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OILSEEDS focus

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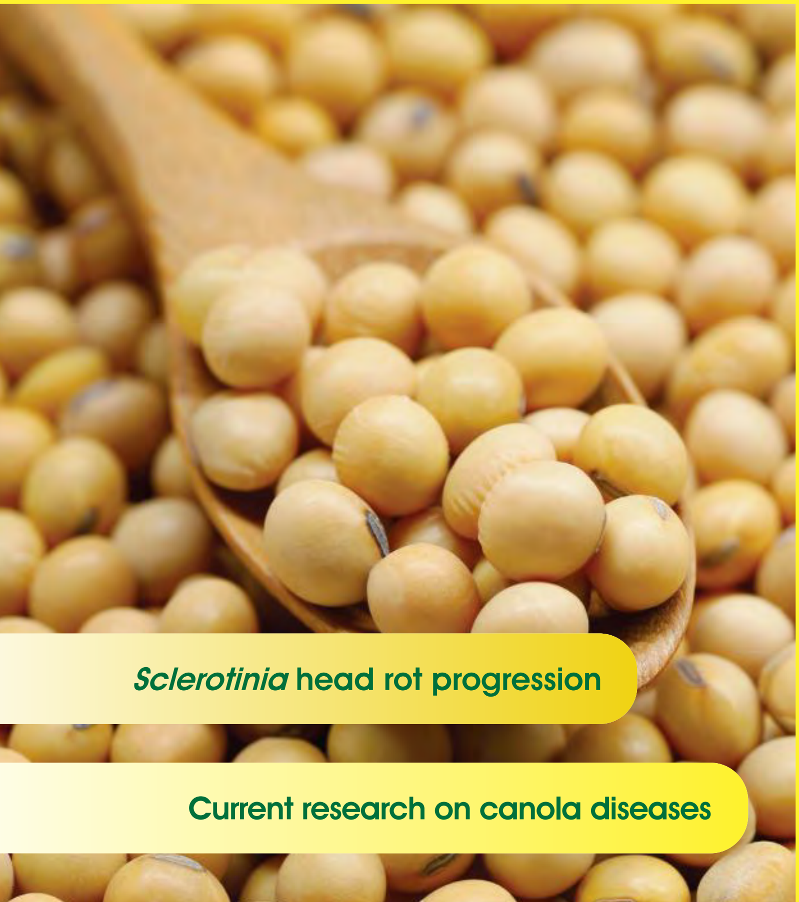

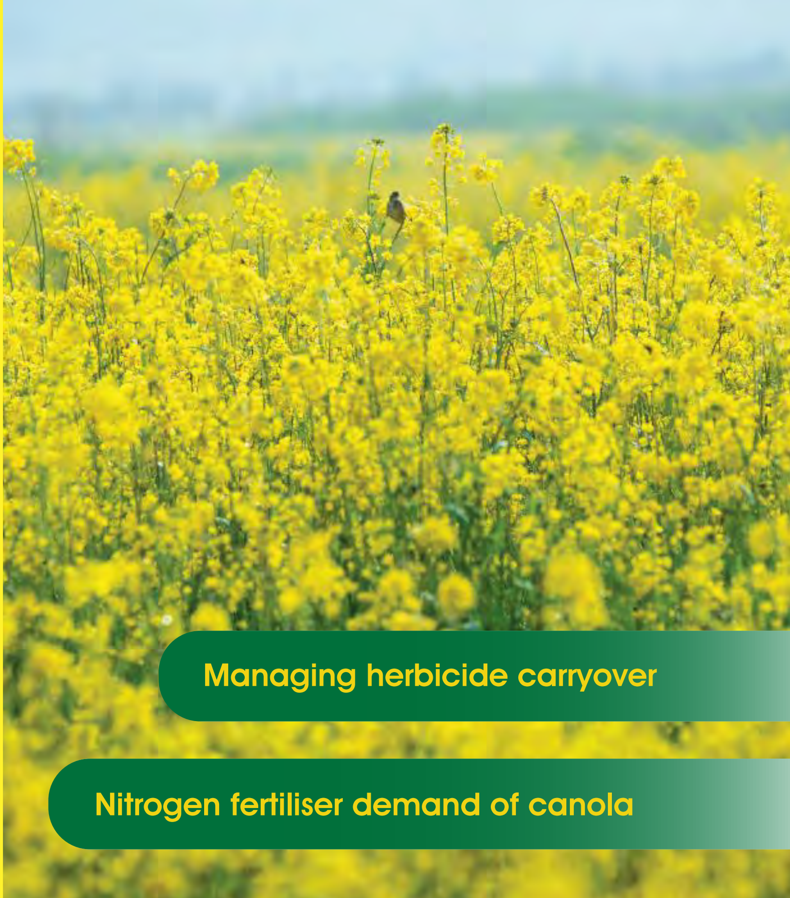

Sclerotinia head rot progression

Managing herbicide carryover

Current research on canola diseases

Nitrogen fertiliser demand of canola

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Innovation with Integrity


Wiana Louw.

Testing in support of food safety

By Wiana Louw, general manager, The Southern African Grain Laboratory

South Africa produces excellent quality grain and oilseeds to meet both domestic food and feed needs. But how do we assess the quality of the commodities we produce and how do we compare it with what we import?

The answer lies in reliable, internationally benchmarked testing facilities. These facilities enable the development of databases containing long-term, quality data paramount for good decision-making and marketing.

The World Health Organization, or WHO, regularly publishes data on the impact of foodborne diseases. This information highlights the strain on healthcare systems and the harmful effects on national economies, tourism and trade. Decisions taken to confirm that foodstuffs are safe and nutritious for consumption, risk assessments that inform food safety legislation, and rejection of export/import consignments are all based on the measurement results produced by food testing laboratories.

Ensuring peace of mind

The core requirements for producing reliable and comparable measurement results are described in the ISO/IEC 17025 international standard for the competency requirements of calibration and testing laboratories. From a consumer perspective, there is a need for information regarding the quality of the products they buy and consume, and at the same time peace of mind that contaminants such as naturally occurring toxins (e.g. mycotoxins) and environmental pollutants (e.g. persistent organic pollutants or POPs) are being monitored and managed to ensure safe final products.

These contaminants can infiltrate our staple foods such as maize and other cereals, as well as oilseeds. Through consumption, they accumulate in the human body. To prevent long-term exposure and risks, such as immune system disruption, developmental issues or cancer, monitoring programmes are essential. These programmes enable food and feed-producing facilities, through the survey results, to manage the levels of mycotoxins and/or POPs, when present, to minimise the risks they pose to food and feed safety.

Other concerns include heavy metals such as lead, cadmium and mercury which can cause neurological and kidney damage, and thus need to be monitored as well.

Key role of laboratories

World Laboratory Day, which was celebrated on 23 April this year, highlighted how controlled laboratory spaces have benefited humans over the years. In the past decades, science and research reached new heights across the world, increasing the scope laboratories need to cover in order to address regulations and voluntary agreed standards for food and feed safety.

This has also resulted in the need for large-scale testing laboratories with the capability to conduct research in accurate measurement and to stay abreast of food and feed industry requirements.

Risks and acceptance of results

Discussions on the risks of contaminated food and feed always include references to the availability of accurate measurement to provide answers and guidance to manage the risks effectively. The recent recall of certain products due to higher-than-acceptable levels of aflatoxin again highlighted the importance of regular monitoring for contaminants such as mycotoxins.

To facilitate fair trade and ensure food safety, international standards such as ISO/IEC 17025 are being implemented. This standard outlines general requirements for competent, impartial, and consistent laboratory operations. It also establishes traceability of the measurement result to the International System of Units, the SI. Results generated under this standard, anywhere in the world, will be accepted globally.

The importance of having these well-established capabilities in any country can therefore not be underestimated. Regulatory changes to align with global trade partners require sound scientific data to substantiate the proposed changes. For South Africa, it is not only important to have a good regulatory framework, but also to be able to prove compliance.

Global competitiveness

While advances in specialised testing equipment are improving the testing capabilities of laboratories on an ongoing basis, this technology comes at a price. Investing in the latest technologies must be weighed against the need for South (and Southern) Africa to remain globally competitive and to protect the health of its population(s). For the grain and oilseed sectors, the value of having sound scientific data justifies the major investments required to maintain the testing facilities to ensure efficiency in the grain and oilseed value chain.

An important pillar of research and development is the collaboration between academic institutions and the agricultural industry to ensure effective solutions through targeted research, and to create an understanding of the application and interpretation of testing results. The Southern African Grain Laboratory NPC collaborates with several universities on research studies which were developed based on the available long-term monitoring data.

For more information, contact Wiana Louw on 012 807 4019 or email Wiana.Louw@sagl.co.za.

Agricultural trade: An overview

The growth value of South African agricultural trade was 17% year-on-year at the end of 2023. The value of exports is still almost double that of imports. This is despite the logistical challenges the industry has faced, and continues to face – notably the performance of our ports. The agricultural industry's main export trading partners are the European Union and the Southern African Development Community.

Unfavourable weather conditions

So much has changed since the last edition of *Oilseeds Focus*. Anticipated rainfall in early 2024 turned out to be inconsistent and numerous areas had to contend with below-normal rainfall. This culminated in a significant reduction in maize and soya bean volumes produced this season.

Maize production is estimated at 13,39 million tonnes, 19% less than in 2023, and soya bean production at 1,82 million tonnes, 34% lower than the record crop of the previous season. Sunflower production was fortunately slightly less affected at an estimated 615 000 tonnes, 15% less than last season.

A record 237 450 tonnes of canola were harvested in the winter rainfall region in 2023. In terms of the current season, the record intentions to plant of 141 100ha are looking very promising.

Price increases

The rapid transformation from exporting to importing maize and soya bean/soya bean meal, due to the lower yields, resulted in expected price increases. When comparing the first few days of trading in May, South African Futures Exchange (Safex) prices increased – white maize increased by R1 550, yellow maize by R590, soya bean by R783 and sunflower by R610/tonne.

Green soya beans

The industry has experienced an unusually high percentage of green soya beans in certain areas of the country this year. This resulted in the downgrading or rejection of soya bean deliveries. Green soya beans present the challenge that, if present at excessive levels, oil will have a green colour once processed, rendering it commercially unusable. Full-fat soya will also have a green colour and will be rejected by the end user. These beans have been shown to contain some abnormal nutrients, and it is much more difficult to reduce trypsin inhibitors during processing.

Efforts are ongoing to understand the implications of the high percentage of green beans. Many storage operators have come to the aid of the industry by creating a possible blending strategy. The implications for the quality of soya bean meal are also being assessed. The cause is not due to any fault of the producer, but can be ascribed to abnormal weather conditions.

Dr Erhard Briedenhann

Send us your contributions and suggestions to make *Oilseeds Focus* an enjoyable and valuable publication for the oilseeds industry.
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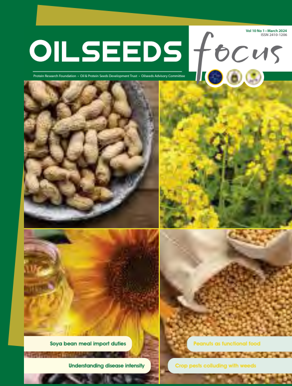
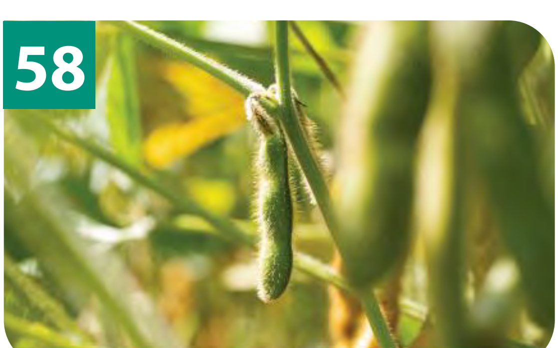


CONTENTS



Tiger Brands opens new facility

Black Cat, South Africa's most loved peanut butter brand, has a new home following a R300 million capital investment by Tiger Brands. The new peanut butter manufacturing facility is in Chamdor, Krugersdorp, on Johannesburg's West Rand.

The plant was officially opened during a celebratory event attended by Tiger Brands' CEO, Tjaart Kruger, and the deputy minister of the Department of Trade, Industry and Competition, Nomalungelo Gina. This is one of the biggest capital investments the company has made in a single project, signalling the opportunity the peanut butter category presents for sustainable returns.

The South African peanut butter category accounts for 50% or R1,7 billion of the total South African spreads market (excluding margarine), which is worth R3,4 billion. Black Cat peanut butter is one of the biggest in the market, with five million kilograms of Black Cat sold per annum in formal retail stores. – *Bizcommunity*

FAO Food Price Index up marginally

The benchmark for world food commodity prices edged higher in April, as higher prices for meat and modest upticks for vegetable oils and cereals outweighed decreases in sugar and dairy product prices, the Food and Agriculture Organization (FAO) of the United Nations reported.

The FAO Food Price Index, which tracks monthly changes in the international prices of a set of globally traded food commodities, averaged 119,1 points in April, up 0,3% from its revised March level, while down 9,6% from its level a year ago.

The FAO Vegetable Oil Price Index increased by 0,3% from March, reaching a 13-month high, as higher quotations for sunflower and rapeseed oil more than offset slightly lower prices for palm and soya oils.
– Food and Agriculture Organization of the United Nations

Sunflower seed production set to grow

The International Grains Council (IGC) expects global production of sunflower seeds to reach 58,5 million tonnes in its first estimate for the 2024/25 marketing season. The anticipated increase in production is based in particular on higher yield expectations despite an approximately 2% reduction in the area planted.

According to the IGC, the reasons for the expected decline in the area are a good global supply of sunflower seed and a low price level.

The output of sunflower seed in the EU-27 is expected to amount to 10,5 million tonnes, slightly more than the 10,2 million tonnes produced in the marketing period 2023/24. According to investigations conducted by Agrarmarkt Informations-Gesellschaft, the IGC anticipates larger harvests, especially for Romania and Bulgaria.

Production is also projected to increase in Brazil and Argentina. For Russia, the world's largest supplier of sunflower seed, the council forecasts a harvest volume of 17,4 million tonnes, which translates to a 200 000 tonne decrease on the current season. – *Biofuels International*

Crop estimates revised

The estimated total production figures of commercial wheat, barley, canola and oats for 2023 as released by the National Crop Estimates Committee (CEC) were revised, using the published figures of the South African Grain Information Service (Sagis) of actual deliveries as the basis for the calculations.

Comparing the final calculated crop figures with the numbers set by the CEC in February 2024, the size of the commercial wheat crop is now 2 050 000 tonnes, which is 28 025 tonnes or 1,35% less than the final crop estimate figure of 2 078 025 tonnes. For barley, the recalculated crop size is 377 000 tonnes, which is 805 tonnes or 0,21% more than the final crop estimate figure of 376 195 tonnes.

The final recalculated canola crop estimate figure is 236 300 tonnes, which is slightly lower (1 150 tonnes or 0,48%) than the final crop estimate figure of 237 450 tonnes. – *Crop Estimates Committee*

Oilseeds rally for import market

India's sunflower oil imports rose by 51% in March from the previous month to reach the second highest level on record, as lower prices led refiners to increase their purchases while reducing buying of rival palm oil, five dealers told Reuters.

Lower palm oil purchases by India, the world's biggest importer of vegetable oils, could cap the rally in benchmark Malaysian palm oil futures that are trading near their highest in a year. Higher sunflower oil purchases will help to reduce sunflower oil inventories in the Black Sea region.

March sunflower oil imports surged 51% month-on-month to 448 000 metric tonnes, the second highest on record, according to estimates from dealers. Palm oil imports fell 3,3% to 481 000 tonnes, the lowest since May 2023, they said. – *Business Standard*


Mixed outlook on global canola production

Australian canola production is expected to rise in 2024/25, while the European rapeseed crop will likely be smaller on the year, according to updated estimates from the United States Department of Agriculture's (USDA) Foreign Agricultural Service.

Citing favourable price expectations for canola compared to wheat and barley, the USDA's Australian attaché was forecasting an 8,5% increase in seeded canola area in the country in 2024/25, with production up by 14% at 6,5 million tonnes. If realised, that would be Australia's third-largest canola crop on record. Canola exports from Australia are forecast at 5,1 million tonnes, which would be up by 16% on the year.

Australian producers already seeded their next canola crop – moisture conditions were generally in better shape than they were a year ago.

Meanwhile, European producers reduced rapeseed plantings in 2024/25 according to the Vienna-based attaché, with the EU ban on the use of neonicotinoids and declining availability of other plant protection products contributing to the smaller plantings. Profitability compared to other planting options in the EU was also said to be behind the 4,8% reduction in area. – *Farmtario*

Kenya promotes fertiliser access

Kenyan president, William Ruto, urged African leaders to adopt strategies to make fertiliser affordable and accessible to producers. Ruto, who opened the Africa Fertilizer and Soil Health Summit in the Kenyan capital of Nairobi, emphasised the need for co-operation among African countries to boost the continent's capacity to produce fertiliser using locally available raw materials.

"Our focus should not only be on increasing fertiliser usage, but also on ensuring its judicious application to revitalise responsive soils and rehabilitate degraded ones," Ruto said.

Ruto called for prioritising investments in nitrogen fertiliser production facilities, developing real-time mechanisms to track fertiliser market trends to ensure timely availability, and developing sustainable strategies to make fertiliser more affordable and accessible. – *Peoples Gazette*

Biofuels battle in Australia

GrainCorp says it will cost the company more than AU$500 million to build a new large-scale oilseed crushing plant as it jostles with Cargill and giant West Australian farming co-operative, CBH, to become a big player in biofuels.

The company's chief executive, Robert Spurway, revealed the price tag recently, saying he was concerned that market speculation around the cost was too low. GrainCorp said it was still eyeing sites in Western Australia for the plant despite Cargill moving first to secure prime land for a crushing operation next to a rail line and the CBH Kwinana grain terminal south of Perth.

Spurway said a final decision would be based on supply of canola and other factors, with sites in the eastern states also in contention. The company's existing processing assets, including a small plant in Western Australia, crushed a record 282 000 tonnes of canola seed in the six months to 31 March. – *Financial Review*

Can fresh approaches save oilseed rape?

The vibrant yellow expanses of oilseed rape are dwindling in western Europe, with growers facing mounting challenges in pest management and a shrinking array of chemical solutions. In regions such as the United Kingdom, crop cultivation has plummeted by up to 70%. Meanwhile, the demand for seed oils continues to rise. Recent geopolitical upheavals, such as the conflict in Ukraine, have worsened the supply crunch. Unless effective pest control measures are devised, further drops in production appear unavoidable.

A special edition of the journal *Pest Management Science* is dedicated to illuminating novel integrated crop protection methods for oilseeds, according to a press release from Rothamsted Research. Emphasising the pursuit of sustainable alternatives to synthetic pesticides, the focus lies on their development and application.

The journal's papers include research demonstrating the potential for controlling cabbage stem flea beetle through nematodes and pathogenic fungi, insights into how innovative taxonomic approaches to disease-causing organisms are paving the way for new control methods, and progress in surveillance technology, including the use of optical sensors to detect invading insects. Additionally, enhanced comprehension of insect pest migration and ecology is yielding promising insights for implementing more precise management strategies. – *SeedWorld.com*

Save the date: WCCA 2024

The ninth World Congress on Conservation Agriculture (WCCA) will take place from 22 to 25 July 2024. For more information, contact Dr Johann Strauss, secretary of Conservation Agriculture Western Cape at johann.strauss@westerncape.gov.za or visit *www.wcca9.org*. The programme can be viewed at *www.wcca9.org/programme-tours#programme-at-a-glance*.

In-field climatic factors driving *Sclerotinia* head rot progression across different sunflower planting dates

By Phrasia Mapfumo, Sikelela Buthelezi, Emma Archer, Dirk Swanevelder, Markus Wilken and Nicky Creux

Sunflower (*Helianthus annuus*) is South Africa's third most important crop (after maize and soya bean). South Africa is a major sunflower-producing country in southeastern Africa (Pilorgé, 2020) and ranks 15th globally (Food and Agriculture Organization statistics, 2022).

Sunflower is mostly grown under dryland conditions in the summer rainfall regions of the country and is usually planted from November to January (Anonymous, 2009). Sunflower can also be considered a catch crop due to its hardy nature and is often grown as an alternative to soya or maize in dry years when rains are delayed (Meyer and Van der Burgh, 2015).

Local production has been declining since 1999, particularly in the North West province, due to several factors including *Sclerotinia* disease incidence (Meyer and Van der Burgh, 2015). *Sclerotinia* head rot is the most significant yield-limiting disease in sunflower, and *Sclerotinia sclerotiorum* was identified as the causal agent (Bolton *et al*., 2006).

Sclerotinia incidence and control

Sclerotinia head rot has been a disease of major concern in South Africa since the first severe outbreaks in the late 1970s (Holtzhausen and Van der Westhuizen, 1980). During the South African 2013/2014 growing season, *Sclerotinia* head rot caused sunflower losses of up to 60% due to the cool, wet conditions (Crave *et al*., 2016). In the 2019/2020 season, sunflower planted in Clocolan in the Free State on 19 December 2019 had around 50% *Sclerotinia* head rot incidence, whereas the January plantings (16 and 27 January 2020) had lower incidences of only about 3 and 6%, respectively (Meiring *et al*., 2021).

Reports suggest that environments associated with a specific planting date are important drivers of *Sclerotinia* head rot establishment and progression; however, no studies have assessed this in South Africa or globally.

Limited measures are currently available to control *Sclerotinia* head rot. Agricultural production practices, such as crop rotations, are ineffective due to the wide host range of *S. sclerotiorum* and the long survival time of soilborne sclerotia (Rothmann and McLaren, 2018). Short-interval, staggered plantings have been suggested as an escape strategy to limit the number of plants flowering during periods of favourable climatic conditions for *Sclerotinia* head rot development. However, in seasons with late rain onset, this may be difficult to manage, especially around the end of the planting window (Bureau for Food and Agricultural Policy, 2020).

Only two biological or chemical control agents against *S. sclerotiorum* are registered in South Africa: the fungal biological control *Coniothyrum minitans* and the fungicide benomyl for preventive use on sunflower seed (Rothmann and McLaren, 2018).

The use of benomyl is prohibited in the United States and Europe due to its toxic effects and is regarded as a food and environmental contaminant (Mehtap *et al*., 2021), thus suggesting a limited life span for this chemical in South Africa. Furthermore, some studies have identified *S. sclerotiorum* strains that are resistant to benomyl, which may further limit the usefulness of this chemical as the pathogen evolves (Gossen *et al*., 2001).

Integrated disease management strategies remain the primary tool to combat infection in sunflower, but the continued unpredictable and severe outbreaks of *Sclerotinia* head rot suggest that the current practices still require adjustments.

Host ranges

S. sclerotiorum is one of two very similar *Sclerotinia* species that have been identified in South Africa (Van der Westhuizen and Eicker, 1988). This necrotrophic fungus is prevalent in humid and temperate sunflower-growing regions globally (Bolton *et al*., 2006). *S. sclerotiorum* has a wide host range of more than 400 host species (Bolton *et al*., 2006) and includes several agriculturally important field and vegetable crops (Rothmann and McLaren, 2018). The pathogen relies on sclerotia (a melanised mycelial mass) for long-term survival in the soil (Bolton *et al*., 2006).

Sclerotinia minor is the other *Sclerotinia* species that has been reported in South Africa and has similar growth conditions and host ranges (Melzer *et al*., 1997). *S. sclerotiorum* and *S. minor* have almost indistinguishable morphological traits, with subtle differences in the size and texture of sclerotia, with side-by-side comparisons of these structures being used to identify the species in the past (Laemmlen, 2002).

With the advent of molecular tools and markers, more accurate sequence or polymerase chain reaction confirmations can now be performed (Abd-Elmagid *et al*., 2013).

Germination processes

Sclerotia are the principal infectious propagules for *S. sclerotiorum* and can germinate either carpogenically or myceliogenically (Bolton *et al*., 2006). Carpogenic germination produces sexual fruiting bodies (apothecia). Apothecia formation generally requires temperatures between 5 and 25°C, with temperatures above 26°C being detrimental to apothecia production and survival (Smolińska and Kowalska, 2018). Ascospores are wind-dispersible and can lead to the colonisation of different above-ground plant tissues (Bolton *et al*., 2006).

In sunflower, head rot results from carpogenic germination of ascospores that tends to occur under 85% relative humidity and temperatures between 5 and 25°C (Clarkson *et al*., 2014; Huang and Kozub, 1991). The ascospores germinate on the sunflower head and enter the plant tissue through senescing florets, resulting in disease establishment (Bečka *et al*., 2016; Harikrishnan and Rio, 2008; Payen, 1983).

Once infection has been established, necrotic lesions form on the back of the sunflower head (Gulya *et al*., 1997). The infection spreads throughout the head, disintegrating and shredding the soft tissue to the typical broom-like appearance. Sclerotia develop in the head after seven to ten days and drops to the ground to re-establish infection (Gulya *et al*., 1997).

Climate factors investigated

Though extensive research into the lifecycle of *S. sclerotiorum* has been done, there have been far fewer studies focussed on understanding the in-field environmental factors facilitating disease establishment and progression in the sunflower head during a *Sclerotinia* head rot infection.

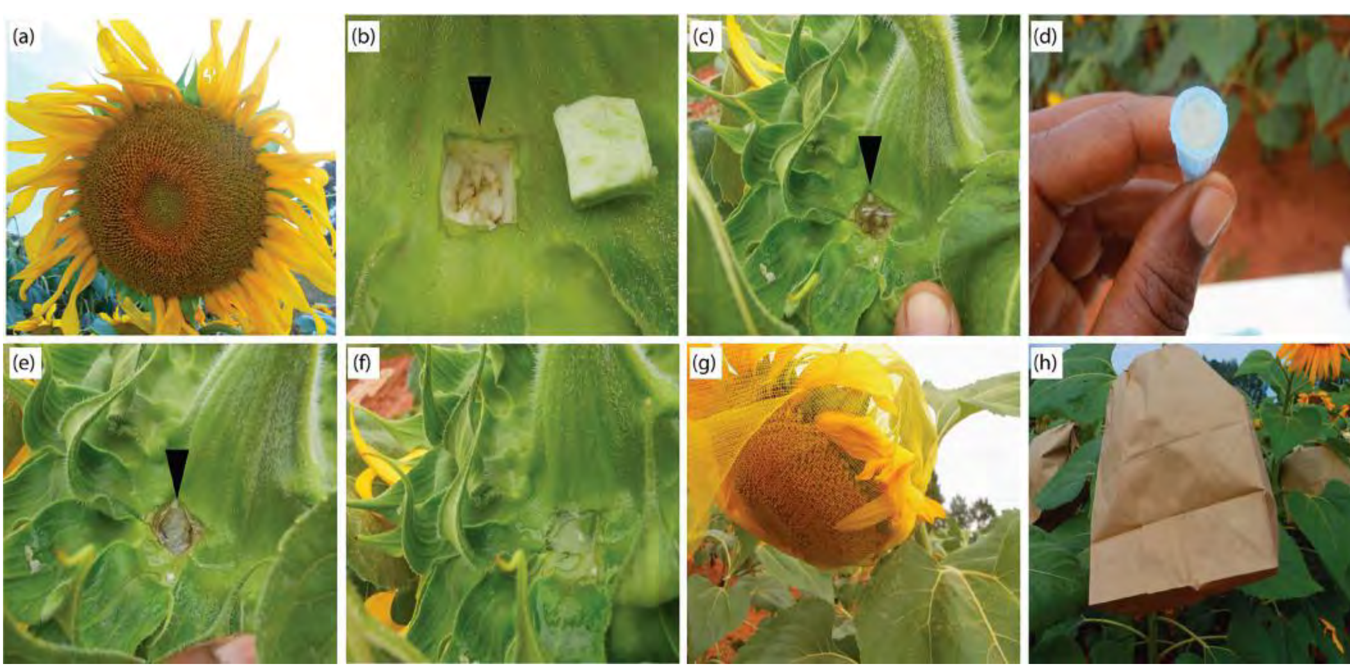
Studies by Bester (2018) and Meiring *et al*. (2021) were carried out in South Africa where sclerotia applied to the soil or ascospore suspensions were applied at different flowering stages to investigate the disease epidemiology. These two studies showed *Sclerotinia* head rot incidences in natural field conditions to be between 40,4 and 53,3%. They assessed disease incidence across several planting dates including a November planting date, four December planting dates and a January planting date, but did not assess the whole growing season or how environmental factors influenced disease progression within the sunflower head.

In the current study, we aimed to investigate the influence of climate factors associated with monthly planting dates on *Sclerotinia* head rot progression across the entire growing season.

The objectives of this study were:

- To artificially inoculate plants sown at different monthly planting dates with *S. sclerotiorum* mycelia at a late flowering stage and monitor disease establishment and progression in the head.
- To correlate disease establishment, progression and severity with prevailing climate factors such as rainfall, temperature and relative humidity over the inoculation and monitoring period.
- To evaluate disease severity across the six planting dates over this period.

According to our knowledge, this is one of the first studies to detail disease



Mycelial plug method of inoculation to ensure infection and vigorous growth so that disease progression in the head can be monitored. Plants at the R5.9 growth stage (a) were selected for inoculation (Schneiter and Miller, 1981). A 1cm³ hole (b) was cut into the back of the capitula (black arrowhead) for inoculation. The cut section was moistened with a rainwater spray (c). A 6mm plug with mycelia was obtained using the back of a sterile 1mℓ pipette tip to cut out a plug from the actively growing mycelia in a standardised fashion (d). The mycelial plug was placed in the cut hole (e) of the capitula and sprayed with water again (black arrowhead). The removed piece of flower head was replaced to cover the mycelial plug and again sprayed to ensure good moisture and disease establishment (f). The flower head was covered by a pollination bag (test plants to limit bird damage) (g) or brown paper bags (positive control; to retain humidity) (h) and disease progression was monitored.

progression within the sunflower head at different planting dates in the field and correlate this with climatic conditions during infection and disease progression.

We found strong correlations between planting date and *Sclerotinia* head rot progression that were primarily driven by temperature at the time of infection. Our findings suggest that sunflower plantings that align flowering with the warmer parts of the season would be beneficial in limiting *Sclerotinia* head rot damage. However, the close association with climate at the time of infection suggests there is unlikely to be a single planting date that consistently limits *Sclerotinia* head rot due to high seasonal variability.

Results and discussion

Sunflower production in South Africa is impacted negatively by diseases, such as *Sclerotinia* head rot. Short-interval, staggered sunflower plantings have been suggested as an escape strategy to limit the number of plants at the flowering stage when environmental conditions are conducive for *Sclerotinia* head rot (Bureau for Food and Agricultural Policy, 2020).

However, these planting strategies pose several challenges, including complicating field management practices. With dryland agricultural practices, as is common in South Africa (Meyer and Van der Burgh, 2015), short-interval, staggard plantings can be difficult when late rains push plantings towards the end of the planting window.

In this study, we have investigated the influence of climatic factors and planting dates on *Sclerotinia* head rot progression across the entire summer season to evaluate how planting dates might impact *Sclerotinia* head rot establishment and progression.

In a broader planting date trial, we observed *Sclerotinia* disease occurrences to vary across location or season and these were not consistently associated with a specific planting date, probably due to the inter-seasonal weather variability in South Africa. The country has a high inter-seasonal variability often brought about by the wet and dry cycles as the region transitions between El Niño and La Niña events (Ndlovu *et al*., 2021; Rusere *et al*., 2023).

S. sclerotium has specific requirements in terms of temperature and relative humidity at specific stages of its life cycle (Bečka *et al*., 2016; Clarkson *et al*., 2014; Harikrishnan and Rio, 2008; Payen, 1983; Smolińska and Kowalska, 2018), and the changes can be small and only required for a short time to induce disease establishment.

Inoculation trial incorporated

These factors make seasonal generalisations difficult and probably contribute to the erratic nature of *Sclerotinia* head rot outbreaks, particularly in South Africa (Crave *et al*., 2016; Holtzhausen and Van der Westhuizen, 1980; Meiring *et al*., 2021). We, therefore, implemented a small inoculation trial in a single season and location to better understand the in-field local climatic factors that drive disease establishment and head rot progression within the sunflower head at different planting dates.

While the temporal occurrences of these optimal conditions for *S. sclerotiorum* growth might shift from season to season and location to location, their influence on disease progression should remain similar and may provide insights into which factors are key to infection.

We systematically inoculated randomly selected plants in monthly plantings across the summer season and monitored disease progression within the sunflower heads at three-day intervals so that we could directly compare the progression of the disease to the prevailing climatic conditions at each time point.

Climate and planting dates

Generally, we found that disease establishment after inoculation was suppressed by low relative humidity and extreme cold conditions occurring at the time of inoculation. While disease progression within the heads was significantly suppressed by high temperatures, cold conditions could suppress *Sclerotinia* head rot only if both the night- and daytime temperatures were low.

In this study, we considered disease establishment as the six-day period after inoculation where lesions first start to be observed on the flower head. In a natural *S. sclerotiorum* head rot infection, an ascospore will land on the flower head, germinate, enter the head via senescing florets and the mycelial growth will advance across the entire head (Bečka *et al*., 2016; Harikrishnan and Rio, 2008; Payen, 1983). We placed mycelia directly into the back of the flower head so that we could assess how the mycelia establish and progress across the head and identify the climatic factors contributing to these processes.

We noted two interesting deviations from good disease establishment in our trials. The first was on the January planting date, where the study plants that were inoculated and exposed to the environment had slow disease establishment and lesions were only observed after six days post inoculation (dpi). However, the positive control plants that were inoculated and covered with a paper bag to maintain humidity around the flower head showed lesions forming more rapidly (before three dpi).

Similarly, for the very late March planting date, we noted that both the positive control and study plants had suppressed lesion development, with the first lesions developing between three and six dpi. This suggested that local relative humidity was not an influencing factor, but rather the severe cold snap (approximately 0°C night-time temperatures at the time of inoculation) suppressing the disease establishment in both sets of plants.

While our inoculation strategy does not allow for the study of ascospore attachment or germination and entry to the head, these processes have been found to occur at a relative humidity of more than 85% and between 5 and 25°C (Clarkson *et al*., 2014). It is reasonable to assume that the lower humidity on our January planting date and extremely low temperatures on the March planting date could affect these processes in a natural infection as well.

Disease progression

The next phase investigated head rot progression, which was measured from inoculation to 30 dpi, when most heads were completely infected. In terms of disease progression, the data can be separated based on progression and temperature, which is related to the time of the season for each planting date. The spring and early summer planting dates (October and November) showed the slowest disease progression, only

reaching areas under the disease progress curve (AUDPC) scores of 75,15 and 29,4, respectively.

When we compared this to the daily temperature maxima and minima during the monitoring period, we observed that in both months the maximum temperatures during the inoculation and monitoring period were consistently above 25°C. The natural growth range for *S. sclerotiorum* mycelial growth is between 5 and 25°C, and temperatures of 27°C or higher are detrimental to disease progression (Abawi and Grogan, 1975; Ebrahimi *et al*., 2013; Smolińska and Kowalska, 2018; Weiss *et al*., 1980).

In the November planting date inoculation, some plants showed no symptoms or presented with recovery after inoculation, resulting in very low disease severity index (DSI) and AUDPC scores. No other planting dates showed inoculation failure or plant recovery for any of the plants inoculated. It is likely that, for this planting date, the high temperatures placed the fungal pathogen under significant stress, while these temperatures were more favourable for the sunflower plants providing an opportunity to counter the infection and recover (Velásquez *et al*., 2018).

Rondanini *et al*. (2006) reported that average temperatures consistently over 30°C begin to influence yield and oil production in sunflower. This suggests that selecting a sunflower planting date that ensures that flowering aligns with the hottest parts of the summer season, may help limit *Sclerotinia* disease progression in regions where the summers average over 27°C consistently without major impacts on production.

Influence of planting date

The December, January and February planting dates presented the fastest disease progression, with AUDPC scores ranging between 84 and 90. The DSI scores also showed fast progression, with scores between 90 and 100% by 24 dpi. These results are expected if we look at the climatic variables associated with the inoculation period of these planting dates. Where the December and January planting dates showed relative humidity between 90 and 100%, February had a slightly wider range from 85 to 100%. This is around the optimal relative humidity for *S. sclerotiorum* growth and development (Clarkson *et al*., 2014).

Even when we look at the results of the greater planting date trial across two seasons and two sites where the 2020/2021 season was hotter and drier than the second, we observed *Sclerotinia* head rot within this planting window, with a possible early shift in the hotter drier season. It may be useful to monitor seasonal forecasts and try to identify the hottest months in different seasons, to try and limit *Sclerotinia* head rot by aligning planting dates within this window.

The late summer and early autumn planting dates of February and March showed that low daily maximum and minimum temperatures together suppress *Sclerotinia* head rot progression, while low daily minimum temperatures alone are not sufficient for suppression. While interesting in terms of the biology of the pathogen, which has been well studied in the past (Imolehin *et al*., 1980; Uloth *et al*., 2015), this does not have much in the way of agricultural implications, given freezing conditions may limit growth and development in even the hardiest frost-tolerant crop plant (Mangin *et al*., 2017).

Sunflower has consistently been shown to be more susceptible to cold snaps and freezing temperatures, which significantly limit yield (Hammer *et al*., 1982; Hniličková *et al*., 2017). There are several breeding efforts to improve frost tolerance in sunflower, possibly by using introgression from wild species (Tetreault *et al*., 2016) and perhaps this will alter the planting window and provide flexibility to aligned plantings and flowering stages with environments less conducive to *Sclerotinia* head rot in the future.

In conclusion

We found that planting date was correlated with *Sclerotinia* head rot progression, but that this varied across seasons and locations, and was influenced by different climatic variables including relative humidity and temperature. We showed that disease establishment by mycelia in the sunflower head is suppressed by low humidity and severe cold, while *Sclerotinia* head rot progression was suppressed by extremely high or low temperatures.

To limit adding additional *S. sclerotiorum* strains or inoculum to our shared field site, we used a single isolate that we collected from the same site the previous year and used molecular tools to confirm the identity and produce a pure culture. It would be interesting in future studies to test other isolates with varying levels of pathogenicity.

We used the plug inoculation technique because it was robust and allowed us to investigate head rot progression across all planting dates. Several members of our team are focused on developing a reliable protocol for ascospore production, and it will be interesting to repeat this trial using a more natural mode of infection in the future. It would also be interesting to repeat this trial in the coming seasons as South Africa is transitioning back into a hotter, drier period with El Niño returning (Sihlobo, 2023).

Bester (2018) evaluated several inoculation techniques and focussed on understanding the effect of short-interval, staggered plantings on *Sclerotinia* head rot incidence in South Africa, while our study focussed specifically on understanding how environmental factors impact *Sclerotinia* head rot progression across monthly planting dates to assess the entire summer season.

This is the first study of its kind and presents important findings on which weather variables should be considered at flowering to limit *Sclerotinia* head rot progression. We show that high temperatures suppress disease progression and aligning plantings to ensure bloom periods coincide with the hottest part of the season may aid in suppression of *Sclerotinia* head rot.

This study provides a solid base from which to further assess strains, infection processes and other environmental conditions, which is critical knowledge for the development of more effective control strategies.

This article has been shortened for publication in *Oilseeds Focus*. For the full article and references, visit *www.bsppjournals.onlinelibrary.wiley.com/doi/full/10.1111/ppa.13873* or email Nicky Creux at nicole.creux@fabi.up.ac.za.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stops feeding immediately
with no further crop damage
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Spray nozzle maintenance

Spray nozzles play an integral role in the application of crop protection products, yet they are often overlooked. Whether producers acknowledge it or not, the most significant crop protection expense finds its way through a spray nozzle. Neglecting proper maintenance or choosing the wrong type or size nozzle can severely impact a farm's profitability.

Spray nozzles are like car tyres: You can buy the best and latest bakkie on the market, but if you are using low-profile racing tyres, navigating the farm will be a challenge.

Replacement of nozzles

A question often asked by producers is when is the best time to replace nozzles? Unfortunately, there is no straightforward answer as each farm, crop and sprayer setup is unique. To come back to the tyre comparison: Depending on the driver and the road surface, one set of tyres can last for a long time, while another set must be replaced sooner.

Luckily it is easy to assess whether a spray nozzle adheres to its specifications. All manufacturers provide delivery specifications for their spray nozzles at specific pressures. For example, a 04 red is supposed to deliver 1 600mℓ/min at three bars of pressure. To ensure accurate ground application, the variation across the length of the boom should not exceed 10%.

A spray nozzle must thus be replaced when it delivers 5% more or less than the specified rate. In terms of our example, a 04 red spray nozzle should be replaced if it delivers 1 520mℓ/min at three bars or exceeds 1 680mℓ/min.

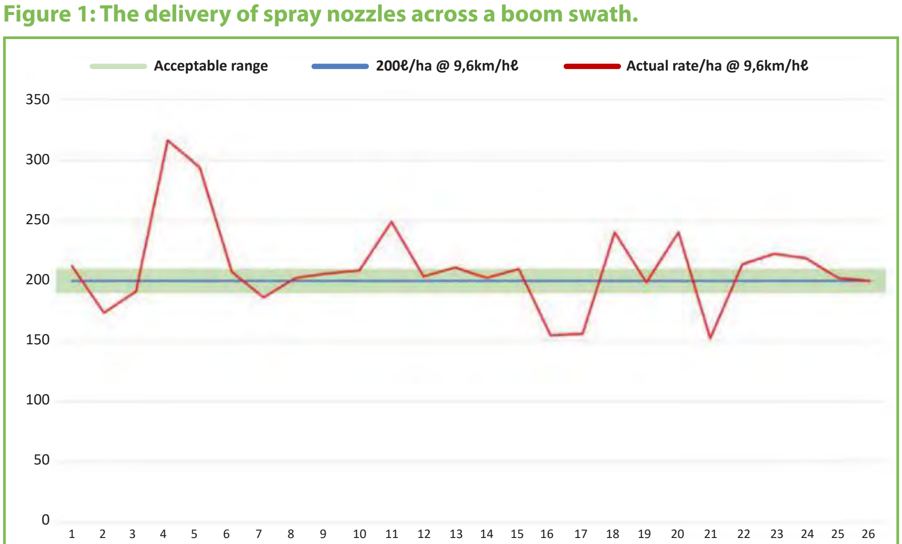
Accurate delivery

Sceptics may wonder just how significant the impact can be and whether the cost of expensive spray nozzles is justified. To address these questions, a real-world example is used.

Figure 1 illustrates the delivery of spray nozzles across a boom swath. The producer aimed for a delivery of 200ℓ/ha, represented by the blue line. Achieving this target is challenging but feasible, if the spray nozzle operates within the 5% variation (indicated by the green block). However, the red line reveals the actual situation.

In the case of the entire spray boom, the average 5% deviation is challenging to detect, especially when the nozzle incorporates a flow regulator that manages delivery across beam segments. The flow regulator measures product delivery at the point where it enters the boom. Consequently, if the overall average remains accurate, the machine does not flag any issues.

Figure 1: The delivery of spray nozzles across a boom swath.



Differences in spray nozzles

When examining the differences among individual spray nozzles, the reality becomes evident. Spray nozzle 04, for example, delivered 316ℓ/ha at three bars and 9,6km/h – far exceeding the intended 200ℓ/ha. This represents 158% of the planned delivery, effectively resulting in a 58% over-delivery. Conversely, within the same strip, there is also a substantial 155,6ℓ/ha average under-delivery, which falls 22% short of the planned dose.

These variations in delivery have significant financial implications. Given a product cost of R500/ha, the loss amounts to R43,63/ha when factoring in the acceptable tolerance. While this may not seem substantial, it does become problematic when extrapolated across 200ha, and adds up to a new set of spray nozzles (and perhaps a beer or six). Addressing this issue promptly is crucial, as prolonged neglect will simply exacerbate the losses.

Worn-out spray nozzles significantly impact operating costs, making the investment in a new set entirely justifiable.

For more information, visit *www.syngenta.co.za*.

Current research on canola diseases

By Gert van Coller, Huibré Schreuder and Diane Mostert (Photographs: Gert van Coller)

The South African canola industry has grown steadily over the last 25 years. After a record average yield of over 2t/ha was achieved in 2020, the year 2023 marked the period of both the highest area planted to canola (131 200ha) and the highest total canola production (237 500t).

With this growth comes the need to address some of the challenges that canola production faces. Blackleg and *Sclerotinia* stem rot are the most damaging canola diseases globally and in the Western Cape, and local producers have become increasingly aware of their impact over the past few years.

Hurdles to disease control

Blackleg is caused by the fungi *Leptosphaeria maculans* and *Leptosphaeria biglobosa* and occurs only in the *Cruciferae* family (*Brassica* species). Blackleg is managed by integrating host resistance with chemical control. Agronomical practices such as ploughing or burning stubble, which decreases the inoculum load, effectively reduce disease levels but cannot be integrated with conservation agriculture.

Planting canola at least 500m away from the previous year's stubble, which enables the crop to evade the disease, is also effective, but limited space on farms often makes this impractical. The use of host resistance is the most durable, cost-effective and environmentally friendly approach to managing blackleg, but must be managed carefully due to the large number of genetically distinct races of the pathogen occurring globally. While chemical control can effectively reduce blackleg, it must also be carefully managed to avoid the build-up of resistance to fungicides.

To address these problems facing canola producers, the Western Cape Department of Agriculture and the Department of Plant Pathology at Stellenbosch University are conducting numerous research projects aimed at mitigating the detrimental effects of blackleg and *Sclerotinia* stem rot.

The cultivar trial at Uitkyk farm in the Hessequa-region near Riversdale was established to assess the resistance of canola cultivars to blackleg under field conditions.

In this article, the work being addressed in the respective research projects is briefly discussed.

Leading causes of blackleg

The first task at hand is determining the race structure and genetic diversity of *Leptosphaeria* species causing blackleg disease of canola in the Western Cape. Resistance to the pathogens causing blackleg in canola is provided by both major genes (qualitative resistance) and minor genes (quantitative resistance) in the canola plants, of which the former is better understood and more widely used to control blackleg.

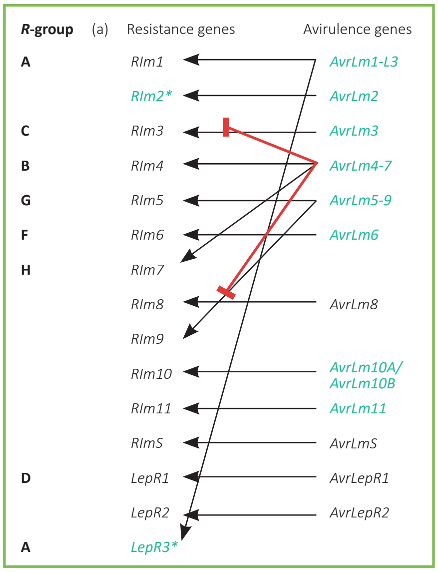
Major gene resistance occurs as a gene-for-gene interaction between canola and *L. maculans*. This means that a resistance response depends on the presence of a resistance gene (*R*-gene) in the canola plant and a corresponding avirulence (*avr*) gene in the pathogen. Conversely, the lack of an *R*-gene in the plant or an *avr* gene in the pathogen results in a susceptible reaction and subsequent disease development in the canola plant. To date, at least 15 *R*-genes have been identified in *Brassica* species conferring resistance to *L. maculans*, while 12 corresponding *avr* genes have been identified in *L. maculans* (*Figure 1*).

The total number of possible *R-avr* combinations could theoretically generate thousands of different races of the fungus. In Manitoba, Canada, for example, 170 races of the pathogen have been identified.

This is one of the primary reasons why blackleg is so difficult to manage. No single canola cultivar is resistant to all possible races of the pathogen. The occurrence and frequency of races of the pathogen within a country or region is also not static, but changes in response to the major resistance genes present in canola cultivars.

When cultivars with the same complement of major resistance genes

Figure 1: Interaction between *Leptosphaeria maculans* avirulence genes and *Brassica* resistance genes. (Source: Van de Wouw and Howlett, 2020)



are cultivated each year in the same region, it results in the rapid increase of races not suppressed by these resistance genes, up to the point where resistance is effectively overcome. This can happen within three years, as witnessed in Australia and France. The pathogens are heterothallic, meaning that the different mating types (similar to male and female) are carried on separate individuals.

Sexual reproduction occurs easily and in large numbers in canola stubble, and results in offspring carrying genetic material from both parents. This ability, coupled with the seed-borne nature of the pathogens, allows for the introduction of new races into production regions.

While the *R*-genes present in canola cultivars planted locally are known, no information on the *avr* gene profile of the pathogen occurring in the Western Cape has been available before this study, which aims to determine the prevalence, genetic diversity and distribution of races of *Leptosphaeria* species associated with canola across the Western Cape.

To achieve this, an isolate collection of more than 4 000 isolates was obtained from various locations throughout the Western Cape over three seasons. All isolates were identified, which showed that *L. maculans* is the dominant pathogen responsible for blackleg of canola in the Western Cape. Whole genome sequence data was then generated for a subset of these isolates, which reveals the *avr* allele profile of the isolates, thereby elucidating the race structure of the pathogen in the Western Cape.

This project is in its final year and will provide baseline information needed to utilise major gene resistance in canola cultivars locally. This project also provided us with the opportunity to collaborate in an international study on the genetic diversity of *L. maculans* globally, which was published this year in an international journal and provides us with an invaluable research tool for future research.

Cultivar resistance to blackleg

The canola cultivars planted in South Africa are primarily of Australian origin. Upon arrival in South Africa, producers are provided with a resistance rating against blackleg based on how they performed in blackleg resistance trails in Australia. It is important to note that this rating is based on how the cultivars performed against blackleg in Australia, not the Western Cape.

The resistance response of a cultivar is dependent on the races of the pathogen present at a location, as well as environmental conditions, and although South Africa has a similar climate to Australia, a cultivar which achieved a high resistance rating in Australia will not necessarily perform the same under South African conditions, due to possible differences in the race structure of the pathogen.

To assess the resistance of the commonly available canola cultivars under local conditions, cultivar trails have been conducted at Langgewens research farm (Malmesbury region), Waterboerskraal farm (Hopefield region) in the Swartland, Tygerhoek research farm (Riviersonderend, Overberg) and Uitkyk farm (Riversdale, Hessequa region) from 2021 onwards. The same cultivars evaluated in the annual canola cultivar evaluation programme are included in our trials each year. The cultivars to be assessed this year, along with the *R*-genes present in each cultivar, are included in *Table 1*.

From 2021 to 2023, blackleg severity for each cultivar was rated close to harvest by determining the disease severity index (DSI) on a cross-section of the lower stem, since crown cankers were traditionally the most damaging aspect of the disease. This allowed us to determine the blackleg resistance rating of all the cultivars included each year at all locations.

In recent years, however, a shift has been detected in blackleg disease symptoms,

Table 1: Canola cultivars to be evaluated for resistance to blackleg in 2024 at four locations.

Name	Type of cultivar	*R*-group
Defender CT	Clearfield, Triazine tolerant	ADF
PY327C CL	Clearfield	Unknown
PY421C CL	Clearfield	A
PY520 TC	Clearfield, Triazine tolerant	BC
45Y95	Clearfield	C
Diamond	Conventional	ABF
Alpha TT	Triazine tolerant	BF
Blazer TT	Triazine tolerant	ADF
44Y94	Clearfield	BC
Quartz	Conventional	ABD
Hyola Solstice CL	Clearfield	ADFH
Hyola Equinox CL	Clearfield	ADF
CC90014	Conventional	ADFH
Hyola Continuum CL	Clearfield	ADF
HyTTec Trophy	Conventional	ADF
HyTTec Trifecta	Conventional	ABD
PY429TT	Triazine tolerant	Unknown
Ceres CL	Clearfield	AD

(A) Canola stem with limited stem canker visible on the outside. (B) The same canola stem exhibiting extensive disease on the interior.

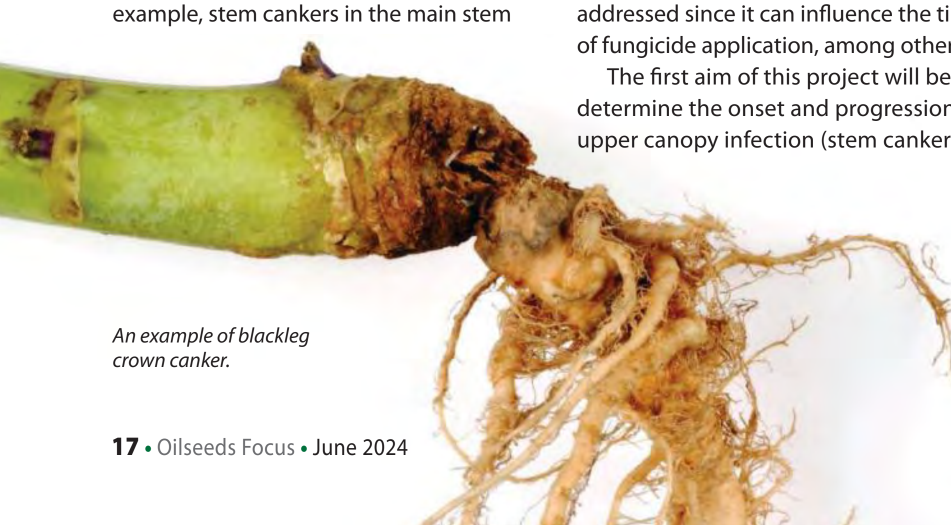
which prompted us to launch a new project from this year onwards, which is discussed in the following section.

Disease management

Previously, crown cankers were the most devastating phase of the disease, which was also true for the Western Cape. Determining resistance against blackleg therefore relied on determining the DSI of the crown region.

Over the past decade, a shift in disease symptoms has occurred in Australia and is collectively known as upper-canopy infection. This includes infection and development of symptoms in main stems, side branches, flowers and seedpods (all above-ground parts 5cm above the soil surface), which are becoming increasingly common, while crown cankers are becoming less severe.

Similarly, in recent years in the Western Cape, the incidence of plants with stem cankers in the main stem (above the soil surface and up to the first branching of the plants) has increased drastically. At Tygerhoek research farm during 2023, for example, stem cankers in the main stem were detected in almost 75% of canola plants. An interesting aspect of these stem cankers on the main stem is that the stems appear relatively healthy on the outside, with only small canker lesions visible on the exterior, while the damage is much more severe internally.

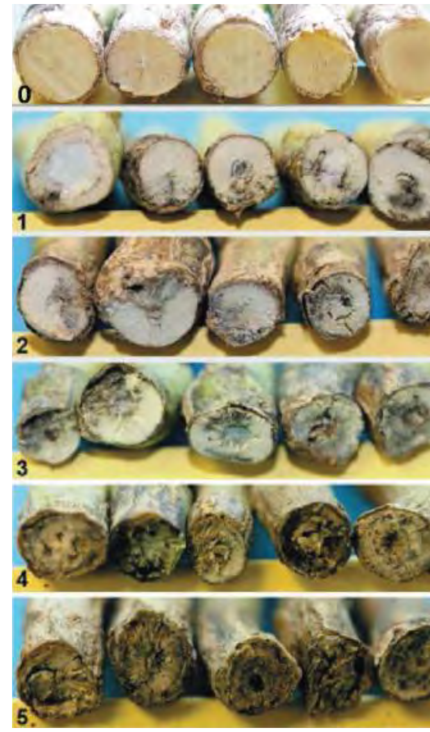


An example of blackleg crown canker.

The worrisome aspect of this shift is that while blackleg stem cankers have been known for a long time in the Western Cape, they were previously fairly scarce. Anecdotal evidence suggests that infection of side branches, flowers and seedpods is also increasing. Determining resistance of canola cultivars against blackleg based only on the DSI of the crown region is therefore no longer accurate, since it does not take into account the incidence or severity of upper canopy infection. Development of a new resistance rating method is therefore needed to provide producers with accurate results.

Furthermore, we do not have any information, to date, on potential differences in disease onset and progression of upper canopy infection in different cultivars, which must also be addressed since it can influence the timing of fungicide application, among others.

The first aim of this project will be to determine the onset and progression of upper canopy infection (stem cankers, infection of side branches, seedpods and flowers) in selected cultivars at different locations, using a rating system to be developed during the first year of this project.



The disease severity scale used to determine crown canker disease severity index. (Source: Peng et al., 2021)

The second aim will be to determine the resistance of local canola cultivars against blackleg in different production regions. To achieve the second aim, a two-phased approach is needed, namely:

- Determine the resistance of canola cultivars to upper canopy infection using the methodology developed for the first objective.
- Determine the DSI of crown cankers in different canola using existing methodology. This research will commence this year.

Management via fungicides

As mentioned earlier, blackleg is managed by integrating host resistance with chemical control. While chemical control of blackleg in the Western Cape was previously limited to seed treatments, given the cost of foliar fungicides and lower yields obtained in the early days of canola production, the use of foliar fungicides has increased drastically in the past years. Indeed, the use of DMI

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Manganese (Mn) 38.8 g/L
Copper (Cu) 3.9 g/L
Iron (Fe) 9.1 g/L
Boron (B) 2.6 g/L
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(A) Canola plant with a diseased side branch and (B) diseased canola seedpods. (Photograph B: Piet Lombard)

fungicides (triazoles, which include tebuconazole and prothioconazole, among others) has contributed to the 50-fold increase in canola production in Australia over the last 30 years.

The high genetic variability of the pathogens, however, allows for the build-up of tolerance toward fungicides over time, and represents a real threat to continuing canola production. This has been reported in Australia, Europe and Canada. Resistance against DMI fungicides now occurs in all canola-growing regions of Australia, with 15% of fungal populations there currently displaying a high level of resistance against DMI fungicides.

To determine the efficacy of foliar fungicides to manage blackleg, five fungicides registered against blackleg of canola as well as an unregistered fungicide were evaluated in field trials on two cultivars during 2022 and 2023. The trials were situated at the same locations as the trials to determine cultivar resistance.

Results from these trials have shown that foliar applications of all fungicides registered for blackleg management at the three- to five-leaf stage, decrease the crown canker DSI. The results also showed that the benefit derived from a fungicide application depends on the blackleg resistance of the cultivar and the disease pressure in the area.

The largest reductions in DSI were seen in susceptible cultivars in areas where disease pressure was high, while only marginal reductions in DSI were observed in resistant cultivars where disease pressure was low. A subset of isolates from each location are also currently being screened to determine the EC_{50} value against different fungicides and to determine whether any differences in fungicide sensitivity exist in the pathogen population.

(A) Healthy canola stems and (B) canola stems with extensive disease on the interior.

In conclusion

The work we have done on blackleg over the past three years is the first major study on blackleg of canola in South Africa. The work presented in this article is only part of the research we are currently conducting.

In future articles we will discuss the work we are currently doing regarding:

- The effect of planting retained seed on blackleg, fungicide deposition and disease management achieved at the five-leaf and 30% flowering stage using different spray volumes, forward tractor speed, as well as aeroplane and UAV (drone) applications.
- The occurrence and distribution of different races of *L. maculans* on *Brassica* cover crops and weeds and the possible threat they pose to canola.
- The epidemiology and control of *Sclerotinia* stem rot of canola, which we are undertaking in collaboration with Lizette Nowers from the Western Cape Department of Agriculture.

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Keep growing | CORTEVA agriscience

By Henry Hoek, category marketing manager for herbicides, Corteva Agriscience South Africa

Corteva Agriscience offers a comprehensive portfolio of crop protection products designed to safeguard crops from insects, diseases, and weeds. Find the right crop protection technology to maximise your hectares. We aspire to work alongside you, our producers, as you strive to produce food that society demands, safely and responsibly.

Different crops have different demands. Regardless of what you cultivate, we support your success with seed, crop protection, and digital farming technology. Our commitment lies in adapting to the evolving needs of your crops and operations. As a company dedicated to sustainable crop protection solutions, we share this responsibility.

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We understand the challenges our producers face in striving for profitability, success and sustainability. With changing climates, multiplying pests and increasing resistance, adaption is crucial. By incorporating crop protection solutions that strive to best serve the industry, the environment and the global population, Corteva Agriscience makes this transition easier.

For controlling weeds in canola sustainably and consistently, our innovative crop protection solutions are ready to assist.

Kerb™ FLO 400 SC (Reg no: L4065) is a suspension concentrate herbicide used for annual winter grasses in canola, as well as other crops, as indicated on the label, in the winter rainfall areas.
Kerb™ FLO 400 SC includes good residual control of grasses that have not germinated during application although caution should be taken when it comes to deep germinators such as *Avena* and brome.

Annual grasses controlled by **Kerb™ FLO 400 SC** include:

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- Canary grass, *Phalaris canariensis*.
- Common wild oats, *Avena fatua*.
- Mouse barley, *Hordeum murinum*.
- Rat's-tail fescue, *Vulpia myuros*.
- Ripgut brome, *Bromus diandrus*.
- Rescue grass, *Bromus catharticus*.
- Ryegrass, *Lolium* spp.
- Volunteer wheat, *Triticum aestivum*.

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At Corteva Agriscience, our future-focussed approach to crop protection positions us at the very heart of agriculture – from soil to table. We stand alongside our producers in producing only the best. By equipping our producers with the right products for specific crops at the right time, we strive for optimal outcomes. We are continuously evolving our crop protection portfolio by integrating even more safe and sustainable solutions into our product offering.

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To learn more regarding Corteva's crop protection options, visit their website at *www.corteva.co.za*

Rhizobia: A promising source of plant growth-promoting molecules and their non-legume interactions

By Sara Fahde, Said Boughribil, Badreddine Sijilmassi and Ahmed Amri

Many studies have been investigating the use of rhizobia with crops such as rice, maize, barley, sunflower, and radishes, among others. The results of these studies have shown that some non-legume plants can interact with rhizobia and benefit from their plant growth promotion activities.

However, much more research is needed to fully understand the potential benefits and drawbacks of such relationships, as well as to focus on the development of rhizobial strains that possess the ability to enhance crop productivity across diverse environmental conditions.

Rhizobia diversity and ecology

Considering the limitations and negative consequences associated with the prolonged use of chemical fertilisers, alternative approaches such as biofertilisers have gained significant attention in recent years. Biofertilisers offer a more sustainable and environmentally friendly solution for enriching soil with nutrients in high-input cropping systems.

Unlike chemical fertilisers, biofertilisers consist of beneficial micro-organisms that promote nutrient availability and uptake by plants while improving soil health and fertility. Plant growth promoting rhizobacteria (PGPR) biofertilisers are considered a highly promising means of reducing reliance on agrochemicals, including fertilisers and pesticides.

PGPRs are beneficial bacteria that colonise plant root systems and enhance their growth and health, and have beneficial effects on plant growth and health by improving nutrient uptake, suppressing plant pathogens, and promoting stress tolerance.

According to the level of interaction they have with plant root cells, PGPRs can be divided into two groups:

- Intracellular plant growth-promoting rhizobacteria (iPGPR) that live inside plant tissue.
- Extracellular plant growth-promoting rhizobacteria (ePGPR) that live in the soil surrounding plant roots.

Endophytic PGPR can colonise the plant tissue and benefit the plant, such as increased resistance to abiotic and biotic stress, improved nutrient uptake, and growth promotion. They are known to produce growth-promoting compounds, such as indole acetic acid, gibberellins, and enzymes such as phytase and protease, which can help in nutrient acquisition.

Rhizosphere PGPRs, on the other hand, interact with the plant roots, and they can provide benefits to the plant, such as improving soil structure, nutrient uptake, and plant growth. They can compete with pathogens for space and nutrients, reducing the ability of pathogens to infect the plant. They can also act as biocontrol agents by producing antibiotics or other compounds that inhibit the growth of pathogens.

Numerous soil microbes from various genera have been identified as highly efficient PGPR. Among these, the most commonly utilised genera are *Pseudomonas*, *Agrobacterium*, *Arthrobacter*, *Azotobacter*, *Bacillus*, *Burkholderia*, *Caulobacter*, *Chromobacterium*, *Erwinia*, *Flavobacterium*, *Micrococcus*, and *Serratia*, which are classified within the ePGPRs. The iPGPR encompasses a variety of micro-organisms that can symbiotically fix atmospheric nitrogen (N) with higher plants. *Frankia* is one of the known and well-studied species. Endophytes are a diverse group of soil bacteria, such as *Allorhizobium*, *Azorhizobium*, *Bradyrhizobium*, *Mesorhizobium*, and *Rhizobium*.

PGPRs are highly effective in the remediation of sites contaminated with pesticides and hydrocarbons and play a significant role in various biotic processes within the soil by promoting nutrient cycling and contributing to sustainable crop production.

The commercialisation of PGPRs as biofertilisers is a relatively new field, but it is growing rapidly. Several PGPR bacterial strains are commercially available as formulated products (such as Kodiak®, Serenade® and Bio-YIELD®). The commercialisation of PGPR biofertilisers is driven by an increasing demand for sustainable farming practices, and by the need to improve crop yields in a changing climate.

Characteristics of rhizobia

Rhizobia can form symbiotic relationships with specific plant species, mainly legumes, resulting in natural N fixation, which enables the bacteria to convert atmospheric N into a form that can be used by plants. In return, the plant host provides rhizobia with a source of carbon. This process is called symbiotic N fixation.

Rhizobia are gram-negative bacteria, belonging to the phylum *Proteobacteria*. Specifically, they are classified into Alpha- and Betaproteobacteria subclasses. The exact number of species in rhizobia is not fixed, as new species are continually being discovered and described. The genus *Rhizobium* alone contains over 150 known species, and the other genera within the *Rhizobiaceae* family contain multiple species. In addition, there are many uncharacterised and uncultivated species that have been detected in different environments.

The family *Rhizobiaceae* encompasses a variety of bacterial genera, such as *Bradyrhizobium*, *Azorhizobium*, *Mesorhizobium*, *Ensifer* (*Sinorhizobium*), *Neorhizobium*, *Pararhizobium*, and *Allorhizobium*, which are characterised by their ability to establish intracellularly, N2-fixing infections in many different types of plant hosts. This feature is intricate and often closely co-evolved with the specific plant hosts they reside in.

Relationship with roots

Additionally, rhizobia can form a non-specific associative relationship with roots of other plants (non-legumes) without creating nodules. These associative interactions between plant roots and bacteria have growth-promoting effects and are of great significance, as many crops exhibit an improvement in yield upon inoculation.

The symbiotic relationship between rhizobia and legumes is a complex process that involves a series of molecular interactions between the bacteria and the host plant. The process of plant infection by rhizobia includes several steps, such as recognition and attachment of the bacteria to the host plant's root hairs through the production of chemical signals called Nod factors, penetration into root hair cells, differentiation into an infection form called bacteroid, formation of nodules, and maintenance of the symbiotic relationship.

Nodules are specialised structures that allow the rhizobia to fix atmospheric N and provide it to the plant in exchange for carbohydrates and other nutrients. Many common crop legumes and model plants, including *Medicago* spp., pea, *Lotus japonicus*, bean, and soya bean, experience this type of infection. It is important to note that the process may vary among different rhizobia species and host plants.

Rhizobia have been shown to stimulate root growth, protect plants from soil-borne pathogens, enhance stress tolerance and induce systemic resistance. This is achieved through mechanisms such as solubilising minerals and producing plant growth hormones, such as auxin, gibberellin and cytokinin. Along with their N2-fixing abilities with legumes, rhizobia also act as PGPR and can reduce disease susceptibility.

Biofertilisers and biopesticides

Biofertilisers are recognised as products that are formulated using living micro-organisms, either bacteria, fungi, or algae, that improve soil nutrient availability in plants. The chosen micro-organism can be used alone or in combination with other living cultures. The key advantage of biofertilisers is their direct application to seeds, plant surfaces, or soil where they can colonise the rhizosphere or inside of the plant, thus enhancing the supply of essential elements to the host plant.

Micro-organisms that promote host plant development through the inhibition of phytopathogens are considered biopesticides. Consequently, some PGPRs represent both biofertilisers and biopesticides.

There are many different formulations of bacterial biofertilisers on the market. They can be found as granular powder or fluid-bed granules.

Inoculation studies

The most indicated use of biofertilisers in legumes is inoculation with *Rhizobium* spp. It has been present in the market since 1896 when Nobbe and Hiltner acquired a United States patent associated with the utilisation of pure cultures of rhizobia. They commercialised their patented culture under the name of 'Nitragin'.

Strains of *Allorhizobium*, *Azorhizobium*, *Bradyrhizobium*, *Mesorhizobium*, *Rhizobium*, and *Sinorhizobium* were considered powerful PGPR for their role as biofertilisers. In another study, it was found that *Rhizobium* (*R. etli* bv. *Phaseoli*, *R. leguminosarum* bv. *trifolii*) and *Sinorhizobium* sp. improved maize growth, plant height and grain yield of maize in several agro-ecological fields.

The evaluation of *Bradyrhizobium diazoefficiens*-based bio-inoculants confirmed their capacity to amplify soya bean production, irrespective of the carrier material employed. Both liquid and peat-based bio-inoculants demonstrated the capability to augment nodulation and yield of soya bean, surpassing the outcomes observed in the control group.

Ismail *et al*. have developed a *Rhizobium* liquid biofertiliser technology. This has been reported to improve crop yields of green gram, black gram, pigeon pea and chickpea, soya bean, and groundnut by 10 to 28%.

Under drought stress, the faba bean was inoculated with *R. leguminosarum* bv. *viciae* (F46) to study its impact. The increase in growth parameters, including root dry weight, total N content, and relative water content, was notable. Additionally, inoculation with *Rhizobium* under water deficit significantly enhanced water use in chickpea.

The use of other supplements (e.g., fungicides, nutrients, and fertilisers) that could weaken the viability or efficiency of rhizobia is one of the main difficulties facing the application of *Rhizobium* inoculants. To overcome this, co-inoculation with a microbial consortium, rather than a specific species, has been widely reported to have a better result.

Consortia are defined as a mix of bacteria or fungi to ensure a wide range of applications and soil conditions. Figueiredo *et al*. reported that the co-inoculation with *Rhizobium* and another PGPR in common bean reduced the impact of drought stress and improved nodulation and N content. The co-inoculation with *Bacillus* and *Rhizobium* strains can enhance bean, pigeon pea, and soya bean nodule development and root structure.

Conclusions

It is important to be cautious about the potential risks related to the inoculation process, such as the possibility of rhizobia negatively affecting the host plant or competing with native populations. To mitigate these risks, it is important to carefully choose a suitable rhizobia strain for the targeted crop, evaluate the conditions under which the inoculation will occur, monitor the process, and make adjustments as necessary to ensure long-term success.

The inoculation of rhizobia into non-legume crops has great promise in advancing agriculture by improving crop growth and soil fertility. By being mindful of the potential risks and benefits, it is possible to fully reap the benefits of this innovative technology and promote sustainable agriculture practices for the future.

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"Pannar is a company that looks after the farmers and the quality of seed is consistent."

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Offering a profitable combination of yield potential and exceptional agronomic characteristics, Pannar's cultivars demonstrate stability over different yield potentials, production areas and seasons. We provide a full range of maturity classes covering almost all planting dates and densities. Jacques Botha from Castello Boerdery attests to that: "PAN 1521R provides the highest yield stability on our farm. It is a top performer in our own trials, season after season."

Farming for the future means building your farming operation on a long-term vision and objectives that will keep you in business for generations. The versatile Pannar® brand soya bean package has unparalleled stability at different yield potential levels and over different production regions. It is a proven and safe choice.

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Pannar has access to the very best commercial soya bean cultivars, either locally bred or accessed from around the world. Pannar's policy is to release the best varieties possible into the South African market, regardless of their origin. If a cultivar appears in our range, you can be certain it has already been thoroughly tested by the most comprehensive evaluation programme in the country.

Pannar has managed to contain the cultivar package to five exceptional products, offering a full range of maturity classes that will cover almost all planting date/production area combinations.

Jacques Botha from Castello Boerdery.

All Pannar cultivars are compatible with rhizobial strain groups A, B, C and D. All yield data is generated using group A strain WB74, which means that if a producer chooses to use a different strain of *Rhizobium*, the yield information and cultivar recommendations provided may vary.

Table 1: Agronomic characteristics of Pannar's five soya bean cultivars.

Cultivar	Maturity group (MG)		Relative no. of days to 50% flowering*	Relative no. of days to harvest maturity*	Plant and seed characteristics							Recommended plant population	
	Early: MG 4,5 – 5,4 Medium: MG 5,5 – 6,4 Late: MG 6,5 – 7,4		Temperate areas mid-November planting date	Temperate areas mid-November planting date	Standability	Shattering resistance	Compatibility with Rhizobia strain groups#	Growth type	Pubescence	Flower colour	Hilum	Early planting ('000)	Late planting date or narrow row widths ('000)
PAN 1532R	Early	5,3	60	132	9	9	A; B; C; D#	Indeterminate	Grey	Purple	Buff	350	550
PAN 1521R	Medium	5,7	61	137	9	9	A; B; C; D#	Indeterminate	Grey	Purple	Imperfect black	300	450
PAN 1555R	Medium	5,7	63	138	8	9	A; B; C; D#	Indeterminate	Tawny	Purple	Brown	300	450
PAN 1588R	Medium	5,9	64	139	8	9	A; B; C; D#	Indeterminate	Grey	Purple	Imperfect black	300	450
PAN 1644R	Late	6,7	63	142	7	8	A; B; C; D#	Indeterminate	Grey	Purple	Imperfect black	300	380

**Varies according to planting date and temperatures during the growing season.*
Rhizobia strain groups#: Group A: (strain WB74) NFX/MicroN/GraphEx (Microbika); Nitro-Liq/RhizoLiq/Signum (MBFi); Soycap (Soygro); Rhizomax (Inteligro); Stimuplant. Group B: (strain 532C) HiStick/Rhizoflo (BASF). Group C: (strain 5080) Biocult Maximise (Nulandis/N Lab). Group D: (strains USDA 110 and 442) Induct/Induct Pro (MBFi). Group E: (strain 5079) Elite (MBFi) not tested.
Disease ratings: 8 to 9 = highly tolerant; 6 to 7 = tolerant; 4 to 5 = moderately tolerant; 1 to 3 = susceptible; Blank = insufficient data.

Always follow grain marketing, stewardship practices and pesticide label directions. Glyphosate-tolerant varieties (including those designated by the letter 'R' in the product code) contain genes that confer tolerance to glyphosate herbicides. Glyphosate herbicides will kill crops that are not tolerant to it.

For more information, visit Pannar's website at *www.pannar.com*.

Sunflower oil content considerations

Sunflower is the ideal crop for South African producers in summer rainfall areas due to its capacity to withstand drought conditions, tolerate extreme temperatures, and adapt to different planting dates. Yet sunflower is often cultivated as an alternative grain crop, especially during seasons when precipitation is insufficient or if it is too late for maize or soya bean plantings.

Late plantings

At the recent Grain SA congress, Willie Marais, a member of the organisation, highlighted the pressures faced by the sunflower industry. To increase profitability, he said, producers need to consider different production options.

Speaking at the sunflower working group's breakaway session during the congress, Dr Safiah Ma'ali, a researcher at the Agricultural Research Council's Grain Crops division in Potchefstroom, pointed out that very often, yields that follow late planting are well below the crop's yield potential. She said although environmental factors were the main reason producers plant sunflower outside the optimal planting window, a lack of soil moisture was also a highly limiting factor affecting yield.

Planting dates

According to Charles Basson, a sunflower breeder and product placement lead at Syngenta, choosing the optimal crop planting time is crucial for maximising natural resources during specific physiological growth stages. "By planting sunflower at the optimal planting date, the crop is better able to absorb essential nutrients from the soil and consequently develop into healthier plants. Optimal planting time ensures good germination, root system development, growth, and yield."

Planting dates are affected by air and soil temperature, rainfall, soil moisture, hybrid maturity (long growers must be planted earlier) and planting location. The following aspects can influence yield:

- Not planting at the optimal planting dates.
- Planting density.
- Field selection (soil pH).
- Fertilisation.
- Hybrid selection.
- Environmental factors.
- Planting sunflower as a catch crop.

Reducing plant stress

Dr Ma'ali has done various studies on sunflower cultivation in South Africa. To better understand the effect of the planting date on yield and quality, she emphasised the need to consider each plant growth stage. By anticipating the timing of critical stages, producers can mitigate sunflower exposure to stressful environmental factors. Early plantings are often recommended to escape the risks posed by heat and water stress during anthesis.

The study reveals that on average, oil and protein content were more hybrid related than planting date related, while seed and oil yield were more affected by the planting date. The trial results show that the probability of obtaining higher yield, higher oil content and higher oil yield under a specific threshold decreased when sunflowers were planted after December.

"To achieve the yield target, a producer who plans on planting sunflower as the main crop should consider planting during November, and no later than the end of December. If you consider planting sunflower as a cash crop, do not treat it as a catch crop," Basson said.

Syngenta has the answer

Although sunflowers are planted in South Africa mainly for oil production and bird feed purposes, the future of this crop certainly lies in oil production. Syngenta's Sensako brand boasts two sunflower hybrids – SY 3970 CL and SNK 270 CL – that can be strategically cultivated to deliver high oil content.

"The future of sunflower lies in oil," Basson pointed out. "In the past, the focus used to be on grain yield only, leaving processors with the short end of the stick. Now, the focus is on hybrids with a high oil content, which can contribute to better profitability for growers and processors alike."

The current oil-content standard for sunflower grain is 36 to 38%, but with SY 3970 CL growers have been achieving 42 to 50% oil in recent years. "There are several new hybrids in the Syngenta pipeline and growers can look forward to products that will not only yield a high oil content, but will also perform very well in terms of grain yield," said Basson.

For more information on Syngenta's product range, visit *www.syngenta.co.za* or *www.sensako.co.za*.

Syngenta's Sensako sunflower hybrids not only yield a high oil content but will also perform very well in terms of grain yield.

CRISPR-mediated technology for seed oil improvement in rapeseed: Challenges and future perspectives

By Essa Ali and Kewei Zhang

Clustered regularly interspaced short palindromic repeats or CRISPR/CRISPR-associated (Cas) systems, which were first discovered to give bacteria and archaea adaptive protection against viral and plasmid infections (Barrangou *et al*., 2007), have been widely used in recent years to modify the genomic deoxyribonucleic acid (DNA) in many organisms.

Since their inception, the CRISPR-mediated genome editing systems have promised to significantly improve crop genetics with exceptional features (Zhu *et al*., 2020). The CRISPR-based genome editing technique has unmatched advantages over other genome editing systems such as the zinc finger (ZFN) nuclease system and transcription activator-like effector nucleases (TALEN transcription) system (Zhang *et al*.,2017).

The quick genetic studies of intricate regulatory circuits by allowing several single-guide RNA (sgRNAs) encoded in a single CRISPR array to delete different target sites, is one of those advantages. In addition to deleting genes, it may also be used to insert specific DNA fragments into target sites and specifically change the transcriptional activity of genes (Li *et al*., 2013; Lowder *et al*., 2015).

Since its initial application in 2013 for plant gene editing, CRISPR/Cas9 technology has been used extensively in food crop species (rice, wheat, tomato, etc.), industrial crops (*Cichorium intybus*, coffee, dandelion, etc.), ornamental crop species (lily, lotus, rose, etc.), oil crop species (rapeseed, soya bean, sunflower, etc.), fibre crop (cotton), and feed crop (alfalfa) (Ricroch *et al*., 2017; Liu *et al*., 2021). These findings demonstrate the critical role CRISPR/Cas9 is playing in crop improvement and plant functional genomics research.

Canola research and breeding

Brassica napus, also known as canola in North America and oilseed rape in Europe, the third largest vegetable oil source in the world, is grown primarily for its oil-rich seed. The meal produced as a byproduct is utilised as animal feed, primarily in poultry and dairy industries (Wallenhammar *et al*., 2022). China alone contributes about 20% of the total world production. It is also cultivated in other countries such as India and Canada, as well as in the European Union (Hu *et al*., 2017).

For centuries rapeseed producers have relied on traditional breeding methods to develop better varieties. Contrarily, *B. napus* is an allotetraploid species with several repetitive sequences. Gene redundancy makes it very inefficient to alter traits using traditional genetic methods like hybridisation and random mutation. However, gene editing technologies may assist in speeding up the process.

A CRISPR-Cas9 strategy was successfully used in *B. oleracea* for genome editing, indicating that a transfer to oilseed rape might also be possible (Lawrenson *et al*., 2015). To prevent seed loss by boosting shatter resistance, the CRISPR/Cas9 technology was initially used in rapeseed in 2017 to target two BnALC homologous genes for site-directed mutagenesis (Braatz *et al*., 2017). The last five years have seen significant agronomical trait advancements in rapeseed using CRISPR/Cas9-mediated genome editing. As of 2022, numerous studies on the effective use of CRISPR/Cas9 technology in *B. napus* breeding have been published (Zhang *et al*., 2019; Yan *et al*., 2021; Liu Y *et al*., 2022; Tan *et al*., 2022).

Indicating the application of this genome editing technology in rapeseed is becoming even more mature and has been extensively used in the creation of germplasm resources and genetic improvement of oilseed rape. CRISPR/Cas9 technology has become an important tool to analyse gene function and molecular mechanisms in rapeseed.

Advantages of CRISPR/Cas9

B. napus is an allotetraploid species, and the majority of its genes have redundant functions and multiple copies (Chalhoub *et al*., 2014). It is exceedingly inefficient to alter features by random mutations because of gene redundancy. To enhance one feature, it is frequently required to modify several genes. The Cas9 protein can be directed to specific regions by a variety of sgRNAs, which presents an opportunity to carry out multiple gene editing by expressing Cas9 along with the various sgRNAs (Cong *et al*., 2013; Lawrenson *et al*., 2015).

Because numerous mutations can be caused simultaneously in polyploid rapeseed, CRISPR/Cas9 technology provides clear advantages. There is currently a growing number of research using CRISPR/Cas9 to knock out multiple copies of genes in *B. napus*, demonstrating how promising this technology is for understanding polyploidy in this organism. Whether using a single or multiplex genome editing strategy, the CRISPR/Cas9 system is a useful tool and is frequently employed for crop improvement (Lohani *et al*., 2020).

Multiple gene mutants are typically needed when analysing the functions of homologous genes and members of gene families with high sequence similarity. Due to their ability to effectively produce

Table 1: The genes targeted for seed oil improvement in *Brassica napus* L by CRISPR technology.

Targeted gene	Effects	Reference
BnFAD2	Increased oleic acid content	(Okuzaki *et al.*, 2018; Huang *et al.*, 2020)
BnTT8	Yellow-seeded traits	(Zhai *et al.*, 2020)
BnTT2	Yellow-seeded traits	(Zie *et al.*, 2020)
BnGTR2	High oil content	(Tan *et al.*, 2022)
BnLPAT2	Enlarged oil bodies and low oil content	(Zhang *et al.*, 2019)
BnLPAT5	Enlarged oil bodies and low oil content	(Zhang *et al.*, 2019)
BnFAE	Low erucic acid	(Liu Y. *et al.*, 2022)
BnLEC1	Reduced seed oil content and C18:1, increase of C18:2	(Yan *et al.*, 2021)

mutants with numerous gene mutations, distinct sgRNAs connected in tandem exhibit a significant advantage in multiple gene editing (Xiong *et al.*, 2019).

It is also of prime concern how specific CRISPR/Cas9 technology is when used for targeted gene editing in plants. Typically, any off-target locations should be examined to guarantee that mutation is as specific as desired.

Main genes edited

Rapeseed breeding has historically focussed on improving the fatty acid (FA) composition and increasing oil content. Since the introduction of CRISPR/Cas9 in 2017 in rapeseed, the research on genome editing in this species has expanded (Braatz *et al.*, 2017). After that, a significant number of rapeseed genes were modified, creating a useful germplasm resource for studying the fundamental biology of rapeseed and cultivating novel varieties (*Table 1* and *Figure 1*).

LPAT changes oil content

The Kennedy pathway's key enzyme, lysophosphatidic acid acyltransferase (LPAT), catalyses the conversion of FAs into triacylglycerol (TAG), which encourages oil production (Chapman and Ohlrogge, 2012). Using CRISPR/Cas9, all seven *BnLPAT2* homologous copies and four *BnLPAT5* homologous copies were eliminated to examine their respective functions in the rapeseed oil biosynthesis.

The oil content was reduced to diverse degrees in the knockout mutants of the various copies of *BnLPAT2* and *BnLPAT5*, with a 32% decrease in *Bnlpat2* lines, a 29% decrease in *Bnlpat5* lines, and a 39% decrease in *Bnlpat2*/*Bnlpat5* double mutant lines.

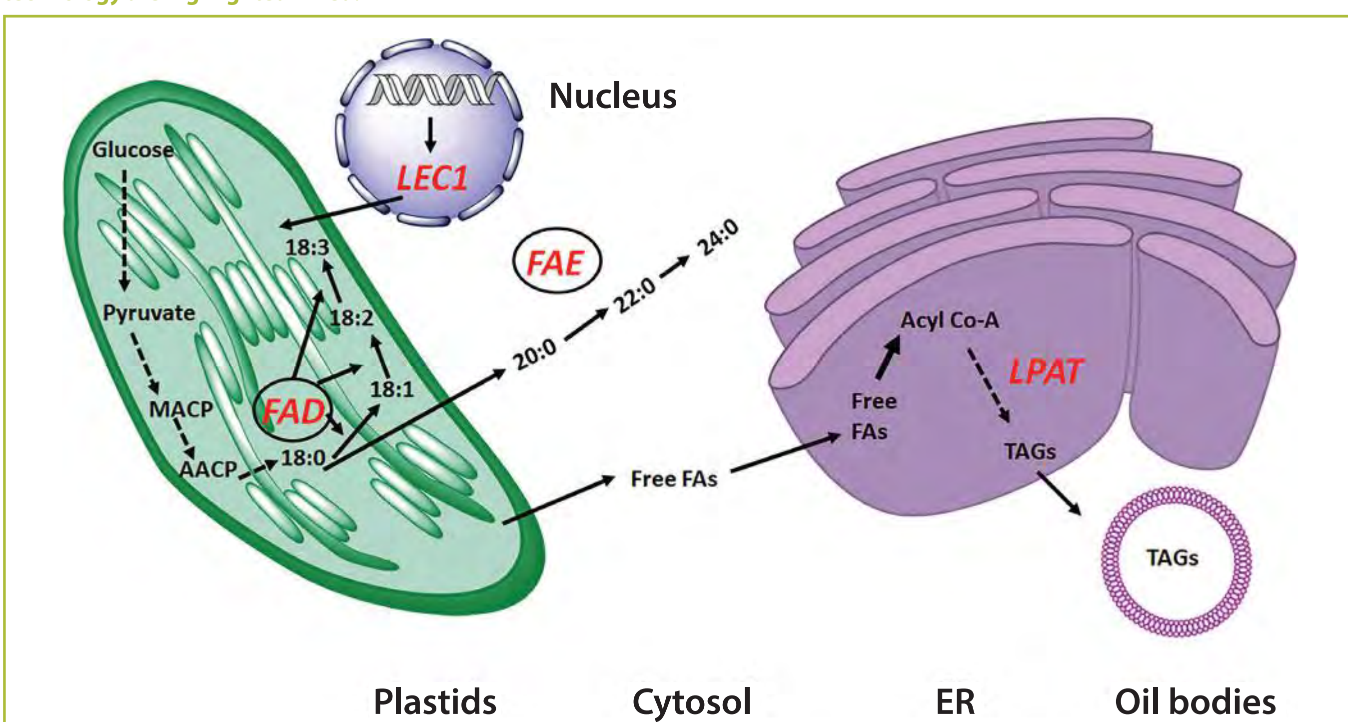
This study confirmed that all *BnLPAT* copies could change the oil content and that oil bodies with knockouts of all copies were larger and contained less oil (Zhang *et al.*, 2019).

Transparent testa

For instance, by knocking out the *B. napus* transparent Testa-8 (*BnTTS*) gene using CRISPR/Cas9 technology, yellow-seeded mutants with increased seed oil and protein content as well as altered FA composition were created.

Transparent testa 8 (*TTS*), according to mounting evidence, controls the

Figure 1: Overview of a fatty acid biosynthesis pathway. The genes targeted for seed oil improvement in *Brassica napus* by CRISPR technology are highlighted in red.



FFAs: free fatty acids; MACP: malonyle ACP; AACP: acyle ACP; LPAT: lysophosphatidic acid acyltransferase; FAE: fatty acid elongase; LEC1: leafy cotyledon; FAD: fatty acid desaturase; ER: endoplasmic reticulum.

accumulation of flavonoids in a variety of crops including *Medicago truncatula* (Li *et al*., 2016; Escaray *et al*., 2017). It has been determined that the *B. napus* transparent testa 2 (*BnTT2*) allelic variation in the C genome (*BnaC*) plays a role in rapeseed FA production and seed colour development (Zhou *et al*., 2016). Yellow-seeded mutants were produced using the CRISPR/ Cas9 technique by knocking out *BnTTS* and *BnTT2* homologs (Xie *et al*., 2020; Zhai *et al*., 2020), which displayed enhanced seed oil and changed FA composition.

Only two yellow-seeded mutants, *BnTTS* and *BnTT2*, have been produced so far. It is highly encouraging to produce additional yellow-seeded mutants by selectively knocking out essential flavonoid pathway genes.

Fatty acid desaturase 2

One of the main priorities for genetic manipulation in oilseed rape is FA content, which influences the nutritional and manufacturing quality of vegetable oil. In oilseed rape, oleic (18:1), linoleic (18:2), and linolenic acid (18:3), synthesis is influenced by the FA desaturase 2 gene (*FAD2*). The allotetraploid rapeseed contains four copies of *BnFAD2*.

All the copies of *BnFAD2* were altered using CRISPR/Cas9-based genome editing technology to produce novel allelic variants in oleic acid and other FA levels. Two targeting sites produced many mutants, and the phenotypic diversity of the mutants was extensively assessed. Compared to the wild type's 66%, the oleic acid content of the mutant seeds grew dramatically, reaching a maximum of 80%, while the levels of linoleic and linolenic acids declined.

Compared to *BnFAD2* mutations, *BnFAD2.A5* mutations led to more significant changes in the FA profile. Additionally, mixing various *BnFAD2* mutant alleles can even drastically widen the variety. It was discovered that the impact of various mutation types at *BnFAD2* alleles on oleic acid levels varied, indicating a potential for FA level manipulation by precise mutation at specific regions of a gene (Huang *et al*., 2020).

A recent study on *BnFAD2* showed that the CRISPR/Cas9-mediated genome editing of the *BnFAD2's* double loci (A5 and C5) can precisely edit the targeted genes, increasing the seed's oleic acid content to a much greater extent than can a single locus-editing technique (Liu H *et al*., 2022). Recent findings also reveal that induced mutations in the *BnFAD2* genes by CRISPR/Cas9-mediated editing have produced high oleic acid germplasm from the CY2 cultivar (Shi *et al*., 2022).

Leafy cotyledon 1

Leafy cotyledon (*LEC1*) controls more than 50% of the genes in *Arabidopsis* involved in plastid FA production (Mu *et al*., 2008), demonstrating its importance as a transcriptional activator for controlling seed oil content. In *B. napus*, though some signal has also been seen in the cytoplasm, *BnLEC1* is primarily confined to the nucleus. The two *BnLEC1* homologs have comparable expression patterns, with expression rising during seed development and peaking at 23 DAP.

Additionally, the high-oil content line had higher *BnLEC1* gene expression than the low-oil content. The decreasing and increasing pattern of seed oil content was caused by overexpressing and knocking out *BnLEC1*, respectively, demonstrating that *LEC1* homologs have conserved functions in positively regulating seed oil content (Yan *et al*., 2021).

Fatty acid elongase 1

Vegetable oils' processing and edible qualities are influenced by the FA composition, and erucic acid is the FA that may be harmful to human health. Low erucic acid has therefore always been a breeding characteristic of *B. napus*. In the synthesis of erucic acid, fatty acid elongase 1 (*FAE1*) is essential.

In three *B. napus* germplasms with high erucic acid (>30%) and high oil (>50%), the CRISPR/Cas9 technology was employed to produce targeted mutations on two homologous copies of *BnFAE1*. The double mutation of *BnAOS.FAE1* and *BnC03.FAE1* (*a08c03*) resulted in nearly zero erucic acid in all BnFAE1-edited germplasms, and the level of oleic acid was increased.

This demonstrated that the erucic acid content was significantly reduced by more than 10% in the mutant of *BnC03.FAE1* (*c03*). Furthermore, elimination of *BnAOS.FAE1* or/and *BnC03.FAE1* had no appreciable impact on other agronomic parameters but marginally reduced seed oil content. These results showed that CRISPR-based technology can be successfully used in producing low erucic acid germplasms of *B. napus*, which offers a workable method for upcoming low erucic acid breeding (Liu Y *et al*., 2022).

In another study, CRISPR/Cas9 mediated genome editing was used to generate novel knockout plants of *BnFAE1* genes to improve the nutritional quality of rapeseed cultivar CY2. As a result, a significant increase in oleic acid (70 to 80%) content was shown in new lines (Shi *et al*., 2022).

Challenges and solutions

Off-target effects can result in unwanted outcomes even though they are not as serious for CRISPR/Cas applications in plants, removing off-target effects is still necessary for genome editing. Off-target effects can be greatly reduced by direct delivery of the protein or RNA of Cas enzymes and sgRNAs, such as by RNP transformation. This is because these functional molecules are not integrated into plant genomes; as a result, they can swiftly decay after performing their roles and only have a short life in plant cells, which reduces their ability to target additional areas (Zhang *et al*., 2021).

In addition, utilising the whole 23 nucleotide (protospacer plus PAM) sequence as a query in the *Brassica* genome using BLAST searches in conjunction with other CRISPR/Cas9 online resources can enable the selection of guide RNA with no or a low number of projected off-targets (Lawrenson *et al*., 2019).

According to recent research, precision sgRNA design can be used to combat off-target mutations (Jacinto *et al*., 2020). To prevent unexpected results, it is crucial to design sgRNAs with a minimum amount of off-target activity. Currently, several free online prediction tools, like CRISPOR (*www.crispor.org*) and CCTop (*www.crispr.cos.uni-heidelberg.de*) (Stemmer *et al*., 2017; Concordet and Haeussler, 2018), has been utilised to assist researchers in designing sgRNA to minimise off-target effects.

Additionally, several machine learning-based techniques have been created and applied to the prediction of sgRNA activity in agronomy to discover sgRNAs with high on-target activity (Hesami *et al*., 2021; Niu *et al*., 2021). The creation of these techniques aids in determining the activity of intended sgRNA in crops and helps prevent unanticipated outcomes. Numerous studies have mentioned that they did not find any off-target activity in possible off-target locations. The off-target editing is insignificant and much less common when gRNAs are carefully generated than naturally occurring variability in plants.

To create rapeseed variants with fewer regulatory restrictions, it is also necessary to develop transgene-free genome editing techniques in this plant. A recent approach for efficiently delivering CRISPR complexes to rapeseed protoplasts using transient transfection has been discovered by researchers (Li *et al*., 2021). Other rapeseed researchers will benefit greatly from the advice provided by this improved protoplast regeneration methodology.

Additionally, by infecting pollen with magnetic nanoparticles and then using that pollen to pollinate plants, transgenic cotton was effectively produced. Other nanoparticles, such as DNA origami and DNA nanostructures, as well as carbon nanotubes, have also been successfully tested for the unaided transport of exogenous DNA (Zhao *et al*., 2017; Demirer *et al*., 2019; Kwak *et al.*, 2019).

If CRISPR/Cas9 for rapeseed genome editing could effectively use delivery by nanomaterials without tissue culture, it would be a quick way to create non-genetically modified (GM) rapeseed while evading stringent GM laws. The CRISPR/Cas9 technology will produce additional top-notch rapeseed germplasm resources, and provide enormous economic value with future advancement and the progressive resolution of remaining difficulties.

Potential prospects

To effectively utilise this technology for seed oil improvement in *B. napus*, we seek to present a concise description of the developments in CRISPR-mediated genome editing technology, as well as its applications and potential prospects. The further advancements in CRISPR/Cas technology, coupled with other breakthroughs, will significantly benefit the genetic improvement and molecular breeding of *Brassica* crops in terms of seed oil improvement and other agronomic traits.

More gene targets for CRISPR/Cas9-based crop improvement will be discovered with the aid of current multiple omics, such as whole genome sequencing, RNA-seq, and small RNA-seq. The advent of straightforward, precise genome-editing tools using CRISPR/Cas9 has revolutionised crop breeding and plant biology research.

In addition, new applications for CRISPR/Cas technologies will be created, with the potential to change the tempo and focus of *Brassica* research. Improvements in *B. napus* basic genetic research, the development of innovative delivery methods, boosting public confidence in the security of CRISPR-modified crops, and the development of supporting regulatory frameworks are just a few of the many more successes that are needed in the future.

To promote functional genomics and aid in the breeding of new *Brassica* varieties with improved seed oil characteristics, we believe that CRISPR/Cas technologies will be extensively used in this crop species.

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Effective management of herbicide carryover

By Prof Charlie Reinhardt, North-West University

When it comes to herbicide performance, it is reasonable to expect that it will control weeds effectively for as long as possible during the crop-growing season. Some herbicides meet this expectation and others do not, yet others could exceed expectations and persist too long in the soil thereby creating problems for the next crop in a rotation system.

For the sake of the safety of the follow-up crop the time for which the herbicide persists in soil, i.e. the duration of its weed control effect, should not be so long that it results in carryover in soil of active residues to the following growing season where the next crop in the rotation system could suffer damage if it is susceptible to the herbicide in question. Rotation systems involving maize, soya beans, dry beans, potatoes, sunflower, etc., are prone to crop damage due to carryover of herbicide residues in soil.

Herbicide carryover

Fortunately, not all herbicides have a carryover risk to consider because their persistence in soil is measured in days or weeks and not in months. Herbicides with relatively long persistence in soil and, therefore, associated carryover risk are certain members of the following chemical groups: triazine (atrazine and terbuthylazine), triketone (mesotrione and sulcotrione), imidazolinone (imazapyr and imazethapyr), and the auxin-type herbicide group (picloram and aminopyralid).

The important herbicides are all organic by nature, i.e. their basic building blocks comprise atoms of carbon, hydrogen, oxygen, and nitrogen. Consequently, many types of herbicide molecules are subject to decomposition by soil microbes that use them as food. However, herbicides vary in their resistance to microbial breakdown, resulting in herbicide inactivation based on the extent to which they are 'protected' by the presence of antimicrobial atoms in their structure, including the atoms chlorine, boron, and fluorine.

For example, the herbicide with arguably the longest persistence in soil, picloram, resists microbial attack due to three chlorine atoms in its molecular structure. Mesotrione molecules are subject to microbial breakdown in soil, whereas the breakdown of atrazine and terbuthylazine molecules is ascribed to both microbial and chemical breakdown.

Chemical breakdown: Atrazine

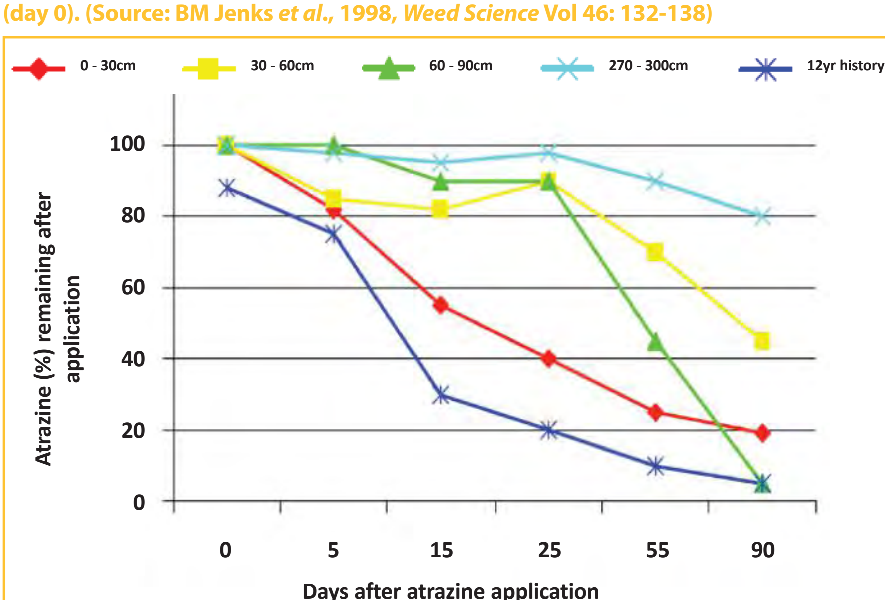
Figure 1 shows the breakdown rates of atrazine in a field study done in the United States. Atrazine was applied and its concentration determined over time at different soil depths. The atrazine breakdown rate was slowest at the deepest depth of 270 to 300cm, and relatively fast in the topsoil zone (0 to 30cm). Microbial activity often decreases with soil depth, and this probably explains the slower and reduced breakdown of atrazine with increasing soil depth (*Figure 1*).

In the same soil (*Figure 1*), where atrazine had been applied annually for 12 years, the breakdown rate was the quickest, indicating that soil microbes with a preference for atrazine as food had been promoted over those 12 years.

Also important to consider is that chemical breakdown of atrazine occurs faster under acidic soil conditions (pH [H_2O] 4 to 5) and slower in neutral and alkaline soil (pH [H_2O] 7 to 8). This could partly be attributed to differential microbial activity at low and neutral or alkaline soil pH. Furthermore, in acidic soil, atrazine is strongly attracted to and fixed on negatively charged soil colloids due to atrazine's positive charge (atrazine$^+$) at low soil pH (pH [H_2O] 4 to 5).

Atrazine becomes a neutral molecule without electric charge at neutral soil pH which causes it to be weakly fixed

Figure 1: Factors influencing the breakdown rate or persistence of herbicides in soil. Amount (%) of atrazine remaining in soil at different depths following application (day 0). (Source: BM Jenks *et al.*, 1998, *Weed Science* Vol 46: 132-138)



or adsorbed on soil particles with a negative electric charge (clay and humus colloids) – this pH-dependent behaviour explains why atrazine carryover damage to susceptible crops often occurs after a liming event due to the herbicide being readily available for uptake or absorption by crop roots.

The practical implications of reduced and slower breakdown of atrazine with increased soil depth mean that its active residues can remain safe and accumulate at deeper depths where soil microbial activity is relatively low, especially at neutral (pH=7) and higher soil pH levels.

This behaviour of atrazine in soil has two types of consequences for an atrazine-susceptible crop:

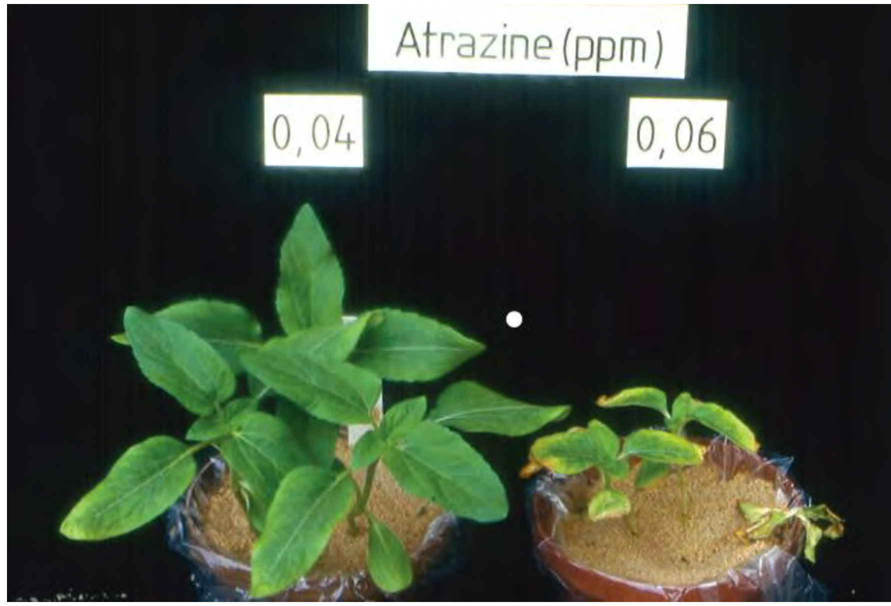
- The crop can initially grow well and only later in the season reach and absorb the atrazine residues through expanded root systems, and/or
- The atrazine residues can move upward due to pull or capillary forces created by water evaporation on the soil surface and damage crop seedlings at an early stage.

The role of drought

Herbicide uptake or absorption by plant roots occurs in a water medium, similar to the process for nutrients. Under low soil-moisture conditions, root uptake of herbicides is relatively low to zero because lack of soil moisture increases the attraction or fixation of the herbicide molecule on soil colloids (clay minerals and humus) and molecules are not able to move along a water gradient towards and into plant roots.

Besides herbicidal effect being low to non-existent under drought conditions, the breakdown of herbicides slows down or ceases due to lack of chemical degradation, which can only occur in a water medium, and/or due to low to zero microbial activity, which reduces or eliminates biological breakdown of herbicides.

Microbes need optimum soil moisture levels to maintain their activity. Therefore, low soil moisture, especially when it lasts for prolonged periods, results in extended persistence of soil-applied herbicides. In the case of herbicides with inherently long persistence it means increased risk of residue carryover to the following growing season and crop, with consequent crop damage.



Response of sunflower to simulated atrazine residues (ppm = mg herbicide per kg soil). Will you know that atrazine caused such damage symptoms? Diagnosis of herbicide damage on crops is best left to those skilled in the art. (Photograph: CF Reinhardt)

Limited rainfall following herbicide application to soil not only reduces herbicidal activity due to reduced uptake by plant roots, but also limits the extent to which herbicides can dissipate from soil, thereby influencing herbicide persistence. Herbicide dissipation or loss from the soil is a function of rainfall and herbicide mobility, especially vertical mobility or leaching down the soil profile and out of the next crop's root zone.

Low rainfall for extended periods results in low to zero herbicide dissipation in soil, and hence, the risk of residue carryover increases under drought conditions. For the reasons mentioned before, certain herbicide labels specify the minimum rainfall that must be received between the time of herbicide application and planting of the follow-up crop.

Adhering to waiting periods

Registration holders of herbicide products manage the risk of herbicide carryover in the soil through 'waiting periods' or 'safe periods' that must lapse after herbicide application before the herbicide-susceptible follow-up crop can be planted. Such waiting periods are stipulated on the labels of those herbicide products of which the active ingredient or herbicide has the propensity to persist for relatively long periods in soil.

It may surprise conscientious label-readers, and better still adherents to label instructions, to hear that waiting periods are often ignored, either through ignorance or deliberately. Ignore waiting periods at your peril. One year it might not matter if the waiting period instruction has not been followed but just the next year, or on another farm in the same season, you and the innocent crop might just suffer the consequences.

This past year's widespread drought conditions, or below-average rainfall, through February, March and even April have created situations that are conducive to the extended persistence of soil-applied herbicides. The risk of follow-up crop damage due to herbicide carryover in the soil is very high for the rest of this year, at least for certain herbicides.

Producers are advised to have soils tested for herbicide residues. Laboratory analysis reveals the total amount of herbicide residue present in the soil, whereas bioassays conducted through pot experiments allow the effect of biologically active residue to be determined for a specific crop and even cultivar.

Charlie Reinhardt is a professor in agronomy at North-West University, and research lead in the South African Herbicide Resistance Initiative (SAHRI) at the University of Pretoria (*www.up.ac.za/za/sahri*). He can be reached at 083 442 3427 or dr.charlie.reinhardt@gmail.com.

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Figure 1: (A) Nutrient medium showing mycoparasitism of *Fusarium oxysporum* by *Trichoderma asperellum*. (B) Illustration of *Trichoderma* hyphae coiling around its host.

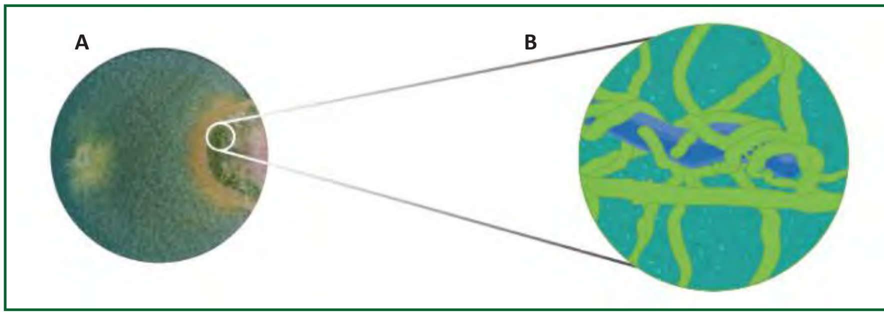

Figure 2: Nutrient medium showing pathogen suppression by *T. asperellum* and the formation of a clearing zone due to the production of bio-active compounds by *T. asperellum*.

Fungal control mechanisms

Mycoparasitism

T. asperellum can form symbioses with host plants by colonising their root systems. This is a useful attribute as *T. asperellum* can also detect other fungi, including pathogenic fungi, through extracellular signalling molecules. Once *Trichoderma* encounters the pathogen, it coils around and grows alongside the host's hyphae (*Figure 1*).

Trichoderma produces cell-wall degrading enzymes that hydrolyse and penetrate the pathogen's cell wall via an infection peg. Once the *Trichoderma* has penetrated the host, it can spread and overtake the pathogen through the production of a range of bioactive compounds (*Figure 2*).

Nutrient and space competition

T. asperellum has a fast growth rate and strong potential to mobilise and utilise soil nutrients, which allows it to easily colonise the rhizosphere of plants, thereby excluding pathogens from these especially critical areas.

Additionally, since iron is an essential mineral nutrient for many microbes, *T. asperellum* can produce small, high-affinity, iron-chelating compounds called siderophores. These siderophores seize iron from the environment, making it (i) easily accessible to the plants and (ii) unavailable for other fungi. Thus, the sequestration of iron causes *Trichoderma* to suppress the growth of fungal pathogens in the soil.

Induce systemic resistance

T. asperellum produces a range of micro-organism associated molecular patterns that are known to induce different signals in the plant and lead to the expression of defence proteins. These proteins not only suppress pathogens directly, but also enhance biochemical and structural barriers to protect the plant from pathogen attack.

Damage-associated molecular patterns that are liberated by the *T. asperellum* from both plants and fungal pathogens can also be recognised by plant receptors to activate the defence cascade in the plant.

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Nitrogen fertiliser demand of canola in conservation agriculture systems

By Dr Izané Crous, Dr Johan Labuschagne and Prof Pieter Swanepoel

Most canola producers in the Western Cape province have adopted conservation agriculture (CA). As a result of less soil disturbance, implementing crop rotation and preserving stubble (or inclusion of cover crops), the soil's chemical, physical and biological characteristics improved dramatically.

The resultant higher soil organic carbon (C) content improved soil structure and a more favourable environment to host a more diverse microbial population ensured improved crop productivity and resilience. The increased availability of inorganic nitrogen (N) in CA systems may reduce fertiliser N requirements.

Dr Johan Labuschagne, a scientist at the Western Cape Department of Agriculture at the beginning of the trial, identified the need to perform in-field N trials to refine current canola norms. Prof Pieter Swanepoel from Stellenbosch University and Dr Izané Crous from Omnia Holdings joined the team later. Prof Swanepoel took on the role of co-study leader and Dr Crous as a PhD student.

Nitrogen and soil type

Trials were established at Riversdale, Riviersonderend (Tygerhoek), Moorreesburg (Langgewens), Darling, and Porterville to investigate the effect of different N rates on canola seed yield and oil content. At all the sites canola followed wheat in the crop rotation systems. The N treatments consisted of a control treatment, where no N fertiliser was applied, and treatments where 25kg N ha^{-1} was applied at planting.

Depending on the type of planter used, between five and 15kg N ha^{-1} was placed in or beneath the row during planting and the rest broadcasted by hand, immediately followed by the planting process. Nitrogen topdressings were applied at the four to six leaf stage at rates of 0, 25, 50, 75, 105, 135 and 165kg N ha^{-1}. Total N applied was therefore 0, 25, 50, 75, 100, 130, 160 and 190kg N ha^{-1}.

Soils differed with shallow, sandy loam soil at Riversdale, shallow shale-derived soil at Riviersonderend and Moorreesburg, deep, reddish clay-loam soil at Porterville and deep sandy soil at Darling. High stone contents characterise the soils at Riversdale, Riviersonderend and Moorreesburg. The C content of the soils at Riversdale and Riversdale was higher than at the other sites. In-season rainfall

Table 1: Monthly and total in-season rainfall (in millimetres) from April to September for the different research sites included in the study.

Sites	Year	April	May	June	July	August	September	April to September
Riversdale	2016	-	-	30	68	34	63	195
	2017	4	11	33	40	44	17	149
	2018	16	13	26	18	35	68	176
	2019	13	21	18	37	3	26	118
Riviersonderend	2016	16	2	42	106	30	74	270
	2017	7	8	26	37	47	16	141
	2018	11	12	32	38	31	55	179
	2019	7	9	19	34	1	26	96
Darling	2016	28	7	65	58	43	26	227
	2018	29	35	112	62	48	41	327
	2019	5	26	48	78	36	17	210
Moorreesburg	2016	47	4	98	74	52	44	319
	2017	13	10	70	29	33	15	170
	2018	37	54	105	35	52	43	326
	2019	10	32	58	95	24	8	227
Porterville	2017	5	3	64	31	35	15	153
	2018	10	32	61	36	39	55	233
	2019	8	40	38	32	12	8	138

Figure 1: Canola seed yield and oil content as influenced by fertiliser N application rate during the 2016, 2017, 2018 and 2019 seasons at Riversdale. No common letter above bars and below dots (*italics*) indicates differences (p < 0,05) between mean seed yield or oil content, respectively.

Canola in full bloom at the Darling trial site.

received during the study period is summarised in *Table 1*.

Seed yield and oil content

For this publication, we will only look at the response of canola to N application rates in terms of seed yield and oil content. Seed yield in response to N fertiliser rate varied between years at all sites during the years covered by the study (2016 to 2019). Rainfall and the distribution thereof played a crucial role in canola's response to fertiliser N rate.

These results from the study prove that there are no fixed recipes for the N rate required and the N rate is influenced by, among others, the environmental conditions during the growing season. It is particularly important to note that our focus is to identify the N rate where further increases in fertiliser N rate did not result in a significant response in canola seed yield.

Riversdale

During the 2019 season at Riversdale (*Figure 1*), no significant response to

Figure 2: Canola seed yield and oil content as influenced by fertiliser N application rate during the 2016, 2017, 2018 and 2019 seasons at Riviersonderend. No common letter above bars and below dots (*italics*) indicates differences (p < 0,05) between mean seed yield or oil content, respectively.

N fertilisation was observed. This finding is the exception rather than the rule. It can, however, be explained by low in-season rainfall (118mm), including a dry September (26mm), which most probably restricted seed filling.

During the 2016, 2017 and 2018 seasons, canola yields at applications of 50, 25 and 75kg N ha^{-1}, respectively, did not differ significantly from the maximum yields recorded. The lack of response to N in 2017 was caused by a dry September (17mm) adversely affecting the seed-filling stages. The 2016 and 2018 seasons were characterised by sufficient in-season and high rainfall during September.

The Tygerhoek trial site while being prepared for sowing.

Riviersonderend

At Riviersonderend (*Figure 2*) during 2016, 2018 and 2019, no significant increases in yields were recorded when N rates were increased above 50kg N ha^{-1}. In-season and September rainfall were relatively high during 2016 (270 and 74mm) and 2018 (179 and 55mm), thereby increasing yield potential accompanied by an increase in N demand of the canola crop.

The response during 2019 might have been influenced by other environmental conditions as no significant yield increases were found when N application rates were increased above 50kg N ha^{-1} despite low in-season (96mm) as well as relatively low September (26mm) rainfall. Due to the low in-season (141mm) and September (16mm) rainfall received during 2017, the canola responded only significantly to a maximum of 25kg N ha^{-1}.

Darling

The sandy soil at Darling resulted in relatively high N demands. During 2016 and 2018, in-season rainfall and September

Figure 3: Canola seed yield and oil content as influenced by fertiliser N application rate during the 2016, 2018 and 2019 seasons at Darling. No common letter above bars and below dots (*italics*) indicates differences (p < 0,05) between mean seed yield or oil content, respectively.

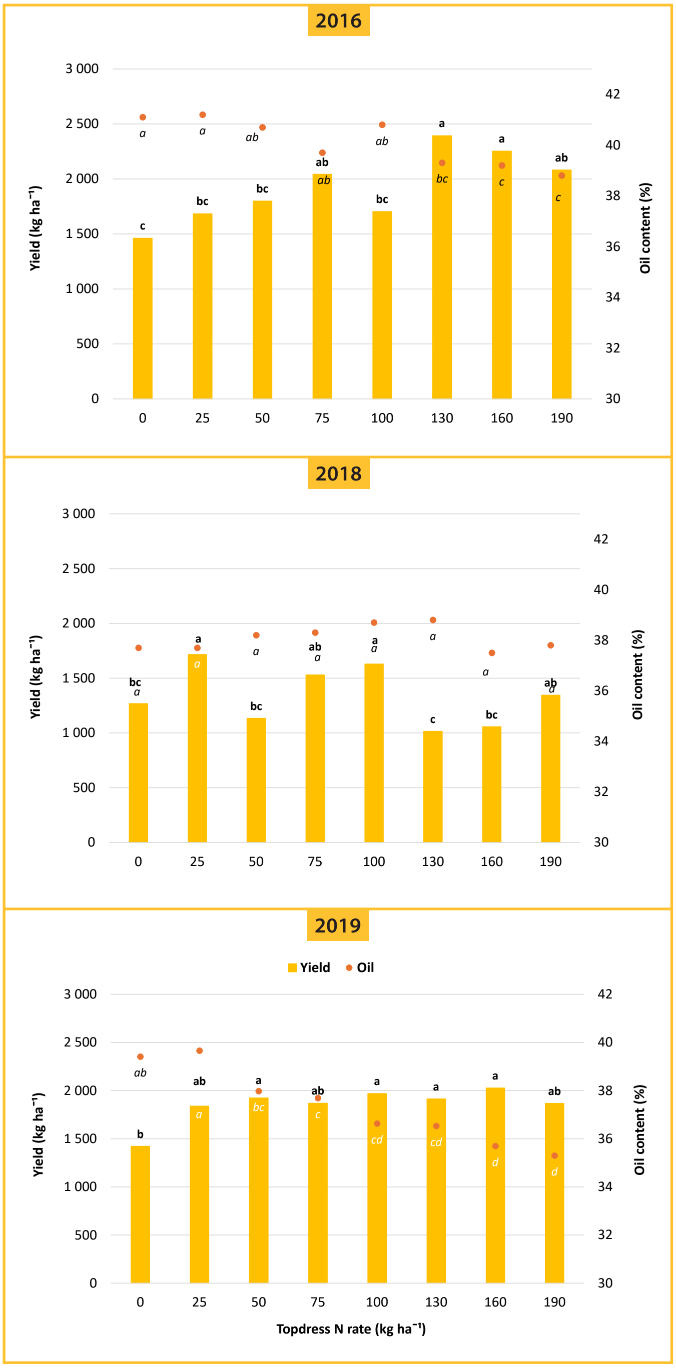
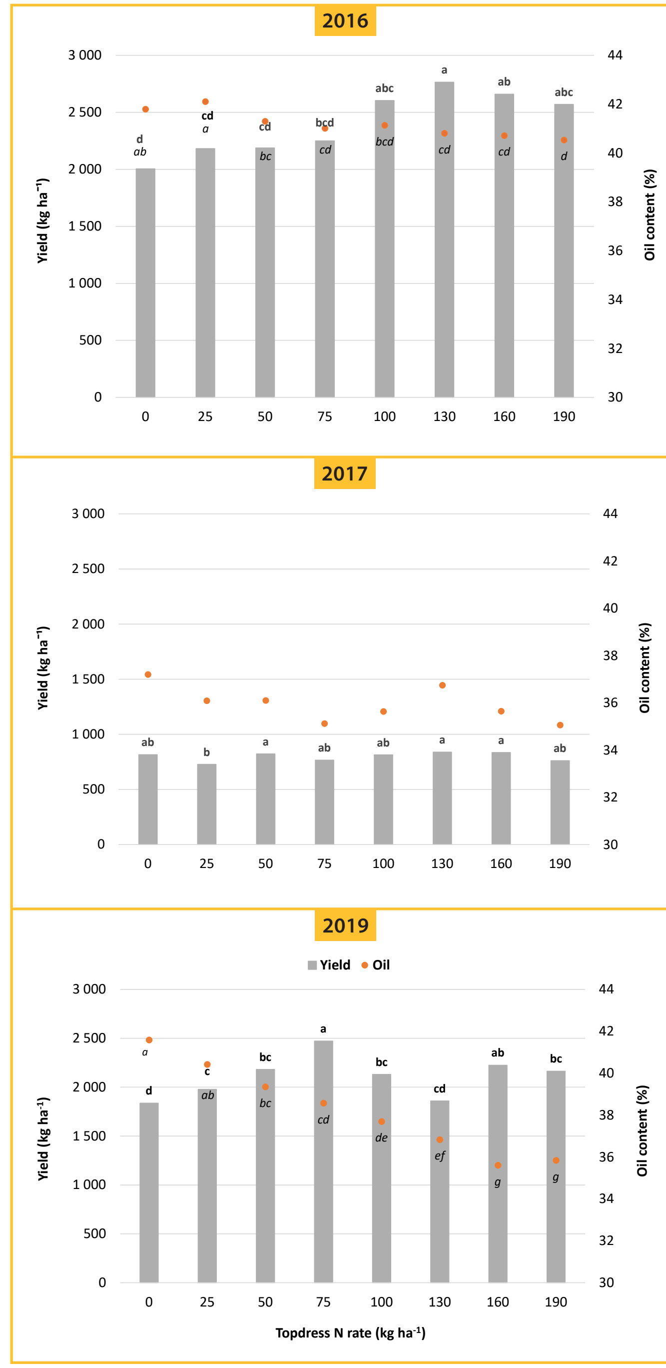


Figure 4: Canola seed yield and oil content as influenced by fertiliser N application rate during the 2016, 2017 and 2019 seasons at Moorreesburg. No common letter above bars and below dots (*italic*) indicates differences (p < 0,05) between mean seed yield or oil content, respectively.



rainfall were relatively high (*Figure 3*), especially in 2018 (327 and 41mm), resulting in no significant responses where N rates were increased above 75 and 25kg N ha^{-1}.

Lower in-season (210mm) and September (17mm) rainfall in 2019 restricted significant yield increases to 25kg N ha^{-1}. Leaching losses in the sandy soil of Darling complicate explaining responses to N application rates. Due to substandard establishment, the 2017 canola crop at Darling was terminated.

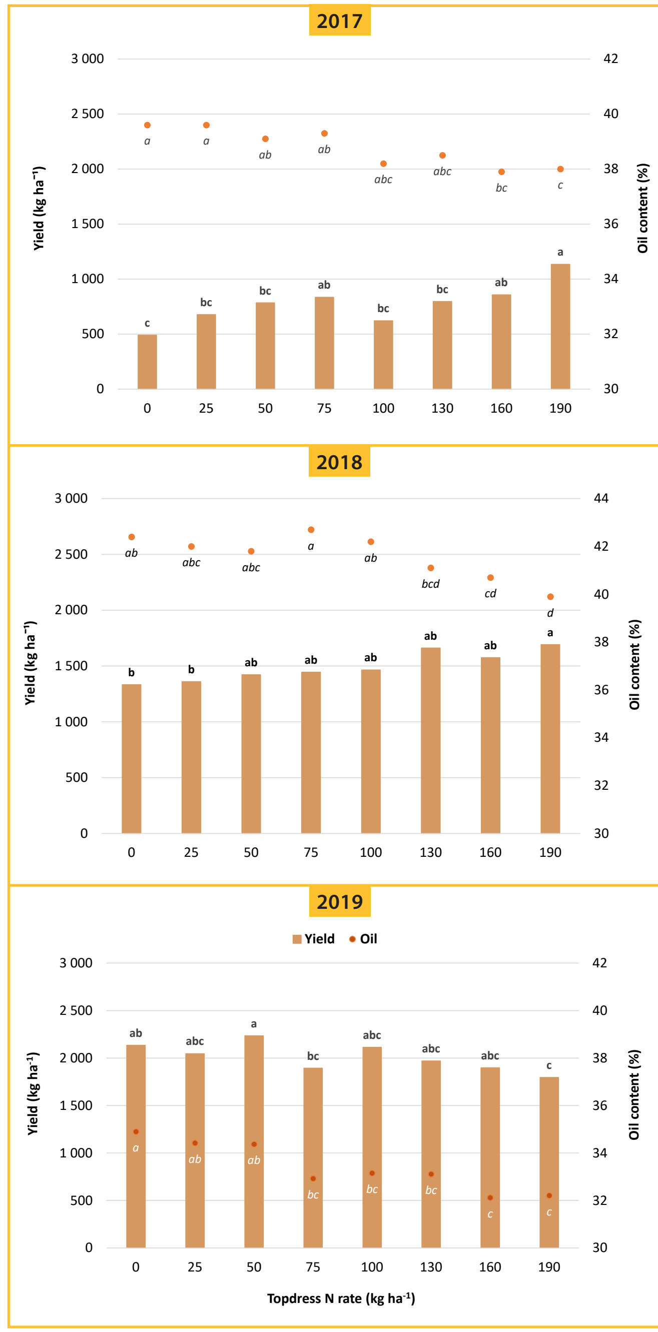
Moorreesburg

Wind damage a week before harvesting in 2018 caused considerable seed loss to the Moorreesburg site and rendered data unreliable. The 2017 season was very dry and only 170mm in-season and 15mm September rainfall (*Figure 4*) were received, and the canola crop did not respond to fertiliser N application rates. The high in-season (319mm) as well as high September (44mm) rainfall in 2016 increased the yield potential, resulting in no significant increases in yield where more than 100kg N ha^{-1} was applied.

Table 2: Nitrogen fertiliser rate and seed yield where no further significant yield increases were found and the guidelines of Fertasa for the different sites were included in the study. No N guidelines are available for the Darling area.

Sites	Year	Yield (kg ha^{-1})	N rate (kg ha^{-1})	Fertasa (kg ha^{-1})
Riversdale	2016	2 091	50	60 – 90
	2017	1 228	25	30 – 50
	2018	1 508	75	50 – 70
	2019	1 247	0	30 – 50
Riviersonderend	2016	2 153	50	60 – 90
	2017	1 798	25	50 – 70
	2018	1 844	50	60 – 90
	2019	2 148	50	60 – 90
Moorreesburg	2016	2 603	100	100 – 130
	2019	2 471	75	110 – 130
Porterville	2018	1 422	50	70 – 90
	2019	2 135	0	90 – 110

Figure 5: Canola seed yield and oil content as influenced by fertiliser N application rate during the 2017, 2018 and 2019 seasons at Porterville. No common letter above bars and below dots (*italics*) indicates differences ($p < 0,05$) between mean seed yield or oil content, respectively.



First flowers at the Langgewens trial site.

Less in-season (227mm) and extremely low September (8mm) rainfall during 2019 reduced the significant response to 75kg N ha^{-1}.

Porterville

At Porterville, the establishment of the crop was poor in 2016. No further significant yield increases were observed where more than 75 and 50kg N ha^{-1} were applied in 2017 and 2018, respectively (*Figure 5*). Response to rainfall, however, differed as only 153mm in-season and 15mm September rainfall were received in 2017 compared to 233mm and 55mm in-season and September in 2018. Although yields were relatively high in 2019, low in-season (138mm) and very low September (8mm) rainfall resulted in no responses to N rates.

Comparing the N rate and seed yield where no further significant yield increases were found as the N rate was increased with the guidelines of the Fertiliser Association of South Africa (Fertasa) demonstrates that fertiliser N demand is lower under CA (*Table 2*).

At all sites and years, the oil concentration (%) tended to decrease as N rates were increased. Oil content often declined to concentrations below 40% at the higher N rates.

The authors wish to express their gratitude for the permission granted by the Western Cape Department of Agriculture allowing us to use the data for Dr Crouse's PhD.

For more information or references, contact Dr Johan Labuschagne at jlabuschagne@sun.ac.za

The importance of good fertilisation practices: Sulphur in the spotlight

By Jason Sparrow, Kynoch agronomist, Northern Cape

Kynoch

Oilseed crops are high-value agricultural commodities used in refined edible oil products. As the world population continues to increase, the demand for high-quality seed oils also grows. Oilseed crops are amazing crops from which we can extract oil that can be utilised for numerous uses in our daily lives. Examples of oilseed crops include sunflower, soya bean, canola, and groundnuts (peanuts).

It is important to understand that it takes a tremendous amount of energy to produce oil from these crops. This comes in the form of biochemical energy generated from photosynthesis. As with any other crop, there is an energy balance between the accumulation of sugars through photosynthesis and the use of sugars through the process of respiration. Oilseed crops are unique from many other crops as they have the ability to direct the energy derived from photosynthesis into the production of oils, instead of starch.

Oil from sunflowers

Sunflower is a very interesting crop, as it has specialised photocells built into the leaves at the attachment site between the leaf and stem. These photocells regulate the water dynamics and movement within the plant, and control the movement and position of the head and leaves.

Photo means 'light' and light controls the activation of these specialised cells. The leaf senses the position of the sun and adjusts the head and leaves accordingly to maintain a perpendicular interception position. This way, the sunflower is able to ensure that it receives the maximum photosynthetic energy in order to produce oils within its seeds.

Sunflower is also one of the most efficient crops when it comes to utilising soil water. It has an extensive root system that can utilise soil profiles in ways other crops can't.

The role of sulphur

Among many other elements that come into play during a crop's life cycle, sulphur (S) is the most important as it is involved in the production of oilseeds and nuts. It is also a vital component of protein synthesis. Certain amino acids such as lysine, for example, cannot be produced without S.

Amino acids are the building blocks of proteins which are the building blocks of the oils in plants. Sulphur is an important nutrient for higher yield and better quality oilseed crops. It is required for the synthesis of proteins, vitamins and chlorophyll, as well as S-containing amino acids such as cystine, cysteine, and methionine which are essential components of oil-producing proteins.

Soil and leaf analyses are important tools used to determine deficiencies. Heavy S removal by crops under intensive cultivation and neglect of S replenishment has contributed to widespread S deficiencies in arable soils. Sandy soils are also more prone to S deficiencies due to the leaching ability of S. Sulphur is an anion which is a negatively charged ion that cannot be adsorbed by soils because soil also has a negative charge.

Due to S deficiency, plant leaves become pale green, yellowish green or entirely yellow. The leaves are smaller and narrower, and stem growth is affected. Other elements such as boron and molybdenum are important for the pollination of these oilseeds. Potassium is also a crucial element in oilseed crops as it helps to translocate the vital carbohydrates needed to produce the oil in these crops.

Talk to the specialists

Kynoch specialises in the fertilisation of all oilseed crops. We have a wide range of S-containing products that can enhance produce yield and quality.

As a bonus for producers, it is a well-known fact that sufficient S nutrition ensures better disease resistance in crops and helps to secure a better grading (quality) of the harvested product (Barker and Pilbeam, *Handbook of Plant Nutrition*, 2007).

For more information and references, email jason.sparrow@kynoch.co.za or visit *www.kynoch.co.za*.

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Concentration (g/litre)	Ni	Co	Mo	Density (kg/ℓ) at 20°C	Act 36/1947 Reg. No.
Fertilin NCM	24	8	120	1.34	B6079
Fertilin Nickon	1.15	-	-	1.31	B5957

Concentration (g/litre)	B	Ca	Cu	P	Si	Density (kg/ℓ) at 20°C	Act 36/1947 Reg. No.
Fertilin CalSiBor	4	45*	-	-	40*	1.15	B6078
Fertilin Cupriton	-	-	120*	-	-	1.15	B6080
Fertilin CaP	-	40	-	135	-	1.33	K11111

* Nano particles ensure effective bioavailability

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Density (kg/ℓ) at 20°C	1.71	1.40	1.51	1.41	1.37	1.80	1.48

* Nano particles ensure effective bioavailability

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Effective foliar nutrition

By Dr FG Adriaanse for Kimleigh Chemicals SA

Along with specific pre-season soil analyses, foliar analyses should be used for diagnosing and treating nutrient deficiencies during seasons. Reasons for performing foliar analyses include leaching of nitrogen (N), boron (B) and molybdenum (Mo) down the soil profile, phosphorus (P) sorption by clay minerals, unavailability of Mo under acidic soil conditions, unavailability of zinc (Zn), B, manganese (Mn), Mo, iron (Fe) under alkaline conditions, and copper (Cu) fixation by organic material.

The norms for dried leaf analysis have been well-established for many crops over the years. Leaf sap analysis was introduced more recently but norms have also been well established for many different crops. Leaf sap analyses include more and different analyses of both older and younger leaves at specific growth stages.

The objectives of this study were to compare the accuracy of diagnosing nutrient deficiencies according to dried leaf analyses and leaf sap analyses, based on soya yield responses to foliar application of new-generation, highly advanced foliar fertilisers from Kimleigh Chemicals SA.

Materials and methods

Leaf samples were taken from a field close to the Vaal River, approximately 30km from Potchefstroom on 4 January 2023. Dried leaf samples were analysed by NviroTek Laboratories and leaf sap by NovaCropControl, and interpreted by Agropedo. According to the dried leaf analyses, deficiencies of B, Cu and Mo were identified whereas the leaf sap analyses indicated Zn, B, Mn, Mo, Fe, P and calcium (Ca) deficiencies.

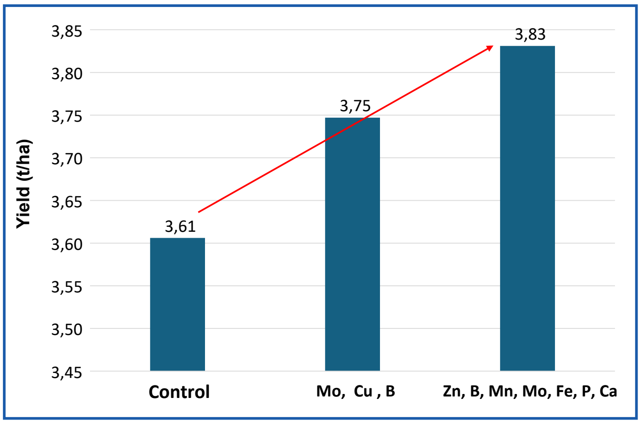
Soil analyses from October 2021 in respect of the top 15cm increment, showed: clay = 15%; pH (potassium chloride or KCl) = 4,9; P (Bray 1) = 21mg/kg; potassium (K) (AmAc) = 148mg/kg; Ca (AmAc) = 280mg/kg; Mg (AmAc) = 85mg/kg; and S (AmAc) = 6mg/kg. Only 4,3 ton of compost/ha was broadcast, and soil incorporated before planting, but no fertiliser was applied.

Eight foliar spray treatments and four replications were arranged in a randomised block design. This article only focusses on a control treatment which received no foliar spray, a treatment according to deficiencies identified by dried leaf analyses (Treatment 1), and another according to leaf sap analyses (Treatment 2).

Treatment 1 received 48g B/ha, 48g Cu/ha, and 18g Mo/ha. Treatment 2 received 129g Zn/ha, 48g B/ha, 99g Mn/ha, 33g Fe/ha, 18g Mo/ha, 270 g P/ha, and 80 g Ca/ha. Treatment 2 was repeated twice within each replication.

The Metalin range of micronutrients supplied as suspension concentrates from Kimleigh Chemicals were used. Of these elements, Zn, Cu, Mn, and Fe were based on nanotechnology. The water-soluble product, Fertilin CaP from Kimleigh Chemicals, supplied macronutrients. The trial was planted on 15 November 2022 at a plant population of 223 498/ha and treatments were sprayed on 21 February 2023 (R5 growth stage). Harvesting took place on 2 May 2022. Yields were corrected to 12,5% moisture.

Figure 1: Yield response of a control treatment compared to Metalin micro-elements (Treatment 1, n = 4) and Metalin + Fertilin CaP (Treatment 2, n = 8) foliar applications. Least significant difference (LSD) (P = 0,05) = 0,15t/ha. LSD (P = 0,10) = 0,12t/ha. CV = 2,72%.



Results and discussion

Treatment 1 increased yield by 0,14t/ha (3,88%) above the control, which was statistically significant at 90% (*Figure 1*). The increase in income at a soya price of R8 500/t is R1 190/ha and the product cost is R209,31/ha resulting in an increase in profit of R980,69/ha. Treatment 2 increased yield by 0,22t/ha (6,09%) above the control, which was statistically significant at 95%. The increase in income is R1 870/ha and the product cost is R521,50/ha resulting in an increase in profit of R1 348,5/ha. The accuracy of results is further confirmed by a very low coefficient of variation (CV) for yield of 2,72%.

Conclusions

Soya bean yield responses to foliar applications based on leave sap analyses were economically more justifiable than when based on dried leaf analyses and should therefore be preferred. Leaf sap analyses also identified deficiencies for more elements compared to dried leaf analyses.

The Kimleigh Metalin range of advanced micronutrients together with Ferilin CaP demonstrated to be very effective in addressing nutrient deficiencies. A specific combination of Zn, B, Mn, Mo, Fe, P and Ca increased soya yield which was 95% statistically reliable and economically justifiable, increasing profit above product cost by R1 348,5/ha at a soya price of R8 500/t.

Thanks to Dewald Bothma and Anievaal Boerdery for conducting this trial and providing results. Consult Kimleigh Chemicals for product details, location-specific applications, and references. Visit *www.kimleigh.com* or call 018 293 1028.

Analysing oilseed market dynamics

By Johan Teesen, economist intern, Grain SA

The first four months of this season brought forth several distinctive challenges for the grain industry. These obstacles included planting difficulties for producers because of saturated fields, followed by a midsummer drought that threatened the survival of crops.

The result was a delay in harvesting due to rain, ending with producers struggling with the quality of their grains as they commenced crop delivery. This article delves into how these challenges impacted the prices of soya beans and sunflowers.

Production levels

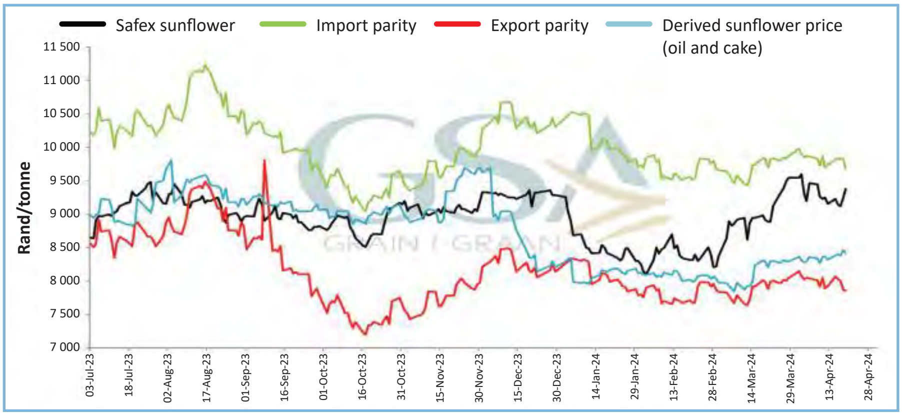
It is evident that these challenges influence South Africa's production levels and the quality of its grains. The January *Crop Estimates Report's* initial projection by the Crop Estimates Committee (CEC) revealed a 9,7% decrease in hectares planted to soya beans, with sunflowers showing a 10,4% increase.

This trend, however, was anticipated due to the El Niño phenomenon forecasted for the season. At that time, nationwide rainfall patterns did not suggest that the anticipated impact of El Niño would be more severe.

Moving forward to the end of February, the CEC report indicated an 8,2% increase in soya bean hectares and an 8,7% reduction in sunflower hectares. Furthermore, the initial forecast for oilseed crops projected a soya bean crop of 2,13 million tonnes (22,7% lower than in 2023) and a sunflower crop of 671 100 tonnes (6,7% lower than in 2023). These figures surprised many, as the effects of El Niño had already begun affecting crops by late January.

The March CEC report indicated a slight decrease in both sunflower and soya bean hectares planted, but all eyes were on the second production forecast. Soya beans experienced a 15,22% reduction in production, while sunflowers followed closely with a 12,23% decrease, emphasising the struggles faced by producers and the national grain crop.

Figure 1: Sunflower import and export parity prices. (Source: Grain SA)



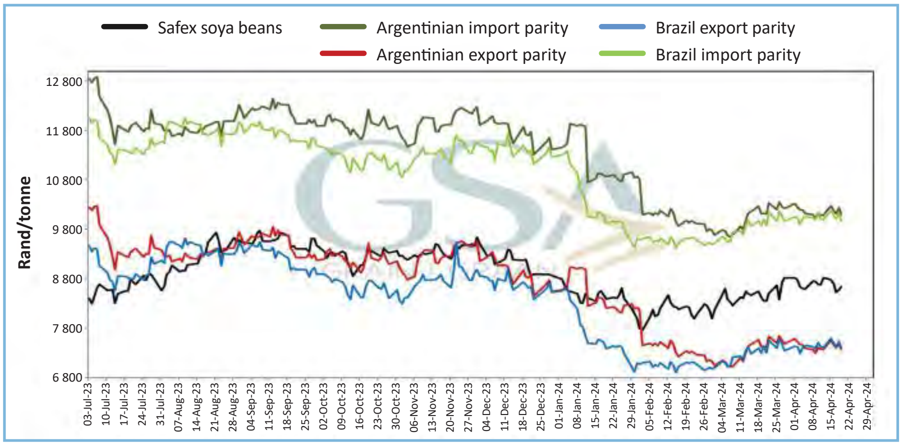
Price movements

As previously mentioned, the evidence of El Niño and its effects began to manifest at the end of January, prompting reactions in the market. *Figure 1* and *2* both depict a shift in prices from a downward trend to an upward trend starting late January and early February.

Figure 1 reflects occasional rallies during February, but the sunflower price mostly traded sideways. It began at R8 118/t on 1 February and ended at R8 222/t on 28 February. The first significant rally occurred in early March, pushing prices away from the European Union (EU) export parity price. Subsequently, the price fluctuated sideways until mid-March, when a second rally occurred, bringing the local sunflower price closer to EU import parity than to EU export parity.

Figure 2 shows that the soya bean price also began an upward trend, albeit not as pronounced as the sunflower price. It started at R8 025/t on 5 February and rose slightly to R8 190/t by 1 March. From then until 19 April, the soya bean price increased at an accelerated rate, reaching R8 646/t. This indicates that while the soya bean price mostly traded sideways, the international price decreased, whereas the sunflower price gained over R1 000/t during the same period.

Figure 2: Soya bean import and export parity prices. (Source: Grain SA)



Conclusion

The market's reactions and movements over the past four months illustrate the significant influence that crop supply can exert on prices. This influence can vary in magnitude, as demonstrated by the substantial impact on the sunflower market compared to the relatively smaller effect on the soya bean market. However, the question still remains: To what extent will the challenges faced by producers in respect of quality affect these two markets?

For more information, email the author at JohanT@grainsa.co.za.

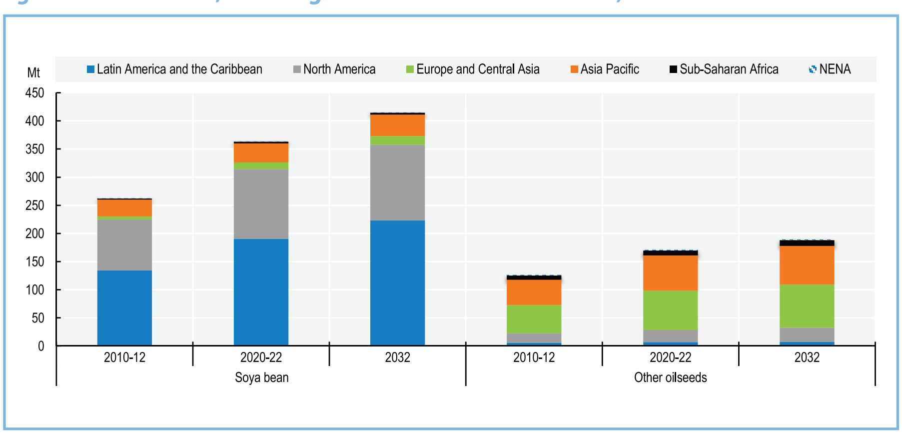
Oilseed production highlights
Extract from: *OECD-FAO Agricultural Outlook 2023-2032*

The worldwide production of soya beans is projected to grow by 0,9% per annum, compared to 2,2% per annum over the last decade. Growth will be dominated by yield increases, accounting for almost three quarters of production growth. Soya beans benefit from their fast growth, which allows for double cropping, especially in Latin America. Consequently, a considerable share of additional harvested area increase will result from double-cropping soya beans following maize in Brazil and wheat in Argentina.

Brazil has in recent years been the largest producer of soya beans and is expected to grow at 0,8% per annum over the next decade – slightly stronger than the United States (US), the second largest producer, at 0,6% per annum, due to double cropping with maize. The production of soya beans is projected to grow strongly elsewhere in Latin America, with Argentina and Paraguay producing 51 and 12 megatonnes (Mt), respectively, by 2032 (*Figure 1*).

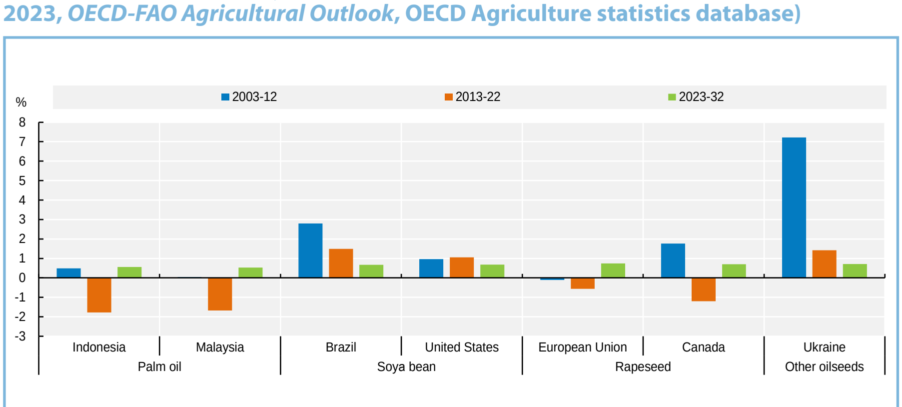
In China, soya bean production is expected to continue to increase in response to reduced policy support for the cultivation of cereals, but at a slower pace than the previous decade. Soya bean production is also expected to increase in India, Russian, Ukraine and Canada.

Figure 1: Oilseed production per region. (Source: OECD/FAO 2023, *OECD-FAO Agricultural Outlook*, OECD Agriculture statistics database)



NENA: Near East and North Africa.

Figure 2: Average annual yield growth for palm oil and oilseeds. (Source: OECD/FAO 2023, *OECD-FAO Agricultural Outlook*, OECD Agriculture statistics database)



Slow growth projected

The production of other oilseeds (rapeseed, sunflower seed and groundnuts) will also grow at a slower pace, at 0,9% per annum compared to 2,6% per annum over the previous ten years (2013 to 2022). China (a major producer of rapeseed and groundnuts) and the European Union (EU), which mainly produces rapeseed and sunflower seeds, are the most important producers of other oilseeds, with a projected annual output of 40 and 30Mt, respectively, by 2032.

However, limited output growth is projected for both regions (0,8% per annum for China and 1% per annum for the EU) as relatively higher prices for cereals are expected to generate strong competition for limited arable land. Canada, another major producer and the largest exporter of rapeseed, is projected to increase its production of other oilseeds by 1,2% per annum, to reach 20Mt by 2032.

Declining production between the contribution of yield and area shows that yields for major producers of palm oil and some major suppliers of rapeseed have fallen or grown slowly during the last decade (*Figure 2*).

Reasons for this development

- A strong increase in production area so that less favourable land is used for production, reducing average yields.

- The ageing of oil palms as well as labour shortages has reduced yields.
- Restrictions in the use of pesticides adversely affected average rapeseed yields in the EU.
- Shifting weather patterns adversely affected yields.

It remains uncertain how this will play out over the coming decade, but lower area expansion could result in a recovery in yields over the period stipulated in the *Outlook* document. If this is not the case it will be a challenge to satisfy growing demand, especially for vegetable oil.

Soya bean stocks are projected to reach a stock-to-use ratio of almost 12% by 2032, which remains low compared to the past two decades, so harvest failures could quickly lead to market shortages.

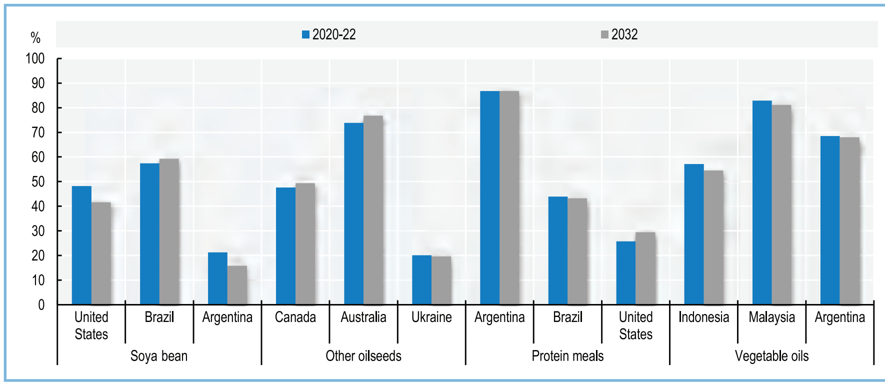
Oilseeds trade

Over 40% of world soya bean production is traded internationally, a high share compared to other agricultural commodities. The expansion in world soya bean trade is directly linked to the projected slower growth of the soya bean crush in China, and Chinese imports are projected to grow by 0,7% per annum to around 102Mt by 2032 (down from 4% per annum in 2013 to 2022), accounting for around 60% of world soya bean imports. Exports of soya beans originate predominately from Brazil and the US.

Whereas the US was historically the largest global exporter of soya beans, Brazil has now taken over with steady growth in its export capacity and is projected to account for 53% of total global soya bean exports by 2032.

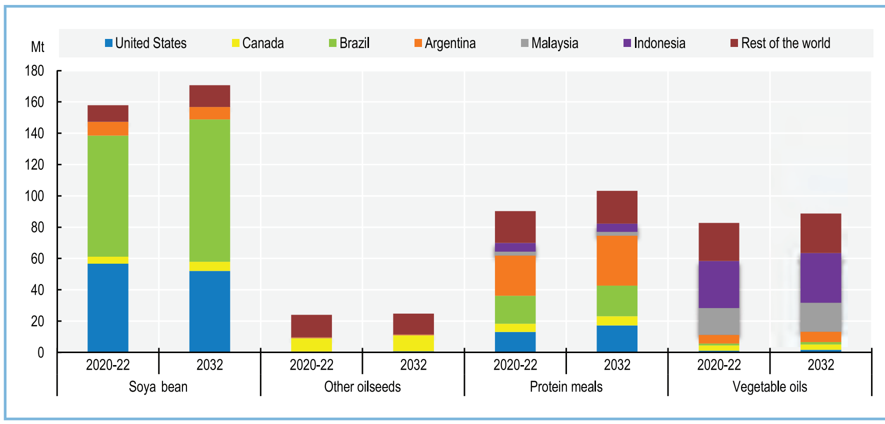
For other oilseeds, the internationally traded share of global production remains much lower at around 14% of world production as the two largest producers, China and the EU, are net importers. The main exporters are Canada, Australia and Ukraine, projected to account for 70% of world exports by 2032. In Canada and especially in Australia, more than half of the production of other oilseeds (primarily rapeseed) is exported (*Figure 3*). Additional oilseed production is crushed domestically and exported in the form of vegetable oil or protein meal.

Figure 3: Share of exports in total production of oilseeds and oilseed products for the top three exporting countries. (Source: OECD/FAO 2023, *OECD-FAO Agricultural Outlook*, OECD Agriculture statistics database)



The figure only shows the direct share of exports and does not include the export of further processed products, which would lead to higher export shares.

Figure 4: Exports of oilseeds and oilseed products by region. (Source: OECD/FAO 2023, *OECD-FAO Agricultural Outlook*, OECD Agriculture statistics database)



Oil and oilseed products exports

Vegetable oil exports, which amount to 38% of global vegetable oil production, continue to be dominated by a few players. Indonesia and Malaysia are expected to continue to account for almost 60% of total vegetable oil exports during the *Outlook* period (*Figure 4*).

However, the share of exports in production is projected to contract slightly in these countries as domestic demand for food, oleochemicals and, especially, biodiesel uses is expected to grow. India is projected to continue its strong growth in imports at 1,5% per annum, reaching 18Mt by 2032, to meet increasing demand driven by population growth, urbanisation, and rising disposable income.

The projected growth in world trade of protein meal is 0,9% per annum over the *Outlook* period and Argentina is expected to remain by far the largest meal exporter with its clear export orientation. The largest importer is the EU, with imports expected to decline due to reduced domestic demand for protein meal.

More than three-quarters of the global import growth in protein meal is projected to occur in Asia, in particular in Southeast Asia with its increasing animal production. As the domestic crushing capacity in Asian countries is not expected to keep pace with protein meal demand, expansion of the livestock sector is expected to require imported feed.

This information was sourced from the *OECD-FAO Agricultural Outlook 2023-2032* document.
To view the full document, visit *www.agri-outlook.org*.

World oilseed markets and trade:
Record sunflower seed oil trade predicted

Issued by the United States Department of Agriculture's Foreign Agricultural Service

The 2023/24 United States (US) soya bean ending stocks estimate is raised to 340 million bushels (± 9,25 million metric tonnes or mt) on lower soya bean exports. The soya bean export forecast is reduced to 1,7 billion bushels (± 46,24 million mt) on reduced soya bean commitments and strong competition from South America.

Internationally, global sunflower seed and rapeseed crush for marketing year (MY) 2023/24 have increased to record highs. Global sunflower seed oil trade was raised on higher imports from India, Egypt, and the European Union (EU) as sunflower seed oil prices have been very competitive, compared with other vegetable oils.

Projections for the rapeseed crush in Canada and the US were increased to record highs on the strong demand for rapeseed oil from the biofuel industry. The ending stocks of the four major vegetable oils for marketing year 2023/24 increased by 0,3 million tonnes, reaching a total of 28,4 million mt (*Figure 1*).

International oilseeds outlook

Global sunflower seed oil trade forecast for 2023/24 increased in April by 0,5 million mt to a record-high 14,5 million mt due to higher global sunflower seed oil supply and competitive prices against palm oil and soya bean oil.

Since January this year, the free-on-board (FOB) sunflower seed oil price in Ukraine has been trading at a discount compared to palm oil. This price difference has led to increased demand from countries such as India and Egypt, as well as the EU (*Figure 2*). Historically, sunflower seed oil has been a premium-priced oil compared to palm oil and soya bean oil as it is considered a non-genetically modified vegetable oil.

Relatively low sunflower seed oil prices in Ukraine are driven by higher domestic sunflower oil supply as well as competition from Russia, which is also reporting a larger supply year-on-year. In addition, the weak Ukrainian hryvnia further supports Ukraine's export volumes. Ukraine's sunflower seed oil export forecast for MY 2023/24 is raised to 5,9 mt on higher sunflower seed crush. Sunflower seed crush has increased to 14,7 million mt.

In addition to higher exports from Ukraine, sunflower seed oil export forecasts for Russia and the EU were raised in April this year. The beneficiaries of higher sunflower seed oil supply are mainly the major vegetable oils importers including India and Egypt. India's sunflower seed oil imports were raised in April to 2,9 million mt, while the palm oil import forecast was reduced with the corresponding amount.

Egypt's sunflower seed oil import forecast increased by 250 000mt to

Figure 1: Global major vegetable oil stocks in million metric tonnes. (Source: USDA, Economic Research Service using USDA, Foreign Agricultural Service, *Production, Supply and Distribution* data)

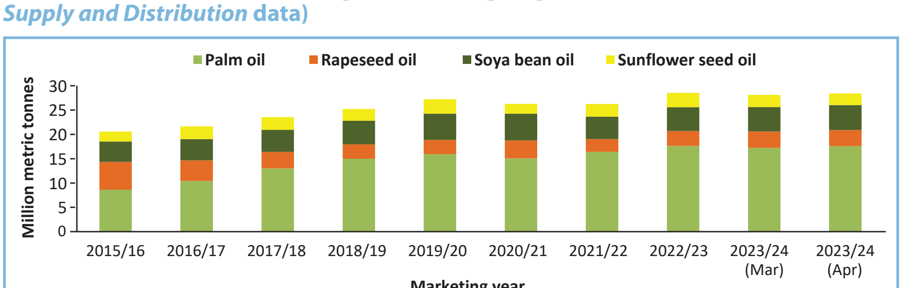
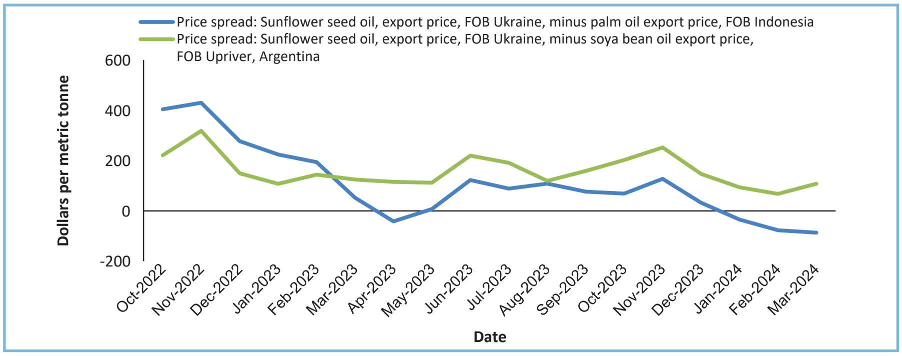


Figure 2: Ukrainian sunflower seed oil price spread (in dollars per metric tonne) versus Indonesian palm oil and Argentine soya bean oil from October 2022 to March 2024. (Source: USDA, Economic Research Service using data from the International Grains Council)



FOB: free on board.

600 000mt on higher arrivals and higher domestic consumption of sunflower seed oil. As a result of a higher forecast for sunflower seed oil consumption, soya bean oil consumption in Egypt was reduced by 125 000mt.

Global rapeseed production

Global rapeseed production for MY 2023/24 was forecast up in April this year by 0,3 million mt to 88,4 million mt, driven by a rise in Australia's and Moldova's production. Australia's rapeseed production was forecast at 5,7 million mt, up 0,2 million mt from March on better-than-expected yields in Victoria, New South Wales and South Australia, but remains below the MY 2022/23 record-high production.

Dry conditions in Western Australia resulted in lower yields for this state. With higher domestic production, rapeseed exports for Australia and Moldova are forecast higher, which are partially offset by lower exports from Canada. Canada's rapeseed exports from August 2023 to February 2024 totalled 3,4 million mt, down 1,5 million mt from the same period in MY 2022/23 on smaller shipments to China.

With a strong demand for rapeseed oil from the US, Canada's domestic rapeseed crush is forecast up 0,4 million mt to a record-high 11 million mt. According to Statistics Canada, the August 2023 to February 2024 period's crush totalled 6,4 million mt, up 12% from the same period in MY 2022/23. With higher domestic production of rapeseed oil and meal, exports are forecast higher. Rapeseed oil exports in Canada are forecast at a record-high 3,8 million mt with higher exports to the US.

Reduced South African output

South Africa's oilseeds production output for MY 2023/24 was reduced in April by 0,5 million mt to 4,6 million mt on lower soya bean and sunflower seed production (*Figure 3*). Soya bean production is lowered by 0,3 million mt to 1,8 million mt on the lower yield. The yield forecast declined by 17% to 1,6t/ha on unfavourable weather this growing season and is down 21% from MY 2022/23.

Soya beans are traditionally planted from the second half of October until mid-December. Soya bean and sunflower seed production benefited from rainfall recorded between October and December 2023 over most of the producing areas. However, excessive heat and dryness across South Africa during February, when the crop was in the early pod-filling stages, deteriorated the yield potential.

Sunflower seed production in South Africa for MY 2023/24 is forecast at 590 000mt, down 80 000mt from March's forecast on lower harvested acreage. The sunflower seed harvested acreage was reduced in April by 85 000 to 530 000ha. If realised, this would be the lowest harvested area since MY 2020/21.

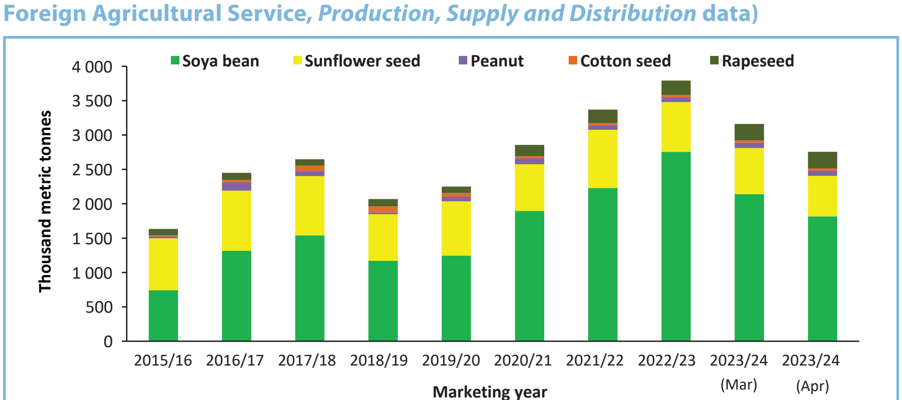
The sunflower seed area in South Africa has not seen much growth compared with soya bean and maize areas, mainly due to the yield potential. Both maize and soya bean yields have improved over the last decade due to better varieties of seed and technology, resulting in higher returns for those crops compared with those realised for sunflower seed production.

Weather influences

The sunflower seed yield for South Africa is forecast at 1,1t/ha, down 15% from last year. Yields are lower due to an El Niño induced dry spell and heatwave that occurred during February and March. In addition, producers in South Africa also plant rapeseed, cottonseed and groundnut, but those are minor oilseed crops.

With a lower forecast for soya bean production, the soya bean crush volumes and export forecasts are reduced by 50 000mt and 100 000mt, respectively. The soya bean crush volume for MY 2023/24 is projected at 1,6 million mt, down 50 000mt from MY 2022/23. South Africa's soya bean exports forecast is down from MY 2022/23 and stands only at 150 000mt, down significantly from MY 2022/23's volume of 637 000mt.

Figure 3: South Africa's oilseed production (in thousand metric tonnes) from 2015/16 to 2023/24. (Source: USDA, Economic Research Service using USDA, Foreign Agricultural Service, *Production, Supply and Distribution* data)



This article was condensed for publication in *Oilseeds Focus*. To read the full article, visit *www.fas.usda.gov*.

South African oilseed exports: Season ends on a high note

Adapted from the Sacota Newsletter, April 2024

As the 2023/24 season drew to a close, South Africa's grain and oilseeds export market reflected notable achievements, particularly in soya bean exports. The soya bean season, which ended on 29 February this year, saw remarkable growth in exports, surpassing all expectations and signalling positive developments for the country's agricultural trade.

Soya bean exports during the season totalled an impressive 597 045 tonnes, marking a significant increase from the previous season's exports of 277 504 tonnes. This substantial growth underscores South Africa's expanding presence in the global soya bean market and highlights the country's competitiveness in selected agricultural export markets.

Exporting partners

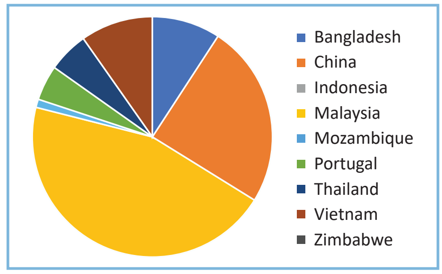
Of the total soya bean exports, 591 912 tonnes were exported to seven countries through deep-sea exports. Among these exporting partners, Malaysia emerged as the largest importer, receiving 269 972 tonnes of South African soya beans. Following closely behind, China imported 147 497 tonnes, further solidifying its position as a key market for South African soya bean exports.

The surge in soya bean exports reflects the country's strategic geographical positioning relative to Southeast Asia and the Middle East. With increasing emphasis on plant-based proteins and versatile applications of soya beans in various animal feed industries, South Africa's soya bean exports are poised for continued growth in the coming seasons – assuming that the weather conditions return to normal.

Since South Africa has relatively small export volumes compared to countries such as Brazil and Argentina, we could be selective in targeting only the most profitable markets. With the current season's crop being under strain, this further underscores the importance for South Africa to continue investing in and adopting innovative technologies, specifically seed, to increase the productivity and yield of our crops.

Strengthening trade relations with key partners will be instrumental in sustaining the momentum of soya bean exports and driving overall agricultural prosperity in South Africa.

Figure 1: Total soya bean exports per destination in 2023/24. (Source: Sacota Newsletter, April 2024)



For more information, visit Sacota's website at *www.sacota.co.za*.

Advancements and collaborations: Insights from the global groundnut industry

By Adri Botha, Oilseeds Advisory Committee

The inaugural World Peanut Meeting (WPM) convened in Córdoba, Argentina, in March this year, drawing over 350 attendees from more than 30 nations. This landmark event, hosted by the Argentine Peanut Chamber (CAM), illuminated crucial facets of the global groundnut industry with discussions and insights shedding light on key developments, challenges, and opportunities within this industry, spanning various regions worldwide.

Delegates and speakers from diverse backgrounds converged to explore market dynamics, consumer trends and sustainability imperatives, positioning the event as a pivotal platform for industry stakeholders.

Global groundnut landscape

Representatives from major groundnut-producing nations such as China, the United States (US), India, and host Argentina shared valuable insights, underscoring the resilience and potential of the commodity worldwide.

Discussions spanned fluctuating supply-demand dynamics, climate vulnerabilities, the burgeoning popularity of peanut butter consumption, and a growing snack and edible market in regions previously not considered high snack consumers. Notably, Argentina emerged as a beacon of sustainable groundnut production, with a steadfast commitment to quality and innovation.

Argentina's groundnut evolution

Diego Yabes, president of CAM, emphasised Argentina's pivotal position in the global groundnut market, particularly in the realm of sustainable production and premium quality products. Despite challenges such as inflation and logistical hurdles, Argentina's proactive approach and dedication to sustainability set a benchmark for the industry.

Expanding beyond traditional boundaries, groundnut cultivation has flourished, fuelled by profitability and technological advancements. Yabes highlighted the industry's resilience amid challenges such as tax burdens and competition from neighbouring countries, stressing the need for governmental support and regulatory clarity.

Collaborative efforts

Insights extended to sustainable cultivation practices, emphasising minimal soil disturbance, diverse crop rotations, and disease management strategies. Initiatives such as carbon footprint measurement and promotion of good agricultural practices underscore a commitment to long-term sustainability and environmental stewardship.

Collaboration among industry stakeholders is instrumental in driving advancements in groundnut production and trade worldwide. In Argentina, for instance, collaborative initiatives spearheaded by organisations such as the Peanut Scientific and Technological Network and the Argentina Peanut Institute have fostered innovation, knowledge sharing, and research endeavours aimed at enhancing the competitiveness and sustainability of the sector.

Innovative production practices

Advancements in groundnut production techniques have led to improved crop yields, quality, and sustainability. Across different regions, producers have embraced precision agriculture technologies, disease-resistant varieties, and sustainable farming practices such as conservation tillage and cover cropping.

These innovations have not only boosted productivity, but also minimised environmental impact and resource use, with producers prioritising traceability and adherence to food safety standards. From cultivar and seed selection to processing, rigorous quality control measures ensure that groundnuts meet global quality requirements, bolstering consumer confidence and market reputation.

Argentina has thus emerged as a leading exporter of high-quality, and mostly high-oleic, groundnuts thanks to its focus on meeting stringent quality standards and establishing strong relationships with importers. The country's groundnut exports have grown significantly, driven by efforts to ensure consistency, flavour, and nutritional quality in its products. Argentina's success underscores the importance of quality assurance and market acceptance in driving international trade.

Global growth opportunities

Groundnuts offer numerous opportunities for product development, nutritional enhancement, and market expansion. With a low carbon footprint, high nutritional value, and versatility in product applications, groundnuts are poised to meet the evolving demands of consumers worldwide. Collaborative efforts within the industry, coupled with advancements in research and development, will be key to unlocking these opportunities and driving future growth.

Demand Panel insights

From Europe to Asia and beyond, experts provided valuable insights, highlighting opportunities for collaboration, innovation, and growth in the global groundnut industry. The Demand Panel provided a comprehensive overview of groundnut consumption trends, challenges, and opportunities across different markets.

European savoury snack market

Marcos Lafuente, representing Intersnack Procurement, offered valuable insights into the European groundnut market. Lafuente highlighted Argentina's significant role in meeting European demand, discussing global production figures and consumption patterns.

Lafuente dissected evolving consumer behaviours, noting a shift towards private-label products and discount supermarkets. Despite challenges such as inflation, the European savoury snack market continues to show promising growth, especially also in emerging segments such as peanut butter consumption.

Addressing challenges head-on, Lafuente emphasised the importance of adapting to evolving regulations and outlined Intersnack's commitment to sustainability initiatives to ensure a resilient future for groundnut businesses in Europe.

China's growing influence

He Miao, senior director at China Metaintl Corporation, provided a comprehensive overview of China's role in the global groundnut market, highlighting its transition from a major producer to a significant importer. Insights into export trends and consumption patterns shed light on China's evolving position in the industry.

Despite steady growth in demand for groundnut products in China, challenges such as supply chain disruptions and geopolitical tensions pose risks to future demand dynamics, requiring careful navigation by industry stakeholders.

South Africa's market landscape

Andreas Snyman, head of GWK International, discussed the challenges and opportunities facing South Africa's groundnut industry, including factors such as drought, fluctuating yields, and exasperating challenges such as inflation and limited government support. "Despite hurdles, South Africans are resilient by nature, and we remain a key player in the global groundnut market, with potential for further growth and hope to once again in future be invited to participate on the Supply Panel," he said.

Snyman emphasised the importance of diversifying import sources to mitigate risks and addressed recent aflatoxin contamination issues, highlighting the need for stringent quality control measures by all role-players, regardless of size and market.

Russia's import trends

Sergey Khaesh, founder and general manager of AGROIMPEX, shed light on Russia's emergence as a major importer of groundnuts, discussing import trends and market structure.

He emphasised Russia's stringent quality standards and import regulations, underlining the importance of adherence to quality specifications, dispelling misconceptions regarding the Russian market, and stressing the significance of adhering to quality standards to facilitate smooth customs screenings and trade operations – which can prove to be challenging and complex.

US market overview

Anne-Marie DeLorenzo, senior strategic sourcing manager for peanuts at Mars Wrigley, provided insights into the US groundnut market, highlighting the dominance of peanut butter consumption and innovative marketing strategies driving consumer interest.

Despite trade disputes and challenges, DeLorenzo expressed optimism regarding the outlook for the peanut butter market, underscoring opportunities for growth and innovation in the sector. According to her, this can be done by utilising the love of peanut butter and sentiment to reach consumers on different socio-economical levels.

Supply Panel insights

Representatives from prominent groundnut-producing countries presented their perspectives on aspects of groundnut production, export markets, and sustainability initiatives.

Groundnut production in Brazil

Pablo Rivera, CEO of Beatrice Peanuts, took the stage to shed light on Brazil's significant role in the global groundnut market. Despite challenges such as rising production costs and environmental concerns, Brazil has witnessed remarkable growth in groundnut cultivation over the past decade. However, Rivera underscored the need for collaborative efforts to overcome obstacles and sustain this growth trajectory, especially in addressing issues such as food safety and market diversification.

Nicaragua's dedication to quality

Joaquin Zavala, general manager of Comasa, provided insights into Nicaragua's groundnut industry, emphasising its dedication to producing high-quality groundnuts for demanding markets. Despite facing challenges such as climate variability, Nicaraguan producers remain committed to maintaining production standards and supplying international markets. Zavala joined other speakers in highlighting the importance of sustainability initiatives and collaboration to ensure the long-term viability of the industry.

Perspectives from China

Zhang Peng, senior consultant at the China Chamber of Commerce, offered unique perspectives on the Chinese groundnut industry, focussing on data discrepancies and consumption trends. Highlighting the complexity of data collection and the impact of changing consumer preferences, Peng emphasised the need for innovation and adaptation to market dynamics.

During the field visits, the World Peanut Meeting group benefitted from presentations on post- and pre-emergence application and management.

India's advantages and challenges

Tushar Thumar, director at Khedut Feeds and Foods, provided an overview of groundnut production in India, emphasising its competitive advantages and challenges. With India being a leading producer and exporter, Thumar discussed government initiatives and policies supporting the industry while addressing challenges such as export restrictions, perception, and logistical issues.

Insights from the US

Ryan Lepicier, president and CEO of the National Peanut Board, shared insights into groundnut production in the US, discussing challenges and outlook for the industry. With a focus on enhancing groundnut demand and consumption, Lepicier highlighted the importance of weather conditions and upcoming United States Department of Agriculture reports in shaping the industry's future.

Argentina's commitment

Yabes concluded the panel discussions by emphasising Argentina's commitment to quality and sustainability in groundnut production. From groundnut growing areas to export statistics and market insights, Yabes provided a comprehensive overview of Argentina's role in the global groundnut market, reaffirming the country's dedication to innovation and excellence since 1975.

In conclusion, the Supply Panel discussions at the WPM showcased the diversity of perspectives and strategies employed by key groundnut-producing countries to address challenges and capitalise on opportunities in the ever-evolving groundnut industry. Through collaboration, innovation, and a shared commitment to quality and sustainability, these stakeholders are committed to the continued success and growth of the global groundnut industry.

Exploring the field

The tenth edition of the Peanut Circuit (tour) drew over 1 800 participants to General Dehaze in Córdoba in March. The event was organised by the Centre of Agricultural Engineers of General Cabrera and Zone and the INTA General Cabrera. Mariela Monetti, head of INTA General Cabrera, described the circuit as a reflection on groundnut cultivar growth, showcasing research, development, and productivity-improving technology.

The circuit provided a platform to demonstrate progress in genetic improvement to combat issues such as *Sclerotinia* and peanut smut disease. Various materials were tested in trials under different environmental conditions, highlighting the ongoing efforts to enhance groundnut cultivation techniques.The success of the Argentinian groundnut industry in the past two decades owes much to the Peanut Scientific and Technological Network, which fosters collaboration between academic, scientific, and productive sectors to drive innovation and development processes.

During the field visits, the WPM group benefitted from presentations on post and pre-emergence application and management. Discussions delved into cultivar development, local planting conditions, crop rotation management, advancements in combating peanut smut, and the dominance of high oleic cultivars.

The need for increased direct participation by all sectors within the groundnut industry was once again stressed and emphasised the importance of showcasing the entire cultivation process, from planting to processing. Unfortunately, the WPM schedule only allowed for an afternoon visit to the field trials, omitting the highly anticipated visits to selection and production sectors.

Reflections on the WPM

The WPM has provided a platform for meaningful discussions and knowledge sharing among industry stakeholders, highlighting the importance of collaboration, innovation, and sustainability in the groundnut sector. By addressing challenges and leveraging opportunities, the global groundnut industry is poised for continued growth and success, with Argentina's collaborative initiatives serving as a model for industry advancement.

As the local industry looks ahead, further development and collaboration opportunities abound. By embracing innovation, sustainability, and market-driven strategies, stakeholders can navigate challenges and capitalise on emerging trends to ensure a vibrant and resilient groundnut industry for years to come.

For South Africa, participation in such international events raises questions regarding our relevance and potential learning. Despite only being the 34th largest groundnut-producing country globally, with exports below 1% of world exports, our recognition as a leading Spanish-type origin, consistently supplying high-quality groundnuts, holds significance. While our crop volumes face pressure, our focus on high-quality output positions us uniquely, catering to markets with stringent quality requirements for direct human consumption.

The question arises: What can we learn from these international exposures? Recognition on an international stage alongside major players such as the US, Argentina, and China is invaluable. Neglecting such opportunities risks relegating us to insignificance, hindering efforts to re-establish South Africa as a significant origin.

These events also foster personal and meaningful exchanges with counterparts from other countries. Interactions with organisations such as the US Peanut Board and the Argentinean Peanut Foundation open collaboration and knowledge exchange avenues. South Africa's potential participation in an international groundnut forum signifies a step towards broader industry engagement, with opportunities to address pressing issues such as international trade barriers, tariff matters, and the generic advancement of groundnut production and consumer development.

Looking ahead, key areas for development and marketing include groundnuts' low carbon footprint, water-conscious farming practices, and the crop's versatility in respect of product development and nutritional benefits. Exploring markets not traditionally associated with groundnut snacks, lifestyle products, and peanut butter consumption presents untapped growth opportunities.

International developments

In recent years, the global groundnut industry has witnessed significant developments in both production techniques and product innovation. Across various regions, stakeholders have been actively engaged in enhancing groundnut cultivation practices to meet growing demands for quality, sustainability, and nutritional value.

Production advancements

Sustainable farming practices: Many countries have embraced sustainable farming practices to minimise environmental impact and enhance resource efficiency. Techniques such as conservation tillage, crop rotation, and integrated pest management are being increasingly adopted to promote soil health and biodiversity.

Technology integration: The integration of technology, including precision agriculture, satellite imagery, and digital farming tools, has revolutionised groundnut cultivation. These advancements enable producers to optimise inputs, monitor crop health, and improve yields while reducing resource usage.

Climate-resilient varieties: With changing climate conditions posing challenges to groundnut production, breeders have focussed on developing climate-resilient varieties. These varieties exhibit traits such as drought tolerance, disease resistance, and adaptability to varying environmental conditions, ensuring more consistent yields and quality.

Product innovation and growth

Groundnuts are recognised for their nutritional richness, containing essential nutrients such as protein, healthy fats, fibre, vitamins, and minerals. As consumer awareness of health and wellness grows, groundnuts have gained popularity as a nutritious and versatile, yet affordable food ingredient.

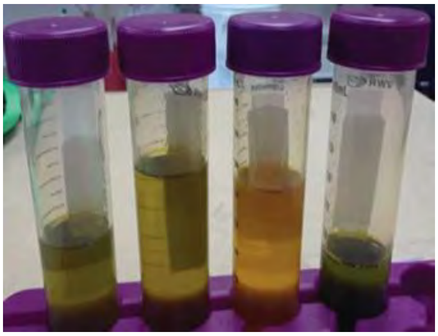
Compared to many other crops, groundnuts have a relatively low carbon footprint, requiring less water and fewer fertiliser inputs per unit of yield. Sustainable farming practices reduce greenhouse gas emissions, making groundnuts an environmentally friendly crop choice.

Groundnuts are considered a low-waste commodity, as almost the entire plant can be utilised. Beyond the edible kernels, groundnut shells can be used for animal feed, biomass energy production, or as a source of biochar for soil improvement. Additionally, groundnut oil extraction generates by-products such as meal and cake, which find applications in various industries.

Peanut butter and peanut-based snacks have witnessed significant growth in global markets, driven by changing dietary preferences, increased snacking habits, and the versatility of groundnuts as a culinary ingredient. Health-conscious consumers are turning to peanut butter as a protein-rich spread or snack option, while innovative snack products such as roasted peanuts, trail mixes, and energy bars offer convenient, on-the-go nutrition.

Overall, the international groundnut industry continues to evolve, driven by technological advancements, market demands and sustainability imperatives. As stakeholders collaborate to address challenges and capitalise on opportunities, groundnuts are poised to play a crucial role in meeting global food and nutrition needs while promoting sustainable agricultural practices.

For more information on this event, send an email to groundnutforum@opot.co.za.



Oil extracted from harvested, immature soya beans shows the green colour from chlorophyll compared to the desired oil from mature soya beans. (Photograph: Kenneth Hellvang)

Green or drought-stressed SOYA BEANS:

Effects on nutrition and quality

Compiled by Feed First

Soya beans are one of the most important legume crops in the world due to the number of industries that can benefit from it, including the animal feed industry. The maturity stage of soya beans significantly affects their nutritional composition and quality.

When soya beans have not reached their full maturity by harvest time, often the beans are still green-coloured. The green colour in a soya bean indicates that chlorophyll is still present in the bean. Chlorophyll plays a role in providing energy and nutrients for the development of soya bean seeds.

As the seeds mature, chlorophyll levels decrease, allowing other pigments, such as carotenoids, to become more visible. This change in pigment composition is associated with the transition from green to yellow-brown in soya bean pods as they mature.

Drought stress

Drought stress can lead to delays in soya bean maturation, increasing the time it takes for pods to reach full maturity. As a result, soya bean plants may take longer to produce dry matter and complete the maturation process, leading to delayed pod filling and seed development. Drought stress can induce premature maturation in soya bean plants, causing leaves to change colour, wilt, and drop prematurely.

As a result, soya bean plants may prematurely abort flowers and pods, leading to fewer seeds and yield under drought conditions. Concerns exist regarding the nutritional quality of soya oilcake produced from immature green or drought-stressed soya beans and the impact of the soya oilcake on broiler production.

Nutritional composition

Significant differences were found in the nutrient composition of immature green, drought-stressed soya beans, and mature soya beans with regard to oil, protein and fibre (*Table 1*).

Immature green soya beans generally have a lower oil content compared to mature soya beans. The oil content in immature soya beans may range from approximately 5 to 8%, while mature soya beans typically contain around 15 to 20% oil. Drought-stressed soya beans have a lower oil content (8 to 12%) due to the decrease in the concentration of digestible carbohydrates such as glucose, fructose, and sucrose under drought conditions.

Immature green soya beans often have a higher protein content compared to mature soya beans. The protein content tends to decrease as soya beans mature and enter the seed-filling stage. Immature soya beans may contain protein levels ranging from 35 to 45%, whereas mature soya beans generally contain around 30 to 40% protein.

Due to a lower yield and a decreased rate of seed filling, the synthesis of protein in drought-stressed soya beans will be slower and the protein levels will be slightly higher than in mature soya beans. Seed-filling processes and the accumulation of reserves in the developing and maturing seeds are highly sensitive to environmental changes.

Sucrose and fibre content

Immature soya beans may contain higher levels of sucrose to support seed development, whereas mature soya beans have lower sucrose levels as sugars are converted into starches during seed maturation. While drought-stressed soya beans will potentially have lower sucrose levels due to the decreased rate of seed filling and therefore lower concentration of digestible carbohydrates.

Table 1: Nutrient values of normal, immature green, and drought-stressed green soya beans.

	Normal	Immature green	Drought-stressed green
Protein %	30 – 40	35 – 45	37 – 44
Fibre %	8 – 10	5 – 8	10 – 15
Oil %	15 – 20	8 – 12	5 – 8

Immature green soya beans tend to have a lower fibre content compared to mature soya beans due to the stage of development, whereas mature soya beans have a higher fibre content as the seed coat becomes more fibrous during maturation.

With the information in *Table 1* in mind the quality of soya oilcake will be affected. Some literature state that when chlorophyll is still present in soya beans it may be present in the soya bean oil, giving it a green tint.

Trypsin inhibitor

Trypsin inhibitors are proteins naturally occurring in soya beans that interfere with the activity of the trypsin enzyme. Studies have shown that the concentration of trypsin inhibitors tends to decrease as soya beans mature. This decrease is due to physiological changes that occur during seed development, including the breakdown of proteins and the activation of protease inhibitors.

As soya beans mature, they undergo processes that reduce the levels of anti-nutritional factors, including trypsin inhibitors, to support seed germination and growth. When soya beans age prematurely due to drought stress, the rate at which proteins are broken down may decrease and result in higher-than-expected trypsin inhibitor levels.

Impact on broiler performance

The inclusion of soya bean oilcake from immature green or drought-stressed soya beans in broiler diets can have varying effects on growth, feed efficiency, and carcass characteristics. Reduced growth and poor performance may be observed when soya oilcake is included at high levels in the feed due to higher trypsin inhibitor levels seen in immature green and drought-stressed soya beans. The quality of soya oilcake and soya oil may differ due to the nutritional composition of the soya beans.

Conclusion

Drought stress can have a major effect on soya bean maturation, leading to delayed development, reduced seed size and yield, premature ageing, and changes in seed composition. While the concentration of trypsin inhibitors generally decreases with soya bean maturation, factors such as genetic variation and environmental conditions, e.g. drought stress, can influence the levels of trypsin inhibitors in soya beans.

The use of soya oilcake and oil produced from immature green or drought-stressed soya beans should be used with caution in broiler diets.

For more information and references, visit *www.feedfirst.co.za* or email info@feedfirst.co.za.

Studying an evaluation model of the nutritional quality of edible vegetable oil based on dietary nutrient reference intake

By Xuemei Zhao, Xia Xiang, Jiazhang Huang, Yunqian Ma, Junmao Sun and Dazhou Zhu

Edible vegetable oil forms a vital part of the human diet and can provide the energy and fatty acids needed by the body and promote the digestion and absorption of fat-soluble vitamins. With the improvement of people's living standards, China's per capita vegetable oil consumption remains high.

According to data provided by the first volume of the 2013 *Report on the Nutrition and Health Status of Chinese Residents*, the average daily fat intake of Chinese urban and rural residents is 79,7g while the 2013 *China Dietary Reference Intake – Acceptable Macronutrient Distribution Ranges* suggests that the total fat intake from the diet should be 20 to 30% of the total energy intake. If the daily energy intake per person is calculated to be 2 000kcal, the total daily fat intake per capita should be 44,4 to 66,7g. However, the current total daily fat intake per capita in China is substantially higher than the recommended value.

Sources of fat

The top five food sources for fat are edible oils (50,1%), animal meat (22,5%), flour (6,4%), others (5,7%), and eggs (3,3%). Edible vegetable oil provides about 50% of the total dietary fat, which is equivalent to about 39g of edible vegetable oil per day, of which the top three edible vegetable oils are rapeseed (12,8%), peanut (7,4%), and soya bean oil (6,5%). The 2016 *Chinese Dietary Guide* recommends daily consumption of edible oil per person of 25 to 30g. However, the real daily intake is far higher than this guide.

Many research studies suggest that the primary fatty acids in edible vegetable oil are palmitic (C16:0), stearic (C18:0), oleic (C18:1), and linoleic acid (C18:2) of which oleic and linoleic acid display the highest levels. However, rapeseed, peanut and soya bean oil are high in oleic and linoleic acid, and maintaining a prolonged diet pattern high in linoleic acid leads to excessive intake of omega 6, damaging the balance between n-6 and n-3 polyunsaturated fatty acids (PUFAs). Although the intake of aquatic products and seafood in the coastal areas may be adequate to increase the n-3 levels, it remains too low in some inland regions.

Nutritional components

Edible vegetable oil consists of triacylglycerol (95 to 98%) and other trace compounds (2 to 5%), which can provide most of the fatty acids required by the human body for physiological activities. Furthermore, edible vegetable oil also contains certain amounts of vitamin E and phytochemicals, such as phytosterols and squalene.

The content of five major fatty acids in maize, sunflower, soya bean, tea, rapeseed and peanut oil were compared and indicated that the average unsaturated fatty acid content in all types of edible vegetable oils exceeded 80%, while that of saturated fatty acids (SFAs) was about 10%. Further experiments compared the vitamin E content in nine edible vegetable oils (138 different brands), showing that it ranged from 5,9 to 1 246,6mg/kg, with an average of 652,4mg/kg. The vitamin E level was the highest in first-grade soya bean oil, ranging from 804,5 to 1 246,6mg/kg.

Furthermore, edible vegetable oil is rich in phytosterols, providing an excellent way for humans to ingest these compounds. Measuring the phytosterol content, such as campesterol, stigmasterol, rapeseed sterol, and β-sitosterol in 56 edible vegetable oils and seven edible blend oils, indicated that all of them contained only two of the four sterols, β-sitosterol and campesterol.

Nutritional quality

The various ingredients in edible vegetable oil all have their respective functions during the process of human physiological metabolism. For example, n-3 PUFAs play a critical role in promoting the health of the brain and retina. α-Linolenic acid, which belongs to n-3 fatty acids, has physiological functions such as anti-atherosclerotic, prevention of cardiovascular and cerebrovascular diseases, weight loss and lowering of blood lipids. It can be converted into long-chain n-3 PUFAs docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) in the human body, increasing the levels of DHA and EPA in most tissues and exerting similar physiological functions as that of DHA and EPA.

Vitamin E is a fat-soluble vitamin, which is a natural antioxidant and immunomodulator. In the daily diet, vitamins are mainly derived from edible vegetable oils of which germ oil and soya bean oil are the most abundant. Phytosterols have critical physiological functions that can decrease the risk of cholesterol while playing anti-inflammatory, anti-atherosclerotic, antioxidant, and antitumor roles if they are present in adequate amounts.

An examination of perilla, almond, and hemp seed oil found that the linoleic acid content was the highest in the hemp seed oil, α-linolenic content was the highest in perilla oil, and monounsaturated fatty acid (MUFA) content was the highest in almond oil. The characteristic fatty acids in the three types of edible vegetable oils were all different, displaying a variety of contents.

Several studies compared the fatty acid composition of olive, camellia, peanut, rapeseed, and soya bean oil in which the content was analysed. Results indicated that both olive and camellia oil were rich in n-9 fatty acids; peanut, olive, and camellia oil were low in n-3 fatty acids; and peanut and soya bean oil contained high levels of n-6 fatty acids.

From a nutritional perspective, edible vegetable oil rich in n-9 fatty acids, i.e., oleic acid, is not suitable for single long-term, uninterrupted consumption because it is not an essential fatty acid according to dietary reference intakes (DRIs), and prolonged ingestion will result in an insufficient intake of essential fatty acids.

The calories, SFA content, n-6/n-3 ratio, and vitamin E content of rapeseed, soya bean, peanut, cottonseed, maize and palm oil were also determined. Except for soya bean, sunflower and cottonseed oil, the ratio of polyunsaturated and vitamin E content was ideal in the rest of the plant oils. Therefore, edible vegetable oil exhibiting sufficient levels of fatty acid saturation, n-6/n-3 ratio, and appropriate vitamin E content should be selected to adequately fulfil human dietary requirements.

The methods currently used for evaluating edible vegetable oils focus primarily on describing and comparing the nutrients. Therefore, the nutritional content is simply used as a representation of the nutritional quality of edible vegetable oil, rarely linking with the demand of humans and ignoring the overall nutritional balance. Consequently, it is necessary to build a comprehensive, scientific, quantitative evaluation model denoting the nutritional quality of edible vegetable oil.

The evaluation model

Evaluation index

The establishment of the evaluation model was based on the 2013 *China Dietary Reference Intake* and *French Population Reference Intakes* (ANCs) *for Fatty Acids* screening indicators, including SFA, total MUFA, atherosclerotic fatty acids (C12:0 + C14:0 + C16:0), linoleic acid, α-linolenic acid, vitamin E and phytosterols.

Threshold calculation

The 2013 *China Dietary Reference Intake* stipulates the recommended daily intake of some fatty acids of which linoleic acid and α-linolenic acid are essential, while the acceptable range for the daily intake of EPA and DHA is 0,25 to 2g. Currently, there are two essential fatty acids in China, including linoleic acid and α-linolenic acid.

In the 2013 *China Dietary Reference Intake*, the DRIs are set for linoleic acid and α-linolenic acid; additionally, the acceptable macronutrients distribution ranges (AMDRs) are set for the total fat content, saturated fatty acids, total intake of n-6 PUFAs, and total intake of n-3 PUFAs.

MUFA daily intake

MUFA is widely found in food, such as nuts, vegetable oils, meat, and dairy products and primarily includes palmitoleic and oleic acid, which are abundant in common edible vegetable oils. Evidence shows that instead of carbohydrates, it can increase high-density lipoprotein (HDL) levels, and by replacing SFA, especially atherosclerotic fatty acids, it can reduce the ratio of (low-density lipoprotein [LDL] + total cholesterol)/HDL.

Based on the recommended intake of MUFA = total fatty acid intake (%E) – SFA (%E) – PUFA (%E) – trans fatty acids (%E), the maximum amount is between 7 to 17 %E. A meta-analysis found that in two groups with six months of high and low MUFA (<12 %E) ingestion, respectively, the higher group (MUFA >12 %E) significantly decreased the blood pressure and diastolic blood pressure of the high consumption group.

France has formulated appropriate reference amounts of oleic acid intake, recommending that the daily intake of oleic acid content be within 15 to 20%E while the 2013 *China Dietary Reference Intake* does not provide a recommended value for MUFA. To ensure the appropriate ingestion of MUFA, the daily intake should be no less than 15%E.

Recommended fatty acid intake

The 2013 *China Dietary Reference Intake* specifically recommended that the daily

Table 1: Recommended intake of different fatty acids, vitamin E, and phytosterol – the total daily energy intake per person is 2 000kcal.

Fatty acids	%E	Calories (kcal)	Recommended intake (g)
Linoleic acid	4	80	9
α-linolenic acid	0,6	12	1,5
Total fat	20 – 30	400 – 600	44,4 – 66,7
SFA	<10	<200	<22,2
MUFA	>15	>300	>33,3
Atherogenic fatty acids	–	–	<18g
Total value of n-6 PUFAs	2,5 – 9	50 – 180	5,6 – 20
Total value of n-3 PUFAs	0,5 – 2	10 – 40	1,1 – 4,4
EPA and DHA[1]	–	–	0,25 – 2
Vitamin E	–	–	14mg
Phytosterol[2]	–	–	0,9 – 2,4

[1]The unit of EPA and DHA is g/d. [2]Represents the specific recommended value of phytosterols and the maximum tolerable intake.

intake of phytosterol is 900mg, and the maximum tolerable intake is 2 400mg.

According to the nutrition and health surveys of Chinese residents in 2002 and 2013, the total per capita daily sterol intakes in China were 322,41 and 372,52mg, respectively, which were far below the specifically recommended value. In 2013, the nutrition and health data of residents showed that vegetable oil intake was 41,8g, providing 42,86% of the total sterol content, which is equivalent to 140,38mg. Therefore, the suggested daily intake of edible vegetable oil was 20g, while it was recommended that all types of edible vegetable oils be evaluated with 70mg of phytosterols as the minimum threshold.

Table 1 shows that 2 000kcal is taken as the daily total energy intake, and the proportion of fatty acid energy is converted into daily intake, and the unit is expressed in gram. EPA + DHA, vitamin E, and phytosterol were directly expressed as daily intake. In *Table 1*, the evaluation index of total atherogenic fatty acids (C12:0 + C14:0 + C16:0) is added, which is according to *ANCs for Fatty Acids*.

At present, there is no reference intake threshold of atherogenic fatty acids in China. However, atherosclerosis is a common disease seriously endangering human health. In recent years, the incidence rate of this disease has increased significantly in China. According to autopsy results, the detection rates of coronary and aortic atherosclerotic lesions were 58,36 and 88,31%, respectively, in 40 to 49-year-old people and gradually increased with age.

The 2013 *Report on the Nutrition and Health Status of Chinese Residents* shows that the current daily intake of edible oil per person in China is 41,8g of which vegetable oil accounts for 37,1g, which varies slightly from 39g. The recommended amount of edible vegetable oil accounted for 50% of the total dietary fatty acids because the daily fat intake of edible vegetable oil per person should be 22,2 to 33,3g. When the actual model was established, the daily intake of vegetable oil per person was 20g, accounting for approximately 45% of the total daily fat intake per capita.

Because there are no EPA and DHA in edible vegetable oil, we decided to select saturated fatty acid, MUFA, linoleic acid, α-linolenic acid, total atherogenic fatty acid (C12:0 + C14:0 + C16:0), vitamin E, and phytosterol as evaluation indexes finally.

Conclusions

This study established a preliminary model to evaluate the nutritional quality of fatty acids for 13 kinds of edible vegetable oils in the Chinese market. Among them, peony seed, flaxseed, low erucic acid rapeseed, and edible blend oil had the highest score of seven. Palm oil had the lowest score of two. However, the model established in this paper only considers fatty acids as a nutritional component.

From the perspective of fatty acid evaluation, people can get more balanced fatty acids from edible vegetable oils with a higher score. However, although olive oil has a low score, it has a high content of vitamin E, low saturated fatty acids (2 to 21%), and high antioxidant phenols. Therefore, in daily dietary consumption, consumers can try to choose edible vegetable oils with a higher score because edible vegetable oils with a higher score can provide more balanced fatty acids.

At the same time, vegetable oil is only a food material, and the final dietary structure has more influence on human health. Therefore, consumers also need to pay attention that different kinds of vegetable oils have different effects.

Although some edible vegetable oils may have a lower score, such as olive oil, they may provide other nutrients. Therefore, in addition to edible vegetable oils with a high score, we also could eat various kinds of edible vegetable oils at the same time, which will be more conducive to improving the current fatty acid diet structure in China.

This article was shortened for use in *Oilseeds Focus*. For the complete article and references, visit *www.pubs.acs.org/doi/10.1021/acsomega.0c05544* or email Dazhou Zhu at zhudazhou@caas.cn.

Amendments in respect of tenure on farms

By Clarissa Pienaar, Moolman & Pienaar Incorporated

The *Extension of Security of Tenure Amendment Act, 2018 (Act 2 of 2018)* or the *Amendment Act*, as well as the regulations issued in terms of the *Act*, came into effect on 1 April 2024, introducing several amendments to the *Extension of Security of Tenure Act, 1997 (Act 62 of 1997)* or the *ESTA*. Among other things, this involves amending certain definitions and adding others.

New definitions

A dependent is defined as "a family member whom the farm dweller/occupier has a legal duty to support".

Family means:

- A spouse in a customary marriage, whether or not the marriage is registered.
- A child, including an adopted child or foster care child.
- A grandchild.
- A parent.
- A grandparent.

'Reside' means to live at a place permanently, and 'residence' has a corresponding meaning.

In another amendment, development subsidies are replaced with the provision of tenure grants, with a view to promoting long-term security of tenure. This enables occupiers (and former occupiers) to acquire suitable alternative accommodation and to compensate owners and/or persons in charge for the provision of accommodation and services to occupiers and their families.

Other amendments

An occupier has the right to take reasonable measures to maintain the dwelling occupied by him/her or members of his/her family.

Any person has the right to erect a tombstone on, mark, place symbols or perform rites on his/her family graves. However, this is subject to any reasonable condition imposed by the owner or person in charge of such land in order to safeguard life or property or to prevent the undue disruption of work on the land.

> Before an eviction order can be granted, the parties must have attempted mediation to settle the dispute or referred it for arbitration.

An occupier may be evicted from land only if a court order has been issued. Such an occupier must have had legal representation at the eviction proceedings, unless the occupier expressly waived his/her right to obtain state-funded legal representation, and the court determined that the interests of justice would not be harmed by the lack of legal representation.

Before an eviction order can be granted, the parties must have attempted mediation to settle the dispute or referred it for arbitration. The regulations are very specific on this subject. The court that orders the eviction of the occupier will also take into account reasonable weather conditions under which the eviction order may be carried out.

Application for a tenure grant

An application for a tenure grant must be submitted in person, by registered post or electronically (on the Department's official website) to the director-general of the Department of Agriculture, Land Reform and Rural Development.

A crucial point to note is that applications for tenure grants in terms of the *Amendment Act* can only be submitted if a competent court has granted an eviction order, or if there is a threat of eviction and/or the occupier or former occupier or his/her family members' right of tenure is uncertain.

A person applying for a grant in terms of the *Amendment Act* must confirm in writing that the land on which the accommodation and or services will be provided will be transferred (full title) to the occupiers or former occupiers or family members before grants are paid.

Specific conditions apply to the alienation of land acquired through a tenure grant. Beneficiaries of the tenure grant are also prohibited from selling or disposing of the land within a period of ten years from the date of having acquired the property, unless the land is first presented to the director-general. The latter must either accept or reject the offer in writing within 90 calendar days.

Guidelines for handling disputes

A person involved in a dispute that concerns the administration of the *Amendment Act*, can report the dispute to the nearest department offices and request them to resolve it. The office concerned must attempt to resolve the dispute and if they are unsuccessful, the office must refer the matter to the director-general so that mediation or arbitration under the *Amendment Act* can be facilitated.

If mediation or arbitration is unsuccessful, the department must assist the person in obtaining representation through Legal Aid South Africa and have the case referred to the court.

For more information, contact the author at clarissap@mmlaw.co.za or 033 032 0241.

Bonuses: A right or a privilege?

By James Pretorius, legal advisor, LWO Employers Organisation

The payment of bonuses is an issue that often leads to friction between employers and employees. Under what circumstances is the payment of bonuses mandatory and what are the different types of bonuses that employees can qualify for?

In the context of labour law, a bonus is defined as a financial incentive paid to employees in addition to the regular salary or wages they receive or can expect. Typically, employers pay bonuses to motivate their employees or reward them for their work performance. This makes employment very attractive to prospective employees.

A bonus as part of a competitive compensation package and other benefits, gives the employer an advantage over other employers while allowing the business to retain valuable employees in the process.

There is no statutory requirement in labour law to pay bonuses. An employee can only claim a bonus when it is prescribed by the sectoral determination or bargaining council agreement applicable to a particular industry or sector.

Different types of bonuses

The most common types of bonuses are the following:

1 Discretionary bonus

This type of bonus is paid solely within the discretion of the employer. Such a bonus may be awarded to an employee for exceptional work performance as a way of rewarding the employee. Note, though, that there need not be a specific reason for awarding such a bonus as it is within the employer's discretion.

2 Performance bonus

This type of bonus is linked to an employee's performance and/or the performance of the employer. Performance bonuses are set out in the employee's contract of employment, stipulating specific goals or targets the employee must meet before the bonus is payable.

3 Guaranteed bonus

A guaranteed bonus or so-called thirteenth cheque is typically paid at the end of the year or on an employee's birthday. This type of bonus is stipulated in the employee's employment contract and forms part of the employee's terms and conditions of employment.

The payment of a guaranteed bonus to the employee is therefore mandatory and the employer cannot choose whether or not to pay such a bonus as it is a contractual obligation. The employment contract usually stipulates the date on which this bonus is payable.

A guaranteed bonus is also payable in industries or sectors where a bargaining council agreement or sectoral determination prescribes the payment of such a bonus. Two examples of mandatory bonuses payable to employees are the restaurant industries in the Pretoria and Johannesburg area, as well as the contract cleaning industry.

An existing expectation

If an employer frequently paid bonuses to employees in the past, there might be a reasonable expectation among employees that bonuses will also be paid in future. It could lead to uncertainty and dissatisfaction if the employer decides not to pay a bonus to employees.

Whereas labour law does not contain a statutory requirement for the payment of bonuses, the employer must include a stipulation in the contract stating that the payment of bonuses is within the sole discretion of the employer. This will ensure that there is no obligation on employers to pay bonuses to employees.

If paying bonuses is already an established practice or part of the workplace policy, the employer cannot unilaterally decide not to pay bonuses. This will constitute an amendment to employees' terms and conditions of employment. The employee may even refer the matter to the Commission for Conciliation, Mediation and Arbitration (CCMA). Employers are advised to consult with the employees concerned before taking such a decision.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