based digital soil mapping
15:00:00	15:20:00	**Karabo Deane** Commercial scale crop irrigation using untreated circumneutral mine water in Mpumalanga	**Estelle Kempen** Tomato fruit quality in a soilless growing system in relation to the nutrient solution composition	**George van Zijl** Evaluating the base status family criterion for use in the South African soil classification system
15:20:00	15:40:00	**Mzwandile Mabuza** Response of crops and soil to irrigation with simulated acid mine drainage.	**Salfina Mampa** Effect of nitrogen application on the phytochemical content of patty pan varieties	**Jasper Dreyer** Gamma-ray spectrometry to determine soil properties for soil mapping in precision agriculture
15:40:00	16:00:00	Afternoon tea		
16:00:00	16:20:00			

		Concurrent session 3		
		Auditorium **Conservation Agriculture** Chair: Johann Strauss	Conference Room 1 **Hort Production and Cultivation Practices** Chair: Kgabo Pofu	Conference Room 2 **Soil Fertility** Chair**:** Corrie Swanepoel
16:20:00	16:40:00	**Guy Musto** Regenerative Agriculture vs Conservation Agriculture: potential effects on soil quality, crop productivity and whole-farm economics in Mediterranean-climate regions	**Siphokuhle Mbuyisa** The effect of Moringa leaf extracts on growth, development, fruit yield and nutritional status of sweet pepper (*Capsicum annuum* l.)	**Prosper Sibanda** Evaluation of irrigation water quality guidelines for aluminium, manganese and iron
16:40:00	17:00:00	**Jaco Engelbrecht** The potential of mixed cover crops as dryland fodder or pasture	**Mampe Ndlovu** Yield and quality response of indeterminate tomato as affected by grafting method and rootstock cultivars	**Zwane SM** Organic carbon in soils treated with cattle and pig slurries relative to solid manures: a global meta-analysis
17:00:00	17:20:00	**Lisa Matthews** Greenhouse gas emissions from different crop rotation systems in the Swartland, Western Cape	**Bonga Ngcobo** Effect of artificial daylength enhancement (pre-sunrise and post-sunset) with blue and red led lights on tomato plant development, yield and fruit nutritional quality	**Samukelisiwe Vilakazi** Characteristics of biochar types from potato waste and pine-bark and their implications for carbon storage, nutrient recovery and liming of acidic soils
17:20:00	17:40:00	**Justin Brittion** Evaluating the soil health and fertility status of conservation and regenerative agricultural systems across multiple ecotopes.	**Johane Niemann** Understanding citrus rootstock seed production in South Africa	**Mmabopele Mmotong** The effects of maize/legume intercropping on soil nitrogen dynamics
17:40:00	18:00:00	**Pieter Swanepoel** Tactics to facilitate alkali movement in conservation agriculture dryland crop production systems	**Johleen Malaka** Ranking of six high-value essential oil crops in terms of their water productivity	**Matome Ngoetjana** Selected soil chemical properties and emerging contaminants in soil-plant systems amended with biosolids
18:30:00	Braai - Uitspan / LC De Villiers sports grounds / UP			
20:00:00				
21:00:00				
22:00:00				
		Wednsday 25 January		

07:00:00	07:20:00	Registration		
07:20:00	07:40:00			
07:40:00	08:00:00			
08:00:00	08:20:00	Keynote: **Dr Graham Barry** XLnT Citrus		
08:20:00	08:40:00	Trained as a Horticultural Scientist, what now?		
08:40:00	08:50:00	10 Min venuse change		
		Concurrent session 4		
		Agrometeorology Chair: Michael van der Laan	**Postharvest technology and Physiology** Chair: Nicy Taylor	**Crop nutrition and Soil fertility** Chair: Adornis Nciizah
08:50:00	09:10:00	**Michael Savage** Modelling Class-A pan evaporation using weather data	**Sbulelo Mwelase** Chitosan-24-epibrassinolide composite coating induces chilling tolerance of cold-stored pomegranate fruit by enhancing antioxidant defense systems	**Stefan Steenekamp** Potato production sustainability in the Western Free State: A study on water and nutrient use efficiencies on sandy soils
09:10:00	09:30:00	**Stephan Steyn** Synoptic weather patterns related to increased fire danger over the central grassland biome of South Africa	**Relebogile Shibure** The effect of harvest time and hydrocooling technique on postharvest wilting of cowpea leaves	**Chalin Malele** Response of pigeon pea [*Cajanus cajan* (l.) millspaugh] growth, phosphorus yield, phosphorous recovery efficiency, and grain yield to phosphorus fertilization under rainfed smallholder farming system under rainfed no-till smallholder farming system
09:30:00	09:50:00	**Simon Kiongo** Potato mineral nutrition, gaseous exchange, leaf ultrastructure and tuber quality responses to concurrent elevation in carbon dioxide and temperature	**Mark Penter** Xenic effects in macadamia	**Roeline Van Schalkwyk** Predicting soil water retention curves from soil physical properties of old store-and-release covers in Mpumalanga Highveld, South Africa
09:50:00	10:10:00	**Robert Mangani** Planting date and cultivar choice as potential climate change adaptation opportunities for South African dryland maize production	**Khodani Maumela** Mac like a tree and leaf	**Jacobus Smith** Long-term effects of micro-fine and class A calcitic lime application rates on soil acidity and rooibos tea yields under Clanwilliam field conditions
10:10:00	10:30:00	**Morning tea**		
10:30:00	10:50:00			
		Concurrent session 5		

		Auditorium **Crop breeding & adaptation** Chair: Magdeleen Cilliers	Conference Room 1 **Hort crop potection** Chair: Isa Bertling	Conference Room 2 **Soil Physics and Policy** Chair: **Andrei Rozanov**
10:50:00	11:10:00	**Linus Franke** The potential of hybrid potato in South Africa	**Pinda Magagula** The potential control strategy of white root rot in commercial avocado orchards	**Mariné Blaauw** Soil governance in South Africa: the *status quo*
11:10:00	11:30:00	**Kwame Shamuyarira** Genetic analysis of yield and yield-related traits and biomass allocation in newly developed wheat populations.	**Conny Matlala** Response of *Scutellonema brachyurus* to nemarioc-al phytonematicide	**Anneliza Collett** Towards the development of a soil information policy for South Africa
11:30:00	11:50:00	**Nthombifuthi Mabuza** Agronomic, Genetic and Quantitative Trait Characterization of Nightshade Accessions.	**Tlangelani Nghondzweni** Effect of seasonal variation on composition and antimicrobial activity of essential oils on potato soft rot bacteria (*Pectobacterium carotovorum*)	**Liesl Wiese-Rozanov** Assessing countries' commitments for soil organic carbon protection and sequestration under the three Rio conventions
11:50:00	12:10:00	**Abe Ayodeji** Evaluation of stem borer resistant white maize genotypes for resistance to fall armyworm (*Spodoptera frugiperda* J.E. Smith) infestation.	**Portia Morifi** Host status of 16 crops used by potato farmers in crop rotations against *Meloidogyne enterolobii* , *Meloidogyne incognita* and *Meloidogyne javanica*	**Althea Grundling** Management and rehabilitation of peatlands in South Africa
12:10:00	12:30:00	**Onalo Zungu** Oat (*Avena sativa* L.) cultivar evaluation for the breakfast cereal industry in South Africa.	**Lehlogonolo Shalang** Resistance of rosemary (*Rosimarinus officinalis*) to *Melodogyne enterolobii* , *Melodogyne incognita* and *Melodogyne janvanica*	**Aimee Thomson** Identifying the most suitable soil databases for crop modelling applications in South Africa
12:30:00	12:50:00	**Hanneke Augustyn** The quantity of nitrogen available in the soil following legume crops.	**Mawande Shinga** Efficacy of *Opuntia ficus indica* mucilage coating on cell wall integrity of banana fruit at retail conditions	Crop Policy Discussion
12:50:00	13:10:00	Lunch and Posters		
13:10:00	13:30:00			
13:30:00	13:50:00			
13:50:00	14:10:00			
		Concurrent session 6		

		Auditorium **Crop Protection** Chair: Juan Vorster	Conference Room 1 **Indigenous and medicinal plants** Chair: Louisa Blomerus	Conference Room 2 **Chemistry and Fertility** Chair: Gerhard Nortje
14:10:00	14:30:00	**Conrad Baker** Sweet sorghum (*Sorghum bicolor*) performance in a legume intercropping system under weed interference	**Karin Hannweg** A review of factors affecting seed germination and seedling establishment of the pepperbark tree (*Warburgia salutaris*)	**Willie Cloete** Determining the best method for measuring soil organic carbon content to be used for calculating carbon credits in South Africa
14:30:00	14:50:00	**Maryke Craven** Efficacy of graminicide-glyphosate tank mixtures for couchgrass (Cynodon dactylon) control	**Mabako Mabusela** The effect of phenological growth stages on the antioxidant activity of *Buddleja saligna*	**Elmarie Kotzé** How does long-term wheat management affect soil aggregates and intra-aggregate carbon?
14:50:00	15:10:00	**Nhlanhla Shabangu** Target-site mutation in the EPSPS and ALS region endowing resistance to EPSPS and ALS inhibitors in smooth pigweed in South Africa	**Riana Kleynhans** Exploring different approaches to ensure standardized activity in *Greyia radlkoferi*	**Mkhonza NP** Organic carbon fractions and aggregates stability in Umbric Rhodic Ferralsols soils under green cane compared to pre-harvest burning
15:10:00	15:30:00	**Gert Conradie** The effect of cover crop management on the weed seedbank dynamics under conservation agriculture	**Ivy Makena** Antioxidant activity of *Helichrysum odoratissimum* , influenced by phenology	**Nozibusiso Mbava** CO2 emissions and nitrogen and phosphorus mineralization in soils amended with biochar types from residues of different cultivars of maize (*Zea mays* L.) and sorghum (*Sorghum bicolour* (L.) Moench)
15:30:00	15:50:00	**Maryke Craven** Competitive ability of four grass weeds in maize	**Ambrose Ndayakunze** Can sustainable agronomic practices improve the edaphic and biotic dynamics of the Moringa rhizosphere?	**Isaac Gura** Investigating the use of mid-infrared spectroscopy in rapid analysis of minerals in wheat and maize under irrigation
15:50:00	16:10:00	**B Herrmann** Yellow Field Peas in South Africa: Effect of tillage practices and planting density on soil health and grain yield	**Mary Maluleke** Comparing the financial benefits of different grain farming systems in South Africa	**Corrie Swanepoel** Mopane worms and soil fertility: an undervalued service provider?
16:10:00	16:30:00			**Arnu Kock** Development of soil pectroscopy prediction models for soil properties used in precision agriculture, North West

16:30:00	16:50:00	**Afternoon tea**		
16:50:00	17:10:00			
17:10:00	17:30:00	SASCP AGM	SASHS AGM	SSSSA AGM
17:30:00	17:50:00			
17:50:00	18:10:00			
18:10:00	18:30:00			
18:30:00	18:50:00	**Coctails and poster session**		
18:50:00	19:10:00			
19:10:00	19:30:00			
		Thursday 26 January		
08:30:00	15:00:00	**Excursions**		
		SASCP Multiseed Vegetable & Pepper grower Brits	SSSSA ARC Roodeplaat	SASHS Blueberry & Ornamental Citrus producers Brits
18:00:00	22:00:00	Awards dinner		
		CSIR International Conference Center		

POSTER PRESENTATIONS

Soil Science

Biology

1	WISH-ROOTS: TUNING THE WHEAT ROOT MICROBIOME TO IMPROVE SOIL HEALTH AND OPTIMIZE RHIZOSPHERE NITROGEN CYCLING AND AVAILABILITY	Roopnarain, A., Kidson, M., Mndzebele B. and Ndaba, B
2	BIOACCUMULATION OF NON-ESSENTIAL METALS IN SELECTED INDIGENOUS MICROBES USED FOR BIOREMEDIATION OF SOIL FOLLOWING IRRIGATION WITH TREATED WASTEWATER	Kekana, I.K.J.1, Kgopa, P.M.1 and Munjonji, L.2
3	WISH-ROOTS: POTENTIAL OF AVENA SATIVA AS A COVER CROP FOR NITROGEN DEPLETION FROM THE SOIL	Kidson, M., Roopnarain, A., Mndzebele, B. and Ndaba, B.
4	MODELLING SOIL CARBON SEQUESTRATION FOR SOUTH AFRICA USING THE ROTHC MODEL	Morgenthal, T.L., Avenant, P., Collett, A.

CHEMISTRY

5	COMPARISON OF ULTRA-SONICATION AND MICROWAVE EXTRACTION FOLLOWED BY FILTRATION OR SPE CLEAN-UP FOR PAH DETERMINATION FROM SEDIMENT AND SLUDGE	1.3Sinayo Ndwabu and 2Precious Mahlambi
6	SOIL PHOSPHORUS FRACTIONS VERSUS ALTERNATIVE PHOSPHORUS FERTILIZER SOURCES IN FIVE DIFFERENT SOILS	Ramphisa, P.D. and Davenport, J.R.

FERTILITY

7	IMPLICATION OF LAND USE CHANGE FOR SOIL ORGANIC CARBON STORAGE: A CASE STUDY	Corrie Swanepoel1, Minkie Radzilani
8	SOIL PHOSPHORUS FRACTIONS VERSUS ALTERNATIVE PHOSPHORUS FERTILIZER SOURCES IN FIVE DIFFERENT SOILS	Ramphisa, P.D. and Davenport, J.R.
9	EFFECTS OF LAND USE CHANGE TO ARABLE CROPPING ON CARBON DIOXIDE EMISSIONS FROM TWO CONTRASTING HUMIC SOILS OF KWAZULU-NATAL	1,2Malepfane, N.M. 1Muchaonyerwa, P. 1Hughes, J.C and 1Zengeni, R.
10	THE EFFECT OF BIOCHAR DERIVED FROM TWO DIFFERENT FEEDSTOCKS ON SOIL PH, ELECTRICAL CONDUCTIVITY, AND SOIL AGGREGATES STABILITY	Letsoalo M.L., Odhiambo, J.O.J. and Lukhele-Olorunju, P.
11	COMPOST APPLICATION AND SOYBEAN-TEFF INTERCROPPING AFFECT SOIL ORGANIC CARBON AND CROP YIELD UNDER DIFFERENT TILLAGE PRACTICES	1Masowa, M.M., 2Kutu, F.R., 1Dlamini, P., 3Khetsha, Z., 3Sedibe, M.M. and 4Makgato, M.J.

12	EFFECT OF TREATED WASTEWATER USED FOR IRRIGATION ON SELECTED SOIL FERTILITY VARIABLES	Ntimbane P. and Kgopa P.M.
13	QUANTUM YIELD AND CHLOROPHYLL FLUORESCENCE OF CHICKPEAS GENOTYPE IN RESPONSE TO BIOFERTILIZER	Mashishi, S., Ogola, J.B.O., Odhiambo, J.JO. and Maseko, S.T.
14	INFLUENCE OF MAIZE/LABLAB INTERCROPPING ON SOIL MINERAL NITROGEN AND SOIL WATER CONTENT	Thaba, R.S., Odhiambo, J.J.O and Bracho-Mujica, G.
15	SHORT TERM TILLAGE EFFECTS ON SOIL MOISTURE DYNAMICS AND ENZYME ACTIVITIES IN A SORGHUM PRODUCTION SYSTEM IN A SANDY SOIL, IN ARID AREA	HZ Mabasa, AD Nciizah and P Muchaonyerwa
16	COMPARING THE GROWTH OF TWO CULTIVARS OF SORGHUM GROWN ON SANDY CLAY LOAM SOIL IN SUB-HUMID AND SEMI-ARID AREAS IN SOUTH AFRICA.	Mrubata, K., Nciizah, A.D., Muchaonyerwa, P.
17	SUGARCANE BAGASSE BASED MULCH MATS EFFECTS ON SOIL MOISTURE & TEMPERATURE DYNAMICS AND SPINACH YIELD	Nciizah AD1, 2, Mcinga S3 & Dube E3
18	SOIL CARBON AND PHOSPHORUS AFTER 40 YEARS OF CONTRASTING TILLAGE AND STRAW MANAGEMENT IN DRYLAND WHEAT PRODUCTION UNDER SEMI-ARID TEMPERATE CLIMATE	Nondumiso Zanele Sosibo1,2*, Pardon Muchaonyerwa1, Ernest Dube3 and Toi John Tsilo4
	PHYSICS	
19	EFFECT OF WATER STRESS AND SOIL TEXTURE ON GROWTH AND YIELD OF POTATOES (SOLANUM TUBEROSUM L)	Hlatshwayo CM., Mzezewa J., Odhiambo J.J.O
	SOIL TECHNOLOGY	
29	IMPACT OF IN-FIELD RAINWATER HARVESTING ON SMALLHOLDER VEGETABLE PRODUCTION	Anderson JJ1, Chitja J2, Siwela M2, Khuzwayo M1 & Botha JJ1
21	EXPLORING THE POOR UPTAKE OF NEW AGRICULTURAL TECHNOLOGIES IN RURAL COMMUNITIES IN SOUTH AFRICA	Wessels CH1, Anderson JJ1 & van Niekerk JA2

HORTICULTURE

INDIGENOUS AND MEDISINAL PLANTS

CROP PRODUTION

CROP PROTECTON/ WEEDS AND INVADERS

	CROP BREEDING	
45	RESPONSES OF MAIZE INBRED LINES TO COMBINED EFFECTS OF HIGH TEMPERATURE AND ALUMINUM TOXICITY	Zishiri, R.M.1, Mutengwa, C.S.1, Bradley, G1.
46	USE OF DROUGHT TOLERANCE INDICES TO SCREEN WHEAT GENOTYPES FOR DROUGHT TOLERANCE UNDER FIELD CONDITIONS IN THE EASTERN CAPE PROVINCE, SOUTH AFRICA	Mzileni L.S.[1], Mutengwa C.S.[1], Ripley B.[2], Kondakwenda A.[1]
47	GENETIC MAPPING OF QTL ASSOCIATED WITH YIELD COMPONENT TRAITS IN A DOUBLED HAPLOID WHEAT (*TRITICUM AESTIVUM* L.) POPULATION	MC Lephuthing[1,2*], TP Khumalo[1], VL Tolmay[1,2], E Dube[3] and TJ Tsilo[1,2]
48	GENETIC VARIATION OF WHEAT GENOTYPES FOR GERMINATION PERCENTAGE, COLEOPTILE LENGTH AND ROOT LENGTH	TM Bapela[1,2], TP Khumalo[2], R Patose[2], TJ Tsilo[2] and H Shimelis[1]
	CROP MODELLING	
	AN OPEN-ACCESS WEB PORTAL TO SUPPORT MONITORING AND DECISION-MAKING IN CROP MANAGEMENT USING SATELLITE IMAGERY INDICES	Wallace, MG.[1] and Basson, F.C.[1]
49	CALIBRATION AND VALIDATION OF DSSAT FOR SIMULATING GROWTH AND YIELD OF BARLEY (*HORDEUM VULGARE L.*) IN LIMPOPO PROVINCE, SOUTH ARICA	Koketso S. Madimabe[1,2], Sue Walker[1,3] and Michael van der Laan[1,2]
	CROP NUTRITION AND WATER	
50	GROWTH AND YIELD RESPONSE OF SWISS CHARD (*BETA VULGARIS L.*) TO DIFFERENT FERTILIZER LEVELS AND SOIL MOISTURE REGIMES	[1, 2]Maduna, M.K., [1]Bopape-Mabapa, M.P. and [2]Kutu, F.R.
51	EFFECT OF DIFFERENT IRRIGATION WATER REGIMES ON BIOMASS OF DIFFERENT MULTI-PARENTAL ADVANCED GENERATION INTER-CROSS (MAGIC) AMARANTH GENOTYPES	Khoza L.N[1&2], Mavengahama S[2], Nyathi MK[1], Araya H[1], Bairu MW[1&2], Venter S[1], Denby K[3].
52	IRRIGATION WITH UNCLARIFIED, NEUTRALISED ACID MINE DRAINAGE FROM A HIGH-DENSITY SLUDGE PLANT	Magwaza, S.N., Annandale, J.G. and Tanner, P.D
53	GENETIC, ANATOMICAL, AND MORPHOLOGICAL CHARACTERIZATION OF BAMBARA GROUNDNUT (*VIGNA SUBTERRANEA* (L.) VERDC) LANDRACES IN SOUTH AFRICA	Baloyi, N.H.[1], Swanepoel, P.[1], and Voster, A.A.[2],
	CROP PHYSOLOGY	

54	EFFECT OF GAMMA-IRRADIATION ON PLANTAGO GROWTH AND SECONDARY METABOLITES	Ndou, V.,[1] Sonopo, M.S.[1] and Selepe, M.A.[2]
55	KEY PROTEINS DIFFERENTIATING BETWEEN DROUGHT AND HEAT SENSITIVITY/TOLERANCE IN SOYBEAN	Musa Akanbi[1], N. Ludidi[1, 2]
56	QUANTUM YIELD AND CHLOROPHYLL FLUORESCENCE OF CHICKPEAS GENOTYPE IN RESPONSE TO BIOFERTILIZER	Mashishi, S., Ogola, J.B.O., Odhiambo, J.JO. and Maseko, S.T.
57	EFFECT OF DROUGHT AND RUSSIAN WHEAT APHID INFESTATION ON WHEAT YIELD AND QUALITY TRAITS	Jesumayowa Ajidahun[1], Mpho Mafa[1], and Lintle Mohase[1]
	CONSERVATION AGRICULTURE	
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CROP SCIENCE

ORAL ABSTRACTS

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GROWTH AND YIELD OF WATER EFFICIENT MAIZE (WEMA) IN RESPONSE TO NITROGEN FERTILIZER AND PLANT DENSITY UNDER DRYLAND CONDITIONS IN SOUTH AFRICA

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INTRODUCTION

For many years, agronomists have focused on increasing the yield of maize, an important economic and food security crop. Extensive research was directed at specific agronomic practices that affect maize yields like cultivar selection, nitrogen fertilization, and plant density. Nevertheless, more still needs to be learned on the contributions of different growth attributes to the overall maize yield in response to N fertilizer rates under different plant populations. Hence, this study assessed growth and yield response of Water Efficient Maize (WEMA) to nitrogen fertilizer rates and plant density on a dryland agroecology in South Africa. We hypothesize that WEMA growth and yield will respond differently to different nitrogen fertilizer rates and plant densities.

MATERIALS AND METHODS

A field study was conducted over two planting seasons (2015/16 and 2016/17) in two localities (Taung and Molelwane) of North-West Province. The trial comprised three plant densities: 33 333, 44 444 and 55 555 plants ha^{-1} and five nitrogen rates: 0, 60, 120, 180 and 240 kg N ha^{-1} as main and subplots, respectively. The experiment was laid out in split-plot, fitted into a randomized complete block design with four replicates. Parameters measured included plant height, number of leaves, leaf area index, grain yield, shelling percentage, and harvest index. Data were analyzed using Analysis of Variance (ANOVA) with GenStat. Differences in treatment mean values were tested using Duncan Multiple Range Test (DMRT) measured at 5% probability level.

RESULTS AND DISCUSSION

During vegetative stage, Maize planted at 44 444 plants ha^{-1} and supplied with 240 kg N ha^{-1} had significantly tallest plant (264.2 and 245.0 cm) and highest number of leaves (15.68 and 14.85) than the control at Molelwane and Taung. The highest leaf area index of 3.21 and 3.39 was obtained with 33 333 and 55 555 plants ha^{-1} treated with 240 kg N ha^{-1} at Molelwane and Taung, respectively. At Molelwane and Taung, grain yields of 4.38 t ha^{-1} and 5.72 t ha^{-1} were recorded with 33 333 and 55 555 plants ha^{-1}, fertilized with 180 kg N ha^{-1}, respectively. Highest shelling percentage (93.8 and 77.5%) was recorded with 44 444 plants ha^{-1} unfertilised at Molelwane and Taung, respectively. However, highest harvest index of 0.56 and 0.69 was recorded in plots with 44 444 and 55 555 plants ha^{-1} and fertilized with 60 kg N ha^{-1} in Molelwane and Taung. This showed that WEMA maize performed better under dense plant density with application of high mineral fertilizer.

CONCLUSIONS AND RECOMMENDATION

It is concluded that at the study locations WEMA performed optimally at 44 444 plants ha^{-1} when fertilized with 240 kg N ha^{-1}. This combination is recommended for increasing maize production in this dryland region of South Africa.

KEYWORDS: grain yield, leaf area index, nitrogen fertilizer rates, Water Efficient Maize

THE QUANTITY OF NITROGEN AVAILABLE IN THE SOIL FOLLOWING LEGUME CROPS

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INTRODUCTION

Nitrogen is one of the growth-limiting factors in crop production. Nitrogen from fertilisers is available at a high financial, as well as environmental cost. Legumes can fix nitrogen with a symbiotic relationship with rhizobia bacteria, thereby relieving the reliance on additional fertilisers. The amount of nitrogen that pulses (e.g., grain producing legumes) fix has been tested internationally, however, in Western Cape this amount is unknown. The aim is thus to determine the amount of nitrogen that different pulses fix and its effect on the yield of the following cash crop in a crop rotation system.

MATERIALS AND METHODS

Inoculated pulses consisting of four lupin cultivars (*Lupinus albus, L. angustifolius)*, four pea cultivars (*Pisum sativum*), a faba bean cultivar (*Vicia faba*) and a chickpea cultivar (*Cicer arietinum*) were established at Moorreesburg and Riversdale in a randomised block design with three replications in 2020. Yields of cash crops (wheat at Moorreesburg and canola at Riversdale), were determined in 2021 following the pulses. No additional fertiliser was applied, besides 5-8 kg ha^{-1} nitrogen during planting for pulses and cash crops. Soil nitrate and ammonium contents were determined by taking soil samples (0-300 mm) before and after the cash crop in 2021.

RESULTS AND DISCUSSION

Wheat yield following pulses at Moorreesburg was similar, regardless of the previous pulse crop/cultivar, with an average of 6.4 t ha^{-1}. Canola had significant yield responses following pulses at Riversdale. Canola following one of the pea cultivars, three lupin cultivars, the faba bean- and chickpea cultivars resulted in the highest canola yield. Before the pulses were planted, the average ammonium was 10 and 6 mg kg^{-1} and the average nitrate was 17 and 34 mg kg^{-1} at Moorreesburg and Riversdale, respectively. Available nitrogen at the end of the season was generally lower compared to the start of the season. The average ammonium was 10 and 5 mg kg^{-1} and the average nitrate was 7 and 6 mg kg^{-1} at Moorreesburg and Riversdale, respectively at the end of the cash crop season.

CONCLUSIONS

Pulses fixed sufficient nitrogen to ensure average, to above-average yields of cash crops planted in the subsequent year. Soil samples, however did not give a clear indication of the amount of nitrogen fixed. This study will continue for the next two years to determine the effect of pulses over an extended period. Western Cape grain producers will benefit from findings to supplement their fertilisation programmes.

KEYWORDS: *ammonium, nitrate, crop rotation system*

SWEET SORGHUM (*SORGHUM BICOLOR*) PERFORMANCE IN A LEGUME INTERCROPPING SYSTEM UNDER WEED INTERFERENCE

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INTRODUCTION

Sweet sorghum (*Sorghum bicolor* L. Moench) is highly susceptible to weed competition during the early growth stages; hence, intercropping is considered to overcome the weed competition challenge. This study was conducted to determine the performance of sweet sorghum in legume intercropping systems under different weed management pressures.

MATERIALS AND METHODS

A randomized complete block design (RCBD) with a split-plot treatment structure was used for three crops, viz. sweet sorghum (*Sorghum bicolor* L. Moench) var. Supasweet II, dry bean (*Phaseolus vulgaris* L.) cultivar Ukulinga, cowpea (*Vigna unguiculata* L.Walp.) var. Agrinawa. Three cropping systems (sole crop, inter-row, and intra-row intercropping) as main plot and three weed management levels (no weeding after crop emergence, ceasing weeding 50 days after crop emergence, and weeding throughout) as sub-plot were tested.

RESULTS AND DISCUSSION

Intercropping pattern had a significant ($P < 0.05$) impact on the plant and the number of leaves per plant, while other treatments remained insignificant during the 2017/18 growing season. During the 2018/19 growing season, the intercropping pattern had a significant ($P < 0.05$) effect on dry and fresh biomass and plant height at 60 days after emergence. An increase in weeding frequencies reduced Brix (°Bx). The uncontrolled weed plots had the lowest sweet sorghum dry biomass accumulation, whereas the biomass increased as weeding frequencies increased, but remained insignificant as weeding frequencies further increased from 50% to 100% in both seasons.

CONCLUSIONS

It can be concluded that sweet sorghum/dry bean intra-row intercropping and intermediate weeding resulted in optimum sweet sorghum biomass production and sugar levels.

KEYWORDS: biomass; Brix; intercropping; weeding frequency; weed management

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EVALUATING THE SOIL HEALTH AND FERTILITY STATUS OF CONSERVATION AND REGENERATIVE AGRICULTURAL SYSTEMS ACROSS MULTIPLE ECOTOPES

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INTRODUCTION

Conventional agriculture degrades soil health and fertility through excessive synthetic fertilizer use, intensive tillage, and monoculture crop production (Sanaullah et al. 2020). Transitioning to conservation (CA) and regenerative agriculture (RA) is advised to mitigate and reverse this degradation (Newton et al. 2020). Conservation agriculture pactices include minimal tillage, crop diversification, and permanent soil cover, while RA adds integration of cover crops and livestock grazing. However, information on these systems' potential soil health and fertility benefits remains limited, especially considering South Africa's many ecotopes. We hypothesised that implementing CA and RA systems will significantly improve soil health and fertility, with integrated crop-livestock RA systems providing the most benefits. Furthermore, we hypothesised that the soil health and fertility status would vary between ecotopes.

MATERIAL AND METHODS

Five different replicates of on-farm trials in the Maluti (Marquard and Clocolan) and Mpumalanga Highveld (Kinross and Standerton) regions were monitored during the 2020/2021 and 2021/22 summer growing seasons. The RA system (with a maize, soybean, cover crop rotation, and livestock integration) was compared to CA and conventional tillage (CT) systems that incorporated maize and soybean rotations, as well as grazed veld as a reference system. Soil sampling occurred approximately 100 days after the planting of maize. Collected samples were sent to Ward Laboratories (USA) to conduct the Haney Soil Health Tool analysis, while active carbon was analysed at the North-West University.

RESULTS AND DISCUSSION

Comparing soil health scores and active carbon levels between the different agricultural systems revealed no significant difference. Soil health scores were greatest in the natural veld and the trend in crop treatments was RA > CA > CT. The highest soil health score during both seasons was recorded in the RA system in one of the Mpumalanga Highveld ecotopes near Standerton, characterised by Sepane soil with a clay content ranging between 40-47%. This high clay content exposes the probability of higher soil health scores, including possible explanations for higher soil organic matter and active carbon readings. No significant trend for the first two seasons is not entirely surprising as soil ecosystems take time to recover.

CONCLUSIONS

The studied soils remain degraded with low soil organic matter and organic carbon levels (soil health scores). Consequently, the RA systems have to date effected minimal restoration to the soil health and fertility. The results confirm that soils are degraded by CT systems and are recovering slowly, whereby successful soil restoration using RA systems requires a minimum transformation period of three years.

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KEYWORDS: *Haney Soil Health test, soil active carbon*

QUALITATIVE ANALYSIS OF WHEAT GENOTYPES UNDER DROUGHT USING NEAR INFRARED (NIR) REFLECTANCE

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INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is an important crop globally, but its production is restricted by drought stress. Its quality is determined by the grain storage protein and starch composition. Drought stress causes substantial fluctuations in protein composition, resulting in bread quality variation. Silicon has shown to improve nutrient uptake, however, there is little research on its effect on bread quality. Near infrared (NIR) reflectance spectroscopy is a non-destructive, cost-effective, and efficient tool in the grain industry for assessing quality traits. The objective of this study is to qualitatively examine the effect of silicon on wheat genotypes under drought stress for nitrogen, carbon, sulphur, silicon, and grain protein content.

MATERIALS AND METHODS

Twenty wheat lines were subjected to two silicon formulations, under drought stressed and non-stressed conditions and evaluated across greenhouse and field environments. Liquid silicon was applied as a weekly drench until anthesis, whilst the granular silicon was applied at planting. Drought was imposed at anthesis until maturity. Wheat grain for all treatments were collected and 120 random samples were milled into whole-grain flour. Grain and whole-grain flour was subjected to scanning using NIR of wavelength range 3500-12500 nm. Fifty randomly selected whole-grain flour samples were selected for DUMAS testing for carbon, nitrogen and sulphur using a LECO CNS analyser. Grain protein was calculated by a nitrogen conversion factor of 5.69. Foliar material from both trials were milled and scanned for silicon uptake. Genotype MC14 foliar material was selected and tested chemically using acid digestion for silicon uptake. Carbon, nitrogen, grain protein sulphur and silicon linear regression models were generated from the flour and chemical testing.

RESULTS AND DISCUSSION

The nitrogen model generated an R^2 of 91.3% with an RMSEP of 0.06. Carbon generated an R^2 of 50.13% with an RMSEP of 0.444. Sulphur generated an R^2 of 77.01% with an RMSEP of 0.023. Grain protein generated an R^2 of 84.21% and an RMSEP of 0.463. Silicon generated an R^2 of 96.25% and an 18.9 RMSEP. The effect of silicon on carbon, nitrogen, sulphur, and grain protein of wheat under drought stressed and non-stressed conditions is dependent on genotype and silicon formulation. The silicon model showed that the untreated MC14 genotypes had minimal silicon compared to those treated with silicon under drought. This indicates that silicon is actively taken up by MC14.

CONCLUSIONS

Silicon affects nutrient uptake and is dependent on formulation and genotype. Silicon application can effectively improve wheat grain nutritional quality under drought conditions.

KEYWORDS: *near-infrared reflectance, quantitative analysis, silicon*

EVALUATING PRE-HARVEST SPROUTING OF SOUTH AFRICAN WHEAT (*Triticum aestivum L.) CULTIVARS* IN THE EASTERN CAPE PROVINCE

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INTRODUCTION

Pre-harvest sprouting (PHS) of wheat is the germination of mature grain in the ear at or prior to harvest (Patwa and Penning 2020), due to a lack of dormancy during rainfall events accompanied by conducive conditions. This results in the synthesis of the enzyme, alpha-amylase, which immobilises seed reserves thus reducing grain yields and quality. Areas with rainfall during the harvesting period, such as the Eastern Cape Province, are at highest risk to PHS.

MATERIAL AND METHODS

In the Eastern Cape Province, two trial sites (University of Fort Hare Experimental Farm near Alice and Zanyokwe irrigation scheme near Keiskammahoek) were used. At both sites, 40 wheat cultivars were planted in a latinised row-column design with three replicates. Three assessments (visual score, falling number and alpha-amylase testing) were performed to assess PHS. Ten hand harvested ears per plot were placed into a rainfall simulator for 72 hours with 10 mm of simulated rainfall four times in a 24-hour period. Visual scores were evaluated on a 1 (no sprouting) to 8 (fully sprouted) scale. The falling number was determined using American Association of Cereal Chemistry (AACC) method 56-81.03, and enzyme assay was conducted using AACC method 22-02.0. These results were correlated to evaluate the genotype x environment interaction.

RESULTS AND DISCUSSION

In terms of visual assessment, most cultivars responded similarly across the two environments with few cultivars being significantly different between sites, however a genotype x environment interaction ($p<0.05$) was detected. A genotype x environment interaction ($p<0.05$) was present between sites for falling number. When grouping the cultivars according to minimum falling number required for grading, all cultivars except one, had falling numbers of more than 220 seconds for Zanyokwe. Many cultivars at Fort Hare, however, had low falling numbers. Although a significant interaction was present for both visual score and falling number between sites, there was no correlation ($p>0.05$) between visual score and falling number. In contrast, there was a negative correlation ($p<0.05$) between falling number and alpha-amylase, and no correlation ($p>0.05$) between alpha-amylase and visual score.

CONCLUSIONS

Preliminary results show some cultivars concurrently have low falling numbers and high visual scores. This, however, is not the case for all cultivars. A significant but weak correlation was detected between falling number and visual score. More work is needed over multiple years to draw rigorous conclusions and to understand the disconnect or poor correlation between the visual score and falling numbers.

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KEYWORDS: *alpha-amylase, cultivar evaluation, falling number*

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THE EFFECT OF COVER CROP MANAGEMENT ON WEED SEEDBANK DYNAMICS UNDER CONSERVATION AGRICULTURE

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INTRODUCTION

Weed management is a major challenge for Western Cape grain producers. Weeds can result in reduced crop yields. Producers practicing conservation agriculture (CA) rely on herbicides and the development of herbicide resistance further complicates effective weed control. Untested claims regarding weed dynamics in CA systems exist, including the use and management of cover crops to reduce viable weed seed production. The aim of the study is to determine if cover crop type and utilisation influence weed seedbank dynamics, thus effective weed control.

MATERIALS AND METHODS

An experiment was conducted at the Langgewens Research Farm (-33.276822 S 18.703171 E) in the Swartland. Two cover crop types (whole plot factor: mainly cereal- and mainly legume-based) were left as a mulch, removed as hay, or grazed by sheep (sub-plot factor). To evaluate the weed seedbank dynamics, twelve soil cores (to a 5 cm depth) were taken per sub-plot prior to the first rains in 2017, 2018, 2019 and 2020. Soil cores of each sub-plot were placed in one tray in a germination area, followed by destructive counting of emerging weed seedlings. Weed seedlings abundance was compared between the sample taken immediately before the cover crop was sown with the sample taken in the subsequent season.

RESULTS AND DISCUSSION

Reductions in total – and *Lolium* seedling abundance were variable between sub-plots so no significant ($P>0.05$) effects of treatment were observed. Trends observed were, legume-based cover crops reduced *Lolium* abundance for the period 2017 to 2018 by 13.2, 52.2 and 340.0 seedlings m^{-2} for cover crop managed as mulch, removed as hay, and grazed by sheep, respectively. Similar figures were reported for periods 2018 to 2019 (241.8, 196.0, 202.5) and 2019 to 2020 (0.1, 280.0, 291.4). Trends observed were, cereal-based cover crops reduced *Lolium* abundance for the period 2017 to 2018 by 804.0, 666.8 and 627.7 seedlings m^{-2} for managed as mulch, removed as hay, and grazed by sheep, respectively. Similar figures were reported for periods 2018 to 2019 (106.4, 185.0, 78.3) and 2019 to 2020 (222.2, 143.7, 202.7).

CONCLUSIONS

All treatment combinations were equally effective as a weed management strategy in reducing total– and *Lolium* abundance. Cover crops utilised as hay or grazed might be the better choice since cash flow should improve if hay or animal production already forms part of the farming system.

KEYWORDS: *Lolium management, weed seedbank*

EFFICACY OF GRAMINICIDE-GLYPHOSATE TANK MIXTURES FOR COUCH GRASS (*Cynodon dactylon*) CONTROL

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INTRODUCTION

A survey carried out amongst local maize producers during 2018, identified couch grass (*Cynodon dactylon*) as the most problematic and difficult to control grass weed. The current study investigated, through glasshouse trials, the efficacy of graminicide-glyphosate tank mixtures on two couch grass populations from Bethlehem and Potchefstroom respectively.

MATERIALS AND METHODS

Two glasshouse trials (26°C/18°C) were conducted during 2021/22 at ARC-Grain Crops (Potchefstroom) and ARC-Small Grain (Bethlehem) respectively. Couch grass sods were collected at each site and transferred to seedling trays, which were then used in the respective glasshouse trials. The trays were covered with a layer of soil and watered three times a week. Spraying commenced once sufficient regrowth occurred (± 4 weeks after covering). Ten products, consisting of glyphosate, topramezone, topramezone/dicamba, clethodim, fluasifop-p-butyl, haloxyfop-R methyl ester and saflufenacil, were included whereby a total of 29 treatment combinations were evaluated (replicated five times). Percentage green material was determined at 0, 14, 28, 42 and 56 Days after treatment (DAT). Dry weight (g) was determined after the above ground material were removed (56 DAT) and dried for 48 h at 60°C. Weed Control$_{(Visual)}$ and Weed Control$_{(Dry\ weight)}$ were calculated and expressed as a % of the respective control treatments, which did not receive any herbicide application.

RESULTS AND DISCUSSION

Weed Control$_{(Visual)}$ observed in the majority of treatments indicated that regrowth occurred from 28 DAT onwards, resulting in the grass staying green for longer, compared to the untreated control. The Bethlehem couch grass population was, however, acceptably controlled by Roundup Turbo (1X label rate), followed after three days with Fusilade Forte (1X) or Fusilade Forte (2X) (double knock treatment), as well as Mamba (1X) + Galant Super (2X) tank mixture. The Potchefstroom couch grass was best controlled by Roundup Turbo (1x) followed after 3 days with Fusilade Forte (0.5X) or Fusilade Forte (2x) (double knock treatment) as well as Slash (1X) + Series (2X) in tank mixture.

CONCLUSIONS

The two couch grass populations differed slightly regarding the treatment that gave effective control. Glyphosate used in spraying programmes with fluazifop-p-butyl, haloxyfop-R-methyl ester or clethodim were identified as giving acceptable couch grass control. These treatments will be evaluated under field conditions during 2022/23 and 2023/24.

KEYWORDS: *Bermuda grass, double knock, tank mixtures*

ACKNOWLEDGEMENTS

Agricultural Research Council and Maize Trust for funding, as well as Syngenta, BASF and AECI for product donation.

COMPETITIVE ABILITY OF FOUR GRASS WEEDS IN MAIZE

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INTRODUCTION

Knowledge of the competitive ability of weeds provide a better understanding of the requirements for weed control. The ability of four common grass weeds in maize were investigated in glasshouse studies.

MATERIALS AND METHODS

Two glasshouse trials were conducted (2018/19 and 2019/20, 28°C/18°C). Two soil types namely a sandy clay-loam (35% clay, 59% sand and 5% silt) and a sandy loam soil (16% clay, 79% sand and 5% silt) were included as treatments. *Eleusine coracana, Panicum maximum, Urochloa mosambicensis* and *U. panicoides* were respectively planted in 80 ℓ pots to obtain maize:grass ratios of (1) 1:0 (control), (2) 1:2, (3) 1:4, and (4) 1:7, simulating densities of 14, 28 and 49 grasses m^{-2}. Each treatment was replicated four times. Maize cultivar P2707WYR was planted one week after grasses emerged. Pots were watered daily (2 ℓ pot^{-1}). Plant height and total biomass of the maize plants were determined at flowering and physiologically mature growth stages respectively. Dry weed biomass per pot was established ±15 weeks after planting. Analyses of variance was conducted per trial (P=0.05).

RESULTS AND DISCUSSION

ANOVA results demonstrated that competition with *U. mosambicensis* resulted in significantly lower maize plant height, as well as maize biomass when compared to *E. coracana* across the two soil types, whilst yielding similar plant heights and maize biomass than *P. maximum* and *U. panicoides* in both trials. The competitive ability of the four weeds was accordingly ranked as *U. mosambicensis* > *U. panicoides* ≥ *P. maximum* > *E. coracana*.

CONCLUSIONS

U. mosambicensis dominated regarding competitive ability as measured through maize height and biomass production in both soil types, whilst *E. coracana* was the least competitive.

KEYWORDS: *Eleusine coracana, interference, Panicum maximum, Urochloa mosambicencis, Urochloa panicoides*

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SOIL MINERAL NITROGEN RESPONSE TO N FERTILIZER APPLICATION IN A CONSERVATION AGRICULTURE SYSTEM WITH CANOLA (*BRASSICA NAPUS* L.)

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INTRODUCTION

Soil nitrogen (N) dynamics change due to a shift from conventional- to conservation agriculture (CA) practices. To ensure the successful determination of N fertilizer requirement, more information on site specific in-season soil N relations is needed. The aim of this study was to determine the relationship between N fertilizer application and the resultant soil mineral N response.

MATERIALS AND METHODS

Field trials were executed at Darling, Porterville, Moorreesburg, Riviersonderend and Riversdale from 2016 to 2019. Eight N rates ranging from 0 to 190 kg N ha^{-1} in the form of limestone ammonium nitrate (LAN) at the 4-5 leaf stage were evaluated. A randomised block design with four replications was used. Soil samples were collected to a depth of 300 mm before planting, pre-topdress, post-topdress and post-harvest. NO_3^--N and NH_4^+-N were determined colorimetrically on a SEAL AutoAnalyzer 3. For the purpose of this presentation total mineral N was calculated as the sum of NO_3^--N and NH_4^+-N.

RESULTS AND DISCUSSION

At planting, soil mineral N concentration was highest ($p < 0.05$) after dry years and lowest where sites received severe rainfall with consequent leaching prior to planting. Generally, no differences in soil mineral N concentration were found between treatments receiving 0 kg N ha^{-1} and 25 kg N ha^{-1} at planting. After topdressing <13 mm of rainfall showed to be sufficient to initiate crop N uptake in sandy soils, whereas, in clayey soils <12 mm of rainfall was insufficient to initiate crop N uptake due to slow water movement with longer exposure of soil water to evaporation losses. In shale-derived soils, mineral N concentration generally increased as rainfall increased. After harvest, the highest ($p < 0.05$) soil mineral N concentration was found after applying 190 kg N ha^{-1} at all sites during dry years, while no differences ($p > 0.05$) were found between N rate treatments during wetter years.

CONCLUSION

Soil mineral N concentration varied according to soil properties, crop N demand (biomass production) and total rainfall following topdressing. Results obtained highlight the necessity to avoid excessive N fertilizer applications, especially during dry years, as excessive soil mineral N concentration does not increase yield, but results in an oversupply of soil N, which can contaminate natural resources and reduce profit.

KEYWORDS: *soil mineral N concentration, canola N demand, rapeseed*

COMMERCIAL SCALE CROP IRRIGATION USING UNTREATED CIRCUMNEUTRAL MINE WATER IN MPUMALANGA

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INTRODUCTION

Coal mining powers many industries and employs countless South Africans. All this, however, occurs at great risk to the environment as coal mining leads to the formation of mine waters. Agricultural irrigation may provide an opportunity for some of these waters to be utilized beneficially. The main objective of this study is to demonstrate the successful use of untreated circumneutral mine water for the irrigation of field crops on a commercial scale in the medium to long term.

MATERIALS AND METHODS

A field experiment is being carried out at the Beestepan maize farm, next to Mafube Colliery in Mpumalanga (25°48'38.0"S 29°45'15.1"E). The experiment started in the spring of 2016 and is currently in its seventh season. The study consists of three trial sites, each comprising of a dryland and pivot irrigated area. Two of the pivots extract water from a fresh water dam, while the third applies circumneutral mine water from Mafube Colliery. The mine water is gypsiferous with a pH of 7.8 and an EC of 290 mS/m, containing 72.5 mg/l of sodium, 304 mg/l of magnesium and 370 mg/l of calcium, with major anion concentrations of 15.8 mg/l chlorine and 2005 mg/l sulphate. Maize (cultivar PHB 32B07BR) was planted at all three sites and the agronomic practices are kept the same at all three sites and have remained relatively constant since the trial's inception. Soil and plant samples were taken and analyzed at the end of every season, while irrigation and borehole water samples were taken twice a month. An economic analysis was also done at the end of every season.

RESULTS AND DISCUSSION

The crop performed similarly at all three sites. The crops grown using the mine water had element concentrations that were well below international thresholds for food and fodder safety. The borehole water samples showed that the water quality remained relatively unchanged. The soil element concentrations of the dryland and mine water irrigated field were very similar. Economic analyses showed that growing field crops using mine water is more profitable than growing crops under dryland conditions in Mpumalanga.

CONCLUSIONS

In the short to medium term, some untreated circumneutral mine waters can indeed be used to successfully irrigate field crops on a commercial scale, producing profitable yields with crops that are safe to consume without causing unacceptable harm to the environment. The trial is on-going to determine the long-term sustainability of this practice.

KEYWORDS: *food safety, crop irrigation, untreated mine water*

ACKNOWLEDGEMENTS

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THE POTENTIAL OF MIXED COVER CROPS AS DRYLAND FODDER OR PASTURE

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INTRODUCTION

Cover crops have the potential to offer improvements to soil structure, water relations and soil biological life. As fodder, it offers a more balanced diet than a pure crop stand. To enable producers to make more informed decisions on the implementation of a mixed cover crops in their rotation systems it is necessary to test the production potential and quality of these mixtures.

MATERIALS AND METHODS

To evaluate cover crop mixtures as potential quality dryland pastures for livestock, eight treatments varying in species composition were compared to two control pastures currently in use. The controls included a pure fodder oat crop and a pure medic pasture. The ten treatments were replicated three times in a complete randomised block over a two-year period at the Langgewens Research Farm in the Swartland. Biomass was determined monthly up to four months following establishment cuts 1, 2, 3 and 4. Representative samples were analysed and fodder quality was determined. The eight quality parameters included fiber, acid detergent fiber (ADF), neutral detergent fiber (NDF), Ash, protein, fat, calcium and phosphorus content. The data were subjected to analysis of variance (ANOVA). Fisher's least significant difference (LSD) was calculated at the 5% level to compare treatment means, followed by a Dunnett's t-test to compare mixtures to controls.

RESULTS AND DISCUSSION

Significant differences were found between biomass produced as well as in the eight fodder quality parameters assessed. Dry biomass production between the cover crop treatments outcompeted the two controls on multiple occasions during both seasons. The results point to the usefulness of the cover crop mixtures in that a producer can compile his pasture according to his specific requirements in terms of the quality needed. Biomass sampling indicated that more biomass was produced by the different treatments if grazed early (cut 1) and late in the season (cut 4), compared to grazing monthly (cuts 1, 2, 3 and 4). The current study leads to the question of whether high intensity grazing over short periods of time will have a different result in terms of biomass production and quality of the cover crop mixtures.

CONCLUSIONS

The potential of cover crop treatments as balanced pastures is illustrated. With sufficient dry biomass production (grazing potential), together with eight different fodder quality parameters serving its own unique contribution to the overall diet.

KEYWORDS: biomass, Conservation Agriculture, grazing, mixtures, quality

THE POTENTIAL OF HYBRID POTATO PRODUCTION IN SOUTH AFRICA

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INTRODUCTION

All commercially grown potatoes in South Africa are tetraploid. Breeding tetraploid potato varieties is slow and expensive, and genetic gains in potato breeding have been minimal. Tetraploid varieties must be clonally reproduced to maintain genetic uniformity, which is time-consuming and entails the risk of accumulating tuber-borne diseases over generations. Due to recent advances in breeding techniques, it is now possible to breed hybrid, diploid potato varieties from genetically uniform parent lines. Hybrid potato breeding holds the promise of rapid progress in breeding, as well as a faster reproduction of promising new varieties from seed. It is important to test and optimize the agronomic performance of hybrid varieties under South African conditions. Hybrid potato breeding may have considerable impact on the seed tuber production sector and the potato sector in general. We present results from a research project testing hybrid potato varieties for the first time in South Africa.

MATERIAL AND METHODS

Field trials were conducted at the experimental farms of the University of Pretoria and the University of the Free State in the 2021/22 growing season. Plantlets of 10 different hybrid varieties were grown from seed under controlled conditions in greenhouses and transplanted 6-8 weeks after seeding. The performance of hybrid varieties was compared with that of two popular commercial varieties grown from tubers (Mondial and Sifra). Seed tubers were planted at the time when hybrid plantlets were transplanted into the field. Potato plants from tubers and from seed received similar field management.

RESULTS AND DISCUSSION

Plantlets were successfully produced (>90% success rate) from seed under controlled conditions. High rainfall during the season resulted in crop damage and a high disease pressure due to bacterial wilt and fungal diseases. The survival rate of plantlets transplanted into the field was lower than the establishment from tubers. The yield per plant from hybrid varieties equaled 20-50% of that of the two tuber-based varieties, with a relatively high fraction of small tubers (< 100 g) from hybrid varieties.

CONCLUSIONS

The growth and yield of hybrid varieties was not competitive with that of popular tuber-based tetraploid varieties yet. This is likely related to a lack of experience and inherent challenges with the production of potato plants from seed, as well as the genetic qualities of hybrid varieties that have never been screened under South African conditions. As the propagation material (seed or tubers) and the genetic background of varieties were confounded, future trials will also include hybrid varieties grown from tubers.

KEYWORDS: hybrid breeding, seed tubers, *Solanum tuberosum,* true potato seed, variety testing

YELLOW FIELD PEAS IN SOUTH AFRICA: EFFECT OF TILLAGE PRACTICES AND PLANTING DENSITY ON SOIL HEALTH AND GRAIN YIELD

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INTRODUCTION

Successful establishment of yellow field peas (*Pisum sativum*; YFP) in South Africa has the potential to play a significant role by incorporating a legume in the crop rotations of grain and/or oilseed crops. No research has been conducted on the cultivation of YFP in South Africa. The main objective of the study was to determine optimum seeding rates for YFP across different agroecological zones in South Africa. The second objective was to investigate the influence of tillage on YFP performance and soil health properties.

MATERIALS AND METHODS

Field trials were undertaken from 2021 to 2022 at six sites across South Africa, namely Caledon, Moorreesburg, Vrede, Middelburg, Malelane and Komatipoort. At each site, the experiment was laid out in a randomised split plot design with two treatment factors, namely tillage system and YFP seeding rate, replicated in four blocks. The tillage system was defined as the whole plot factor and involved tillage and no-tillage. The seeding rates were the subplot factor and included seeding rates of 120, 150 and 180 kg ha^{-1} for the 2021 growing season. Planting densities were reduced to 80, 100, 120 and 140 kg ha^{-1} for the 2022 growing season according to literature and industry inputs. Plant biomass was measured twice during the growing season in combination with leaf area measurements. Yield components were determined at crop maturity prior to harvest. Soil samples were taken and analysed before planting, during the growing season and after harvest.

RESULTS AND DISCUSSION

For both tillage and no-tillage treatments the highest grain yields, seeds per pod and pod length were obtained for seeding rates of 150 kg ha^{-1} during the 2021 growing season. Higher seeding rates produced higher biomass yields. Soil organic matter, soil carbon and active carbon were significantly higher under no-tillage. During the 2022 growing season the no-tillage treatment produced the highest yields at a seeding rate of 100 kg ha^{-1}, where tillage treatment produced the highest yields at a seeding rate of 120 kg ha^{-1} at all trial sites. Tillage increased soil microbial richness and soil microbial abundance at both sites.

CONCLUSIONS

Preliminary results indicate that planting densities of 150 kg ha^{-1} (2021), 100 and 120 kg ha^{-1} (2022) produced the highest grain yield. YFP cultivated under both till and no-tillage conditions improve soil microbial activity, increase soil organic matter, soil organic carbon and active carbon.

KEYWORDS: *conventional tillage, conservation tillage, crop rotation, seeding rates, soil biology*

ACKNOWLEDGEMENTS

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POTATO MINERAL NUTRITION, GASEOUS EXCHANGE, LEAF ULTRASTRUCTURE AND TUBER QUALITY RESPONSES TO CONCURRENT ELEVATION IN CARBON DIOXIDE AND TEMPERATURE

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INTRODUCTION

The current rapid increase in atmospheric carbon dioxide (CO_2) concentration and global temperatures has major impacts on crops' physiology, growth, yield and quality. Potato is classified as a heat-sensitive temperate crop and is expected to be negatively affected by rising temperatures, but is also expected to respond positively to elevated CO_2 ([eCO_2]). This study investigated the leaf ultrastructural, physiological, leaf mineral nutrient and tuber quality responses of potatoes to elevated temperature (eT) and the role of [eCO_2] in counteracting the negative effects of eT.

MATERIALS AND METHODS

A growth chamber trial was conducted using cultivars Mondial and BP1 and two CO_2 levels: ambient ([aCO_2] = 415 ppm) and elevated [eCO_2] = 700 ppm. Two temperature regimes were applied: ambient (aT, T_{min}/T_{max} = 12/25°C) and eT (T_{min}/T_{max} = 15/38°C), rising gradually from 6:00 to reach T_{max} at noon and maintained until 16:00. Light increased gradually from 06:00 until 12:00 (1000 µmol m^{-2} s^{-1}), followed by a gradual decline until 20:00 (14 hours). The planting medium was a compost / sand mixture. Humidity was set at 60-70% and fertigation was done twice a week. Gaseous exchange measurements were done at 21, 42, 63 and 84 days after emergence (DAE), while leaf ultrastructure imaging and mineral analyses were done at 63 DAE and tubers harvested at 140 DAE.

RESULTS AND DISCUSSION

Elevated CO_2 enhanced photosynthesis at both temperature regimes and increased the concentration of most micro and macronutrients in potato leaves, but reduced N and K concentrations. The elevated temperature increased Mg concentration, while P was not affected by CO_2 and temperature. The elevated temperature increased stomatal conductance and stomatal opening and reduced leaf starch grains size. Elevated [CO_2] did not affect tuber concentration of most minerals, but significantly reduced K, P, Cu, Zn, and Mo concentrations. Tuber flour colour, ash, fat, pH and crude protein were not affected by [eCO_2]. However, [eCO_2] increased tuber starch content, dry matter content and specific gravity.

CONCLUSIONS

Future elevated temperatures will increase stomatal opening, increase stomatal conductance and reduce leaf starch grain size, while [eCO_2] will enhance photosynthesis and ameliorate the negative effects of eT. Elevated CO_2 will increase the concentration of most nutrients in potato leaves, while eT will have minimal effect on leaf nutrient concertation. Elevated CO_2 will have minimal effect on tuber mineral nutrients, but the reduction in K might affect tuber nutritional value and quality.

KEYWORDS: *nutrients, photosynthesis, starch grain, stomata, stomatal conductance*

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RESPONSE OF CROPS AND SOIL TO IRRIGATION WITH SIMULATED ACID MINE DRAINAGE

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INTRODUCTION

The use of untreated Acid Mine Drainage (AMD) from coal mines for crop irrigation on strategically limed soils is being considered a potential option for mine water management, particularly in isolated areas without water treatment infrastructure. However, soil accumulation and trace element loading of plant tissue are of potential concern, as these waters often contain high concentrations of potentially toxic, acid-generating metals (Al^{3+}, Fe^{2+}, and Mn^{2+}), which may hyper-accumulate in soils and plant tissue. Hence the aim of this study was to evaluate the response of different crops to irrigation with untreated AMD.

MATERIALS AND METHODS

Two glasshouse pot trials were conducted in the summer and winter seasons of the 2021/2022 cropping season. Four summer crops (*Zea mays, Sorghum bicolor, Vigna unguiculata,* and *Glycine max*) and four winter crops (*Tritium aestivum, Avena sativa, Pisum sativum,* and *Medicago sativa*) were grown under irrigation with simulated AMD. Soils used are sandy loam textured and classified as a deep Hutton loamy, kaolinite, mesic, typic, highly weathered soil. Irrigation with AMD began two weeks after crop emergence, with a 15% leaching fraction. All crops were subjected to four treatments; 1. Tap water with lime, 2. Tap water with extra lime, 3. AMD with lime and 4. AMD with extra lime. Extra lime catered for acidity brought by AMD. The experimental design was a split plot with lime and irrigation water treatments as main plot treatments and crop species as sub-plot treatments. Data were collected on biomass and grain yield, plant tissue analysis, and soil parameters (EC, pH, Al, Mn, Fe, and Mn).

RESULTS AND DISCUSSION

Irrigated summer crops were successfully grown until physiological maturity. However, irrigation with untreated AMD significantly ($P<0.05$) reduced grain yield in maize, cowpeas, and soybeans. Winter crop yield was reduced by 61 % in lucerne, while some field pea plants dried up soon after flowering. Calculated Target Hazard Quotient (THQ) showed that harvested grain was safe for human consumption. Soil pH (KCl) varied between 5.0 and 6.5 across all treatments, possibly due to the applied lime and high soil buffering capacity. The ECe, as well as Al, Fe, and Mn contents in the soil were all inversely correlated with pH, demonstrating that H+ activity controls these metal concentrations in the soil. Due to low solubility of Al in the pH range found in the soil, the relationship between Al and other soil parameters was poor.

CONCLUSIONS

It is concluded that leguminous crops are more susceptible to acidity due to AMD, while cereals can be irrigated with untreated AMD on limed soils. Management of soil pH is key if untreated AMD is to be used for crop irrigation. It is recommended that more crop species be screened to select crops for mine water irrigation trials and consider root zone effects of irrigation with such waters be conducted over several seasons.

Keywords: *crop irrigation, hazard quotient, health risk, hyper-accumulate, plant tissue*

ACKNOWLEDGMENTS

Water Research Council for funding this project and the University of Pretoria for providing all necessary facilities.

AGRONOMIC, GENETIC AND QUANTITATIVE TRAIT CHARACTERIZATION OF NIGHTSHADE ACCESSIONS

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INTRODUCTION

Morphological characterization of available accessions is key to identify and select superior accessions for breeding or production. Nightshades (*Solanum nigrum* complex) are among many underutilized and neglected African indigenous leafy vegetable (AILVs) crops. These species play an important role in the food security of many resource-poor farming families and have potential value as a genetic resource for the global community. The study's goal was to perform a quantitative morphological characterization of nightshade accessions to compute genetic variance components to identify superior parental lines exhibiting desirable traits for breeding.

MATERIALS AND METHODS

The study was conducted at the North-West University Mafikeng, Crop Science Garden (25. 810 S and 25. 630 E, at an elevation of 1276 m). Fifteen nightshade accessions were evaluated in field trials conducted using a randomized complete block design with three replicates over two growing seasons. The following morpho-agronomic traits were collected: plant height, number of leaves, number of primary branches, stem diameter, leaf chlorophyll content, plant spread, number of fruits, fruit fresh mass, leaf fresh mass, leaf dry mass, stem fresh mass, stem dry mass, smallest leaf area, biggest leaf area, number of days to 50% flowering, days to fruit forming, days to fruit repines, leaf yield in grams per plant, stem yield in grams per plant, fruit yield in grams per plant, total biomass in grams per plant, and harvest index.

RESULTS AND DISCUSSION

The highest fresh leaf yield was exhibited by accessions Scabrum (805.30 g/plant) and Ncampus (718.60 g/plant), while NigSN18 (1782.00 g/plant) and ManTown (1507.90 g/plant) were the top fresh fruit yielders. The first four principal components (PCs) accounted for 86.82% of the total variation, which had an eigenvalue greater than 1. The cluster analysis grouped the accessions into 14 groups, based on their genetic similarity and dissimilarity. Results of genetic studies revealed that phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all parameters evaluated, indicating the higher environmental influence on the expression of these traits. GCV and PCV were higher for the largest leaf area, moderate to high for the remaining characters, and low for leaf fresh yield per plant. High heritability (H^2=70.59%), coupled with genetic advance as a mean percentage (GAM-142.4%) were computed, indicating the presence of additive gene effects. Hence, recurrent selection can be employed for the improvement of this trait in nightshades.

CONCLUSIONS

The tested accessions revealed sufficient agronomic and genetic variability, which can be exploited for crop improvement. Scabrum, Nshad40 and NigSN18 have been identified as the best accessions which could contribute to development of improved varieties which are high-yielding and late flowering.

KEYWORDS: accession, genetic advance, heritability, morphological, *Solanum*, PCA

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PROSPECTS FOR MINE WATER IRRIGATION IN THE UPPER OLIFANTS CATCHMENT

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INTRODUCTION

With the mining industry in South Africa producing large volumes of mine-affected waters, and the agricultural industry requiring large water inputs to improve and optimize the yields of crops, irrigation with mine-affected waters presents a noteworthy opportunity. In the Mpumalanga Coalfields, the Upper Olifants catchment was identified as being highly impacted by mining activities, especially due to mine water decanting into river systems. The use of mine water for irrigation in this catchment would present an opportunity to address the mine water challenge while also contributing to agricultural production and socioeconomic development. The aim of this study was to evaluate the potential for crop irrigation with mine waters in the Upper Olifants catchment.

MATERIALS AND METHODS

High level desktop studies were conducted to identify operational mines in the Upper Olifants catchment, as well as to obtain excess mine water quantity and quality data for the different mines. A site-specific, risk-based irrigation water quality Decision Support System (DSS) was used to ascertain the suitability of these waters for irrigation. Two cropping systems were modelled, a maize monocrop system and a soybean-wheat crop rotation system. The area of land required to fully utilize the excess mine waters was calculated using modelled irrigation water requirements obtained using the DSS.

RESULTS AND DISCUSSION

Most of the assessed waters are not very acidic, and it appears feasible to utilise them untreated, especially if growers commit to the application of limestone to their fields. Less yield reductions associated with salinity are expected for the soybean-wheat crop rotation system. This can be attributed to these crops being more salt tolerant than maize. The maize monocrop system will require larger areas to utilize the excess volumes of water than the soybean-wheat crop rotation system. This can be attributed to the monocropping system having less water requirements than the crop rotation system. Furthermore, higher irrigation requirement is expected in this area during winter as there is no rainfall to supplement the irrigation. Current projections indicate that the amount of excess water available in the next ten years would allow for the irrigation of several thousands of hectares of land.

CONCLUSIONS

The prospects for irrigation with mine water in the Upper Olifants catchment are good. There are many technical considerations that require attention when setting up a mine water irrigation scheme and it would be prudent to control or regulate the process if considered. However, with careful management and planning, irrigation with mine waters is worth considering.

KEYWORDS: *crop production, mine impacted water*

ACKNOWLEDGEMENTS

Water Research Commission for funding the research.

RESPONSE OF PIGEON PEA [*CAJANUS CAJAN* (L.) MILLSPAUGH] GROWTH, PHOSPHORUS YIELD, PHOSPHOROUS RECOVERY EFFICIENCY, AND GRAIN YIELD TO PHOSPHORUS FERTILIZATION UNDER RAINFED SMALLHOLDER FARMING SYSTEMS

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INTRODUCTION

Although pigeon pea (*Cajanus cajan*) is classified as a multi-purpose crop, it is one of the most underutilized, neglected legume crops in South Africa. The majority of smallholder farmers in South Africa still grow traditional unimproved pigeon pea landraces, which comprise a mixture of genotypes. In addition, the crop is mostly grown in poor and nutrient-depleted soils caused by continuous maize cropping with little or no fertilizer inputs. The study aimed to assess growth, P-uptake, phosphorous recovery efficiency (PRE), phosphorus use efficiency (PUE), and grain yield of pigeon pea varieties in response to P-fertilizers under a smallholder no-till system.

MATERIAL AND METHODS

Dryland experiments were carried out on smallholder farmers' fields at Ofcolaco and Zoeknog from December 2019 to July 2021 without disruption under dryland conditions. The field experiment was established as a randomized complete block design (RCBD) in a 4 x 2 factorial arrangement with four replications at each location. The two treatment factors were pigeon pea varieties, namely, Komboa, Tumia, Ilonga 14-M2, local landrace, and phosphorus (P) fertilizer application rates of 0 kg ha^{-1} and 60 kg ha^{-1}. Shoot biomass, plant height, and grain yield were collected, measured and calculated according to standard procedures. Harvest index (HI), P yield, and phosphorus recovery efficiency (PRE) were also determined.

RESULTS AND DISCUSSION

The study results showed that shoot biomass ranged from 5375 to 9937 kg ha^{-1} and 5532 to 10149 kg ha^{-1} at Ofcolaco and Zoeknog, respectively. The differences in shoot biomass production at the two locations might have been caused by the differences in environmental conditions. The results showed that Komboa was the shortest across all varieties at both locations. Grain yield ranged from 507 to 1136 kg ha^{-1} and 725 to 1306 kg ha^{-1} in the first and second harvests at Ofcolaco. P yield ranged from 11.10 to 23.89 kg ha^{-1} at 120 DAP and 15.11 to 41.4 kg ha^{-1} at 470 DAP, respectively. P yield in Komboa, was 60% and 63% lower than Ilonga 14-M2 at Ofcolaco and Zoeknog, respectively. PRE ranged from 7.35 to 60.9% in all varieties across sampling dates.

CONCLUSIONS

The study concluded that Ilonga 14-M4 is suitable for fodder production due to its higher shoot biomass production, Komboa suitable for grain production, and Tumia was found to be an intermediate and dual-purpose variety.

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COMPARING THE FINANCIAL BENEFITS OF DIFFERENT GRAIN FARMING SYSTEMS IN SOUTH AFRICA

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INTRODUCTION

The dominant crop production model focuses on maximum yields using intensive conventional tillage (CT) and high levels of production inputs. This has accelerated land degradation and climate change on the one hand, and rising costs of production on the other hand (WWF, 2021). This also sparked an urgent need to consider more sustainable alternatives such as no-tillage (NT) and Regenerative Conservation Agriculture (CA/RA). To assist producers in different regions with informed choices, the aim of this study was to analyse and compare the financial viability and sustainability of the three farming systems, namely CT, NT and CA/RA.

MATERIALS AND METHODS

A financial cost-benefit analysis was conducted using data obtained from on-farm trials, local farmers, cooperatives (i.e. VKB and NWK) and Grain South Africa in the Mpumalanga Highveld, North West and Maluti regions. Certain assumptions were included in the model configuration regarding, e.g. farm size, inflation, crops (selling prices, rotation system and yield), livestock integration, dry matter, agro-chemical input efficiency, and capital replacement period. These were used to calculate net operating cash flows, free cash flows (FCFs), and average cash flow per hectare in real terms (ACFs), for all three farming systems. To manage sensitivities, two scenarios were modelled for each trial, an optimistic and a conservative scenario.

RESULTS AND DISCUSSION

The AFCs per ha for the CT system in most cases started off positively in the short term and drops significantly over the longer term (15 years +); while the NT system maintains positive AFCs throughout 20 years, but at a decreasing rate of return. The CA/RA optimistic scenario produced positive ACFs in the long term (15 years +), but in some cases the conservative scenario produced negative ACFs. In the short term (5 to 10 years) the AFCs under CA/RA took a dip (so-called J-curve) due to additional investments necessary for restoration, before it recovered into positive territory.

CONCLUSION

The results show that CT is not sustainable in the long run, NT is not an ideal best practice for maximum return on investment in the long run, and CA/RA offers the best opportunity for farmers to maximise returns while protecting the environment and food security in advancing the development of sustainable agriculture in South Africa over the medium to long term.

KEYWORDS: *conventional tillage, cost benefit analysis, no-tillage, regenerative conservation agriculture*

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PLANTING DATE AND CULTIVAR CHOICE AS POTENTIAL CLIMATE CHANGE ADAPTATION OPPORTUNITIES FOR SOUTH AFRICAN DRYLAND MAIZE PRODUCTION

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INTRODUCTION

The anticipated climate change in South Africa is of great concern as it threatens the country's ability to sustain maize production in the long-term, thus challenging food security in the region. The formulation of effective adaptation measures calls for understanding how projected changes in temperature, precipitation, and climate extremes (heat and cold) during different maize developmental stages might impact production.

MATERIALS AND METHODS

We analysed the climate change impacts on dryland maize production in Bloemfontein and Lichtenburg, which makes part of the major maize growing regions of South Africa. The climate projections generated by six Global Climate Models under the Representative Concentration Pathways (RCP) 4.5 and 8.5 were used. Analyses were performed for four representative planting dates: November 15 (early), December 15 (optimal), January 15 (late), and February 5 (very late) and two maize cultivar types (short and medium season cultivars). For each location of interest, we explored sixteen scenarios by combining 3 factors, including two maize cultivar types, four current assessments of planting dates, and two RCP's across the 21st Century. Data analysis was performed in the R software environment (Version 4.0.0, R Core Team, 2020) using the Zyp package version 0.10-1.1 for trend and change rate estimations.

RESULTS AND DISCUSSION

Time to maturity decreased as years progressed from baseline period (1991-2020) to the far future period (2051-2080), at both locations with higher rates projected under RCP 8.5. The results suggest a longer summer season with receding freeze dates in these regions and might provide additional flexibility for adaptive strategies. At the optimal planting dates, the future climate will likely affect maize's vegetative and reproductive stages, leading to a decrease in the time to maturity and likely limiting yields. A shorter growing season will result in low water resource use efficiencies, leading to lower yields. A major factor affecting maize growth is extreme temperature, with the number of days above 35°C expected to increase as climate change progresses.

CONCLUSIONS

The results reveal that there may be opportunities to shift planting to later dates in these regions. The wide variation of impacts between locations indicates that location-specific research is required to fully grasp the climate change impacts in the maize production provinces of South Africa. Concerted efforts from the private and public sector are needed in this regard in financing such research projects.

KEYWORDS: *extreme temperatures, growing degree days, heat stress, corn, food security*

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GREENHOUSE GAS EMISSIONS FROM DIFFERENT CROP ROTATION SYSTEMS IN THE SWARTLAND, WESTERN CAPE

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INTRODUCTION

In agriculture, greenhouse gas (GHG) emissions are associated with specific on-farm activities and indirectly the use of inputs. Crop choice, machine actions, inputs and production practices influence the amount and types of GHGs emitted. Livestock incorporation and legumes in crop rotations reduce fertiliser and machine actions, changing both direct (on-farm) and indirect emissions. It is uncertain which crop rotation system will have the lowest GHG balance as current models were developed to fit continentally, and little data exists for the Western Cape dryland systems. Awareness emission points are necessary to achieve environmental sustainability.

MATERIAL AND METHODS

The experimental site was a 25-year crop rotation systems trial situated on Langgewens Research Farm outside Moorreesburg. Three rotation systems: wheat – wheat – wheat – canola (WWWC); wheat – canola – wheat – cover crop mix (WCWL); wheat – medic pasture – canola – medic pasture (WMCM) were compared on the basis of GHG emissions per energy equivalent of the agricultural outputs. Direct soil emissions were sampled weekly over one year via the closed chamber method. Soil organic carbon sequestration was measured over a 21-year period. Emissions for the rest of the production systems (seeds, fuel usage, fertilisers, and pesticides) were estimated using published literature. Carbon footprints were compiled for all rotation systems, with the livestock production excluded from system boundaries. Total emissions (CO_2-eq) per production of a grain equivalent (GE) were determined.

RESULTS AND DISCUSSION

Preliminary results showed that WMCM emitted the least emissions: 19.7 kg CO_2-eq GE^{-1}, followed by WCWL and then WWWC (30.7- and 43.5 kg CO_2-eq GE^{-1}). Soil carbon sequestration was highest in WMCM, followed by WWWC and offset the system emissions in all rotations. Methane emissions were negligible in WWWC and were sequestered in WCWL and WMCM. Significant amounts of N_2O were emitted in the fallow summer in response to a sporadic rainfall event. These off-season N_2O emissions only occurred in WMCM and WCWL, systems with legume inclusion, due to stored organic nitrogen. Long-term differences ($p < 0.05$) in wheat protein content confirm higher nitrogen availability in WMCM, and the least in WWWC.

CONCLUSIONS

The crop rotation, excluding legumes and livestock, had lower N_2O soil emissions, but higher inputs and inferior yields outweighed this benefit. Lowering system inputs, through system diversification and legume inclusion led to a more sustainable cropping system with a lower global warming potential.

KEYWORDS: Carbon sequestration, climate change, life cycle assessment, livestock integration, nitrous oxide; environmental sustainability

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POTATO CROP GROWTH MONITORING USING GROUND-TRUTHING AND REMOTE SENSING TECHNOLOGY

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INTRODUCTION

Remotely sensed spectral vegetation indices (VIs) allow real-time assessment of crop vegetation status over relatively large areas, which is critical for development of management information for potato (*Solanum tuberosum* L.). However, the nature of the relationship between VIs and ground measured data is not well known for potato. Therefore, this study was carried out to validate remote sensing derived growth indices with ground-measured potato canopy state variables.

MATERIALS AND METHODS

Eight commercial potato farms, one farm in Gauteng and seven farms in Western Free State regions were selected for the study during the 2021/2022 summer potato growing season. Ground analysis of potato phenological growth was conducted and included measurement of leaf area index (LAI), fractional interception (FI) of solar radiation, green canopy cover percentage (GCC), leaf colour (SPAD meter), total biomass and final yield. Destructive sampling of whole plant samples was done at three-weekly intervals for LAI and biomass determination. Canopeo®, a mobile phone application was used to estimate GCC, while FI was measured using a handheld ceptometer. Vegetation indices of normalized difference vegetation index (NDVI), leaf area indicator (LAInd), and photosynthetic activity index (PAI) were derived from remotely sensed images obtained from Sentinel-2 satellite. The indices were then correlated with ground measured growth parameters using regression analysis.

RESULTS AND DISCUSSION

There was a strong positive correlation between the ground measured LAI and satellite derived LAInd, with R^2 ranging from 0.70 – 0.93. FI increased exponentially between 30 to 50 days after emergence (DAE) to a maximum of 0.95. NDVI showed a similar trend to FI, reaching a maximum of 0.85 at 50 DAE. Ground measured FI, GCC, LAI and dry matter yield showed a strong positive correlation with NDVI ($R^2 > 0.65$) for all fields. Green canopy cover correlated well with FI, suggesting that GCC measured by Canopeo® can be used successfully to estimate FI of potato during the growing season. The SPAD meter readings, taken as a measure of chlorophyll content, had a poor relationship with PAI values ($R^2 < 0.1$), which suggest that PAI may not be a good proxy for chlorophyll content of potato crops.

CONCLUSIONS

A strong positive correlation between ground measured parameters and most satellite derived indices suggest that satellite indices can be used as proxies for ground measured parameters during the season. However, PAI may not be a good indicator of leaf chlorophyll content.

KEYWORDS: crop growth assessment, growth measurement, vegetation index

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REGENERATIVE AGRICULTURE VS CONSERVATION AGRICULTURE: POTENTIAL EFFECTS ON SOIL QUALITY, CROP PRODUCTIVITY AND WHOLE-FARM ECONOMICS IN MEDITERRANEAN-CLIMATE REGIONS

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INTRODUCTION

Small-grain farming systems in Mediterranean climatic regions are characterized by poor quality soils, high climate variability, and resulting heavy agrochemical reliance. Adopting Conservation Agriculture (CA), comprising no-tillage, permanent soil cover, and crop rotations, along with the integration of conventionally grazed pasture phases has proven beneficial. Soil quality and crop productivity have been enhanced with fewer inputs, and financial risk mitigated. However, there are still challenges such as fertiliser prices rising disproportionately to product prices, herbicide resistance, and increasing climatic variability and predictability, which threaten sustainability and drive the need for ongoing innovation in these systems. The use of selected agroecological practices, constituting a Regenerative Agriculture (RA) concept, were evaluated for their potential to address these challenges from a soil quality, crop productivity and whole-farm economics perspective, in the given context.

MATERIAL AND METHODS

This research comprised an extensive review of existing literature on the following agroecological practices in small-grain systems of a Mediterranean-type climate: organic amendments, bioeffectors, and cover crops subjected to adaptive multi-paddock grazing. Where literature was lacking or not available for the given context, inferences were made from similar production regions and farming systems alike.

RESULTS AND DISCUSSION

Organic soil amendments derived from organic wastes, offer promising perspectives for supplying appropriate quantities of nutrients to reduce/ replace mineral fertilisers and offset their economic and agroecological costs. Although the viability of microbial bio-effectors/ inoculants in small-grain agroecosystems was largely under question, non-microbial bio-effectors and certain combination options represent more efficient and cost-effective uses of this technology. Their widely reported abiotic stress priming functions and crop productivity enhancement under poor growing conditions may improve yield stability and financial resilience in small-grain Mediterranean CA systems. Finally, the cultivation of multi-species cover crops subjected to adaptive multi-paddock (AMP) grazing as a phase within the crop rotation may reduce weed pressure, enhance soil multi-functionality, and improve overall resilience against environmental stresses.

CONCLUSIONS

Appropriately adapted use of organic inputs, bioeffectors, and cultivation of multi-species cover crops with AMP grazing, may improve soil quality, crop productivity, and farm economics, offering promising perspectives in addressing emerging sustainability issues. However, these improvements can be highly variable and difficult to predict. Thus, to validate their potential in Mediterranean small-grain CA systems, more long-term and context-specific research is called for.

KEYWORDS: *Agroecological intensification, biodiversity, bio-stimulants, management-intensive grazing, multi-species pastures, organic inputs.*

ACKNOWLEDGEMENTS

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EVALUATION OF STEM BORER RESISTANT WHITE MAIZE GENOTYPES FOR RESISTANCE TO FALL ARMYWORM (*SPODOPTERA FRUGIPERDA* J.E. SMITH) INFESTATION

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INTRODUCTION

Stem borers (SB) and more recently fall armyworm (FAW) are two yield-limiting insect pests threatening the production and productivity of maize in sub-Saharan Africa (SSA). Cultivation of varieties with resistance to SB and FAW is the most economical and sustainable option to enhance maize grain yields in SSA. It is postulated that SB-resistant genotypes could confer resistance to FAW. In this study, some SB-resistant maize genotypes were evaluated for their responses to FAW infestation.

MATERIALS AND METHODS

Twenty-nine white maize genotypes with varying levels of resistance to SB were evaluated in two seasons under artificial FAW infested and non-infested conditions. The experiment was laid in a randomized complete block design with three replicates. Data were collected on grain yield (GY) and agronomic traits under both conditions, while data on FAW leaf damage (FAWLD) and FAW ear damage (FAWED) were collected only under FAW infested condition. The FAWLD and FAWED were rated on a scale of 1 to 9, where 1 = no visible damage to leaf/ear, and 9 = severe damage to whorl and furl leaves/ear. Data were subjected to analyses of variance and correlation. A Base index (BI) was used to select promising genotypes that combined high GY with resistance to FAW.

RESULTS AND DISCUSSION

Significant genotypic differences were observed for all the traits under both FAW infested and non-infested conditions. The GY ranged from 3.44 t/ha (genotype FAWTH-8) to 5.81 t/ha (genotype FAWTH-1), with a mean of 4.61 t/ha under FAW infested condition and from 3.42 t/ha (genotype FAWTH-25) to 6.85 t/ha (genotype FAWTH-18), with a mean of 4.86 t/ha under non-infested conditions. Averaged across genotypes, GY reduction due to FAW infestation was low (5.14%), suggesting that SB resistance conferred resistance to FAW damage. The association of GY under FAW infested condition with FAWLD (r=-0.45) and FAWED (r=-0.65) were negative and highly significant. Highly significant correlations were also found between BI and GY (r=0.93), ear aspect (r=0.84), FAWLD (r=-0.66) and FAWED (r=-0.78). Six partially resistant/tolerant genotypes (FAWTH-1, FAWTH-13, FAWTH-4, FAWTH-10, FAWTH-23 and FAWTH-6) which had GY ≥ 5.13 t/ha, and positive BI ≥ 4.0 under FAW infestation were identified.

CONCLUSIONS

Genetic variation exists among the genotypes evaluated for resistance to FAW. Base index and low FAW damage scores could be used as selection criteria for combined tolerance to FAW and high grain yields. The identified genotypes are recommended as candidates for further evaluation and development as FAW tolerant varieties.

Keywords: *base index, fall armyworm ear damage, fall armyworm leaf damage, maize grain yield, stem borer resistance*

TACTICS TO FACILITATE ALKALI MOVEMENT IN CONSERVATION AGRICULTURE DRYLAND CROP PRODUCTION SYSTEMS

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INTRODUCTION

Most crop farmers in the Western Cape Province of South Africa have adopted no-tillage farming practices to improve soil health and sustain agricultural productivity. Due to slow movement of surface applied lime in the absence of soil tillage, the limitations of pH stratification and subsurface acidity require further investigation. Lime and gypsum combinations are hypothesized to assist downward alkali movement in a moderately weathered soil of the Swartland region.

MATERIALS AND METHODS

A two-year field experiment was conducted on an Oakleaf soil on a farm in the Swartland region during 2021 and 2022. Pre-treatment soil $pH_{(KCl)}$ were 5.9, 5.3, 4.3 and 4.2 in the 0–5, 5– 10, 10–20 and 20–30 cm depths, respectively. Treatments consisted of a control, surface application of 1.6 Mg ha^{-1} calcitic lime, 1.6 Mg ha^{-1} incorporated calcitic lime through once-off tillage, 1.56 Mg ha^{-1} hydrated lime, 1.75 Mg ha^{-1} pelletised micro-fine lime, 1.11 Mg ha^{-1} calcitic lime plus 0.62 Mg ha^{-1} gypsum and 0.55 Mg ha^{-1} calcitic lime plus 1.25 Mg ha^{-1} gypsum. Treatments were applied on the 12th of April 2021. Parameters of soil, wheat (*Triticum aestivum* L.) and canola (*Brassica napus* L.) were measured in year one and two, respectively.

RESULTS AND DISCUSION

Surface application of one part lime to two parts gypsum (based on Ca content) decreased ($p<0.05$) exchangeable acidity in the 20–30 cm depth by 0.30 cmol kg^{-1} relative to the control treatment 12 months after treatments were applied. Lime incorporation through a once-off chisel (20–30 cm deep) action and surface application of one part lime to two parts gypsum both significantly ($p<0.05$) raised soil $pH_{(KCl)}$ by 0.45 units in the 20–30 cm depth relative to the control treatment 18 months after treatments were applied. Once-off lime incorporation through a chisel tillage action resulted in the lowest wheat plant population ($p<0.05$) compared to all treatments in year one. However, leaf area index, aboveground biomass, yield and seed quality were not affected by the treatments ($p > 0.05$) in both years.

CONCLUSIONS

Limited crop responses within the first 18 months since treatments establishment suggests that economic return on lime application is slow. Surface application of one part lime to two parts gypsum can be considered as an economically viable alternative to lime incorporation in terms of raising subsurface pH within 18 months in no-tillage crop production systems on moderately weathered soils.

KEYWORDS: exchangeable acidity, gypsum, lime, no-tillage, subsurface acidity, tillage.

INTEGRATION OF CULTIVAR SELECTION, MULCH, AND FUNGICIDE APPLICATION TO IMPROVE POTATO YIELDS IN DRYLAND SMALLHOLDER PRODUCTION SYSTEMS

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INTRODUCTION

Water scarcity from low, erratic, and unpredictable rainfall, early and late blight fungal diseases, and the use of uncertified seeds are major contributing factors to the low yields obtained in dryland smallholder settings (Franke and Sekoboane 2021). Low potato yields are often associated with reduced potato quality, which reduces the marketability and commercial value. The objectives of the study were to determine the influence of cultivar, mulching, and fungicide application on potato yield and quality in a rainfed production system.

MATERIALS AND METHODS

Three factors were tested, four cultivars (Electra, Sababa, Mondial, and Panamera), two mulch (no-mulch and mulch) and fungicide (no-fungicide and fungicides) application levels, conducted in three smallholder locations in Swayimane, two in Appelsbosch in KwaZulu Natal. Trials were planted in a randomized complete block design. Emergence percentage, stem count, canopy cover, disease infection, and yield data were collected.

RESULTS AND DISCUSSION

Cultivar selection had a significant effect ($P<0.05$) on the stem count, leaf canopy cover, and final yield. Electra reached 114.7, 118.19, and 106.4 t /ha in Swayimane and 101.6 and 90.5 t ha^{-1} in Appelsbosch. Mondial yielded 85.0, 79.0, 57.4 t/ha, and 78.6, 55.3 t/ha in Swayimane and Appelsbosch, respectively. Swayimane had a yield of 90.5, 117.2, and 82.8 t/ha for Panamera, whereas Appelsbosch had a yield of 81.51 and 59.4 t/ha. Sababa yielded 96.6, 117.2, and 84.6 t/ha at Swayimane and 93.7 and 60.6 t/ha at Appelsbosch. The insignificant yield response to mulch can be attributed to abundant rainfall that was received during the cultivation period, hence mulch did not perform well because soil moisture was always adequate, as was reported by Xing et al. (2012). The two-way interaction of cultivar by fungicide showed a significant difference in suppressing the incidence of diseases, giving high canopy cover, and increasing tuber yield (Mekonen and Tadesse, 2018). Significant cultivar yield differences across agroecologies were attributed to observed differences in cultivar genetics, soil and climatic conditions during the growing season.

CONCLUSION

The interaction of cultivar x mulch x fungicide application did not affect yield, however, interaction of cultivar x locality and fungicide x locality, and factors solely had a significant effect on the final yield. Howver, mulch had an insignificant effect on yield. Cultivar Electra had a high yield and stem count, and is recommended for dryland production with fungicide application at these sites. It is recommended that mulch should not be applied when wet soil conditions are expected.

KEYWORDS: *agroecology, blight infection, Electra, Mondial, Panamera, Sababa*

MODELLING CLASS-A PAN EVAPORATION USING DAILY WEATHER DATA

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INTRODUCTION

Class-A pan evaporation data have for many decades served as a useful tool, together with a crop factor, for estimating evapotranspiration. Stanhill (2002) maintains that, for developing countries, where cost and complexity are limiting factors, properly sited and managed evaporimeters "still have an important role to play in improving both water conservation and food production and so serve as a cheap and simple method of increasing the efficiency of water use in irrigated agriculture".

The justification for this study is to extend, for any location, the record of Class-A pan evaporation data. Such data serves as an inexpensive and relatively simple surrogate for grass reference evapotranspiration. A physically based Class-A pan evaporation model, based on the Penman-Monteith approach and collected weather data, is employed.

MATERIAL AND METHODS

Daily weather data used are from four Mpumalanga weather stations: Barbeton (2001-2006), Kaalrug (2001-2017), Nelspruit (2001-2006), Tenbosch (1990-2006). The weather data, most often, contained measured or computed solar irradiance, minimum and maximum air temperatures, minimum and maximum relative humidity and wind speed. Various weather data checks were applied.

The model developed for calculating class-A pan evaporation (ETpan), based on that by Allen et al. (1998), Penman (1948) and Rayner (2007), was implemented in Microsoft Excel VBA. Model estimates of daily Class-A pan evaporation were compared with measured pan evaporation for the four stations. Model implementation involved determining both the radiative and aerodynamic components of evaporation.

RESULTS AND DISCUSSION

Initial results for Kaalrug showed that the evaporation pan model explained almost 75 % of the variance in Class-A pan evaporation (slope value of modelled (y) vs measured (x) of 0.904). The model tended to consistently underestimate Kaalrug ETpan by about 10 %, with improved agreement between modelled and measured data during winter months. In general though, for Kaalrug, the model was reasonably consistent in estimating Class-A pan evaporation. The model will also be applied to the three other stations and this will be reported on in more detail in the presentation.

CONCLUSIONS

Initial results, for Kaalrug, showed reasonable agreement between measurements and model estimates of Class-A pan evaporation. These results would allow the record of Class-A pan evaporation, as a surrogate for grass reference evaporation, to be extended to periods when only weather data were available.

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ACKNOWLEDGEDMENTS

The weather data supplied by the South African Sugarcane Research Institute is gratefully acknowledged.

KEYWORDS*: class-A pan evaporation, daily weather data, modelling evaporation.*

TARGET-SITE MUTATION IN THE EPSPS AND ALS REGION ENDOWING RESISTANCE TO EPSPS AND ALS INHIBITORS IN SMOOTH PIGWEED IN SOUTH AFRICA

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INTRODUCTION

Smooth pigweed (*Amaranthus hybridus* L.) from the genera *Amaranthus* is a major weed for summer crops. Although smooth pigweed has been a known weed in crops in South Africa for a long time, herbicide resistance has not been recorded. In 2019, field reports from KwaZulu-Natal Province of suspected glyphosate-resistant smooth pigweed were received by SAHRI. This study aimed to evaluate herbicide resistance in *A. hybridus* as well as the underlying molecular mechanisms of resistance.

MATERIALS AND METHODS

Seeds from single plants that survived glyphosate applications were collected from fields in KwaZulu-Natal Province (Bergville and Winterton) and compared to a sensitive population from Hendrina (Mpumalanga Province). Plants were grown under glasshouse conditions (25°C) at the University of Pretoria. Herbicide applications were done when plants were at 6-leaf stage, at four different doses (0.5X, 1X, 2X and 4X the recommended field rate). Glyphosate efficacy and visual injury ratings were assessed at 16 DAT, with 0 indicating no survival and 10 indicating complete survival. Surviving plants were sampled for molecular analysis to determine any target site mutation in the *EPSPS* and *ALS* gene endowing herbicide resistance to glyphosate and *ALS* inhibitors. Molecular analysis was carried out using CLC Genomic Workbench.

RESULTS AND DISCUSSION

Results indicated survival rates of 100% in the Bergville and >80% in the Winterton population. No treated plants survived from the sensitive Hendrina population. An amino-acid mutation, consisting of Thr-102-Ile, Ala-103-Val and Pro-106-Ser, was identified in all Bergville and Winterton accessions. These findings support that the high level of glyphosate resistance of *A. hybridus* populations was conferred by triple mutation TAP-IVS found in the *EPSPS* gene. A target site mutation, conferring resistance to *ALS*, occurs in BE and CAD domains. In the BE domain, all accessions from Hendrina and Winterton had no mutation at 574 (Trp-574-Leu) and one accession from Bergville had a mutation. All accessions from Hendrina and Bergville had no mutation at position 653 (Ser-653-Asn). From the Winterton population, 75% of samples possessed the Ser-653-Asn mutation. No mutations were found in the CAD domain in all the accessions used in this study.

CONCLUSIONS

These findings confirmed target site resistance to *EPSPS* and *ALS* inhibitors and will serve as a base for other herbicide resistance cases and the development of programmes to control and minimize the spread of this weed in South Africa.

KEYWORDS: *ALS, Amaranthus hybridus, EPSPS, gene-mutation, target-site resistance*

ACKNOWLEDGEMENTS

South African Herbicide Resistance Initiative, University of Pretoria Bursary, The Maize Trust, Bayer SA and National Research Foundation for funding, and the University of Pretoria for providing glasshouses and biotechnology laboratory.

GENETIC ANALYSIS OF YIELD AND YIELD-RELATED TRAITS AND BIOMASS ALLOCATION IN NEWLY DEVELOPED WHEAT POPULATIONS

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INTRODUCTION

Root biomass is a major soil-organic carbon source and may confer drought adaptation in water-limited environments. Understanding the genetic bases and inheritance of yield-related traits and biomass allocation in wheat is fundamental for drought tolerance breeding and soil health. The objective of this study was to determine the general and specific combining ability, maternal effects and the mode of gene action controlling the major yield-related traits and biomass allocation in wheat to identify good combiners for breeding and enhanced carbon sequestration.

MATERIAL AND METHODS

Ten selected wheat genotypes were crossed in a full diallel mating design, and 90 F_2 families were generated and evaluated in the field and greenhouse under drought-stressed and non-stressed conditions.

RESULTS AND DISCUSSION

Significant differences were recorded among the tested families, revealing substantial variation in plant height (PH), kernels per spike (KPS), root biomass (RB), shoot biomass (SB), total plant biomass (PB) and grain yield (GY). Additive gene effects conditioned PH, SB, PB and GY under drought, suggesting the polygenic inheritance for drought tolerance. Strong maternal and reciprocal genetic effects were recorded for RB under drought-stressed conditions. The parental line LM75 maintained the general combining ability (GCA) effects in a positive and desirable direction for three traits, including SB, PB and GY. Line BW162 had high yield and biomass production and can be used to transfer favourable genes to its progeny.

CONCLUSIONS

Early generation selection using PH, SB, PB and GY will improve drought tolerance by exploiting additive gene action through recurrent selection under drought conditions. Higher RB production may be maintained by a positive selection of BW162 as a male and LM75 as a female parent to capture the significant maternal and reciprocal effects found in this study.

KEYWORDS: carbon sequestration, drought, gene action, maternal effects, root biomass

ACKNOWLEDGEMENTS

The Water Research Commission (Project Number: 2020/2021-00646) for funding, the University of KwaZulu-Natal and the University of South Arica for administration support

CROPPING SYSTEMS AS A SUSTAINABLE ALTERNATIVE FOR FERTILISERS TO IMPROVE WHEAT PROTEIN

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INTRODUCTION

Since the green revolution, nitrogen fertilisers have been used to improve the production and quality of wheat. This was done with great success but the production and use of nitrogen degrades the environment. The increase in nitrogen fertiliser costs and the environmental degradation are forcing producers to use less nitrogen fertilisers. Cropping systems which include legumes and increase soil carbon have the potential to lower the need for nitrogen fertilisers.

MATERIAL AND METHODS

The trial was conducted under rain-fed conditions in the Swartland region of the Western Cape South Africa, with a Mediterranean climate. Eight cropping systems containing wheat under conservation agriculture (2002 to 2021) were used. Four of the systems were cash cropping systems and the remaining four systems were a combination of cash crops and pasture systems. The four mixed pasture/cropping systems and two of the cash cropping systems contained legumes. Wheat yield, the amount of nitrogen fertiliser applied and protein content of the grain were compared between the different systems. The experimental design was a randomised block design with two replications.

RESULTS AND DISCUSSION

Wheat yields and protein content did not correlate with the amount of nitrogen applied. Less nitrogen fertilisers were applied in mixed cropping systems, but these systems contained more protein in the grain compared to cash cropping systems. The reduction in nitrogen applied in the mixed cropping system did not lead to a reduction in wheat yield. In the cash cropping systems which contained legumes, more nitrogen were applied compared to the mixed systems. The reason for this may be the fact that the mixed systems contained 50% legumes, compared to the two cash cropping systems which contained 25% legumes.

The benefits of incorporating legumes into a cropping system are clear as this led to a reduction in nitrogen fertiliser. The frequency of legumes in a cropping system and type of legume (cash crop or pasture) may influence the benefits of the legume.

CONCLUSIONS

Cropping systems containing legumes can improve sustainability by reducing the amount of nitrogen fertilisers while sustaining production and increasing quality. This can reduce the negative impact on the environment whilst improving the profitability of wheat production.

KEYWORDS: conservation agriculture, nitrogen, pasture

POTATO PRODUCTION SUSTAINABILITY IN THE WESTERN FREE STATE: A STUDY ON WATER AND NUTRIENT USE EFFICIENCIES ON SANDY SOILS

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INTRODUCTION

The profitability of agricultural production has significantly declined due to the rising cost of agricultural inputs. Sustainable agricultural practices should be prioritized to ensure a profitable agricultural sector that contributes to food security. It is well-known that there is a high risk of water and nutrient losses when shallow-rooted crops, such as potatoes, are grown on sandy soils. The project's overall aim is to conduct field studies to determine how efficiently farmers manage their resources by monitoring nutrient and water application rates and methods, drainage of water and leaching of nutrients from potato fields, and carry-over effects of nutrients and water to the subsequent rotation crop in the Wester Free State growing region.

MATERIALS AND METHODS

This study was concluded in the Christiana district of the Western Free State. The seven monitored sites were each situated on different farms in the area. The fields were irrigated by centre pivot systems and irrigation rates were measured by flow meters and pressure transducers. Rainfall was monitored using automatic rain gauges and soil water content was monitored using capacitance probes. Water drainage and nutrient leaching were measured by installing passive drainage lysimeters in fields. Potato plants and tubers were sampled every three weeks to determine biomass accumulation. Canopy cover was calculated from measured incoming and intercepted solar radiation. Final tuber yields were determined at the end of the growing season. Water and nutrient balances, and water use efficiencies were estimated from the collected data.

RESULTS AND DISCUSSION

Results showed that the inputs and losses varied substantially between fields. Total rainfall ranged from 217 – 374 mm, while irrigation applied ranged from 139 – 399 mm. Total evapotranspiration ranged from 490 mm – 540 mm and drainage ranged from 7 – 353 mm. Final tuber yields ranged from 50 - 114 t ha^{-1}, while water use efficiencies varied from 105 – 270 kg ha^{-1} mm^{-1}. Total nutrients leached ranged from 4.4 – 159.5 kg ha^{-1} for nitrogen, 1.3 – 3.9 kg ha^{-1} for phosphorous and 0 – 47.7 kg ha^{-1} for potassium. Total calcium leached ranged from 87 – 751.8 kg ha^{-1}, magnesium ranged from 78.1 – 231.6 kg ha^{-1} and sulphur from 45 – 332.8 kg ha^{-1}.

CONCLUSIONS

Preliminary results indicate that higher irrigation water and precipitation volumes did not necessarily correlate with higher yields. Total amount of nutrients leached form the soil correlated with the amount of water drained from the soil profile. The influence of environmental conditions and management on drainage, nutrient leaching and tuber yield must be examined further to assess their effect on water- and nutrient use efficiency. The financial implications of recorded water and nutrient losses will be determined by considering total input and output costs.

KEYWORDS: *drainage, leaching, nutrient use efficiency, potato-based rotations, water use efficiency*

ACKNOWLEDGMENTS

Potatoes South Africa for funding, University of Pretoria for access to facilities, farmers for supplying agricultural land, and all colleagues involved.

SYNOPTIC WEATHER PATTERNS RELATED TO INCREASED FIRE DANGER OVER THE CENTRAL GRASSLAND BIOME OF SOUTH AFRICA

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INTRODUCTION

The South African interior plateau grasslands are subject to seasonal wildfires that occasionally inflict serious damage to livestock production systems and infrastructure. Weather conditions, in combination with local topography and fuel characteristics, influence fire behaviour. For this reason, climatic elements such as air temperature, relative humidity, precipitation and wind speed are required as input to several fire danger rating systems. However, these daily weather characteristics observed over a specific area are controlled by the large-scale or synoptic atmospheric state. Knowledge of the synoptic circulation patterns that have historically resulted in increased surface fire-weather conditions furthers understanding of the interactions between wildfire and climate variability over a particular region. Such knowledge is beneficial in understanding and predicting the conditions leading to devastating wildfires. The objective of this study was thus to identify those synoptic-scale circulation patterns that lead to increased climatological fire danger over the central grassland biome of South Africa.

MATERIAL AND METHODS

ERA5 reanalysis data were used for the surface climatic variables required to calculate the spatial mean and maximum Lowveld Fire Danger Index (LFDI) value over the study area daily from 1981 – 2010. ERA reanalysis data over a larger domain covering southern Africa and the surrounding ocean was also used for the classification variable (i.e. the 850 hPa geopotential heights). Self-organizing map (SOM) analysis was used to identify a set of 20 nodes, representing the range of synoptic conditions that influence the weather of southern Africa during the fire season (i.e. May – November). The number of very dangerous LFDI days of each node in the master SOM was subsequently recorded.

RESULTS AND DISCUSSION

The SOM analysis revealed archetypical synoptic patterns ranging from well-developed westerly waves (and accompanying surface cold fronts) to high-pressure systems dominating the subcontinent during the fire season. The highest number of very dangerous days were linked to the warm, dry and windy conditions typically experienced ahead (i.e. east) of a well-developed frontal trough that is making its way across the country.

CONCLUSIONS

These findings concur and formalise local forecaster experience and will allow aspirant fire weather forecasters to better predict hazardous fire weather conditions over the central grassland. Fire suppression personnel should consult the weather forecast and be aware of very dangerous fire-weather conditions associated with the passage of a well-developed cold front.

KEYWORDS: *fire danger index, fire weather, self-organizing map*

WATER RESEARCH OBSERVATORY: A CLOUD-BASED PLATFORM FOR AGROHYDROLOGICAL MODELLING AND BIG DATA APPLICATIONS

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INTRODUCTION

South Africa faces mounting socio-economic and environmental challenges. Big data and artificial intelligence are drastically changing the world we live in, but applications to address issues such as food insecurity and water scarcity in South Africa are still in their infancy. Most of South Africa's agricultural and natural resource data are currently stored and used in an uncoordinated way. There is, therefore, a widespread recognition that making data and information more FAIR (Findable, Accessible, Interoperable, Re-usable) will improve the efficiency of scientists and enable research to build on previous research more effectively. In addition, bringing together a diverse range of datasets could also provide new insights. The goal of this paper is to describe an initiative funded by the WRC to build a cloud-based platform to enhance agro-hydrological modelling called the Water Research Observatory.

MATERIALS AND METHODS

Following consultations with multiple stakeholders, CKAN was selected from which to build the user interface for uploading and discovering data. Google Cloud Platform (GCP) was selected for storing the data, while it also contains many other useful tools, such as those to run SQL queries on very large datasets, and machine learning and cell phone app building tools. The platform will also be compatible with other commercial cloud platforms. Data storage architecture and access management have been carefully designed to ensure the sustainability of the platform.

RESULTS AND DISCUSSION

A prototype of the platform to archive and analyse data is up and running (www.waterresearchobservatory.org). Landcover, soil and weather data for South Africa are available for parameterising and running SWAT, DSSAT, and similar models. In addition to agro-hydrological modelling, the platform can also serve to store and analyse Internet of Things (IOT) data in real-time, and to host citizen science data capturing applications. Google Cloud tools such as BigQuery and Vertex AI have been successfully used in big data analytics. Model applications have already been used for estimating crop yield and streamflow.

CONCLUSIONS

The strength in a cloud-based platform will lie in its widespread use and sharing of data. Meticulously captured metadata are essential for ensuring the proper application of archived data. Special attention is being given to data democratisation to guarantee that not only researchers but also members of the public can access and use the data in their own interests. Potential users and others interested in the platform are encouraged to register and use the Water Research Observatory.

KEYWORDS: *Artificial intelligence, big data, DSSAT, SWAT, machine learning,*

ACKNOWLEDGEMENTS

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OAT (*AVENA SATIVA* L.) CULTIVAR EVALUATION FOR THE BREAKFAST CEREAL INDUSTRY IN SOUTH AFRICA

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INTRODUCTION

Oat (*Avena sativa* L.) is the seventh widely cultivated cereal crop globally for food and feed (Kim *et al*., 2022). Historically it was grown mostly for animal feed and there is limited information available to select suitable oat cultivars for the South African breakfast cereal industry. Cultivar trials as field experiments play a critical role in breeding and agronomic research to accurately measure and predict grain quality and yield components. The objective of this study was to identify high yielding and quality oat cultivars for the growing breakfast cereal industry in South Africa.

MATERIALS AND METHODS

This study was conducted on two irrigated and two dryland sites across the Western Cape province, South Africa. The study localities included Caledon (34º 13'15.98" S; 19º 25'30.84" E; irrigated and dryland), Moorreesburg (33º 16'35.57" S; 18º 42'14.91" E; dryland), and Graafwater (32º 09'12.27" S; 18º 36'15.13" E; irrigated). At each site, an experiment was conducted using a randomised complete block design with four replications. Fourteen oat cultivars were evaluated in the first season (2021) and 21 in the second season (2022). Relevant agronomical data were collected to determine cultivar performance.

RESULTS AND DISCUSSION

The top-performing cultivar at Moorreesburg, had a mean yield of 5.0 t ha^{-1}, but there were two other cultivars that did not significantly differ ($P<0.05$) from it. At the Caledon's site, the cultivar with the highest grain yield had a mean of 4.5 t ha^{-1} and it was not significantly different from other cultivars that exhibited yields ranging between 3.3 and 4.1 t ha^{-1}. Under irrigation conditions at the Caledon site, the best cultivar had a mean yield of 6.5 t ha^{-1}, followed by a mean yield of 6.3 t ha^{-1}. Without showing a significant difference ($P>0.05$) between the two cultivars. Yields at the Graafwater site ranged from 1.0 to 5.0 t ha^{-1} and the best performing cultivars yielded 4.0 t ha^{-1}. At all locations, the hectoliter mass for the cultivars with the highest grain yield ranged between 44.0 and 51.0 kg hl^{-1}, which is within the grading range required by the breakfast cereal market. The study identified high yielding oat cultivars with large, and plump kernels, which are highly preferred by producers.

CONCLUSION

The data will allow farmers to identify the best-suited cultivars for a specific environment, based on agronomic and grain quality parameters. However, two production years' data are not sufficient for long-term conclusions. This data will serve as the basis for the compilation of a production guideline in future.

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KEYWORDS: *cultivar performance, oats yield, oats quality, Western Cape*

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HORTICULTUR

ORAL ABSTRACTS

In alphabetical order

EFFECTS OF LONG-TERM STORAGE POTENTIAL ON THE PHYSIOLOGICAL RESPONSE AND QUALITY ATTRIBUTES OF POMEGRANATE (*PUNICA GRANATUM* L.) FRUIT

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INTRODUCTION

Due to inappropriate handling and storage, pomegranate fruit are highly susceptible to postharvest physiological disorders and quality losses. The main objective of this study was to evaluate the storage performance of 'Wonderful' pomegranate based on quality attributes and physiological response during prolonged storage. In addition, the optimal storage condition and duration were determined in order to maintain fruit quality and reduce losses.

MATERIAL AND METHODS

Commercially mature pomegranate (cv. Wonderful) fruit were obtained from Sonlia Pack-house (33°34′851″S, 19°00′360″E) in Western Cape, South Africa. The fruit were stored at 5 ± 0.7°C, 7.5 ± 0.3°C, 10 ± 0.5°C with 90-92 ± 6% relative humidity (RH) and 21 ± 3°C with 65 ± 6% RH for 5 months. During which the chemical attributes and fruit respiration was measured, and the incidence of physiological disorders determined.

RESULTS AND DISCUSSION

Chemical attributes like total soluble solids and acidity increased after one month at all cold storage temperatures and gradually declined with an increase in storage duration. Cold storage of fruit resulted in a decline in respiration rate (RR) at all storage regimes. After a 3-month storage duration fruits showed higher RR at 5°C compared to 7.5°C. The severity and occurrence of physiological disorders (shriveling, husk scald, aril browning, and chilling injury) were reduced at lower temperatures (5°C and 7.5°C). However, fruit became more susceptible to internal and external disorders with prolonged storage (after 2 months).

CONCLUSIONS

Considering that fruit stored for 2 months at 5°C showed reduced respiration rate and lower incidence of physiological disorders compared to other investigated temperatures, it could be recommended that the 'Wonderful' pomegranate cultivar can be stored at 5°C and >93% RH for up to 2 months. Overall, there is a need for further studies focused on postharvest treatments of these fruit before storage to minimize physiological disorders and fruit decay, especially for prolonged storage of the investigated cultivar.

KEYWORDS: *chilling injury, fruit quality, husk scald, physiological disorders, respiration rate*

ACKNOWLEDGEMENTS

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INVESTIGATING THE USE OF APPLE FRUIT AS A BIOLOGICAL SUPPRESSANT FOR POTATO TUBER SPROUTING DURING POSTHARVEST STORAGE

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INTRODUCTION

The potato (*Solanum tuberosum*) is a highly valuable starchy crop worldwide, serving as an important staple food. However, its postharvest quality is compromised during storage due to sprouting. Currently, the potato industry relies heavily on synthetic chemicals such as CIPC, maleic hydrazide and ethylene gas to control sprouting for tuber maintenance, which is environmentally unfriendly, cost-ineffective, and complex to apply. Thus, simple, eco-friendly, and cost-effective sprout-inhibiting agents are needed. Climacteric fruit such as apples has the potential to be used as biological sprouting-inhibition agents due to their excessive ethylene production, which is a sprout suppressant agent in tuber crops. Thus, the study is aimed to delay sprouting development in potato tubers using apple fruit as a biological anti-sprouting agent.

MATERIALS AND METHODS

Potato tubers were collected from two commercial farms located in Bochum and Dendron, Limpopo, South Africa. Thereafter, tubers were stored alone (control) and with apple fruit at ambient temperature (23 $^{\circ}$C) for 30 days. Tuber mass, sprouting, starch and dry matter content were measured at a 15-day interval for 30 days.

RESULTS AND DISCUSSIONS

Tubers stored with apple fruit had a significantly ($P<0.05$) reduced mass loss after 30-day storage compared to the control. Moreover, tubers stored with apple fruit had significantly reduced sprouting compared with the control during storage. Tubers stored alone had significantly ($P<0.05$) reduced dry matter and starch content compared to tubers stored with apple fruits for both of the production sites. The results suggested that potato tuber mass loss and sprouting could be reduced by storing the tubers with apple fruit. This is due to ethylene gas emitted by apple fruit during storage as they ripen, which diffuses into tubers and inhibits sprout growth.

CONCLUSIONS

Storing potato tubers with apple fruit delayed sprouting. The study demonstrated that storing potato tubers with apple fruit at ambient temperature can be used as a biological suppressant in potato tubers. Therefore, the method could be adopted as an alternative to synthetic ethylene gas and various chemicals used to control potato tuber sprouting during postharvest storage

KEYWORDS: *climacteric fruit, dormancy, ethylene, shelf-life, sprout suppressant.*

ACKNOWLEDGEMENTS

National Research Foundation for their financial assistance. Mr. Albert Ramolotja for technical assistance.

ENHANCING THE NUTRITIONAL AND PHYSIOLOGICAL QUALITY OF SWEET PEPPER FRUIT THROUGH INCORPORATING BIOSTIMULANTS, ORGANIC, AND INORGANIC FERTILIZERS INTO THE GROWING MEDIUM

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INTRODUCTION

The heavy reliance of most growers on inorganic fertilizers has resulted in several negative side effects, potentially culminating in environmental deterioration and human health problems. Reducing the usage of inorganic fertilizers by blending fertilizer (using moringa leaf powder (MLP), organic, and inorganic fertilizer blends) is likely to reduce the environmental deterioration caused by applying solely inorganic fertilizer. Sweet pepper is a high-value crop that is cultivated worldwide and appreciated for its high nutritional value, as it contains high concentrations of vitamins and antioxidants. These phytonutrients are known to be beneficial to human health. The aim of this study is to produce high-quality sweet pepper fruits in a more environmentally friendly approach.

MATERIALS AND METHODS

Experiment was conducted in the glasshouse, MLP (20g) was blended with chicken litter (CL) (30g), and NPK (3:1:3) at different concentrations (10g, 20g, and 30g), and applied to the root zone of sweet pepper plants. Yellow 'Kavango' sweet pepper was planted into 5L plastic pots filled with growing medium, fertilizer, and biostimulants were thoroughly mixed with the growing medium just prior to transplanting. Vegetative growth parameters and fruit nutrient quality were analysed. Each treatment had three replication and the experiment were arranged in a complete randomised design (CRD).

RESULTS AND DISCUSSIONS

Treating sweet pepper with NPK (20) + CL (30) + MLP (20) resulted in the highest sweet pepper yield, with fruits containing increased phytonutrient concentrations (total carotenoids) compared with other treatments, whilst the vegetative growth parameters of this treatment were significantly higher compared to the control. Treating sweet pepper seedlings with NPK (3:1:3) (20g) + CL (30g) + MLP (20g) enhances vegetative growth, which ultimately translates into higher fruit yield with increased phytonutrient quality compared to NPK (20g).

CONCLUSIONS

To reduce the environmental deterioration impact caused by the over-use of inorganic fertilizers, sweet pepper growers should opt for blending inorganic fertilizers with organic fertilizers and MLP. According to this study, the preferable concentration of blending for sweet pepper fruits with high phytonutrients is NPK (3:1:3) (20g) + CL (20g) + MLP (20g).

KEYWORDS: *biostimulants, carotenoids, inorganic fertilizers, moringa, organic fertilizers*

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THE EFFECT OF CO_2 ON PHYTOCHEMICAL ALTERATIONS OF SWEETCORN (*ZEA MAYS* L. VAR. *SACCHARATA*) COBS

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INTRODUCTION

The atmospheric CO_2 concentration has significantly increased over recent decades and is speculated further increase in the future. Fluctuations in phytochemical could be affected by altered environmental conditions, potentially affecting key components of food sources (DeLucia *et al.,* 2012). Consequently, consumer awareness towards the environment and food quality has stimulated research into the effect of environmental conditions on particular quality parameters of vegetables. One specific environmental factor is atmospheric carbon dioxide. This study aimed to investigate the effect of elevated CO_2 on the quality of sweetcorn with a focus on certain phytochemical parameters.

MATERIALS AND METHODS

Sweetcorn (STAR7719) seeds were established in two adjacent glasshouses, of either ambient CO_2 (aCO_2, ~430 ppm) or elevated CO_2 (eCO_2, ~500 ppm). Elevation of CO_2 was achieved using "Because Nature Mycelium CO_2 generator bags". Fresh cobs were harvested and analyzed for ascorbic and carotenoid concentrations. At the same time, total protein and soluble solids (TSS) in sweetcorn kernels were determined in three locations on the cob.

RESULTS AND DISCUSSION

Ascorbic acid and total soluble solids significantly increased under eCO_2 compared with aCO_2. Overall, carotenoids and total protein were not significantly affected by the CO_2 elevation; however, kernel from the bottom part of the cobs contained significantly higher carotenoid concentrations than those from the top and middle cob part. As ascorbic acid and carotenoids are important stress-protective molecules for plants and humans, the slight increase inCO2 investigated in this research seems to positively affect sweetcorn quality characteristics, as no significant yield decline was recorded under eCO_2.

CONCLUSIONS

While worldwide rising CO_2 levels are of great concern, the slight CO_2 increase expected over the next decades will positively affect sweetcorn quality parameters. Of particular importance is, that ascorbic acid in the kernels increased significantly. Further increases in CO_2 might also yield positive, significant effects on kernel color and carotenoid concentrations, making sweetcorn kernels healthier than they are today.

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KEYWORDS: *ascorbic acid, carotenoids, elevated CO_2, sweetcorn quality*

THE EFFECT OF TREE WINDBREAKS ON FRUIT QUALITY AND YIELD OF BEARING 'TANGO' MANDARIN (*CITRUS RETICULATA*) TREES IN THE WESTERN CAPE, SOUTH AFRICA

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INTRODUCTION

During spring and summer, severe south-easterly winds in the Western Cape cause significant wind scar damage. Tree windbreaks significantly reduce wind speed, but wind protection is non-uniform compared with shade netting. Immature fruit (12 weeks after petal drop) is most susceptible to wind scarring. This study's main objective was to quantify wind effect on fruit quality and yield of 'Tango' mandarin (*Citrus reticulata*) at different distances from established *Casuarina cunninghamiana* and *Populus simonii* windbreaks in the Western Cape, South Africa.

MATERIALS AND METHODS

Two commercial 'Tango' mandarin orchards in the Stellenbosch region were used for the study: Rust en Vrede and Babylonstoren. Trees were grafted on 'Carrizo' citrange rootstock and planted in 2015. Trials were conducted during the 2020/21 and 2021/2022 seasons. Distance treatments (southeastern windbreak as the reference point): trial 1 – 3H (30 m), 10H (90 m) and 16H (140 m) and trial 2 – 2H (25 m) and 4H (40 m). Yield per tree was determined (kg.tree^{-1}) by stripping 10 trees per treatment. Wind scar damage was evaluated at harvest and during summer (immature fruit): Class 1 (no damage), Class 2 (light damage) and Class 3 (severe damage). Data analysis performed in SAS Enterprise Guide 7.1 - One-way ANOVA at a 5% significance level.

RESULTS AND DISCUSSION

The wind speed during summer was substantially higher (17%) at 16H (140 m) compared with 3H (30 m). Maximum wind speed reductions were observed at 2H – 4H for both trials. The yield efficiency for both trials was non-significant between treatments. The highest packout (Class 1 fruit) was observed near the windbreak (3H) and significantly decreased (18%) as the distance increased towards 10H (90 m) and 16H. There were no significant differences in severe wind scar damage incidence (Class 3 fruit) between the distance treatments for both trials. During 12 weeks after petal drop, 87% of severe wind damage occurred on small immature fruit.

CONCLUSIONS

Results confirmed the detrimental impact of wind on external fruit quality and the limitations of tree-based windbreaks, which partly supports the current movement towards full enclosure of orchards with shade nets. Tree windbreaks provided adequate protection against wind scar damage up to 4H (4 times the mean height of windbreak trees). The production of 'Tango' mandarin trees is not significantly affected by tree windbreaks in the Western Cape, South Africa.

KEYWORDS: *quality losses, shelterbelts, soft citrus, wind protection, wind scarring*

ACKNOWLEDGMENTS

Johan and Gideon Roos from Rust en Vrede and Ian de Villiers at Babylonstoren for their support and permission for the field experiments. The FarmImpact project was supported by the Federal Ministry of Education and Research (BMBF, grant no. FKZ01LZ1711C) as part of the Client II.

A REVIEW OF FACTORS AFFECTING SEED GERMINATION AND SEEDLING ESTABLISHMENT OF THE PEPPERBARK TREE (*WARBURGIA SALUTARIS)*

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INTRODUCTION

Warburgia salutaris conservation programs seek to address the threat of pressure on local populations that could become locally and eventually regionally extinct in the wild, with negative implications for biodiversity conservation and socio-economic wellbeing. *Warburgia salutaris* (Bertol.f.) Chiov. is an important medicinal plant. It is used widely to treat several ailments throughout its distribution range and as a result is under threat due to overharvesting. The Pepperbark tree is currently listed as an endangered species and is only found in isolated populations in the wild in the eastern regions of South Africa. It is highly sought-after on the traditional medicine markets and supply does not keep up with demand. A review of several multi-disciplinary studies which resulted in the identification of factors affecting seed germination and seedling establishment will be presented.

MATERIAL AND METHODS

Flowering and fruit set, healthy seed development, seed storage regimes and seed germination studies were recorded over several seasons. For seedling establishment, growth media mixes and seedling size classes were used to determine growth rate and seedling establishment. A novel fungal species was also isolated, identified and a control program developed.

RESULTS AND DISCUSSION

Flowering and subsequent fruit set appeared to be dependent on the population from which seeds were harvested. Healthy seeds had a relatively high germination rate, although could not be stored for any length of time before viability was lost owing to the species being categorized as intermediate recalcitrant. Germination rate and subsequent seedling growth did not appear to be affect by sun/shade. Seeds germinated readily in any planting medium, but seedling growth rate was highest in a bark:vermiculite mixture which had good water holding capacity and aeration. Seedlings could be transplanted from the two-leaf stage to 12-15 leaf stage, with larger seedlings establishing more quickly than the smaller seedlings which appeared to suffer from a greater degree of transplant stress. Under adverse climatic conditions (unseasonal heavy rainfall in winter), small seedlings up to the 6-leaf stage were highly susceptible to a novel *Colletotrichum* species. Control was achieved using a single copper spray.

CONCLUSIONS

Practical application of the findings of the multidisciplinary studies has resulted in the successful rolling out several conservation programs throughout north-eastern Southern Africa having a significant impact on not only conservation but also socio-economic well-being. Over 40 000 saplings have been distributed to traditional healer practitioners over the last decade.

KEYWORDS: *establishment factors, Pepperbark tree, seeds, seedlings*

TOMATO FRUIT QUALITY IN A SOILLESS GROWING SYSTEM IN RELATION TO THE NUTRIENT SOLUTION COMPOSITION

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INTRODUCTION

Closed hydroponic growing systems where the drained nutrient solution is re-used are an environmentally friendly technology (Sonneveld and Voogt 2009). For optimum yield and quality, soilless grown tomatoes require high nutrient concentrations with an electrical conductivity (EC) between 3.5 and 9.0 $mS.cm^{-1}$ (Dorais et al. 2001). The ratios between ions in solutions will however start to deviate from the target values due to selective ion uptake. This study aimed to determine the effect of altered macronutrient ratios on tomato fruit quality to support re-use of nutrient solutions.

MATERIALS AND METHODS

Tomato (cvs. MFH 9343 and FA593, Sakata) seedlings were planted in 5L containers filled with nutrient solution at different ECs - with constant nutrient ratios – and varying EC treatments (EC 0.8, 2.4, 4.0, 5.5 $mS.cm^{-1}$) and three macro nutrient ratio combinations. The ratios were based on the change in the concentration of nutrients in leached nutrient solutions. Plants were cultivated for 71 days whereafter growth, biomass partitioning, and fruit quality were assessed.

RESULTS AND DISCUSSION

Increasing the total-N and K^{++} concentrations in the nutrient solution reduced fruit biomass, increased fruit expansion rate and fruit quality. A high rootzone EC (5.5 $mS.cm^{-1}$) limited leaf area development and the RGR (relative growth rate) of plants. A high N:K ratio reduced the number of fruit and fruit size. A high EC, with a high K:N ratio increased fruit dry matter, total soluble solids (TSS), titratable acidity and lycopene content. The Ca^{++} concentration in the nutrient solution did not affect the dry weight or TSS content. There was a good correlation between the K^{++} and SO_4^{--} concentration and fruit quality.

CONCLUSIONS

In re-circulating systems, high ECs negatively affect fruit set and yield but can increase fruit quality if the ratio between nitrogen, potassium and sulphates are maintained. These results support prolonged use of the drained nutrient solution in closed hydroponic systems.

KEYWORDS: *electrical conductivity (EC), nutrient solution, soilless production, tomato fruit quality, uptake concentrations (UC)*

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THE IMPACT OF DEGREENING ON LEMON FRUIT QUALITY

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INTRODUCTION

Citrus rind colour should ideally develop fully while on the tree; however, factors like changes in fruit internal quality, pest pressure, and packing volumes make this commercially unattainable. Degreening, to promote external colour development, is a well-known practice in the South African citrus industry. Some important changes impacting degreening efficacy in South Africa include the drastic expansion of cultivars and the planting of citrus in production regions not generally known for colour development of such citrus types. Additionally, due to phytosanitary requirements, the new lower temperatures required for the export of citrus are insufficient for the development of rind colour that would have normally occurred at these temperatures (4-11˚C). This project aimed to address the physiological response of citrus rind to ethylene and conventional degreening conditions.

MATERIALS AND METHODS

Fruit of a seedless lemon cultivar sampled from an orchard were used for this trial. Fruit of similar size from three different rind colour classes (yellow, yellow/green, and green) were harvested, degreened for 72 hours, and placed in cold storage at temperatures of -0.6˚C and 4˚C for 30 days. Fruit colour was analysed after harvest (day zero), after degreening, 24 hours after degreening, 15 days in cold storage, 30 days in cold storage, and then after seven days of shelf life. In addition, the weight loss and internal quality were also determined.

RESULTS AND DISCUSSION

Colourimeter readings for all fruit colour classes indicated the breakdown of chlorophyll in the rind as illustrated by an increase in the Hunter a/b ratio. A higher rate of colour development was observed for fruit stored at 4˚C compared to those stored at -0.6˚C. No significant weight loss occurred for any of the fruit throughout the trial. Green fruit had a significantly higher Brix˚ than the yellow fruit at day zero, and no significant difference was observed between colour classes for %juice at day zero.

CONCLUSIONS

Degreening of yellow/green and green fruit and storing at 4°C allows for better colour development than when stored at -0.6°C. If a temperature of -0.6°C is required for export, fruit should not be less mature than the yellow/green classification to allow for the best degreening to occur during shipping. Degreening does not affect external or internal quality of seedless lemons negatively. In fact, it only helps to enhance the breakdown of chlorophyll present in the rind.

KEYWORDS: *colour development, cultivars, degreening, rind colour classes, seedless lemons*

ACKNOWLEDGEMENTS

Citrii and Indigo for allowing us to use their fruit and Lucern Pack for allowing us to use their facilities for degreening the fruit.

EXPLORING DIFFERENT APPROACHES TO ENSURE STANDARDIZED ACTIVITY IN *GREYIA RADLKOFERI*

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INTRODUCTION

Greyia radlkoferi is a native South African tree in the Melianthaceae family. Extracts from the leaves of this species have shown to effectively treat skin hyperpigmentation in humans (anti-tyrosinase IC_{50} value of 17.86µg/ml). Large differences in activity were however observed in a specific population of trees established at the Mothong community project in Mamelodi. The aim of the research was thus to explore reasons for this variation in activity and assess possible solutions to overcome the variation. For commercial application it is essential that a standardized extract with good activity can be produced.

MATERIAL AND METHODS

To explore the reasons for variation a detailed phenological study was conducted and activity during different physiological plant stages and for different leaf ages were evaluated using a tyrosinase inhibition protocol as well as through ^{1}H-NMR metabolomic analysis. To overcome variation three approaches were investigated. Vegetative propagation from stem cuttings were assessed in four different seasons, using cuttings of 4 different lengths and 3 different positions (randomized complete block design - 3 replicates). The pollination system (different hand pollination methods) was investigated to determine breeding strategies and a targeted water stress (severe, moderate, mild and control) was applied before harvesting to assess if the variation could be limited (randomized complete block design with 6 replicates). Data relevant to the various trials were collected and analyzed using an ANOVA.

RESULTS AND DISCUSSION

Rooting of more than 80% was obtained from hardwood basal cuttings of 15-20cm long, taken during the winter season. Natural open pollination resulted in the highest fruit set, seed set, and number of seeds produced but can, however, increase the variation currently observed. As an alternative, hand pollination between different flowers of the same inflorescence achieved comparable seed set and seed numbers and can thus be used to assess if more homogenous material can be produced. Targeted water stress did not solve the variation in activity and no clear differences in treatments could be observed. Extracts obtained from leaves of plants in the flowering stage and from younger leaves (1-4 month old) resulted in significantly better tyrosinase activity compared to material collected during the vegetative stage and from older leaves.

CONCLUSIONS

Using an established protocol for vegetative propagation of individual plants with good activity, can assist to curb the variation in activity. Collecting material during the flowering phase when leaves are younger will contribute to increased tyrosinase activity.

KEYWORDS: *cuttings, metabolomic analysis, phenology, pollination, tyrosinase activity, water stress*

EFFECT OF SMOKE-WATER FROM DIFFERENT PLANT SOURCES ON GERMINATION OF AGRONOMIC AND HORTICULTURAL CROPS

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INTRODUCTION

Wildfires are a common feature, vital for pyric succession in fire-prone ecologies around the world. Smoke, produced from burning plant material has been discovered to exert both, stimulatory and inhibitory effects, on germination of several plant species. A group of butenolides, the karrikins (KARs) were discovered in plant-derived smoke, which acts in very low concentrations (<1nM). Another butenolide, trimethylbutenolide (TMB) (Light et al. 2010), with antagonistic effects to (KAR_1), was also discovered in plant-derived smoke (Van Staden et al. 2004). The aim of the present study was to evaluate the effects of smoke-water (SW) produced from four different plant sources (black wattle, blue gum, maize straw and South African mesic grass species) on the germination of crop and flower species.

MATERIAL AND METHODS

Seeds of cereal rye, onion and gazania were subjected to an *in vitro* seed germination test and treated with undiluted SW, prepared according to (Gupta *et al.* 2019), as well as ten dilutions from 1:5 v/v to 1:5000 v/v at varying temperature conditions (10/15ºC night/day temperature, 75% RH for cereal rye, 15/25ºC night/day temperature, 75% RH for onion, 18/25ºC night/day temperature, 75% RH for gazania).

RESULTS AND DISCUSSION

At high concentrations, all smoke-water types were generally highly inhibitory, with only undiluted SW produced from black wattle and blue gum exhibiting some seed germination in all three crops. Inhibition was reduced at less concentrated dilutions with improved germination when seeds were treated with SW from black wattle, blue gum and SA mesic grasses. Seed treated with SW from maize straw generally performed poorly compared with seed treated with other SW types.

CONCLUSIONS

While SW is effective in stimulating or inhibiting germination and growth of various plant species, the extent of these effects is also determined by the type of smoke water and the plant species it is used on. It is, thus, important to determine the best combination of crop/SW type to yield the result which could become standard treatments to improve the germination of these species.

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KEYWORDS: *blue gum, emergence, germination percentage, grass smoke-water, maize straw, wattle*

THE EFFECT OF PHENOLOGICAL GROWTH STAGES ON THE ANTIOXIDANT ACTIVITY OF *BUDDLEJA SALIGNA*

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INTRODUCTION

Buddleja saligna a small to medium evergreen tree, indigenous to South Africa is used traditionally for the treatment of sores, colds, coughs, irritable eyes, and urinary problems. The species has many promising ethnobotanical, phytochemical, and pharmacological activities. These activities have been extensively explored but there is still a gap regarding when the plant material should be harvested for optimal activity, especially for use as ingredient in sunscreens. Phenological stages of plants play a major role in the phytochemistry and biological activity of plants. The study aimed to characterize the phenological growth stages of *B. saligna* and identify the best time for harvesting plant material for optimum bioactivity.

MATERIAL AND METHODS

For the phenological study, five trees were selected, and three branches were marked per tree to observe the phenological growth phases (vegetative and flowering), and data were collected weekly. Leaves and twigs of *B. saligna* were harvested during seven different phenological stages and shade dried. Ethanolic extracts were tested for antioxidant activity using the 2,2 diphenyl-1-picrylhy-drazyl (DPPH) radical scavenging and nitric oxide (NO) assays with gallic acid as a positive control.

RESULTS AND DISCUSSION

Buddleja saligna grows all year round with defined vegetative peaks. During the winter months (June-August) the plant however grows slowly compared with Autumn (March-April) when there is active vegetative growth. The reproductive phase occurs between September and January. Phenological stages influenced the antioxidant activity as plant material collected during the flowering and vegetative growth stages had higher DPPH (EC_{50} of 4,7 µg/ml and 5,4 µg/ml respectively) and NO activity, (EC_{50} values of 65,0 µg /ml and 53,8 µg /ml respectively). NO activity was comparable to the Gallic acid control (EC_{50} values 1,21 µg/ml and 63,25 µg/ml for DPPH and NO respectively). The best reported (Twilley *et al.* 2021) DPPH activity (EC_{50} of 8.1 µg/ml) was obtained from samples collected in summer which corroborates the current results (8.8 µg/ml) obtained during the fruiting stage (summer), but flowering and vegetative growth stage samples in the current study resulted in improved activity.

CONCLUSION

For application of extracts as sunscreen, high antioxidant activity is essential. The leaves of *Buddleja saligna* should thus be harvested during autumn when the plants were actively growing or during the flowering stage to ensure higher activity.

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KEYWORDS: *antioxidant activity, Buddleja saligna, phenological stages*

THE POTENTIAL CONTROL STRATEGY OF WHITE ROOT ROT IN COMMERCIAL AVOCADO ORCHARDS

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INTRODUCTION

Rosellinia necatrix, the causal agent of white root rot (WRR), has grown in importance in regions that produce avocados, particularly in Spain, Israel, and more recently South Africa (van Den Berg et al. 2018). Due to the pathogens' broad host range and resistance to most fungicides, WRR is particularly difficult to manage and eradicate. This study aims to assess the infield efficacy of the fungicide Fluazinam and the biological control agent Extrasol (*Bacillus subtilis* and *Bacillus amyloliquefaciens*) against *R. necatrix* in commercial avocado orchards.

MATERIALS AND METHODS

Field trips were conducted in Tzaneen, Limpopo, South Africa, during the 2021 season to survey avocado orchards infested with WRR. Confirmation of *R. necatrix* infection was done using a species-specific quantitative PCR assay (Schena et al. 2002). The trees were categorized as either WRR-Asymptomatic, WRR-Symptomatic or WRR-Uninfected. The trees within each category were divided into four treatment groups: (1) Fluazinam, (2) Fluazinam + Extrasol, (3) Extrasol and (4) Control. Both orchards received two applications of Fluazinam and four applications of Extrasol at six- and three-month intervals, respectively. Disease progression was monitored using a disease scoring system, measuring the leaf area index, and baiting for the pathogen using avocado twigs.

RESULTS AND DISCUSSION

Rosellinia necatrix was confirmed in a total of 205 trees across two orchards. Treatment groups with Fluazinam (1 and 2) were found to demonstrate slower disease progression, and a proportion of WRR-Asymptomatic and WRR-Symptomatic trees within these groups have subsequently tested negative for the pathogen. Trees from the WRR-Symptomatic group have also demonstrated improved leaf area index values.

CONCLUSIONS

Preliminary results indicate that Fluazinam may be able to suppress WRR disease progression. Extrasol was found to be less effective against the pathogen, with WRR-Symptomatic trees treated with the product showing no improvement. The second year of applications is currently underway, and an emergency application for the registration of Fluazinam on avocado has been submitted.

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KEYWORDS: *biocontrol, fungicide, leaf area index*

THE HYDROCOOLING TECHNIQUE ON POST-HARVEST QUALITY OF COWPEA LEAVES: EFFECTS OF WATER TEMPERATURE AND DIPPING TIME

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INTRODUCTION

The leaves of cowpea, as an indigenous leafy crop contain essential nutrients, flavonoids, vitamins and carbohydrates providing a healthy balanced diet to many poor communities. However, their availability is threatened by postharvest losses resulting from continuously high respiration rates after harvest. Hydrocooling is one of the precooling methods used to reduce respiration of produce. Cowpea leaves are a tropical crop, susceptible to cold stress, hence; water temperature and the treatment duration that will not induce cold stress when hydrocooling must be determined. Therefore, the study's objective was to determine whether hydrocooling efficacy on cowpea leaves depends on the water temperature and dipping time.

MATERIAL AND METHODS

Cowpea leaves were harvested 90 days after sowing. Thereafter, 20 grams of the leaves per replicate were hydrocooled at 5, 10 or 15 ˚C for 10 minutes. In another experiment to determine dip time, leaves were hydrocooled with 10 ˚C water for 5, 10, or 20 minutes. Non-hydrocooled leaves served as a control. The leaves were then stored at ambient temperature for 4 days.

RESULTS AND DISCUSSIONS

The results showed that hydrocooling cowpea leaves with 5 and 10 ˚C water significantly ($P<0.05$) reduced mass loss, wilting and senescence compared with 15 ˚C water and the control during ambient storage. This indicated that the hydrocooling technique prolongs the shelf life of cowpea leaves. However, due to the risk of chilling stress, 10˚C could be an ideal temperature for cowpea leaves compared to 5 ˚C. It took 20 minutes for 10˚C water to reduce the initial leaf temperature (20˚C) by half. This resulted in reduced mass loss, delayed senescence and higher chlorophyll content during ambient storage.

CONCLUSIONS

The study demonstrated that the postharvest quality of cowpea leaves could be prolonged by the hydrocooling technique using 10 ˚C water for 20 minutes. Therefore, this technique could be adopted by resource-poor cowpea vegetable farmers to maintain the shelf-life of the produce. Moreover, the method is practical and affordable.

KEYWORDS: *cooling coefficient, indigenous produce, precooling, vegetable quality, Vigna unguiculata*.

ACKNOWLEDGEMENTS

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ANTIOXIDANT ACTIVITY OF *HELICHRYSUM ODORATISSIMUM,* INFLUENCED BY PHENOLOGY.

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INTRODUCTION

Helichrysum odoratissimum 'Imphepho' is a popular indigenous aromatic herb of South Africa, selected due to its photoprotective and antioxidant activities. There is a growing need for plant material of this species for commercialization. Therefore, information on the phenological growth stages is needed to determine the best time to harvest plant material with high biomass and good activity. The aim of this study is to provide a complete phenological description triggered by seasonal changes in *H. odoratissimum* and to determine if phenological growth stages affect bioactivity of antioxidant compounds.

MATERIALS AND METHOD

Phenological observations were done on weekly basis over two years (2019-2020) at Afriflower nursery, Cullinan, South Africa. The growth and developmental stages were coded according to BBCH scale (Meier et al. 2009), and seven different principal growth stages were described. Ethanolic extracts were made from shade dried leaves and stems harvested during 4 phenological growth stages (growth flush, budding, flowering and dormancy). Antioxidant activity was evaluated using the DPPH and nitric oxide scavenging assays.

RESULTS AND DISCUSSION

Imphepho grows vegetatively all year round, except during cold periods (winter) when it initiates dormancy and dies back if frost occur. It resprouts as soon as temperatures rise in spring. The reproductive phase starts during spring and continues into summer. The results are in accordance with those reported on *H. italicum* (Cesaraccio et al. 2004). The ethanolic extracts of plant material harvested during the flowering growth stage showed the lowest radical scavenging activity using DPPH and nitric oxide assays with EC_{50} values of 6.19±0.17 and 141.0±5.40 µg/mL, respectively. Extracts of plant material harvested during dormancy showed a high DPPH inhibition with an EC_{50} of 3.19±0.38 µg/mL, while extracts of plant material harvested during growth flush showed a high nitric oxide inhibition with an EC_{50} of 54,15±8.79 which was comparable to the positive control (2.28±0.13 and 62.22±0.04 µg/mL, respectively).

CONCLUSION

Clear recognizable phenological stages were identified, that can be used for collection of material. For better antioxidant activity, *H. odoratissimum* leaves and stems should be harvested during flush growth and dormant stage.

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KEYWORDS: *antioxidant, DPPH, Helichrysum, phenology*

RANKING OF SIX HIGH-VALUE ESSENTIAL OIL CROPS IN TERMS OF THEIR WATER PRODUCTIVITY

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INTRODUCTION

Essential oil crop water productivity (WP) is becoming a key issue, especially in semi-arid and arid areas, where crop production relies on the use of limited water supply. Essential oil yield and constituent major compound WP could be defined in relation to NWP as a measure of oil yield and major compound outcome per unit of water consumed. Therefore, this study investigated the influence of varying irrigation regimes on water productivity of essential oil yield and quality of six selected essential oil crops.

MATERIALS AND METHODS

A glasshouse experiment was carried out from September 2020 to May 2022 at the Agricultural Research Council - Vegetable, Industrial and Medicinal Plants (ARC-VIMP), Pretoria, South Africa. Rose geranium, rosemary, lemon balm, marjoram, thyme and yarrow were treated with three different water supply regimes (10, 20 and 50% depletion of plant available water) applied through drip irrigation under different temperature regimes of 11.0 - 26.7, 12.6 - 33.1, and 16.7 - 36.6 °C. Herbage yields from all research treatments were quantified and analyzed statistically using GenStat® statistical software. The fresh herbage materials from the best performing treatments were analyzed for oil yield following oil extraction using a steam distillation method, and oil quality was determined through GC-MS analysis.

RESULTS AND DISCUSSION

The highest significant oil yield and major compound WP were obtained under the following conditions for different crops: (1) yarrow - high temperature and moderate irrigation (0.0007 kg m^{-3} and 0.0003 kg m^{-3} γ-elemene); (2) lemon balm – low temperature and high irrigation (0.0032 kg m^{-3} and 0.0005 kg m^{-3} geranial); (3) marjoram – medium to high levels of both temperature and irrigation (0.0004 kg m^{-3} and 0.0001 kg m^{-3} terpinen4-ol); (4) thyme – high levels of both temperature and irrigation (0.0030 kg m^{-3} and 0.0006 kg m^{-3} p-cymene); (5) rose geranium – high temperature and low irrigation (0.0099 kg m^{-3} and 0.0033 kg m^{-3} citronellol) and (6) rosemary – low levels of both temperature and irrigation (0.0058 kg m^{-3} and 0.0031 kg m^{-3} 1,8-cineole). Thus, considering the standard oil prices in South Africa, the highest income potential per m^{-3} of water utilized for crop production is expected from lemon balm (R28.8), followed by rose geranium (R24.7), thyme (R6.9), rosemary (R4.3), yarrow (R2.1) and marjoram (R0.6).

CONCLUSIONS

Rose geranium and rosemary had the highest water productivity of oil yield and major compound, relative to other crops. Under limited water supply conditions, South African farmers can potentially achieve maximum income generation by cultivating essential oil crops of high yield and economic value. The first three crops with such potential are lemon balm, followed by rose geranium and thyme.

KEYWORDS: *lemon balm, marjoram, rose geranium, rosemary, thyme, yarrow.*

EFFECT OF NITROGEN APPLICATION ON THE PHYTOCHEMICAL CONTENT OF PATTY PAN VARIETIES

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INTRODUCTION

Patty pans *(Cucurbita pepo* L) is a fruit vegetable with good nutritional value. It is cultivated worldwide as an efficacious vegetable with biological activities that are attributable to its phytochemical content. Nitrogen (N) is known to be a limiting nutrient element in horticultural crop production. It is an essential element that can influence plant growth and development, also phytochemical and mineral content. The objective of the study was to evaluate the effect of N application on phytochemical and mineral content of patty pan varieties.

MATERIALS AND METHODS

The research study was conducted at the Agricultural Research Council, Roodeplaat, South Africa under open field. The experiment was laid out as a 6 x 2 factorial with six levels of N (0, 70, 140, 210, 280 and 350 kg ha^{-1}) and two patty pans varieties (Star 8080 and Pinwheel). Limestone ammonium nitrate (LAN, 28%) was used as the source of nitrogen. The effect of variety and N application on the vitamin C, beta-carotene, total phenolic, total flavonoids, antioxidants, and mineral element [potassium (K), phosphorus (P), calcium (Ca), iron (Fe), sodium (Na), zinc (Zn) and magnesium (Mg)] contents of patty pans were evaluated.

RESULTS AND DISCUSSIONS

Pinwheel variety had high vitamin C, beta-carotene, and total phenolics content as well as high antioxidant activity when compared to Star 8080. A strong variety and N interaction was also observed on vitamin C, beta-carotene, total flavonoids and total phenolics content. Application of N at 140 to 350 kg ha^{-1} resulted in low phytochemical content. High mineral element (Ca, P, K, Mg, Na and Fe) content was obtained at 0 kg ha^{-1} N application followed by 70 kg ha^{-1} N application as compared to other levels. The results also revealed a significant interaction between the variety and N application on the above-mentioned elements.

CONCLUSION

The application of N between 0 and 70 kg ha^{-1} resulted in higher mineral elements and acceptable phytochemical contents. However, the recommended N application rate that resulted in higher yield and quality of patty pans was 280 kg ha^{-1}. Therefore, it is advisable to growers to take into consideration when producing patty pan to apply optimum N levels in order to achieve good yield with acceptable nutritional value.

KEYWORDS: *minerals, nitrogen, patty pan, phytochemicals.*

EFFECT OF POSTHARVEST CALCIUM CHLORIDE DIPS ON THE IMPROVEMENT OF 'CLASSIC ROUND' TOMATOES (*SOLANUM LYCOPERSICUM*) FRUIT QUALITY ATTRIBUTES AND SHELF-LIFE

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INTRODUCTION

Tomato (*Solanum lycopersicum*), being a climacteric and soft-textured fruit, faces various challenges in postharvest life. The development of appropriate postharvest treatments would be essential to effectively maintained quality and shelf-life. The current study was initiated to investigate the effect of different calcium chloride ($CaCl_2$) concentrations and dipping time on the quality and shelf-life of tomato fruit.

MATERIALS AND METHODS

Tomato 'Classic round' fruit harvested at the pink physiological stage were dipped in three different concentrations of $CaCl_2$ at 0, 0.004, 0.01, and 0.03% at different dip times (0, 30, and 60 minutes) and were studied over eight days of shelf-life (0 - 7 days). Treated fruit were stored at 15°C and 80 – 90% RH for 4 weeks, subsequently, held at ambient temperature for 8 days. During shelf-life, data were collected on mass loss, firmness, color, total soluble solids (TSS), titratable acidity (TA), potential hydrogen (pH), physiological and pathological disorders.

RESULTS AND DISCUSSION

The results showed that $CaCl_2$ dips of 0 and 0.01% for 60 minutes significantly ($p < 0.001$) reduced physiological mass loss compared to $CaCl_2$ dips of 0.004 and 0.03%. Tomato fruit dipped in 0.03% $CaCl_2$ for 0 minutes were firmer than fruit dipped in 0.004 and 0.01% $CaCl_2$. This study found that $CaCl_2$ treatment delayed color development of tomato fruit from pink to red during shelf-life. In general, tomato fruit treated with 0 and 0.004% $CaCl_2$ for 0 and 30 minutes had the highest level of TSS after three days of shelf life. The fruit dipped in 0.01% $CaCl_2$ for 60 minutes from day 0 to 4 of shelf-life had a higher TA than that dipped in 0.004% $CaCl_2$. The results showed that postharvest $CaCl_2$ treatment effectively decreased the prevalence of pathological and physiological disorders in tomato fruit.

CONCLUSION

This study showed that different concentrations of $CaCl_2$ had a significant effect on the studied quality attribute and shelf life of tomato fruit. It can be recommended that growers and traders use postharvest $CaCl_2$ treatment of 0.01 and 0.03% to maintain quality and extend the shelf-life of 'Classic round' tomato fruit.

KEYWORDS: *firmness, potential hydrogen, titratable acidity, total soluble solids*

ACKNOWLEDGEMENTS

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RESPONSE OF *SCUTELLONEMA BRACHYURUS* TO NEMARIOC-AL PHYTONEMATICIDE

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INTRODUCTION

In agriculture, *Scutellonema brachyurus* is of great interest due to its wide host range on commercially important agricultural crops. The nematode species reduces crop yield from as high as 30% to crop failure. Although cucurbitacin phytonematicides (Nemarioc-AL and Nemafric-BL) consistently suppress small (r strategists) nematodes, the products appear to have limited effects on large (K strategists) nematodes due to their ability to adjust their body parts as an adaptation strategy to environmental disturbances. Measurements of different nematode body parts, referred to as morphometrics, could provide some evidence of the existence of adaptation to cucurbitacin phytonematicides in K strategist nematodes. The objective of the study was to determine the effects of Nemarioc-AL phytonematicide on morphometric characters of *S. brachyurus* nematodes.

MATERIALS AND METHODS

Post exposure of *S. brachyurus* to 0, 2, 4, 8, 16, 32 and 64% Nemarioc-AL phytonematicides, nematodes were subjected to a three-step fixation process and then mounted on permanent slides. Body length (L), tail length, oesophagus length, distance from anterior to vulva, stylet length, post vulva sac length and distance of excretory pore from the anterior end were measured using a Zeiss microscope equipped with an electronic measuring tool. Five De Man's ratios were calculated: a = L/mid-body diameter, b = L/oesophagus length), c = L/tail length), c'= tail length/anal body diameter) and V = distance from anterior end to vulva/L. Data were subjected to analysis of variance, with significant treatment means further subjected to lines of the best fit.

RESULTS AND DISCUSSION

Morphometric characters of *S. brachyurus* treated with Nemarioc-AL phytonematicide exhibited either negative or positive quadratic relationships, with some instances showing no significant relationship. Increase in morphometrics of certain organs at low concentration is a classic example of nematode adjustment to changes in the environment. Generally, when body length gradually increases as concentrations of phytonematicides increase, certain mid-body diameter and other morphometric openings decrease.

CONCLUSIONS

The observed three density-dependent growth (DDG) patterns, namely, stimulation, neutral and inhibition, suggested that *S. brachyurus* has the ability to adjust its body when subjected to Nemarioc-AL phytonematicide. This is an indication that the nematodes were tolerant to cucurbitacin phytonematicides, particularly at the concentrations used in management of population densities of the notorious *Meloidogyne* species.

KEYWORDS: *cucurbitacin phytonematicides, density-dependent growth pattern, morphometrics, Scutellonema brachyurus*.

ACKNOWLEDGEMENTS

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MAC LIKE A TREE AND LEAF

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INTRODUCTION

Leaves play a critical role in plant water use, thus evaluating leaf and petiole anatomy may reveal variations linked to drought tolerance. In South Africa, *Macadamia integrifolia*, *Macadamia tetraphylla* and their hybrids are commonly grown for their edible nuts and consequent nutritional benefits. To improve yields, irrigation is used to grow these trees in regions where rainfall is often inadequate. Selecting cultivars with desirable leaf anatomies, capable of withstanding drought, is one strategy to increase water use efficiency. To test the potential efficacy of this strategy in Macadamia, we tested differences in multiple traits related to water use efficiency in common South African macadamia cultivars.

MATERIALS AND METHODS

After the vegetative flush in spring 2021 and summer 2022, we collected leaves of various macadamia cultivars (695, A4, 814, 816, and 842) from the northern (Levubu, Nelspruit, and Komatipoort) and southern (KwaZulu Natal) regions of South Africa. Using standard microscopy techniques, we determined leaf area, stomatal density, the thickness of the palisade and spongy parenchyma tissues, xylem cross-sectional area of the petiole and vein density, as these are of direct functional relevance to water use.

RESULTS AND DISCUSSION

According to preliminary findings, leaf anatomy varies between cultivars, with clear and interacting effects between various flushes and between regions. In both seasons, cultivars 695, 814, and 816 had the highest average stomatal densities throughout orchards, whereas other leaf anatomical characteristics differed widely between cultivars. The number of stomata per leaf area, the thickness of the palisade, the spongy parenchyma tissues, and the xylem cross-sectional area of the petiole are all significantly influenced by the timing of the vegetative flush, although the growing region and cultivar appear to have a minor impact.

CONCLUSIONS

Leaf anatomical characteristics related to water use vary substantially and in ways that are flush, region and cultivar dependent. This means that any effects on water use efficiency and potential drought tolerance may be difficult to predict and will require direct experimentation under various irrigation schemes and in different crop-growing regions. Results will be made available to macadamia growers, and it is hoped that a better understanding of leaf anatomical proxies of water use will lead to better management practices, such as the selection of drought-tolerant cultivars and enhanced irrigation management, in the South African macadamia industry.

KEYWORDS: *drought tolerance, macadamia, stomatal density, vein density, water use, xylem cross-sectional area*

THE EFFECT OF MORINGA LEAF EXTRACTS ON GROWTH, DEVELOPMENT, FRUIT YIELD AND NUTRITIONAL STATUS OF SWEET PEPPER (*CAPSICUM ANNUUM* L.)

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INTRODUCTION

Sweet pepper (*Capsicum annuum* L.) from the Solanaceae family, ranked as the third most lucrative vegetable crop, following potato and tomato. *Moringa oleifera* extracts (MLEs) are a promising growth-enhancing bio-stimulant that shows potential for application in agriculture to improve crop growth and fruit yield. Moringa leaf extracts is an excellent source of minerals, antioxidants and phytohormones, particularly cytokinin-zeatin. Thus, this study aimed to evaluate extraction methods of moringa leaf powder on the growth, yield and nutritional quality of sweet pepper.

MATERIALS AND METHODS

A completely randomized design (CRD) with four replications was used in this experiment. Thirty-six healthy, similar-sized Kavango Golden Yellow pepper seedlings were selected, with four plants per treatment. Treatments included a control (no application), 2.5 g MLE (15 min), 2.5 g MLE (30 min), 5 g MLE (15 min), 5 g MLE (30 min), 10 g MLE (15 min), 10 g MLE (30 min), NPK (5 g) and NPK + 2.5 g MLE (15 min). All MLEs extracted with hot water at 100°C. Treatments were applied two weeks after transplanting, each plant receiving 50 ml of foliar spray until runoff. Data on vegetative growth parameters were collected at 7 day-intervals until fruiting. Total fruit yield, fruit size, fruit mass and internal quality parameters (ascorbic acid content and total carotenoids) were measured immediately after harvesting. Results were subjected to one-way ANOVA using GenStat.

RESULTS AND DISCUSSIONS

Results revealed that the MLE application at an early stage of development enhanced all vegetative growth parameters measured. Total yield, fruit mass and diameter increased significantly with the application of NPK+MLE. This may be due to increased fruit set and reduced fruit abscission. These phenomena were ascribed to MLE as natural source of phytohormone zeatin, minerals, sugars, vitamins and antioxidants, which are directly and indirectly involved in fruit growth and developmental processes by triggering the production of endogenous hormones, which regulate fruit set and fruit abscission. MLE+NPK application additionally enhanced vitamin C content. This may be due presence of cytokinin zeatin in MLE which also play a crucial role in ascorbic acid biosynthesis in plants.

CONCLUSIONS

The results indicate that, hot water MLE extracts can be used in the farming community as a sustainable and environmentally friendly approach to increasing crop productivity while reducing synthetic and chemical-based compound utilization, thereby sustaining the environment and reducing health concerns of consumers.

KEYWORDS: *ascorbic acid, cytokinin-zeatin, minerals, natural-biostimulants, yield*

SYMBIOTIC PLANT GROWTH-PROMOTING MICROORGANISMS ASSOCIATED WITH CANCER BUSH IN LIMPOPO PROVINCE

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INTRODUCTION

Cancer bush (*Sutherlandia frutescens*) is one of the many traditional medicinal plants considered of conservation concern in South Africa (Raimondo et al. 2009). To effectively preserve the plant through commercial production as proposed by the South African government, an understanding of the symbiotic relationships with other organisms in the rhizosphere is required. Hence, the objective of the study was to identify and characterize the symbiotic growth promoting microorganisms in cancer bush nodules from two natural populations in Limpopo Province.

MATERALS AND METHODS

Twenty nodulated roots of cancer bush were collected from two locations, Tubatse and Magkupheng, Limpopo Province, South Africa. The nodules were detached from the roots, surface sterilized (70% ethanol - 30 seconds) and rinsed with double distilled water. The pure cultures were produced using a previously described method (Koskey et al. 2016), with the description of isolated bacteria based on morphological and molecular characteristics (Somasegaran and Hoben 1985).

RESULTS AND DISCUSSION

Fourteen different symbiotic bacteria belonging to eleven genera were isolated from the two locations on cancer bush. Six isolates were identified from Tubatse and eight isolates from Makupheng. Of the fourteen symbiotic bacteria isolates, three belong to *Stenotrophomonas*, two *Leucobacter*, and one species each from *Alcaligenes*, *Enterobacter*, *Microvuga*, *Rhizobium*, *Sphingobacterium*, *Serratia*, *Brucella*, *Bacilus,* and *Cellulosimicrobium*. Each nodule had more than one species of bacteria.

CONCLUSION

This is the first comprehensive documentation of symbionts of cancer bush in South Africa. The report indicates that cancer bush in Limpopo Province is colonized by a vast number of symbiotic bacteria, with each nodule having more than one species. This work provides critical information in the move towards commercial cultivation of cancer bush in South Africa. It will guide on which species are dominant in the different areas. Moreover, understanding the symbiotic interaction between the two organisms has a great potential of improving growth and yields through nitrogen fixation and other essential nutrients, and reduce the need for inorganic fertilizer use by farmers.

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KEYWORDS: *16S rRNA gene, cancer bush, growth promotion, nitrogen fixing, plant growth-promoting rhizobacteria (PGPR), symbiosis.*

HOST STATUS OF 16 CROPS USED BY POTATO FARMERS IN CROP ROTATIONS AGAINST *MELOIDOGYNE ENTEROLOBII, MELOIDOGYNE INCOGNITA* AND *MELOIDOGYNE JAVANICA*

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INTRODUCTION

In South Africa, all commercially produced potato (*Solanum tuberosum*) cultivars are good hosts of root knot nematodes (*Meloidogyne* species). In most production systems, *M. incognita* and *M. javanica* occur as mixed populations with *M. javanica* considered to be more aggressive than *M. incognita.* Previously, synthetic nematicides were widely used to manage root-knot nematodes, but many of them have been withdrawn. After the withdrawal, the use of non-host plants in crop rotation systems is the most preferred strategy for managing nematode population densities. Therefore, the objective of this study was to determine whether the reproduction potential (RP) values of *M. incognita, M. javanica* and *M. enterolobii,* on 16 crops used in potato crop rotation systems, would be below one.

MATERIALS AND METHODS

Three separate trials, for *M. enterolobii*, *M. incognita* and *M. javanica* were conducted. In each trial, 16 treatments, namely, White maluti oats, Dolichos bean, Forage sorghum, *Crotalaria juncea*, Black saia oats, Rye, Sunflower, Barley, *Crotalaria spectabilis*, Forage rape, Jap radish, Common vetch, Rhodes grass, Velvet bean and *Eragrostis curvula* were planted in 20-cm plastic pots in a randomized complete block design (RCBD), with six replications and they were inoculated at one level. At 56 days after inoculation, nematode variables were collected.

RESULTS AND DISCUSSION

For the *M. enterolobii* trial, only common vetch, velvet bean and *E. curvula* had reproductive potential values of less than 1. For the *M. incognita* trial, white maluti oats, common vetch, rye, Rhodes grass and *E. curvula* were non-host crops. In the *M. javanica* trial, all tested crops were hosts except for White maluti oats and *Eragrostis curvula*.

CONCLUSIONS

Crops with non-host attributes identified in this study could be used in rotation with potatoes to decrease nematode population densities. However, nematode resistance studies are required, where various nematode levels will be used to determine whether crops are tolerant or resistant to the test nematode species.

KEYWORDS: *crop rotation, host status, Meloidogyne species, reproductive potential,*

ACKNOWLEDGEMENTS

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CHITOSAN-24-EPIBRASSINOLIDE COMPOSITE COATING INDUCES CHILLING TOLERANCE OF COLD-STORED POMEGRANATE FRUIT BY ENHANCING ANTIOXIDANT DEFENSE SYSTEMS

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INTRODUCTION

Low-temperature storage is one of the most effective methods and is extensively used to maintain the quality and prolong the storage life of many fresh horticultural crops. However, pomegranate fruit are highly susceptible to chilling injury when stored at low temperatures for extended periods, which affects fruit quality and results in an increased deterioration rate. Thus, there is a need to develop environmentally friendly technologies to improve postharvest quality management of pomegranate fruit. This study evaluated the efficacy of chitosan-24-epibrassinolide (CH-EBR) composite coating in alleviating chilling injury (CI) and maintaining the quality of cold-stored pomegranate fruit (cv. Wonderful). Furthermore, this study investigated the mechanism involved in chilling injury alleviation by CH-EBR.

MATERIALS AND METHODS

Following our previous studies, early harvest pomegranate fruit were treated with CH + 10 µM EBR applied by immersion method and distilled water was used as a control treatment. The fruit were air dried and subjected to storage for 4 months at 4.5 ± 1 °C; 85 ± 5 RH, and quality was evaluated at 4-week intervals after fruit storage at 25 °C for 3 days to simulate retail conditions. Fruit physiological responses, physicochemical properties, phytochemical contents, antioxidant capacity, physiological disorders and enzyme activities were monitored during storage.

RESULTS AND DISCUSSION

The results showed that the CH + 10 µM EBR coating significantly reduced fruit weight loss, decay, and susceptibility to CI. This was highly correlated with lower electrolyte leakage (EL) and higher fruit texture. Moreover, the treated pomegranate fruit had a higher antioxidant capacity and lower hydrogen peroxide (H_2O_2) accumulation, which is attributed to the higher activity of the antioxidant enzymes catalase (CAT) and peroxidase (POD). Also, the higher PAL/PPO enzyme activity ratio of the treated fruit resulted in enhanced total flavonoid accumulation, contributing to the higher antioxidant capacity. The treated pomegranate fruit also showed higher titratable acidity (TA), with slight differences observed in total soluble solids (TSS).

CONCLUSIONS

These results suggest that chitosan-24-epibrassinolide (CH-EBR) composite coating is a promising natural preservation technique to maintain quality and alleviate chilling injury of pomegranate fruit. However, more studies are still required to optimise the coating formulation and understand the effect from the metabolomic viewpoint.

KEYWORDS: *antioxidant capacity, enzymatic activity, quality, postharvest storage, phenolics*

ACKNOWLEDGEMENTS

The National Research Foundation of South Africa and the University of Johannesburg Research Committee for their financial support. Ubali pomegranate farm for supplying fruit for the research study.

YIELD AND QUALITY RESPONSE OF INDETERMINATE TOMATO AS AFFECTED BY GRAFTING METHOD AND ROOTSTOCK CULTIVARS

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INTRODUCTION

Limited comparative research exists in evaluating the performance of tomato rootstocks and growers face challenges when deciding which rootstock and grafting method to use. Therefore, the objectives of this study were to determine the effect of the grafting method and rootstock cultivars on yield and quality of tomatoes grown in a plastic tunnel and a shadenet structure.

MATERIALS AND METHODS

The experiment was conducted from December 2021 to April 2022 in a plastic tunnel and 40% white shadenet structure. Three different rootstock cultivars (Booster, SVTX6258, and Goldbac) were grafted with 'SCX824' scion with either 1 or 2 stems. Un-grafted 'SCX824' (control treatment) was used and pruned to 1 stem and 2 stems in a plastic tunnel. Horizontal wires supported plants to grow upright. Treatments were allocated in a randomized complete block design with four replicates in each structure. Data on early harvest yield, total yield, fruit physiological disorders, weight loss, total soluble solids (TSS), pH and electrical conductivity (EC) of tomato juice, and fruit mineral content were collected.

RESULTS AND DISCUSSION

Plastic tunnel: Grafting had no significant effect on TSS, pH and EC of tomato juice, and percentage weight loss, yield and fruit firmness. However, the 'Booster' rootstock with double stem scion had high fruit Mg, K, P and Fe content while 'Goldbac' grafted with single and double stem scion had high fruit Ca and Fe content compared to other treatments.

Shadenet: 'Booster' grafted with a double stem scion had a high early harvest and total yield followed by 'Goldbac' with a double scion stem. Higher incidences of fruit cracking were noticed on 'Booster' grafted with a single stem scion. Generally, grafted plants had improved Mg, K, and P content except for 'SVT6258' grafted with a single stem. 'Booster' with a double stem scion had significantly higher Mg, K and P while sodium fruit content was high on 'SVT6258' with a single stem scion. Grafting did not significantly affect fruit physiological disorders, shelf life, and TSS, pH, and EC of tomato juice.

CONCLUSION

Grafting had a significant effect in improving the fruit mineral content of tomatoes in both structures. Early harvest and total yield can be improved by combining a rootstock and a 2-stem scion in a shadenet structure. However, further studies on plant spacing need to be carried out in plastic tunnels when plants are grafted with a 2-stem scion to optimize space.

KEYWORDS: *calcium, early harvest, potassium, phosphorus, scion.*

EFEECT OF ARTIFICIAL DAYLENGTH ENHANCEMENT (PRE-SUNRISE AND POST-SUNSET) WITH BLUE AND RED LED LIGHTS ON TOMATO PLANT DEVELOPMENT, YIELD AND FRUIT NUTRITIONAL QUALITY

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INTRODUCTION

Various patterns/ratios of delivering light doses of various wavelengths have been investigated. The combined effects of continuous illumination with different wavelengths on plant growth and nutritional quality of cherry tomatoes has been tested previously, however, there are important aspects, such as the effect of the timing of light exposure, as it is not clear when to start and stop subjecting plants to LEDs of various wavelengths in order to achieve optimal yield and quality of a certain fruit vegetable crop. Therefore, this research investigated the combined effect of red and blue LED lights on tomato plants and fruit.

MATERIALS AND METHODS

Selected tomato plants were illuminated with a combination of red light (RL) and blue light (BL) at a ratio of (1:1) with a combined photosynthetic photon flux density (PPFD) of 138 ± 5 µmol m^{-2} s^{-1}. This illumination was installed above the plants and was terminated at different stages of plant growth; namely, at 50% flowering (FLW) and when fruit were mature green (MG). The plants were allowed to receive natural light during the day and were exposed to light treatments three hours after sunset and three hours before sunrise. Control plants received only natural light. Growth, yield, and quality parameters were assessed.

RESULTS AND DISCUSSION

Both light treatments, whether terminated at FLW or MG, significantly enhanced plant height, number of leaves and branching, with light treatment until the MG stage having a lesser, but nonetheless significant, effect when compared to light treatment until FLW. Plants that were treated with additional light until fruit were MG had a significantly increased total fruit mass compared with other treatments. Surprisingly, plants treated until FLW showed a significant increase in number of fruits per plant. Both treatments did not have a significant effect on colour parameters, while light treatments, particularly treatment until MG, were able to significantly enhance chlorophyll degradation in fruit. In addition, both light treatments resulted in a significant increase in fruit lycopene, the most important carotenoid in red tomato, while also increasing the concentration of β-carotene, as well as total soluble solids (TSS), phenolics and vitamin C.

CONCLUSIONS

Treating tomato plants with a combination of LED light sources only until FLW was sufficient to enhance growth, yield and antioxidant phytonutrients in tomatoes with no additional increase with further light treatment.

KEYWORDS: *controlled environment, daylength, growth and yield, light quality, tomato quality*

EFFECT OF SEASONAL VARIATION ON COMPOSITION AND ANTIMICROBIAL ACTIVITY OF ESSENTIAL OILS ON POTATO SOFT ROT BACTERIA (*PECTOBACTERIUM CAROTOVORUM*)

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INTRODUCTION

Washing freshly harvested potatoes with chemical products has led to several environmental and health problems. As an alternative, natural antimicrobial agents have attracted the attention of modern consumers and the fresh produce industry. Phytochemicals based on plant essential oils are gaining support. The objective of the study was to evaluate the effect of seasonal variation on the composition of essential oils of *Artemia afra*, *Lippia javanica* and *L. rehmannii*. Also, to determine the antimicrobial effect of the essential oils isolated during different seasons, towards the potato soft rot pathogen *Pectobacterium carotovorum*.

MATERIALS AND METHODS

Essential oils were isolated by hydrodistillation of freshly harvested leaf material during all four seasons of the year. For quantification of essential oil constituents, samples were dissolved in hexane (AR grade) as 20% (v/v) solution and subjected to gas chromatographic analysis. Relative retention indices were determined using *n*-alkanes as reference compounds. *In vitro* antibacterial screening of essential oils against soft rot, bacteria was conducted on a fresh culture strain using the serial dilution method. Dosages of essential oils were applied to the test tube dilution series. Samples of 100µl were smeared onto nutrient agar growth medium in Petri dishes and incubated for 24h at 35°C. Their efficacy was determined by bacterial colony count on the Petri dishes.

RESULTS AND DISCUSSION

Essential oil composition differed significantly from season to season. All plants tested generally had a higher production of major chemical compounds during spring, followed by winter. Although *L. rehmannii* and *L. javanica* contained similar minor compounds, there were distinct differences in the major compounds. Essential oils from winter exhibited higher antibacterial activity against *Pectobacterium* followed by spring oils, with *L. rehmannii* exhibiting the best activity. A 100% bacterial growth inhibition was achieved at relatively low concentrations of 0.3 and 0.5 µl/ml, as compared to the registered chemical dosage of 1.5 µl/ml for SporeKill. The lowest antibacterial activity was noticed in the autumn oils.

CONCLUSIONS

The chemical profile of the plant at a given season and phsiological stage, determines the antimicrobial activity of the essential oils. Post-harvest application of essential oils may serve as an alternative to synthetic crop protection products to reduce the incidence of bacterial soft rot. When isolating essential oils for antimicrobial activity, it is best to harvest plant material during winter and spring.

KEYWORDS: *antimicrobial activity, bacterial soft rot, essential oil, medicinal plants*

ACKNOWLEDGEMENTS

National Research Foundation and Potatoes South Africa for funding, Agricultural Research Council for plant material and Tshwane University of Technology for research facilities.

UNDERSTANDING *CITRUS* ROOTSTOCK SEED PRODUCTION IN SOUTH AFRICA

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INTRODUCTION

Citrus rootstocks, a determining factor for the success of commercial citrus plantings are mainly propagated through seeds. Therefore, a high seed quantity and quality are important for a continuous supply to the industry. Currently, no citriculture guidelines exist to ensure consistent seed production of rootstock trees. The aim was to obtain information on the phenology of the important rootstock cultivars currently being used in South Africa to develop production guidelines to ensure seed demand is met.

MATERIAL AND METHODS

Trials were conducted on a commercial rootstock seed farm in Uitenhage, South Africa (-33.77361° S, 25.32619° E) over two seasons 2020 and 2021. The rootstocks included in the trial was Rough lemon, 'C-35' citrange, 'X639' citrandarin, 'Carrizo' citrange, 'Swingle' citrumelo, 'MxT' hybrid and 'US-812' citrandarin trees all grafted on 'Carrizo'. Data collection included, monthly fruit size measurements, yield (kg), fruit number and seed volume per tree, and seed quantification at different maturity stages. The germination percentage were determined at the three-maturity stages in an incubator for 20 days. The experimental layout was completely randomized, and significant differences were determined at $P \leq 0.05$.

RESULTS AND DISCUSSION

'Swingle' had the highest average seed number/fruit (19), and 'US-812' the lowest (3). Rough lemon trees produced the highest fruit yield and 'C-35' the lowest during both seasons. 'X639' produced the highest number of fruit/tree and 'Carrizo' the highest volume (mL) viable seed production per tree. Large fruit produced more mature seeds than small fruit. Seed germination was higher at color-break than green fruit, except for rough lemon. For full colored fruit, rough lemon and 'US-812' showed very good germination (>85%), and 'MxT' had the lowest. In most cases, the germination percentage increased from green to full color, except rough lemon and 'C-35'. This data plays an important role in forecasting future rootstock plantings, i.e., more hectares should be planted for rootstocks with low fruit production and seed count ('MxT', 'Swingle' and 'C-35').

CONCLUSIONS

These results provide valuable cultivar-specific information to develop management strategies to ensure consistent fruit set, yield and seed supply of rootstock trees to the citrus industry.

KEYWORDS*: germination, Poncirus trifoliata, 'Swingle' citrumelo, viable seed*

ACKNOWLEDGEMENTS

RCE and CRI for funding of this project, and a special thanks to the Citrus foundation personal who willingly assisted during the trials.

XENIC EFFECTS IN MACADAMIA

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INTRODUCTION

In macadamia, protandry and pollen tube growth inhibition reduce self-pollination (Sedgley *et al*., 1985), although limited self-pollination does occur. However, it is accepted that macadamia is largely outcrossing (Trueman et al. 2019a) and that cross pollination increases yields (Trueman et al. 2019b). Pollen source may also affect nut quality (xenic effects). This work examines the role of pollen source on nut set and quality in cultivars grown in South Africa.

MATERIAL AND METHODS

Two experiments are reported on:

1. For four cultivars, ten nuts were collected from each of six trees. For each nut, pollen parent was determined using DNA markers. For quality analysis, nut-in-shell and kernel weights, kernel recovery, kernel breakage and the extent of kernel discoloration were recorded.
2. Twelve cultivars were divided into two groups of six (early vs late flowering). Within each group 20 inflorescences per cultivar were bagged to exclude pollinators to allow controlled hand pollination with their own pollen and that of the other five cultivars in the group. At maturity, the nuts were harvested, and quality was analyzed as above. Nut set was also recorded.

RESULTS AND DISCUSSION

For the marker trial, significant differences in kernel size and recovery were recorded, this being dependent on both seed and pollen cultivar, with a trend towards smaller kernels and lower kernel recovery in self-pollinated nuts. For the hand-pollination trials, pollen source resulted in significant differences in nut set, with relatively few self-pollinated nuts obtained in comparison with cross-pollinated nuts. Quality parameters are currently being analyzed and will be discussed.

CONCLUSIONS

Pollen source plays a role not only in nut set and yield, but also in nut quality. It is thus critical that growers not only maximize yield through cross pollination but also combine the specific combinations of cultivars required for optimal quality.

KEYWORDS: *macadamia, pollination, quality, xenia*

ACKNOWLEDGEMENTS

This work was funded by Macadamias South Africa NPC (SAMAC) and the Agricultural Research Council (ARC-TSC).

RESISTANCE OF ROSEMARY (*ROSIMARINUS OFFICINALIS*) TO *MELOIDOGYNE ENTEROLOBII, MELOIDOGYNE INCOGNITA AND MELOIDOGYNE JAVANICA*

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INTRODUCTION

Rosemary is one of the most important sources of phenolic compounds, having a strong antioxidant activity and gaining popularity in the medical industry. Currently, rosemary has been identified for possible use in the management of nematodes since the extracts from rosemary have been shown to display nematicidal properties due to the high concentration of volatile compounds, such as alkaloids and tannins found in leaves. The *ex vitro* resistance of rosemary to *Meloidogyne* species is however unknown. The degree of nematode resistance is determined based on relative susceptibility (RS). Therefore, the objective of this study was to determine the relative susceptibility of rosemary using the reproductive potentials (RP) of both the crops (RS = RP of test nematode on rosemary/RP of test nematode on tomato roots) compared to nematode-susceptible tomato cv. 'Floradade'.

MATERIALS AND METHODS

The study was conducted at the University of Limpopo. Rosemary cuttings and tomato seedlings were transplanted into 20-cm diameter pots containing steam-pasteurised soil. At two weeks after transplanting, plants were inoculated with 250 eggs + second-stage juveniles (J2) of *Meloidogyne enterolobii, Meloidogyne incognita and Meloidogyne javanica,* arranged in a randomised complete block design (RCBD) with 10 replications. Data were collected 56 days after inoculation using the maceration and blending method. Data was analysed on basis of relative susceptibility.

RESULTS AND DISCUSSION

The relative susceptibility (RS) of rosemary relative to tomato was 0.16, 0.37 and 0.16 when inoculated with the three *Meloidogyne species* respectively. The average final nematode population (Pf) on rosemary was significantly lower than on the susceptible tomato irrespective of the *Meloidogyne* isolate used, which resulted in all the RS values being less than unity. Plants are termed resistant if the nematodes numbers observed on the test plants are lower than those observed on the susceptible plants. The RS values less than one, indicated that the nematodes were unable to reproduce on the test plant as opposed to the known susceptible tomato cv. 'Floradade'.

CONCLUSIONS

In conclusion, RS values on rosemary were less than unity, suggesting that rosemary was resistant to the test *Meloidogyne* species. It is therefore, recommended that rosemary can be used in crop rotation systems to manage the population densities of nematodes.

Keywords: *Meloidogyne species, relative susceptibility, Rosmarinus officinalis.*

ACKNOWLEDGEMENTS

Agricultural Research Council (ARC) for consumables, National Research Fund (NRF) for funding and University of Limpopo (UL) for Enrolment.

THE EFFECT OF HARVEST TIME AND HYDROCOOLING TECHNIQUE ON POSTHARVEST WILTING OF COWPEA LEAVES

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INTRODUCTION

Cowpea is an indigenous vegetable and an important source of phytonutrients, responsible for a healthy diet. However, cowpea leaves are highly perishable. Harvesting cowpea leaves at different times may indicate which stage is more susceptible to moisture loss. Prevention of moisture loss is important for postharvest management of cowpea leaves. Hydrocooling was used to reduce moisture loss and maintain quality in coriander leaves. However, its effect on cowpea leaves is limited. Thus, the objective of the study was to determine the effect of hydrocooling on preserving cowpea leaf quality harvested at different times.

MATERIALS AND METHODS

Cowpea seeds (*cv*. Black-eyed) were planted in a pot under shade-net. Fresh leaves with no sign of wilting were randomly harvested manually 60 and 90 days after sowing (DAS). In the laboratory, leaves were hydrocooled by immersing in 10 $^{\circ}$C water for 10 minutes. Thereafter, leaves were dried using paper towel and stored at ambient temperature for 4 days. A 2x2 factorial experiment arranged in CRD was used. Factors included 2 harvest times (60 and 90 DAS) and 2 hydrocooling treatments (no hydrocooling and hydrocooling). Twenty gram of leaves per replicate was used. The experiment comprised 4 replicates. Wilting was subjectively assessed using a 4-point hedonic scale and percentage calculated.

RESULTS AND DISCUSSIONS

The results showed that hydrocooling, in comparison with the control, significantly ($P<0.05$) reduced mass loss of leaves harvested 60 DAS, with no significant ($P>0.05$) difference at 90 DAS. This suggested that hydrocooling reduced respiration rate and maintained leaf quality. Harvest time and hydrocooling had no significant effect on chlorophyll content. The study showed that harvesting leaves 60 DAS plus hydrocooling reduces wilting compared to 90 DAS+hydrocooling. It was observed that hydrocooling improved the shelf life of cowpea leaves harvested at 60 DAS compared to 90 DAS by presenting more turgid leaves without signs of wilting; an essential factor for consumer acceptance.

CONCLUSION

These results suggest that leaves should be harvested at 60 DAS and hydrocooled with 10 $^{\circ}$C water for 10 minutes to maintain postharvest quality. Therefore, this technique could be adopted by resource-poor farmers to maintain the shelf-life of cowpea leaves.

KEYWORDS: *cowpea maturity, precooling, senescence, storability, Vigna unguiculata*

ACKNOWLEDGEMENTS

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EFFICACY OF *OPUNTIA FICUS INDICA* MUCILAGE COATING ON CELL WALL INTEGRITY OF BANANA FRUIT AT RETAIL CONDITIONS

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INTRODUCTION

Rapid ripening is a common problem in climacteric fruit, such as bananas, resulting in postharvest losses. Rapid ripening is accompanied by fruit softening, which is associated with cell wall degradation after harvest. In this study, mucilage from prickly pear (*Opuntia ficus indica (OFI))* cladodes was used as a sustainable coating to minimise softening and degradation of the cell wall of bananas subjected to retail conditions.

MATERIALS AND METHODS

Prickly pear (*Opuntia ficus indica (OFI))* cladodes were harvested, and mucilage was extracted, sieved, and freeze-dried. Freshly harvested mature green banana fruit (n=510) were collected from Johannesburg fresh produce market and arranged in a completely randomised design. Different OFI mucilage coatings were prepared at 1, 2 and 3% concentrations and applied by dipping in triplicates, followed by storage at 23 ± 2°C and 85 ± 2% relative humidity. Physicochemical quality attributes, including pulp firmness, total soluble solids (TSS) and titratable acidity (TA) in pulp, peel colour, fruit weight loss, physiological responses (ethylene production, respiration rate, ion leakage), peel pigments (total carotenoids and chlorophyll) and cell wall degrading enzymes (cellulase, pectin methyl esterase (PME) and polygalacturonase (PG)) and chlorophyll degrading enzyme activities (chlorophyllase and chlorophyll degrading POD activities), were measured at 2-day intervals. Data analysis was carried out using Genstat ® 20th software, and means separation was performed at 5% probability.

RESULTS AND DISCUSSION

The results obtained showed that fruit treated with OFI mucilage coating had low activities of chlorophyll and cell wall degrading enzymes, leading to delayed peel colour changes (a* higher and b* lower) and carotenoid accumulation and ultimately inhibiting ripening associated processes compared to control fruit. Among the treatments tested, significant effects were observed for 2% mucilage, with higher firmness, chlorophyll content and TA, and lower TSS content, ethylene, and respiration rate, as well as ion leakage, compared to other treatments, including the control (uncoated).

CONCLUSION

The treatment also regulated the investigated cell wall softening enzyme activities. These findings could provide a practical approach to reducing postharvest losses of bananas in retail markets. However, further research is still required to verify this in a semi-commercial setup.

KEYWORDS: banana softening, cell wall degrading enzymes, *Opuntia ficus-indica* mucilage, postharvest handling

SOIL SCIENCE

ORAL ABSTRACTS

In alphabetical order

SOIL GOVERNANCE IN SOUTH AFRICA: THE STATUS QUO

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INTRODUCTION

South Africa, as a Member State of the Food and Agricultural Organisation of the United Nations, endorsed the revised World Soil Charter in 2015. One of the action guidelines for governments, is the incorporation of soil management guidelines into legislation and policy with the aim of resulting in national soil policy. Another guideline is the establishment of a national institutional framework for monitoring of a country's soil resources. While the country has been praised internationally for the progressiveness of its environmental legislation when it was first promulgated in 1998, it is uncertain to what extent its soil resources are protected against degradation by policies and legislation. The aim of this study was to determine the status quo of soil governance in South Africa and to identify the gaps that must be addressed to ensure holistic management of the country's soil resources.

MATERIALS AND METHODS

The current legislative framework for soil management in South Africa was investigated with a review of all existing laws, policies, and guidelines that either address aspects of soil directly or through implication. The review also focused on the respective authorities that are responsible for the execution of it.

RESULTS AND DISCUSSION

The results show that there is currently no specific national soil policy or law that governs soil with all its functions and ecosystem services, in its entirety. While there is specific legislation for water, air quality and biodiversity under the National Environmental Management Act, soil management is largely left to the Conservation of Agricultural Resources Act. Other legislation touches on some aspects of soil functionality, for example the Mineral and Petroleum Resources Development Act and the National Water Act. The current fragmented approach to soil management through legislation, is mirrored by the different authorities that are responsible for enforcing the compliance to it.

CONCLUSIONS

Soil is an important resource of the country that not only form base of its agricultural production but also provides several other ecosystem services. While some of its functions are included in sectoral legislation, there is no singular law or policy that protects soil against degradation. It is concluded that the lack of an integrated approach to soil governance requires more attention to ensure South Africa follows the guidelines outlined in the World Soil Charter.

KEYWORDS: *Soil policy, legislation, South Africa, governance*

TOWARDS DETERMINING THE BEST METHOD FOR MEASURING SOIL ORGANIC CARBON CONTENT FOR CALCULATING CARBON CREDITS IN SOUTH AFRICA

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INTRODUCTION

Selling carbon credits in South Africa for sustainable farming practices are increasingly becoming a hot topic in South Africa. Such carbon credits need to be accounted for, which commonly requires carbon content measurement. However, there are three different methods commonly used in South Africa including: Walkley-Black wet oxidation (WB), total dry combustion (TDC) and loss-on-ignition (LOI). These methods give different carbon content for the same samples. To be able to compare values between fields and seasons, a single measurement should be used, or credible transfer functions should exist. This study focused on comparing and evaluating the conventional methods for determining SOC content for further calculating carbon credits in South Africa.

MATERIAL AND METHODS

One-hundred samples were collected from five different catchments throughout South Africa, each with different carbon content values. These samples were analysed for soil organic carbon (SOC) with the three different conventional methods. Although TDC also measures inorganic C and LOI measures organic matter, correction factors were applied to values before correlations were done. Based on these values, correlation transfer functions were determined between the different methods, whereby carbon content values from one method could be transferred to the other. Additionally, the results were interpreted together with available literature and the best method for calculating carbon credits were suggested.

RESULTS AND DISCUSSION

Overall, the WB measured the lowest SOC content (mean = 2.73%, maximum = 7.82%), while the TDC method measured the highest SOC content (mean = 3.83%, maximum = 15.74%). Despite the large gap in measurements, they were highly correlated ($r^2 = 0.94$). The three methods were overall statistically correlated at a 95% confidence level, with the lowest correlation found between TDC and LOI with an r^2 of 0.82. The LOI method is recommended when the carbon content measured is being used for calculating carbon credits, as it is less expensive and there is a lower chance of underestimation and overestimation of C as with the WB and TDC methods.

CONCLUSIONS

While there were differences between the carbon content measured with the different methods, all were highly correlated and therefore acceptable transfer functions between carbon content values measured with the different methods could be created. Based on the larger possibility of inaccuracy and the cost of the WB and TDC methods, however, we recommend that the LOI method should be used when measuring the carbon content for calculating carbon credits.

Keywords: Carbon accounting, Carbon sequestration, Loss-on-ignition, Sustainable farming practices, Total dry combustion, Walkley-Black.

TOWARDS THE DEVELOPMENT OF A SOIL INFORMATION POLICY FOR SOUTH AFRICA

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INTRODUCTION

"Without soil there will be no agriculture and without agriculture there will be no food ***and*** without food..…… no human race" (DALRRD, 2022). The use of soil is to be done in such a manner that the resource is conserved, sustainable production maintained or improved and the provision of essential ecosystem services ensured. The significant contribution of soil towards sustainable food production is captured within the Constitution of South Africa, with reference to the section 24, where it is stated that every citizen has the right to a secure environment that enhances human well-being. Further to the mentioned, section 27 states that everyone has the right to access sufficient food and water and that the State has the responsibility to provide legislative or other measures to ensure such outcomes. This can only be done through a clear understanding and in-depth knowledge of soil, its function, composition, and structure together with the continued spatial-temporal evaluation and monitoring of the properties (physical, chemical and biological) in relation to various land uses. Continuous improvement and expansion of soil data contributes towards enhanced knowledge on the potential, capability, suitability and status of the soils of the country. This forms the basis for improved decision-making on the optimal, but sustainable utilization of soil resources, at all levels. Soil surveys form part of any agricultural related activity and as such, many surveys have been conducted in the country over the years. South Africa lacks, however, a comprehensive, coordinated and structured approach towards the management and improvement of soil information. This includes the absence of a clear identification of roles and responsibilities of stakeholders, relevant standards, operating procedures as well as a national, accessible, funded and maintained platform for the safekeeping of soil data. In view thereof, a (draft) Soil Information Management Policy has been developed to formalize the establishment of a coordinated approach towards the improvement and management of soil data in the country. The aim of this presentation is to provide an overview of the draft Soil Information Policy for South Africa with the vision "To establish and maintain a national knowledge system on the soil resources of the country that will encapsulate existing soil data and information and enable the enhancement and maintenance of updated, as well as newly researched soil data and derived information, by both the public and private sectors in a standardized format that is accessible to all role-players" (DALRRD, 2022).

DISCUSSION

The draft policy elaborates on the problem statement, sets the strategic significance and purpose, outlines the principles in relation to the soil resources and data management requirements and provides expected outcomes. In the latter, this entails proposing the development of a national coordinated and structured Soil Information Programme comprising of a national Soil Information System, Soil Monitoring and Evaluation Programme as well as a funded Soil Research Programme. Each of the mentioned outcomes are further described through various policy options and linked to relevant existing legislative mandates. The policy further proposes the development of an implementation and communication plan as well as the monitoring and evaluation thereof.

WAY FORWARD

Comments are invited on the draft policy, specifically from the soil science fraternity, towards ensuring completeness and improvement thereof. The policy will thereafter be subjected to relevant formalised approval procedures, prior to implementation.

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Keywords: Soil data, soil information management, Soil Information Policy

GAMMA-RAY SPECTROMETRY TO DETERMINE SOIL PROPERTIES FOR SOIL MAPPING IN PRECISION AGRICULTURE

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INTRODUCTION

Soil maps are critical for various land use applications and form the basis for the successful implementation of precision agriculture in crop production. High-resolution soil data is now required in the management of sustainable land-use practices and traditional soil maps often fail to provide these data. There is currently a stronger demand to understand soil variation at a finer scale. The use of gamma-radiometric data in conjunction with other information such as digital elevation models (DEM) or aerial photos has become an important source of data for digital soil mapping. The objective of this study was to determine the extent to which aerial gamma-ray spectroscopy, can successfully and practically be used to accurately determine soil management zones and topsoil properties for precision agriculture in the South African context.

MATERIAL AND METHODS

Airborne gamma-ray data was correlated with topsoil properties and soil types from a grid soil survey. The SCORPAN approach in the digital soil mapping was used for the predictive modelling and mapping of the soil properties and soil types. The covariate data consist of spectral, terrain and gamma data. The different soil properties were modelled using the Cubist and Random Forests regression decision trees. To predict the spatial distribution of soil types, the Multinomial Logistic Regression (MNLR) classification model were used, using 75% and 50% of the grid observations respectively.

RESULTS AND DISCUSSION

In this study the gamma-ray data was successful in predicting the soil particle fractions of sand, silt and clay, as well as the soil carbon (C), calcium (Ca) and magnesium (Mg). The Pearson's correlation yield correlations of 0.73 to 0.81 between the gamma data and these soil properties. With the digital soil mapping method, R^2 and Concordance values of between 0.53 and 0.82 where obtained. The gamma-ray data gave accuracies of 92% to 96% and Kappa coefficients of 0.81 to 0.89, with the mapping of soil types.

CONCLUSIONS

Gamma-ray data can be used to map soil properties and soil types accurately, with 50% of the conventional soil samples and observations. This is a saving in both time and money. More research needs to be done in bigger areas in South Africa to test the concept in the majority of crop production areas.

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Keywords: Airborne gamma-ray spectrometry, digital soil mapping, precision agriculture, soil maps, soil properties.

TRANSITIONING TO SUSTAINABLE FOOD PRODUCTION: WHAT CAN NEMATODES TELL US ABOUT SOIL ECOSYSTEM HEALTH?

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INTRODUCTION

Producing food sustainably requires a fundamental shift in how we farm and interact with nature. Therefore, farming '**in partnership with nature**' is a central theme in various approaches [e.g. regenerative agriculture (RA)] aimed at utilising the benefits provided by soil ecosystems. Nematodes, for example, play a central role in ecosystem functioning (e.g., nutrient cycling) and we can use nematode-based indices (NBIs) as an ecological toolset to monitor progress in soil health restoration. This work aimed to reflect on insights gained through using NBIs in assessing soil ecosystem status in agricultural and natural systems.

MATERIAL AND METHODS

Multiple study sites were investigated, including ongoing RA research trials implemented in the summer of 2019/20 and located in the Clocolan and Standerton regions. Conservation agriculture (CA) and undisturbed grasslands near Vrede and Emalahleni, respectively, were also studied. Appropriate reference systems were included and replicated soil samples collected up to a depth of 20 cm using a soil auger. Nematodes were extracted using the sugar flotation method and counted and identified up to genus or family level. Finally, nematode-based indices were calculated using the NINJA online tool, while descriptive and inferential statistics were used to explore and interpret the generated data.

RESULTS AND DISCUSSION

No significant differences in soil ecosystem status were recorded between the treatments in research trials, likely due to the short time since implementation. Soil ecosystems can take substantial time to recover following physical and chemical degradation. However, the CA farmlands showed significant improvement in soil ecosystem health and functioning compared to a conventional agriculture reference system. Additional investigations revealed a negative correlation between food web structure and inorganic nitrogen, demonstrating the need to reduce fertiliser usage. Finally, the grassland habitats showed substantial seasonal variation in soil ecosystem status, highlighting the importance of considering natural ecosystem dynamics.

CONCLUSIONS

This work evidences the timely recovery of soil ecosystems after implementing more sustainable food production systems. It also validates the use of nematode-based indices as a powerful toolset in the ecological assessment of agricultural systems. However, as with most biological parameters, the land use and environmental context should be considered for accurate interpretation.

ACKNOWLEDGEMENTS

Project collaborators from the Agricultural Research Council, ASSET Research, and the North-West University.

Keywords: Bioindicators, ecosystem functioning, soil biology, soil health

MANAGEMENT AND REHABILITATION OF PEATLANDS IN SOUTH AFRICA

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INTRODUCTION

Wetlands, including peatlands, are crucial for national climate commitments. South Africa has experienced 51 peat fires across 20 peatland systems from 1988 to date. Peat fires are characterized by subsurface fire, dominated by smoldering combustion, and can persist under low temperatures, high moisture content and low oxygen concentrations for long periods, despite rain events. With the United Nations Convention to Combat Desertification, the Land Degradation Neutrality approach strategically places conservation, management and restoration in the context of land use planning. If a wetland is degraded by erosion, invasive alien vegetation or a combination thereof, its peat and/or organic soil can be rapidly lost, along with related ecosystem services. There is a need to develop guidelines for the prevention, management and rehabilitation of degraded peatlands; as well as protocols to control peat fires.

MATERIAL AND METHODS

Case studies were selected that represent different types of peatlands located in the Western Cape, KwaZulu-Natal and North West provinces. The hydrology, peat characteristics, landscape setting and land use /cover changes in the catchment from 1994 to 2022 were described. A Russian peat auger was used to take peat samples along transects. These samples were classified according to the Von Post Humification Scale. Wells and piezometers were installed along transects to monitor water levels and determine subsurface flows.

RESULTS AND DISCUSSION

The results show an increase in water demand nationally over the past few decades. For example, the greater city of Mafikeng in North West Province grew by 121.41 km^2 over 26 years, exerting higher supply demand from the Molopo-Oog Peatland. The Onrus River peatland in the Western Cape suffered from inflow disruption due to the De Bos Dam and increased water-use through irrigation in the upper catchment; whilst an increase in tree plantations in KwaZulu-Natal reduced water-levels in the Maputaland primary aquifer with its relatively dense occurrence of peatlands. These land use changes resulted in the drying of the peat in peatlands in each of these catchments and subsequently in peat fires. Surveys reveal spatial variability of the peat and organic soil accumulation across these peatlands. We recommend identification of the most vulnerable areas within the peatland, and specific threats to the system. Resources should be focused on priority areas to prevent degradation but also create awareness of key management interventions with landowners and other partners.

CONCLUSIONS

The findings will contribute towards drafting South Africa's manual on the rehabilitation of burnt peatlands and support the national peatland protocol. This study has also provided substantial evidence to give input to the envisaged wetland policy for management and rehabilitation.

ACKNOWLEDGEMENTS

Water Research Commission for financially supporting this research.

Keywords: peat, organic soil, degradation, management, rehabilitation, protocol.

SUSTAINABLE NATURAL RESOURCES USE THROUGH BIOTECHNOLOGIES

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INTRODUCTION

A consortium of 21 European and African R&D organisations drive the Revenue Diversification pathways in Africa through bio-based, circular Agricultural Innovations (DIVAGRI) project. This project, intend to adapt biotechnologies to African conditions, in order to utilise local resources optimally, turn waste into use and enhance smallholder viability and productivity by creating business opportunities. The project will initiate seven bio-based technologies at pilot sites and subsequently to farmers at demo sites in five African countries, including South Africa.

MATERIAL AND METHODS

The biotechnologies that will be applied during the study include a desalination greenhouse and artificial wetland; using waste to produce energy and fertiliser (biogas digester and biochar kiln); improving production (subsurface irrigation and intercropping) and adding value to agricultural products (mobile bio-refinery) at pilot sites. The approach is to pilot these technologies at pilot sites, co-create and adopt with farmers at the demo sites and explore opportunities and value chains with participating communities. Baseline data, from all the demo sites across Africa, to be used in the establishment of farmer profiles as well as to monitor progress over the project lifetime (2021-2025). The KwaNdaba Community of Practice (CoP) is one of the sites selected in KwaZulu-Natal, South Africa for a demo site. The pilot site will be established at the ARC experimental farm at Roodeplaat, near Pretoria.

RESULTS AND DISCUSSION

The preliminary results from the baseline survey show that the KwaNdaba farmers have limited access to services and resources, and struggle with market access. To their advantage, the climate and soil allow for two cropping seasons per year and sufficient irrigation water is available. The soil is fertile, and crops cultivated include maize and vegetables on plot sizes that vary from 0.15-3 hectares. Education is limited and translation is often required. Basic municipal services are unavailable. Family labour is used, but labour is also rented. Farmers rent basic mechanisation, followed by manual planting, weeding and harvesting. External input is limited to fuel, seed, and some chemicals. Farmers depend heavily on opportunistic traders to sell their crops. Notably, input and output data are difficult to obtain – farmers do poorly on record keeping. Livestock mostly entails poultry, cattle and goats and production is poor. Food security is a real issue. There is scope to improve production through proper management practices, making KwaNdaba an ideal site to adopt the biotechnologies.

CONCLUSIONS

This project aims to ensure sustainable implementation and natural resources use through agricultural innovations such as water and soil technologies to improve livelihood.

ACKNOWLEDGEMENTS

European Commission (Grant Agreement number: 101000348 — DIVAGRI — H2020-SFS-2018-2020 / H2020-SFS-2020-2) for financially supporting this project.

Keywords: biotechnology, irrigation, intercropping, biochar.

INVESTIGATING THE USE OF MID-INFRARED SPECTROSCOPY IN RAPID ANALYSIS OF MINERALS IN WHEAT AND MAIZE UNDER IRRIGATION

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INTRODUCTION

Nutrient management is a major concern for the future of intensive crop production not only in South Africa but throughout the world. Routine plant analyses used as a guidance tool for fertilization is less common due to high costs involved. Cheaper, accurate and more easily accessible methods for plant nutrient analysis are urgently needed. This study investigates the use of the mid-infrared (MIR) spectroscopic technique to predict nutrients in wheat and maize. Specific objectives are to (i) quantify the accumulation of nutrients by wheat and maize under irrigation (ii) examine whether MIR can predict plant nutrients in wheat and maize as well as compare the models in precision and robustness.

MATERIALS AND METHODS

Wheat and maize samples were collected at two irrigated fields using EC_a-directed sampling approach at the end of the 2016 winter and 2016/17 summer seasons respectively. Nutrients in the plant samples were measured using closed tube digestion procedure. MIR spectral data was obtained using iS50 Nicolet Fourier Transform Infrared sensor. Regression models were developed with principal component regression and partial least squares regression using TQ analyst software. Model performance was evaluated using coefficient of determination (R^2), root mean square error (RMSE) and residual prediction deviation (RPD).

RESULTS AND DISCUSSION

The MIR calibration and validation statistics results obtained from this study demonstrated the potential of MIR as a predictive tool for rapid analysis of nutrient concentrations in wheat and maize. Particularly with the wheat, majority of the measured nutrients were excellently predicted by MIR models. However, models developed from spectra of maize samples were not as accurate as models derived from spectra of wheat samples. Nonetheless, MIR was still an acceptable approach for acceptable and quick analysis of nutrients in maize with no sample preparation.

CONCLUSION

Our findings show that the MIR spectroscopic technique can be used successfully in plant analysis, and this would enable interested parties in South Africa to step more rapidly into precise site-specific nutrient management.

ACKNOWLEDGEMENTS

Water Research Commission (WRC) for funding

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Keywords: MIR spectroscopy; nutrient management; regression

EFFECTIVENESS OF VARIOUS AMELIORANTS TO CREATE STABLE STRUCTURE IN CRUSTED SOIL

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INTRODUCTION

A study was conducted in a large area at Dinokeng Game Reserve which has been barren for the past 50 years with no recovery evident. The topsoil layer was removed by sheet erosion and a very thin, dense surface crust had formed. Different soil ameliorants were tested to alleviate the crust. Determination of structure stability was one of three methods used in testing the efficacy of the ameliorants.

MATERIAL AND METHODS

A bulk sample of 10-15 mm surface soil was collected for soil structure stability studies, by means of wet sieving. The following ameliorants and combinations thereof were added at the following per hectare equivalents: Pilyacrylamide (PAM) 5kg/ha, 10kg/ha, 15kg/ha, 20kg/ha, Gypsum 2.5t/ha, Molasses meal 5t/ha plus an untreated control. The samples were wetted, crumbed and incubated in a controlled temperature room at 24º C for 1 week and 1 month. After incubation, the soil was oven-dried for 24 hours at 50ºC, after Yoon *et al*. (2015). Three samples of 50g each from each batch of oven dried soil were used for wet sieving. Sieving was done through a 0,25mm sieve on a mechanical wet sieving machine. The remaining soil, oven dried for 24 hours at 50ºC and weighed.

RESULTS AND DISCUSSION

All PAM treatments alone and molasses alone and in combinations with gypsum and PAM, improved structure stability significantly to highly significantly over the control. Only gypsum alone and in combination with PAM failed to improve structure stability statistically significantly.

CONCLUSIONS

All amendments were effective in creating stable soil structure, except gypsum alone and in combination with an organic anion, the latter concurring with Laker & Vanassche (2001). The efficacy of the lowest PAM treatment is economically important.

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Keywords: *Gypsym, molasses meal, polyacrylamide, structure stability, Wet sieving.*

ACKNOWLEDGEMENTS

South African Soil Science Society and University of South Africa for funding and University of Pretoria for the use of their laboratories.

BIOACCUMULATION OF NON-ESSENTIAL METALS IN SELECTED INDIGENOUS MICROBES USED FOR BIOREMEDIATION OF SOIL FOLLOWING IRRIGATION WITH TREATED WASTEWATER

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INTRODUCTION

Developing remediation strategies to mitigate accumulation of toxic metals due to irrigation with treated wastewater, based on indigenous microbes could be an effective way of restoring soils for crop productivity. Bioaccumulation is a metabolically active process whereby pollutants are initially adsorbed on the surface of living cells and transported into the intracellular space for accumulation and degradation of the pollutant (Chojnacka, 2010). The objective of this study was to investigate bioaccumulation of non-essential metals in selected indigenous microorganisms used for bioremediation following irrigation with treated wastewater.

MATERIAL AND METHODS

The study was conducted at University of Limpopo Soil Science Laboratory. Soil for the study was collected from a fallowed land at University of Limpopo Experimental Farm at depth of 0-30 cm and treated wastewater was collected at an exit of Mankweng Wastewater Treatment Plant. Soils were irrigated with wastewater for 12 weeks and indigenous microorganisms that are tolerant to toxic metals, identified as *Aspergillus flavus, Staphylococcus aureus, Pseudomonas aeruginosa* and *Escherichia coli* were then isolated from the irrigated soils, and used for bioremediation of non-essential metals. Soils used for bioremediation were analysed using ICP-OES whereafter the accumulation factor for the selected microbes were calculated. Data were subjected to analysis of variance.

RESULTS AND DISCUSSION

S. aureus had the highest bioaccumulation factor for Al (0.017), As (0.124), Cr (0.031), and Pb (0.153) with bioaccumulation percentages of 1.7%, 12.4%, 3.1% and 15.3% for Al, As, Cr, and Pb, respectively. While *A. flavus* had the lowest bioaccumulation factor for As (0.072), Cr (0.006) and Pb (0.026) with bioaccumulation percentages of 7.2% (As), 0.6 % (Cr), and 0.03 % (Pb). A bioaccumulation factor for Al (0.013) was lowest in soils inoculated with *E. coli,* with a bioaccumulation percentage of 1.3%. Bioaccumulation is influenced by the bioavailability of pollutants to microorganisms, thus irrigated alkaline soils (pH of 8.6) might have limited bioavailability of pollutants.

CONCLUSION

S. aureus had the highest bioaccumulation factor which suggests that the soil conditions induced by irrigation with treated wastewater favoured *S. aureus* compared to other selected indigenous microbes used for bioremediation of soils following irrigation with treated wastewater.

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Keywords: Bioaccumulation factor, bioremediation, *non-essential metals*

ACKNOWLEDGEMENTS

University of Limpopo for providing necessary infrastructure and resources to complete this research.

BIOREMEDIATION OF NON-ESSENTIAL METALS USING INDIGENOUS MICROBES FOLLOWING IRRIGATION WITH TREATED WASTEWATER

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INTRODUCTION

Treated wastewater has the potential to alleviate global water scarcity for irrigation purposes. However, presence of toxic metals in this water is a potential drawback to usage of treated wastewater for irrigation purposes (Khan *et al.,* 2011). The objective of the study was to determine whether the selected microbes tolerant to indigenous toxic metals would remediate non-essential metals in soil following irrigation with treated wastewater.

MATERIAL AND METHODS

The study was conducted at University of Limpopo Soil Science Laboratory. Soil for the study was collected from fallowed land at University of Limpopo Experimental Farm at a depth of 0-30 cm and treated wastewater was collected at an exit of Mankweng Wastewater Treatment Plant. Soils were irrigated with wastewater for 12 weeks and indigenous microbes that are tolerant to toxic metals, identified as *Aspergillus flavus, Staphylococcus aureus, Pseudomonas aeruginosa* and *Escherichia coli* were then isolated from the irrigated soils and used for bioremediation of non-essential metals. Treated wastewater, and pre- and post-experiment soils were analysed for non-essential metals using ICP-OES. Data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Irrigation with treated wastewater led to a significant increase of non-essential metal concentrations in soils (31.11% for As, 54.00% for Cd, 25.34% for Pb, 109.97% for Al, and 31.02% for Cr, respectively). Following bioremediation, non-essential metals decrease was highest in soils inoculated with *P. aeruginosa* (56.49% for Al), *P. aeruginosa* (19.69% for As), *S. aureus* (49.73% for Cr), *A. flavus* (7.46% for Pb) and *E. coli* (16.72% for Cd). The low percentage loss of non-essential metals (As, Pb, Cr and Cd), suggest that bioavailability of these metals was low, due to high pH and an increase in organic matter concentration following irrigation with treated wastewaters.

CONCLUSION

Irrigation with treated wastewaters increased the concentration of non-essential metals in soil. Inoculation of selected indigenous microbes in soils irrigated with treated wastewaters led to a decrease in concentration of non-essential metals in soil.

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Keywords: Bioremediation, non-essential metals, treated wastewater

ACKNOWLEDGEMENTS

University of Limpopo for providing necessary infrastructure and resources to complete this research.

CARBON LOSSES AND GAINS IN AGRICULTURAL SOILS: A BASELINE STUDY OF THE MICROBIAL COMMUNITY OF TWO SOILS UNDER TWO CULTIVATION PRACTICES

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INTRODUCTION

The soil is a self-sustaining living organism with vast numbers of diverse microbes. Several biotic and abiotic factors affect the structure of the rhizospheric microbial community. These can include soil characteristics, land use history, plant species and plant genotype as well as stage of development. Arguably, the most important single factor that shapes the rhizosphere community is the range of soil characteristics. The factors in the soil that shape the microbial community include the physical and chemical traits, moisture, nutrient availability, and pH

METHOD

The farms used for the study were near Bela Bela in Limpopo with a clay soil ("turf") and Reitz in the Free State, for a sandy soil. Reference composite soil samples were taken from the Conservation Agriculture (CA) and Conventional Cultivation (CC) fields, and adjacent veld. The samples were taken as reference samples for the carbon losses and gains trial at the ARC. The bacteria and fungi DNA were extracted using the Zymo Quick DNA™ extraction kit, analysed using the NGS 16S Amplicon sequencing, and processed with Qiime 2 and Pipit.

RESULTS AND DISCUSSION

The microbial community composition varied for two cultivation practices which were (CA) and (CC). Veld samples adjacent to the CA and CC fields, were used as the reference for the base line samples. NGS analysis revealed the presence of 708 Genera for the six composite samples, of which an average of 54% could not be identified. Of the remaining 344 genera identified, a literature search revealed that 54 bacterial genera demonstrated functionality relevant to agricultural soils. These included nitrification, carbon cycling and decomposition, chemoheterotrophs, PCB (polychlorinated biphenyls) and xenobiotic decomposers, as well as phosphorus cycling microbes. The number of microbes with the ability to metabolise PCBs and xenobiotics is also encouraging, as agricultural soils frequently require remediation after introduction of foreign chemicals, such as herbicides and insecticides.

CONCLUSION

Although the number of organisms whose functionality could be identified was limited, it was encouraging to see the diversity. The soil type had an influence on the community make-up. It was expected that the disturbance of the soils, as with ploughing and discing, there would be greater variation in the microbial community. However, it was inconstant, for example, *Bradyrhizobium*, a nitrogen fixer, was most dominant in the CA Reitz sandy soil followed by the veld. For the turf soils, the CC and CA composition was almost similar due to the short period of adjustment.

Key words:
Functionality, Rhizosphere, Soil microbial community, Cultivation practice

DEVELOPMENT OF SOIL SPECTROSCOPY PREDICTION MODELS FOR SOIL PROPERTIES USED IN PRECISION AGRICULTURE, NORTH WEST PROVINCE

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INTRODUCTION

The spatial variability of soil in South Africa poses numerous problems for implementing precision agricultural methods in practice. Precision agriculture require constant and extensive monitoring of soil variables like chemical soil properties to effectively manage soils for maximum crop yields and ensuring soil conservation. Obtaining enough soil chemical data from conventional soil analysis methods are costly and expensive, limiting the available data for precision applications. Soil spectroscopy can be used to determine the soil chemical properties by predicting the soil properties routinely used in precision agriculture like pH, Phosphorus (P), Calcium (Ca), Sodium (Na), Magnesium (Mg) and Potassium (K) from soil spectral scans.

MATERIAL AND METHODS

A dataset of 979 soil samples from across the North West Province with soil property data and accompanying soil spectral data was used. Prediction models for each respective soil property was created by calibrating prediction models using Cubist, PLSR and RF with a calibration dataset and independent validation set selected using k-means clustering using a 75:25 ratio. The independent dataset was used to measure the accuracy and precision of the predictions against the laboratory measured chemical data using statistical performance parameters used in soil spectroscopy.

RESULTS AND DISCUSSION

Three prediction models were created for each soil property respectively using the three calibration methods resulting in a total of 18 prediction models. Improved results were obtained from the pH and P prediction models that already exist for this dataset and new prediction models were calibrated for Ca, Na, Mg and K respectively. Calibrations for pH, Ca and Mg yielded useable soil spectroscopy models, while prediction models for P, K and Na did not meet the minimum requirements to be regarded as reliable and accurate.

CONCLUSIONS

Soil spectroscopy has proven to produce accurate and reliable soil property predictions from soil spectral data. This study has successfully created more and better prediction models for routinely used soil properties used in precision agriculture in the North West province of South Africa. Underperforming models can be improved upon with further study and expansion of the prediction model capabilities of each respective soil property to the rest of South Africa is possible. Other soil physical and chemical properties can also be predicted using soil spectroscopy and will be explored in the future.

Keywords: Cubist, k-means clustering, random Forest, Soil spectroscopy, South Africa, Spectral library

HOW DOES LONG-TERM WHEAT MANAGEMENT AFFECT SOIL AGGREGATES AND INTRA-AGGREGATE CARBON?

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INTRODUCTION

Soil aggregate dynamics has garnered wide attention as a key soil quality indicator in recent years because of their relevance in carbon (C) stabilization. Soil organic C also acts as a cementing agent to maintain soil aggregate structure. Despite our growing knowledge of the relationship between soil aggregation and SOC stabilisation, management systems that can restore or improve aggregate stability and SOC sequestration in arable lands still needs to be researched in detail. The objective of this study was to examine the response of soil aggregates and intra-aggregate C following the 41-year application of different wheat production management practices in the semi-arid eastern Free State, South Africa. We hypothesise that less tillage intensity promotes formation of larger aggregates and soil C within these aggregates in this sandy-loam Plinthosol.

MATERIAL AND METHODS

Management practices that have been applied for 41 years on this site include two straw management practices (unburned and burned), three tillage systems (no-tillage, stubble mulch and mouldboard ploughing) and two weeding methods (chemical and mechanical). Soil cores were taken at 0-10 cm and 10-20 cm soil depths and fractionated to aggregates of different sizes [> 2.0 mm (large macro-aggregates), 2.0-1.0 mm (small macro-aggregates), 1.0-0.25 mm (large micro-aggregates) and 0.25-0.1 mm (small micro-aggregates)] using wet sieving. All the fractions including bulk soil were analysed for C by dry combustion.

RESULTS AND DISCUSSION

Unburned plots had more small macro-aggregates in the 0-10 cm (35%) and 10-20 cm (33%) soil depths, but less large macro-aggregates (26%) and bulk C (27%) in the 10-20 cm depth compared to the burned plots. No-tillage had 68% more large macro-aggregates in the 0-10 cm depth compared to stubble mulch. Small macro-aggregates, large micro-aggregates and bulk soil under no-tillage had on average 25% higher C compared to those under mouldboard ploughing in the 0-10 cm soil layer.

CONCLUSIONS

Throughout the study, there was a shift from C-rich macro-aggregates to C-depleted micro-aggregates, as tillage intensity increased. Considering the duration of the trial (41 years), surface retention of wheat straw and exclusion of soil cultivation unfortunately did not have such a big impact on macro-aggregate formation as was expected. Nonetheless, no-tillage and to some extent stubble mulch showed potential to stimulate SOC accumulation not only in different aggregate sizes but also in the bulk soil compared to mouldboard ploughing.

Keywords aggregate-size distribution, intra-aggregate carbon, semi-arid agro-ecosystem, straw management, tillage systems

42 YEARS OF FIRE FREQUENCY LEVELS EFFECT ON SOIL INVERTEBRATE COMMUNITY IN THE SAVANNA BIOMES, SOUTH AFRICA

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INTRODUCTION

Fires are common in South African savanna habitats, which can disrupt the dynamics of entire invertebrate populations, endangering biodiversity, and the environment. Ants and insects are a highly plentiful and varied group of organisms and are quick to respond to environmental disturbances The objective of the study was to determine the impact of the various levels of frequency on the changes to soil invertebrate species composition and diversity taking ants as an indicator species.

MATERIALS AND METHODS

The University of Fort Hare research farm is in the Eastern Cape under a predominantly savanna biome. The experimental layout was a randomized complete block design with two replications and the experimental plots were permanently kept since 1980. Pitfall traps were used to collect ants and other insects, which were then identified under a microscope. Three soil samples were taken from each plot to assess selected soil nutrients, moisture, and soil pH. The Shannon diversity index, richness, and population of, ants, and other insects were calculated, and a one-way ANOVA analysis was done to test for significant differences among treatments. A correlations study was used to look for any influence connected to soil parameters, including the diversity indices.

RESULTS AND DISCUSSION

There were no significant variations in the measured parameters between the different fire frequency levels. The triennial burn treatment insignificantly enhanced the insect diversity, richness, and evenness of ant species difference while the diversity, evenness, and richness were lowest in the sexennial burn plot. The ants were evenly distributed in the no-burn plot compared to the other plots, with K having a lower density than the other plots except for B4, K being slightly more diverse than B6, and B1 with a slightly lower diversity than the other plots, and it being the third species rich plot after B2 and B3, followed by the rest of the plots.

CONCLUSIONS

This study implied that fire frequency has an insignificant impact on invertebrates in a savanna biome.

KEYWORDS

Fire frequency, semi-arid savanna, soil invertebrates, ants, biodiversity

LAND SUITABILITY ASSESSMENT FOR AGRICULTURAL DEVELOPMENT IN PLOT37 PALMIETFONTEIN AREA OF POLOKWANE MUNICIPALITY IN LIMPOPO PROVINCE, SOUTH AFRICA

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INTRODUCTION

Agricultural productivity of any area of land depends on the suitability of the land for the selected agricultural enterprises. Investment in agricultural production without assessment and consideration of land suitability may therefore be a futile initiative. The scope of this part of the project was to determine the agricultural suitability (soil physical) and irrigation potential of the farm. The total area investigated was 9,99ha.

MATERIALS AND METHODS

The area investigated is located at Capricorn District, approximately ±30km South of Polokwane Town, Polokwane Municipality, Limpopo Province. A standard hand-held auger with a depth of 120cm was used to investigate the project area (or shallower if a restricting layer such as rock was encountered). At each sampling point the soil was described in a form and family level according to "Soil Classification – A Natural and Anthropogenic System for South Africa, Soil Classification Working Group 2018". The Soil Form and Family of a site are always good initial indicators of the agricultural and land capability of the area. Standard procedures for the assessment of land for irrigation development in South Africa were applied to the area.

RESULTS AND DISCUSSION

The soil potential of the Zondereinde and Sandile (53,65%) soils falls into Irrigation Class 3. The relatively high clay content of the soils is the main limiting factor in terms of irrigation potential of the area. The Estcourt soil form (38,84%) falls in Irrigation Class lV due to poor infiltration, internal drainage is slow and external drainage is limited.

CONCLUSION

As vegetables and cotton are highly susceptible to waterlogged conditions, soils with poor drainage should be avoided. Although theoretical possible to drain the soil in this class it is going to be very expensive and troublesome to drain.

ACKNOWLEDGEMENTS

Limpopo Department of Agriculture and Rural Development (LDARD) for the implementation of this project and the farmers for their support during soil classification.

KEYWORDS: Irrigation potential, land suitability, soil classification

CO_2 EMISSIONS AND NITROGEN AND PHOSPHORUS MINERALIZATION IN SOILS AMENDED WITH BIOCHAR TYPES FROM RESIDUES OF DIFFERENT CULTIVARS OF MAIZE (*ZEA MAYS* L.) AND SORGHUM (*SORGHUM BICOLOUR (L.) MOENCH*)

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INTRODUCTION

Combined effects of soil fertility decline and climate change pose a severe threat to crop production. The incorporation of biochar from maize and sorghum residues, could improve carbon sequestration and soil fertility. However, the effectiveness of this strategy could depend on the biochar characteristics, which can be affected by cultivars (feedstocks) and pyrolysis temperature. The objective of the study was to determine effects of cultivar and pyrolysis temperature on CO_2 evolution and mineral nitrogen in soils amended with residues and biochar of maize and sorghum.

MATERIALS AND METHODS

Soil was amended with residues (R), biochar types from pyrolysis residues of different maize cultivars (R201, SC701, Border King) at 350 (B350) and 650ºC (B650). The treatments were mixed with 100 g of soil at rates equivalent to 10 t C ha^{-1} and replicated 3 times, a control with soil only was also included. The treatments were incubated at field capacity moisture in a constant temperature room at 25ºC for 120 days. The amended soils were sampled after 0, 7, 14, 21, 28, 42, 56, 84, 112 and 120 days of incubation for analysis of CO_2 emission, ammonium-N, nitrate-N. The same experiment was repeated with residues and biochar types from cultivars of sorghum (O5-POTCH, PAN8816, AS8).

RESULTS & DISCUSSION

Carbon dioxide emissions increased up to day 28 of incubation and decreased thereafter in all treatments. Between days 7 and 56 the CO_2 from biochars at 350ºC was higher than those at 650ºC and the feedstocks for all the maize cultivars, except SC701 feedstock. The results of sorghum followed the same trend where biochar at 350ºC had the highest. Ammonium-N reached a maximum after 14 days while NO_3^--N started increasing on day 21. The biochar at 350ºC had higher NH_4^+-N than at 650ºC and feedstock. Amongst maize cultivars SC701-B350 had the highest NH_4^+-N and NO_3^--N whilst R201-R had the lowest. For sorghum PAN8816-B350 resulted in the highest NH_4^+-N and NO_3^--N whilst AS8-B650 had the lowest.

CONCLUSIONS

Addition of biochar produced at 650ºC from different cultivars of maize and sorghum reduce CO_2 emission and increase the release of soil essential N, that depended on the cultivar. Biochar at 650ºC has higher potential of sequestering carbon into the soils than feedstocks.

Keywords

Carbon Sequestration, Maize Residues, Pyrolysis, Soil fertility, Sorghum Residues

CAN PLANTS AND MICROBIAL ACTIVITY BE USED TO INDICATE SOIL DEGRADATION OF ALPINE SOILS SITUATED IN THE NORTHERN DRAKENSBERG, SOUTH AFRICA?

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INTRODUCTION

Alpine soils play an important role in carbon sequestration, water provisioning and sustaining biodiversity but are often subjected to degradation. Plants can be used as indicators to describe environmental changes. However, can it be used in conjunction with soil microbial activity to determine different degrees of soil degradation? This study aimed to address this question for finding relations between phytosociological classification, microbial activity and various other soil parameters in a remote alpine area.

MATERIALS AND METHODS

Thirty topsoil samples were collected from the Amphitheatre summit area in the northern Drakensberg, representing different soils and terrain attributes. Soil organic carbon (SOC) was determined from the Loss-on-Ignition method, while active carbon (AC) was determined using potassium permanganate ($KMnO_4$) oxidation. Microbial activity was determined with the fluorescein diacetate hydrolysis (FDA) method. Bacterial community structure was quantified using Biolog Ecoplates™. Soil phosphorus, exchangeable cations and CEC was determined using the Olson method, ammonium acetate (NH_4OAc) and sodium acetate (NaOAc), respectively. Cover abundance of vascular plants were estimated using the modified Braun-Blanquet method. Plant communities were determined by performing a modified TWINSPAN classification in JUICE.

RESULTS AND DISCUSSION

Soils were humified (SOC ≥ 5%) with a mean acidic $pH_{(H2O)}$ of 4.95. Positive Pearson correlations ($p \leq 0.01$) existed between SOC and $pH_{(H2O)}$ ($r = 0.44$), SOC and AC ($r = 0.52$), AC and CEC ($r = 0.59$) as well as microbial activity and AC ($p > 0.05$). Principal component analysis of the Biolog data showed the extent of dissimilarities between bacterial communities and visualised through a dendrogram. Three main groups of bacterial community structures were identified. Group 1 had a 60% dissimilarity from both groups 2 and 3, while the latter two had 35% dissimilarity. The mean SOC, AC, CEC, exchangeable cations, phosphorus, microbial activity resulted in three preliminary categories: degraded (group 1), transitional (group 2), and undegraded (group 3). *Helichrysum dasyphalum* and *Helichrysum pumilio* subsp. *pumilio* correlated with microbial activity. The undegraded group had higher microbial activity, AC, CEC, exchangeable cations and phosphorus compared to the transitional and degraded group. However, the latter had a higher CEC, phosphorus, Ca, Mg and Na concentration compared to the transitional group. Surprisingly, plant communities did not correlate well with microbial derived degradation groups.

CONCLUSIONS

The study concludes that various degrees of soil degradation within an ecosystem as determined by microbial activity and soil properties might not indicate degradation in plant communities. Plant communities were therefore a poor indicator of soil degradation in this area.

Keywords: Carbon, ecosystem, microbial activity, plant communities, soil degradation

ORGANIC CARBON FRACTIONS AND AGGREGATES STABILITY IN UMBRIC RHODIC FERRALSOLS SOILS UNDER GREEN CANE COMPARED TO PRE-HARVEST BURNING

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INTRODUCTION

Pre-harvest burning of sugarcane is a major management system globally and could have significant effect on soil organic carbon (SOC) fractions, aggregates stability and nutrient cycling, while green cane can be more beneficial on soil quality and environmental sustainability. The current study examined the effects of green cane relative to burnt cane on aggregate stability, represented by mean weight diameter (MWD) and SOC fractions in a loamy Umbric Rhodic Ferralsols soils.

MATERIAL AND METHODS

Soils under green cane were compared with an adjacent burnt cane field. The soils were sampled, in March 2021, from the 0-5, 5-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-80 and 80-100 cm depths, using micropits in the top 10 cm and using augers for deeper layers. Soil aggregate stability was determined using the wet-sieving method. The SOC fractions were determined using the physical and chemical separation, followed by determination of SOC content in different fractions by the wet oxidation method. The data of aggregate stability and associated SOC fractions in the soils were subjected to two-way analysis of variance (ANOVA) with production system (green cane and pre-harvest burning) and soil depth as the main factors using GenStat Ed 18. The least significant difference (LSD), at 5% level was used to compare treatments means.

RESULTS AND DISCUSSION

Burning reduced soil aggregate stability by 42.8% when compared to green cane in the top 10 cm depths. The carbon in the macro-aggregates fraction constituted > 60% of total SOC, making it the primary C storage fraction under both green and burnt cane. Green cane resulted in 20.4 and 45.2% higher SOC in macro- and micro-aggregate fractions, respectively, when compared to burnt cane. Burning increased mineral-associated C from bulk soil fractionation by 23.7% when compared to green cane. Upon further dispersion of macro-aggregates, the SOC in the particulate organic matter (POM-C) of coarse and fine particle size were higher in green cane management. All the C fractions, except for the mineral-associated C, decreased with increase in soil depth.

CONCLUSIONS

These findings imply that green cane production increases aggregate stability and SOC storage in different soil fractions, except mineral associated C, with potential reduction in greenhouse gas emission and sustainable sugarcane production when compared with the burnt cane on sandy loam Umbric Rhodic Ferralsols soils.

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Keywords: Acidic soils, Aggregates stability, Carbon sequestration, Green cane, Pre-harvest burning, Soil organic carbon

THE EFFECTS OF MAIZE/LEGUME INTERCROPPING ON SOIL NITROGEN DYNAMICS

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INTRODUCTION

Poor nitrogen management, which is evident through nitrogen deficiencies or toxicities is a major threat to sustainable and profitable crop production. Understanding N transformations will provide insight on the nitrogen use efficiency that is associated with the intercropping practice. This can serve as an efficient and cost-effective nitrogen management system to mitigate heavy application of N fertilizer. Therefore, this study seeks to investigate the effect of maize/legume intercropping on soil nitrogen dynamics.

MATERIALS AND METHODS

A split plot field trial was conducted intercropping maize (*Zea mays*) with chickpea (*Cicer arietinum*) and mungbean (*Vigna radiata*) at the university of Limpopo experimental farm (UL Farm) under two irrigation regimes. Soil fertility variables i.e. bulk density, aggregate stability, pH, phosphorus and organic carbon: and nitrogen fractions: biological nitrogen fixation (BNF), mineralization, uptake, residual and leaching were measured using standard procedures. All data was subjected to analysis of variance using the GenStat 20th Edition software.

RESULTS AND DISCUSSION

The results revealed that the interaction between cropping system and irrigation regime did not have a significant effect on soil conditions bulk density, aggregate stability, pH, organic carbon. Biological nitrogen fixation, mineralization and residual nitrogen increased in intercropping relative to sole cropping under both irrigation regimes. Conversely nitrogen leaching was lower in intercropping compared to sole cropping. Intercropping resulted in a significantly lower nitrogen uptake in the irrigated plot however resulted in an increase in the rainfed plot. The increase in nitrogen mineralization can be associated with the increase in N-rich crop and residues microbial activity and diversity. The greater nitrogen fixation in intercropping can be as a result of increased competition for available soil nitrogen, which results in the intercropped legume fixing a greater amount of atmospheric nitrogen.

CONCLUSION

Overall, the study showed that cereal- legume intercropping can be a sustainable way of minimizing synthetic inputs and consequently nitrogen losses from the system. The observed synchrony between nitrogen mineralization and uptake suggest that legume intercropping can serve as a mechanism for efficient utilization of nitrogen sources.

Keywords: *Intercropping, irrigation, nitrogen budgets, nitrogen mineralization, nitrogen losses*

ACKNOWLEDGEMENTS

University of Limpopo for providing necessary infrastructure and resources to complete this research.

CAN SUSTAINABLE AGRONOMIC PRACTICES IMPROVE THE EDAPHIC AND BIOTIC DYNAMICS OF THE MORINGA RHIZOSPHERE?

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INTRODUCTION

The soil health quality and the agro-ecosystem sustainability in Moringa plantations can be assessed through physico-chemical and biological indicators. Therefore, this investigation is set to characterize the effect of sustainable agronomic practices on the edaphic and biotic dynamics of the Moringa rhizosphere in a semi-arid area of South Africa.

MATERIALS AND METHODS

Soil samples were collected within the top 30 cm soil layer, from the rhizosphere of research treatments consisting of the following sustainable agronomic practices: deficit irrigation, soil water conservation and organic soil amendment. The biotic assays were performed under ideal conditions and included the total bacterial counts, enzymatic activities such as the dynamics of acid phosphatase and β-glucosidase, as well as the community-level physiological profiling technique (Biolog Ecoplate™ technique).

RESULTS AND DISCUSSION

The results indicated that in terms of C-source utilization (AWCD), Shannon diversity and richness, as well as β-glucosidase, the treatments associated with improved sustainable agronomic practices outperformed the control treatment which had planting pits as the only sustainable agronomic practice. The interaction between water regimes/soil conservation and soil amendments showed higher total bacterial counts (1.1×10^{10}) than the control (6×10^{8}). Under water stress conditions, grass-mulching excelled in the presence of manure (total bacterial counts = 3.0×10^{10}), whereas compost was more effective under plastic-mulching (total bacterial counts = 3.1×10^{9}).

CONCLUSIONS

The treatments under the rainfed-manure and plastic-mulch-manure conditions were the least healthy and healthiest, respectively, due to their biological indices. Therefore, sustainable agronomic practices, especially the blend of deficit irrigation, plastic mulch and manure, can promote sustainable management of Moringa through active rhizospheric microbial communities and healthy soil.

KEYWORDS

acid phosphatase, β-glucosidase, Biolog Ecoplate™ technique, enzymatic activities, total bacterial counts.

SELECTED SOIL CHEMICAL PROPERTIES AND EMERGING CONTAMINANTS IN SOIL-PLANT SYSTEMS AMENDED WITH BIOSOLIDS

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INTRODUCTION

The benefits and drawbacks of using biosolids on soil chemical and physical properties as well as crop production have been investigated in several regions of the globe. Nonetheless, there is scant information on the fate of emerging contaminants from a long-term field scale. The aim of this study was to investigate the long-term (> 15 years) effects of biosolid use in contrasting cropping systems on a) selected soil chemical, b) sulfamethoxazole (SMX) and triclosan (TCS) accumulation in the soil, and c) uptake of SMX and TCS by maize crop (Zea mays L.) and their resulting risk to humans.

MATERIAL AND METHODS

Soil and maize plant samples were collected at harvest from a long-term (>15 years) field trial, consisting of two contrasting cropping systems (rainfed and irrigated maize). Each cropping system was treated with three biosolid application rates (4, 8, and 16 t ha^{-1}), a commercial inorganic fertilizer, and a zero control. Soil organic carbon (SOC) was determined by the Walkley-Black method and soil pH and EC were measured in the soil-water suspension of 1:2.5. Total nitrogen (TN) was analyzed by dry combustion method using Carlo Erba NA1500 C/N analyzer. Identification and quantification of TCS and SMX, were achieved with the aid of Shimadzu Liquid Chromatograph Mass Spectrometer (LC-MS/MS model 8030).

RESULTS AND DISCUSSION

Biosolid application significantly ($p \leq 0.0001$) improved SOC and TN in the uppermost 30 cm soil layer. However, it significantly ($p \leq 0.0001$) increased soil acidity and salinity though too low to cause negative impacts on soil productivity. TCS and SMX concentration in the top 30 cm soil layer was below instrument detection limits. Similarly, SMX concentration in maize crops was below detection limits. However, TCS was detected on maize crops treated with 8 t ha^{-1} and high biosolid rates with the highest concentration recorded on the stems (666 - 892 ng/g dry weight) and lowest on the grain (35.5 - 42.8 ng/g dry weight). The estimated daily TCS intake for the current study is well below the Acceptable Daily Intake.

CONCLUSIONS

Therefore, biosolids use in agricultural lands could contribute to the United Nations Sustainable Developmental Goals without significant negative impacts on soil and human health risks via dietary intake of TCS and SMX.

Keywords: Biosolids, Soil, Sulfamethoxazole, Triclosan, Rainfed, Rainfed-Irrigated.

INVESTIGATING THE ACCURACY OF DIGITIZED SOIL DATA IN DIGITAL SOIL MAPPING

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INTRODUCTION

The acquisition of soil data in South Africa as a developing country has always been limited due to the lack of resources. However, these limitations were overthrown by the introduction of Digital Soil Mapping with machine learning algorithms. Over the years, soil classification has been conducted and the soil data recorded manually on topographic maps to indicate the different geographical locations. The introduction of geo-referencing and digitizing of scanned maps increased the availability of the recorded soil data for digital soil mapping. However, due to the unavailability of GPS at the time, this data was perceived to be geographically inaccurate. The aim of this research is to investigate whether digitized soil data affect the accuracy of soil mapping.

MATERIALS AND METHODS

The Olifants catchment was used as the study area where soil point data and covariate data were collected. The k-means clustering machine learning algorithm was used to run a code in R studio to create three different soil maps using different datasets. Dataset 1 included legacy and recently samples soil data, dataset 2 included legacy, recently sampled, and digitized soil data, and dataset 3 included digitised data only. The algorithm was calibrated with a constant sample size of 75% before creating the maps. Furthermore, kappa values (K-values) for the validation dataset and training dataset were recorded for each map to indicate the accuracy thereof.

RESULTS AND DISCUSSION

The created soil maps resulted in significantly different kappa values for the validation and training datasets. The soil map created using dataset 1 yielded K-values: 0.6850321 and 0.1410959 for the validation and training dataset respectively. Dataset 2 yielded K-values: 0.3492505 and 0.1323693 for the validation and training dataset respectively. Dataset 3 yielded K-values: 0.4897643 and 0.01732283 for training and validation dataset respectively. The map created from dataset 1 yielded the highest K-values for both the training and validation datasets resulting in the most accurate soil map. However, the map created from dataset 3 yielded the lowest K-values, resulting in the least accurate soil map.

CONCLUSIONS

The maps created with datasets that included digitised soil point data indicated the lowest accuracy as compared to the other map without the digitised soil point data. This could be accounted to the uncertainty about the geographical locations of the soil points and the geo-referencing process used for assigning real-world coordinates to the pixels of the scanned topographic maps where the points were initially recorded.

KEYWORDS: *South Africa, Kappa Values, Geo-refenced data, Machine learning Algorithms, Map accuracy*

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MICROORGANISM SPECIES THAT GROW ON RECALCITRANT SOIL GLOMALIN

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INTRODUCTION

Glomalin was discovered in 1996, while attempting to find an immunological probe for AM fungal hyphae, that AM fungi produce a glycoprotein subsequently named glomalin, on hyphae actively growing for 20-22 weeks. A probe, based on the use of a monoclonal antibody (MAb32B11), was immunoreactive with glomalin on hyphae of arbuscular mycorrhizal (AM) fungi, but not with other typical fungi, namely, Rhizoctonia, Gaeumannomyces, Endogone, Mucor, and Phytophthora. Glomalin has been observed to coat AM fungal hyphae, portions of colonised roots, soil particles, and arbuscules within root cells using fluorescent microscopy. Glomalin is a highly stable and hydrophobic glycoprotein (produced by AM fungi which provides a hydrophobic coating to soil aggregates. In its stable and hydrophobic nature, glomalin might not be a source of either carbon or nitrogen to soil microbes. The objective of this study was to determine whether glomalin is a source of carbon and/or nitrogen to soil microbes.

MATERIALS AND METHODS

Microbial growth media with glomalin, humic acid and glucose were tested for microbial cultures they would sustain. Soil from an undisturbed treed vegetation site (1 Kg) was used to extract glomalin. A 20 mM citric acid at pH 7.0, extraction buffer was prepared in bulk (8 L) and autoclaved at 121 ^{0}C and 103 kPa for 45 min (Wright and Upadhyaya 1996). The extract was oven-dried at 55^{0}C and yielded 71.2 g of glomalin powder. Basal medium did not have neither C nor N source. Tests also had N as a factor of microbial sustenance. Fungal species purified on potato dextrose agar were identified by morphological features under a microscope. Meanwhile, while bacterial species purified on nutrient agar were identified through sequencing of rRNA 16S gene. There were no statistical analyses conducted, microorganisms that were sustained on these growth media were only observed for identification.

RESULTS AND DISCUSSION

Fungus sustained by glomalin growth medium was Aspergillus, while growth medium of glomalin with N sustained Aspergillus and Penicillium. Bacteria on glomalin were Bacilus pumilus, Stenotrophonas maltophilia, and Enterobacter spp., while glomalin with N did not sustain any bacterial species. Humic acid without N supplement sustained fungi genuses of Penicillium and Fusarium, however addition of N onto the medium was only left with Penicillium. Bacteria could not be sustained on humic acid growth medium, without or with N. Glucose sustained comparatively higher numbers of fungi and bacteria, though glucose without N could not sustain fungal culture types. Fungi could not be sustained on basal growth medium, though small number of bacterial culture types could be sustained on this medium.

CONCLUSION

Microorganism cultures sustained on glomalin medium are degraders of hydrophobic and recalcitrant substrates. Aspergillus and Penicillium, the fungi sustained on glomalin with N growth medium, are pectin degraders. Bacillus pumilus and Stenotrophonas maltophilia, the bacteria sustained on glomalin growth medium, are degraders of hydrocarbons (Khanna et al., 2011; Tebyanian et al., 2013). Enterobacter spp., bacteria also on glomalin growth medium, has a membrane that is resistant to degrading biomolecules in animal gut (Grimont and Grimont, 2006).

Keywords – bacteria, carbon source, degrade, fungi, glomalin, nitrogen source

SORPTION OF SOLUBLE ALUMINIUM, IRON AND MANGANESE: IMPLICATIONS FOR IRRIGATION WATER QUALITY GUIDELINES

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INTRODUCTION

Acid Mine Drainage from closed mines flood nearby rivers and dams. Treatment of these mine effluents is costly and partial treatment has been considered for irrigation in South Africa. However, the South African Water Quality for Irrigation model (SAWQI) projects long-term irrigation with such partially treated mine effluents may exceed preset accumulation thresholds of Al, Fe and Mn in <100 years. Globally, some regulatory frameworks consider a risk-based approach, which focusses on metal bioavailability (not total) for which soil pH, sorption and redox potential are essential. The objective of this study was to assess if bioavailable Al, Mn and Fe under ideal soil conditions for crops (aerated, pH 6-7) depend on initial soluble load. The hypothesis was that, the water-soluble fraction of these metals will not increase as a function of initial soluble load under ideal soil conditions.

MATERIALS AND METHODS

A batch sorption experiment was conducted using a red sandy clay loam soil in a constant temperature room (25 °C). The soil (pH 6.5) had water soluble concentrations of 2.1, 0.46 and 5.28 mg/kg of Fe, Mn and Al, respectively. Six metal loading rates from 93.75 mg/l to 3000 mg/l for Al/Fe and from 3.75 mg/l to 120mg/l for Mn, using a soil: solution ratio of 180 g: 300 ml, were applied in ternary systems, with each load either limed or not and either aerated or not, leading to four different lime/aeration treatment combinations. Variable liming rates were applied depending on metal load's acid generating potential to maintain a pH range of 6-7. Dissolved oxygen measurements guided the frequency and intensity of aeration. The whole design was replicated three times. All samples were hand shaken daily and the supernatants were analysed for metal content after three weeks of incubation.

RESULTS AND DISCUSSION

The water soluble concentrations of Al and Fe across all loads under ideal soil conditions did not differ significantly from that of the untreated soil, due to nearly 100 % sorption efficiency. Un-limed soils could not effectively sorb the metals at high loads regardless of oxygen status which was attributed to low soil pH. Mn sorption efficiency was <50 % at high loads, regardless of lime/oxygen regime, which may be due to slow Mn sorption kinetics and substrate inhibition of biotic Mn oxidation at high loads.

CONCLUSIONS

The results of this study suggest that mine effluents and potentially other water sources containing Al and Fe, deemed unacceptable for irrigation by SAWQI due to projected exceedance of thresholds of Al and Fe may not pose a phytotoxic risk, and recommends SAWQI to consider their bioavailability. Further research on Mn in this regard is warranted.

KEYWORDS: Irrigation water quality guidelines, sorption, metal bioavailability

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TOWARDS A HYDROLOGICAL SOIL MAP OF SOUTH AFRICA: DOWNSCALING LEGACY SOIL INFORMATION FOR MACHINE LEARNING BASED DIGITAL SOIL MAPPING

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INTRODUCTION

The lack of a detailed and accurate hydrological soil map for South Africa has recently been identified as hindering progress in hydrological modelling, catchment management and land use change management. Recent advances in Digital Soil Mapping has made it possible to create large scale soil maps for large areas using legacy soil data. However, various questions remain regarding an appropriate methodology for using legacy soil information. The main objective of this study was to assess various approaches to downscaling legacy soil information for machine learning based digital soil mapping for hydrological soil mapping purposes.

MATERIALS AND METHODS

Three levels of soil information was used to create a hydrological soil map of the 5790 km^2 Sabie-Sand catchment. The first level of soil information contained all legacy soil information available (12992 observations) in the catchment. Using k-means clustering a second level was created by downscaling the majority soil class (Mountainous deep recharge), and lastly, a proportional downscaling of majority soil classes also using k-means clustering. These three datasets were analysed using QQ plots and Welsh's t-test to test the significance and representativeness of the datasets. These three datasets were also then used to create three hydrological soil maps of the catchment using multinomial linear regression and analysed using confusion matrixes and Kappa statistics.

RESULTS AND DISCUSSION

We hypothesize that the most detailed level of soil information will yield the most representative and significantly correlation to terrain derived variables, but a poor association to other environmental covariates such as mean annual precipitation and NDVI values. Followed by the second levels of soil information and lastly by the third level of downscaled soil information. Therefore, more soil information should improve the representativeness of observations variables against catchment variables. However, more soil observations do not necessarily improve mapping accuracy. This is based on the machine learning algorithm interprets the data. We hypothesize that the downscaled soil datasets will yield more accurate hydrological soil maps than using all the available soil data, with the majority soil classes being proportionally downscaled yielding the statistically best hydrological soil map of the catchment.

CONCLUSIONS

Legacy soil information is imperative to creating large scale hydrological soil maps. However, legacy soil data is often times only highly detailed in specific areas within a landscape. These datasets need to be downscaled to appropriate class distributions for use in machine learning based digital soil mapping. Downscaling majority soil class distributions is an effective approach to improving the mapping of large scale hydrological soil maps using legacy soil information.

KEYWORDS: *Digital soil mapping, downscaling, hydrological soil map, machine learning*

ACKNOWLEDGEMENTS

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LONG-TERM EFFECTS OF MICRO-FINE AND CLASS A CALCITIC LIME APPLICATION RATES ON SOIL ACIDITY AND ROOIBOS TEA YIELDS UNDER CLANWILLIAM FIELD CONDITIONS

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INTRODUCTION

Previous research on the effect of soil liming on rooibos tea growth were limited to short-term greenhouse trials. Joubert et al. (1987), Muofhe and Dakora (1999) and Lourenco (2018) reported a significant positive effects of liming on rooibos seedling growth and N fixation in an acid, sandy soil over 5-6 month pot trial periods. Lime fineness has been shown to affect its effectivity in the field. Therefore, the aim of this study was to investigate the effects of different lime application rates (0-5 tons ha^{-1}) and different lime types (micro-fine and class A) on soil pH and rooibos yields over a 4-year rooibos production cycle under Clanwilliam field conditions.

MATERIALS AND METHODS

The experimental site was located in a rooibos plantation in Clanwilliam that had never been limed. The soil was a sand (97% sand) with pH_{KCl} of 4.4. Clanwilliam is a major rooibos production area in South Africa, with Mediterranean climate and average rainfall of 248 mm. Micro-fine and class A calcitic lime with similar purity were incorporated at rates of 0, 0.5, 1.0, 2.0 and 5.0 tons ha^{-1} to 15 cm, prior to planting. Soil pH was measured in 1M KCl in 1:2.5 soil to solution ratio. Soil EC was measured in distilled water in a 1:2.5 soil to solution ratio. Rooibos mortality and yields were then measured over a period of 4 years, with foliar nutrients determined in Year 4.

RESULTS AND DISCUSSION

Micro-fine lime resulted in significantly higher soil pH values (0.5 pH unit) than class A lime. Both limes achieved maximum soil pH and EC values in Year 2, and then declined significantly in Year 3 and 4, likely due to leaching and exhaustion of the most soluble lime fractions. Although micro-fine lime had positive effects on foliar N and Ca concentrations and bush survival, liming appeared to have a negative effect on rooibos tea yields. Yields tended to decline with increasing lime application rate over the entire production period.

CONCLUSIONS

In contrast to previous short-term liming pot trial studies, the present long-term field trial showed that that liming is unnecessary under Clanwilliam field conditions. Further long-term field studies in other major rooibos production regions should be carried out.

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Keywords: *Aspalathus linearis*, soil acidity, lime fineness, soil amelioration

MOPANE WORMS AND SOIL FERTILITY: AN UNDERVALUED SERVICE PROVIDER?

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INTRODUCTION

Mopane worms are the caterpillar of the mopane moth (*Gonimbrasia belina*), and are known as a traditional food source and seen as a delicacy by many people in southern Africa. However, mopane worms not only provide food and generate income during outbreak periods, they provide an important ecosystem service by facilitating nutrient cycling and contributing to soil fertility (Chapman et al. 2003). The mopane worms produce casts, or frass, that effectively convert tough mopane leaves into easily mineralizable organic matter. In this study we used ammonium (NH_4^+) and nitrate (NO_3^-) as indicators of mineralization rates. During an incubation trial, we compared the rates of decomposition and nutrient release between mopane leaves and frass to determine the contribution and importance of mopane worms to facilitate nutrient cycling in semi-arid regions.

MATERIAL AND METHODS

Topsoil, mopane leaves and caterpillar frass were collected from Venetia Nature Reserve, close to the Botswana border, in a region that is known for regular mopane worm outbreaks. A completely randomized design was followed during the incubation trial, at the University of Venda. Glass jars were filled with soil, and brought to field capacity, after which four treatments were added: control (soil only), frass, whole leaves and fine leaves. Treatment rates were based on typical biomass of leaves in mopane veld. Four replicates of each treatment were sampled on day 0, 1, 3, 7, 14, 21, 40 and 60, and analyzed for NH_4^+ and NO_3^- to determine mineralization rates (Van Niekerk *et al.* 2011).

RESULTS AND DISCUSSION

Most notably, a sharp increase in NH_4^+ release occurred in the frass treatment after treatment application. NH_4^+ reached a peak in the frass treatment on day 3 with 30.95 ± 0.22 mg kg^{-1}, compared to 3.6 (± 0.49) mg kg^{-1} and 3.07 (± 0.21) mg kg^{-1} for control and whole leaf treatment, respectively. NO_3^- was slower to respond, and release of NO_3^- was delayed in all treatments. Overall, over the course of 60 days, the total cumulative release of inorganic N ($NH_4^+ + NO_3^-$) release was higher in frass with 112.8 mg kg^{-1}, followed by whole leaves 70.5 mg kg^{-1} and then fine leaves 26.9 mg kg^{-1}. Mineralization and N release were faster for frass treatment compared to mopane leaves, confirming that mopane worms play an important part in nutrient release and cycling.

CONCLUSIONS

Our results show that frass produced by mopane worms had a higher N turnover than whole leaves and fine leaves Not only do mopane worms convert the leaves into small sizes, the digestion process converts the leaves into an organic product that can decompose faster and release nutrients back into the environment at a faster rate and more effectively. This suggests that mopane worms form an integral part of the nutrient cycling process.

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KEYWORDS: ecosystem service, mineralization, mopane worms, nitrogen, nutrient cycling

ACKNOWLEDGEMENTS

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IDENTIFYING THE MOST SUITABLE SOIL DATABASES FOR CROP MODELLING APPLICATIONS IN SOUTH AFRICA

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INTRODUCTION

Obtaining accurate soil parameter information for crop model applications is a global challenge. The use of freely available online soil databases is becoming increasingly popular, but there is uncertainty around the quality of the data. This study catalogued local and global soil databases applicable to South Africa and investigated the accuracy of a selection of databases by conducting three case studies which assessed model sensitivity to the different database parameters.

MATERIAL AND METHODS

Of approximately 50 databases investigated, 15 were identified as applicable to South Africa based on geographic coverage and relevant parameter availability. SWAT-SA, iSDA, AfSoilGrids250m, HC27SoilGrids, and Harmonised World Soil Database were selected after an initial screening according to data quality, resolution, ease of use, and availability of parameters required by the Decision Support System for Agrotechnology Transfer (DSSAT) cropping systems model. In addition to direct comparisons to the measured values of various sites across South Africa, the sensitivity of the parameters was analysed by simulating yield and evapotranspiration with DSSAT.

RESULTS AND DISCUSSION

It is hypothesised that the estimated parameters of databases will be considerably different to measured data of the study sites, but that SWAT-SA, iSDA, and AfSoilGrids250m will outperform HC27-SoilGrids, and the Harmonised World Soil Database based on their resolutions and locality. Additionally, it is thought that both the estimated soil parameters will be erroneous to an extent that will negatively affect model outputs. Currently, there are notable differences between estimated and measured parameters, as well as amongst the various databases.HC27-SoilGrids does particularly well in terms of following trends of measured data.

CONCLUSIONS

This study narrows down a labyrinthine pool of databases and makes suggestions on the most suitable soil databases for crop modelling applications in South Africa. When measured data cannot be obtained, knowledge on the strengths and weaknesses of different soil databases is extremely helpful, saving the modeller time and potential errors. It also places emphasis on the need for a national soil database.

KEYWORDS: *DSSAT, SWAT-SA, iSDA, HWSD, AfSoilGrids, DSM*

ACKOWLEDGEMENTS

The Water Research Commission (WRC Project no. C2020/2021-00440) for the funding and support of this project.

RELATING SOIL MICROBIAL DIVERSITY AND ENZYME ACTIVITY TO DIFFERENT TILLAGE PRACTICES AND AGROCHEMICAL APPLICATIONS IN A DRYLAND FARMING SYSTEM

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INTRODUCTION

The soil microbial community is essential for nutrient cycling. However, intensive tillage and excessive application of synthetic agrochemicals can reduce soil microbial diversity and enzyme activity. This study aimed to assess the progressive impact of tillage practices and varied rates of synthetic agrochemical application on soil microbial diversity and enzyme activity in a dryland cropping system.

MATERIALS AND METHODS

The research was conducted between 2018 and 2020 at Langgewens Research Farm (33°17'0.78'' S, 18°42'28.09'' E) of the Western Cape Department of Agriculture, in the Swartland. The Swartland has a Mediterranean-type climate with a mean annual rainfall of 395 mm. Four tillage treatments (continuous mouldboard plough, shallow tine tillage, no-tillage and infrequent tillage), and three rates of synthetic agrochemical application (standard, reduced and minimum) were investigated. Soil samples were aseptically collected from the 0-150 mm soil layer of each plot. Soil microbial species richness and abundance were measured by using the Shannon-Wiener diversity and Evenness indices. The activities of four soil microbial enzymes: β-glucosidase, acid and alkaline phosphatase, and urease, were used to evaluate ecosystem functioning.

RESULTS AND DISCUSSION

Microbial diversity indices (Shannon-Wiener, and Evenness) were not significantly affected by any treatments. The reason for the lack of differences was not clear but we speculate that the application of *Trichoderma asperellum* as a bio-chemical control agent in the systems with reduced and minimum synthetic agrochemicals could have affected the soil microbial diversity.

Microbial enzyme activities were significantly affected by the rate of synthetic agrochemical application. In all cases, the system with reduced synthetic agrochemicals resulted in higher enzyme activity than the system with standard synthetic agrochemicals. The enzyme activity also generally increased with a reduction of tillage intensity. β-glucosidase was significantly more active in the no-tillage treatment (1001 μg g^{-1} h^{-1}) than in the mouldboard treatment (690 μg g^{-1} h^{-1}) probably due to readily available mulch on the soil surface which had minor disturbances. Acid phosphatase was more active than alkaline phosphatase due to the low soil $pH_{(KCl)}$ (<5) of the trial site.

CONCLUSIONS

The soil microbial diversity was not affected by any treatments, but enzyme activity generally increased with a reduction in the application of synthetic agrochemicals and tillage intensity. We recommend that a combination of non-intensive tillage and reduced synthetic agrochemical application has the potential for improving soil microbial activity in cropping systems, but this requires further exploration experimentally.

Keywords: Bio-chemicals, infrequent tillage, soil enzyme activity, synthetic agrochemicals

PREDICTING SOIL WATER RETENTION CURVES FROM SOIL PHYSICAL PROPERTIES OF OLD STORE-AND-RELEASE COVERS IN MPUMALANGA HIGHVELD, SOUTH AFRICA

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INTRODUCTION

A study was conducted at the Mpumalanga Highveld, South Africa, to predict the soil water retention curves (SWRCs) of old (> 20 years) store-and-release covers (SRCs). Furthermore, data sets of well- and poorly constructed covers, and the availability of data on appropriate input parameters for predicting long-term performance of such covers are limited. This includes SWRCs and SWRCs are time consuming, labour intensive and costly, where the accuracy of SWRCs is important for long-term cover performance modelling.

MATERIAL AND METHODS

In this study, multiple linear regression models of SCRs were developed from particle-size distribution, soil organic matter (SOM) and soil bulk density. Soil water retention curves of 14 matric potentials were established using the pressure plate apparatus. The SRCs data-set was split into training and testing sets to validate the SWRC model.

RESULTS AND DISCUSSION

The statistical analysis of the *best-fit* SWRC model of 14 matric potentials had an adjusted $R^2 = 0.827$ from three fractions of sand-, two fractions of silt-, clay content, SOM, and bulk density.

CONCLUSIONS

The SWRC model performed fairly well and the validation versus the field measured data was satisfactory.

KEYWORDS: *Pedotransfer functions, soil physical properties, soil water retention curve*

ACKNOWLEDGEMENT

This work was supported by Water Research Commission and The CoalTech Research Association NPC. Pieter I. Steenkamp characterised the configuration of SRCs in this study.

IMPROVING THE SOUTH AFRICAN SOIL CLASSIFICATION SYSTEM: REVISITING THE NORMS FOR BASE STATUS FAMILY CRITERIA

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INTRODUCTION

There have been repeated calls to revise the base status family criteria for the apedal and red structured diagnostic horizons in the South African soil classification system. Despite this, only one study has attempted to address this issue with a localized study. This paper will address that gap by comparing the current South African base status family criterion with the ones found in the World Reference Base, as well as a previously suggested family criterion of the effective cation exchange capacity (ECEC). The base status criteria is supposed to indicated how well leached a soil horizon is, and as such should have relatively good correlations to the climate, parent material and topography soil forming factors, which influence the leaching of a soil profile. The assumption that is being used is that the better the correlations between a supposed criteria with the precipitation, base status of parent material and position in the landscape, the better the criteria would be to reflect the leaching status of a soil.

MATERIAL AND METHODS

The red and yellow-brown apedal horizons from the ARC-SCW modal soil profile database was used, which provided 2777 different soil profiles. The current South African base status criterion (SA :BS = S-valueX100/Clay%), as well as the two WRB BS calculations (WRB1: BS = S-value/(S-Value+Al); WRB2: (S-value+Al)/CEC and the ECEC (S-value+titratable acidity) were calculated for each horizon. Thereafter a scatterplot of each calculation between each calculation and the median annual rainfall (MAP), CEC, pH and clay% was created, together with the Pearson correlation coefficient. Additionally, a box and whiskers plot was created for each calculation with the different parent materials on which the horizons were found. Maps were also created with the different BS classes based on the different calculations, for the spread across the country to be assessed.

RESULTS AND DISCUSSION

All the different calculations showed increasing BS with increasingly mafic parent materials. These trends were weak, but did show as expected. Based on the Pearson correlations, the WRB2 calculation proved the best fit as it had the best correlation with MAR. It had the highest coefficients for MAP (-0.6), with SA being a tight second (-0.56). Only negligible correlations were found with pH (max = 0.07), and CEC (max = -0.08), except for ECEC, which as expected had a considerably correlation with CEC (0.67). Based on the scatterplot, SA had the highest R^2 value for each of MAP (0.41) and pH (0.59). From the maps it was clear that the SA calculation had the most equal spread of the different calculations.

CONCLUSIONS

SA and WRB2 did perform better than the other two calculations, but it is unclear which of those calculations perform better to indicate leaching of the soil horizon. Based on these results there are no compelling evidence to change the current criteria for calculation of BS.

Keywords: climate, leaching factor, parent material, soil forming factors, topography.

CHARACTERISTICS OF BIOCHAR TYPES FROM POTATO WASTE AND PINE-BARK AND THEIR IMPLICATIONS FOR CARBON STORAGE, NUTRIENT RECOVERY AND LIMING OF ACIDIC SOILS

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INTRODUCTION

Over 30% of food produced across the world goes to waste and ends up at landfills. The food wastes, including potato wastes, have high concentrations of carbon and nutrients and, when disposed of at landfill sites, pollute the atmosphere through greenhouse gases and ammonia, and ground water through leaching of nitrates. Waste management strategies that return these food wastes to agricultural land could enrich soils and maintain or even improve crop productivity. In addition to direct soil application, pyrolysis can produce biochar that has essential benefits in improving soil quality while limiting environmental pollution. The objective of this study was to determine the effect of feedstock and pyrolysis temperature on the physico-chemical characteristics and liming potential of biochar produced from potato peels (PP), cull potatoes (CP) and pine bark (PB).

METHODS AND MATERIALS

The study characterised biochar produced from potato peels (PP), cull potato (CP) and pine bark (PB) by pyrolysis at 350 and 650 ºC. Proximate analysis was done following ASTM standard 1762-84, while other physico-chemical properties, calcium carbonate equivalents (CCE) and elemental composition were also analysed. Surface functional groups and external morphology characteristics of the biochar types were determined using Fourier transform-infrared spectroscopy (FTIR) and scanning electron microscopy (SEM); respectively. In order to understand their liming ability, the biochar types were added to soils from the 0-20 cm depths and incubated in a Luvisol and a Ferralsol, based on their $CaCO_3$- equivalent rates and analysed for soil pH after 10 days**.**

RESULTS AND DISCUSSION

Potato waste biochars had lower yield and fixed carbon (FC), and higher ash content and volatile matter than pine bark biochar. There were no major differences in the characteristics of biochars from cull potato and potato peels. The biochars from potato waste showed an increase in pH (up to pH 12), calcium carbonate equivalence (CCE), and K and P contents with increasing pyrolysis temperature. Relative to pine bark biochar, potato waste biochar had more functional groups even at high pyrolysis temperature. The liming potential of potato waste biochar pyrolyzed at 650 °C was greater than that of PB biochars.

CONCLUSION

These findings indicate that pyrolysis of potato waste produces biochar that may be valuable for soil C storage, remediating acidity and increasing availability of nutrients especially K and P in acidic soils.

Keywords

Calcium carbonate equivalent, Potato waste, Pine-bark, Pyrolysis, Soil fertility.

ASSESSING COUNTRIES' COMMITMENTS FOR SOIL ORGANIC CARBON PROTECTION AND SEQUESTRATION UNDER THE THREE RIO CONVENTIONS

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INTRODUCTION

Agricultural land-based measures to protect and sequester soil organic carbon (SOC) stocks are increasingly recognized and advocated for their benefits to address climate change, tackle food security, support ecosystem restoration, and maintain biodiversity. In the climate change context, countries' SOC-related agricultural commitments in Nationally Determined Contributions (NDCs) submitted under the Paris Agreement have been well assessed. The NDCs do not necessarily reflect existing national level interest, policies, or commitments to SOC protection and sequestration. Moreover, many countries prioritize SOC protection and sequestration in efforts to minimize land degradation, offset degradation through rehabilitation and restoration actions, and protect biodiversity.

The purpose of this study was to understand the nature of national agricultural commitments related to SOC protection and sequestration under the three Rio Conventions through countries' NDC, LDN and Aichi Target commitments related to SOC, grasslands, wetlands, and peatlands.

MATERIAL AND METHODS

This study reviews countries' agricultural (including cropland, grassland, wetland, and peatland) SOC and wetland commitments in Land Degradation Neutrality (102 countries) and biodiversity targets (175 countries). Results are compared with SOC and wetland commitments in the latest NDCs and discussed in the context of outcomes from the 26th United Nations Framework Convention on Climate Change Conference of the Parties held in Glasgow (November 2021). Results are compared with SOC and wetland commitments in the latest NDCs and discussed in the context of outcomes from the 26th United Nations Framework Convention on Climate Change Conference of the Parties held in Glasgow (November 2021).

RESULTS AND DISCUSSION

This study identified at least 62 countries with explicit agricultural SOC (including in croplands, grasslands, and wetlands) or explicit wetland commitments in LDN or biodiversity targets that are not reflected in NDCs. Identifying countries' priorities for SOC-related climate finance, technical support, and capacity development thus requires shining the search light wider than commitments in the context of climate change under the Paris Agreement alone.

CONCLUSIONS

The opportunity for shared SOC assessment and monitoring for multiple Conventions is particularly important to reduce the burden on developing countries and contribute to the collective and mutually beneficial use of national agricultural resources.

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KEYWORDS: *Biodiversity targets, Grasslands, Land Degradation Neutrality, Nationally Determined Contributions, soil organic carbon, wetlands.*

ORGANIC CARBON IN SOILS TREATED WITH CATTLE AND PIG SLURRIES RELATIVE TO SOLID MANURES: A GLOBAL META-ANALYSIS

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INTRODUCTION

Intensive animal production systems produce large amounts of wastes, which are mainly applied to soils for nutrient cycling and carbon storage to mitigate greenhouse gas emissions in view of climate change. Some studies have shown some contradictory effects of slurries from pig, beef, dairy production on soil organic carbon (SOC), possibly as a result of variations in climate, soil type, slurry composition, soil management. Understanding the factors associated with positive, negative or no effects of animal manure slurries on SOC is essential for the effective management of these resources. The study used a metanalysis to determine effects of different factors on SOC in soils amended with animal slurries on a global scale.

MATERIALS AND METHODS

The database used in the meta-analysis was made with data from 39 articles comparing effects of liquid manures with solid manures, mineral fertilizer and unamended control on SOC. The literature was accessed using suitable keywords such as liquid manure, slurry, animal slurries etc. The data was grouped according to climate, soil texture, type of manure, tillage system, period of application. A t test ($p < 0.05$) was used to analyse the results and boxplots were made using SigmaPlot 10.0 software. Principal component analysis (PCA) and Spearman's rank correlation were done using R software and Genstat Ed 18, respectively.

RESULTS AND DISCUSSION

The result indicated that, slurry application increased C in both conventional and no tillage. Like solid manures, cattle and pig slurries increased SOC mainly in sandy and loamy soils, while in clay soils pig slurry did not have an effect. The increase in C storage was observed in temperate but not in subtropical and tropical climatic conditions, possibly due to more rapid decomposition of organic matter resulting in a net effect on SOC storage of zero under sub-tropical and tropical climate. Overall, SOC increased following long term (>10 years) application of both cattle and pig slurry, while in the short-term pig slurry reduced SOC.

CONCLUSION

The results show that application of slurries can increase SOC in loamy and sandy textured soil, especially in the temperate climates. Although both slurry types increase SOC under conventional tillage, pig slurry does not have an effect SOC under no tillage.

Keynotes: Climate, liquid manure, metanalysis, organic carbon, soil texture

CROP SCIENCE

POSTER ABSTRACTS

In alphabetical order

EFFECT OF DROUGHT AND RUSSIAN WHEAT APHID INFESTATION ON WHEAT YIELD AND QUALITY TRAITS

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INTRODUCTION

Drought has persistently hampered food production globally, including in South Africa, and Russian wheat aphid (*Diuraphis* noxia) infestation further intensifies vulnerable plant productivity. The combined responses to drought and aphid infestation are not fully elucidated, and this study aimed to investigate the effect of drought and Russian wheat aphid infestation on wheat yield and quality traits.

MATERIALS AND METHODS

The experimental design was a split-split plot arrangement fitted in a randomised complete block design with three replicates in one season under greenhouse conditions. Four wheat cultivars differing in tolerance to drought and aphid infestation were planted in pots and exposed to three drought levels [100, 50 and 30% water holding capacity (WHC)] from tillering to physiological maturity. Plants at the booting stage were infested with the Russian wheat aphid (RWASA2) at the rate of 20 aphids per plant. Agronomic data, including plant height, head length, 100 seed mass, total seed mass and biochemical analysis of seed quality (carbohydrate, protein and phenolic acid content), were assayed using Megazyme kits. Data were analysed using STATISTICA-13 and Tukey's HSD test at 5% was used to separate the treatment means.

RESULTS AND DISCUSSION

The results indicated that drought and genotype had a significant effect on plant height and head length, where severe drought (30% WHC) significantly ($p \leq 0.05$) reduced plant height. All the interactions (genotype x drought x infestation) significantly reduced the total seed mass, especially under severe drought (30% WHC). Nonetheless, 50% WHC did not significantly change the seed mass. A combination of drought and infestation drastically reduced the seed mass in most cultivars. The effect of drought and infestation on starch, soluble sugars, total protein and phenolic acid will be discussed in the context of drought tolerance and plant resistance to infestation.

CONCLUSIONS

These findings demonstrate that exposing wheat plants to a combination of stresses reduces yield and alters nutritional quality. The anticipated results should highlight the effect of drought tolerance mechanisms on the resilience of wheat to aphid infestation and the associated grain quality.

KEYWORDS: *soluble sugars, wheat yield*

KEY PROTEINS DIFFERENTIATING BETWEEN DROUGHT AND HEAT SENSITIVITY/TOLERANCE IN SOYBEAN

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INTRODUCTION

Drought and heat stress are the most limiting environmental factors reducing crop production worldwide. Plants suffer changes in growth and development when both stresses occur together than isolated. Among the crop severely damaged by these abiotic factors is soybean, an important leguminous crop of great protein value. Comparative studies of two contrasting drought and heat plant genotypes can help facilitate key genetic elements of plant phenotypic variations in response to abiotic stress. This study evaluates the proteomic changes of two contrasting soybean genotypes exposed to drought, heat, and the combination.

MATERIALS AND METHODS

The field study was conducted on soybean, HMC 201 and KDP2, at the PBRG research site using two side-by-side rain shelters, one to incorporate heat while the other for non-heat conditions. Both rain shelters were partitioned into two, one for well-watered and the other for treated plants. The well-watered plants were maintained with full capacity daily irrigation till harvest, while the water-deprived were only irrigated until the V1 stage. All experimental plants were grown at temperature ranges of 25 – 30 °c, however, at the beginning of flowering (V4 stage for water-deprived), the plants in the heat rain shelter were subjected to heat treatments (38 – 46 °C, 10 am – 5 pm daytime; 30°C night time) for 21 days. Plants were harvested 85 days after planting (50 days after withholding water from water-deprived and 21 days after commenting heat treatment) following signs of stress. Physio-biochemical parameters such as biomass and lipid content were assessed. Further, a label-free Liquid Chromatography-Mass spectroscopy proteomics analysis was utilized to understand the protein expression profiles between the two genotypes under the three abiotic stresses.

RESULTS AND DISCUSSION

The results showed that combined drought and heat stress caused more severe damage to soybean health than individual stresses, as observed from the physio-biochemical and protein expression profiles. These damages were more pronounced in KDP2 genotype than in HMC 201, implicating KDP2 as the sensitive genotype. The HMC 201 uniquely upregulates 8, 39 and 70 proteins in response to drought, heat and combined drought and heat respectively, whereas KDP2 only upregulates 8, 2 and 4 proteins in similar conditions. The gene ontology and Kyoto encyclopedia of genes and genome reveal the proteins' biological function and metabolic pathways.

CONCLUSIONS

The proteins identified that serve promise for future soybean drought and heat research are alpha-galactosidase, asparagine synthetase, NADH/Aldehyde dehydrogenase, and peroxidase P7/12.

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KEYWORDS: *abiotic stress, quantitative proteomics*

EVALUATION OF THE PLANT GROWTH-PROMOTING POTENTIAL OF PSYCHROTOLERANT BACTERIA IN BIOGAS DIGESTATE

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INTRODUCTION

The residue of anaerobic digestion, digestate, harbors a wide diversity of beneficial microbes, especially those that exhibit plant growth-promoting (PGP) traits substantiating digestate potential in agriculture. While the presence of PGP bacteria has been extensively reported in digestate obtained from mesophilic and thermophilic anaerobic digesters, it remains poorly investigated for psychrophilic digesters. Information about cold-adapted PGP bacteria contained in psychrophilic digestate is anticipated to bring new insight into its potential to benefit crop production, particularly under temperature-stressed conditions. Therefore, the aim of the study was to screen for cultivable facultative anaerobic, psychrotrophs with plant growth-promoting attributes in psychrophilic digestate.

MATERIALS AND METHODS

Cultivable cold-tolerant bacteria were isolated from the psychrophilic digestate using a standard serial dilution plating technique. The ability of pure bacterial isolates to promote plant growth at low temperatures (15°C) was then assessed using cultural techniques. The cultural techniques comprised tests for soil fertility attributes such as phosphate solubilisation, siderophore production, atmospheric nitrogen (N) fixation and indole acetic acid (IAA) production. The indirect PGP of isolates was further evaluated by testing their ability to produce hydrolytic enzymes including protease and cellulase.

RESULTS AND DISCUSSION

Among the twenty cold-tolerant bacteria that were isolated from psychrophilic digestate, 60% were able to solubilize phosphate from insoluble compounds in a solid medium at 15°C, while approximately 50% showed N fixation activity in an N-free medium. However, unlike other PGP attributes, indole acetic acid (IAA) and siderophore production were less common among psychrotrophic isolates and detected in only 30% and 10% of strains, respectively. Furthermore, hydrolytic enzyme production also varied with cellulase production observed as a common trait, since all isolates produced varying levels of cellulose ranging from 3.3 to 15.3 mm activity diameter, and isolate B5-5 displayed maximum cellulolytic activity with an activity diameter of 15.3 mm. However, protease was produced by only 2 of the bacterial isolates (B5-5 and B5-2), but B5-5 exhibited maximum proteolytic activity with an activity diameter of 14 mm.

CONCLUSIONS

The study highlights the digestate of psychrophilic AD as a reservoir of cultivable and cold-tolerant bacterial strains that exhibit remarkable PGP properties. Digestate enriched with cold-adapted and plant-beneficial bacteria may have applications as soil amendments for the protection of crops from biotic and abiotic stresses. However, further evaluation of PGP attributes under greenhouse and field conditions is warranted.

KEYWORDS: *Plant growth-promoting bacteria, psychrotrophs, psychrophilic digestate*

ACKNOWLEDGEMENTS

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PRODUCING VEGETABLES IN A CONSERVATION AGRICULTURE SYSTEM: EFFECTS ON SELECTED SOIL HEALTH INDICATORS AND CROP PRODUCTIVITY

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INTRODUCTION

Vegetable production is generally intensive and consequently poses a great concern for soil health. Conservation agriculture (CA) is a plausible strategy to preserve soil health and simultaneously enhance yields in intensively managed cropping systems (Norris and Congreves, 2018). However, there is a paucity of information on the impact of CA practices on soils of vegetable production systems and vegetable productivity. Thus, this study aims to assess the impact of CA practices on selected soil health indicators within a cauliflower (*Brassica oleracea)* seed, tomato (*Solanum lycopersicum*), legume, and cucurbit production system.

MATERIALS AND METHODS

A two-year study, which forms part of a six-year fixed crop rotation system was conducted at three sites near Lutzville. The trial consisted of three treatments; 'business as usual' approach (control), wheat straw mulch, and cover crops for summer and winter cropping seasons each year. Relevant analyses were conducted for selected soil parameters, weed composition, and vegetable crop performances.

RESULTS AND DISCUSSION

According to preliminary findings from the winter cropping season, cover crops alleviated soil compaction, and mulch influenced extractable soil phosphorus and organic carbon ($p<0.05$), but not sodium, cation exchange capacity, sulfur, and calcium ($p>0.05$). The soil pH was lower for cover crops ($p<0.05$), which can be attributed to cover crop residue decomposition. The control revealed higher ($p<0.05$) cauliflower productivity, and the cauliflower leaf analyses were higher ($p<0.05$) in ammonium content in comparison to other treatments, while other nutrients were unaffected by any of the treatments. High weed biomass ($p<0.05$) was associated with the mulch treatment, which could have resulted from the wheat straw. The effect on microbial communities and enzymatic activities varied mostly between sites, treatments, and sampling events, which could be ascribed to microbial change over time and the inherent soil properties.

CONCLUSIONS

The findings show that, in comparison to cover cropping, the control and mulch treatments had a positive effect on most of the soil properties and cauliflower productivity. Cover crops, however, largely indicated the potential to alleviate soil compaction. Site-based variations signify that various sites and soil properties respond differently to different CA practices. More improvement is anticipated in soil health and vegetable productivity over time.

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KEYWORDS: cover crops, mulch, soil health, vegetable productivity

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GENETIC, ANATOMICAL, AND MORPHOLOGICAL CHARACTERIZATION OF BAMBARA GROUNDNUT (*VIGNA SUBTERRANEA* (L.) VERDC) LANDRACES IN SOUTH AFRICA

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INTRODUCTION

Bambara groundnut (*Vigna subterranea* (L.) Verdc.) is a grain legume widely grown by smallholder farmers in Africa. It is cultivated at a low scale in South Africa. Bambara groundnut has the potential to yield better seed and can grow under adverse weather conditions. However, it remains one of the underutilized and under-researched legume crops. To date there are no improved commercial varieties and farmers rely on using unimproved low-yielding varieties based on their preferences, thereby unconsciously contributing to the genetic erosion of the crop. The aim of this study was to characterize and determine whether Bambara groundnut landraces classified based on seed coat colour are both morphologically and genetically similar to eventually aid the selection of genotypes with favourable attributes for breeding programs and the development of genetically enhanced varieties.

MATERIAL AND METHODS

Forty-eight Bambara groundnut landraces, each replicated ten times, collected from the Limpopo Province were assessed using morphological descriptors such as the number of pods per plant and type of growth habit. Landraces were analysed for anatomical differences in the leaf epidermis, such as trichome type and density. The extent of the landraces' genetic diversity and population structure were assessed through genotyping using Restriction-Site Associated DNA Sequencing.

RESULTS AND DISCUSSION

Significant differences in the yield parameters, number of pods per plant, and growth habit were observed, suggesting some genotypes yield more than others. A preliminary study with growers indicated that the bunch and semi-bunch growth types were preferred by farmers for ease of harvesting because the pods attach to the crown of the stem. Nevertheless, the spreading type was preferred to suppress noxious weeds. Anatomical assessment of the leaves revealed that some genotypes have high trichome density. Two types of trichomes were present on the same plant, which make them more resistant to pests and diseases. However, there is little evidence that these findings are related to the seed coat colour, which therefore means that use of one morphological character to classify genotypes into landraces should not be attempted. This was further supported by the genotyping and population structure analysis results, which indicated the presence of two sub-populations unrelated to seed coat colour.

CONCLUSIONS

This the first report to highlight the importance of trichome type and density as a morphological descriptor to aid the selection of landraces for introduction into effective breeding programs.

KEYWORDS: *population structure, RAD sequencing, trichome.*

ACKNOWLEDGEMENTS

Ethel E. Phiri

GENETIC VARIATION OF WHEAT GENOTYPES FOR GERMINATION PERCENTAGE, COLEOPTILE LENGTH AND ROOT LENGTH

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INTRODUCTION

Seedling establishment is a key aspect of crop production, which is dependent on seedling traits such as germination percentage, coleoptile length and root length. Seed germination rate is associated with seedling survival and vegetative growth and ultimately affecting the yield and quality of the crop. Coleoptile length determines the apt sowing depth of the seed (Ma et al., 2020). Therefore, wheat genotypes with superior seed germination and coleoptile length can help promote adaptation to various environmental conditions for crop performance. The objective of the study was to explore the genetic variation of spring wheat lines for germination percentage, coleoptile length and root length.

MATERIAL AND METHODS

In this study, 98 spring wheat genotypes, selected for their variation in drought tolerance were evaluated at the seed germination laboratory, at the Agricultural Research Council-Small Grain using a modified blotter-paper germination protocol. There were three replications for each genotype. The following data was collected: germination percentage (%), coleoptile length (cm) and root length (cm). In each experiment, 30 healthy seeds were germinated on a wet paper towel and carefully placed in plastic bags and suspended vertically in a growth chamber for 14 days at 20°C, following the method described by Sidhu et al. (2020) and Ma et al., (2020), with minor modifications.

RESULTS AND DISCUSSION

The evaluated lines displayed a significant variation ($P < 0.001$) for germination percentage (GP), coleoptile length (CL) and root length (RL). GP ranged from 3 to 100%, with an average of 86%. Of the 98 genotypes tested, 80.6% displayed a germination rate of between 80-100% within 72 hours. Fifteen genotypes displayed 100% germination within 72 hours. CL ranged from 1.85 to 7.9 cm, with an average of 4.1 cm. The top five genotypes (LM46, LM13, LM94, LM63 and LM4) displayed increased CL of between 6.33 and 5.7 cm. These genotypes are essential for deep-sowing and proper stand establishment. RL ranged from 10.76 to 28.19, with an average of 19.84 cm. The top five genotypes (LM18, LM29, LM34, LM37 and LM64) displayed increased root length of 28.20 to 24.95 cm.

CONCLUSIONS

Genotypes LM4, LM34 and LM94 could be valuable germplasm sources for longer coleoptile breeding and crop establishment. Thus, our study provides valuable insights into the genetic variation of the coleoptile length and root length in wheat.

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INVESTIGATING PARAQUAT RESISTANCE AND GERMINATION IN *LOLIUM* SPP.

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INTRODUCTION

Herbicide resistance is a growing problem in commercial agriculture. Farmers are reliant on chemical herbicides such as paraquat (1,1'dimethyl-4,4'-bipyridynium dichloride) in high-intensity cropping systems to control unwanted plants i.e., ryegrass (*Lolium* spp.). Successful weeds and crops share similar lifecycles i.e., germination and establishment. Paraquat-resistant ryegrass was first observed in South Africa in 2004, yet paraquat is still frequently sprayed. Germination and dose-response experiments were conducted on ryegrass to analyse the effects of paraquat resistance in terms of lifecycle adaptations and lethal effective-dose (ED50) in South Africa.

MATERIALS AND METHODS

Ryegrass seeds, collected from the following sites were used: Welgevallen Experimental Farm (WS), Stellenbosch (consistently sprayed for 30 years), separating seeds from the centre of the field and perimeter (SS); Langgewens Research Farm (LS), Moorreesburg (sprayed sporadically) and commercially available ryegrass (*Lolium multiflorum*) as control plants (BC). Germination experiments were conducted following the International Rules for Seed Testing (ISTA), determining mean germination time (mgt), mean germination percentage (mgp) and thousand-seed weight (TSW) calculated using Data Count S 25+. Under stressful glasshouse conditions i.e., heat stress, plants were subjected to a dose-response experiment using a randomised block design with four replications per treatment. The varying number of treatments were increasing doses of Gramoxone® (paraquat) starting from 0.25X to 13.5X, where X is the recommended dose of 1.5 L ha^{-1}. Surviving plants i.e., had living tissue, were recorded and the data was analysed using R to investigate adaptations to paraquat.

RESULTS AND DISCUSSION

Significant results were seen across germination experiments and between each site, with BC reaching a mgp of 96% and mgt of 3.1 days; LS had the longest ($p<0.05$) mgt at 10.1 days; yet the lowest mgp being SS at 42%. The preliminary dose-response experiment showed significant resistance ($p<0.05$) with ED50 at about 1.5X, 37X and 85X in LS, WS and SS respectively. This difference is due to the spraying practices with paraquat i.e., continuous versus sporadic. A negative correlation ($p<0.05$) between TSW and paraquat-resistance was seen, as well as between mgp, mgt and paraquat-resistance ($p<0.01$), indicating ryegrass lifecycle adaptations.

CONCLUSIONS

A portion of the resistance seen across the ryegrass plants can be attributed to age-induced resistance and increased plant defence mechanisms, given the stressful glasshouse environment. However, resistance in WS and SS plants reached magnitudes that can only be explained by the effects of continuously spraying the same chemicals.

KEYWORDS: *herbicide resistance, ryegrass*

ACKNOWLEDGEMENTS

Western Cape Department of Agriculture for resources, the Chair in Plant Health, Barenburg and Winfield United for funding.

EFFECT OF PHOSPHORUS FERTILIZER AND RHIZOBIUM INOCULATION ON GROWTH, NODULATION AND ROOT CHARACTERISTICS OF TWO CHICKPEA (*Cicer arietinum* L.) CULTIVARS.

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INTRODUCTION

Chickpea (*Cicer arietinum* L.) is a cool-season legume crop that belongs to the Fabaceae family and Papilionaceae subfamily. Leguminous plants, including chickpea, host a rhizobia bacterium in their roots within the nodules, which can fix atmospheric nitrogen (Bano and Igbal, 2016). However, a lack of nodulation has consistently been reported across various sites in North-eastern South Africa (Lusiba, 2015, Ogola, 2015) probably due to the lack of native rhizobia in soils in this region (Ogola, *et al*., 2020). Therefore, this study assessed the effect of phosphorus fertilizer and rhizobium inoculation on growth, nodulation and root characteristics of two chickpea cultivars.

METHODS AND MATERIALS

A pot experiment was conducted in the winter of 2022 at the University of Venda, Thohoyandou. Treatments consisted of a factorial combination of two chickpea genotypes (ACC#1 and ACC#5) and four amendment treatments [Zero control, rhizobium inoculation (R), 90 kg phosphorus ha^{-1}, rhizobia and phosphorus (R+P)] laid out in a randomized complete design and replicated three times. Nodulation, plant height, number of branches, shoot biomass and root characteristics were determined at 50% flowering and data were subjected to analyses of varience using STATISTICA version 10.

RESULTS ANDD DISCUSSION

Nodulation was greater in ACC#5 compared to ACC#1. Moreover, fertilizer treatment increased nodulation relative to the zero control with R+P, exhibiting the highest number of nodules. There was a significant interaction of genotype x ammendment on plant height. ACC#5 exhibited greater root diameter and shoot biomass compared to ACC#1. The higher shoot biomass in ACC#5 was probably due to the observed greater nodulation in the cultivar.

CONCLUSION

ACC#5 recorded superior performance compared to ACC#1 irrespective of fertilizer levels. Also, R+P exhibited greater nodulation which probably resulted in higher shoot biomass in both cultivars.

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KEYWORDS: *rhizobial inoculation, rhizosphere*

EFFECT OF PLANT DENSITY AND NITROGEN ON YIELD OF STEVIA (*Stevia rebaudiana*) IN SOUTH AFRICA

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INTRODUCTION

Stevia (*Stevia rebaudiana*), characterised by its sweetness, is cultivated commercially to produce steviol glycoside, which is about three hundred times sweeter than cane sugar (Randy and Politud 2016). Currently, producers obtained higher annual dry leaf yields (17-21 ton ha^{-1}) with a plant density of 50 000 plants ha^{-1} than the 6.5 t ha^{-1} for the recommended 150 000 plants ha^{-1}. There is no adequate information on stevia's optimum plant density and nitrogen requirement under South African conditions (Chakraborty 2022). The objective of this study was to determine the effect of plant density and nitrogen level on the growth and yield of stevia.

MATERIALS AND METHODS

A field trial was conducted in the north coastal region of KwaZulu-Natal on Avalon soil. Four plant densities (50 000, 100 000, 150 000 and 200 000 plants ha^{-1}) and four nitrogen levels (0, 50, 100 and 200 kg ha^{-1}) was investigated. The treatment combinations were replicated three times, and the trial was laid out in a strip-plot design. Plants were spaced in plots (6 m^2) 25 cm apart in the row and either 80, 40, 27, or 20 cm between rows. Plants were harvested four months after transplanting. Final plant height, above fresh mass and leaf dry mass were determined. Analysis of variance was done on the data using NCSS 2022 and Tukey's test for significance ($p<0.05$).

RESULTS AND DISCUSSION

The interaction between plant density and nitrogen level significantly influenced final plant height and above fresh mass yield. Significantly taller plants were obtained at 100 000 plants ha^{-1} and when 100 kg N ha^{-1} was applied. An above fresh mass yield of 60.17 t ha^{-1} was recorded for a density of 150 000 plants ha^{-1} and 100 kg N ha^{-1}. However, dry leaf yield was not significantly influenced by plant density or nitrogen level..

CONCLUSION

Plant density and nitrogen levels significantly influenced the plant height and above fresh mass yield, but not leaf dry mass. Results demonstrated that, during the first four months of growth, it is possible to obtain higher dry leaf mass yields with 50 000 plants ha^{-1} as opposed to the recommended 150 000 plants ha^{-1} and that nitrogen levels do not significantly influence it.

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IDENTIFICATION OF OKRA LINES FOR NUTRITIONAL QUALITY BREEDING

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INTRODUCTION

Okra is fruit vegetable crop, which is highly nutritious and contribute to food security. Despite its importance for food, nutritional and health benefits, the crop is cultivated in some parts of the country particularly in northern (Limpopo) and northeast (Mpumalanga) provinces of the country in South Africa by small-scale farmers. There is a need to investigate the genetic variation in the nutritional quality of okra plant and identify potential parental lines for nutritional quality breeding in South Africa. Hence, the objective of this study was to quantify the nutritional quality of okra genotypes to select promising parental lines with unique nutritional quality traits for production and cultivar development for nutritional quality.

MATERIAL AND METHODS

Fourty six okra genotypes were obtained from the World Vegetable Center, Taiwan for this study. The experiment was conducted at the Roodeplaat (latitude 25.604º S, longitude 28.345 E) research station in Gauteng Province, South Africa during the 2015 cropping season. The field experiment was carried out using a randomized complete block design with three replications. Each plot consisted of 4 m rows, with inter- and intra-row spacing of 1 m and 30 cm, respectively. Two seeds were sown and later thinned to one seedling per stand. Agronomic management practices have been carried out as recommended to the crop. Data were recorded on Fe, Zn, Mn, Mg, K, P, and total phenol in the seeds. Nutritional data were extracted using the methods suggested by Amoo et al. (2012), respectively. Data were analyzed by means of analysis of variance using Agrobase Generation II (2008).

RESULTS AND DISCUSSION

Analysis of variance for the tested genotypes was significant ($P < 0.01$) for all evaluated nutritional traits including [(Cu, 11.02 mg 100 g^{-1}), (Fe, 20.27 mg 100 g^{-1}), (Mg, 535.00 mg 100 g^{-1}), (Mn, 10.42 mg 100 g^{-1}), (Na, 158.33 mg 100 g^{-1}), (P, 815.83 mg 100 g^{-1}), (Zn, 20.36 mg 100 g^{-1}), (K, 1085.83 mg 100 g^{-1}), and (phenol, 16.47 mg GAE g^{-1}) contents, suggesting presence of genetic variation among the evaluated genotypes. The identified genotypes with superior content of a desired element(s) and total phenol can be used as parental line(s) for nutritional quality improvement and recommended for cultivation in the country.

CONCLUSIONS

Genotypic variation was observed for all the traits evaluated for nutritional and phenolic traits indicating the existence of high genetic variability among them. This variation indicated the existence of genetic potential for selection of parental line(s) for nutrition quality improvement in the future okra-breeding programs.

Keywords: Genotype, nutrition, okra, variability

ACKNOWLEDGEMENTS Agricultural Research Council for funding and World Vegetable Center for supplying planting materials.

DRY BEAN GRAIN QUALITY INFLUENCED BY PHOSPHORUS FERTILIZER RATE, CULTIVAR AND ENVIRONMENTAL VARIATION

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INTRODUCTION

Dry beans play an important role in food security. The problem experienced by dry bean farmers in South Africa (SA) is low soil fertility, especially phosphorus rate on sandy soils. Selection of high-quality cultivars under different climatic and environmental conditions is still a challenge. The objective of this study was to determine the effect of cultivar, phosphorus fertilizer rate and location on dry bean grain quality.

MATERIALS AND METHODS

The research was carried out during the 2017/18 planting season at three locations in North West Province namely, NWU Farm (Molelwane) at Mafikeng, Department of Agriculture experimental station at Taung, and a farmer's field at Ventersdorp. Three dry bean cultivars (PAN 148, PAN 123 and PAN 9292) were planted and five respective rates of phosphorus fertilizer were applied (0, 30, 45, 60 and 75 kg P ha^{-1} at Taung, 0, 45, 60, 75 and 90 kg P ha^{-1} at Ventersdorp and 0, 110, 114, 118 and 120 kg P ha^{-1} at Mafikeng). Variations in phosphorus fertilizer application rates were based on the soil analysis results of the three locations. Dry bean seeds were analyzed for crude fiber, ash, protein, starch and fat content using a NIR (Near Infrared Reflectance) grain analyzer.

RESULTS AND DISCUSSION

Cultivar had a significant effect on dry bean crude fibre, ash, fat and starch content. The crude fibre and ash content of PAN 123 were significantly higher than other cultivars. PAN 9292 had a significantly higher fat content as compared to other cultivars. PAN 148 had significantly higher starch content. This observation could be attributed to the variation in the seed coats of the cultivars. Location had a significant effect on the ash, protein and fat content of dry bean grains. Dry beans planted in Taung had significantly higher ash, fat and protein content than those planted at other locations. The higher grain quality at Taung could be attributed to favourable environmental conditions, soil type and nutrient availability in the soil.

CONCLUSIONS

In this study, dry bean grain quality in terms of ash, fat and protein content was highest for Taung. The grain quality differed among cultivars. The results indicated higher starch content for PAN 148, while PAN 123 produced higher grain ash and crude fibre content. PAN 123 is highly recommended for dry bean producers due to its high grain quality. The phosphorus fertilizer rates in this study did not influence the grain quality of dry bean.

KEYWORDS: location, quality response

ACKNOWLEDGEMENTS

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EFFECT OF DIFFERENT IRRIGATION WATER REGIMES ON BIOMASS OF DIFFERENT MULTI-PARENTAL ADVANCED GENERATION INTER-CROSS (MAGIC) AMARANTH GENOTYPES

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INTRODUCTION

Traditional vegetables are piloted as champion species for sub-Saharan Africa, a region experiencing high nutritional food insecurity and water scarcity. The major benefit of traditional vegetables is high nutrient density (iron, zinc, and Vitamin A); therefore, they are deemed suitable for improving the dietary diversity of rural resource-poor households. Amaranth is one of the traditional leafy vegetables that has excellent potential to be commercialized in South Africa. The study's main objective was to assess the effect of different water regimes on four drought-tolerant amaranth genotypes.

MATERIALS AND METHODS

An experiment was conducted under rain shelters at ARC-VIMP, Roodeplaat Pretoria, Gauteng, during the 2020/2021 summer season. The experiment was laid out as a 3 x 4 factorial treatment in a completely randomized design with Amaranth genotypes (ARC2, AVRDC2, AVRDC3 and AVRDC4) and irrigation water regimes (25%, no water stress), (65%, moderate water stress), and 85%, severe water stress), replicated three times. During the growing period, Amaranth genotypes were harvested four times; the first harvest was after four weeks and the other harvests were every after two weeks). Data collected included total dry biomass (leaves plus stems), dry edible biomass (leaves only), stem dry mass, and the harvesting index (dry leaves/ total dry biomass).

RESULTS AND DISCUSSION

The study findings showed no interaction effect for irrigation water regimes and genotypes for the selected variables. Similarly, there was no significant effect for single factor irrigation regimes and stem dry mass. However, there was a significant difference ($P \leq 0.05$) for genotype total biomass, dry edible biomass, and the harvest index (HI). Total dry biomass ranged from 33.7 to 44.2 t ha^{-1}, dry stem mass ranged from 8.3 to 11.1 t ha^{-1}, and the HI ranged from 0.29 to 0.60 t ha^{-1}. Although there was no significant effect for irrigation water regimes, higher productivity (total biomass, dry biomass and HI) was observed from the combination of no water stress and genotype AVRDC2. Generally, this suggests that water stress slightly reduced the productivity of amaranth genotypes.

CONCLUSION

The findings of the study revealed that the AVRDC2 amaranth genotype is likely to be more productive than the other amaranth genotypes. Therefore, this genotype can be recommended to farmers who want to commercialize amaranth. To attain higher productivity, the farmers should produce it under no water stress conditions, assuming that agronomic management is the same. This experiment should be repeated to confirm the findings of the study and seasonal effect on the productivity of different amaranth genotypes.

KEYWORDS: *amaranth genotypes, water scarcity, crop productivity, water use*

THE EFFECT OF PLANTING DATE ON CANOLA PRODUCTION IN THE WESTERN CAPE OF SOUTH AFRICA

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INTRODUCTION

Canola was first introduced in the Western Cape in the 1990's and has since become a prominent cash crop used in rotation with wheat. Being a cash crop, one of the important factors when selecting canola cultivars is yield. Planting date in the Western Cape is solely dependent on sufficient rainfall, while harvesting time and yield are affected by weather conditions, like the rise in temperature and moisture stress. Planting later in the season, shorten the growth period of canola and potentially affect yield. Thus, this research was conducted to determine the effect of planting date on canola production.

MATERIALS AND METHODS

Two canola cultivars were planted at two separate planting dates over a period of 8 years (2011-2019) on Langgewens Research Farm (33°16'0" S and 18°42'0" E). The first planting date occurred after an adequate rainfall event, while the second date occurred within 7 to 14 days. Adequate rainfall equates to more than 20mm over a period of a week. The two canola cultivars were AGAMax (a short growing length cultivar) and Hyola 50 (a medium growing length cultivar). Planting dates ranged from the first week of May until the second week of June. Canola seeds were direct harvested, and seed yield were determined. Rainfall amount during the growing season were measured, as well as days from planting till first flower.

RESULTS AND DISCUSSION

The results show an overall reduction in canola yield with a delay in planting dates. AGAMax, with a loss of 525kg.ha^{-1} per week, was less affected by the later planting dates than Hyola 50 with a loss of 742kg.ha^{-1} per week. Planting later in the season resulted in less rainfall during the growing season as well as fewer days from planting until flowering. AGAMax was less affected by planting date than Hyola 50 but yield potential under favourable conditions was higher for Hyola 50, while yield at the later planting dates did not differ.

CONCLUSIONS

This research indicates the importance of sowing date. Earlier sowing is beneficial for canola production if adequate rainfall occurs. Further analysis on the effects of extreme environmental conditions (high temperatures and moisture stress) during critical stress periods for canola (flowering) is needed.

KEYWORDS: *Canola production, flower initiation, sowing date*

GENETIC MAPPING OF QTL ASSOCIATED WITH YIELD COMPONENT TRAITS IN A DOUBLED HAPLOID WHEAT (*TRITICUM AESTIVUM* L.) POPULATION

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INTRODUCTION

Grain yield is a complex trait, strongly that is influenced by interacting genetic and environmental factors. The identification of major quantitative trait loci (QTL) for yield component traits (YCT) is important for improving yield potential through wheat breeding. Many studies have identified QTL using wheat germplasm adapted to various production systems around the world and little is reported about the germplasm adapted to Sub-Saharan Africa. It is hypothesized that there is a significant variation among the parental lines and the Tugela-DN x Elands doubled haploid (DH) population. Therefore, the objective of this study was to identify and validate QTL for YCT using single nucleotide polymorphism genotype-by-sequence (SNP GBS)-based and silicoDArT markers in the existing DH wheat population.

MATERIALS AND METHODS

We performed a QTL analysis for YCT in the 158 DH population using a SNP GBS- and a silicoDArT-based genetic map. The DH lines were developed from Tugela-DN × Elands cross. Field trials were conducted using an augmented design under rain-fed conditions across five environments in the Free State Province of South Africa during the 2017–2018 and 2018–2019 cropping seasons.

RESULTS AND DISCUSSION

Analysis of variance revealed a significant difference ($p < 0.001$) between DH lines and environments. However, for GxE interactions, significant differences ($p < 0.05$) were only observed for spikelet number per spike. Broad-sense heritability estimates ranged between 0.44 and 0.81. Nine QTL, viz. *QPh.sgi-6A.2* and *QPh.sgi-4D* for plant height (PH), *QSl.sgi-6A.2* and *QSl.sgi-7A* for spike length (SL), *QGns.sgi-3B* for grain number per spike (GNS), *QGwps.sgi-7B* for grain weight per spike (GWPS), *QGw.sgi-2A* and *QGw.sgi-7A* for grain width (GW), and *QGl.sgi-3B* for grain length (GL), were identified on chromosomes 2A, 3B, 4D, 6A, 7A, and 7B, respectively, in two or more environments. Some of these QTL exhibited pleiotropic effects. The *QPh.sgi-6A.2* QTL for PH and *QGwps.sgi-7B* for GWPS could potentially be novel QTL, while the rest of the reported QTL validated previously identified QTL for YCT. The study also reported a trade-off between GL and GNS on chromosome 3B, which should be further investigated.

CONCLUSIONS

The findings of this study will be useful in elucidating the genetic architecture of YCT contributing to the development of new dryland wheat varieties with high and stable yield. Overall, these results will contribute to our understanding of the genetic basis of YCT and could be used to improve grain yield in wheat through marker-assisted selection breeding.

KEYWORDS: *genotype-by-sequencing, plant height, QTL, yield component traits, yield potential improvement*

CANOLA YIELD POTENTIAL IN THE SWARTLAND OF THE WESTERN CAPE ON THE RISE

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INTRODUCTION

During the past 20 years, there was a huge increase in the seed yield ha^{-1} of commercial canola (*Brassica napus*) in the Western Cape. This study focuses on the increase in the seed yield potential in the national cultivar trials at Langgewens. The genetic material originates from Australia.

MATERIALS AND METHODS

Canola cultivar trials (randomized block design with three replicates) were planted seasonally at Langgewens in the Swartland. The trials were planted annually (2002-2021) at the optimum planting date during May. The trials were planted in dry soil if it did not rain before the 15th of May. The onset of rain did however vary and the first onset of rain was often after planting. The climatic data for the Langgewens Research Farm was used in the study. The annual mean seed yield for the trials and the kg seed yield mm^{-1} of rainfall was determined for this study.

RESULTS AND DISCUSSION

The mean seed yield in the trials over the 20 growing seasons increased from 1758 kg ha^{-1} to 3474 kg ha^{-1} ($R^2 = 0.484$), and the seed yield per mm rainfall, increased from 4.3 to 14.1 kg mm^{-1}. The percentage increase per year was 9.9 and 16.5%, respectively. To understand the yield increase, the breeding and selection programme in Australia and the northern hemisphere should be investigated. Australian canola breeders have successfully improved seed yield and adaptation of oilseed rape, from 1970 to 2000, in a closed population (18 ancestral varieties). Two breeding programmes developed spring type lines from winter × spring *B. napus* crosses. Those breeding programmes showed that winter *B. napus* germplasm can be used for the improvement of seed yield in spring *B. napus* hybrids, which out-yielded the commercial spring hybrid cultivars.

CONCLUSIONS

The yield increase as we experience in the Western Cape is the result of both plant genetics and management practices. The commercial yield increased over the corresponding period but not to the same extent. The Western Cape producers can expect to see further increases in yield based on the results from the national cultivar evaluation programme.

KEYWORDS: *Brassica napus,* seed yield, seed yield mm^{-1} rainfall

INVESTIGATE THE EFFECT OF DIFFERENT PLANTING DATES ON SUNFLOWER SEED YIELD AND OIL CONTENT IN THE FREE STATE AND NORTH-WEST

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INTRODUCTION

In South Africa, sunflower is often used as a catch crop and is planted as an alternative when rainfall onset is too late for maize or soybean plantings. Therefore, the stable yields under these late planting conditions are well below the crop's yield potential. To maximize the use of natural resources, optimum planting date of a crop is essential because it ensures good seed germination and optimum root system development, which in turn, enables the plant to absorb essential nutrients from a large volume of soil. Therefore, the objectives of this study were to study the effect of different planting dates on sunflower grain yield and quality, and to demonstrate and promote the optimum planting dates for farmers' fields.

MATERIALS AND METHODS

Four field trials with different planting dates were established at Potchefstroom Grain Crops (26°44'09.95"S - 27°04'24.83"E) and three at Steynsrus in Free State (27.9492° S, 27.5672° E). Nine sunflower hybrids were evaluated for seed yield and oil content in a randomized complete block design with three replications. Data were analyzed statistically.

RESULTS AND DISCUSSION

At Potchefstroom, a highly significant effect of planting date on all studied parameters was observed. The first planting date planted in 2021 (2 November) yielded the highest seed and oil yield of (3.54 t ha^{-1} & 1.37 t ha^{-1}) respectively, followed by the second planting date in 2021 (7 December), while the lowest seed and oil yield (1.87 t ha^{-1} & 0.79 t ha^{-1}) was recorded for the third planting date in 2022 (11 January). The third planting date recorded the highest oil content 42.39% across hybrids, while the second planting yielded the lowest oil content of 38.66%. Mean seed and oil yield across hybrids and different planting dates was (2.72 t ha^{-1} & 1.05 t ha^{-1}). At Steynsrus, planting dates and hybrids showed highly significant effects on all studied parameters. Second planting date in 2022 (5 January) recorded the best seed (2.82 t ha^{-1}) and oil yield (1.15 t ha^{-1}). The last planting date in 2022 (26 January) yielded the lowest yield (1.92 t ha^{-1}) and oil yield (0.82 t ha^{-1}), however it produced the highest oil content of 42.44%. Tested sunflower hybrids showed significant differences for all studied parameters under different planting dates. Mean seed and oil yield across hybrids and planting dates was 2.36 t ha^{-1} & 0.97 t ha^{-1}.

CONCLUSIONS

Planting date showed a significant effect on all studied parameters. At Potchefstroom, November and December plantings produced higher seed and oil yield, while at Steynsrus planting in the first week of January produced the highest seed and oil yield.

KEYWORDS: *Grain yield, oil percentage, planting time*

ACKNOWLEDGEMENTS

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THE EFFECT OF DROUGHT AND SALT STRESS ON SEED GERMINATION OF 70 BAMBARA GROUNDNUT (*Vigna subterranea* L.) LANDRACES

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INTRODUCTION

Bambara groundnut is an underutilised grain legume, grown mainly by smallholder and subsistence farmers in Africa. However, Bambara groundnut productivity is low, due to several abiotic stresses, particularly drought and salinity stress. The lack of drought and salt-tolerant Bambara groundnut genotypes is a major constraint in improving Bambara productivity, especially on the African continent. Therefore, it is important to test Bambara groundnut landraces for drought and salinity tolerance traits at the germination stage. The main study objective was to evaluate the effect of polyethylene glycol (PEG 6000) induced drought and salinity stress on seventy Bambara groundnut landraces.

MATERIALS AND METHODS

Seventy Bambara groundnut landraces were obtained from different sources in South Africa. The seeds were sorted and categorised by seed coat colour, testa colour in combination with eye patterns and seed coat pattern. Three PEG-6000 levels (10%, 15% and 20%) and three NaCl levels (4<8 dS/m, 8<16 dS/m and ≥ 16dS/m) were included in the study along with the control (0) to induce drought and salinity stress. Data relating to germination percentage (GP), germination energy (GE), germination rate index (GRI), mean germination time (MGT), vigour index (VI) and two stress tolerances indices, stress susceptibility index (SI), and stress tolerance index (STI) were collected.

RESULTS AND DISCUSSION

The findings from this study showed that the different levels of drought (PEG-6000) and salinity (NaCl) significantly ($P<0.001$) affected the germination of Bambara groundnut, but differently so amongst the Bambara groundnut landraces tested. With no PEG or NaCl added to the irrigation solution, germination was 100% in all the landraces. When the NaCl concentration was the main factor in the solution, PEG-6000 could stimulate drought stress to a certain level that can alleviate the inhibition of salt ions on seed germination. This might have been due to the adsorption of the salt ions by PEG-6000 macromolecules, which can alleviate ion toxicity severity to moderate salt concentrations in seeds during germination.

CONCLUSIONS

Drought and salinity stress inhibited Bambara groundnut seed germination and the inhibitory effect became more evident as the degree of the stress increased. However, the combination of drought and salinity stress treatments alleviated the stress effects of a single factor and improved Bambara groundnut seed germination characteristics. Unique seed germination mechanisms displayed by the landraces can be beneficial to Bambara improvement programmes when selecting drought and salinity-tolerant landraces.

KEYWORDS: Bambara groundnut landrace, NaCl, PEG

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VARIABILITY IN MINERAL NUTRIENT CONTENT OF NIGHTSHADE ACCESSIONS (*SOLANUM* SECT. *SOLANUM*)

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INTRODUCTION

African indigenous leafy vegetables are an underutilized source of minerals and vitamins that can help alleviate poverty, food insecurity, and malnutrition. The goal of this research was to assess the nutritional composition and heritability of nutritional traits, as well as to identify lines with higher nutrient content for use in a crop improvement program.

MATERIALS AND METHODS

The trials were conducted in the North-West University Mafikeng Campus Garden for two consecutive seasons (2020 and 2021), using a Randomized Complete Block Design (RCBD) with three replications. Accessions were sourced from various parts of the country and in gene banks (Agricultural Research Council (ARC) and Department of Agriculture Land Reform and Rural Development (DALRRD). The nutritional value of nightshade accessions' leaves and young tender shoots were used for mineral content evaluation. Mineral elemental constituents (N, Ca, Mg, K, P, Zn, Cu, Mn, Fe, Na, and Al) were analyzed by Cedara prior to the validated protocol and working conditions (http://www.kzndard.gov.za/ quick-links/167-soil-analysis).

RESULTS AND DISCUSSION

There were significant ($P < 0.05$) differences in mineral nutrient composition among the nightshade accessions studied. The average nutrient composition for accessions was 2.97, 3.44, 0.78, 2.94, 0.20, 2341.54, 69.05, 30.94, 143.93, 1333.82, and 1841.75 mg/kg for N, Ca, Mg, K, P, Na, Zn, Cu, Mn, Fe, and Al, respectively. In this study, the phenotypic coefficient of variation (PCV) values were relatively higher than the genotypic coefficient of variation (GCV) values for all traits. The first two major components (PC 1 and 2) accounted for 74.61% of the total variation in nutritional traits. Ca, Mg, Na, Zn, Fe, Al, N, K, and P content contributed more to the variability. Using dendrogram cluster analysis, the accessions were divided into 14 clusters. Moderate heritability estimates for Fe (32.35%) and Al (34.78%) are accompanied by increasing genetic progress of 277.12 and 435.73, indicating the presence of additive gene effects that can be exploited through heterosis breeding. Meanwhile, moderate broad sense heritability, together with moderate genetic advance was observed for Zn (32.48% and 11.24) and Mn (30.32% and 15.91), which is indicative of the non-additive gene effect, which suggests slow progress during selection.

CONCLUSIONS

The leafy vegetable has a high mineral nutrient content, and accessions Nshad5, SRetrflr, ManTown, NigSN18, and Scabrum were identified as good sources of the mineral traits studied, and thus could become parental lines in further germplasm improvement through selection.

KEYWORDS: genetic advance, heritability, mineral nutrient, traits, variation

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Department of Agriculture Land Reform and Rural Development (DALRRD), North-West University for the following bursaries - North-West University bursary, Faculty of Natural and Agricultural Sciences (FNAS), and Food Security and Safety Focus Area.

CALIBRATION AND VALIDATION OF DSSAT FOR SIMULATING GROWTH AND YIELD OF BARLEY (*HORDEUM VULGARE L.*) IN LIMPOPO PROVINCE, SOUTH ARICA

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INTRODUCTION

Crop models are commonly used for simulating crop yield, estimating agronomic efficiency and developing optimal management practices. Crop coefficients for barley cultivars in South Africa have not yet been generated for use in cropping systems models such as DSSAT (Decision Support System for Agro-Technology Transfer). This study reports on growth analyses to calibrate genetic coefficients for CERES-Barley of the Overture barley cultivar under irrigated conditions, and to validate DSSAT for further studies on barley yields, water use and expected impacts of climate change.

MATERIALS AND METHODS

The study was carried out in a northern barley growing area called Koedoeskop (Limpopo Province). Iterative simulations were used to select the genetic coefficients using phenological stages, biomass production, leaf area index (LAI) and grain yields of the first season experiment. After calibration, model performance was tested using data from SABBI historical cultivar assessments (2016-2020). The coefficient of determination (R^2), root mean square error (RSME), mean absolute error (MAE) and D-index were calculated to evaluate the model performance.

RESULTS AND DISCUSSION

The model performed satisfactorily in estimating phenological stages, biomass, LAI, stem dry matter and grain yield. Phenological stages, as estimated by days to 50% flowering and maturity, were in good agreement. The LAI, stem dry matter and biomass were simulated satisfactorily (R^2 >0.9452) when compared with observed values at specific growth stages of the crop. The final simulated grain yield value in 2020 for Overture (8124 kg ha^{-1}) was in close agreement with the observed value of 8232 kg ha^{-1}, with RMSE and R^2 values of 108 kg ha^{-1} and 0.9876, respectively. The simulated biomass at specific growth stages of the crop was similar to those observed, with an R^2 of 0.9882 and D-index of 0.9814. The relationship between simulated and observed grain yields for the validation process were strong, with R^2 and D values of 0.8688 and 0.8560, respectively. This shows that the model was making good predictions.

CONCLUSIONS

The CERES-Barley model has been successfully calibrated and validated for barley cultivar Overture and it can now be used for further applications in natural resources management and climate change impact studies under Limpopo irrigation conditions.

KEYWORDS: *CERES-Barley, model calibration, validation*

GROWTH AND YIELD RESPONSE OF SWISS CHARD (*BETA VULGARIS L.*) TO DIFFERENT FERTILIZER LEVELS AND SOIL MOISTURE REGIMES

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INTRODUCTION

Swiss chard (*Beta vulgaris* L.) is a leafy vegetable consumed in many parts of the world because of its high nutritive status. Food and nutrition insecurity constitute major challenges faced in sub-Sahara African (SSA) countries due to the rapid decline in soil fertility status and climate change leading to unpredictable rainfall patters and water scarcity. The study aim was to evaluate the growth and yield response of Swiss chard to different soil moisture regimes and fertilizer levels.

MATERIALS AND METHODS

The experiment was conducted under greenhouse conditions at the University of Mpumalanga farm, Mbombela, South Africa. The pot experiment was laid out as 3 x 6 factorial design fitted into a completely randomized design. The experiment consisted of three irrigation levels representing depletion to approximately 30, 60 and 90% field capacity (FC), and 6 fertilizer rates, namely sole inorganic NPK (2:3:2 (30) rate of 250 kg ha^{-1}, 10 t ha^{-1} poultry manure, different mix ratios of 50% NPK and 50% poultry manure, 25% NPK and 75% poultry manure, and 75% NPK and 25% poultry manure. An unamended control treatment was included as control. The recommended NPK rates for Swiss chard and poultry manure were used. The amount of nutrients added by manure was 307 kg/ha N, 158 kg/ha P and 213 kg/ha K. The trial was replicated four times. The 30 cm plastic pots were filled with 7 kg sterilised soil. Growth parameters collected included plant height, number of leaves, chlorophyll content index and stomatal conductance (at 2-weekly intervals) and dry biomass yield at harvest, while leaf area (LA) was computed as LA=L×W×(0.65). Data collected were subjected to Statistix 10.0 and mean separation was done using least significant difference test at 5% probability level.

RESULTS AND DISCUSSION

Fertilizer application rates exerted a significant ($p<0.05$) effect on the measured growth and yield parameters, while only the number of leaves and stomatal conductance were significantly affected by the interaction between fertilizers and irrigation level. Based on pooled data across the sampling dates, all measured growth parameters except stomatal conductance were significantly affected by soil amendments. The interaction between 50% poultry manure and 50% inorganic NPK mix ratio gave the highest dry biomass yield of 1.43 g/pot while irrigation water level of 60% FC gave the highest dry biomass yield of 1.18 g/pot.

CONCLUSIONS

Based on the current study, the combination of 50% poultry manure and 50% inorganic NPK, and irrigation water level of 60% FC produced maximum dry biomass yield. However, the study recommends the use of 50% poultry manure and 50% inorganic NPK to improve dry weight biomass of Swiss chard.

KEYWORDS: *inorganic fertilizer, moisture stress, poultry manure*

ACKNOWLEDGEMENTS

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IRRIGATION WITH UNCLARIFIED, NEUTRALISED ACID MINE DRAINAGE FROM A HIGH-DENSITY SLUDGE PLANT

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INTRODUCTION

The eMalahleni Water Reclamation Plant (eWRP) operates a high-density sludge (HDS) process that uses hydrated lime to neutralise and remove metals from such waters. This process produces large volumes of gypsiferous sludges that are expensive to manage. Irrigation directly with neutralised but unclarified water may address this problem. However, there are concerns that the continuous use of sludge-laden water may result in excessive amounts of gypsiferous solids accumulating in the soil profile. This study aims to determine how much sludge can be applied to a field and how the crop will respond to high levels of sludge.

MATERIAL AND METHODS

A glasshouse pot trial was established at the University of Pretoria's Innovation Africa campus. The experiment was a RCBD with 19 treatments replicated three times. Long-term irrigation of wheat with unclarified neutralised mine water was simulated by mixing two different sludges (GypFeMn - Fe and Mn-rich gypsum; and GypB - gypsum with brucite) at 25%, 50%, 75% and 100% on a mass basis to soil. The soil and sludge mixtures were analysed for pH, salinity, and elemental content before planting and at harvesting. Crop parameters that were measured include, germination percentage, plant height and biomass accumulated.

RESULTS AND DISCUSSION

The application of both sludges increased pH and soil EC. The GypB sludge treatment at 25%, pH was increased by 3.04, and at 75% by 3.96. The GypFeMn sludge treatment recorded a pH increase of 2.05 at 25%, and 3.53 at 75% application rates. Both sludges increased EC by more than 96% from the initial soil salinity of 9.81 mS m^{-1}. Percentage wheat germination was impacted by the increase in the rate of sludge application. Seeds in the sludge-soil mixture treatments (25%, 50%, 75%, and 100%) took the longest to germinate (7–10 days), compared to the 5 days taken by the treatment with no sludge applied. With the increase in sludge application rates, average plant height was reduced. The control treatments and 25GypFeMn treatment recorded an average plant height of more than 50 cm while all the other treatments with sludge showed signs of stunting. Data on biomass accumulation showed that wheat biomass was reduced significantly ($P< 0.05$) with the application of both sludges at the time of trial termination (eight weeks).

CONCLUSION

The application of either sludge reduced average plant height and biomass production due to salinity effects. To counter this, leaching the growth medium to remove some of the salts before planting may be recommended.

Keywords: *AMD, HDS, sludge-soil mixture, unclarified neutralised mine water, wheat*

ACKNOWLEDGEMENTS- University of Pretoria, Water Research Commission, MINTEK, National Research Foundation

CARABID BEETLES AS INDICATORS OF SUSTAINABLE AGROECOSYSTEM MANAGEMENT PRACTICES

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INTRODUCTION

The sustainability of agroecosystems is at risk due to continuous anthropogenic disturbance. As a result, there is a need to evaluate indicator taxa that may be used to monitor the stability or health of agricultural land. Carabid beetles are ubiquitous and critically important in agroecosystems. Their rapid response to anthropogenic disturbances has been proposed as a practical and realistic tool for monitoring the sustainability of agricultural management practices. We aimed to assess the viability of carabid beetles as indicators of sustainable management practices.

MATERIALS AND METHODS

The research was carried out in commercial grain agroecosystems in two dryland areas in South Africa's Eastern Free State Province: Bethlehem (S28° 09' 55.12" S 28° 18' 32.97" E) and Reitz (S27°52'40,57" E28°32'38.10"). The study area consists of different farming systems (i.e., conservation grazing, conventional tillage, semi-conservation agriculture and semi-natural grassland) that are located 5 kilometers apart. The beetles were sampled over a two-year period, from 2020 to 2021, using pitfall traps. Within each sampling site two parallel transects of four pitfall traps each yielding eight traps were placed at the center of each sampling site, 10 m away from the edges.

RESULTS AND DISCUSSION

During this study, 774 carabid morphospecies and 3 034 individuals were recorded. The results of the generalized linear mixed model (GLMM) showed that the abundance and richness of carabids were significantly greater under conservation grazing and semi-conservation management than under semi-natural grassland and conventional tillage. Pairwise analysis ADONIS revealed a statistically significant difference in assemblages between agroecosystem types ($F = 7.07$, $R^2 = 0.39$, P-value = 0.001) and management practices ($F = 3.37$, $R^2 = 0.49$, P-value = 0.001). The indicator analyses (IndVal) were carried out for all management practices using "Indicspecies". Of the 14 carabid species recorded across the study area, seven carabid species (50%) were considered indicators of conservation grazing practices. According to IndVal, two carabid species were significantly associated with semi-conservation management, two with conservation grazing and conventional tillage, and one species with all agroecosystem management. No carabid species recorded was indicative of semi-natural grassland.

CONCLUSIONS

This study provides a basis for employing carabid beetles as indicators in sustainable management assessments and biomonitoring programmes to identify areas of high conservation priority, particularly in the South African agroecosystem where such studies are scarce.

KEYWORDS: agroecosystem stability, composition, diversity, ecological disturbance, indicator species, IndVal

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ANTIFUNGAL PROPERTIES OF OF CACTUS PEAR (*OPUNTIA FICUS-INDICA*) FRUIT PULP

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INTRODUCTION

Cactus pear is a perennial drought-tolerant plant from the *Cactaceae* family (Mobhammer et al. 2006). The spineless cactus pear cultivars' antifungal properties in South Africa have not been documented. Therefore, a study was conducted to investigate the antifungal effect of cactus pear fruit pulp on four different fungi.

MATERIALS AND METHODS

Ripe cactus pear fruits of 'Morado' and 'American Giant' were harvested from the University of Free State cactus pear orchard located at Bloemfontein. Cactus pear fruit extracts were prepared using the maceration extraction method. The agar dilution method, was used for determining the inhibition of mycelial radial growth of four economically important test organisms (*Alternaria alternata*, *Rhizoctonia solani*, *Fusarium graminarum* and *Fusarium oxysporum*) at four concentrations (0, 0.5, 10 and 20 mg ml^{-1}). Each treatment combination was replicated 5 times. Plates were incubated for 3 days at 25 °C in a growth cabinet. Mycelial growth was determined after 3 days and calculated as percentage mycelial growth inhibition compared to the control. Data were subjected to ANOVA using the Statistix 10.0 and mean separation was done using the Tukey test at $p = 0.05$.

RESULTS AND DISCUSSION

All four fungi tested responded differently to the fruit pulp extract of the two cactus pear cultivars at different concentrations when the percentage growth inhibition was considered. Fruit pulp extracts of 'Morado' showed 100% growth inhibition of *Rhizoctonia solani* and *Fusarium graminarum,* irrespective of the concentration compared to the control treatment. A 100% inhibition of *Fusarium oxysporum* was also observed for 'Morado' at a concentration of 10 or 20 mg ml^{-1}. The growth of *Alternaria alternata* was 100% inhibited by 'American Giant' at 0.5 mg ml^{-1} and *Fusarium oxysporum* with 85.6% at 10 mg ml^{-1}.

CONCLUSION

Except in the case of *A. alternata* (79% and lower) the extracts of 'Morado' completely (100%) inhibited radial mycelial growth of *R solania* and *F graminarum*, emphasizing the broad-spectrum fungicidal potential of the plant, whereas 'American Giant' did not respond the same. *F. oxysporum* and *A. alternata*, were more resistant to treatment with crude extracts from different cultivars. 'Morado' extract has the potential to be applied as a corrective measure against infection of plants by three of the tested fungi at a concentration as low as 0.5 mg ml^{-1}.

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EVALUATING MACHINE LEARNING APPROACHES FOR SUB-FIELD MAIZE YIELD PREDICTIONS TO INFORM PRECISION AGRICULTURE

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INTRODUCTION

Understanding the relationships between crop yields, soil properties, and input application is important for agricultural management. Data variation is key for statistical and machine learning (ML) analysis, to better understand the relationship between yields, crop management, and spatial and temporal variability. An opportunity to use precision agriculture datasets to develop, and test different ML models in South Africa is presented through the implementation of Data Intensive Farm Management (DIFM) trials. The objective of this study was to compare the predictive accuracy of various ML models for predicting maize yields using different combinations of seeding and fertilizer rates.

MATERIALS AND METHODS

This study was conducted in Henneman, Free State, using a dataset from an 80 ha commercial field. The dataset included 5749 subfield scale observations of maize yields linked to crop management, soil properties and remotely sensed NDVI values for the 2019 – 2020 growing season. The important variables included plant population, fertilisation rate, grain yields, soil pH, clay content, soil depth, soil P availability, NDVI and CEC. Multiple linear regression, random forest, multiple layer perceptron, decision tree and autoML models were developed and tested to identify the best ones that are able to relate crop management, yields and soil properties.

RESULTS AND DISCUSSION

AutoML was the most succesful at predicting yields with an R^2 of 0.76 and MAE of 0.44. Multiple linear regression was the least succesful in predicting yields, with an R^2 of 0.37 and MAE of 0.77. Feature importance was also used to identify the most significant variables contributing to yield. AutoML feature importance analysis indicated that P content in the subsoil was the most contributing factor to yield variation, and urea application was the most significant input that influenced maize yield.

CONCLUSION

These results indicate that AutoML predicted maize yields with higher accuracy than the other ML models. The study also indicated that the distribution of soil nutrients in different parts of the field brought about by spatial variability is important in describing yield variability in precision agriculture fields. The results show that ML approaches can be used to predict yields and to make input application reccomendations for regions with comparable soil characteristics.

KEYWORDS: *spatial variability, artificial inteligence, automl, random forest, multilayer perceptron*

QUANTUM YIELD AND CHLOROPHYLL FLUORESCENCE OF CHICKPEAS GENOTYPE IN RESPONSE TO BIOFERTILIZER

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INTRODUCTION

The chlorophyll fluorescence provides information on the stress level and ability of plants to acclimate to stress. For example, it is becoming more common to use the chlorophyll parameter (Fv/Fm) for measuring plant heat stress because it is fast, non-destructive, sensitive and shows damages before visible symptoms appear (Wilson & Greaves, 1990). Chlorophyll fluorescence of unstressed plants ranges between 0.75-0.85 and for stressed plant it is less than 0.75. Biofertilizers have been previously reported to significantly increase plant tolerance to abiotic stress (Langeroodi, *et al*., 2020). Therefore, we assessed the effect of biofertilizers on chlorophyll fluorescence at two sites, characterised with contrasting temperature regimes and soil type.

MATERIALS AND METHODS

An experiment was conducted at Thohoyandou (warm) and Syferkuil (cool) during winter 2021. The experiment was a factorial combination of 6 biofertilizer levels (mycoroot [M], kelpak [K], rhizobium inoculation [R], M+R, K+R, & zero control) and 2 chickpea cultivars (ACC#7 & ACC#3) arranged in a randomised complete block design and replicated 3 times. ACC#7 and ACC#3 are heat tolerant. Leaf chlorophyll fluorescence was measured at flowering stage using a PAM -200 portable chlorophyll fluorometer according to the fluorescence nomenclature proposed by Baker and Rosenqvist (2004).

RESULTS AND DISCUSSION

At Thohoyandou, biofertilizers significantly affected chlorophyll fluorescence and its parameters, with K+R (0.33) and K (3.66) showing the highest ΦPSII and Fv/Fo, while at Syferkuil, R (0.33), K (3.12), and M, M+R (0.77) exhibited the highest ΦPSII, Fv/Fo and Fv/Fm respectively. However, at Thohoyandou (warmer) Fv/Fm was not significantly affected. ACC#7 recorded higher Fv/Fm compared to ACC#3 at Syferkuil (cooler). The interactive effect of biofertilizer and genotype significantly affected ΦPSII with R x ACC#3 giving the highest ΦPSII at Thohoyandou. Fv/Fo and Fv/Fm were consistently higher at Thohoyandou than at Syferkuil. These results suggest that the efficacy of biofertilizers may be greatly influenced by the environment and climate.

CONCLUSION

Chlorophyll fluorescence parameters increased with biofertilizer application. Higher chlorophyll parameters were observed at the warmer site of Thohoyandou than in the cooler site of Syferkuil. Also, rhizobium inoculation co-applied with Kelpak and mycoroot showed a synergistic effect on some of the chlorophyll parameters. However, there is a need to carry out further trials before justifiable agronomic recommendations can be made.

KEYWORDS: *biofertilizers*

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ASSESSING PRE- AND POST-HARVEST RESPONSES OF CORIANDER GROWN UNDER A VERTICAL NFT HYDROPONIC SYSTEM

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INTRODUCTION

The adoption of hydroponics as a strategy to increase food production is faced by loss of quality in post-harvest storage. This is in particular for high value leafy herbs. Therefore, efforts that reduce post-harvest losses, particularly if they are economically feasible, are of great significance to farmers and consumers. The main objective of the study was to obtain optimum plant spacing at pre-harvest phase, and extend shelf life using packaging material at post-harvest phase of the selected high-value leafy herb crop "coriander".

MATERIALS AND METHODS

The study was conducted at the Agricultural Research Council – Vegetable, Industrial and Medicinal Plants, located in Roodeplaat. Coriander seedlings (4-week-old, cultivar "Cribe Cilantro") were transplanted under a plastic tunnel using coco peat on a nutrient film technique (NFT) vertical recirculating hydroponic system with three replications using two plant spacings (10 and 20 cm). Fertigation was maintained at 1.0 – 2.0 dS/m EC using a combination of calcium nitrate and Hygroponic® soluble fertilizers. At maturity phase (6 weeks after transplanting), the crop was harvested, packaged at 20 g inside an anti-mist modified atmosphere material and cold stored for 12 days at 4.0 - 4.4 ºC to monitor shelf-life quality parameters (fresh mass, leaf colour, wilting, decay, gas composition and marketability).

RESULTS AND DISCUSSION

At pre-harvest, plants spaced at 10 cm had higher fresh weight (18.4 g/plant) compared to those spaced at 20 cm (13.5 g/plant). Similarly, 10 cm spaced plants had lower oxygen (O_2 = 3.7 – 16.0%) and higher carbon dioxide (CO_2 = 1.0 – 2.4%) than those spaced at 20 cm (5.2 – 18.4% and 1.8 – 1.7% for O_2 and CO_2, respectively). This suggests that narrow plant spacing in hydroponic systems can maintain a good post-harvest crop quality. The depletion of O_2 and/or enrichment of CO_2 improves shelf-life and sensory qualities of fresh produce by reducing respiration, delaying ripening, reducing chlorophyll degradation, and alleviating physiological disorders.

CONCLUSIONS AND RECOMMENDATIONS

Spacing coriander at 10 cm during the production phase, followed by anti-mist modified atmosphere packaging material during the post-harvest phase proved to be the best way to improve coriander yield and quality. These cultural practices should, however, be evaluated in terms of their economic feasibility prior to their transfer to farmers.

KEYWORDS: *leafy herbs, nutrient film technique, spacing, shelf-life.*

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CHARACTERIZATION OF GRAS SALT-INSPIRED FICUS MUCILAGE-BASED FILMS

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INTRODUCTION

Food packaging is the key contributor to high rates of environmental contamination; therefore, the development of biomaterials of agriculture products and wastes is a global trend. Research on edible coatings (EC) focused on developing coatings with low environmental impacts while assuring optimum food quality. Mucilage from *Opuntia ficus-indica* has the capacity to form molecular networks, and its viscosity makes it a candidate for edible films/coatings in food packaging. EC can be enhanced with low-toxicity substances and is generally regarded as safe (GRAS) salts reported to have antimicrobial properties. To our knowledge, no comparative study has been reported on GRAS salt-inspired mucilage composite films. This study aimed to develop and investigate the effects of different GRAS salts on the properties of Ficus-mucilage edible films for new potential sustainable biomaterial.

MATERIALS AND METHODS

In the current study, Ficus-mucilage composite films of *Opuntia ficus-indica* were produced by incorporating GRAS salts (Potassium carbonate, Sodium formate, propionate and carbonate) at different concentrations i.e., 0.5%, 1% and 2% (w/w) by solution casting method and replicated three times. Films with 0 % salt were used as a control. To evaluate the effect of GRAS salts, films were characterized using physical, mechanical and barrier properties.

RESULTS AND DISCUSSION

Films with sodium carbonate, formate and propionate showed high moisture content, with no statistical difference from the control. However, the GRAS salts increased the films' solubility, which could be attributed to an increase in the size of microspheres in the carrier system. Films without salt showed higher swelling property than those with potassium and sodium carbonate. Sodium formate and propionate exhibited similar swelling capacity with no statistical difference compared to the control. Furthermore, films without salt showed transmittance > 50%; however, films with GRAS salts showed decreased transmittance. This correlated to film colour, where films without salts had a significantly ($p < 0.05$) higher lightness than films with potassium and sodium carbonates. This suggests films with low transparency could be used for UV protection in food packaging. Tensile strength varied, with films incorporated with salts having a lower tensile strength compared to the control, which could be attributed to interaction of the salts and the *Ficus*-mucilage, which weakened the matrix.

CONCLUSION

Edible films of potassium and sodium carbonate showed decreased swelling capacity and lower light transmittance. These results show the potential of GRAS salts to enhance Ficus-mucilage film properties. With the ongoing investigation, this could be a promising alternative green technology in food preservation and packaging.

KEYWORDS: *cactus, characterization, edible-films, GRAS-salts*

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THE RESPONSE OF DRY BEAN VARIETIES TO FIVE LEVELS OF PLANT POPULATION AT NWAMITWA VILLAGE IN LIMPOPO PROVINCE

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INTRODUCTION

Dry bean (*Phaseolus vulgaris* L.) is an important protein grain crop grown mostly for human consumption and its production is much lower than the South African demand. The deficit is covered by imports from China and Ethiopia. Farmer yields per hectare remain low because of low plant populations and there is a need to test some agronomic practices to improve the yield. The study seeks to determine the response of two dry bean varieties to five plant populations.

MATERIALS AND METHODS

Field experiments were conducted at Nwamitwa village in the Greater Tzaneen Municipality, Limpopo Province, South Africa (22º44'24'S, 30º 49'E) during 2020 and 2022 planting seasons. The study involved two varieties of dry bean which are Kranskop (indeterminate, red speckled) and PAN 123 (determinate, small white) and five plant population levels: 70 000, 105 000, 150 000, 210 000 and 300 000 plants ha^{-1} at an interrow spacing of 0.95 m. Planting, weeding and harvesting was done by hand. Irrigation was done by drip twice a week. Data collected was plant height at 21 days after planting (DAP), 65 DAP and 90 DAP. Plant weight, total dry matter yield, number of pods, seeds, branches $plant^{-1}$, number of seeds pod^{-1}, pod weight, grain yield, hundred seed weight and harvest index were measured and calculated.

RESULTS AND DISCUSSION

The results revealed that plant weight, total dry matter yield, number of pods, seeds, branches per plant, number of seeds pod^{-1}, pod weight, grain yield, hundred seed weight and harvest index were all influenced by variety and plant population interaction ($p \leq 0.01$). The highest plant weight was produced by Kranskop (104 g $plant^{-1}$), with 70 000 plants ha^{-1}, while the highest grain yield ha^{-1} was found for Kranskop (5.066 t ha^{-1}) at 150 000 plants ha^{-1}. The highest dry matter yield was produced by Kranskop (21.25 t ha^{-1}) with 300 000 plants ha^{-1}. The results revealed that the yield $plant^{-1}$ for both Kranskop and PAN 123 were significantly correlated with number of pods $plant^{-1}$, number of seeds $plant^{-1}$, hundred seeds weight and harvest index.

CONCLUSIONS

The results suggest that for Kranskop the most productive plant population is 150 000 plants ha^{-1} and for PAN 123 the best plant population is 210 000 plants ha^{-1}.

KEYWORDS: *common bean, dry bean varieties, number of pods, plant density*

EFFECT OF SEED AGE ON RYEGRASS GERMINATION

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INTRODUCTION

Year after year ryegrass (*Lolium* spp) shed seeds in the soil; this is evident by ryegrass infestations that compete vigorously early in the crop growing season. This necessitates an evaluation of the effect of seed age on ryegrass germination percentage and rate. Thus, the objective of this study was to evaluate ryegrass viability of seeds stored in a cool dry area, collected over a ten-year period.

MATERIAL AND METHODS

Ryegrass seeds were collected from 2009 to 2019 in one camp at Langgewens (Moorreesburg), Western Cape (33.280671º S, 18.710166º E) and stored at room temperature. Four thousand seeds in 20 replicates and in batches of 20 seeds were tested. Seeds were incubated at a constant temperature of 20°C in the dark in a germination cabinet. Experiments were conducted at the Welgevallen experimental farm of the Stellenbosch University (33° 56´33" S and 18° 51´56" E). Germination was monitored daily for 14 days; after which germination percentage and rate was subsequently calculated. The seeds that did not germinate, were treated with 2,3,5-triphenyl tetrazolium chloride to determine viable dormant seed percentage (ISTA 2020). All experiments were repeated twice.

RESULTS AND DISCUSSION

In both experiments, seed age had a significant effect on seed germination percentage and germination rates ($p < 0.01$). In the first experiment, seeds collected after 2012 gave higher germination percentage and thus had the lowest dormancy level. Ryegrass seeds collected before 2013 gave lower germination percentage and thus had the higher dormancy level. In the second experiment, seeds collected after 2015 had significantly higher germination percentage. Germination rate was not consistent in the two experiments. The fact that ryegrass seeds collected after 2012 showed an acceptable total viability emphasizes that ryegrass is a successful weed, and this may be explained by its high genetic adaptability, variability and fecundity (Goggin et al. 2012).

CONCLUSIONS

Seeds collected in 2013 still managed to germinate when the study was conducted in 2020. It is possible that in the field older seeds from 2013 may still be viable and will remain a problem in farmers' fields. Seed bank depletion has been reported as an exceptional way to control ryegrass in winter crops. Thus, early synchronic ryegrass germination stimulation through tillage or bio-stimulants will be necessary to deplete ryegrass seedbanks.

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KEYWORDS: *dormancy, seed longevity, seed populations, tetrazolium*

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DRYBEAN PERFORMANCE AS AFFECTED BY PHOSPHORUS FERTILIZER SOURCE, CULTIVAR, AND LOCALITY

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INTRODUCTION

Drybean growth takes place at a virtually exponential rate during the vegetative phase until pod growth commences under optimal conditions. Farmers do not generally consider the types of cultivars that perform best in their growing environments and tend to plant on unsuitable soils. The objective of the study was to evaluate drybean performance as affected by phosphorus fertilizer source, cultivar, and locality.

MATERIAL AND METHODS

This study was conducted at Mafikeng, Kraaipan and Taung in North-West, South Africa, in the 2019/20 growing season. The experiment was a 3×4×2 factorial experiment fitted into a RCBD, with four replications. Phosphorus fertilizer sources were the control, single superphosphate, mono-ammonium phosphate and maxi-phos applied at 60 kg ha^{-1} P. The cultivars used were PAN 9292 and PAN 148. Measured parameters were plant height, leaf number, chlorophyll content, root mass, root length and number of pods per plant.

RESULTS AND DISCUSSION

Phosphorus fertilizer source had a significant effect on plant height, number of leaves and root mass. MAP produced taller plants, higher number of leaves, and greater root mass. This might be attributed to the high-water solubility and high P content of this source. Cultivar had a significant effect on plant height and number of leaves. PAN 9292 had taller plants than PAN 148. PAN 148 produced higher number of leaves than PAN 9292. This might be attributed to the cultivar's growth habits. Chlorophyll content was influenced by location. Drybean planted at Kraaipan had higher chlorophyll content as compared to Mafikeng and Taung. This might be attributed to the lower temperatures in Kraaipan. The number of pods per plant was significantly affected by location. Drybean grown in Mafikeng produced a higher number of pods as compared to Kraaipan and Taung. This might be attributed to the optimum rainfall received by this location during the growing period.

CONCLUSION

Phosphorus fertilizer sources did not result in significantly different grain yields; however, MAP produced more pods per plant as compared to other phosphate sources. In conclusion, MAP is the most suitable P source for drybeans, and PAN 148 is recommended for improved drybean performance. Mafikeng is recommended as a favorable location for good drybean performance.

KEYWORDS: *drybean, phosphorus fertilizer source, cultivar, location*

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ARGEMONE OCHROLEUCA PHYTOCHEMICALS AND THEIR EFFECT ON GERMINATION OF SOYBEAN

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INTRODUCTION

Argemone ochroleuca is an alien invasive weed with potential to affect crops and has been reported to release allelochemicals that inhibit the germination and growth of crops (Muche *et al*., 2018). The aim of this study therefore was to characterise phytochemicals present in different extracts of *A. ochroleuca* and to assess their effect on the germination of soybean seeds.

MATERIALS AND METHODS

Shoots and roots of *A. ochroleuca* were weighed and 100g of each was separately extracted with 1000 ml deionised water, hexane or acetone. Ten shoot or root equally spaced concentrations of water extracts ranging from 10 to 100 g/mL were separately used for seed germination bioassays, and three equally spaced concentrations of acetone and hexane extracts ranging from 2.5 to 7.5 g/L were used. Ten soybean seeds were placed on filter paper in a 9-cm-diameter Petri dish and separately treated with respective concentration of water, hexane or acetone extracts. Seeds treated with deionised water served as control in all germination bioassays. The Petri dishes were then kept in a growth chamber set at 25 ℃ for 10 days. Each treatment was replicated three times with three independent trials conducted for each experiment. Data obtained were subjected to ANOVA through Statistix 10 software. Thin layer chromatography analysis was used to compare the chemical composition in water, hexane and in acetone extract of *A. ochroleuca.*

RESULTS AND DISCUSSION

Higher concentration of *A. ochroleuca* water, hexane and acetone extracts inhibited the germination of soybean seeds, whereas lower concentrations had a stimulating effect. Water extracts from root and shoot decreased germination variables by 26–49 and 31–100%, respectively. Hexane shoot extract decreased germination variables by 35–40%, whereas root extract stimulated germination variables by 33–53%. Acetone shoot and root extracts decreased germination variables by 24 and 33%, respectively. TLC analysis eluted different classes of compounds in *A. ochroleuca* extracts, which include flavonoids, lactones, phenolic acids, alkaloids, saponins, anthracene derivatives and essential oils. Terpenoids, alkaloids, phenolics, and flavonoids were among the metabolites previously observed in plants of *Argemone* species (Brahmachari *et al*., 2013) and these chemical compounds have been reported to have allelopathic effects on seed germination (Cheng and Cheng, 2015).

CONCLUSION

The present study indicated that *A. ochroleuca* extracts suppress the germination of soybean seeds and this could be due to the presence of phytochemicals observed in these plant extracts.

KEY WORDS: allelochemicals, allelopathy, *Argemone ochroleuca*, invasive alien plants

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EVALUATING SOIL ORGANIC CARBON FROM CONSERVATION AGRICULTURE SYSTEMS IN OTTOSDAL AND LADYBRAND AREAS OF SOUTH AFRICA

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INTRODUCTION

Soil organic carbon (SOC) is the basis of soil fertility. Many variables, including climate, soil type, baseline SOC, crop management, sampling depth, and planting technique, affect how much SOC differs between conservation systems (Page *et al*., 2020). Conservation agriculture (CA) is one of the approaches used to promote SOC storage. Not only does SOC provide energy and substrates to soil organisms, but it also increases the overall ecosystem resilience by moderating climate change through carbon sequestration (Lal, 2009). However, the capacity to store SOC varies with the agro-ecological conditions and farm-based activities. This study reports on a preliminary investigation of how CA systems implemented on farmer fields affect SOC storage in two distinctive ecotopes of Ottosdal (North-West) and Ladybrand (Free State) Provinces.

MATERIALS AND METHODS

Farmer fields with more than five years of history of maize-based CA were chosen as study sites. An adjacent conventionally tilled (CT) field and the natural veldt were also sampled for reference purposes. Therefore, the study was composed of three treatments. Soil samples were taken from a 15 cm depth. Five random soil samples were collected to make a composite sample. Soil organic carbon was measured following the Walkley-Black method (AgriLASA, 2004). A pairwise correlation test was done on permanganate-oxidizable carbon (POXC), also known as active carbon and particulate organic matter (POM) to test the relationship between SOC and other measured parameters.

RESULTS AND DISCUSSION

Preliminary results show no influence of the ecotope related factors such as sampling area and soil texture on the measured SOC, even though the two ecotopes have distinctly different climatic and pedological conditions. However, sampling date and treatments showed significant effects ($P<0.001$) on SOC. Conservation agriculture systems consistently had higher SOC values than CT, however, both systems had lower values compared to the natural veldt. Higher SOC values in nearby natural veldt point to an existing gap to realize the carbon storage potential in the study areas. Soil organic carbon was positively correlated to active carbon ($R^2=0,34$, and POM $R^2=0,36$, $P<0.001$, respectively). Further studies are underway to measure the SOC changes over time.

CONCLUSION

Whilst CA provides an opportunity for farmers to build SOC, more needs to be done to close the gap between the current SOC levels and the potential of the sampled veldt to store carbon. More research is needed to measure the impact of other farm-level practices besides CA components on SOC levels.

KEYWORDS: *conservation agriculture, conventional tillage, natural veldt, soil organic carbon*

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EFFECTS OF RAINFED AND IRRIGATED MAIZE-LEGUME INTERCROPPING SYSTEMS ON PLANT GROWTH AND YIELD PARAMETERS

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INTRODUCTION

Cereal and legume intercropping is known for multiple yield benefits. Intercropping can be implemented to solve the problem of crop failure. This can be achieved by efficiently using of available resources during the growing season. This study seeks to evaluate the effect of intercropping on plant growth and yield under different moisture regimes.

MATERIALS AND METHODS

A split plot field trial was conducted by intercropping maize (*Zea mays*) with chickpea (*Cicer arietinum*) and mungbean (*Vigna radiata*) at the University of Limpopo experimental farm (UL Farm) under two irrigation regimes. Plant growth parameters chlorophyll content, leaf area and plant height were recorded three times during the growing season and the plant biomass was recorded as an indicator for crop yield. All data were subjected to analysis of variance using the GenStat 20th Edition software.

RESULTS AND DISCUSSION

The interaction between irrigation regime and cropping system did not have a significant effect on chlorophyll content, leaf area, plant height and biomass. The cropping system showed a significant effect on chlorophyll content, leaf area and plant height at the flowering and maturity stage. Cropping system and water regime had a significant effect on leaf area, plant height and biomass at flowering and maturity stages. The water regime did not have a significant effect on the chlorophyll content and plant height during the vegetative stage. Intercropping maize with mungbean produced the highest plant height in the irrigated plot for maize. The high biomass in sole maize can be explained by the high nitrogen and phosphorus uptake recorded in the subplot.

CONCLUSION

Intercropping increased chlorophyll content and plant height in maize. It also increased leaf area for the legumes and aboveground biomass for maize under rainfed conditions. The study showed that intercropping has a positive effect on growth and yield parameters.

KEYWORDS: *chickpea, irrigation, mungbean*

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ENCAPSULATION AND CHARACTERIZATION OF *ALOE FEROX* GEL FOR POTENTIAL POSTHARVEST APPLICATIONS

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INTRODUCTION

Aloe ferox is a South African plant and has been used since ancient times in folk medicine; however, the use of inner, non-bitter gel as a food supplement is a recent development, and there is no documentation of the use of *Aloe ferox* gel for food-related purposes. The main challenge with using *Aloe ferox* gel is its oxidative and enzymatic deterioration after extraction; therefore, there is a need to stabilize the quality integrity and bioactivity using innovative technology. Encapsulation is an innovative method to increase the stability of *Aloe ferox* gel by turning the gel into a powder that can be easily dissolved in distilled water when required. The main objective of the study was to encapsulate *Aloe ferox* gel using a combination of carrier agents and characterize the encapsulated powder for potential postharvest applications.

MATERIAL AND METHODS

Aloe ferox gel was diluted with distilled water at 50°C to 1 °Brix. Diluted gel was mixed with blends of gum Arabic (GA) and maltodextrin (MT) at ratios of 1:2, 1:1 and 2:1 at 10% (w/v), with control treatment without a carrier. The mixture was subjected to continuous stirring using a magnetic stirrer, followed by homogenization, frozen at -80° for 12 h and freeze-dried for 72 h. The samples were ground to a fine powder and stored at room temperature. Physicochemical, phytochemical composition and antioxidant activity were investigated.

RESULTS AND DISCUSSION

Production yield of *Aloe ferox gel* ranged between 0.6 and 9.93%, with 2:1 GA:MT (9.93%) having the highest yield. Moisture content ranged from 3.18 to 11.19 %, with control the highest. pH ranged between 6.61-7.04 when total soluble solids were adjusted to 1ºBrix. The bulk density varied between 0.44-0.67g/ml, and control was the highest. Solubility was between 14.9 -24.2% with 1:1 being the highest at 24.2% and control the lowest at 14.9%. Total phenolics ranged from 0.1 to 0.2 GAE/gDM, with control being the highest. Regarding FRAP activity, control, 1:2 and 2:1 maintained high FRAP activity and 1:1 maintained the lowest FRAP activity.

CONCLUSION

The present study may provide an alternative postharvest technology suitable for application and potentially reduce postharvest losses. This study proved that *Aloe ferox gel powder* can be stable and suitable for formulation of edible coatings that can potentially reduce postharvest losses.

KEYWORDS: *Aloe ferox*, *encapsulation, gum Arabic, maltodextrin*

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GROWTH, YIELD, AND WATER USE EFFICIENCY RESPONSE OF LETTUCE AS AFFECTED BY WATER FLOW, PLANT SPACING, AND ENVIRONMENTAL CONDITIONS IN A VERTICAL NFT HYDROPONIC SYSTEM

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INTRODUCTION

The vertical nutrient film technique (NFT) has been considered a highly productive leafy vegetable production system with many advantages when compared to traditional agriculture. These include shorter production cycles, local production, and high yield while using minimum natural resources such as water and space. Generally, these cultivations are conducted in protected and controlled environments. However, with depleting natural resources and unaffordable environmental control systems, resource use efficient practices have to be introduced in vertical NFT hydroponic systems. Therefore, the present study investigated the impact of environmental conditions, plant spacing, and water flow patterns on the production of lettuce in a vertical NFT hydroponic system.

MATERIAL AND METHODS

The experiment was conducted during winter (June – July 2021) at the Agricultural Research Council - Vegetable, Industrial and Medicinal Plants in Roodeplaat, Pretoria. The experiment used a factorial arrangement laid out in a randomized complete block design with three factors, namely: (1) environment (plastic tunnel and shade net); (2) plant spacing (10, 20 and 30 cm) and water flow patterns (continuous flow and intermittent flow), replicated three times. Seedlings of leafy lettuce, cultivar "Multigreen", were planted in net cups filled with cocopeat. Growth, yield and physiological parameters were collected and analysed using statistical software GenStat® version 11.1.

RESULTS AND DISCUSSION

The interaction between environment and plant spacing significantly affected the growth and yield of lettuce. The results showed that crops grown in the tunnel at 10 cm spacing and intermittent water flow significantly increased growth and yield (4.60 kg m^{-2}), compared to widely spaced crops (30 cm) grown in a shade net (0.80 kg m^{-2}). Furthermore, the interaction between water flow and environment significantly affected water use and water use efficiency of lettuce. Plants grown under intermittent water flow in a shade net had higher water use efficiency (0.097 kg L^{-1}) compared to continuous water flow under a tunnel (0.030 kg L^{-1}). Although the lettuce grown under the shade net was more water use efficient, the plastic tunnel had a significantly higher yield when compared to the shade net yield.

CONCLUSIONS

Winter lettuce production is suitable under a tunnel with narrow spacing (10 cm) and intermittent water flow. Although shade net resulted in increased water use efficiency, the plastic tunnel is recommended due to significantly improved yield. Identifying appropriate agronomic practices will help to improve resource use efficiency, farmers' profitability, and overall sustainable food production in hydroponic systems.

KEYWORDS: *indoor cultivations, plant physiology, vertical farming, water use efficiency*

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NORTHERN CORN LEAF BLIGHT ASSESSMENT ON MAIZE HYBRIDS AND THE ASSOCIATED YIELD LOSS IN O.R. TAMBO DISTRICT, SOUTH AFRICA

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INTRODUCTION

The control of fungal foliar diseases remains a challenge in local maize production. Grey leaf spot (GLS), northern corn leaf blight (NCLB) and common rust (CR) are the main foliar diseases. This study was initiated to assess the severity and impact of NCLB fungal foliar disease in smallholder farms of the Eastern Cape.

MATERIALS AND METHODS

An on-farm experiment was conducted at Njiveni in Ngqeleni sub-district (31˚34' 5, 79'' S and 29˚8' 33, 48''E) during 2021/22. Nine maize hybrids were evaluated for NCLB susceptibility in a RCBD with three replications. Plot size was 25 m^2 with a total of seven rows and plant density of 53 333 ha^{-1}. During planting, NPK fertilizer was applied as recommended and insecticide was used. In order to quantify NCLB severity, ten plants were selected randomly from each plot's two middle rows and tagged. Disease severity was recorded based on percent leaf area infected at the silk dry stage. Tagged plants were also used for plant height and leaf area measurement during milking stage. In addition, grain yield and climatic data were recorded. Data collected was subjected to the analysis of variance.

RESULTS AND DISCUSSION

Hybrids DKC 74-74BR and PAN 5R-582R exhibited maximal improvements in leaf area, plant height and grain yield. High grain yield was associated with maximum leaf area, taller plant height and maximum cob weight. Minimum grain yield was recorded from P1788BR and PAN 5R-854R. Among maize hybrids, yield losses caused by NCLB severity varied based on susceptibility to NCLB. Hybrids that were highly susceptible to NCLB were PAN 4R-728BR, PAN 3R-724BR and P1788BR, compared to DKC74-74BR, PAN 5R-582R and DKC80-40BR that showed some level of being moderately resistant.

CONCLUSION

Maize hybrid DKC 74-74BR and PAN 5R-582R were moderately resistant to NCLB and recorded maximum grain yield. Moderately resistant or resistant hybrids should not be treated with fungicides, since they are unlikely to benefit economically from an application. It may be appropriate to consider fungicides with hybrids that are in the moderately susceptible to susceptible categories.

KEY WORDS*: Northern corn leaf blight, maize hybrid, grain yield*

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EFFECT OF DIFFERENT CROPPING APPROACHES ON SELECTED CROP PRODUCTIVITY MEASURES FOR WHEAT, BARLEY AND CANOLA

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INTRODUCTION

The adoption of Conservation Agriculture (CA), based on minimum tillage, permanent soil cover, and crop rotations (including conventionally grazed pasture phases), has improved soil quality and enhanced crop productivity. However, emerging sustainability issues such as herbicide resistance, rising inputs costs and climate variability and predictability, stress the need for ongoing innovation of CA systems. The aim of this study was to compare Regenerative Agriculture (RA), to the standard CA approach, in terms of its potential to sustain crop productivity without costly chemical inputs.

MATERIALS AND METHODS

The experiment was laid out in a split-plot design with two factors. The whole plot factor (system) had two levels: RA and CA. The subplot factor (crop type) consisted of three levels: canola, wheat, and barley. Each treatment combination was replicated in three blocks. The CA treatments received current best practice production inputs. All RA subplots were fertilized with 200 kg ha^{-1} chicken manure at planting and as a top-dressing. Wheat and barley seed in RA plots were biologically treated and received an in-furrow biological treatment. Canola seeds only received an in-furrow treatment in the RA plots. Crop productivity and yield parameters from the respective systems were determined according to standard procedures. Analysis was done through a mixed model ANOVA in R (Imer package) in Statistica and Fisher's least significant difference (LSD) was calculated at the 5% level to compare treatment means.

RESULTS AND DISCUSSION

Compared with CA, the RA system had no effect ($p > 0.05$) on germination and establishment of barley and canola, however, it did improve wheat germination ($p \leq 0.05$). The mean wheat germination under RA was 102.9 plants m^{-2} (± 50.1) and under CA it was 51.4 (± 44.0). All crops in the RA system had a lower leaf area index (LAI) than crops under CA ($p \leq 0.05$). Biomass production, yield components, and final grain yields did not differ ($p > 0.05$) between CA and RA for wheat, however, CA consistently outperformed RA for canola and barley treatments ($p \leq 0.05$). Although there were similarities and differences in the crop productivity parameters between CA and RA, it is important to consider that RA is a long-term approach, and its benefits are governed by the slow build-up of soil organic C.

CONCLUSIONS

From the preliminary data, it appears that the combination of selected RA practices may permit the exclusion of fertilisers and agrochemicals without significant compromises to wheat production.

KEYWORDS: Agroecological intensification, bioeffectors, management-intensive grazing, multi-species pastures, organic inputs.

ACKNOWLEDGEMENTS

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USE OF DROUGHT TOLERANCE INDICES TO SCREEN WHEAT GENOTYPES FOR DROUGHT TOLERANCE UNDER FIELD CONDITIONS IN THE EASTERN CAPE PROVINCE, SOUTH AFRICA

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INTRODUCTION

Globally, wheat (*Triticum aestivum* L.) is one of the most important commodity crops. In recent years, interest in crop response to environmental stresses has greatly received attention due to yield losses. Hussain et al., (2018) reported that drought is the most important abiotic stress restricting wheat production in arid and semi-arid regions. The objective of this study was to identify appropriate drought tolerance indices that can be used as selection tools under field conditions.

MATERIALS AND METHODS

Field trials were conducted during the 2020 and 2021 winter seasons using a 5 x 8 alpha lattice design with two water regimes (optimum and drought conditions). A total of 40 wheat genotypes from diverse sources and backgrounds were evaluated. Data on grain yield was recorded under both optimum and drought conditions. Drought tolerance indices that were used to identify drought tolerant genotypes in this study include mean productivity (MP), geometric mean productivity (GMP), harmonic mean (HM), tolerance index (TOL), stress susceptible index (SSI), sensitive drought index (SDI), and stress tolerance index (STI). Correlation analysis was performed among the indices mentioned above to determine the most appropriate indices that can be used to select superior genotypes.

RESULTS AND DISCUSSION

Results revealed that MP, GMP, and HM were identified as the most appropriate drought tolerance indices as they showed a strong positive and significant correlation with grain yield under drought and optimum conditions. A strong positive correlation was also observed among these three mean indices. TOL, SSI, SDI, and STI showed weak correlations with grain yield under drought and optimum conditions, and their effects were not significant. These findings depicted that drought tolerant genotypes could be identified based on high values of MP, GMP and HM. The following drought tolerant genotypes were identified: G5, G22, G8, and G21. Conversely, genotypes G19, G16, G2, and G20 were more sensitive to drought as they showed low values of MP, GMP and HM.

CONCLUSION

The study revealed that MP, GMP, and HM are the ideal indices for selecting drought tolerant genotypes. Genotypes G5, G22, G8, and G21 are potential sources of drought tolerance genes and, therefore, can be used as parents or for quantitative trait loci (QTL) mapping when breeding for drought tolerance.

KEYWORDS: drought, tolerance indices, wheat genotypes

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Sources of germplasm: SENSAKO Pty (Ltd); ARC-Grain Crops Institute; Corteva AgriScience; Stellenbosch University and International Centre for Agricultural Research in the Dry Areas (ICARDA).

EFFECT OF GAMMA-IRRADIATION ON PLANTAGO GROWTH AND SECONDARY METABOLITES

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INTRODUCTION

Plantago (*Plantago Lanceolata* L.) belongs to the Plantaginaceae family and there are about 270 species that belong to its genus. Plantago species are used as medicinal herbs and contain saccharides, glycosides, triterpene, flavonoids, iridoids, and polyphenols in abundance (Bahador et al. 2020). However, there are limited reports on Plantago's bioactive metabolic profile after stress induction. Gamma (γ) rays are known to cause mutagenesis, alter plant physiology, natural chemistry of plants, and inhibit plant growth (Ahuja et al. 2014). The objective of this study was to determine Plantago's physiological response and secondary metabolites after γ irradiation.

MATERIAL AND METHODS

Plantago populations collected from vineyards and orchards in the Western Cape were used. The seeds were planted in 64 cm^2 square pots and placed in a tunnel. The seedlings were irrigated with a well-balanced nutrient solution. At 2-3 leaf stage they were subjected to γ irradiation using cobalt-60 at doses of 0, 2, 4, 7, 8, 20, 30, and 50 kGy at a dose rate of 22 kGy/h. A day after irradiation plants were returned to the tunnel. Chlorophyll fluorescence and chlorophyll content was measured before and after γ irradiation. Moreover, after seven days ultra-performance liquid chromatography-mass spectrometry was employed to profile the plant metabolites. Extraction was done as described by Marr et al. (2021).

RESULTS AND DISCUSSION

Preliminary results showed that a dose is 7 kGy caused 50% growth reduction (LD_{50}). Dosages above 8 kGy resulted in 100% mortality. Gamma treatment resulted in reduced photosystem II efficiency and chlorophyll content. Most of the isolated compounds were flavonoids and triterpenoids.

CONCLUSIONS

The compounds that were identified and isolated indicate that Plantago is an essential source of bioactive compounds. The majority of the isolated compounds, especially flavonoids and triterpenoids, can be used in the food and medical industries where they will serve as pharmaceutical agents and dietary supplements.

KEYWORDS: gamma irradiation, LD_{50}, chlorophyll fluorescence, *P. lanceolata*, UPLC-MS

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PHYTONUTRIENTS AND ANTIOXIDANT PROPERTIES OF PURPLE-FLESHED SWEET POTATO (*Ipomoea batatas* (L.) LAM.) STORAGE ROOTS

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INTRODUCTION

Sweet potato (*Ipomoea batatas* (L) LAM.) is a dicotyledonous plant in the *Convolvulaceae* family. They are key to food security, nutrition and income generation in sub-Saharan Africa. Consumers are increasingly conscious of their well-being and consider dietary benefits, disease prevention abilities, and health-promoting properties of foods. Hence, interest in purple-fleshed sweet potato is rising. The main aim of this study was to profile the phytonutrient content and antioxidant properties in the roots of five selected purple-fleshed sweet potato genotypes.

MATERIALS AND METHODS

Samples of two experimental lines, a locally sourced variety (Purple-Purple), two ARC breeding lines (2019-11-2 and 2019-1-1) and two imports from USA (08-21p and 16-283p) were acquired from Agricultural Research Council, Roodeplaat north-east of Pretoria (25.6080˚S, 28.3525˚E). The growing period was from January to June 2022. Root yield was measured and harvested roots were subjected to total phenolic and antioxidant assessment using total phenolic content (TPC), ferric reducing antioxidant power (FRAP), 2,2-azino-bis(3-ethylbenzothiazoline-6-sulfonicacid)(ABTS), and 2,2-diphenyl-1-picrylhydrazy (DPPH). Total carotenoids were extracted, β-carotene was used as a standard and results were expressed as mg.g^{1}. These tests were done at the Department of Crop Science Postharvest Technology laboratory, Tshwane University of Technology.

RESULTS AND DISCUSSION

The best marketable yield was obtained from Purple-Purple (89 roots per plot of 20 plants). The highest total phenolic content (chlorogenic acid equivalent) was detected in 2019-11-2 (50,95 mg/g), 16-283p (47,12 mg/g), and 2019-1-1 (45,41 mg/g). Breeding line 2019-11-2 (1,05 mg/g) also showed the highest total carotenoid content, while no carotenoids were detected in 08-21p (0,01mg/g), Purple-Purple (0,01mg/g) and 2019-1-1 (0,00mg/g). Among all genotypes, Purple-Purple (19,68 TEAC mg/g) and 16-283p (18,68 TEAC mg/g) showed the highest ferric-reducing antioxidant power (FRAP). Genotypes 08-21p, 2019-1-1, Purple-Purple and 16-283p exhibited the highest DPPH and ABTS radical scavenging activities.

CONCLUSION

Based on the tested genotypes, Purple-Purple has the greatest potential for commercialization due to its high marketable yield and antioxidant activity. Furthermore, breeding sweet potatoes that are high in anthocyanin will be beneficial to consumers, since anthocyanin has numerous health-promoting properties.

KEYWORDS: *antioxidant properties, carotenoids, genotypes, anthocyanin, root crops.*

ACKNOWLEDGEMENTS

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RESPONSE OF SELECTED VARIETIES OF COWPEA TO RATES OF FLUMIOXAZIN + PYROXASULFONE AS PRE-EMERGENCE HERBICIDE IN IBADAN, SOUTH WEST, NIGERIA

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INTRODUCTION

Cowpea is an important legume crop cultivated for human food and animal feed in Africa. Despite the introduction of genetically improved cowpea varieties to increase yield and enhance food sufficiency, weed interference is still a constraint to optimizing yield. The efficiency of pre-emergence herbicides to enhance weed management in cowpea has been recognized. However, herbicides that were labelled for pre-emergence use in cowpea are limited in Nigeria. This necessitates the need for assessment of emerging new active ingredients that are currently being evaluated for use in some traditionally associated crops like cassava and maize.

MATERIALS AND METHODS

In the minor cropping seasons of 2019 and 2020 in Ido, Ibadan, Nigeria, rates of application of flumioxazin + pyroxasulfone (Fierce®) (0, 0.20, 0.22, 0.24, 0.26, 0.28, 0.30 and 0.32 kg a.i./ha) and a hoe-weeded control, were evaluated for crop tolerance and weed control in three cowpea varieties: IT90K-277-2, IT07K-318-33 and DANILLA. The selected rates evaluated were based on recommendation for use in some crops for which the herbicide was labelled. Herbicide rates were the main plot treatments, while cowpea varieties were in subplots in a split plot arrangement. Data collected on cowpea seedling emergence, crop injury and survival, growth and yield were analyzed using ANOVA and means separated with DMRT at $p \leq 0.05$.

RESULTS AND DISCUSSION

The results indicated that seedling emergence and survival differed significantly for herbicide rates. The 0.20 and 0.22 kg a.i./ha resulted into significant yield reduction, compared with 0.24, 0.26 and 0.28 kg a.i./ha, due to weed interference as a result of poor weed control. The dry weed weights obtained at 8 weeks after treatment from plots treated with the selected herbicide rates were 102, 79, 74, 41, 26, 29, 21 and 22 g/0.5 m^2 respectively, with dominant weeds being *Digitaria horizontalis*, *Gomphrena celosoides* and *Tridax procumbens*. Similarly, the 0.30 and 0.32 rates caused poor seedling emergence, significant crop injury, lower seedling survival and consequently yield reduction. Cowpea varieties did not differ significantly in their responses to the herbicide rates. Also, there were no significant interactions between the cowpea varieties and the herbicide rates for seedling emergence, crop injury, seedling survival, growth and yield of cowpea.

CONCLUSION

Flumioxazin + pyroxasulfone at the rate of 0.24 kg a.i./ha effectively controlled weeds and enhanced yields of cowpea.

KEYWORDS: cowpea varieties, crop injury, Flumioxazin+Pyroxasulfone, herbicide rates, pre-emergence herbicide.

THE INFLUENCE OF PLANT DENSITY AND NITROGEN NUTRITION ON GRAIN QUALITY OF TWO SORGHUM CULTIVARS

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INTRODUCTION

Grain sorghum [*Sorghum bicolor (L.)* Moench] is a staple cereal crop in the semiarid regions of the world, notably in sub-Saharan Africa due to its ability to withstand drought. However, poor soil fertility is one factor that limits its production in small farmers' fields. The objective of this study was to determine the effects of plant density, nitrogen fertilizer rates and cultivar on sorghum grain quality.

MATERIALS AND METHODS

Field experiments were conducted at North-West University experimental farm (Molelwane) and the Taung Department of Agriculture farm in the North-West province of South Africa during the 2016/17 and 2017/18 planting seasons. The experimental design was a split-split plot arrangement fitted into a randomized complete block design (RCBD) with four replicates. The experiment considered high plant density (33 333 plants/ha) with 1 × 0.3 m spacing and low plant density (22 222 plants/ha) with 1.5 × 0.3 m spacing; as the main plot factors. Nitrogen fertilizer rates of 0, 100 and 150 kg N/ha, were the sub-plot factors, while two sorghum cultivars; PAN 8625 (late-maturity) and PAN 8816 (medium-late-maturity) were the sub-sub plot factors. The measured grain quality parameters were ash, fibre, oil, protein and starch content.

RESULTS AND DISCUSSION

Nitrogen fertilizer rate had a significant effect ($P \leq 0.05$) on sorghum ash content during the 2017/18 season. Sorghum without N application had significantly higher ash content (4.44%) than those fertilized with 100 and 150 kg N/ha. Cultivar had a significant effect ($P<0.001$) on protein content during the 2017/18 season. Sorghum cultivar PAN 8816 had a significantly higher protein content (8.87%) than PAN 8625. The difference between the two cultivars in terms of protein content could be attributed to the genetic constitution. Location had a significant effect ($P<0.001$) on starch content during the 2016/17 season. Sorghum planted at Mafikeng had a significantly higher starch content (38.50%) than sorghum planted at Taung. The higher starch content from sorghum planted at Mafikeng might be attributed to better environmental conditions such as rainfall and temperature.

CONCLUSIONS

In this study, application of nitrogen fertilizer did not affect the quality parameters of sorghum grains. Quality parameters of sorghum grains differed in terms of cultivars due to differences in genetic constitution. PAN 8816, which is known to be widely adapted and can tolerate diseases, showed higher oil, protein and starch content.

ACKNOWLEDGEMENT

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KEYWORDS: cultivar, grain quality, nitrogen, seasonal effect.

EFFICIENCY OF FUNGAL ENDOPHYTES EXTRACTED FROM GM AND NON-GM MAIZE CULTIVARS ON *EXSEROHILUM TURCICUM*

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INTRODUCTION

Exserohilum turcicum is a pathogenic fungus that causes Northern leaf blight (NLB) in maize plants. NLB causes significant defoliation of maize plants at grain-filling stage, resulting in high grain losses (Hurni *et al*., 2015). Using an endophytic microorganism such as *Trichoderma harzianum* has been observed to be beneficial in controlling pathogenic diseases in various crops (Wathaneeyawech *et al*., 2015). The current study therefore aim at determining the suppressive effects of endophytic fungi isolated from GM (genetically modified) and non-GM maize cultivars on *E. turcicum.*

MATERIALS AND METHODS

Exserohilum turcicum was isolated from symptomatic maize leaves. The infected leaf tissues with some adjacent healthy tissues of 2 cm were cut and surface-sterilized in NaCl (1%), and distilled water for 30 s and 2 min consecutively. The leaf tissues were placed on Potato Dextrose Agar (PDA) amended with streptomycin and incubated at 25°C for 5 days. To obtain pure cultures, mycelium of *E. turcicum* was sub-cultured on fresh PDA. Fifty-one previously extracted fungal endophyte species were tested for their antagonistic effect on *E. turcicum* using a dual-culture method. Petri dishes of isolated endophytes and pathogen measuring 2 cm each were co-cultured at two opposite ends of PDA plates in an incubator for 10 days at 25°C.

RESULTS AND DISCUSSION

Of the 51 endophytic fungal species tested, 55% were found to be antagonistic, 8% were found to have no effects whereas, 37% were outcompeted by *E. turcicum.* Endophytes of *Aspergillus* and *Trichoderma* species had high inhibitory activity against *E. turcicum*. Sishuba *et al*. (2021) also reported a dominant inhibitory effect of *Aspergillus* species strains pathogenic fungi. Huang *et al*. (2020) explained the antagonistic effects are due to secondary metabolites released by endophytes. The secondary metabolites have antifungal activities, which inhibit the growth of microorganisms, including plant pathogens. In the present study, *Trichoderma* had a very high inhibitory (39%) effect on the growth of *E. turcicum*. Huang *et al*. (2020), reported that *Trichoderma* species showed mycoparasitism on the pathogenic fungi it was co-cultured with.

CONCLUSION

A majority of endophytes isolated from maize plants were found to have an antagonistic effect on *E. turcicum*. Even though the mechanism of control was not studied, there is a potential in the use of these fungal organism in the biological control of Northern leaf blight in maize.

KEYWORDS

Endophytes, *Exserohilum turcicum*, Maize, Northern leaf blight, *Trichoderma harzianum*

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COMPARISON OF PHYTONUTRIENTS AND ANTIOXIDANTS IN LEAVES OF LOCAL SWEET POTATO CULTIVARS AND INTERNATIONAL CULTIVARS

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INTRODUCTION

Leaves of sweet potato (*Ipomoea batata L. Lam*) are consumed as vegetables in many African countries. Phenolic constituents such as caffeic acid, various di- and tricaffeoylquinic acid derivatives and anthocyanins have been identified in sweet potato leaves. Phytonutrients and antioxidant activities of leaves of selected South African bred sweet potato cultivars ("Ndou", 'Bophelo", "Monate" and "Blesbok"), Beuregard, a USA sweet potato cultivar and "199062" a Peruvian cultivar were analysed with the aim of comparing them with established cultivars on the international market.

MATERIALS AND METHODS

Samples for analysis were planted at Agricultural Research Council (ARC-VIMP), Roodeplaat, Pretoria. Planting was replicated three times and harvesting was done 12 weeks after planting. Random harvesting of the leaves, up to the fifth leaf from the tip of the vines was done during morning hours and three samples were collected from each cultivar. Phytonutrients were extracted using organic solvents, phenolic constituents were quantified using the Folin Ciocalteu assay, individual phenolic constituents were determined using an Ultra Performance Liquid Chromatography (UPLC) hyphenated to a Quadrupole time of flight (QTOF) mass spectrometer (MS) and analysed using the chemometric technique. Antioxidant power was determined using the Ferric Reducing Antioxidant Power (FRAP) assay and radical scavenging activities using the 2,2'-diphenyl-1-picrylhydrazyl radical (DPPH) and 2,2'-Azino-bis (3-ethylbenzothiazoline-6-Sulpfonic Acid) ($ABTS^{+}$) assays. Carotenoids were analysed on a High-Performance Liquid Chromatography (HPLC) apparatus.

RESULTS AND DISCUSSION

Thirteen phenolic compounds were identified and the different sweet potato varieties were differentiated based on their distinct metabolites. The varieties from Cluster 1 ("Beuregard" and "Ndou") and Cluster 2 ("199062.1", Bophelo", Monante and Blesbok) were discriminated against using caffeic acid. Concentrations of the compounds rutin, quercetin 3-*O*-galactoside, 3-caffeoylquinic acid (3-CQA), (5-CQA), 1,3 dicaffeoylquinic acid (1,3-diCQA), 1,4-diCQA, and 3,5-diCQA were highest in the leaves of "Bophelo". In addition, Bophelo leaves exhibited the highest antioxidant activities (FRAP 19.69mM $TEACg^{-1}$) and IC_{50} values (3.51 and 3.43mg ml−1) for DPPH and ABTS, respectively, compared to the other varieties. Beta-carotene (10.27 mg kg^{-1}) and zeaxanthin (5.02 mg kg^{-1}) were highest in the Blesbok variety.

CONCLUSIONS

The study showed that the leaves of the three diverse groups of sweet potato cultivars contained similar phenolic constituents, but these differ in concentration. The local sweet potato varieties Bophelo and Blesbok have potential to be developed as functional ingredients to be used in food processing.

KEYWORDS: *antioxidant activity, caffeoylquinic acids, carotenoids, phenolic constituents*

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CONSERVATION AGRICULTURE SYSTEM PROFITABILITY PERFORMANCE IN THE SOUTHERN CAPE

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INTRODUCTION

Crop rotation systems in the southern Cape production area were based on long rotation crop/pasture systems. These systems were based on a lucerne phase for 5 to 6 years, followed by a cash crop phase of similar length. The long-term conservation agriculture (CA) trial based at Tygerhoek Research Farm tested the feasibility of shorter rotation systems based on annual medic/clover pastures and pure cash crop systems for the area. System 1 was the pure cash crop system, System 2 consisted of two years of pasture and one year of crops, System 3 combined two consecutive years of pasture and two years of crops and System 4 alternated pasture and crop annually.

MATERIALS AND METHODS

Gross Margins the four cropping systems was compared over a 19 year period. All crops and/or pastures within each system was present on the field every year, replicated twice in a random block design. The data were subjected to analysis of variance (ANOVA) using the General Linear Models Procedure (PROC GLM) of SAS software (Version 9.4; SAS Institute Inc, Cary, USA). Where repeated measurements on the same experimental unit were taken, a split-plot analysis of variance with year as sub-plot factor was performed to compare treatment differences over time. The Shapiro–Wilk test on the standardized residuals from the model verified normality. Levene's test showed heterogeneity of year variances, therefore a weighted analysis of variances was performed. The weight was the reciprocal of error variance of each year. Fisher's least significant difference (LSD) was calculated at the 5% level to compare means of the factors (main effects) and factor interaction means.

RESULTS AND DISCUSSION

There was differences between systems within years as well as across years ($P \leq 0.05$). The ranking between systems varied each year. The variance depended on the meat and wool prices and yields of the various crops, and the seasonal rainfall. In seven of the 19 years there was no statistical difference between the four systems. In eight of the 19 years the gross margin in the cash crop system was significantly lower than crop/pasture systems 3 and 4. Over years the three crop/pasture systems did not differ significantly from each other, but all three differed from System 1.

CONCLUSIONS

All four systems tested are feasible shorter rotations in the area, but the crop/pasture systems are more stable over years.

KEYWORDS: *cash crops, crop-pasture, gross margin, systems*

ASSESSING THE USE OF EARTHWORMS AS BIOINDICATORS OF SOIL HEALTH IN A CONSERVATION AGRICULTURE SETTING IN THE WESTERN CAPE

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INTRODUCTION

The principles of Conservation Agriculture (CA) are aimed at increasing production while improving the overall health of the soil. A healthy soil is one with the ability to maintain a well-balanced ecosystem with high biodiversity and productivity above as well as belowground. Monitoring soil health can be done using various physical, chemical and biological indicators. Earthworms (Oligochaete) are sensitive to management practices and as a result can potentially be used as a bio-indicator of soil health, especially in CA systems. The aim of the project was to determine how earthworms respond under CA systems and to determine whether they can be useful as soil health indicators in these systems.

MATERIALS AND METHODS

The study was conducted at Langgewens, outside Malmesbury, and Tygerhoek, Riviersonderend, which are two research farms of the Western Cape Department of Agriculture. Earthworm samples were taken four different times throughout the year, using three different sampling techniques, which included hand-sorting, mustard solution and a combination of the two methods. Different CA systems were used for sampling. At Langgewens samples were taken from a monoculture, cash crop rotation and pasture cash crop system. At Tygerhoek samples were taken from a regenerative pasture and cash crop and a CA cash crop system. At both sites samples were also taken from a conventional tillage system as a control.

RESULTS AND DISCUSSION

There was a significant difference in earthworm abundance and richness between the sampling methods ($p<0.001$). Hand-sorting was shown to be sufficient for obtaining a good representation of earthworm fauna. There was a strong positive correlation of earthworm abundance and richness with soil moisture ($p<0.001$). This was also reflected by the effect of sampling stage and farming system on abundance and richness. The sampling stages and the farming systems with the highest soil moisture had the highest earthworm abundance and richness. There was no significant difference between the CA systems and the control for both abundance and richness. Lastly, earthworm abundance and richness were also correlated with a few other soil factors, however, this still requires further investigation.

CONCLUSION

Over the short term, i.e. a year, seasonal factors such as the amount of soil moisture, have a much larger influence on the abundance and richness of earthworms, rather than the CA practices. However, long-term monitoring of earthworms in CA is needed to further understand the influence of these practices on earthworm populations.

KEYWORDS: *bio-indicators, conservation agriculture, earthworms, soil health, soil moisture*

DOES PLANTER TYPE HAVE AN EFFECT ON CROP YIELD OF A SANDY SOIL?

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INTRODUCTION

Conservation Agriculture (CA) research has shown merit in the heavier soils of the Swartland. Both tine and disc planters have been used successfully in the production of different crops in the long-term CA trials hosted at Langgewens Research Farm near Moorreesburg. The question was raised by producers if the same success, with both types of planters, will be observed in the sandy soils of the western part of the Swartland production area.

MATERIALS AND METHODS

To test the effect of planter type on crop production in a CA system, both types were included in a new CA trail established in 2018 on the farm Waterboerskraal, near Hopefield. The trial also included a crop rotation of 6 years. Cash crops included canola, lupine and wheat (wheat following canola and wheat following lupine). Fodder crops included a mixed cover crop and oats. The trial layout was a split-plot design with crop as main plot and the two planters as the sub-plots. Three replications of each crop and planter combination were present every year. Data on planter performance across and within each crop was analysed over a 4-year period using SAS software (Version 9.4; SAS Institute Inc, Cary, USA). Fisher's least significant difference (LSD) was calculated at the 5% level to compare treatment means.

RESULTS AND DISCUSSION

There were no significant yield differences overall between the two planter types over the 4-year period (95% confidence level). Only 2019 showed significant differences between the two planter types in lupine and wheat yields. When lupine and wheat followed canola, the tine planter out yielded the disc planter, while when wheat followed lupine, the disc planter out yielded the tine planter.

CONCLUSIONS

Both planters are viable options in sandy soils. Input costs between the two types might be the determining factor that dictates the producer's final choice.

KEYWORDS: *Conservation Agriculture, crop rotation, disc, tine, planter*

CROPPING SYSTEM STABILITY UNDER CONSERVATION AGRICULTURE PRACTICES

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INTRODUCTION

Conservation Agriculture (CA) research has been the foundation of the long-term crop rotation trials at Langgewens Research Farm since 2002. Dryland farming has inherent risks with varying climatic conditions. Annual rainfall is not consistent, although 80% of the annual rainfall occurs between April and October in the Swartland production area. This paper evaluates the performance of the different cropping systems in three rainfall regimes.

MATERIALS AND METHODS

To test the stability of the 8 different systems in wheat yield and gross margin, rainfall data from 2002 to 2021 was taken into account. The annual production season rainfall was used to determine the average over the 20 years. To divide the rainfall into 3 categories, the 25% of years above the average and the 25% below the average were grouped together and represented the average season grouping. The bottom 25% formed the poor rainfall category and the top 25% the excellent category. Average wheat yield and gross margin per system were then analysed per category to determine which system performed best in each and if there are certain systems that are more stable than others, independent of rainfall. Data was analysed using SAS software (Version 9.4; SAS Institute Inc, Cary, USA). Fisher's least significant difference (LSD) was calculated at the 5% level to compare treatment means.

RESULTS AND DISCUSSION

Systems containing pastures were more stable across all rainfall categories than pure cash crop systems. In the high rainfall category cash crop systems were competitive in terms of wheat yield. Gross margins of the crop/pasture systems were in general more stable than the cash crop systems. The contributing factors for this are income from the animal factor and lower input costs across these systems.

CONCLUSIONS

Rain-fed system yields and gross margins will always be under pressure due to the varying climatic conditions from year to year. The introduction of an animal factor, along with legume pastures as part of the cropping system under conservation agriculture production practices can ensure a more stable and resilient cropping system in the Swartland production area.

KEYWORDS: *cropping systems, gross margins, rainfall, yield*

ASSESSING SOIL HEALTH FROM FARMERS' CONSERVATION AGRICULTURE SYSTEMS IN SOUTH AFRICA USING THE BIOFUNCTOOL® INDEX

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INTRODUCTION

A robust interpretation of soil health requires the testing of a mix of chemical, physical, and biological soil factors. Testing the parameters is costly and time-consuming. However, the Biofunctool® (Biological Soil Functioning Assessment Tool) was created to assess total soil health by combining easy-to-measure soil parameters (Thoumazeau et al. 2019). The tool contains a collection of field indicators of three major soil functions, namely; carbon transformation, nutrient cycling, and structural maintenance, providing a holistic analysis of the soil health status. This study reports preliminary findings on the soil health status of conservation agriculture (CA) systems in two unique ecotopes of South Africa using Biofunctool®.

MATERIALS AND METHODS

The study was carried out in selected commercial farms near Ottosdal (North-West Province) and Ladybrand (Free-State Province) during the winter season of 2022. Two CA fields were chosen in each of the two areas as well as two adjacent conventionally tilled and two natural velds to give a total of 12 sampling sites. The parameters tested as a part of the Biofunctool® included carbon transformation (active carbon, lamina bait, soil respiration), nutrient cycling (ion exchange, NO_3^- ,NH_4^+ content), and structural maintenance (aggregate stability, water infiltration, visual assessment of the structure). The data were analysed using linear regression models to test the effects of the site-related factors on the Biofunctool® parameters and multivariate analysis using principal component analysis (PCA).

RESULTS AND DISCUSSION

The data from the first round of sampling showed the effects of crop rotations on aggregated stability, livestock grazing on ion exchange and nitrogen content, and retention of organic residues on nitrogen and active carbon content. The PCA done on Biofunctool parameters across sites show PC 1-5 were significant and explained 91% of the total variation. However, the variables; infiltration and active carbon had meaningful loadings of above 40% in PC1, whereas in PC2 it was the water infiltration and Lamina bait test. This suggests that these factors have the strongest correlations with impacting the quality of the soil's health at both sites. The next step will be to aggregate the indicators into an SQI (soil quality index) with PCA weighting and to establish how each soil function influences the different agricultural practices.

CONCLUSIONS

With the data collected thus far, we can conclude that each indicator provided unique and necessary information to assess soil functioning. This study reports the first application of Biofunctool® in South Africa to assess the impact of different agricultural practices.

ACKNOWLEDGEMENT

We would like to thank the National Research Foundation (NRF) of South Africa (grant number: 129882)

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USAGE OF *MEARUA ANGOLENSIS* EXTRACTS IN THE MANAGEMENT OF *MELOIDOGYNE INCOGNITA* ON CASSAVA PRODUCTION

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INTRODUCTION

South Africa, just like most developing countries, is faced with challenges of achieving sustainable energy and food supplies. Cassava has the potential of meeting both challenges by being a source of bioenergy and food (Itoba-Tombo et al., 2019). In southern Africa, the crop has a minor status, being produced mainly by smallholder farmers until recently. There is scant information on the effects of root-knot nematodes in cassava production. The aim of the study was two-fold, to determine the (i) host-status and susceptibility of two most produced cassava cultivars, 'Mbonisweni' and 'Mganduzweni' to *Meloidogyne incognita*, and (ii) contribution of *Maerua angolensis* extracts in nematode management.

MATERIALS AND METHODS

Crudely milled *M. angolensis* plant extracts were sourced from the Agricultural Research Council, Nelspruit. Experiments were laid out in a randomized complete block design in a greenhouse with five replications. Treatments of experiment (i) were 0, 25, 50, 125, 250, 625, 1250 and 3125 of *Meloidogyne incognita* population levels, whereas experiment (ii) had 0, Nemacur, 184, 368, 736, 1472 and 2944 kg/ha of *M. angolensis* plant extract powder. Two cultivars cv. 'Mbonisweni' and cv. 'Mganduzweni' were sourced from local communal farms, for the purposes of this experiment. Both cultivars were named after the place of origin. Data was collected four months after nematode and plant extract inoculation and application, respectively.

RESULTS AND DISCUSSION

Both cultivars had nematode reproductive-factors and -potential greater than one and no nematode effect was observed on plant growth variables. *Mearua angolensis* had an equivalent effect on *M. incognita* populations as the commercial nematicide, Nemacur. The effectiveness of *M. angolensis* was also reported by Khosa *et al*. (2020), however, inconsistencies are common in the use of plant extracts.

CONCLUSION

'Mbonisweni' and 'Mganduzweni' were tolerant to *M. incognita,* and *M. angolensis* plant extract have potential use as an alternative to commercial nematicides. For future purposes, it will be imperative to investigate the potential of *M. angolensis* on improving plant growth of cassava.

KEY WORDS: *cassava host status, Meloidogyne incognita, Maerua angolensis, nematode susceptibility*

ACKNOWLEDGEMTS

University of Mpumalanga for resources and the National Research Foundation for funding.

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INFLUENCE OF HARVESTING STAGES ON THE LEVEL OF BIOACTIVE COMPOUNDS AND ANTIOXIDANT PROPERTIES OF LEAVES OF FIVE PURPLE-FLESHED SWEET POTATO GENOTYPES

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INTRODUCTION

Sweet potato (*Ipomoea batatas*) leaf consumption is extremely low without a stable competitive market within a leafy vegetable industry. The leaves are edible with a potential to alleviate poverty and reduce hidden hunger in rural communities of developing countries. This is due to their high levels of nutrients. The main objective of the study was to identify a suitable harvesting stage and recommend a genotype for leaf harvesting by evaluating the morphological traits, the level of phenolic constituents and antioxidant properties of leaves of five purple-fleshed genotypes during three different growth stages.

MATERIAL AND METHODS

Sweet potato planting materials were propagated from genotypes Purple-Purple, 08-21p, 2019-11-2, 16-283p and 2019-1-1 at the Agricultural Research Council-Vegetables, Industrial and Medicinal Plants, Roodeplaat. The young leaves were harvested from eight to sixteen weeks after planting at four-week intervals. Harvest 1 (H1), harvest 2 (H2) and harvest (H3) occurred during vegetative, tuber initiation and tuber bulking/maturation stages, respectively. Leaf area index, photosynthetically active radiation, chlorophyll, colour and morphological characterization were measured with each harvest. Leaves samples were then extracted using methanol:water (80:20) and analyzed for total phenolic compounds (TPC), total carotenoids, Ferric reducing antioxidant power (FRAP), 2,2-diphenyl-1-picryl-hydrazyl-hydrate free radical scavenging activity (DPPH) and 2,20-azinobis-(3-ethylbenzothiazoline-6-sulfonate) scavenging activity (ABTS) using a spectrophotometer.

RESULTS AND DISCUSSION

The general trend observed in TPC, FRAP, ABTS and DPPH results was that H2 exhibited the highest values, H1 had the second highest values and H3 had the lowest phenolic constituent and antioxidant activities. Genotypes (Purple-Purple, 2019-11-2 and 2019-1-1) exhibited high total chlorophyll levels at H1, H2 and H3. The total carotenoids were highest at H1 although genotype Purple-Purple and 08-21p also had highest carotenoid in both H1 and H2. At H1, the highest TPC (301.24 Chlorogenic Acid Equivalent mg/g) and total carotenoid (6.75 Beta-carotene mg/g) contents were observed with genotype 2019-11-2 and 16-283P, respectively. During H2, 2019-11-2 and purple-purple showed highest FRAP (50-82-52.38 Trolox Equivalent Antioxidant Capacity mg/g). Genotype 2019-11-2 also had the most potent ABTS (0.18-0.21 IC50 mg/ml) and DPPH (0.73-0.79 IC50 mg/ml) at H1 and H2.

CONLUSIONS

Purple-coloured leaf genotype 2019-11-2 and tuber initiation stage showed high level of bioactive compounds and antioxidant properties. Lack of significant differences between vegetative and tuber initiation stage suggest that leaves of sweet potato could be harvested during both stages. Therefore, there is a need to commercialize these genotypes as a potential leafy vegetable crop.

KEYWORDS: antioxidant properties, bioactive compounds, harvesting stages, morphological characterisation, sweet potato leaves, purple-fleshed genotypes

ACKNOWLEDGEMENTS We would like to thank SARCHI-National Research foundation (Grant no. 98352) and the Agricultural Research Council (ARC-VIMP) for funding this research study.

SYMBIOTIC RELATIONSHIP BETWEEN COMMERCIAL NITROGEN-FIXING BACTERIA AND INDIGENOUS BAMBARA GROUNDNUT (*VIGNA SUBTERRANEA* (L). VERDC.) CULTIVARS

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INTRODUCTION

Bambara groundnut (*Vigna subterranea* (L) is the third most important legume crop in Africa after cowpea and peanuts. Unfortunately, the yield of Bambara groundnut is declining gradually due to poor soil fertility and limited numbers of symbiotic natural microbes in communal farming soils. Commercial nitrogen fertilizers are unaffordable and generally unavailable to resource-poor communal farmers. The use of commercial symbiotic bacteria to improve yield could be cost-effective, easier, and environment-friendly (Cook, 2017). Hence, the objective of the study was to determine the efficiency of commercial nitrogen fixing bacteria *Bradyrhizobium japonicum* and *Rhizobium* species on Bambara groundnut growth, and nodulation under greenhouse conditions.

MATERIAL AND METHODS

Treatments were arranged in 5 x 3 factorial arrangement fitted into a randomised complete block design with five replicates. Soils used were steam pasteurised to kill all native symbiotes. Five bacterial strains (*Bradyrhizobium japonicum, Rhizobium loti, Rhizobium meliloti, Rhizobium leguminosarum*) biovar phaseoli were separately inoculated on three Bambara groundnut varieties (Black, Creamy white-eye and Red). Unpasteurised soils were used as a source of a local natural bacterial strain. Plant growth and nodulation variables were taken at 110 days after sowing.

RESULT AND DISCUSSION

The results revealed that the interaction between cultivars and bacterial inoculums was not statistically significant. However, bacteria treatments had highly significant effects on the number of leaves, fresh shoot mass, and dry shoot mass, contributing 43, 48, and 47% to the total treatment variable (TTV). Bambara groundnuts inoculated with *Bradyrhizobium japonicum* had the best nitrogen fixing efficiency. The bacteria in untreated soil outperformed commercial inoculum strains on number of leaves, stem diameter, fresh shoot mass, dry shoot mass and fresh root mass on the growth variable. There were also general differences in variety performance, with Black cultivar having the highest number of pods, pod mass, and chlorophyll content, whereas the Cream white-eye cultivar had the highest number of leaves and length of the longest runner.

CONCLUSION

There is variation in the response of the different cultivars of the Bambara groundnuts to the different treatment of the rhizobia strains because different landraces of Bambara groundnut respond differently to various bacteria species. Since bacteria in untreated soil outperformed the commercial inoculum in active nodulation, the identification of this bacteria is recommended for future study. For improved soil status in intercropping systems, *B. japonicum* can be used as inoculum, while if yield of the plant is intended then a natural strain in soils need to be isolated, identified and used.

KEYWORDS: *natural rhizobium strain, nitrogen fixing bacteria, soil fertility, soil nutrition, symbiosis*

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WEED FLORA SURVEY IN A MEDITERRANEAN ENVIRONMENT UNDER DIFFERENT COVER CROPPING SYSTEMS

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INTRODUCTION

There is limited knowledge on the direct and interactive effects of cover crop species at the research farms of Langgewens and Tygerhoek. Although comprehensive listings of Western Cape weeds are available, weed community composition has never been quantified for Langgewens and Tygerhoek. This will be useful in selecting better control procedures and transforming the current flawed paradigm of conventional agriculture. The main objective of this annual study was to rank the most important weed species in cover cropping systems and to determine their frequency, density and uniformity.

MATERIALS AND METHODS

The weed flora survey was conducted in 2019 at two Departmental Reasearch Farms namely, Langgewens (-33.279171, 18.715005) near Mooreesburg and Tygerhoek (-34.16238, 19.90739) near Riviersonderend in the Western Cape Province of South Africa. The layout of the experiments was arranged in a randomised block design, with 11 treatments that included wheat, white mustard, lupine, rye, serradella, Saia oats and vetch planted as pure crop stands. In addition, the following crop combinations were planted: white mustard + lupine, rye + serradella and Saia oats + vetch. The control was an untreated plot of similar dimensions that allowed for natural weed germination. Weed emergence and infestation from the existing weed seed bank were assessed in all treatments in one 0,25 m² quadrat (0,5 m x 0,5 m fixed metal frame) in each plot at 4, 8, 12, and 16 weeks after planting. Frequency, uniformity and relative abundance were used to determine the weed community structure.

RESULTS AND DISCUSSIONS

Ryegrass (*Lolium multiflorum* x *L. perenne*) was the most dominating weed species at both survey localities throughout the growing season. Weed control was more effective at Langgewens than at Tygerhoek. The cover crop combinations performed better at weed suppression than single swards. The present weed survey cannot be assumed to be extensive or complete, but the study was meant to analyse the variation of weed frequency, uniformity, abundance and the identified species obtained represent a sufficient sample size to obtain basic information on current weed problems in the Western Cape cropping systems.

CONCLUSIONS

Priority species, ryegrass, prostrate knotweed (*Polygonum aviculare*) and chickweed (*Stellaria media*), which have started increasing over the past few years are now known and a base for future weed surveys has been established. Results may help guide future research priorities for weed management in cover cropping systems. Using cover crops to reduce production costs by reducing herbicide applications, fertiliser inputs and the running costs of machinery may be seen as a future objective.

KEYWORDS: abundance, community composition, species richness

ACKNOWLEDGEMENTS

Western Cape Department of Agriculture for funding and supplying the land and technical support to conduct this research.

EFFECT OF CONSERVATION TILLAGE OF POTATO ON LEVELS OF SOIL ORGANIC CARBON IN THE SANDVELD

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INTRODUCTION

Tillage plays a major role in modification of soil structure as it influences the distribution of energy rich organic matter within the soil profile and thus impacts on the energy flow and the dynamics of soil geo-chemical functions. The aim of this study was to investigate the effect of conservation tillage on the levels of soil organic carbon in a potato production system.

MATERIALS AND METHODS

The trial was conducted in Aurora, South Africa, in the Sandveld region under a centre pivot from 2013 to 2021 with a planting of once in 4 years. The trial layout was a randomised complete block design. The effect of three tillage treatments on soil carbon levels were investigated and consisted of a conventional tillage treatment with a mouldboard plough to a depth of 350 mm combined with a 600 mm deep rip treatment between planting rows, a conservation rip treatment to a depth of 600 mm in and between planting rows and a conservation paraplough treatment over two planting rows to a depth of 600 mm. The Walkley-Black method to determine soil carbon was utilised, this method involves oxidation of organic matter by potassium dichromate ($K_2Cr_2O_7$) with sulfuric acid (H_2SO_4) to heat the dilution and potentiometric titration.

RESULTS AND DISCUSSION

The first year of the cycle, 2013, resulted in no significant differences in carbon levels between the paraplough and rip treatments, but both were significantly higher than the levels found in the mouldboard treatment. The rip treatment produced carbon levels which were significantly higher than the mouldboard and paraplough treatments in the last two cycles of the crop rotation, with 0.39% C and 0.40% C respectively for 2017 and 2021. The increase in carbon percentage from 2013 to 2021 was 40% (0.32% C), 102% (0.40% C) and 130% (0.31% C) for the paraplough, rip and mouldboard tillage treatments, respectively. The yield rose by 65%, 66% and 66% for the paraplough, rip and mouldboard treatments, respectively, from 2017 to 2021. The 2021 yields were 69.52 t/ha, 70.28 t/ha and 73.6 t/ha for the paraplough, rip and mouldboard treatments. The rip treatment led to a soil carbon level of 0.4%, which was significantly higher than the paraplough and mouldboard treatments and plays a pivotal role in the choice of a tillage method.

CONCLUSION

The higher soil organic carbon levels achieved by the rip treatment in the soil not only promote a more productive soil with higher biological activity but also provide resilience to extreme weather conditions.

KEYWORDS: *conservation tillage, paraplough, rip, soil carbon*

EVALUATION OF MEDIUM-DURATION GROWTH GROUNDNUT VARIETIES IN MPUMALANGA PROVINCE

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INTRODUCTION

Today, groundnut (*Arachis hypogaea L.*) is one of the most important legumes grown in South Africa and a major crop grown by smallholder farmers in Mpumalanga. The plant is grown mainly for human consumption, the economic part being the kernel, which is either consumed or its oil extracted for culinary purposes (Weiss 2000). Groundnut is a major source of edible oil and vegetable protein in South Africa (Holbrook and Stalker, 2003). The best soil for groundnut production is well-drained, light textured sandy or sandy loam that facilitates easy penetration of pegs and pod development.

MATERIALS AND METHODS

Field experiments were conducted during the 2021 – 2022 cropping season at Roodepoortjie 25° 27' 9''S, 28° 52' 36"E) and the University of Mpumalanga Farm (25°25' 30''S, 30° 58' 14"E). Ten varieties were statistically laid out in a randomized complete block design (RCBD) with 3 replications of 9 metres long and 2 rows per plot in both locations. An inter-row spacing of 70 cm and intra-row spacing of 10 cm were used and seeds were placed at a depth of 5-7 cm. The observations were stand establishment, hundred seed mass, shelling percentage and grain yield. The data collected were subjected to analysis of variance (ANOVA) and means separated using Tukey's Honestly Significant Different (Tukey HSD) test with the Statistix 10.0 software package.

RESULTS AND DISCUSSION

Different variety yield results were obtained from Roodepoortjie and Nelspruit, although similar varieties were planted at both locations. The four highest grain yielding varieties at Roodepoortjie were Anel (3417kg/ha), PC 481-k3 (3013 kg/ha), PC480-k14 (2950 kg/ha) and Kwarts (2752 kg/ha). At Nelspruit the four highest grain yielding varieties were Kwarts (557 kg/ha), Akwa (431 kg/ha), Anel (410 kg/ha) and Akwaplus (406 kg/ha). Furthermore, at Roodepoortjie the highest shelling percentage was recorded for variety Kwarts (80%) and the lowest for variety GP 023 with 68%. However at Nelspruit the highest shelling percentage was recorded for variety PC 480-k14 (69%) and the lowest for variety Kwarts (60%).

CONCLUSIONS

The outstanding varieties were selected based on their grain yield and other parameters such as days to maturity, number of seeds pod^{-1} and shelling %. These selected outstanding varieties will be introduced to the smallholder farmers in Mpumalanga Province.

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AN OPEN-ACCESS WEB PORTAL TO SUPPORT MONITORING AND DECISION-MAKING IN CROP MANAGEMENT USING SATELLITE IMAGERY INDICES

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INTRODUCTION

Recent years have seen rapid developments in the online accessibility of free satellite imagery that can support research and decision-making in crop management. This poster discusses an open-data portal approach to facilitating simplified access to, and interaction with such data in the cloud.

MATERIALS AND METHODS

The *Sentinel-2 Viewer App* (https://gis.elsenburg.com/apps/s2v/) was developed in-house by the Western Cape Department of Agriculture's (WCDoA's) GIS Unit, to provide customised functionality to support field-scale monitoring and analysis, based mainly on the Sentinel-2 imagery provided by the European Space Agency, via the Sentinel Hub. A number of popular pre-defined vegetation and soil/moisture indices have been built-in, such as the well-known Normalised Difference Vegetation Index (NDVI). The application is accessible without cost, or even login required.

RESULTS AND DISCUSSION

The intention was to make the interface as unintimidating as possible, such that the user can extract field information with the minimum number of "clicks". The design exploits cloud-based computation, removing much of the inherent complexity and "big data" management demands of conventional remote sensing workflows. Feature Information Services (FIS) are implemented via an Application Programming Interface (API) to perform statistical computations on the satellite data over specified time ranges, upon specified wavebands of the respective satellite images. Processed products, such as the True Colour imagery, and potentially useful vegetation indices such NDVI, Enhanced Vegetation Index (EVI) and many others can be selected. User requests facilitate display (mapping), provide pixel or zonal values, or perform statistical analysis within or between any seasonally relevant images available since the commencement of the respective data time series of the particular satellite. The field boundary dataset for the Western Cape (WCDoA's research mandate is provincial) is built-in, facilitating the ability to easily select and interrogate fields. The user can analyse a field or defined area, monitor it in near real-time and compare seasonal phenology in graph or mapped form. Cloud cover – always a potential issue in optical remote sensing – can be filtered to user specifications.

CONCLUSIONS

Although still in the beta development stage, the application has already attracted a number of more technically orientated users. Exposing this free application to producers should help them to discern true value prospects amongst the many commercial offerings exploiting this relatively untapped market. Such tools, being at the producers' fingertips, have the potential to radically streamline the information feedback loops between crop monitoring and producer response.

KEYWORDS: *crop monitoring, remote sensing, satellite imagery, vegetation indices*

ACKNOWLEDGEMENTS

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RESPONSES OF MAIZE INBRED LINES TO COMBINED EFFECTS OF HIGH TEMPERATURE AND ALUMINUM TOXICITY

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important staple food crops in developing countries, including South Africa. It is projected that by 2050, maize demand will double in developing countries (Ray et al., 2013; Huang et al., 2019). However, its production is highly sensitive to environmental changes. High temperature and Aluminum (Al) toxicity are some of the factors that induce major alterations in maize growth and development. Investigating the interactive effects of these factors will therefore generate information that will be useful for future maize production. The objectives of the study were to (i) evaluate the changes in vegetative traits in maize inbred lines to high temperature x Al toxicity interaction (ii) to identify stress tolerant genotypes. We hypothesized that high temperature does not ameliorate Al stress.

MATERIALS AND METHODS

Six inbred lines (CML486, IBL4, IBL9, QSW13, QSW16, QSY18) with known Al tolerance were grown in growth chambers under 2 levels of temperature (25 ºC and 40 ºC) and 2 levels of Al toxicity (0 and 24 mg kg^{-1} Al_2 $[SO4]_3$). The experiment was laid out in a 2 x 2 x 6 factorial design with three replications, consisting of 10 plants per replicate. Seven growth parameters were evaluated at seedling stage. Tolerance stress response index was used to classify genotypes. Analysis of variance was performed, and significantly different means were separated by the Tukey test at 5% probability.

RESULTS AND DISCUSSION

The results showed that high temperature compensates for the negative effects of Al toxicity in maize, though this may be genotype dependent. This is attributed to the higher pH, which helps immobilize metal toxins within the soil (Guoju et al., 2012, Onwuka, 2018). It is reported that with increase in temperature, Al hydrolysis is raised, and thus, the solubility of Al^{3+} is reduced (Fritioff et al., 2005). The results also suggested that genotypes that are presently susceptible to Al toxicity (QSY18, QSW13, QSW16) may thrive in future climates involving high temperature x Al toxicity. On the contrary, genotypes that are presently tolerant to Al toxicity such as CML486 and IBL4 may not necessarily uphold their tolerance in future climates where temperature is expected to increase.

CONCLUSION

Genotypic variations among the inbred lines grown at high temperature alone or in combination with Al toxicity were observed. It was concluded that high temperature ameliorates the detrimental effects of Al toxicity in maize inbred lines.

KEY WORDS: *Aluminum toxicity, elevated temperature, genotype, inbred lines*

ACKNOWLEDGEMENTS

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HORTICULTUR

POSTER ABSTRACTS

In alphabetical order

EVALUATION OF THE RESIDUAL EFFECT OF BIOSLURRY EFFLUENT ON BIOLOGICAL YIELD AND NUTRITIONAL CONTENT OF SWISS CHARD (*BETA VULGARIS* L.)

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INTRODUCTION

Poor soil fertility and inadequate supply of plant nutrients are the main constraints to crop production in the agricultural systems. However, chemical fertilizers are not the most appropriate solution to overcome these constraints, especially for vegetables like Swiss chard that have a short growing period and is consumed fresh. Chemical fertilizers are expensive and damaging to the environment. Hence, the emphasis on finding alternatives to chemical fertilizers such as use of bioslurry, which is cheaper than other sources of nutrients and relatively safe for the environment.

MATERIAL AND METHODS

An experiment was conducted to evaluate the residual effect of inorganic fertilizer and bioslurry application on biological yield and nutrient content of Swiss chard. The study was conducted at Döhne Agricultural Development Institute (DADI) (32°31' 34.077" S; 27°27' 37.473" E) in Stutterheim, Eastern Cape, South Africa. Following planting and harvesting of two Swiss chard cultivars ('Fordhook Giant' and 'Star 1801') in soil incorporated with 10 L Bioslurry (50% Bio), 20 L Bioslurry (100% Bio) and 40 L Bioslurry (200% Bio), NPK 2:3:4 (30) and 0 application (control), Swiss chard was planted in the same plots without any fertilizer applications. One seedling was planted per hill and the intra- and inter-row spacing was 0.25 and 0.5 m, respectively.

RESULTS AND DISCUSSION

The postharvest soil analysis showed that plots that were previously treated with 40 L (200%) Bioslurry had relatively higher soil nutrient elements compared with other treatments. The interactive effect of residual fertilizer and cultivar showed that the plots previously treated with NPK 2:3:2 (30) resulted in significantly higher dry leaf mass in 'Star 1801' but this effect did not differ significantly with 20 L (100%) and 40 L (200%) Bioslurry in 'Fordhook Giant'. The effect on soil pH revealed that the application of fertilizers resulted in reduced pH levels in summer compared with winter, irrespective of the treatment. The plant mineral analysis showed that the fertilizer residues did not significantly influence plant mineral uptake and no clear trends were observed for the tested elements.

CONCLUSION

The competitive residual effect of 40 L (200%) Bioslurry in comparison with NPK 2:3:2 (30) for DLM in the cultivar x fertilizer interaction suggested that bioslurry applied at higher rates could have a long lasting but positive effect on plant growth and thus could be used as an alternative under conditions where expensive inorganic fertilizers are limited.

KEY WORDS: *biological yield, bioslurry, Fordhook giant, residual effect, Star 1801*

EFFECT OF HARVEST SEASON ON PHENOLIC CONTENT AND SENSORY QUALITY OF *CYCLOPIA GENISTOIDES* (HONEYBUSH TEA)

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INTRODUCTION

Seasonal changes affect the production of crops by altering their physiological and biochemical responses. Cultivation of selected *Cyclopia* species, such as *C. genistoides,* takes place under agro-climatic conditions characterised by distinct dry summers followed by wet winters. Currently, there is limited knowledge about the best honeybush production and harvesting practices for producing good quality honeybush tea. Therefore, determining the effect of harvest season on the production of phenolic compounds and the sensory profile of honeybush tea will assist in determining the optimum harvest time. Phenolic and sensory profiles are second-tier criteria for selecting honeybush plant material for breeding.

MATERIALS AND METHODS

The samples were harvested during the four seasons (summer, autumn, winter and spring) from six genotypes (GG53, GG31, GT1, GK1, GK3 and GK7), originally selected based on biomass yield. The plant material was processed, including “fermented”, and a hot water infusion of the “tea bag fraction” subjected to sensory analysis entailing descriptive sensory analysis. Standardised protocols were followed for processing and sensory analysis. The data were analysed using univariate and multivariate statistical procedures. The phenolic content of the leaves (unprocessed) was determined by HPLC-DAD and analysed using ANOVA.

RESULTS AND DISCUSSION

Summer produced leaves had higher levels of mangiferin and isomangiferin than winter produced leaves ($P < 0.05$), but not autumn and spring ($P \geq 0.05$). Despite moderate correlation of the mangiferin and isomangiferin content of the infusions with bitter intensity ($R = 0.636$ and $R = 0.637$ respectively, $P < 0.05$), the summer and autumn harvests produced herbal tea less bitter than the winter and spring harvests ($P < 0.05$), indicating the possible modulating role of other polyphenols. The autumn harvest delivered herbal tea with a better overall aroma profile, notably higher intensities of the characteristic honeybush aroma notes, ‘fynbos-floral’, ‘fynbos-sweet’ and ‘fruity-sweet’, than the other seasons ($P < 0.05$).

CONCLUSION

The practical significance of the variation in the phenolic composition and sensory quality of the herbal tea caused by harvest season was limited. Summer or autumn harvesting is recommended, achieving high levels of phenolic constituents without detriment to the sensory quality of the herbal tea product.

KEYWORDS: *Cyclopia, honeybush, phenolic compounds, seasonal variation, sensory analysis*

RESISTANCE TO *MELOIDOGYNE ENTEROLOBII*, *M. INCONGITA* AND *M. JAVANICA* IN LEMON BALM (*MELISSA OFFICINALIS*)

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INTRODUCTION

Lemon Balm (*Melissa officinalis)* is an important medicinal plant, which produces essential oil, and used for antiviral and antibacterial suppression. Root-knot (*Meloidogyne* species) nematodes negatively impact most introduced plants. Chemical nematode management strategies are successful in various cropping systems. However, the products had been withdrawn from the agrochemical markets due to environmental concerns. Since the international pressure on the withdrawal of chemicals from the agrochemical markets, the use of plant resistance to manage nematode population densities had been in the forefront. Therefore, the importance of assessing the degree of nematode resistance is required. The study aims to determine the degree of nematode resistance in lemon balm to tropical *Meloidogyne* species.

METHODOLOGY

Three separate trials for *M. enterolobii* (Trial 1), *M. incognita* (Trial 2) and *M. javanica* (Trial 3) were conducted under greenhouse conditions. In the trials, the plants were inoculated at 0; 100; 150; 300; 625; 3125 and 6 250 eggs and second-stage juveniles (J2) of each nematode species. At 56 days after inoculation, data on plant and nematode aspects were collected and subjected to ANOVA using Statistix 10.0 software. Turkey's test achieved mean separation for significant ($P \leq 0.05$) treatments.

RESULTS AND DISCUSSION

Results showed that the three nematodes, reproductive values (RF) were greater, than one except at the highest inoculation level of 6 250 eggs + J2. At all levels of inoculation, nematode infection did not induce damage to lemon balm. In all three trials, plant variables were not affected by nematode infection.

CONCLUSION

Inoculation of lemon balm by *M. enterolobii*, *M. incognita* and *M. javanica* did not have any significant effects on plant variables and RF values were above unity except at the highest inoculation level. The crop was, therefore, a tolerant host to three tests *Meloidogyn*e species.

KEYWORDS: *host-sensitivity, host-status, nematode resistance, reproductive factor.*

ACKNOWLEDGEMENTS

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VEGETATIVE PROPAGATION OF AFRICAN GINGER THROUGH RHIZOME CUTTINGS

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INTRODUCTION

Traditionally, African ginger (*Siphonochilus aethiopicus* (Schweinf.) B.L. Burtt) is propagated vegetatively using whole rhizomes and via plant tissue culture techniques. However, the same rhizome used as planting material is harvested for traditional medicine and product development. Increased demand, exacerbated by the beneficial effect of treating Covid-19 among others, has led to increased harvesting with less propagules available for planting. The main objective of this study therefore was to investigate propagating African ginger by using smaller pieces through rhizome cutting.

MATERIALS AND METHODS

A glasshouse experiment spanning two growing seasons (2019/20 - 2020/21) was conducted at the Agricultural Research Council – Vegetables, Industrial and Medicinal Plants (ARC-VIMP). During spring, immediately after senescence. Medium-sized rhizomes (weighing approximately 40 g) were collected from the ARC-VIMP medicinal plant genebank. In this trial, each rhizome was cut into 12, 8, 4 and 2 pieces, including a control where the rhizome was not cut. The trial was laid out in a randomized complete block design. Rhizome pieces were planted in 5L pots containing potting soil as the growing medium. Growth parameters, which included number of leaves and shoots, plant height and chlorophyll content, were recorded monthly. Rhizome multiplication rate, rhizome and root weight were assessed as part of the yield characteristics. All data were subjected to analysis of variance using GenStat software.

RESULTS AND DISCUSSION

A considerable increase in the number of shoots and leaves was observed in the 12, 8 and 4 pieces compared to the whole rhizomes and 2 pieces. Moreover, although high rhizome and root yield was recorded in the whole rhizomes, followed by 2 pieces, the number of daughter rhizomes was higher in the 8 and 12 pieces. Rhizome buds recorded the lowest number of shoots and leaves, however their use as propagation material can be economically viable due to their ability to produce multiple shoots, roots and daughter rhizomes. In general, the number of shoots and leaves amongst all rhizome cuttings increased with an increase in rhizome pieces.

CONCLUSIONS

The results from this study showed the potential to propagate African ginger using rhizome pieces, which resulted in higher number of shoots, leaves and rhizomes when they were cut into 12 and 8 pieces. Propagation of African ginger through rhizome pieces might contribute to the efficient use of planting material needed with a smaller number of rhizomes required as propagation material.

KEYWORDS: *growth, propagation technique, Siphonochilus aethiopicus, yield*

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HOST STATUS OF ARC-VIMP COWPEA CULTIVARS TO *MELOIDOGYNE ENTEROLOBII*, *MELOIDOGYNE JAVANICA* AND *MELOIDOGYNE INCOGNITA*

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INTRODUCTION

All potato-producing regions of South Africa have high population densities of *Meloidogyne enterolobii, M. incognita* and *M. javanica*. Currently there is no genotype among the economically cultivated potato cultivars with resistance to *Meloidogyne* species. Cowpea cultivars, due to their status as low-input crops, are ideal for use in crop rotations intended to manage nematode population densities in fields, where potato is the main cash crop. The objective of the study was to determine the host status of 10 cowpea cultivars to *M. enterolobii, M. incognita* and *M. javanica* under greenhouse conditions using reproductive potential (RP = nematodes/g fresh root).

MATERIALS AND METHODS

Three trials were conducted in 20-cm diameter plastic pots containing suitable steam-pasteurised loam soil. The treatments, namely, ′C09-VOP′, ′C04-VOP′, ′C07-VOP′, ′C06-VOP′, ′C03-VOP′, ′C02-VOP′, ′C01-VOP′, ′C05-VOP′, ′C08-VOP′, ′C10-VOP′ were arranged in randomized complete block design, with 6 replications. Tomato cv. 'Floradade' was used as a susceptible standard in each replicate. Two seeds were sown directly per pot. Inoculum was prepared by extracting eggs and J2 of each nematode species from roots of nematode susceptible tomato cv. ′Floradade′. Each cultivar was inoculated by dispensing approximately 250 eggs and juveniles. At 56 days after inoculation, nematode eggs and juveniles were collected from roots using the sugar-floatation and centrifugation method and expressed as RP and subjected to analysis of variance.

RESULTS AND DISCUSSION

In each root-knot nematode trial, cultivar effects on RP values were not significant. In all cowpea cultivars RP values were higher than one, which suggested that the cultivars were host to all three *Meloidogyne* species.

CONCLUSION

All test cowpea cultivars were host to the three *Meloidogyne* species and should not be used in crop rotations intended to manage population densities of *Meloidogyne* species.

KEYWORDS: *cowpea cultivars, Meloidogyne species, reproductive potential (RP)*

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MARULA SEED PERFORMANCE IN RESPONSE TO IMBIBITION AND FERTILISERS

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INTRODUCTION

Marula plays an important role in diet, tradition, and culture of many people however, challenges on pre-treatment and germination of marula seed often yielded poor results. The objectives of the study were to determine seed germination after different imbibition temperature treatments and to investigate the effect of different fertilizers on the performance of marula seedlings at Makonde Village.

MATERIALS AND METHODS

Marula seeds collected at Makonde Village were placed at room temperature for 18 months. The opercula were removed as pre-requisite for high germination of the seeds (Moyo et al. 2009). For the imbibition experiment seeds were soaked for 48 h in 75 ml distilled water at four respective temperatures (25°C, 50°C, 75°C & 90°C). Seeds were weighed hourly and data on seed mass was recorded. Seeds were incubated on moistened cotton wool in growth chambers. The seeds that showed radicle protrusions after germination period were planted in pots and kept in the nursery. The performance experiment was conducted in a nursery as a RCBD replicated 4 times with seeds planted in 30 x 30 cm pots filled with 2 kg sandy loam soil and fertilizer rates of 3g kg^{-1} of kraal manure, 3g kg^{-1} of compost and 2g kg^{-1} of 3: 2:1 (28) granules per treatment. Control pots did not receive fertilizer. Irrigation and weeding were done when necessary. Data was taken on plant height and leaf number per seedling daily for twenty-one days. All data were analyzed using an ANOVA.

RESULTS AND DISCUSSIONS

Imbibition caused an increase of 49% in seed mass with rapid imbibition rate observed during the fifth and sixth hours of the 48h period. The general pattern of water absorption at all temperatures was observed which attributed to opercula removed seed with rapid water uptake rate for 8 hours which slowed down thereafter (Moyo et al. 2009). Results showed that imbibition was slower at 25°C which was attributed to increased water viscosity at lower temperatures and to temperature effect on plant membranes. Kraal manure fertilized seedlings were the tallest with many leaves per seedling while compost yielded shortest seedlings with fewer leaves.

CONCLUSIONS

It was concluded that seed imbibition are useful for marula seed germination as shown by radicle protrusion and seedling development.

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KEYWORDS: *Imbibition, fertilizers, kraal manure, marula*

SIMULATING MORINGA PRODUCTIVITY UNDER IN-SITU RAINWATER HARVESTING SYSTEM USING AQUACROP MODELLING IN A SEMI-ARID AREA

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INTRODUCTION

Rainfed agriculture is severely impacted by the effects of climate change, which results in considerable depletion of limited soil water resources, thus very often resulting in poor crop productivity. Moringa offers great potential to be cultivated under rainfed conditions, as it is capable of surviving dry seasons and prolonged dry spells mainly due to its long tuberous taproot. However, research studies have shown that the productivity of Moringa can be improved with increased soil water availability, particularly during its critical reproductive phases such as pollination, fruit set, and pod formation. This can be achieved through the implementation of in-situ rainwater harvesting (IRWH) and conservation practices. Another means of developing good strategies to improve crop productivity under water-limited conditions is through crop modelling.

MATERIALS AND METHODS

This study parameterized the AquaCrop model to predict Moringa production under the in-situ rainwater harvesting system implemented with and without mulching in the semi-arid region of Roodeplaat, Pretoria, during the 2021/2022 growing season. Model parameterization took into account site-specific weather data, crop characteristics and management (growing period, initial canopy cover, planting density), soil fertility and water conservation status, as well as soil profile characteristics. The performance of the model to predict fresh leaf yield and crop water productivity was evaluated with Pearson correlation coefficient (r), model efficiency coefficient (EF) and Willmott index of agreement (d).

RESULTS AND DISCUSSION

A relatively good model performance was obtained with r (0.71 – 0.76), EF (81 – 85%) and d (0.76 – 0.79) for IRWH with and without mulching application. This proved that AquaCrop model was robust enough to predict fresh leaf yield and crop water productivity of Moringa.

CONCLUSIONS

AquaCrop is a promising crop model to be used as a decision-making tool for researchers and farmers in terms of crop water supply associated with the implementation of the IRWH system in Moringa dryland farming.

KEYWORDS: *decision-making tool, model parameterization, mulching, rainfed*

MULTIVARIATE PRINCIPAL COMPONENT ANALYSIS OF PHYSIOLOGICAL AND MINERLA COMPOSITION OF ROSE GERANIUM (*PELARGONIUM GRAVEOLENS* L.) AFFECTED BY CALCIUM TO MAGNESIUM RATION AND STATIC MAGNETIC FIELD

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INTRODUCTION

Increasing global demand for originally produced South African rose geranium calls for increased cultivation of rose geranium to meet the growing demand. However, these demands are difficult to meet due to inconsistent climatic conditions and agronomic practice. Growers mitigate the effects of poor growing conditions by use of static magnetic field (SMF) in conjunction with nutrient regime. These modifications affect plant vigor and nutrient use efficiency. Therefore, the aim of this study was to explore the relationship between mineral utilization in the stem and leaves of rose geranium fertigated with calcium to magnesium ratio exposed to a SMF, using multivariate principle component analysis (PCA).

MATERIAL AND METHODS

The experiment was conducted out at Glen College of Agriculture, Mangaung Municipality, Free State Province. Calcium to magnesium ratio was administered hydroponically at three level (6.30.2.40, 4.31:4.39, and 2.32:6.38 meq·L^{-1}) using Steiner's universal nutrient solution, exposed to two levels of SMF (0mT and 110 mT per plant). Each treatment was replicated three times in a randomized complete block design. Micronutrient were supplied in the following concentrations 6.54 g Fe, 1.89 g B, 0.13 Mo, 1.16 g Zn, and 2.11 g Mn per 1000 L of water. A pH level of 5.5 was maintained by adding 79 ml of nitric acid to 1000 L of water.

RESULTS AND DISCUSSION

Multivariate analysis was used to identify the most significant descriptors in capturing the agronomic attributes and mineral composition in the leaves and stems of rose geranium. Amongst the observed variables, only two principal components accounted for most of the variability. The first principal component (PC1) accounted for 27.23%, while the second principal component (PC2) accounted for 23.78% of the total variance. Significant positive effects of 4.31:4.39 and 2:32:6.38 meq·L^{-1} together with SMF 110 mT were observed on the agronomic attributes. Nitrogen, boron and iron positively accumulated in the stem at 4.31:4.39 meq·L^{-1} exposed to SMF 110 mT. Phosphorus, calcium and zinc were the only mineral affected in the leaves by 4.31:4.39 meq·L-1 together with SMF 110 mT.

CONCLUSIONS

Calcium to magnesium ratios applied at 4.31:4.39 and 2.32:6.38 meq·L^{-1} together with SMF 110 mT is recommended when growing rose geranium using a nutrient solution to improve rose geranium agronomic attributes, mineral accumulation and translocation.

KEYWORDS: *principal component, static magnetic field*

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MACADAMIA ROOTSTOCKS – COMPATIBILITY WITH NEW SCION CULTIVARS

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INTRODUCTION

The South African macadamia industry uses rooted 'Beaumont' cuttings, 'Beaumont' seedlings and 'Nelmak 2' seedlings as rootstocks. None of these are incompatible with any of the major scion cultivars used in the industry. New scion cultivars were recently imported for cultivar trials and for some of these, graft take in the nursery was poor, scion growth was weak and there were significant losses of newly planted trees. In those trials, only 'Beaumont' cuttings were used as rootstocks, to ensure rootstock uniformity. As part of the preparation process for a new round of cultivar trials, the new scions were grafted to multiple rootstock types and the resulting plants were assessed in the nursery to determine whether compatibility between rootstock and scion was of concern.

MATERIALS AND METHODS

Three control scions common to all the cultivar trials were used, namely 'Beaumont', '816' and 'A4'. In addition, a further 18 scion cultivars were used, namely 'A16', 'A38', 'A203', 'A268', '856', '863', '887', '1/40B', '2/18 Mc', '2/5 Mc', '4/44 Mc, '4/7 Mc', 'Nelmak 2', 'TS108', 'TS110', 'TS111', 'TS112' and 'TS113'. All scions were grafted to both 'Beaumont' cuttings and 'Nelmak 2' seedlings. The three control scions were also grafted to 'Beaumont' seedlings. Four months after grafting the graft take, scion flush length and leaf chlorophyll were measured. The graft union was examined for a selection of failed plants to determine visible defects in the union that may have caused the failure. A selection of healthy trees were excised below the graft union and the union was examined after infiltration with Safranin O dye. Above and below ground biomass was determined for these healthy trees, and the roots were examined.

RESULTS AND DISCUSSION

For all rootstock-scion combinations, clonal 'Beaumont' cuttings resulted in the highest graft take and scion vigour, even for cultivars which had experienced high tree losses in previous rounds of grafting. Surprisingly, the lowest graft take was of 'Nelmak 2' scions on 'Nelmak 2' seedlings. 'Beaumont' seedlings outperformed 'Nelmak 2' seedlings. Most failed plants had little callus formation on the scion, indicating a lack of vigour in the graftwood. Very few root deformities were observed. The most obvious difference between this experiment and previous grafting rounds were planting medium and nursery bag size.

CONCLUSIONS

There was no obvious issue with rootstock-scion compatibility in the nursery. Rather, nursery practices may play the largest role in graft success for macadamia.

KEYWORDS: *compatibility, graft, macadamia, nursery, rootstock, scion*

ACKNOWLEDEGEMENTS

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EFFECT OF GROWTH MEDIA ON ROOTING AND DEVELOPMENT OF LEMON BALM (*MELISSA OFFICINALIS* L.) STEM CUTTINGS

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INTRODUCTION

Melissa officinalis L., commonly known as lemon balm, is an economically important aromatic and medicinal plant that has generated interest among growers for its industrial value. Optimizing its propagation protocol is an important step in the production of this crop to meet its growing demand (Ambebe et al., 2018). This study evaluated the effect of growth media and stem cutting position on lemon balm rooting, physiological, and morphological growth.

MATERIALS AND METHODS

The vegetative propagation trial was conducted at the Agricultural Research Council (ARC) – Vegetable, Industrial and Medicinal Plants under controlled glasshouse conditions. A completely randomized design (CRD) was used with three replications and 100 cuttings (apical and basal) as an experimental unit. Treatments included five growth media comprising of river sand, hygromix, cocopeat, germination mix (vermiculite and compost mixture; 1:1 v/v) and a combination of cocopeat and hygromix (1:1 v/v). Data collected included the number of roots, length of root per cutting, rooting frequency, shoot number and shoot length. Data were subjected to analysis of variance using the GenStat® statistical package. The cost-benefit analysis was calculated by considering the costs associated with filling one cavity of a seedling tray with the selected growth media.

RESULTS AND DISCUSSION

The highest rooting percentage was recorded in cocopeat, and the least was in river sand, followed by hygromix. The highest mean number of roots (3.1) and length of rooting per cutting (3.1 cm), were recorded for basal cuttings planted in cocopeat after 2 weeks. On the other hand, apical cuttings planted in germination mix growth medium gave the highest number of shoots (1.3) and shoot length (2.8 cm). However, the cost-benefit analysis revealed that cocopeat would be more costly than germination mix when aiming to produce a large number of cuttings, such as 25000 plants/ha.

CONCLUSIONS

Mass multiplication of lemon balm stem cuttings is dependent on the cutting position and the choice of an appropriate growth medium. It is also recommended that cuttings be transplanted three to four weeks after planting to increase their chances of survival. To guarantee that quality cuttings are transplanted to the field, farmers should use appropriate growing medium that encourages root development.

KEYWORDS: *aromatic plant, cocopeat, cost-benefit analysis, propagation, stem cuttings*

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EFFECT OF POSTHARVEST CALCIUM CHLORIDE INFUSION TO ALLEVIATE CHILLING INJURY AND IMPROVE COLOR CHANGE OF 'HASS' AVOCADO FRUIT

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INTRODUCTION

There has been no report on the effect of postharvest calcium chloride ($CaCl_2$) infusion on the alleviation of chilling injury and improvement of color change of 'Hass' avocado fruit during ripening. The objective of this study was to investigate the effectiveness of $CaCl_2$ to alleviate chilling injury and improve colour change during ripening.

METHODS AND MATERIALS

Early matured 'Hass' avocado fruit were harvested with 10 cm pedicel at commercial dry matter content (22%) from Halls and Sons, Mataffin farm (25°25'39.13"S, 30°55'52.84"E) and transported to the University of Mpumalanga postharvest laboratory (25.4371°S, 30.9818°E). At the laboratory fruit were continuously infused through the pedicel with $CaCl_2$ concentrations (0, 2 and 3 mM L^{-1}) and stored at 5.5°C for 28 days and subsequently, ripened at 21°C. During ripening, chilling injury, firmness and color parameters such as visual color, lightness (L^*), chroma (C^*) and hue angle ($h°$) were evaluated at an interval of 2 days (0, 2nd, 4th, 6th and 8th day).

RESULTS AND DISCUSSION

The results indicated that $CaCl_2$ infusion reduced chilling injury severity when compared with control. Furthermore, results showed that infusion with $CaCl_2$ also maintained firmness and fruit took longer (8 days of ripening) to ripen when compared with control (6 days of ripening). In this study, $CaCl_2$ infused fruit showed improved visual color after 8 days of ripening, fruit changed from green to purple (≈ 4 visual color). While control fruit only changed from green to olive green (≈ 3 visual color) over 6 days of ripening. Moreover, control fruit showed lower L^*, C^* and $h°$ values after 6 days of ripening when compared with $CaCl_2$ infused fruit.

CONCLUSIONS

In conclusion, this study found that $CaCl_2$ infusion effectively alleviated chilling injury, extended shelf-life, and improved color change of 'Hass' avocado fruit during ripening.

KEYWORDS: *chroma, firmness, hue angle lightness, visual colour*

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INVESTIGATING *MORINGA OLEIFERA* YIELD AND QUALITY UNDER DIFFERENT ORGANIC SOIL AMENDMENT PRACTICES

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INTRODUCTION

Moringa (*Moringa oleifera* Lam) is one of the most significant crops in the society at large, as it is utilized almost in every nutritional sector, such as medicine and consumable products. *Moringa oleifera* is commonly cultivated organically, which is why it has so many health benefits for human intake. Therefore, the objective of this study was to evaluate and identify the best organic soil amendment practice for increased Moringa productivity.

MATERIALS AND METHODS

The experiment was conducted on a 9-year-old Moringa stand established in an open-field at Roodeplaat, Pretoria. Measurements were conducted during the 2022-2023 growing season following a Randomized Complete Block Design (RCBD), consisting of three replications and six treatments, as follows: (1) a single source of Kraal manure; (2) a single source of Compost; (3) Kraal manure plus sawdust at 3:1 ratio; (4) Compost plus Kraal manure at 20:1 ratio; (5) Compost plus Vita-Nitro boost (8:1:1 NPK) (Talborne organics (Pty) Ltd) and (6) zero soil amendment applied as the treatment control. Fresh harvestable leaves of four trees per treatment per replication were analyzed statistically using Genstat® 11.1 and the least significant difference test.

RESULTS AND DISCUSSION

First harvest results revealed significantly higher performance in total fresh leaf weight of Moringa trees fertilized with compost plus Vita-Nitro boost (0.24 ton $ha^{-1)}$ compared to the rest of the treatments investigated (0.14 – 0.18 ton ha^{-1}). This increase is caused by the high delivery rate of macro and micronutrients contained in Vita-Nitro boost, which resulted in improved Moringa crop productivity.

CONCLUSIONS

Implementing the compost plus Vita-Nitro boost (8:1:1 NPK) organic soil amendment is a promising way to improve Moringa productivity. Identifying appropriate agronomic practices should help improve resource use efficiency and farmers' profitability.

KEY WORDS: *open-field, organic fertilization practices*

EFFECT OF GIBBERELLIC ACID AND POTASSIUM NITRATE SEED TREATMENTS ON THE EMERGENCE AND SEEDLING VIGOUR OF *AMARANTHUS RETROFLEXUS* AND *CLEOME GYNANDRA*

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INTRODUCTION

Seed dormancy is a major challenge in the cultivation of *Amaranthus retroflexus* and *Cleome gynandra. Amaranthus retroflexus* and *Cleome gynandra* are affected by physiological and physical dormancy, leading to erratic emergence.

MATERIALS AND METHODS

The current study was conducted at Marondera University of Agricultural Sciences and Technology farm during the 2020/21 and 2021/22 seasons. The effects of GA_3 and KNO_3 on the emergence percentage and vigour index of *Amaranthus retroflexus* and *Cleome gynandra were investigated*. The un-soaked seeds were used as a control. Seeds were pre-soaked in GA_3 (100ppm,200pp, 300ppm, 400ppm and 500ppm) and KNO_3 (0,1%, 0,2%, 0,3%, 0,4% and 0,5%) solutions for 24hrs to have a factorial layout within a randomized complete block design replicated three times. Data for both seasons were analysed using ANOVA Genstat 2018 version and mean separation was done using Fisher's Protected LSD at a 0.05 significant level to compare the means of significant effects.

RESULTS AND DISCUSSION

The study showed significant differences in seeds treated with GA_3 and also concentrations showed significant differences. Seeds treated with KNO_3 were not significantly different. GA_3 concentrations increased emergence and vigour index. The highest emergence percentages for *Amaranthus retroflexus* (69.06%) and *Cleome gynandra* (66.83%) were recorded in seeds treated with 500ppm GA_3. The lowest emergence percentages of *Amaranthus retroflexus* (56.50%) and *Cleome gynandra* (56.39%) were obtained in the control. The maximum vigour index of *Amaranthus retroflexus* (524.3) and *Cleome gynandra* (632.8) were also obtained in 500ppm GA_3 while the least vigour index I of *Amaranthus retroflexus* (397.1) and *Cleome gynandra* (468.0) was recorded in control. Control showed significantly different from other GA_3 levels.

CONCLUSIONS

In conclusion, GA_3 enhanced all parameters measured for both vegetables and it is recommended that farmers soak seeds in 500ppm GA_3 for 24 hours before sowing. Further research is required to evaluate the effects of temperature on these vegetables.

KEYWORDS: *dormancy, emergence, pre-sowing treatment*

SOIL SCIENCE

POSTER ABSTRACTS

in alphabetical order

IMPACT OF IN-FIELD RAINWATER HARVESTING ON SMALLHOLDER VEGETABLE PRODUCTION

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INTRODUCTION

The production of nutritious food amongst rural smallholder farmers located in the former homelands, which are characterized as arid or semi-arid and have soils with low agricultural potential, has been a challenge for many years. This can be attributed to various factors, including poor access to water, use of old planting methods, financial challenges, etc. Rural households farm under pronounced resource limitations where dietary diversity in crop choice is likely to be limited and integrated farming is not practiced. Therefore, a new climate-smart technology was introduced to the farmers.

MATERIAL AND METHODS

The in-field rainwater harvesting (IRWH) technique was implemented and demonstrated in comparison with conventional production at selected homestead, community and school gardens in Swayimane village, KwaZulu-Natal. IRWH was applied in combination with sound agronomic management practices (mulching, inorganic fertilizer, manure) to produce cabbage, beetroot, spinach and orange-fleshed sweet potato. Field trials were laid out as a complete randomized block design with three replicates per treatment. The total area of each plot was 36 m^2. All treatments were cultivated under dryland (rain-fed) conditions. After harvesting the vegetables, their nutritional composition was analyzed following standard and referenced methods to assess whether or not agronomic treatments, water-use technology and season affected the micronutrient levels, with particular focus on provitamin A and minerals.

RESULTS AND DISCUSSION

Yield, rainwater productivity and nutrient levels (fat, fibre, protein, Ca, P, Zn, Fe, provitamin A) of the vegetables were enhanced through the adoption of IRWH (Chitja et al., 2020). IRWH in combination with mulching and application of inorganic fertilizer and manure proved to be the best-performing technology in improving yields, particularly for spinach and cabbage. This is significant because cabbage and spinach are the preferred green leafy vegetables for many households in the study area and similar settings. Improved yields are critical for improving food availability and for income generation, which can be used to purchase more food and expand diet diversity.

CONCLUSIONS

Rural, smallholder farmers can apply local, accessible and appropriate agronomic practices in combination with IRWH to achieve economically viable yields of nutritious vegetables to enhance food and nutrition security and household livelihoods.

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Keywords: in-field rainwater harvesting, nutrient levels, provitamin A, food security

EFFECT OF WATER STRESS AND SOIL TEXTURE ON GROWTH AND YIELD OF POTATOES (*SOLANUM TUBEROSUM* L)

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INTRODUCTION

Potato (*Solanum tuberosum* L) is one of the valuable staple crops in South Africa. The crop is susceptible to water stress when compared to other major field crops. Hence its production is limited by water stress in semi-arid regions. Water stress is heavily dependent on soil texture that influences plant available water (PAW) and hence potato yield and quality.

MATERIALS AND METHODS

A pot experiment was carried out during 2021/2022 spring and winter cropping seasons. Only data for 2022 cropping season is presented. Soil samples of various textures were collected from the University of Venda (UNIVEN) Experimental Farm (clay), Tshivhilidulu Irrigation Scheme (sandy loam), and Dovheni Commercial Nursery (sandy clay loam) around Thohoyandou. The samples were air-dried and passed through a 2 mm sieve. Twenty kilograms of each soil texture was potted in three replicates and arranged in a complete randomized design (CRD) inside a plastic tunnel. Fertilizer rates based on soil analysis was applied in all pots. All pots were irrigated to 60% field capacity (FC) before planting. Two potato cultivars (Mondial and BP1) were planted and subjected to different water stress levels (100% FC, 60% FC, and 30% FC). Tensiometers were used to monitor soil water content (SWC). Plant growth parameters (plant height, stem diameter and leaf area) were measured from 44 days after planting (DAP) to 93 DAP. Potato tuber yield was measured after harvest.

RESULTS AND DISCUSSION

Statistical analysis showed that variety effect was non-significant ($p>0.05$), therefore results for the two varieties were combined. Water stress (WS) was not significant on potato plant height throughout the growing period. In contrast soil texture (ST) effect on plant height was significant in the same period. Additionally, WS×ST was not significant at 93 DAP only. WS×ST was significant on stem diameter at 65 DAP only. However, WS was significant at 51, 58 DAP and ST was significant at 44 DAP to 79 DAP. Furthermore, ST had a significant effect on leaf area at 79 DAP and 93 DAP. WS had a significant effect on potato yield. WS at 30%FC recorded a higher marketable yield (373.04) compared to 60%FC and 100%FC water stress levels which recorded 265 and 295 g/pot, respectively. Yet, ST was not significant on potato marketable yield. However, WS × ST was significant on marketable potato yield, with sandy clay loam soil subjected to 30%FC stress level recording the highest potato yield of 411.39 g/pot. This could be attributed to sandy clay loam's ability to provide more PAW, nutrients for plant growth and the crop's ability to utilize limited soil moisture, making it ideal in semi-arid regions.

CONCLUSION

This study showed that the potato crop can be grown successfully in three soil textures (clay, sandy loam, and sandy clay loam). However, sandy clay loam subjected to 30%FC water stress level produced the highest marketable yield compared to the other studied water levels and soil textures. Therefore, the results of this study suggest that farmers who grow potatoes under sandy clay loam and maintain soil water content at 30%FC can produce a high marketable yield. It is recommended that more studies be carried out under field conditions to validate the findings from this study.

KEYWORDS: Field capacity, pot experiment, potato cultivars, semi-arid, soil water content

ACKNOWLEDGEMENTS Potato SA for funding

BIOACCUMULATION OF NON-ESSENTIAL METALS IN SELECTED INDIGENOUS MICROBES USED FOR BIOREMEDIATION OF SOIL FOLLOWING IRRIGATION WITH TREATED WASTEWATER

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INTRODUCTION

Developing remediation strategies to mitigate accumulation of toxic metals due to irrigation with treated wastewater, based on indigenous microbes could be an effective way of restoring soils for crop productivity. Bioaccumulation is a metabolically active process whereby pollutants are initially adsorbed on the surface of living cells and transported into the intracellular space for accumulation and degradation of the pollutant (Chojnacka, 2010). The objective of this study was to investigate bioaccumulation of non-essential metals in selected indigenous microorganisms used for bioremediation following irrigation with treated wastewater.

MATERIAL AND METHODS

The study was conducted at University of Limpopo Soil Science Laboratory. Soil for the study was collected from a fallowed land at University of Limpopo Experimental Farm at depth of 0-30 cm and treated wastewater was collected at an exit of Mankweng Wastewater Treatment Plant. Soils were irrigated with wastewater for 12 weeks and indigenous microorganisms that are tolerant to toxic metals, identified as *Aspergillus flavus, Staphylococcus aureus, Pseudomonas aeruginosa* and *Escherichia coli* were then isolated from the irrigated soils, and used for bioremediation of non-essential metals. Soils used for bioremediation were analysed using ICP-OES whereafter the accumulation factor for the selected microbes were calculated. Data were subjected to analysis of variance.

RESULTS AND DISCUSSION

S. aureus had the highest bioaccumulation factor for Al (0.017), As (0.124), Cr (0.031), and Pb (0.153) with bioaccumulation percentages of 1.7%, 12.4%, 3.1% and 15.3% for Al, As, Cr, and Pb, respectively. While *A. flavus* had the lowest bioaccumulation factor for As (0.072), Cr (0.006) and Pb (0.026) with bioaccumulation percentages of 7.2% (As), 0.6 % (Cr), and 0.03 % (Pb). A bioaccumulation factor for Al (0.013) was lowest in soils inoculated with *E. coli,* with a bioaccumulation percentage of 1.3%. Bioaccumulation is influenced by the bioavailability of pollutants to microorganisms, thus irrigated alkaline soils (pH of 8.6) might have limited bioavailability of pollutants.

CONCLUSION

S. aureus had the highest bioaccumulation factor which suggests that the soil conditions induced by irrigation with treated wastewater favoured *S. aureus* compared to other selected indigenous microbes used for bioremediation of soils following irrigation with treated wastewater.

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eywords: Bioaccumulation factor, bioremediation, *non-essential metals*

ACKNOWLEDGEMENTS

University of Limpopo for providing necessary infrastructure and resources to complete this research.

WISH-ROOTS: POTENTIAL OF *AVENA SATIVA* AS A COVER CROP FOR NITROGEN DEPLETION FROM THE SOIL

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INTRODUCTION

The production of food is an increasing priority for farmers, with decreasing soil fertility. The three main grains for consumption are maize, rice and wheat, of which wheat is the second most produced. Most of the seed sown are highly bred hybrids. The objective of the trial is to monitor the various traits in the respective Landrace varieties including the root structure and reduced nitrogen required to grow, identify positive traits and introduce them into hybrids. The root structure is important to penetrate the soil for optimal nutrient and soil water uptake. Nitrogen is an important element for the natural growth of the plant as well as protein levels in the seed however optimizing Nitrogen Use Efficiency (NUE) is necessary to improve the economic feasibility of wheat cultivation and reduce negative environmental impacts due to leaching and nitrous oxide emissions. An objective of the study was to identify the Landrace varieties that optimally utilize low nitrogen levels in the soil. To conduct such a trial, a field with a low residual nitrogen level was required as a starting point. *Avena Sativa* (oats), a winter crop with allopathic effects on the summer weeds, was selected as a cover crop for residual soil Nitrogen uptake.

MATERIAL AND METHODS

During winter months, soil sampling was done at three depths for reference samples, to determine the residual nitrogen levels in the soil since, the objective of the Wish-Roots trial was to plant Landrace wheat varieties with two low nitrogen application rates. An elevated N-concentration was found, this along with the Broad-leaf purple vetch (*Vicia sativa*), which has N fixing abilities, growing in the field during the five year fallow. Grazing vetch, a legume, is a weed that was introduced for haymaking and as a green manuring crop. Soil samples were taken monthly to monitor the nitrogen levels to determine if the objective was achieved. The Solvita CO_2 burst and Potential Mineralisable Nitrogen was also determined.

RESULTS AND DISCUSSION

The initial Nitrate levels in the top soil was 1.43 mg kg^{-1} and was reduced to 0.32 mg kg^{-1}. By the end of October, the ammonium levels in the top soil was reduced from 8.32 mg kg^{-1} to 4.14 mg kg^{-1}. The Solvita CO_2 burst and the Potential Mineralisable Nitrogen (PMN) analysis are ongoing. This, to determine the microbial activity in the soil to explain the high ammonium levels. Secondly, to establish the amount of latent nitrogen in the residual soil carbon that will become available to the wheat during the growing season, and will potentially influence the low nitrogen fertilizer trial application results.

CONCLUSIONS

Avena Sativa sufficiently reduced Nitrogen in the soil to levels that were necessary for the wheat field trial that is currently underway. The Solvita CO_2 burst gave an indication of low bacterial activity in the soil, explaining the high ammonium levels. The PMN gave the amount of residual nitrogen available to the summer crop. The Wish-Roots project will further demonstrate the traits which allow certain varieties to have a delayed senescence providing more carbohydrates to the roots, prolonging the nitrogen uptake.

***Keywords**:* ammonium and nitrate-nitrogen, rhizosphere, Solvita, Potential Mineralisable nitrogen

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THE EFFECT OF BIOCHAR DERIVED FROM TWO DIFFERENT FEEDSTOCKS ON SOIL PH, ELECTRICAL CONDUCTIVITY, AND SOIL AGGREGATES STABILITY

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INTRODUCTION

Biochar can be used as soil amendment in crop production on low potential soil. Biochar is a stable, porous, carbon rich material, which is generated by pyrolyzing biomass under oxygen limited conditions. The beneficial properties of biochar to soil depends on the feedstock from which the biochar is derived. The aim of this study was to investigate the effect of biochar derived from two different feedstocks on soil pH, electrical conductivity, and aggregate stability.

MATERIAL AND METHOD

A greenhouse pot experiment consisting of two soils (sandy and clay), two biochars derived from two feedstocks (poultry litter and acacia) and four different levels of biochar (0, 5, 10 and 20 t/ha) in a 2×2×4 factorial arrangement, replicated four times in a completely randomized design, was conducted over a period of 45 days with spinach used as a test crop. Soils were weighed into pots and biochar was applied at the stated rates and mixed thoroughly with the soil. The pots were adjusted to 70% field capacity and allowed to equilibrate for seven days. Thereafter, five spinach seedlings were planted in each pot, and after two weeks, seedlings were thinned to two plants per pot. The soil moisture was continuously adjusted to 70% field capacity. After 45 days, the spinach was harvested, and the soil was analyzed for pH, electrical conductivity and soil aggregate stability. The data were subject to ANOVA using SAS software with means separated using LSD test at $p<0.05$.

RESULTS

Soil pH was low in sandy soil compared to the clay soil, with the application of either acacia or poultry litter biochar. Acacia biochar significantly raised the soil pH, compared to the poultry litter biochar in both soils. The application of both acacia and poultry litter biochar from 0 to 20 t/ha significantly increased electrical conductivity of the soils. Electric conductivity was high in the clay when compared with the sandy soil, although the increase was not significantly different between the two biochar's at each application rate. Soil aggregate stability was significantly higher in clay when compared with sandy soil. A significant increase was observed with an ibcrease in the application rate from 5 t/ha and 10 t/ha with acacia biochar in clay soil.

CONCLUSION

Both acacia and poultry litter biochar increased soil pH, electric conductivity and soil aggregates stability of clay and sandy soil, and further studies need to be conducted under microplot and field conditions to verify these results.

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KEYWORDS: *aggregate stability, biochar, clay, sandy*

ACKNOWLEDGEMENT

National Research Foundation (NRF) of South Africa for making this study possible through a research grant.

SHORT TERM TILLAGE EFFECTS ON SOIL MOISTURE DYNAMICS AND ENZYME ACTIVITIES IN A SORGHUM PRODUCTION SYSTEM IN A SANDY SOIL, IN ARID AREA

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INTRODUCTION

Tillage practices such as conventional tillage influence soil physical properties and enzyme activities negatively, thereby degrading soil quality. Therefore, tillage practices with low soil disturbance are needed to offset the negative effects of conventional tillage on soil quality. This study aimed to investigate the short-term tillage effects on soil moisture dynamics and enzymes in a sandy soil under conventional (CT) and no-till (NT) practices.

MATERIALS AND METHODS

The study was conducted in Mphanama village in Limpopo (LP) and Clau-Clau village in Mpumalanga (MP) provinces, South Africa, from 2021-2022. The experiment was carried out in a completely randomized block design with strip-split-plot treatment structure in three replications. The treatments consisted of tillage, planting date, and the two cultivars namely Pan 8816 and Macia. Soil moisture was measured monthly using HydroSense II (HS2) electrodes by inserting the electrodes directly into the soil surface. A 1 g of < 2mm sieved dry soil was used to determine β-glucosidase whereas phosphatase soil enzyme was determined from 0.5g.

RESULTS AND DISCUSSION

There were no significant differences in soil moisture between CT and NT at both sites. However, significant differences were observed in relation to time for both Limpopo and Mpumalanga provinces and ranged from 3.29 to 18.18 and 2.55 to 43.20%, respectively. There were significant interaction effects between site, planting date and tillage on β-glucosidase in MP whereby β-glucosidase was higher under NT than CT on planting date 1 ranging from 35.80 to 12.93 µg p-nitrophenol/g soil, respectively. The lack of significance differences between CT and NT on soil moisture dynamics could be due to the short duration of the study whereas observed significant difference in relation to time may resulted from rainfall variation in both sites. The significant effects on β-glucosidase in MP could be due to the addition of organic matter, which promotes enzyme activities in the soil and the early planting date could have given more advantage to soil enzymes since the site experienced low rainfall or no rain because under warm conditions enzyme activities increase.

CONCLUSION

The results show that tillage alone has no effect on both soil moisture and enzymes in a sandy soil in arid area, therefore, it will be advantageous to investigate the same soil parameters in a long term.

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Keywords: *Tillage, Moisture dynamics, β-glucosidase, phosphatase.*

EFFECTS OF LAND USE CHANGE TO ARABLE CROPPING ON CARBON DIOXIDE EMISSIONS FROM TWO CONTRASTING HUMIC SOILS OF KWAZULU-NATAL

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INTRODUCTION

Humic soils are among the most productive soils in South Africa, especially for sugarcane, forestry, maize and pasture. The humic A horizon, which is well drained, highly weathered, acidic, and has a high content of C (>1. 8 %) (Soil Classification Working Group, 2018), makes these soils unique. Large quantities of soil C, up to 400 Mg ha^{-1} are stored in profiles of humic soils to a depth of 1 meter (Malepfane et al., 2022). As such, humic soils have the potential to release large quantities of CO_2 into the atmosphere through the decomposition of organic matter. Land use change to arable cropping could increase CO_2 emissions from these soils. There is little work done on CO_2 emissions from agricultural soils in Africa (Rosenstock et al., 2016), and there is also a paucity of literature on humic soils in this regard. The objective of the study was to determine the effects of land use change to arable cropping on CO_2 emissions from two contrasting humic soils of KwaZulu-Natal, South Africa.

MATERIAL AND METHODS

The study was conducted in two contrasting humic soils (Cedara and Wartburg) in the KwaZulu-Natal province, South Africa. The two experiments at Cedara (maize and pasture) and Wartburg (forest and sugarcane) were each established as a randomized complete block design with five measurement points for each land use. Measurements were taken over a period of 12 months covering all the seasons. Variables measured included soil temperature, moisture and carbon dioxide emission at each measurement point.

RESULTS AND DISCUSSION

Sugarcane and maize (±19 gC-CO_2 $m^{-2}d^{-1}$) produced about 30 % higher CO_2 emissions than forest and pasture soils (± 12 gC-CO_2 $m^{-2}d^{-1}$) in summer. Seasonal variation in soil CO_2 emissions from land uses followed the same trend and was highest in summer and lowest in winter. Soil CO_2 emissions correlated to moisture and temperature. High soil moisture and temperature corresponding to increase in soil CO_2 emissions under all land uses at Cedara and Wartburg. The stronger relationship of CO_2 with moisture and temperature under maize could be due to the exposing of OC to atmospheric oxygen as a result of tillage, which then enhances C oxidation, leading to increased CO_2 emission. The lack of significant differences in soil CO_2 emissions between the land uses and sites over the dry period could have been due to lower soil moisture and temperature which reduced soil microbial activity (Abdalla et al., 2016).

Conclusion

The findings show that the cultivation of humic soils results in increased CO_2 emissions, which may reduce soil C than when uncultivated, especially under high moisture and temperature conditions.

***Keywords**: Carbon dioxide emissions, humic soil, land use, soil organic carbon.*

COMPOST APPLICATION AND SOYBEAN-TEFF INTERCROPPING AFFECT SOIL ORGANIC CARBON AND CROP YIELD UNDER DIFFERENT TILLAGE PRACTICES

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INTRODUCTION

Although, the responses of crop yield and soil properties to tillage or compost application have been previously reported, the integrated effect of compost application and tillage practice (TP) on crop performance and soil quality is not often studied and requires more exploration. The objective of this study was to determine the effects of compost rate (CR), TP, cropping systems (CSs) and their interactions on crop performance and soil organic carbon (SOC).

MATERIAL AND METHODS

An agronomic field trial was conducted during the 2021/22 cropping season under rainfed condition at the University of Limpopo Experimental Farm (23°50′36.86″S; 29°40′54.99″E). Treatment factors were two CSs (sole - SS and intercropping system - IS), two tillage practices, and three compost rates (0, 10 and 20 t/ha). Reduced tillage (RT) involved chisel-ploughing whereas conventional tillage (CT) involved the use of a chisel-plough followed by a mould-board plough and disc harrow. Treatment factors were laid out in a randomized complete block design with a split-split-plot arrangement replicated thrice. TP, CSs and CR represented main-plot, sub-plot and sub-sub-plot (6 m^2), respectively. Seeding rates of soybean (variety Y657) and teff were 210000 seeds/ha and 10 kg/ha, respectively. For IS, one row of teff was planted between the two soybean rows. Crop yield and SOC (15 cm depth) data collected at harvest were subjected to analysis of variance ($P \leq 0.05$) using the Statistical Analysis Software 9.4. Treatment means were compared using the Tukey's test.

RESULTS AND DISCUSSION

Grain yield (GY) of soybean was affected by the CSs, CR, TP and the interaction of TP and CR. IS resulted in 58% lower soybean GY compared to SS. Soybean GY obtained from the RT was 158% of that obtained from CT. Treatments with 10 and 20 t/ha compost produced 22% and 29% lower soybean GY, respectively, compared to the control. These results concur with that of Martínez-Blanco et al. (2013) that showed approximately 138% decrease in crop yield following a compost fertilization in the short term. IS increased teff GY by 104% compared to SS. Conversely, teff straw yield from IS was 27% lower than that of SS. SOC recorded from RT was 67% higher than that of CT.

CONCLUSIONS

The TP-CR interaction influences soybean GY. Soybean-teff intercropping favours teff grain production.

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KEYWORDS: *Cover crop, intercropping, soil quality, tillage*

MODELLING SOIL CARBON SEQUESTRATION FOR SOUTH AFRICA USING THE ROTHC MODEL

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INTRODUCTION

Atmospheric carbon as gaseous CO_2 or CH_4 is the main sources for global warming. Within terrestrial ecosystems soil carbon is regarded as the biggest carbon pool. Soil organic carbon plays an important role in maintaining soil biota and soil health and is seen as a key indicator for degradation. Agricultural practices and policies need to be implemented to maintain current soil carbon stocks and where possible implement practices that will lead to enhanced soil carbon sequestration. An increase in atmospheric carbon and subsequent increase in temperature will result in the increased release of soil carbon that will accelerate global warming further. Changes in land use and the exposure of soil and underlying geological layers due to cultivation, land degradation and mining further contribute to the release of stored carbon. Recently the Food and Agricultural Organization of the United Nations (FAO) initiated a project to globally map soil organic carbon sequestration with the intent to develop scenarios to promote sustainable agricultural practices that will lead to an increase in soil carbon stocks. The study explores the results from the initial global assessment of soil carbon sequestration for South Africa and the follow-up modelling using South African datasets. Input and modelled results are compared for various known agricultural land use types.

MATERIAL AND METHODS

A modelling framework developed by the FAO was employed to simulate possible future sequestration rates for agricultural areas, using three sustainable management scenarios. The RothC model (Coleman & Jenkinson, 1996) was used for the national modelling exercise. Within the original assessment, available global data was used as input. During follow-up research, these were replaced by readily available national datasets on soil clay and land use. Three scenarios of soil organic carbon input against a business-as-usual scenario, were tested with a 5, 10 and 20 % increase in carbon input in the soil.

RESULTS AND DISCUSSION

Published global results indicate possible sequestration rates between 0.32 and 1.93 Pg carbon/year, with most estimates between 0.44 and 1 Pg carbon/year. However, total global agricultural emissions are estimated to be in the region of 6.63 CO_2-eq Pg/year. The total and mean relative sequestration rates for South Africa were 11.41 Mt C/year and 0.09 t C/ha/year, respectively. Mean relative sequestration rates for Scenario 3 (20% increase) for South Africa globally compared equally with Ethiopia, Kazakhstan and Mexico. The RothC model predicts a loss of 0.0133 Mt C/year for crop fields under a business-as-usual soil management regime in comparison to a 4.045 Mt C/year gain for grasslands.

CONCLUSIONS

South Africa's biggest limitation is its investment in national field-based datasets and monitoring as well as the lack of research in on field studies. Considerable efforts are however made within South Africa to adopt Conservation Agriculture through grant funding and the establishment of working groups for farmers.

COMPARING THE GROWTH OF TWO CULTIVARS OF SORGHUM GROWN ON SANDY CLAY LOAM SOIL IN SUB-HUMID AND SEMI-ARID AREAS IN SOUTH AFRICA.

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INTRODUCTION

The agriculture sector needs to produce more food from less land and water resources to provide for a growing population under the difficult conditions of a changing climate. In this study we tested the suitability of growing sorghum in two areas of differing climate and soils.

MATERIALS AND METHODS

Two cultivars of sorghum, PAN8816 and Macia, were planted on two different planting dates (PD) under two tillage systems (No-Till (NT)) and Conventional Tillage (CT)) in Nongoma, KZN and Thaba Nchu, Free State. Nongoma is characterized by sandy clay soil and sub-humid climate and Thaba Nchu is sandy loam soil with a semi-arid climate. Plant height, panicle length, seed weight and grain yield were determined at harvest.

RESULTS AND DISCUSSION

All three factors significantly affected grain yield in KZN in 2020/21. CT resulted in 77% higher sorghum yield than NT, whilst Pan 8816 yielded 96% higher than Macia. Planting earlier resulted in higher yield (1.29 t/ha), than planted later (0.63 t/ha) and it was only Cultivar in KZN (PAN8816=4.35, Macia =1.19 t/ha) in 2021/2022. Seed weight (SW), Plant height (PH) and Panicle length (PL) were not significantly different in KZN while PD and Cultivar were significantly affected the three parameters in FS. In 2021/2022, PD had a significant effect on SW and PH and PL in FS. The interactive effects of the treatments also showed some interesting findings. CT performed best in terms of yield in the first season for KZN while NT was higher but not significant in the second season pointing towards gradual improvement with time. CT had higher yield in the second season FS which could point towards less restriction to root growth amongst other things. Early planting is favourable in both sites, which agrees with literature because sorghum is sensitive to low temperatures so plants should be well established when the frost season arrives. We found that cultivar also plays a role with Pan8816 performing better than Macia.

CONCLUSIONS

The results of this study show that PD and Cultivar for FS and KZN, respectively tend to lead to greater yields but a closer look in a longer term study is warranted. Also it would benefit this study to compare the climate variations between the two sites.

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Key words: Climate variability, conventional tillage, no-till, planting date, sorghum,

SUGARCANE BAGASSE BASED MULCH MATS EFFECTS ON SOIL MOISTURE & TEMPERATURE DYNAMICS AND SPINACH YIELD

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Introduction

Maintenance of a continuous cover on the soil surface has several benefits such moisture and temperature regulation, reduction of soil erosion etc. However farmers often fail to leave the requisite amount of cover due to competing uses of crop residues. There is therefore need for innovative solutions such as the use of mulch mats fabricated from various combinations of waste biomass. This study sought to determine the effects of sugarcane bagasse mulch mats on soil moisture, temperature dynamics and spinach yield.

Materials and Methods

A glasshouse pot experiment was carried out to determine the effects of sugarcane bagasse based mulch mats on soil moisture and temperature dynamics and spinach yield. The mulch mats were fabricated using various combinations of bagasse, grass and cattle manure as follows; 100% bagasse (100BG); 50% kraal manure + 50% grass (50KM50G); 50% bagasse + 30% kraal manure + 20% grass (50BG30KM20G); 80% grass + 20% kraal manure (80G20KM); 80% bagasse + 20% kraal manure(80BG20KM); 50% bagasse + 50% grass (50B50G); shredded bagasse (SB) and a bare control (C). The treatments were arranged in a completely randomized design replicated three times. Data was collected on spinach fresh and dry weight and plant height. Soil moisture and temperature data was collected using Decagon 5TM sensors. Analysis of variance was done using JMP 14

Results and Discussion

Mulching significantly ($P < 0.05$) affected spinach yield, soil moisture and temperature. All mulch treatments resulted in higher spinach fresh weight than the bare control treatment. However, kraal manure infused mulch mats resulted in significantly higher spinach fresh and dry weight than bagasse only and grass based mulch mats. The 50BG30KM20G treatment resulted in the highest spinach fresh, dry weight and plant height than all other treatments. All mulch treatments resulted in less diurnal fluctuations in soil temperature and significantly higher soil moisture retention than the control treatment.

Conclusion

Whilst this study showed the benefits of bagasse based mulch mats on improving crop yield and regulating moisture and temperature, it may be necessary to match type of mulch mat with agronomic requirements e.g. bagasse/manure mats for improving soil fertility and bagasse or grass only for water retention in drier areas. However, there is need for more studies under field conditions and different climatic conditions.

Keywords: bagasse, cattle manure, mulch mats, soil moisture, soil temperature, spinach yield

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COMPARISON OF ULTRA-SONICATION AND MICROWAVE EXTRACTION FOLLOWED BY FILTRATION OR SPE CLEAN-UP FOR PAH DETERMINATION FROM SEDIMENT AND SLUDGE

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INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are organic contaminants that are derived from both domestic and industrial scale due to incomplete combustion. They often persist in the environment, therefore, this study aimed at optimising microwave assisted (MAE) and ultra-sonication extraction (UE) for the assessment of PAHs in sludge and sediment samples by GC-MS and determining their origin and assessing their ecological risk. This is a requirement through the National Environmental Management: Waste Act, 2008 (NEMWA) license (Water-Affairs, 2013). The extraction methods were compared together with the clean-up method efficiency and the results were then compared to the maximum allowable concentration levels.

MATERIALS AND METHODS

A soil/sludge sample was dissolved in 50mL acetone:nhexane then ultra-sonicated (60 min, 25˚C) or microwaved (15 min at 110 ˚C) and then filtered or SPE cleaned before injecting in GC-MS for analysis.

RESULTS AND DISCUSSION

Both extraction methods can successfully extract PAHs with relative accuracy and sensitivity, shown by the recoveries ranging from 79.7% to121% for F+SPE samples. The limit of detection (LOD) and limit of quantification (LOQ) were 0.0337 - 1.21 µg/kg and 0.0800 - 3.54 µg/kg for MAE, and 0.0192 - 0.215 µg/kg & 0.0491 - 0.642 µg/kg for UE, respectively. However, higher concentrations were obtained for majority of samples with F+SPE cleaned samples at 95.96 – 926.0 µg/kg & 71.62 - 1656 µg/compared to filtered samples at 21.61 – 380.6 µg/kg & 54.39 – 728.4 µg/kg respectively. Fl/(Fl + Pyr) and LMW/HMW were 0.52 and 0.63 respectively, indicating PAHs are from pyrogenic sources. The effects range low (ERL), ER median (ERM) and the benzo(a)pyrene toxic equivalency quotient (TEQ) showed that PAHs possess a mild to high ecological risk to the surroundings while ILCR at 1.01 x 10^{-1} to 4.98 x 10^{-1} suggested a high toxicity risk to humans.

CONCLUSIONS

The optimised methods were found as suitable extraction methods as they gave relatable concentrations of PAHs in solid samples, with clean-up method being the deciding factor where F+SPE-cleaned gave higher concentration than filtered samples.

KEY WORDS: *Gas chromatography, PAHs, pollution, sediment, sludge*

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EFFECT OF TREATED WASTEWATER USED FOR IRRIGATION ON SELECTED SOIL FERTILITY VARIABLES

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INTRODUCTION

The University of Limpopo experimental farm (UL Farm) has implemented the use of treated wastewater (TWW) due to water scarcity. The effect of this water on the soil fertility status at the UL Farm is unknown. As a result, this study investigated the impact of TWW on the fertility status of agricultural soils.

MATERIALS AND METHODS

A 2 x 5 factorial experiment laid out in a randomized complete block design (RCBD) was conducted at the University of Limpopo (UL). There were two temperature conditions [controlled temperature (incubator), and uncontrolled temperature(shade house)] and five TWW/tap water(TP) dilutions (100%TWW, 75%TWW+25%TP, 50%TWW+50%TP, 25%TWW+75%TWW and 100%TWW). Soil samples, TWW and TP were collected from the UL Farm from a fallowed land, night dam outlet, and UL Farm tap respectively. Planting pots were filled with 450g of soil and glass beakers with 225 g of soil, then placed in a shade house and incubator at 37^{o}C respectively. These were irrigated with the dilutions at an interval of 2 days for a period of eight weeks. Irrigated soil samples were analysed for soil organic carbon (SOC), electrical conductivity (EC), soil active and reserve acidity. All data were subjected to analysis of variance using statistix 10.

RESULTS AND DISCUSSION

The interaction between temperature regulation and water dilutions was highly significant on EC and SOC and significant on the reserve soil acidity. A decrease in the TWW in the dilutions resulted in an increase in the SOC and a decrease in the soil EC. 100% TWW increased soil EC, soil active and reserve acidity but decreased SOC. The variations observed on SOC between the irrigation treatments might be because of different microbial populations `introduced by the treatments. Furthermore, this study showed that temperature had a highly significant effect ($p \leq 0.01$) on SOC and active acidity.

CONCLUSION

The use of raw TWW negatively affected the analysed soil variables. Irrigation with the dilutions 50%TWW+50%TP and 25%TWW+75%TP compared to raw TWW favoured an improvement of SOC while having very minimal effects on soil pH. Therefore, maintaining the analysed fertility variables in good condition.

Keywords: *Treated wastewater, soil fertility, microbial activities.*

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National Research Foundation for funding and University of Limpopo for infrastructure.

SOILS IN THE OPENCAST COAL MINING PROCESS

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INTRODUCTION

The process of open-cast coal mining involves the removal of the overlying material (including the soil profile), the storage of that material while the coal is extracted and finally the replacement of the non-utilizable spoil material with the soil being placed on top for final rehabilitation. However, this process involves severe soil disturbance.

Research done in this field by ARC involved two phases.

Firstly, quantifying various properties of stockpiled soils and to compare these materials to the original soil material and to the rehabilitated soils. The aim is to improve both the stripping process as well as the stockpiling phase, and improver the final rehabilitation.

Secondly, using Ground-penetrating Radar (GPR) to assess how it could improve the characterization of the effective depth of rehabilitated coalmine soils.

MATERIAL AND METHODS

Six mines in the Emalahleni area were used, four for the stockpiling and three for the GPR phase (one for both). For the stockpiles, samples were collected and analyzed for a range of physical, chemical and microbiological properties, which were then compared with both non-mined soils and rehab soils. For the GPR phase, transects were followed across rehab areas and the results compared with ground-truthed auger depths at set intervals.

RESULTS AND DISCUSSION

The analytical results from the stockpiles showed significant deterioration in all soil properties with the stockpiling process. On average, clay content increased by between 50% and 60% for both the topsoil and subsoil, while surface bulk density (compaction-related) increased through the entire chain from stockpiling to rehab. Chemically, CEC values showed only a slight increase compared to clay content, showing the effects of leaching after stripping, while pH values showed a large variation, again due to mixing effects of stockpiling. Topsoil organic carbon declined by almost half through stockpiling and only showed a slight increase in the rehab soils, while C:N ratios fell across the whole process.

In the GPR phase, results showed that the equipment was able, in most cases, to predict the depth of the underlying spoil layer with accuracy generally approaching 5 cm, with the results being recorded electronically in data files.

CONCLUSIONS

The empirical results from the stockpiled samples showed the extent of the deterioration, so that recommendations for the depth, period and handling of these soils could be made. The level of accuracy of the GPR results will allow better assessment of the success of the rehab process.

Keywords: Coal mining, stockpiling, GPR, rehabilitation.

SOIL PHOSPHORUS FRACTIONS VERSUS ALTERNATIVE PHOSPHORUS FERTILIZER SOURCES IN FIVE DIFFERENT SOILS

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INTRODUCTION

Composting and anaerobic digestion of organic wastes to mitigate excessive storage, greenhouse gas emissions and odors, generates considerable amounts of phosphorus (P) rich material which, when well utilized, may serve as a valuable P fertilizer. However, effective use of these materials requires an understanding of the P release capacity, crop response and how different soils influence P availability.

MATERIALS AND METHODS

A pot experiment, with maize (*Zea mays*) as a test crop, was conducted using five different soil to compare differences in P availability, soil P chemistry and crop response. Treatments consisted of four P fertilizers and five different soils replicated five times in a randomized complete block design. The P fertilizer sources were chicken manure compost, vegetable matter compost, anaerobically digested dairy manure and mono-ammonium phosphate (MAP), plus a no fertilizer control treatment. The five-soils varied in texture, pH, calcium, and iron content.

RESULTS AND DISCUSSION

Shoot P concentration was higher for MAP (1896 mg P kg^{-1}) than other P fertilizer treatments (1552-1559 mg P kg^{-1}). Maize shoots in Warden soil had the highest tissue P (1942 mg P kg^{-1}) followed by Quincy soil (1668 mg P kg^{-1}) while shoot P concentrations in Houston, Palouse and Skagit soils did not differ significantly. Soils receiving MAP had the highest Olsen test P concentration (19.1 mg P kg^{-1}) followed by AD dairy manure (18.1 mg P kg^{-1}), vegetable compost (17.9 mg P kg^{-1}) and composted chicken manure (17.8 mg P kg^{-1}). Although the soil x P fertilizer interaction effect was highly significant, changes in individual P fractions were largely controlled by the differences in soils. When individual P fractions were averaged across soils, the soluble and loosely bound P (2.73 mg P kg^{-1}) accounted for the smallest pool of inorganic P fractions followed by Fe-P (13.7 mg P kg^{-1}), Al-P (43.4 mg P kg^{-1}) and then reductant soluble P (67.9 mg P kg^{-1}) while Ca-P (466.2 mg P kg^{-1}) accounted for the highest pool of inorganic P.

CONCLUSIONS

The study demonstrated that MAP was more effective in improving tissue P concentrations than the organic alternatives, particularly in soils where initial P concentrations were lower, and calcium or iron content were high. The study also showed that P fertilizers had a very limited influence on individual P fractions while the initial physical and chemical properties of soils explained majority of variation in the concentration of inorganic P fraction.

KEYWORDS: *Anaerobic digestion, compost, fractionation, manure, Phosphorus*

ACKNOWLEDGEMENTS

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WISH-ROOTS: TUNING THE WHEAT ROOT MICROBIOME TO IMPROVE SOIL HEALTH AND OPTIMIZE RHIZOSPHERE NITROGEN CYCLING AND AVAILABILITY

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INTRODUCTION

An increasing human population is reliant on healthy and fertile agricultural soils to improve crop production and plant nutrition. To ensure food security, wheat cultivars have been bred for above-ground traits such as higher yield, with minimal focus on below-ground biomass and soil health. This has resulted in an urgent need for the quantification of below-ground biomass traits that can improve soil health. The soil-microbe-plant interactions play an integral role in soil health status; hence, optimizing these interactions will not only increase crop yields but also improve sustainability. This study is aimed at enhancing the potential beneficial effects of wheat cultivation on soil health through the identification of root traits that can improve soil structure and microbial diversity as well as optimize nitrogen (N) cycling.

MATERIAL AND METHODS

The WISH-ROOTS project builds on unique germplasm resources and preliminary results from project partners at John Innes Centre (UK) and University of Bologna (Italy). Based on functional and morphological root traits, 20 cultivars of bread and durum wheat have been selected to conduct parallel field trials in six locations across three continents. The objective is to confirm the traits in different soils and climate conditions and to link these traits with N cycling in the wheat rhizosphere and key soil physical properties. To achieve this, all wheat cultivars were exposed to high and low N levels. The field trials will determine and quantify soil physical (pore structure and aggregation, water retention), chemical (N availability) and biological (microbiome composition and functionality) parameters. These datasets will provide the variables to develop predictive models for the impact of wheat cultivation on soil health.

RESULTS AND DISCUSSION

Preliminary chemical results of the SA field soil prior to sowing the 20 cultivars of wheat revealed the need for a reduction in the soil N to ensure that residual N will not influence the two N treatments that were applied. This was achieved by cultivating oats as a cover crop prior to wheat cultivation. Following N depletion, the field was planted with the selected cultivars and data collection is ongoing.

CONCLUSIONS

Overall, it is hypothesized that root morphological and functional traits in wheat cultivars can preserve and improve soil health indicators. The results from the field trials in the various countries is anticipated to reveal the genetic resources responsible for the beneficial root traits associated with the promising cultivars.

***Keywords**: nitrogen, rhizosphere, root traits, soil fertility, soil microbiome*

SOIL CARBON AND PHOSPHORUS AFTER 40 YEARS OF CONTRASTING TILLAGE AND STRAW MANAGEMENT IN DRYLAND WHEAT PRODUCTION UNDER SEMI-ARID TEMPERATE CLIMATE

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INTRODUCTION

The effects of conservation strategies on soil organic carbon (SOC) and phosphorus (P) dynamics in dryland wheat under semi-arid temperate conditions are not well understood. This study quantified the effects of tillage and straw management on SOC concentrations and stocks and P fractions after 40 years of dryland wheat under a semi-arid temperate climate.

MATERIAL AND METHODS

The treatments were straw management (burned and not burned) combined with tillage methods [conventional tillage (CT), stubble mulch (SM), and no-tillage (NT)], fertilizer nitrogen (N) and P were applied annually at 60 and 12.5 kg ha^{-1}, respectively. The soils and undisturbed soil cores for bulk density (BD) measurements were sampled from 0–50, 50–200, 200–400, 400–600, 600–800, and 800–1000 mm depths. The samples were analysed for SOC, pH, Bray 1 P and P fractions namely: $NaHCO_3$ Pi, NaOH I Pi, HCl Pi, NaOH II Pi and residual P. The BD was used to calculate soil C stocks for each soil layer. The data were statistically analysed.

RESULTS AND DISCUSSION

The concentration of SOC was not affected by tillage and straw management, except in the 200–400 mm soil layer, where it was higher where the straw was burned rather than retained. This suggests that straw burning increases C sequestration, at deeper soil layers in dryland wheat production systems under semi-arid conditions. The total C stocks (0–1000 mm) was higher under NT with straw burning, CT with no burning, and SM than NT with straw retention and CT with burning. Straw retention treatments suffered significant losses of C in the form of straw blown away by the strong winds that are prevalent in Bethlehem. In the topsoil, NT had significantly higher Bray 1 P, NaOH II Pi, and residual P than SM and CT, while burning straw increased Bray 1 P and $NaHCO_3$ Pi concentrations. The higher Bray 1 P under NT followed by SM suggested that available P accumulated at the surface with less soil disturbance while straw burning increased pH and P availability.

CONCLUSIONS

The findings imply that SOC concentration is not significantly affected by tillage, but is increased by burning in the subsoil only. The SM is recommended over NT with retained straw and CT with burned straw for increasing soil C storage, although NT with burned straw would be preferred for improving soil C storage and available P in dryland wheat systems in a windy temperate region.

KEYWORDS: burned straw, carbon stocks, no-till, phosphorus fractions, stubble mulching

IMPLICATION OF LAND USE CHANGE FOR SOIL ORGANIC CARBON STORAGE: A CASE STUDY

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INTRODUCTION

Soil is the largest terrestrial carbon sink, and conserving and maintaining soil organic carbon (SOC) is essential for soil health, and plays an important role in climate change. Land use can have a significant impact on carbon storage. Most land use changes result in SOC loss (Guo and Gifford, 2002). In cultivated agricultural fields in South Africa, for example, 25 to 53% of SOC has been lost (Swanepoel *et al.* 2016). Some land conversions do result in a net SOC increase, such as rangelands, forests or plantations (Guo and Gifford, 2002). Conversion of natural areas to villages, plantations, orchards and cultivated fields, may severely impact the stored SOC. In this study we evaluate the impact of land use on SOC content in four main land uses in Venda.

MATERIAL AND METHODS

The study site is located in in a subtropical region of Venda, Limpopo Province. The four main land uses identified were pine plantation, macadamia orchard, villages/homesteads and natural forest. Sites were selected within a grid of 3.5 km x 1.2 km, along the same aspect, with similar soil to minimize spatial variation. Reconnaissance surveys in the study area, showed that bare swept soils were most prevalent in gardens (>95%). Our samples were collected on the bare swept soils. Composite topsoil samples (0-20 cm) were taken from seven locations in each land use zone. Soil was analyzed for organic carbon, using Walkley-Black method.

RESULTS AND DISCUSSION

The SOC content was highest in natural forest (3.77±0.63%), followed by pine plantation (3.12±0.16%), in macadamia orchards (2.71±0.21%) and village soils (2.08±0.31%). Compared to natural forests, SOC has decreased in all land uses. In villages up to 45% of SOC was lost. Homesteads are kept neat by sweeping the garden, resulting in removal of vegetation and topsoil. While in orchards and plantation the leave biomass and compost contribute to organic matter.

CONCLUSIONS

Preliminary results show that change from natural vegetation to agriculture or villages in Venda has a negative impact on SOC storage, even under plantations and orchards. However, villages are a complex matrix of houses, gardens and agriculture. Therefore, further studies is needed to evaluate the impact of not only gardens, but the different land uses within the village to better quantify the impact on land use change, and determine what is the best practices to mitigate and manage C in human landscapes.

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KEYWORDS: car*bon storage, land use, macadamia orchard, plantation, Venda*

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INFLUENCE OF MAIZE/LABLAB INTERCROPPING ON SOIL MINERAL NITROGEN AND SOIL WATER CONTENT

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INTRODUCTION

Inclusion of legumes in maize-based cropping systems has the potential to improve nitrogen status of the soils through biological nitrogen fixation but may pose a challenge of competition for soil water. One such legume that can be used under rainfed agricultural production systems in dry areas is Lablab (*Lablab purpureus*), an underutilised legume crop known to be drought tolerant and produces high amount of biomass. The objective of this study was to evaluate maize/lablab intercropping on soil mineral nitrogen levels and soil moisture dynamics to make appropriate recommendations for maize/lablab intercrop systems under rainfed agriculture in dry areas.

MATERIALS AND METHODS

The study was conducted at Syferkuil and Thohoyandou in Limpopo province. Treatments consisted of maize (DKC-2147) and three species of lablab (DL-1002, Q-6880 and Rongai) as intercrops and sole crops. Soil mineral nitrogen was analysed from samples collected at maize flowering and maize harvest at 15, 30, and 60 cm depth. Soil mineral nitrogen was analysed using ICP-AES (Tan, 2015). Soil water content was determined using gravimetric method at V10, VT, R3 and R6 maize growth stages.

RESULTS AND DISCUSSION

At flowering maize/lablab intercropping reduced mineral nitrogen at both sites when compared to sole maize. However, at harvest, intercropping and sole lablab respectively increased mineral nitrogen by 58.12% and 72.56% at Thohoyandou and increased by 124.24% and 244.22% at Syferkuil, relative to maize monocropping. Soil sampling depth had a significant effect on mineral nitrogen at flowering and harvest at Thohoyandou, and the highest levels were observed at 15 cm depth. Intercropping did not affect soil water content across all growth stages at both locations, while sole lablab increased soil water content at VT, R3 and R6 at Thohoyandou and R3 and R6 at Syferkuil. The insignificant effect of maize/lablab intercropping on soil water content may be attributed to increased canopy cover that led to reduced evaporative moisture losses, thus improving water use efficiency. Decreased nitrogen level at flowering was due to increased competition for nitrogen between intercrops in the early growth stages of lablab, which later improved as lablab matured and fixed atmospheric nitrogen.

CONCLUSION

The study showed the potential role of maize/lablab intercropping in enhancing nitrogen input into the soil, offering farmers an alternative nitrogen source. Although soil water content was not affected by maize/lablab intercropping, the potential of the cropping system to maximize yield remains important to resource-constrained farmers.

Keywords: Intercropping, lablab, maize, moisture, nitrogen

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EXPLORING THE POOR UPTAKE OF NEW AGRICULTURAL TECHNOLOGIES IN RURAL COMMUNITIES IN SOUTH AFRICA

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INTRODUCTION

Even though remarkable improvements have been made in farm production worldwide, mainly through the adoption of new agricultural technologies, the uptake of these technologies in rural communities in South Africa remains low. To critically address this challenge, the following question must be answered: "*What needs to be changed in the technology transfer process to ensure that new agricultural technologies are more widely adopted?"*

MATERIAL AND METHODS

Following a literature review, formal and informal interviews with structured questionnaires were conducted with randomly selected households in Krwakrwa and Upper Ncera villages in the Eastern Cape to rate the effectiveness of the technology transfer tools and strategies that were used in a previous project (Anderson et al., 2021). Statistical analysis using SPSS (version 28) was used for quantitative data. Qualitative data were analyzed by creating categories and coding responses accordingly to characterize trends. Statistical significance was accepted at $p \leq 0.05$.

RESULTS AND DISCUSSION

In the study area, there were more women (53%) than men (47%). Only 63% of the participants attended high school. Nine percent matriculated and 25% were only in primary school. All participants' home language is IsiXhosa which explained why 97% of participants had a language barrier and difficulty understanding the English training manuals that were distributed. Only 30% of participants have an adequate supply of water at their residences. Factors such as age, gender, education literacy, language, and water supply play a fundamental role in the adoption of agricultural technologies by smallholder farmers in rural areas.

CONCLUSIONS

Important parameters were identified to get a better understanding of the procedures, tools, and strategies that need to be used to ensure the widespread uptake of new technologies to improve rural agriculture and livelihoods in general. Identified parameters can be used to predict the success rate of the adoption of new technologies in other areas.

REFERENCES

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