ARC • LNR
Excellence in Research and Development

No. 20

Published:
19 August 2024

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Inside this issue:

ARC-Vegetable, Industrial and Medicinal Plants Newsletter

Newsletter of the Vegetable, Industrial and Medicinal Plants, campus in the Crop Sciences Programme of the Agricultural Research Council (ARC)

Disease characterization of Hemp and Cannabis in Gauteng and Limpopo

Compiled by Juanita Engelbrecht and Elsie Cruywagen

In recent years, the cultivation of cannabis, including industrial hemp, (further on referred to as cannabis) has experienced a surge of interest. However, decades of heavy restrictions have left a void in research regarding this versatile crop. Now, as regulations ease and cultivation expand, new challenges are emerging, particularly in the realm of pest and disease management when the crop is grown in monoculture.

Disease symptoms observed on mature cannabis leaves.

Under the umbrella of the DALRDD funded project at the ARC on integrated pest management of vegetables, industrial and medicinal plants, one of the work packages entails a survey and the identification of pests and diseases affecting cannabis cultivation in South Africa. Field trips to Limpopo and Gauteng provinces have provided invaluable insights into the disease progression throughout the growing season, typically for the period from December to March.

During 2023 – 2024, various disease symptoms were observed and samples collected for analyses in the laboratory to identify the causal agents. Among the isolates obtained, notable fungal pathogens identified included *Agrothelia rolfsii* causing southern blight, *Septoria* spp. causing leaf blight and *Golovinomyces* spp. causing powdery mildew. Damping-off was also observed and various species, including *Rhizoctonia solani*, *Pythium* and *Fusarium* species were consistently isolated from these samples. Pathogenicity tests are currently underway to confirm the roles of the different isolates as the causal agents for the various observed disease symptoms. This is essential to accurately identify and address the threats posed by these pathogens to the cannabis industry in South Africa. Various samples with viral related symptoms were also collected and are being analysed. The most prevalent pest observed during the growing season was budworm / bollworm, which are the larval stages of various moths.

With the burgeoning interest in cannabis cultivation for both industrial and medicinal purposes, safeguarding crop health is very important. By understanding the dynamics of pest and disease pressure, growers can implement targeted management strategies to mitigate risks and ensure the sustainability and profitability of their operations. Moreover, this research underscores the critical need for ongoing investment in cannabis crop protection. As the industry continues to evolve, so too must our understanding of the challenges it faces.

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Cannabis field showing plants affected by disease.

A close-up of various disease symptoms observed inside the main stem (left) and on flowers (right) of cannabis plants.

How to make Biochar from *Moringa oleifera* and invasive plants

Compiled by Simon Maleka, Nadia Araya, Hunadi Chaba, Ian Du Plooy, Mariette Truter and Hintsa Araya

As defined by Weber & Quicker (2018), biochar is the solid product of biomass pyrolysis, while charcoal is produced from woody feedstocks. Biochar is a carbon (C)-rich product produced from the pyrolysis of organic material at relatively low temperatures (≈700 °C) (Lehmann & Joseph 2009). Its production and use dates back to several thousand years. The use of biochar will be beneficial to the agricultural sector in South Africa, specifically as South Africa's topsoil is characterized by low organic matter content (>0.5 %). Biochar has the potential to increase the soil organic matter content and further increase the soil's water holding capacity which will be beneficial given that South Africa is amongst the driest countries in the world, ranking number 30, and the annual rainfall is below the atmospheric evaporative demand. Thus, food and nutrition security are threatened by droughts.

Therefore, biochar is being studied due to its ability to sequestrate carbon and its other agronomic potentials, such as altering the soil's nitrogen (N) dynamics. Biochar has promising characteristics in reducing inorganic-N leaching, N_2O emissions, and ammonia volatilisation, while increasing biological nitrogen fixation (Clough et al. 2013; Weber & Quicker 2018). The characteristics of the biochar (chemical composition, surface chemistry, particle and pore size distribution) and physical and chemical stabilisation mechanisms in the soils are the determinants regarding the effects of biochar on soil functions. Biochar incorporation into soils is expected to enhance the overall absorption capacity of soils towards anthropogenic organic contaminants (e.g., polycyclic aromatic hydrocarbons (PAHs), pesticides and herbicides) in a mechanistically different (and stronger) way than amorphous organic matter (Verheijen et al. 2010).

Biochar can be produced from various feedstocks ranging from agricultural waste to invasive plant species. According to Feng et al. (2021), invasive plant species are plants that not only cause damage to natural ecosystems, but also pose a serious threat to human health. They also have strong adaptability, fast reproduction, and spreading capabilities. With some parts of the country experiencing an infestation of invasive plants like Bugweed (*Solanum mauritianum*), Lantana (*Lantana camara*) and Syringa (*Melia azedarach*) (Fig. 1), amongst others, researchers found the use of pyrolysis to turn the invasive species into biochar to be efficient due to their ecological and economic benefits as this process does not only control the expansion of invasive and noxious plants, but also realizes the efficient use of waste.

The ARC-VIMP is researching a biochar kiln stove developed through the collaboration on the EU-funded DIVAGRI project. The kiln stove is energy efficient and multipurpose: 1) a chamber for producing biochar, 2) a chamber for boiling water, and 3) the top of the kiln for the cooking of food. It comes in handy to its users, specifically resource-poor households. Besides biochar production, the kiln stove has various other essential uses as it is equipped with a built-in water tank with a water-holding capacity of around 30 L, which can provide boiling water within 15 minutes, and it can be used for portable uses like cooking and the preparation of tea, and the stove is equipped with a tap to discharge the hot water as and when required by the users. Alternatively, the kiln stove can cook tasty meals by placing a pot on the designated pot-holder stand on top of the stove. Furthermore, the stove provides heat for warming up during cold weather, allowing the users to save significantly on electricity bills and thus reduce the load on the national grid.

Figure 1. Various plants used for biochar production: (A) Moringa (*Moringa oleifera*), (B) Bugweed (*Solanum mauritianum*), (C) Lantana (*Lantana camara*), and (D) Syringa (*Melia azedarach*).

Biochar production steps

Production of biochar requires plant material (feedstock), which is then subjected to the pyrolysis process (Fig. 2), which Weber and Quicker (2018) defined as the thermochemical decomposition of fuel at elevated temperatures without the addition of external oxygen.

Recommendations

Biochar products can be used for various reasons, ranging from carbon sequestration to water retention in the soil. Alternatively, biochar is a highly porous product with a high volume of micropores, depending on the feedstock used. Biochar also helps to improve the soil quality and is environmentally sustainably and eco-friendly. Thus, incorporating biochar into the soil will be a way of getting carbon into soils, improving soil microporosity, and thus enhancing the soil's water retention capacity.

References

Clough, T.J., Condron, L.M., Kammann, C. and Müller, C. 2013. A review of biochar and soil nitrogen dynamics. *Agronomy*, *3*(2), pp.275-293.

Feng, Q., Wang, B., Chen, M., Wu, P., Lee, X. and Xing, Y., 2021. Invasive plants as potential sustainable feedstocks for biochar production and multiple applications: A review. *Resources, Conservation and Recycling*, *164*, p.105204.

Lehmann, J.; Joseph, S. Biochar for environmental management: An introduction. In *Biochar for Environmental Management, Science and Technology*; Lehmann, J., Joseph, S., Eds.; Earthscan: London, UK, 2009; pp. 1–12.

Verheijen, F., Jeffery, S., Bastos, A.C., Van der Velde, M. and Diafas, I., 2010. Biochar application to soils. A critical scientific review of effects on soil properties, processes, and functions. EUR, 24099(162), pp.2183-2207.

Weber, K. and Quicker, P., 2018. Properties of biochar. *Fuel*, *217*, pp.240–261.

Acknowledgements

The European Union's Horizon 2020 Research and Innovation Programme, under the grant agreement 01000348, and the Agricultural Research Council are acknowledged for funding and institutional support.

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Figure 2. Biochar production steps . A) cooker compartment being loaded with feedstocks, B) boiler being filled with water, C) cooker compartment placed in the middle of the stove, D and E) a fire was prepared outside the cooker compartment and a lid placed on the kiln stove, F) biochar removed from the cooker (after cooling if with a bit of water and air-dried).

Spuds of Success: A Timeline of Potato Breeding in South Africa and Prominent Cultivars

Compiled Ntombokulunga Mbuma and Philip Steyn

Potato production in South Africa was originally limited to specific areas where the climate suited the potato cultivars introduced from European countries. The major potato production areas were the highlands of the Mpumalanga and Free State Provinces, where potatoes were planted during spring and grown without supplementary irrigation. Although the rest of the country had a limited production in scattered areas, the supply of fresh potatoes was completely seasonal.

In South Africa, the Department of Agriculture established a potato breeding programme in 1947. Early breeding efforts focused on developing varieties that were resistant to diseases such as potato leafroll virus, late blight and the potato cyst nematode. One of the major breakthroughs in potato breeding in South Africa came in the 1960s with the development of the BP1 variety, which is known for its high yield and disease resistance. In the 1980s, the programme focused on developing new potato varieties with improved yield, high yielding with a good skin finish and common scab resistance.

Potato production in South Africa increased dramatically after the release of the first locally developed varieties, which were adapted to shorter day length conditions and resistant and/or tolerant to the prevailing pests and diseases. Production and yield increased from here due to good seed production, mechanization and irrigation, with production increasing by 20-80% over time. This increase in production was not only due to the development of new production regions in the Limpopo, Free State, Western Cape and Kwazulu-Natal Provinces, but also due to the utilization of different planting dates and seasons in the existing production regions. The expansion of potato production to regions with widely different climates and the utilization of different seasons in these regions, ultimately led to the current need for varieties with improved yield stability, heat tolerance, drought tolerance, and pest and disease resistance. The use of niche varieties fell away due to seed production areas becoming scattered over the country, dictating the use of more widely adapted varieties. Currently, varieties are grouped in processing and table varieties. Processing needs relate to specific sizes, shapes and dry matter content of tubers that is dependent on the products being packed. Production for the table market focused on good skin finish and yield for the farmer. Average yields increased since the 70's from below 20 tonnes per hectare to over 30 tonnes per hectare in the 90's, to 48 tonnes per hectare today. However, today 60-70 tonnes per hectare is not uncommon under certain conditions.

In the late 1990s, the breeding programme targets changed to varieties that are high yielding, have good processing qualities (i.e., high dry matter content), good skin finish, resistance to common scab and tolerance to heat. It takes seven to 15 years from the seedling stage to the release of a new commercial variety (Figs 1 to 3). Since the inception of the ARC-VIMP potato breeding programme, 22 varieties were released. Most of the potato varieties were bred and released prior to the year 2000 (Table 1). In general, the varieties released by the ARC showed high dry matter content and were of good quality.

From the period 2010 to present, varieties released were ARC-PT1301, ARC-PT1302, ARC-Freek and ARC-Arno. In general, the ARC potato varieties are characterized by high tuber yield, good processing quality traits, and resistance to virus and fungal diseases (Table 1). The ARC potato breeding programme continues to work on developing new varieties that are well suited to the changing climate and pest pressures, as well as meeting the demands of consumers and the food processing industry.

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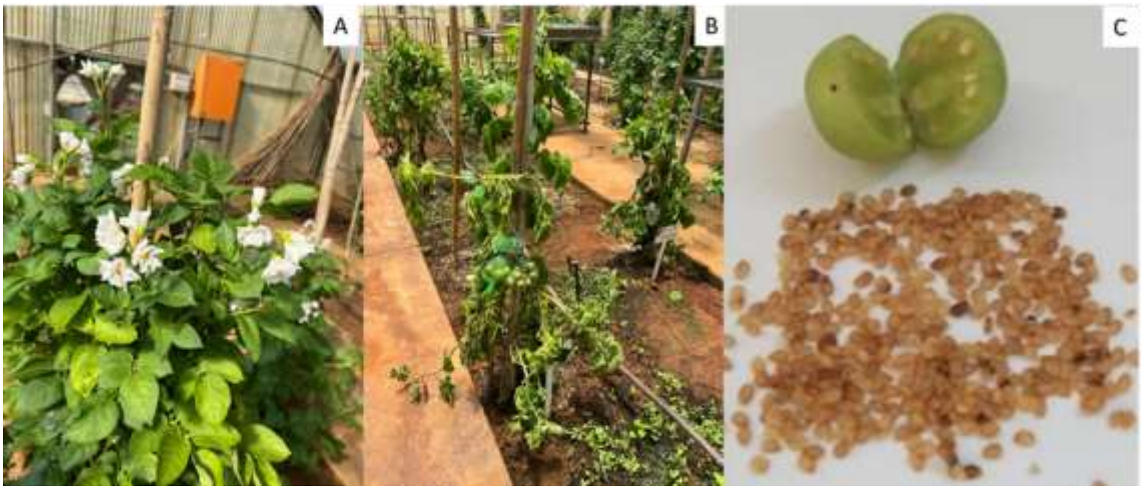
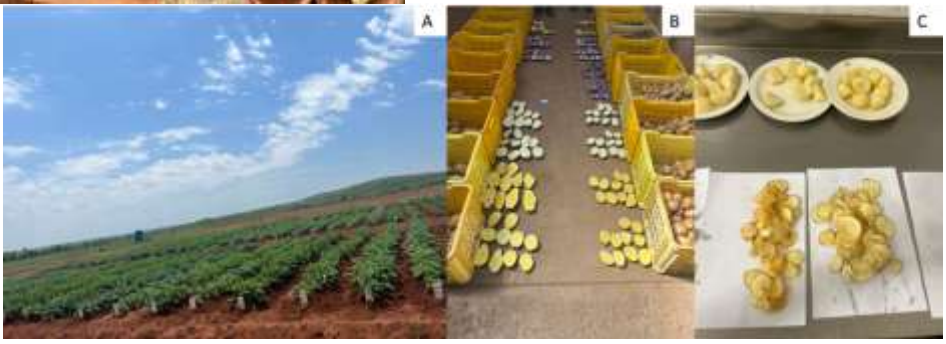


The potato crossing programme: A) Parents flowering, B) Successful hybridization with the formation of potato fruit berries, and C) Fruit berry and true potato seed.

A) Seedling from true potato seed, B) Transplanted seedlings to produce mini-tubers, and C) Harvesting of mini-tubers to be planted as the first generation in the field.



A) Advanced potato breeding trial, B) Tuber evaluation, and C) Tuber quality evaluation.

Table 1. Agricultural Research Council (ARC) released potato varieties and their characteristics

Cultivar	Grant date	Yield potential*	Dry matter	Tuber size distribution	Tuber shape	Internal brown spot	Hollow heart	Skin colour	Flesh colour	Heat tolerance
ARC-Arno	07-May-21	Average	High	Good	Long	Seldom	Occurs	White/cream	White	-
ARC-Freek	07-May-21	High	Good	Good	Oval	Seldom	Seldom	White/cream	White	-
ARC-PT1301	03-Jun-16	High	Good	Good	Oval	Seldom	Seldom	White/cream	White	-
ARC-PT1302	03-Jun-16	High	High	Good	Oval	Seldom	Seldom	White/cream	White	-
Alto	11-Mar-97	Average	Good	Medium to small	Round	Seldom	Seldom	Slight colour markings	Light yellow	-
Aviva	11-Mar-97	Average	Good	Good	Round	None	None	White/cream	Cream	Good
Caren	11-Mar-97	Low	Good	Medium to small	Oval	None	Occurs	White/cream	Cream	Good
Charlie	11-Mar-97	High	Good	Medium to small	Oval	Occurs	Occurs	White/cream	Cream	Good
Darius	11-Mar-97	High	High	Medium to small	Oval	Seldom	Seldom	White/cream	White	-
Dawn	11-Mar-97	High	High	Good	Oval	None	Seldom	White/cream	White	Good
Devlin	01-Jul-97	Low	High	Good	Oval	None	Seldom	White/cream	White	Good
Eyrn	09-Sep-98	High	Good	Good	Oval	None	None	White/cream	White	Good
Esco	09-Sep-98	Low	High	Medium to small	Oval	Seldom	None	Slight colour markings	Light yellow	-
Evan	09-Sep-98	Low	Good	Medium to small	Long	None	None	White/cream	Cream	Good
Fabien	08-Jul-04	Low	Low	Medium to small	Long	None	Seldom	White/cream	Cream	-
Frodo	08-Jul-04	Low	Low	Medium to small	Long	None	None	Slight colour markings	Cream	-
Hoevelder	08-Jul-04	High	Good	Good	Round	None	Seldom	White/cream	Cream	Good
Mnandi	18-May-88	Average	Good	Good	Long	None	None	White/cream	Cream	Good
Ronn	29-Sep-95	Average	Good	Medium to small	Oval	None	None	White/cream	Cream	Good
Ropedi	29-Sep-98	High	Good	Good	Round	None	None	White/cream	Cream	Good
Rotharo	29-Sep-95	Low	Low	Medium to small	Oval	None	None	White/cream	White	Good
Ronewa	18-May-88	Low	Low	Medium to small	Oval	Occurs	None	White/cream	Cream	-
Sandvelder	18-May-88	High	Good	Good	Round	Occurs	None	Slight colour markings	White	-

**Low yield = 20-30 t/ha, average yield = 30-40 t/ha, high = 40-50 t/ha*

Adaptability and stability of selected cassava cultivars in South Africa

AB Assefa, MW Bairu, R Marx and SL Venter

Cassava is an attractive food and industrial crop in many tropical and sub-tropical regions worldwide. With increasing climate variability, cassava has proven to be amongst the most resilient food security crops for more than 800 million people in Sub-Saharan Africa (Tonukari 2004). Cassava was suggested as an alternative starch crop following the severe drought South Africa experienced in 2016 and 2017. There were positive developments, such as the Southern African Development Community (SADC) that recognized cassava as one of the potential industrial crops for SADC farmers, and the Department of Trade and Industry (DTI) included cassava starch in the industrial policy action plan to promote trade activities in the industrialization of cassava in South Africa. The Agricultural Research Council (ARC) and the Technology Innovation Agency (TIA) has a collaborative research project on cassava to provide the blueprint for cassava primary production in South Africa to support a starch industry that imports huge amounts of raw material. To this effect, a multi-location on-farm cultivar evaluation trial was conducted at six locations in three provinces, namely, Mandlakazi and Mutale (Limpopo), Masibekela and Shatale (Mpumalanga), and Nseleni and Mabuyeni (KwaZulu Natal) (Fig. 1). Studying the adaptability and stability of genotypes in a wide range of environments is imperative because genotypic performance alone can be misleading due to the sensitivity of genotypes to environmental fluctuations (Yan et al. 2007). Likewise, stability alone does not ensure a high yield since a consistently low-yielding genotype can also be stable. Studying the quality and suitability of the target environments is also important for future breeding programmes. This study aimed to examine the effect of genotype, environment, and genotype × environment interaction on fresh root yield and dry matter content and to identify superior cassava genotypes with high performance and stability.

Figure 1. Map of a portion of South Africa showing the six trial sites in Limpopo, Mpumalanga and KwaZulu Natal provinces.


Open field production of cassava.

The study evaluated 10 introduced cassava cultivars acquired from the International Institute of Tropical Agriculture (IITA) and the Kenya Agricultural and Livestock Research Organization (KALRO) via the University of KwaZulu-Natal and one landrace from South Africa. The trial was established from disease-free, hardened-off in vitro tissue cultured plantlets and maintained under rainfed conditions. Neither fertilizers nor pesticides were applied. Fresh root and dry yield data were collected and analysed. The performance and stability of the genotypes were also analysed .

Fresh root yield

The vertical line in Fig. 2A & 2B represents the mean fresh root yield (FRY) of 74 tons ha-1. Genotypes on the right side of the vertical axes are high yielding, hence, 98/0002 was the highest-yielding genotype, followed by MSAF2 and UKF3. Similarly, environments located on the right side of the vertical axis are considered high-yielding environments, hence Mandlakazi and Mutale were identified as higher-yielding environments. However, Mabuyeni and Shatale were intermediate and Masibekela and Nseleni were relatively low-yielding environments. The horizontal line represents the stability of the cultivars in which cultivars located near the horizontal axis are considered more stable and those that are further away are unstable. Genotypes 98/0505 and P4/10 were relatively stable, while UKF9 and UKF7 were the most unstable. Likewise, Masibekela and Mabuyeni stood out with no or little contribution to the genotype by environment interaction (GEI), Mandlakazi with a small contribution, and Nseleni, Shatale, and Mutale as having a high contribution to the interaction.

In Fig. 2C, the first interaction principle component axis (IPCA1) was plotted against the IPCA2. Genotypes and environments that were positioned near the origin or on the horizontal axis had the least interaction. Therefore, UKF4, 98/0002, and UKF5 had no or little interaction with the environments, while 98/0505, P1/19, P4/10, UKF3, and UKF8 revealed a minimum interplay between genotype and envi-

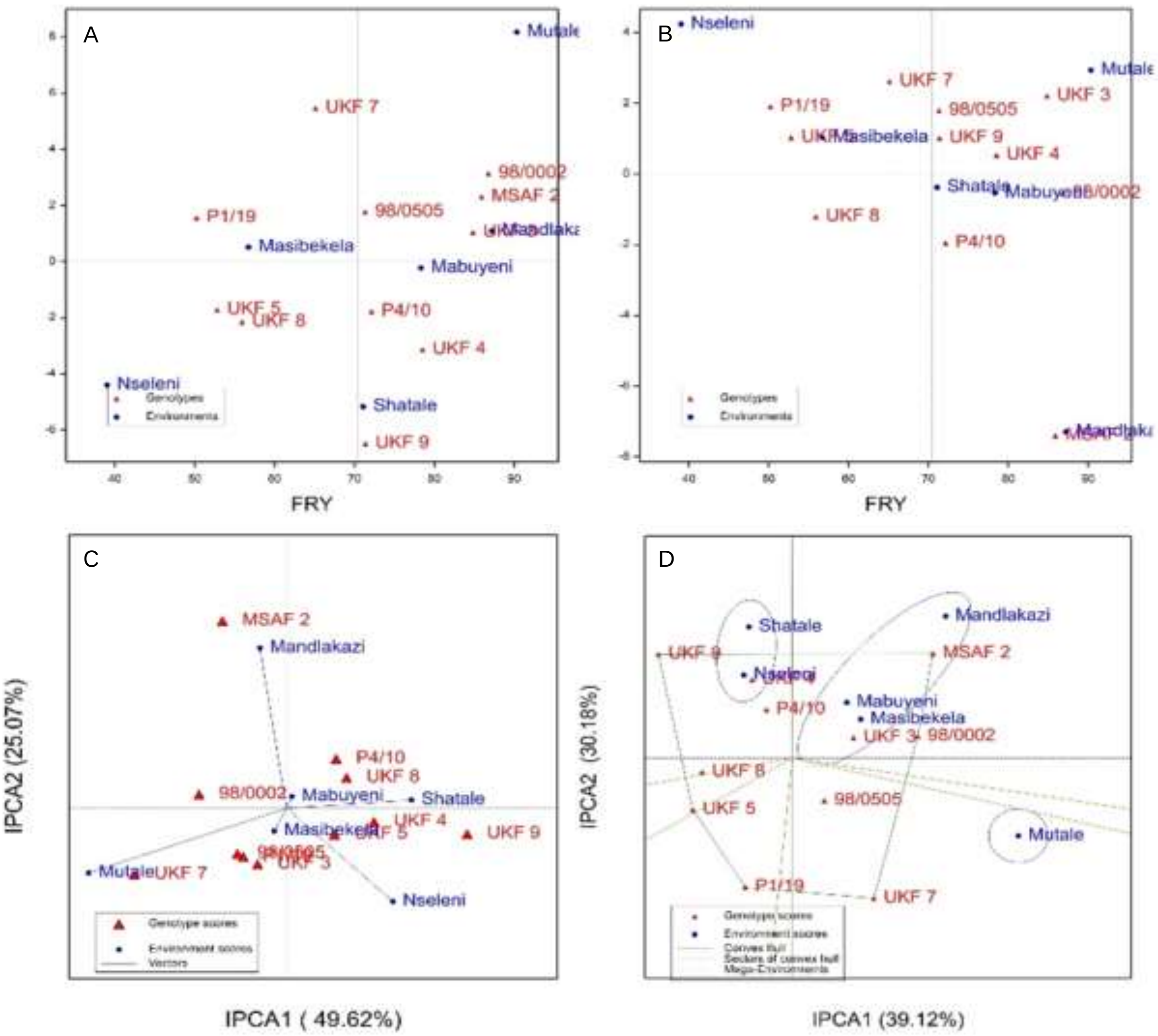


Figure 2. Biplot analysis for 11 cassava genotypes evaluated in six trial sites for fresh root yield (FRY). (A) = AMMI1 biplot showing the IPCA1 vs. main effect (means); (B) = AMMI1 biplot showing the IPCA2 vs. main effect; (C) = AMMI2 biplot showing the first two principal axes of interaction (IPCA2 vs. IPCA1), and (D) = GGE plot.

ronments. MSAF2, UKF9, and UKF7, on the other hand, contributed the most to the interaction variance. Masibekela and Mabuyeni were the largest contributors to the phenotypic stability, whereas Mandlakazi, Nseleni, and Mutale contributed to most of the interaction variation. When cultivars were positioned closer to a given environment, it indicates that the cultivars have a specific adaptability to the environment. From the analysis, UKF7 had a specific adaptation to Mutale, MSAF2 to Mandlakazi, and UKF9 to Nseleni.

The GGE model (Fig. 2D) determines the winning genotype in each environment, identifies high-yielding and stable cultivars, and discriminates and identifies representative test environments. The model subdivides the target environment into sub-regions (mega-environments). For FRY, three mega-environments were identified. The first mega-environment contains Shatale and Nseleni, with P4/10, UKF9, and UKF4 as the winning genotypes. The second mega-environment constituted of Mandlakazi, Masibekela, and Mabuyeni, where 98/0002, UKF3, and MSAF2 were the best cultivars, while Mutale formed the last mega-environment, with UKF7 as the winning genotype.

Dry matter content

The AMMI analysis for dry matter content (DMC) revealed that the mean DMC was 43.3%. Majority (64%) of the cultivars had DMC values higher than the mean. Genotypes P1/19 and UKF9 had the highest DMC while UKF5 and UKF4 had the lowest DMC values. Among the locations, Mutale and Shatale had the highest performance in DMC. Genotype 98/0505, P1/19, and UKF8 had the maximum GEI and were the most unstable genotypes whereas 98/0002, P4/10 and UKF4 were the most stable genotypes with the least interaction with the environment. Shatale and Mabuyeni were the largest contributors to the GEI whereas Mutale and Nseleni were the least contributors of the GEI (Fig. 3A).

MSAF2, P4/10, 98/0002 and UKF3 were the most stable genotypes with the least interaction, while UKF7, 98/0505, UKF4, P1/19, UKF5 and UKF9 were the most unstable genotypes. Shatale, Mabuyeni, and Nseleni were the larger contributors of the GEI and Mutale was the least contributor. There was a positive interaction between Shatale and 98/0505, Mabuyeni and P1/19, Nseleni and UKF7 and Masibekela and UKF3 (Fig 3B).

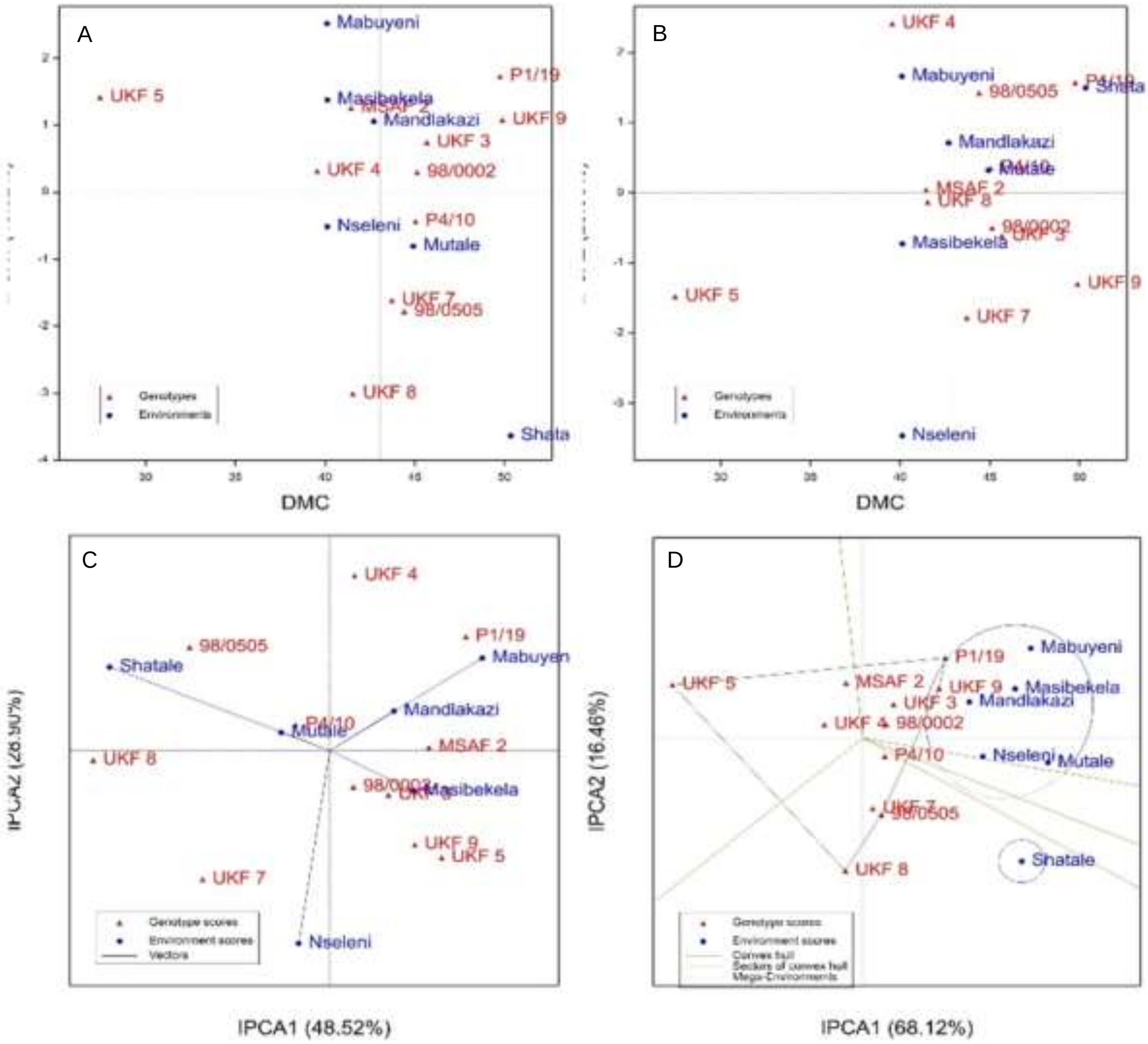


Figure 3. Biplot analysis for 11 cassava genotypes evaluated at six trial sites for dry matter content (DMC). (A) = AMMI1 biplot showing the IPCA1 vs. main effect (means); (B) = AMMI1 biplot showing the IPCA2 vs. main effect; (C) = AMMI2 biplot showing the first two principal axes of interaction (IPCA2 vs. IPCA1); and (D) = GGE plot.

For DMC, only two mega-environments were formed based on winning genotypes. The first mega-environment constitutes Mabuyeni, Masibekela, Mutale, Nseleni and Mandlakazi, with P1/19 and UKF9 as the winning genotypes. The second environment contains Shatale, with 98/0505, UKF7 and UKF8 as the winning genotypes (Fig 3C).

Conclusion

Genotypes UKF3, 98/0002 and P4/10 were the most stable genotypes with the highest fresh root yields, whereas 98/0002, UKF3 and UKF9 were found to be the most stable genotypes with high DMC. However, 98/0002 and UKF3 were identified as combining high stability with superior FRY and DMC. Genotypes identified as high performing and stable for both traits could be utilized as parental genotypes in future breeding programs. Mandlakazi (Limpopo), Mabuyeni (KZN) and Shatale (Mpumalanga) were identified as suitable and representative environments for genotype evaluations and breeding.

References

GenStat. (2020). GenStat for Windows, 19th ed.; VSN International Ltd.: Oxford, UK, 2020.

Jalata Z. 2011. GGE-biplot Analysis of Multi-environment Yield Trials of Barley (Hordeium vulgare L.) Genotypes in Southeastern Ethiopia Highlands. International Journal Plant Breeding and. Genetics 5: 59–75.

Tonukari, N.J. 2004. Cassava and the future of starch. Electron. Journal Biotechnology 7: 5–8.

Yan W.; Kang M.S.; Ma B.; Woods S.; Cornelius P.L. 2007. GGE Biplot vs. AMMI Analysis of Genotype-by-Environment Data. Crop Science 47: 643–653.

Acknowledgements

The Department of Agriculture, Land Reform and Rural Development and the Agricultural Research Council are acknowledged for funding and institutional support.

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Connecting WRC-funded students to water-related research

Compiled by Beverly Mampholo, Hintsa Araya, Mduduzi Sithole, David Sehlola and Mariette Truter

South Africa is mostly a dry to semi-dry country, with low and erratic rainfall (less than 500 mm on average per year), high evaporation rates, and infertile soil. Consequently, crop production is limited, particularly in rainfall-dependent areas, which account for approximately 80% of the country's cultivable territory. The research carried out at the Agricultural Research Council-Vegetable, Industrial and Medicinal Plants (ARC–VIMP) illustrates the benefits of adopting climate-smart research on water resources. The campus engages in collaborative research with many entities, such as the DALRRD, the WRC, and the EU. This work is consistently showcased to farmers, students, and researchers.

On May 14, 2024, postgraduate students embarked on an educational journey and gained industry exposure at the ARC-VIMP, Roodeplaat campus. (Fig. 1). The WRC organised the visit in collaboration with GreenMatter, with the goal of educating students on some of the real-world issues that require innovation in the water and related sectors, demonstrating how research can lead to practical solutions, and giving students a firsthand look at what scientists do on a daily basis. Ms Shanna, the WRC's Research Development Innovation Manager, who initiated the visit, said "that through this programme we annually support a group of postgraduate students with bursaries and also allow them to participate in an expanded professional development programme called the "Water Fellowship". The fellowship supports over 30 students enrolled at various universities studying agronomy, plant and soil science, botany, conservation ecology, agrometeorology, water-related research programmes on wastewater treatment, water resource engineering, biotechnology, hydrogeology, hydrology, and water quality (Fig. 2).

During this excursion, students had the opportunity to observe firsthand open field trial demonstrations (Fig. 3), protected environment trials under hydroponics systems (Fig. 4), analytical laboratory (Fig.5), agro-processing facility (Fig. 6), and crop protection pest and disease observations (Fig. 7). The ARC-VIMP strongly advocates for educational excursions as a means of bridging the gap between theory and practice by granting institutions access to their campus. This not only inspires our students to pursue successful careers in agriculture, but it also provides them with valuable insights and career opportunities in their areas of specialisation.

Positive feedback was received from the students, as well as from the WRC personnel on the research that was demonstrated. This interaction will strengthen the collaboration that the ARC has with the WRC and create awareness among the youth on water related research.

Acknowledgements

The Department of Agriculture, Land Reform and Rural Development (DALRRD), the European Union's Horizon 2020 Research and Innovation Programme, under the grant agreement 01000348, the Water Research Commission (WRC) and the Agricultural Research Council (ARC) are acknowledged for funding the research.

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Figure 1. Group photo of students with the ARC-VIMP, GreenMatter and WRC personnel.

Figure 2. The engagement session with students supported by the Water Fellowship.

Figure 3. Mr. Thabo Nkuna and Dr Lodama Kafua presented at the field trials of the DIVAGRI projects on water saving irrigation technologies under Moringa intercropped with vegetable crops. They also demonstrated the potential production of biochar from invasive plants to improve soil water filtration and retention, nutrient availability, and reduce leaching of agricultural chemicals, which can contribute significantly to limit crop failures.

Figure 4. The hydroponic team showcasing the success of the vertical recirculating hydroponic system on leafy vegetable production.

Figure 5. The students visited the Medicinal Plants Analytical Laboratory, which supports interdisciplinary research programmes on biological screening, chemical profiling, and the isolation and identification of compounds from natural plant products (Dr Anele Mpupa (top) and Mr Bernard Mabotja (bottom)).

Figure 6. Interacting with the students on agroprocessing and prototypes of products developed from indigenous crops and medicinal plants (Dr Ebrahiema Arendse).

Figure 6. The crop protection team (Dr Diedrich Visser - Entomologist, Dr Julia Mulubisana - Viriologist and Ms Brightness Nkosi - Mycologist) educating the students on the identification of various pathogens and the successful management of pests in vegetable production.

International collaboration and visit

Compiled by Prof AS Gerrano[1], Dr Willem Jansen Van Rensburg[1], Dr Mariette Truter[1], Dr Inge Gazendam[1], Dr Adeola Adeola Rotimi[2], Dr Nemera Shargie[3] and Prof Michael Bairu[1]

The Kirkhouse Trust (KT) based in the United Kingdom visited the ARC-VIMP and GC on 31 July and 1 August 2023, respectively. The objective of the visit was to establish collaboration between the ARC and the KT to promote the improvement, and boost the productivity, of important and underutilized legume crops in South Africa via the application of different breeding tools. The strategy of the KT is to support research and development, and capacity building segments targeting sub-Saharan Africa, including South Africa, by providing research grants, improving basic infrastructure of the laboratories, screening glasshouses, advice, training, ongoing mentorship, equipment and supplies to enable the researchers to use molecular biology tools to support crop improvement so that the work can be done in-country.

The KT is currently reaching out to make new contacts and expand their understanding of current ARC legume research projects and the people executing them. The KT expressed their interest during a Microsoft Teams meeting organized by Dr AS Gerrano on 10 July 2023. The KT visited the ARC and met the research team and viewed the current available infrastructure (the ARC-VIMP, ARC-BTP and ARC-GC campuses based in Pretoria and Potchefstroom, respectively). The purpose of the visit was to observe the current ARC organizational infrastructure (greenhouses, genomic and analytical labs) and to discuss how the KT could support projects on crop improvement within the ARC legume research programme.

By meeting face to face, both parties had an opportunity to discuss at length the ideal project that the KT could fund in the ARC. This was a good opportunity to network with the international scientists and funders. Furthermore, the ARC researchers benefited from hosting the delegation by the exchanging of skills, experiences, knowledge and funding opportunities for the breeding programmes of underutilized legume crop species in South Africa. The visit was a platform for showcasing the ARC's achievements and its research facilities at the three campuses mentioned above. The visiting team explained the procedures to be followed in the grant applications. The process will start with the development of concept notes for new projects, after which suitable projects will be selected and detailed project proposals will be requested for evaluation and funding. The meeting presented an opportunity to network with the KT of the UK to the benefit of both parties, which could lead the ARC to new strategic partnerships with other pilot countries in Africa and in the world.

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From top to bottom: Group photo of visitors with the ARC-VIMP scientists, discussion on the variety of analytical work offered at the ARC-VIMP and group photo of visitors with the ARC-BTP scientists.

From field experiments to Southern African Plant Breeders' Association Conference: ARC researchers exploring the latest research findings

Compiled by Ntombokulunga W. Mbuma

The Southern African Plant Breeders Association was established to promote the science and art of plant breeding and facilitate discussions on recent developments in plant breeding technologies and methodologies among private and public crop breeding institutions, as well as increasing collaboration. The purpose of the symposium is to further increase cooperation among breeders and associated scientists to maintain high standards and practices among breeders to ensure higher genetic gains of cultivars produced, and to contribute towards stable and sustainable agriculture in Southern Africa. International invited guest speakers provided insights into developments in plant breeding across the world, providing a benchmark for Southern Africa crop breeding efforts.

The 15th Southern African Plant Breeders' Association symposium took place from 11th to 13th March 2024, at the Monte Bello Estate, located near Bloemfontein. The theme of the 2024 symposium was "Sustainability". Over three days, a range of papers were presented demonstrating the relevance of research to the agriculture industry, science and academic communities. The symposium was divided into six sessions: 1) Sustainability - our responsibility, 2) Corteva Student Session, 3) Plant Breeding Crossroads, 4) Plant Breeding Technologies and Innovation, 5) Omics, and 6) Plant Health. Each session started with a keynote speaker, followed by oral presentations. Eleven ARC-VIMP staff members (researchers and technicians) attended the conference (Fig. 1), and contributed through oral presentations (two Flash talks – student competition), nine out of 33 posters (four on cowpea, two on cassava, two on potato and one on sweet potato), and panel discussions (Dr Amelework Assefa and Mr Khethani Mhelembe). Student posters were evaluated and Mr Moshieng Ntswane (ARC-GC: PhD student registered with the University of the Free State) was awarded the best poster presentation that was titled "Variation in seed protein, selected minerals, phytic acid and potential mineral bio-availability of cowpea [*Vigna unguiculata* (L.) Walp] mutants and accessions". For this research, Mr Ntswane was supervised by Dr Ntombokulunga Mbuma (ARC-VIMP), Prof Maryke Labuschagne (University of the Free State) and Dr Siphiwokuhle Shandu (ARC-GC). Dr Ntombokulunga Mbuma (ARC-VIMP) and Mr Khethani Mhelembe (ARC-VIMP) were elected as members of the executive committee for the period March 2024 – March 2026.

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The ARC-VIMP staff at the Southern African Plant Breeders' Association (SAPBA) Conference. Back left to right: Mr Khethani Mhelembe, Mr Pierre Fourie, Dr Ntombokulunga Mbuma, Dr Amelework Assefa, Ms Mary Maluleke, Ms Mmapaseka Malebane, Dr Mbali Gumede, Prof Abe Gerrano. Front left to right: Ms Roelene Pienaar, Ms Milcah Matjeke, and Dr Sunette Laurie.

Technology transformation: empowerment of stakeholders with variety selection

Compiled by Abe Gerrano, Milcah Masemola, Abueng Moalafi, Kgomotso Seerane, Leoka Mphuthi, Lindiwe Khoza, Julia Mulabisana, and Mariette Truter

Participatory research drives community-led innovation, aimed at encouraging widespread technology adoption of economically viable and ecologically resilient sustainable agricultural production practices among smallholder farmers. Demand driven participatory plant breeding is an approach by which the end users, in particular smallholder farmers, are closely and actively involved in participatory varietal selection and, sometimes, in making crosses and the development of new varieties. This provides an opportunity for farmers to make an informed decisions for the selection of demand driven target products throughout the breeding cycle. It also helps farmers adapt technologies to local agro-ecologies and social and economic conditions, using indigenous and common knowledge.

The Department of Agriculture, Land Reform and Rural Development (DALRRD) is supporting the projects for improvement of legumes and okra for high yield and nutritional value. To help smallholder farmers generate income, the improved varieties will be recommended for production and health benefits for smallholder farmers as part of a participatory breeding programme. This can also help in broadening the South African food-base by making improved high quality plant varieties available to the local farmers and will strengthen the local seed system. Farmer participatory screening of a wide range of cultivars is underway in various provinces, including Limpopo, to select cultivars suitable to the farmers' growing conditions.

The ARC-VIMP, in collaboration with the DALRRD and the Provincial Department of Agriculture and Rural Development of the Limpopo Province and Extension Office, hosted a farmers' day which was held at the ARC Loskop Experimental Research Station, Limpopo Province on 6 February 2024. The event was a culmination of efforts by the Leguminous, Leafy and Fruit Vegetables breeding programme of the ARC–VIMP, with the objective of supporting the smallholder, emerging and commercial farmers in enhancing the agricultural production and productivity in South Africa. In particular, the farmers' day highlighted the collaborative projects focussing on the improvement of legumes and okra production with various stakeholders, including universities, in the country. The event was attended by the scientists from the ARC, University of the Free State, University of Mpumalanga, University of North West, University of KwaZulu Natal, farmers, and private companies who are part of the agricultural value chain. Oral presentations were given by delegates from the ARC-VIMP, the Department of Agriculture and the universities on different topics that are relevant to farmer support. These strengthened the importance of collaboration and participatory breeding in order to scale up and diffuse crop production technology in South Africa.

During the event, products from different crops, such as cassava flour and cassava crisps, were displayed for farmers to see what they can do with produce from different crops. Exhibition material included seeds of cowpea, Bambara groundnuts and okra from the ARC breeding programme, as well as information leaflets and fact sheets of pests and diseases affecting the production of vegetables, legumes and okra, which were also distributed to farmers. The event was a platform for sharing research experience and networking. It is part of the national legume and fruit vegetable pre-breeding programme of the ARC.

Farmers and delegates were taken to the field, where the farmers got to explore the different crops (cowpea, okra, groundnuts and cassava). The farmers were able to learn about the kind of support available to them if they are interested in growing the crops on their farms. The event was a success according to the positive feedback from the guests of honour, the "farmers".

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Scientists of the Leguminous and Okra breeding team at the ARC-VIMP.

Attendees taking notes during the presentations.

Farmers visiting the okra, Bambara groundnut and cowpea fields and getting exposed to the cultivation, seed production and markets of these crops.