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OILSEEDS focus

Protein Research Foundation • Oil & Protein Seeds Development Trust • Oilseeds Advisory Committee




Proactive weed control

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Canola seed size and seeding rate

Grain and oilseed industry growth hampered by inefficient transport

By André van der Vyver, executive director, Sacota

Farmers will produce a near-record soya bean crop in 2022 with the Crop Estimates Committee's third estimate at 1,89 million tons – only 11 000 tons less than the record of 1,9 million tons in 2021. If not for excessive rain in some areas causing damage, we would have seen another record crop. The trend is clearly upward. Recent maize numbers are no different and sunflower seed bounced back with a current crop estimate of 963 000 tons.

Although each industry is different and the soya bean and sunflower seed industries have different product cycles, for the first time several commodities are either exceeding local demand or about to.

Thriving in the long term

For the South African grain and oilseed industries to prosper in the longer term, we need exportable surpluses to increase year on year. Globally, the commodity business is a volume business, meaning low margins and high volumes in most years.

Although South African prices will trade down to export parity for longer periods, this not only means that surpluses can be exported, but also that those commodities are made available to the local market at the cheapest possible prices. This, again, is beneficial for industries depending on commodities as their major input, such as maize millers and feed manufacturers. It also promotes food security in the cheapest possible way, as well as job creation in rural areas.

There is another unique phenomenon with reference to export parity prices. Relatively high international prices, combined with improved production technology and high yields in 2021, meant that many farmers in the eastern Free State, parts of KwaZulu-Natal and southern Mpumalanga could sell for the export market and still make a profit.

Grain SA's budgeted numbers for 2021 showed that farmers would have made a net profit of R692 per ton on a 6t/ha yield. However, actual prices (including premiums) in July 2021 were much higher than the R3 317 per ton used in the budgets. This is a win-win for the industry and South Africa. Global demand for commodities is likely to remain strong, with expectations that post-Covid and post-Ukraine, the world should see a return to high growth and demand.

The unprecedent growth in soya bean production will continue although local inland demand is nearing a saturation point. However, as the central and western production areas continue to expand areas under production and improve on yields, these areas could supply the local market while the eastern production areas could potentially be more suitable for exports.

Export challenges

When doing the same calculation for soya beans produced in the eastern production areas, it could be profitably exported with a net profit of approximately R2 142 per ton ex-farm. This far exceeds storage and transport costs to deliver the product to Durban harbour. Actions are already underway through organised agriculture to prepare the industry for exports.

The lack of an efficient transport network may scupper the long-term potential of the grain and oilseed industries. Through its three Durban bulk grain export/import terminals, South Africa currently exports, on average, seven supermax vessels of roughly 55 000 tons of maize per month – this is maximum capacity. Any future soya bean exports are likely to compete with maize exports.

Even if more vessels could be loaded by increasing capacity at Agriport, supply and removal of products will be a major challenge. Maize and soya beans need to be transported to Durban, and wheat and rice removed from the harbour.

The South African Cereals and Oilseeds Trade Association (Sacota) was instrumental in the re-opening of the port of East London. To date this year, two maize export vessels have been secured, with four more export slots available. Diverting exports through East London may hold part of the solution for the future.

Prioritising the transport hurdle

Globally, cost-effective exports depend on an efficient value chain from farmer to the port, of which storage and transport are two key factors. South Africa is fortunate to have world-class storage facilities. When it comes to transport, as much as possible should be transported by rail and the balance by road.

Our Durban export terminals can handle approximately 35% of volume by rail. Around mid-2021 this percentage was approximately 20%. However, since September 2021, cable theft has caused the percentage to drop to 10%, and at times as low as 5 to 6%.

Although there are ongoing efforts by Sacota in collaboration with storage owners, Grain SA and Transnet Freight Rail (TFR) to address this, it will take time. One such project is a pilot project to install private security cameras on the railway export line. TFR has also launched a project to auction railway line slots for the private sector to lease and manage these services. Although bulk export lines to Durban do not yet qualify, it may be a possibility in the future.

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A promising season for oilseeds, despite challenges

South Africa has experienced several challenges over the past two years. It appears that Covid-19 is slowly becoming more manageable, with a welcome change to legislation taking the country back to some form of normality. This is critical for resuscitating the economy, and observing so many international tourists returning to South Africa is indeed a welcome sight.

This is in stark contrast to China, which has been making every effort to eradicate the virus at the expense of free movement of people and the complete shutdown of some industries in specific regions of the country.

Currently entering our fifth wave, we are expecting the milder outcomes to continue, hopefully allowing normal activity.

Additional challenges

Additional uncertainty was caused by the riots in KwaZulu-Natal in 2021, resulting in major disruptions to the supply chain, from which certain sectors are still recovering. KwaZulu-Natal remained at the brunt of challenges with the devastating flooding in April this year, resulting in widespread infrastructure damage, as well as further supply disruptions that significantly influenced grain export movements.

Russia's invasion of Ukraine caught the world by surprise, despite the continuous threats indicating this had been imminent. The consequences impacting the energy, fertiliser, grain and oilseed sectors have been detrimental, adversely affecting the global food and energy balance. The world is grappling with adjusting to this new normal – South Africa included.

A new season

We have, however, been blessed with a wonderful season of rain – although in some cases excessive – aiding producers to provide excellent crops. The change in the economics of production is likely to see a shift toward oilseeds and we anticipate record oilseed plantings in the coming season.

Enjoy this issue of *Oilseeds Focus*.

Dr Erhard Briedenhann

Send us your contributions and suggestions to make *Oilseeds Focus* an enjoyable and valuable publication for the oilseeds industry. Contact Dr Briedenhann at erhardb@netactive.co.za for more information.

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NEWS

Tanzania plans to end edible oil imports

The government of Tanzania has announced plans to end sugar and edible oil imports by 2025. The plans were announced by the minister for agriculture, Hussein Bashe, and the minister for investment, industry and trade, Ashatu Kijaji.

Bashe said short-term measures to end edible oil imports in the next three years included the distribution of subsidised, certified sunflower seeds to small-scale growers. Long-term measures, added Bashe, included the introduction of tax incentives to large-scale investors in oil palm estates.

The short-term plan on edible oil intervention has started with the distribution of the initial 3 000 tons of certified sunflower seeds to smallholder farmers. Bashe said the government has already allocated 10 000 hectares to one oil palm investor in the Kigoma region of Tanzania. – *Xinhua*

Matutu assumes new role at JSE

The JSE recently announced that Anelisa Matutu will take on the role of head of commodities in the Capital Markets Division. She will be reporting to Valdene Reddy, director of Capital Markets. Anelisa is the fourth generation to lead the division after its creation in 1995, and has worked with all the previous heads as the market matured.

Anelisa joined the JSE in November 2008 as part of a graduate programme and has been exposed to all spheres of the commodities business. More recently she also completed her MBA through GIBBS Business School. Anelisa resumed her new duties on 3 May 2022. – *JSE press release*

Pollinator habitat linked to larger soya beans

Researchers at North Carolina State University have found that soya bean crops planted near pollinator habitats produce larger soya beans than soya bean crops not planted near pollinator habitats.

"Though soya beans are not thought of as being dependent on pollinators, we found that soya bean plants are still attractive to bees," said Hannah Levenson, a postdoctoral research scholar at the university and corresponding author of the study. "We found that the number of seeds was similar for fields near pollinator habitats and fields that were far away," Levenson said. "However, plants in fields that were adjacent to pollinator habitat produced seeds that were 6,5% heavier than the seeds from plants in distant fields."

"Given that soya bean farmers sell their crop by weight, it could make a meaningful difference in a grower's profit margin," said David Tarpy, co-author and professor of applied ecology at the university. – *ScienceDaily*

GM soya bean resistant to cyst nematode

Jilin Academy of Agricultural Sciences researchers successfully developed GM soya bean plants with improved resistance to soya bean cyst nematode (SCN).

SCN is the most economically destructive pathogen affecting soya bean production globally. To combat this pathogen, the researchers produced stable transgenic soya bean plants individually containing the inverted repeats of three SCN genes (*Hg-rps23*, *Hg-snb1* and *Hg-cpn1*) and assessed their resistance to the pathogen.

Results showed that host-induced silencing of essential SCN genes could enhance broad-spectrum SCN resistance in stable transgenic soya bean plants, without negative impacts on the agronomic performance. – *ISAAA*

Sunflower farming soon mandatory in Zimbabwe

All communal farmers in Zimbabwe will soon be required to venture into sunflower farming as the country seeks to substitute US$200 million worth of crude sunflower oil imports. Government has already started providing communal farmers with inputs to enable them to get involved in sunflower farming.

This will ensure the country ceases imports of between 60 000 and 65 000 metric tons of crude sunflower oil from South Africa annually. Government has included sunflower seeds among inputs being given to farmers this summer farming season.

Minister Dr Anxious Masuka said the Zimbabwean government is targeting 120 hectares of land for sunflower cropping in rural communities, and they expect to distribute at least 600 metric tons of sunflower seed to farmers. – *allAfrica*

Drop in soya bean prices expected

The price of soya beans in America looks set to drop this year as supply increases and demand declines. Investors should also benefit from the move. Hackett Financial Advisors sees soya bean prices fetching as little as US$12 a bushel in autumn, 27% lower than the recent price of US$16,37.

Soya bean supplies are already set to increase this year, on top of steady growth over the past three years. America produced 121 million metric tons of soya beans in the 2021/22 season, up from 97 million two years earlier, according to the Department of Agriculture's data.

In May 2021, soya bean prices also fetched US$16,37 a bushel. However, in the interim they have been on a wild ride, falling to less than US$12 in November, according to *TradingEconomics.com*, which collated the data. Prices also hit highs of above US$17,50 in late April, before retreating. – *Barron's*

Omnia wins prestigious chemicals award

Omnia Holdings has won the 2022 Best Sustainable Diversified Chemicals Group in Africa award by leading business and finance platform, *CFI.co*.

Each year, *CFI.co* identifies organisations that contribute significantly to economies and excel in adding value for all stakeholders, while caring for the planet. This honour is thus a testament to the enduring commitment to achieving zero harm, making a positive impact, and creating a better world across Omnia's mining, fertiliser and chemicals divisions.

The prestigious award acknowledges Omnia's commendable progress in consistently adopting sustainable development practices (particularly improvements in emissions, carbon credits, renewable energy projects, oil recycling and water efficiency), while integrating the United Nation's Sustainable Development Goals into its core strategic frameworks.

It also recognises the group's emphasis on driving noteworthy empowerment initiatives, and leveraging leading-edge technology as well as innovation to enhance value for every stakeholder. – *Press release, Omnia Holdings*

Soya dairy unprofitable in developing countries

A new study from the University of Illinois shows that so-called 'soya cows' in many cases are not economically viable and do not provide the expected benefits. A soya cow entails technology that extracts milk from soya beans.

"The soya cow was promoted as a way to increase soya bean utilisation and address poverty and malnutrition," said Peter Goldsmith, professor and director of the Soybean Innovation Lab (SIL) at the university.

In 2016, SIL partnered with the United States Agency for International Development (USAID) in a large-scale study that would help determine whether the soya cow is an appropriate technology for small-scale, rural enterprises.

The soya cow enterprises are located in rural areas, where wages are low and soya milk is not part of the regular diet, so there's also not a large market for the products. "The soya cow has the capacity to produce almost 1 700ℓ of soya milk per month. But these operators were producing about 147ℓ on average, and some as little as 75ℓ."

The authors conclude that soya cow technology would be better suited to urban settings, where the capital investment would be larger, but capacity would be matched to the demand. – *University of Illinois*

New research focusses on the importance of data and technology

By Marion Delport and Dr Dirk Strydom, DIFM team

DIFM, or Data Intensive Farm Management, is a multi-disciplinary research project that has seen several agronomic trials taking place on five farms over the last few years. New experimental techniques have been developed that can significantly reduce the size and cost of agronomic trials and, simultaneously, deliver more data points to base research and decisions on.

The DIFM team includes agronomists, agricultural engineers and economists, statisticians and soil scientists at the University of Illinois, Illinois State University Louisiana State University, University of Massachusetts Amherst, Montana State University, the University of Nebraska-Lincoln, Texas A&M University and Washington State University. Local partners include the Bureau for Food and Agricultural Policy (BFAP), the Protein Research Foundation (PRF), the University of Pretoria (UP) and Grain SA.

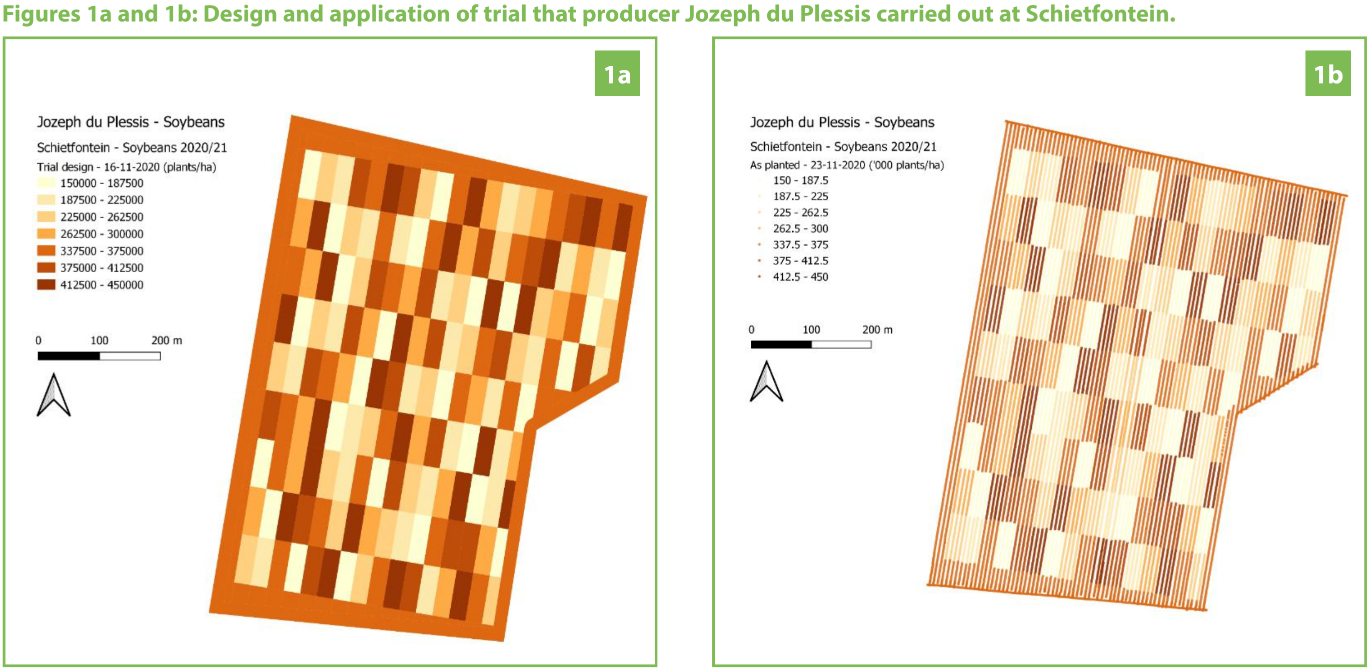
Data-driven management decisions

GPS precision agricultural technology has allowed researchers and producers to collaborate on the DIFM project and conduct large-scale trials on the farm. The purpose of DIFM is to implement precision agriculture management by joining forces with producers to conduct scientific experiments on their own farms.

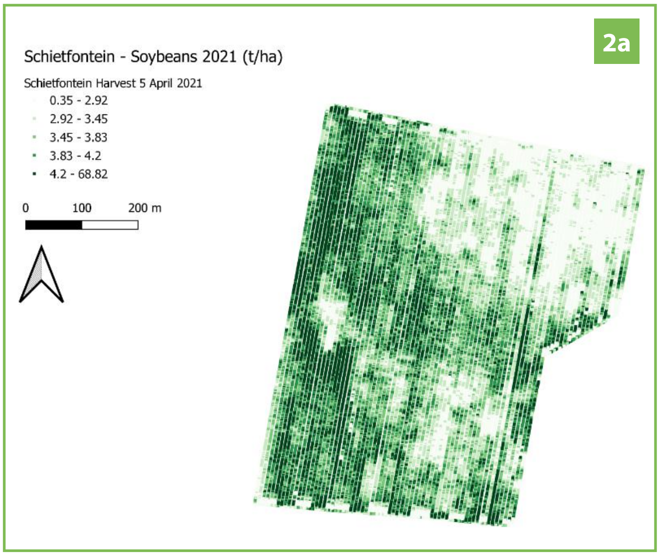
This will allow them to increase their profits by taking data-driven management decisions, as well as determining which variables to consider when designing precision agriculture prescriptions. The DIFM trials are designed to measure both the agronomic and economic response of a crop on fields.

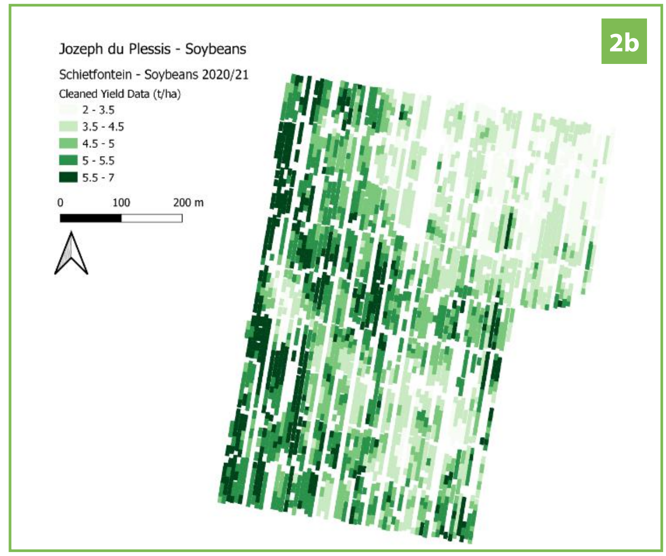
This precision agriculture project involves the producer's ability to use GPS information, and sensors that allow spatially varying planting density and

Figures 1a and 1b: Design and application of trial that producer Jozeph du Plessis carried out at Schietfontein.

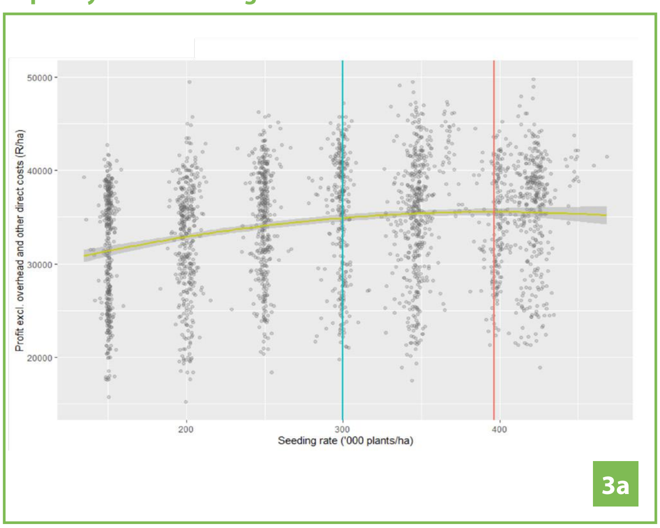


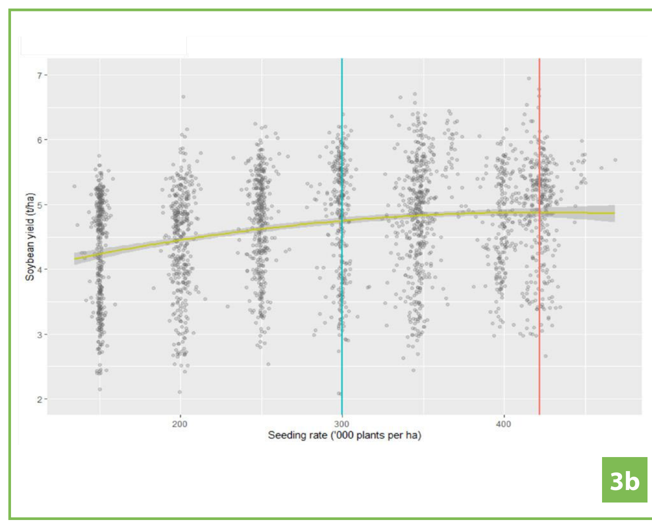
Figures 2a and 2b: Harvest and yield data of trial carried out at Schietfontein.





Figures 3a and 3b: Seed density to maximise profit at Schietfontein trial. Figure 3a depicts profit vs sowing rate and Figure 3b depicts yield vs seeding rate.





fertiliser application, as well as accurate yield monitors on harvesters to conduct a data-driven scientific experiment on his/her farm, without altering current management practices too much. The experiments were created in a bid to utilise producers' existing equipment and methods of planting and application, as well as producers' existing application levels when determining minimum and maximum ranges of trial designs.

Data is collected on a spatial scale (this identifies the geographical location of features and boundaries) so that additional information pertaining to landscape, soil and chemical characteristics, if available, can be included in the final trial analysis. This data and the accompanying analysis will attempt to explain why certain areas within a field respond differently to the experimental treatments (high/low planting density and fertiliser applications).

2021 results: Soya beans North West

Schietfontein is a 42,4ha field used exclusively for the DIFM soya bean trials during the 2021 harvest season in North West. The producer typically plants 300 000 plants per hectare and requested that, during the trial, between 150 000 and 450 000 plants be planted per hectare, in increments of 50 000 plants per hectare.

The producer plants six rows that are 6,85m apart (average row width of 1,15m). The equipment used includes:

- John Deere 6330 tractor.
- John Deere 1750 'vacuum' planter.
- Ag Leader precision agricultural software.
- John Deere S660 combine harvester.

The trial design shown in the left-hand panel of *Figures 1a* and *b* was supplied to the producer and planted on 23 November 2020 (the right-hand panel indicates the quantities planted). Care was taken to maximise planting accuracy.

Following an above-average season, the trial was harvested on 5 April 2021, with an overall average yield of 3,5t/ha. The right-hand panel of *Figures 2a* and *b* indicates the yield data consisting of 2 460 subsections with consistent yield and plant density observations. Machine learning and a clustering algorithm were used to generate the processed data, which was then used for further statistical analysis.

Profit calculation

General addition models (GAM) were matched to the processed data for both yield and optimal profit calculation. *Figure 3* depicts the data with the resultant applicable trends curves, and indicates the producer's typical rate (300 000 plants per hectare in blue) and plant density of 422 000 seeds per hectare for optimal yield (in red).

If the producer were to increase his plant density to 422 000 seeds per hectare in a season with identical growing conditions as in 2020/21, then a projected increase of 0,15t/ha can be achieved. *Figures 3a* and *b* depict the optimal plant density of 397 000 seeds per hectare, and the model estimates that in a season with growing conditions identical to that of the 2020/21 season, the producer could increase his profit by just under R1 000/ha if the optimal 'constant density' had to be applied.

A geographically weighted regression was used to define terrain-specific plots for plant density on the Schietfontein plot.

> The experiments were created in a bid to utilise producers' existing equipment and methods of planting and application.

The best estimate provided by the data and model is that, under growing conditions identical to those of the trials in 2021, the implementation of the recommended site-specific plant density strategy would have increased profit by around R1 360/ha (relative to the typical fixed rate application). The data and model established a statistical confidence level of 95% that profit differences would be between approximately R1 016 and R1 704/ha.

In conclusion

The data can accelerate research and provide new insights to maximise profits. By utilising precision technology, profits can be maximised and subsequently lead to better margins. The key to successful research lies in expanding it to other farms, but also performing it over many years and across a variety of seasons.

The more data can be generated over time, the easier it is to make decisions that are specifically related to climatic conditions. In essence, by managing two variables efficiently, profits can be increased, which will increase the sustainability of production. The added value is that although not all producers have access to the technology, they can reap the benefits of the research results for future application.

For more information, the preceding article can be viewed at *https://sagrainmag.co.za/2021/03/30/optimal-profit-with-data-intensive-farming/*.
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Rhizobia as a source of plant growth-promoting molecules: Potential applications and possible operational mechanisms

By SK Jaiswal, M Mohammed, FYI Ibny and FD Dakora, Tshwane University of Technology

Nitrogen (N) is an essential component of all amino acids and nucleic acids, thus making it an important plant nutrient element. Although the atmosphere consists of 78,1% N_2 gas, plants cannot use it unless it is converted into a usable form. Biological N_2 fixation (BNF) is a free source of N that can be exploited by resource-poor farmers for increased crop yields, making it one of the most important microbiological processes on earth.

So far, 21 bacterial genera have been identified as nodule-forming microsymbionts. These microsymbionts are distributed among major bacterial genera of the alpha-proteobacteria, such as *Rhizobium, Bradyrhizobium*, *Azorhizobium*, *Mesorhizobium*, *Ensifer (Sinorhizobium)*, *Neorhizobium*, *Pararhizobium* and *Allorhizobium*, collectively termed 'rhizobia', which can form symbiotic associations with diverse legumes. Similarly, species of the beta-rhizobia *Cupriavidus*, *Paraburkholderia* and *Trinickia* can also form symbiotic relationships with members of the *Papilionoideae* and *Caesalpinioideae*.

Advantages of rhizobia

Rhizobia undergo differentiation into N_2-fixing bacteroids, which convert atmospheric N_2 into ammonia in a reaction catalysed by the nitrogenase enzyme. Whereas many rhizobia invade roots via the infection thread, others utilise either 'crack entry' or root epidermal cells as points of infection. When N_2 fixation commences, the bacteroids in root nodules supply the host legume with fixed N while receiving C compounds from host photosynthesis.

Besides the provision of symbiotic N, some rhizobia also exhibit physiologically desirable traits such as the production of plant growth-promoting phytohormones, which include indole-3-acetic acids (IAA), cytokinins, gibberellins, riboflavin, lumichrome, Nod factors, etc. (*Table 1*), all of which play diverse roles in enhancing plant growth and productivity.

Thus, rhizobia confer several advantages on plants in addition to the provision of N from symbiotic interactions. The beneficial effects of rhizobia are mediated by the production of diverse metabolites and enzymes that are directly or indirectly elicited by rhizobia and plants during nodule formation (*Table 1*).

Of the plant growth-promoting molecules, the secretion of IAA, 1-aminocyclopropane-1-carboxylate (ACC) deaminase, lumichrome, riboflavin and protons for phosphate solubilisation have been suggested as important PGPR mechanisms underlying plant growth promotion.

ACC deaminase is an enzyme that can decrease deleterious amounts of ethylene in higher plants, leading to increased productivity. Lumichrome and riboflavin are novel molecules from rhizobial exudates that are known to stimulate plant growth. On the other hand, IAA is an important member of the auxin family that is responsible for controlling plant physiological processes, including cell enlargement and division, tissue differentiation and light/gravity responses (*Table 1*).

Plant growth promoting rhizobacteria (PGPR) comprise a diverse group of bacteria that present growth benefits to plants through several mechanisms. The rhizosphere soil of plants tends to contain PGPR that are capable of releasing protons to solubilise soil-bound phosphorus for plant use and are usually referred to as phosphorus-solubilising bacteria (PSB).

The detailed mechanisms by which microsymbionts alter plant growth have remained elusive. Nevertheless, efforts at identifying highly effective rhizobial strains that combine adaptation to their environment with plant-growth promoting traits could improve plant growth and inoculation response under field conditions.

This review addresses the roles played by the secretion of siderophore, IAA, ACC deaminase, lumichrome, riboflavin and protons for P solubilisation in plant growth promotion, especially during the legume-rhizobia symbiosis. The secretion of these molecules by non-rhizobial plant growth promoting bacteria, leading to increased plant development, is also discussed.

Rhizobia and plant growth

Legumes that harbour efficient rhizobia in their root or stem nodules often meet their N requirements from N_2 fixation. It is this symbiotic trait that gives legumes a superior survival advantage over their non-legume counterparts in N-depleted soils where other plant growth requirements are optimal. Nodulation and N_2 fixation in legumes are an interactive process which involve the action of rhizobial Nod factors; during the process, some rhizobia may produce phytohormones such as IAA, gibberellic acid and cytokinins which present plant growth promoting effects (*Table 1*).

Aside from serving as signal molecules in the early stages of nodule formation, Nod factors isolated from *Rhizobium leguminosarum* were also found to increase seed germination, nodulation and plant growth in peas and vetch, as well as pod yield in peas. These observations clearly stress the multiple roles of rhizobial Nod factors as both signal molecules for nodulation and plant growth promoters in diverse crops.

Rhizobia can also increase nutrient availability in the root zone, especially N and P, produce molecules that inhibit pathogens, as well as alter rhizosphere chemistry involving the regulation of ethylene levels. Moreover, aside from the growth promoting effects of cytokinin

Table 1: Rhizobial metabolites and their functional roles in plant growth and development.

Rhizobial metabolite	Functional roles
Lipo-chito oligosaccharides (Nod factors)	*Stimulates seed germination. Stimulates lateral root formation. Induces the expression of flavonoid genes. Regulates phytohormone biosynthesis and homeostasis in legumes. Promotes root colonisation by arbuscular mycorrhizal fungi. Causes cell division and embryogenesis.
Riboflavin	*Increased bacterial root colonisation and nodule occupancy. Primed plant defence response. Serves as vitamins for plants and bacteria. Plant growth promotion.
Lumichrome	Induces plant tolerance to drought through stomatal control. Stimulates seedling growth. Stimulates root CO_2 production. Promotes early tillering in sorghum plants.
Nitrogenase-linked H_2	Increases soil microbial population and carbon deposition.
Indole-3-acetic acid (IAA)	*Promotes nodulation. *Promotes root growth and plant development.
Cytokinin	Regulates nodule organogenesis. Increases plant growth.
Gibberellin	Promotes nodulation in a dose-dependent manner. Promotes seed germination and plant development.
Ethylene	Involved in plant defence response to pathogens. Promotes plant growth.
Siderophore	Mobilises Fe for plant uptake. Increases nodulation and N_2 fixation. Improves plant adaptation to pathogen and stress. *Increased plant growth.
1-aminocyclopropane-1-carboxylate deaminase (ACC deaminase)	*Improves nodulation and plant growth via the regulation of ethylene production.
Rhizobitoxine	*Improves nodulation and plant growth via the regulation of ethylene production.
Jasmonates	Has a role in mycorrhizal and legume-rhizobium symbiosis. Implicated in the autoregulation of nodulation in legumes. Improved plant response to drought stress.
Brassinosteroids	*Regulates nodule number, probably through the regulation of ethylene production. Reported for plant growth promotion.

**Before functional roles indicate experiments in which mutants for a particular trait were compared with wild-type, with one strain being negative for the trait. All other experiments either involved exogenous application of signal molecules, with or without gene expression studies.*

from either plant or bacterial origin, they are also involved in the nodulation process of legumes and plant response to pathogens.

The significant roles of the legume-rhizobia symbiosis in enhancing plant growth and productivity have been demonstrated in several legumes including soya bean, mung bean, chickpea, common bean, cowpea, Bambara groundnut and Kersting's groundnut.

However, a major limitation to tapping the maximum benefit of the symbiosis is related to its susceptibility to diverse environmental stress factors. Thus, tapping the maximum benefit of rhizobia for improved plant performance will require selection and/or engineering strains with multiple adaptive and plant growth promoting traits.

IAA and N_2 fixation in legumes

Indole acetic acid (IAA) is an important member of the auxin family responsible for controlling plant physiological processes, including cell division and enlargement, tissue differentiation and light/gravity response. Rhizobia together with other bacteria, fungi and algae are producers of auxins, especially IAA, a common by-product of L-tryptophan metabolism in several micro-organisms, including rhizobia.

The level of IAA production can vary among rhizobial isolates; endogenous phenolic acids such as protocatechuic acid, 4-hydroxybenzaldehyde and p-coumaric acid in root nodules could increase IAA synthesis by rhizobial isolates from *Vigna mungo*. Microbes and plants can mutualistically benefit from each other, with the microbes releasing plant growth-promoting substances in return for photosynthate from the plant.

Moreover, IAA-producing rhizobia have also been shown to significantly increase free amino acids such as valine, alanine, aspartic acid and glutamic acids in host plants, as well as photosynthetic products supplied to bacteroids in root nodules. These findings together suggest that IAA promotes an increase in nitrogen fixation via the upregulation of the genes involved in carbon transport to N_2-fixing bacteroids.

Bacterial secretion of siderophores

Beyond the reduction of N_2 to NH_3 for direct use by plants in the synthesis of macromolecules such as chlorophyll, RuBisCo and nucleic acids, some rhizobial strains are known to improve the availability and uptake of iron via siderophore production.

Iron (Fe) is one of the essential elements required by plants for growth and is a component of critical macromolecules such as leghaemoglobin and nitrogenase, both required for the N_2 fixation process. As a result, a deficiency in Fe limits the efficiency of N_2 fixation through a reduction in nodule development and nitrogenase activity. Fe exists in soils as divalent (Fe^{2+}) and trivalent (Fe^{3+}) cations, and its availability for plant uptake is governed by several factors including soil pH and the levels of other soil nutrients.

Whereas siderophores are known to have diverse chemical structures, most bacteria produce the catecholate-type, while fungi together with some bacteria produce the hydroxamatetype siderophores. Siderophores have a high affinity for Fe^{3+} where soil Fe is low and can reduce it to Fe^{2+} for uptake and utilisation by legumes.

Identifying siderophore-producing rhizobia is therefore important for increased plant growth and crop yields, especially of nodulated legumes. Several species of rhizobia have been identified as siderophore producers with benefits beyond Fe^{3+} sequestration.

Although the mechanisms of growth promotion remain complex and elusive, several studies involving mutants also point to the plant growth promoting traits of siderophores. To tap the benefits of this trait, siderophore-producing microsymbionts such as *Sinorhizobium meliloti*, *Rhizobium leguminosarum*, *Rhizobium leguminosarum* bv. *trifoli* and *Bradyrhizobium japonicum* have been identified as potential strains for use as Fe-based biofertilisers for increased crop yields.

In addition to enhancing Fe nutrition and promoting plant growth, siderophores have also been implicated in plant adaptation to high concentrations of heavy metals in agricultural soils. Apparently, bacterial siderophores can chelate heavy metals such as Al, Cd, Cu, Pb and Zn to form complexes that are not toxic to plants. Rhizobial siderophores are therefore important in the reclamation of contaminated soils for agricultural use.

Rhizobia need iron for their own use in growth and symbiotic functioning, just as many proteins involved in the N_2 fixation process require iron for the synthesis of hemoglobin needed for transporting O_2 to respiring bacteroids. Rhizobia have the ability to produce a catechol siderophore to acquire iron under iron-poor conditions in the soil.

With the many new symbionts continuously being reported, it is important to also identify their siderophores as a necessary step for their use as Fe biofertilisers. Furthermore, more studies are needed to ascertain the Fe-releasing efficiency of the different types of siderophores.

Lumichrome and riboflavin

Micro-organisms such as rhizobia are crucial in the promotion of plant growth, as they can synthesise and release phytohormones that alter the rhizosphere chemistry in favour of plant growth (*Table 1*). Rhizobial metabolites such as riboflavin and lumichrome are reportedly involved in chemical crosstalks leading to plant growth promotion, as well as improved immune response to biotic and abiotic stresses. As a result, soil microbes such as rhizobia and non-rhizobial bacteria have been used as inoculants because of these additional benefits.

Riboflavin released by rhizobia into the rhizosphere can promote microsymbiont colonisation of root hairs, leading to greater and more effective nodulation and N_2 fixation. Lumichrome, the degradation by-product of riboflavin, is also reported to promote plant growth through improved symbiotic and photosynthetic functioning in legumes (*Table 1*). At the molecular level, lumichrome can induce the expression of genes involved in cell differentiation and cell expansion, leading to increased plant biomass accumulation.

Given their roles at different stages of the legume-rhizobia symbiosis, riboflavin and lumichrome released by rhizobia can maximise plant growth and increase crop productivity via several alterations in the plant's physiology, including enhanced symbiosis and photosynthetic functioning.

The genetic basis of plant growth promotion by lumichrome stems from its ability to induce the expression of genes responsible for cell growth and mitotic division, and appears to co-ordinate cell division and proliferation in developing leaves. Lumichrome is also reported to increase CO_2 concentration in the rhizosphere which is needed for the growth of N_2-fixing rhizobia and mycorrhizal fungi.

Additionally, lumichrome can also reduce the levels of gene expression associated with ethylene metabolism such as *Acc oxydase 1* (*ACO1*) and a C_2H_2 zinc finger protein, leading to a minimal effect of ethylene on plant growth.

ACC deaminase

ACC (1-aminocyclopropane-1-carboxylic acid) deaminase is a known precursor of ethylene and is a plant growth-promoting enzyme (*Table 1*) that uses pyridoxal 5-phosphate (PLP) as substrate. ACC deaminase enzyme localised in the cytoplasm is encoded by the *acdS* gene. When ACC produced by plants is exuded into the rhizosphere, rhizobacteria that express ACC deaminase activity take up the ACC and degrade it within the bacterial cytoplasm.

This enzyme is constitutively expressed during nodule initiation, and under stressed conditions in plant roots. The plant exuded ACC is often used by bacteria as an N source; however, ACC deaminase can also degrade ACC to lower ethylene levels, especially in plants exposed to biotic and abiotic stresses, as well as during nodule initiation by legumes and rhizobia.

The important plant growth promoting traits of these bacteria-produced molecules point to the need to bioprospect for rhizobial strains that possess such traits for increased symbiotic performance, plant growth promotion and increased grain yield. ACC deaminase-producing rhizobia can stimulate nodule formation and function, and thus increase the amount of N_2-fixed needed for plant growth.

Phosphorus acquisition

To increase crop yields for meeting global food security would require major nutrient inputs, especially N and P. Plants take up P in the form of phosphate. The world's vast 5,7 billion hectares of agricultural land are generally deficient in P, which must be added as input to increase crop productivity.

In Africa, most smallholder farmers grow their crops with insufficient or no P input. However, plant growth-promoting bacteria and fungi can influence plant development directly or indirectly by facilitating the supply and uptake of mineral nutrients from the soil. Solubilisation of unavailable soil P compounds by symbiotic rhizobia in the rhizosphere is one strategy for enhancing P availability for plant growth and yield.

Aside from plants, bacteroids in root nodules also require P for their metabolism. Thus, given the vital roles of P in both plant and bacterial metabolism, screening for P-solubilising traits in N_2-fixing rhizobia can be a cheaper and useful strategy to ameliorate the negative effects of soil P stress on plants for improved crop yields and food security.

Immobilisation of P can occur in inorganic and organic forms. During microbial P transformation, the carboxyl and hydroxyl ion containing organic acids release their protons and bind to cations, thus lowering the pH. The acidification caused by microbial activity can result in the release of P ions by substitution with H^+. In low-P soils, rhizobia can solubilise soil-bound P in the rhizosphere through acidification by synthesising gluconic acid under the control of pyrroloquinoline quinone (PQQ) genes.

Of all the organic acids, gluconic acid is most potent in P solubilisation and the oxidation of glucose to gluconic acid by rhizobia is an important step in the solubilisation of soil P. Gene gcd in rhizobia encodes quinoprotein glucose dehydrogenase (PQQGDH), which is involved in the release of organic anions to solubilise inorganic P.

In addition to organic acids, inorganic acids and mycorrhizal fungi in soil can also enhance phosphorus solubilisation. Whereas rhizobia are largely known for their N_2-fixing traits, mycorrhizal fungi are particularly known for their role in the acquisition of phosphorus and other nutrients required by plants.

Rhizobia and other microbes harbour genes such as *phoD* and *phoA* which encode alkaline phosphatase, the *appA* gene which encodes phytase, and the *phn* gene which encodes C-P lyase enzymes that can convert soil organic-P into available P for plant uptake. The organic P, however, occupies about 30 to 50% of the total soil P pool in forms such as inositol phosphate (soil phytate), phosphomonoesters, phosphodiesters, phospholipids, nucleic acids and phosphotriesters.

The activity of microbial P-enzymes on the huge P reservoir in soils largely accounts for P supply to terrestrial plants. P assimilation under P-poor soil conditions is usually achieved using high-affinity P transporters, in contrast to P-rich soils where low-affinity P transporters are involved.

The expression of genes *phoU*, *phoR* and *phoB* in soil microbes largely regulates the P-starvation response in cropping systems for increased use of external P sources. However, information is lacking from a systems approach that links the P status of the soil to plant and bacterial gene expression for P-enzyme formation/release for increased P availability, uptake and utilisation.

Rhizobia and plant defence

The successful induction of root nodules and their subsequent colonisation by rhizobia require the production of rhizobial Nod factors that allow for their recognition by the host legume. Aside from their growth promoting effects, rhizobia have been implicated in processes leading to induced systemic resistance (ISR) in host plants which is governed by complex mechanisms

The response of host plants to pathogen infection can include a molecular crosstalk between salicylic acid and jasmonates, both of which play key roles in the activation of plant defence related genes. Upon attack by insects for instance, intricate processes which include the synthesis of salicylic acid and jasmonates occur, leading to the activation of genes responsible for plant defence.

Moreover, siderophores produced by symbiotic rhizobia and other microbes do not only enhance Fe nutrition for healthy plant growth and grain yield in legumes, but also serve as biocontrol agents against pathogens (*Table 1*).

In addition to their roles as signal molecules in the legume-rhizobia symbiosis, rhizobial metabolites such as riboflavin and lumichrome, as well as vitamins which include thiamine, biotin, niacin and ascorbic acid have been implicated in legume plant defence against pathogens.

Legumes are also reported to protect themselves against pathogens using isoflavonoids, phytoalexins and phytoanticipins. It is therefore possible that the health of a legume plant is dependent on a molecular crosstalk involving several defence molecules such as isoflavones, riboflavin, thiamine and other yet unknown molecules.

Clearly, plants have diverse ways of overcoming biotic and abiotic stress within their environments through the synthesis of novel molecules, and a lot remains to be unravelled regarding the complex chemical crosstalks involved in plant adaptation to disease infection and pathogen attack.

Conclusions

Plant growth and productivity is dependent on multiple factors, which include mineral nutrition, resistance to insect pests and diseases. Fortunately, symbiotic rhizobia are capable of triggering biological pathways that cause outcomes with direct and indirect effects on plant growth promotion and protection.

Studying the interlinkages of outcomes from the legume-rhizobia symbioses has the potential to identify microsymbionts for use as inoculants due to the multiplicity of functions that they elicit. For example, rhizobia can be identified that produce greater symbiotic N for host plant growth and productivity; elicit the synthesis of host-plant compounds for defence and increased plant growth; produce environmental cues that regulate stomatal function; and emit vitamins as growth factors for plant defence and increased growth/productivity.

This article has been condensed for publication in *Oilseeds Focus*. For enquiries, email dakorafd@tut.ac.za or visit *www.frontiersin.org* to read the full article and view all references.

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Three key strategies for improving rainfall effectivity and soil health

By Dr Neil Miles, Soil Health and Plant Nutrition Services

Soil health is close to the heart of every producer. What constitutes healthy soil? Is my soil healthy? Are there simple and practical ways of improving soil health?

When American author and conservationist Louis Bromfield took ownership of Malabar Farm in Ohio in 1948, he described the soil as "a mixture of cement and gravel with traces of acid". Unfortunately, this description, so suggestive of 'droughty' soils, applies all too often to soils in South Africa.

Producer comments along the following lines are sure indications of soil health problems: Yields are not what they used to be; the soil is dead – there is no life in it; the soil sets like a rock, I can't even get a pick into it; water just runs off this land; the crop looks stressed all the time.

'Worn-out' soils inevitably result in poor yields, low investment returns and, consequently, the increased economic vulnerability of farming operations. Let's take a quick look at three very practical strategies for increasing rainfall effectivity while also improving soil health.

Take care of the soil 'skin'

Producers frequently point out that they are endeavouring to 'farm with nature'. However, it is worth remembering that in nature, soils – except in the desert – are always covered by living plants and plant residues.

Recent research has shown that the condition of the top (approximately 1cm) layer of soil has a profound effect on the health of the soil as a whole, as well as on the way in which rainfall enters and is stored in the soil. The best way to take care of this soil 'skin' is to continuously keep the surface covered with growing plants or crop residues.

The benefits of having a cover on the soil are numerous, and include the following:

- Rainfall effectivity is optimised through vastly improved water infiltration and decreased run-off. The improved soil surface conditions resulting from a surface cover are clearly illustrated in *Photographs 1* and *2*. Note the severe crusting on the uncovered soil. Surface crusting results in decreased water infiltration and increased run-off and erosion. Other data presented provide striking evidence of the incremental benefits of increased soil cover on water infiltration.
- Soil cover is of great importance for minimising soil losses by both water and wind erosion. Soil losses by these processes result in reduced crop yields and threaten the sustainability of agricultural operations. There is great truth in the saying "the best soil leaves" since the finer particles carried away by the wind and water mainly include clays, fine organic matter, fertiliser nutrients and soil micro-organisms.
- Maintaining a soil cover promotes soil biological activity and, in particular, promotes earthworm populations. This is readily evident when one lifts residues that have been on the soil surface for some time: spiders, crickets, earthworms and other soil life abounds under the cover. Earthworms are 'soil engineers', with their burrows providing channels for both air and water movement into the soil.

Address acidity in top- and subsoil

Acid soil conditions restricting crop growth occur widely in the eastern half of South Africa. In the higher rainfall areas, soils are often naturally acidic; however, human intervention such as tillage and the application of fertilisers accelerates acidification.

The effects of soil acidity on crop growth tend to go unnoticed by producers, in that it is in the root zone (underground) where the major impact occurs. Damage is caused to the root system by the aluminium and manganese toxicities associated with soil acidity. In particular, aluminium toxicity results in poor lateral rooting, and root tips become thickened and dysfunctional (*Photograph 3*). The resultant inefficient root systems limit yields through poor water and nutrient uptake. Importantly, in seasons of reduced rainfall, aluminium toxicity greatly magnifies the effects of drought.

Where acidity extends into subsoils, the situation with regard to moisture supply is aggravated further, in that moisture reserves in the subsoil are largely unavailable to plants because of restricted root penetration into the lower soil layers. Under these conditions it is not uncommon to see plants displaying symptoms of drought stress even on relatively moist soils.

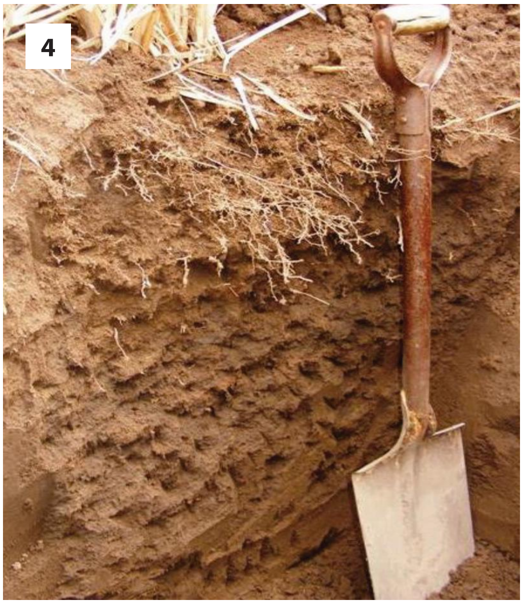
Importantly, because of subsoil acidity, many producers are growing their crops 'in a flowerpot' – the huge tank of water in the soil below the plough layer is not accessed. This aspect is clearly illustrated by the restricted rooting seen in *Photograph 4*. By correcting subsoil acidity through the use of gypsum, the crop roots grow into the subsoil and the improved water supply increases yields and enables the crop to better withstand periods of drought.

How are soil acidity problems identified and addressed? These aspects will be dealt with in detail in a subsequent article; however, soil acidity is not easily detected from symptoms in the above-ground crop, and soil analysis is the only reliable means of identifying the existence of excessive acidity and of determining the amounts of lime and gypsum required to correct the problem.

Topsoil characteristics of a soil under sugar cane that was subjected to different harvesting practices for the past 60 years: No residues remaining after burning at harvest.

Topsoil characteristics of a soil under sugar cane that was subjected to different harvesting practices for the past 60 years: Green cane harvesting with a blanket of surface residue remaining on the surface.

Maize roots exhibiting severe aluminium toxicity symptoms.



Poor penetration of sugar cane roots into a severely acidic subsoil.

Since the incorporation of lime and gypsum is possible only before planting, soil samples should be taken long before the planting operation. This will allow sufficient time for the samples to be processed in the laboratory and for products to be ordered and incorporated into the soil.

Correct soil compaction problems

Soil compaction can play a huge role in restricting crop growth. There is no doubt that compaction is a widespread yield-limiting factor in both crops and intensive pastures in South Africa.

Restricted rooting as a result of compacted soil layers reduces water supplies to plants and renders them more drought prone. Correcting compaction problems through ripping and, where possible, the use of deep-rooted crops such as lucerne and 'tillage-radish' is essential for eliminating this often-serious growth limitation.

Concluding remarks

Erratic rainfall and short-term droughts during growing seasons are increasingly common phenomena affecting agriculture in South Africa. This situation underlines the need for soil health and rainfall effectivity to be optimised, and for crops to develop deep and intensive root systems so as to fully exploit the reserves of moisture in top- and subsoils. The three aforementioned strategies – keeping soils covered, addressing subsoil acidity and correcting compaction problems – will prove crucial for ensuring the sustainability of agricultural enterprises in the years to come.

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By Peet van der Walt, on behalf of Pannar Seed (Pty) Ltd

You may have noticed that Pannar has made a slight but significant change to our tagline – from 'Together we farm for **the** future', to 'Together we farm for **your** future'. We believe this better demonstrates our focus on the producer's success and sustainability.

Producers are much valued by all and play a vital role in the prosperity of our country. When we sit down to a delicious meal, it is easy to perceive the role they play in our lives. Yet, upon closer inspection, producers provide more than just sustenance.

Hoopstad-based producer, Pieter Labuschagne, conducting training with his staff, Graham Brink, John Gcogca, Jan Sethibe, Jan Petersen and Paulus Polori, on his farm Robyn Boerdery.

Agriculture as SA's lifeblood

The very life and vitality of South Africa's rural areas are closely linked to the presence of the agricultural sector, which employs and provides income to thousands of people living in these areas. Farming has a marked positive effect on rural economies, and is closely tied to manufacturing, local industries, various services, and tourism and trade.

What's more, the industry influences our economy on an extremely broad basis. It safeguards our food security, strengthens our national economy, has a positive effect on education, training and the development of entrepreneurial potential, while supplying jobs directly and indirectly to a large percentage of our population. These are the many ways in which farming ultimately contributes to the stability and sustainability of our rural areas and towns.

At Pannar, we recognise that the competitive and dynamic farming sector demands growth and support, both upstream and downstream. Farming requires inputs in the form of seed, fertilisers, agrochemicals, animal feeds, agricultural machinery and more, resulting in many of these sectors' dependence on the farming industry for their very survival. Downstream, farming provides outputs that are processed as both food and non-food products. The food chain itself is substantial, reaching from processing to food distribution, food retail and food services – again providing employment to millions of individuals.

The non-food sector covers fibre, construction materials, textiles, wood products, paper and raw materials derived from farm-produced products. These are used in almost every product manufactured today. Thus, farming outputs processed downstream may include packaging, transport, trade and more. Renewable energy production is also becoming increasingly important.

It all comes down to you

Although agriculture's contribution to the gross domestic product is approximately 2,5%, the value chain associated with our farming industry is vast and makes a huge contribution to the country's prosperity. As an industry, it continuously generates new wealth as producers have the skills and science to cultivate the soil and produce crops by utilising air, water, soil and sunshine, and turn these into commodities. It all comes down to you, the producer.

You need to demonstrate enthusiasm, dedication, persistence, resilience and hard work, regardless of what nature and life throw at you. You proudly cultivate the soil, grow crops, and raise livestock to provide work and food for millions. On any given day, you are more than just a producer. You are also a veterinarian, botanist, mechanic, accountant, marketing expert and high-stakes risk manager – not to mention a family member and a friend. You're a respected business person and esteemed individual in your community, lovingly preserving the environment for our future generations.

That's why at Pannar, we are steadfast in our commitment to you, the producer. Together we farm for your future.

For more information, send an email to Peet van der Walt at petrus.walt@pannar.co.za or alternatively, contact Pannar Seed at 033 413 9500 or visit *www.pannar.com*.

Local hybrids have the potential to increase South Africa's sunflower yield

By Dr Safiah Ma'ali, ARC-Grain Crops

Sunflower is one of the most important oilseed crops in the world. Global production grew steadily over the last 25 years and the Food and Agriculture Organization of the United Nations (FAO) estimates that global sunflower production will approach 60 million tons by 2050.

The four largest producers (Russian Federation, Ukraine, European Union and Argentina) account for 70% of global volume, with an exponential growth of production in the Black Sea region during the last decade, due to increased acreage and higher yields achieved by replacing old varieties with certified and higher yielding hybrids.

Global sunflower seed production for 2021/22 is estimated at 57,19 million tons, planted on 28,75 million hectares, with an average yield of 1,99 tons per hectare, sunflower oil at 21,11 million tons, and sunflower meal at 22,57 million tons.

Sunflower production in SA

In South Africa, sunflower seed is the fourth largest grain crop produced after maize, wheat and soya bean. Between 2010/11 and 2020/21, an average of 734 253 tons of sunflower seed were produced annually on an average area of 565 896ha, with an average yield of 1,3t/ha.

Until the early 2000s, South African sunflower seed yields were comfortably on par with the average yields obtained by the four largest producers and exporters of sunflower in the world. Since 2004, however, the area under production has declined and South African yields have not followed the same increasing trend as the rest of the world. In fact, the ten-year world average yield (2011 to 2021) of 1,75t/ha was 35% higher than the ten-year average of 1,3t/ha in South Africa.

In the sunflower national cultivar trials conducted by the Agricultural Research Council's ARC-Grain Crops, a ten-year average yield of 2,24t/ha was achieved, which is 28% higher than the world average and 72% higher than the national sunflower average for the same period. This is a clear indication that local sunflower hybrids do have the genetic potential to produce yields that are in line with or even higher than the global trend.

Under-utilisation of good farming principles such as optimal planting dates, planting density, field selection (soil pH), fertilisation, introduction of advanced sunflower hybrids, environmental factors, and the fact that sunflower is often not the first-choice crop on South African farms are likely contributing factors to this yield gap.

ARC trial results from 2018-2021

To investigate the performance potential of commercially available sunflower hybrids from different seed companies, 16 hybrids were evaluated for seed yield, oil content and oil yield in 21 different environments (sites and years), in the Free State and North West provinces during the 2018/19, 2019/20 and 2020/21 growing seasons.

A randomised, complete block design with three replicates was executed for each site. Seed yield was recorded for each site individually and an analysis of variance (ANOVA) was performed on the yield data of each individual site. Combined analyses of variance were also performed on the pooled annual data. Seed samples were sent to the Southern African Grain Laboratory (SAGL) for oil content analyses. Seed oil yield was calculated by multiplying oil content (%) with seed yield (t/ha).

Results: Seed yield

Seed yield is a complex trait that is influenced by genotype, environmental factors and management practices. Both additive and non-additive genetic effects play a role in the inheritance of seed yield.

Results of this research showed that the average seed yield recorded across the tested hybrids and growing seasons was 2,49t/ha, with 100% of tested hybrids yielding more than 2t/ha. During the 2018/19 growing season, 94% of tested hybrids yielded more than 2t/ha, with an average yield of 2,25t/ha, which varied from 1,98 (SY 3970 CL) to 2,44t/ha (PAN 7080).

During the 2019/20 and 2020/21 growing seasons, 100% of the hybrids again produced more than 2t/ha. During 2019/20, an average yield of 2,55t/ha was achieved, which varied between 2,34 (SY 3970 CL) and 2,68t/ha (PAN 7080). In 2020/22, an average yield of 2,66t/ha was recorded, which ranged between 2,3 (SY 3970 CL) and 2,84t/ha (PAN 7100) (*Figure 1*).

Results: Oil content

Oil content (OC) was predominantly influenced by the hybrid, followed by environmental factors and agricultural practices. Producing sunflower hybrids with a high OC might contribute to enhanced sunflower production in South Africa.

Significant differences in OC (%) were observed between tested hybrids as well as across different environments and growing seasons, with an average moisture-free OC of 42,38%. The highest OC of 51,53% (SY 3970 CL) was recorded during the 2018/19 growing season and the lowest (37,61%) (AGSUN 5106 CLP) in 2019/20.

During the 2018/19 growing season and across hybrids, the moisture-free OC varied from 40,65 to 51,53%, with 50% of the hybrids recording more than 42% OC and 44% recording an OC of more than 44%. In 2019/20, the lowest OC was 37,61% and the highest 50,61%, with 44% of the hybrids having an OC of more than 42% and 19% having an OC of more than 44%.

During 2020/21, the lowest OC was 37,93% and the highest 49,37%, with 50% of the hybrids recording more than 42% OC and 19% more than 44%. Across the three growing seasons, 50% of the tested hybrids produced an OC of more or equal to 42%, and 25% had an OC of more than 44% (*Figure 2*).

These results demonstrate that

Figure 1: Seed yield for 16 sunflower hybrids tested from 2018/19 until 2020/21.

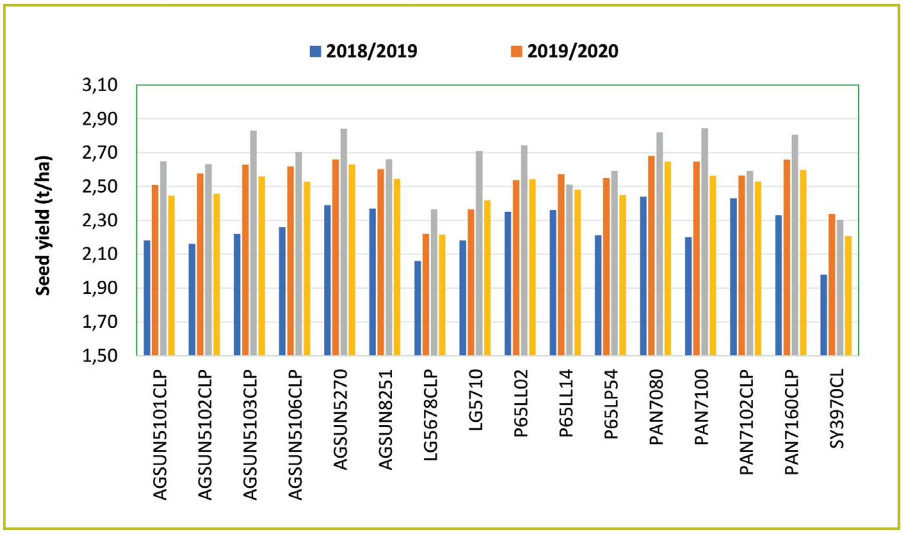


Figure 2: Oil content for 16 sunflower hybrids tested from 2018/19 until 2020/21.

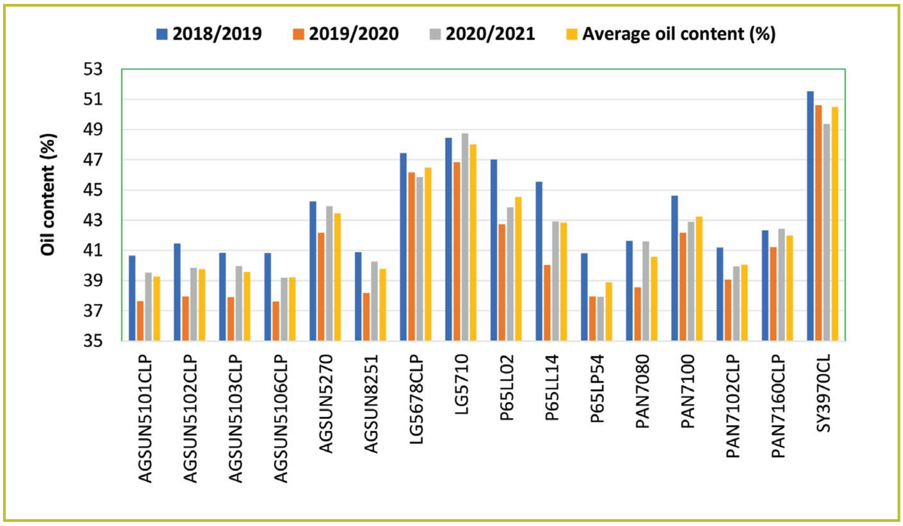
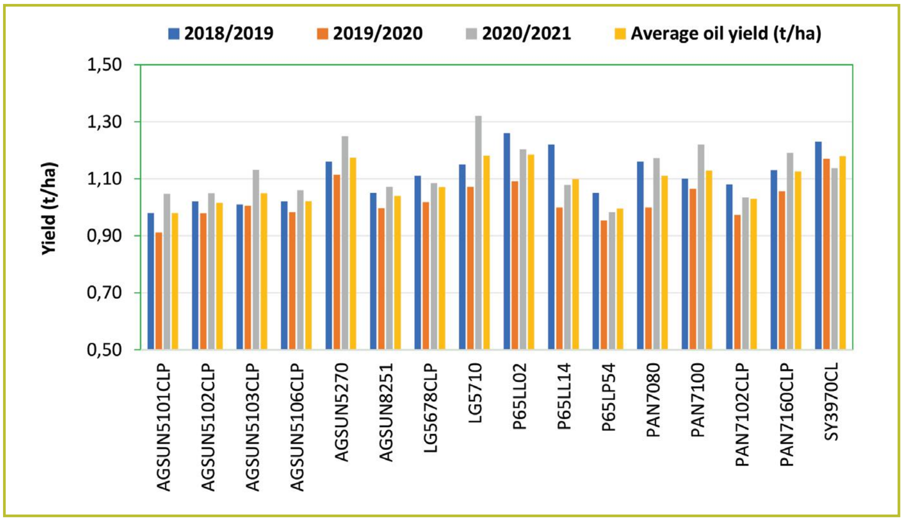


Figure 3: Oil yield for 16 sunflower hybrids tested from 2018/19 until 2020/21.



sunflower OC is not affected only by cultivar selection, but also (often more importantly) by environmental variables and agronomic management practices.

Results: Oil yield

The oil yield per plant is the result of the number of seeds per capitulum, weight per seed, and oil content. These components are determined by genetic factors, although they can be modified by environmental and growth conditions.

Significant differences were recorded among the sunflower hybrids across different localities and during the three growing seasons, with 94% of hybrids having an oil yield of more than 1t/ha. In the 2018/19 growing season, the oil yield ranged from 0,98 (AGSUN 5101 CLP) to 1,26t/ha (P 65 LL 02), with an overall mean of 1,11t/ha.

A total of 94% of hybrids produced an oil yield of more than 1t/ha. During the 2019/20 growing season, the oil yield varied between 0,91 (AGSUN 5101 CLP) and 1,17t/ha (SY 3970 CL), with an overall mean of 1,02t/ha and a total of 69% of hybrids yielding more than 1t/ha.

In 2020/21, the average oil yield was 1,13t/ha, which ranged from 0,98 (P 65 LP 54) to 1,32t/ha (LG 5710), with 94% of hybrids producing more than 1t/ha across environments (*Figure 3*).

Concluding remarks

Cultivar choice and technologies, together with agronomical practices and environmental factors are all important drivers for oil content in sunflower seed. Research conducted by ARC-Grain Crops demonstrated that local sunflower hybrids have the potential to produce moderately higher seed yields with high oil contents, and more importantly, greater than 1t/ha oil yields in the North West and Free State production areas.

The sunflower hybrids that are currently available in the South African market therefore do have the genetic potential to produce higher yields that are more in line with international trends, but producers are yet to tap into their potential.

For more information, send an email to the author at maalis@arc.agric.za.

Seed size and seeding rate effects on canola emergence, development, yield and seed weight

By KN Harker, JT O'Donovan, EG Smith, EN Johnson, G Peng, CJ Willenborg, RH Gulden, R Mohr, KS Gill and LA Grenkow

Canola (*Brassica napus* L.) is the most common dicotyledonous crop in Canada. In 2013, direct-seeded experiments were conducted at nine western Canada locations. Four canola seed sizes (1 000-seed weights ranging from 3,96 to 5,7g) and one unsized treatment (4,4g average) were seeded at two rates (75 and 150 seeds/m). Higher seeding rates led to higher canola emergence and stubble density at harvest.

Higher seeding rates also increased early crop biomass and reduced days to start of flowering and days to crop maturity. Increasing seed size had a positive linear association with early canola biomass and 1 000-seed weights, whereas both days to flowering and days to the end of flowering had a negative linear association with seed size.

Greater biomass from large seeds increases crop competition with weeds and hastens flowering, shortens the flowering period and reduces the risk of canola being exposed to high temperatures, which will negatively impact flowering and pod development.

Canola producers are concerned about the input costs required to grow and protect crop yield potential. Canola seed costs are second only to fertiliser inputs required for canola production. Relatively high seed costs have prompted growers to seed canola at sub-optimal rates.

Crop densities

Recent surveys indicate that approximately half of all western Canada canola growers have crop densities <40 plants/m, but optimal yields require a minimum of 40 plants/m. Furthermore, over a wide range of sites and conditions, only about 50% of planted canola seeds emerge above the soil surface (Harker *et al.*, 2003, 2012a).

In recent years, canola seed size has increased substantially – seed weights greater than 6g x 1 000 seeds are not uncommon. During field experiments from 1995 to 1997, Elliott *et al*. (2008) classed seed ranging from 1,9 to 4g x 1 000 seeds as 'small' to 'large'. 'Very large' seeds ranged from 4,2 to 4,7g x 1 000 seeds.

Canola producers are concerned about the input costs required to grow and protect crop yield potential.

Seed size effects on crop emergence and yield have been inconsistent. Under greenhouse conditions, Hwang *et al*. (2014) showed that mid-size seed (0,7 to 2mm) had a higher emergence rate than smaller or larger seed, but that larger seed led to greater shoot weight and plant height. Under field conditions, the same authors found no seed size effect on canola emergence, but at one of two very low-yielding sites inoculated with *Rhizoctonia solani*, mid-size seed yielded greater than smaller or larger seed.

Using relatively small seeds, Elliott *et al*. (2008) showed consistent increases in canola emergence and yield as seed weight increased. In other studies, seed size did not influence canola emergence or yield (Lamb and Johnson 2004; Clayton *et al.*, 2009).

However, with continual canola improvement and cultivar changes, we felt it necessary to re-examine seed size effects on growth and yield.

We hypothesised that several canola growth, productivity and quality traits would improve as seed size increased. Specifically, we hypothesised that larger seeds would increase canola biomass and reduce compensatory branching within the crop canopy.

Our objective was to determine the effect of two canola seeding rates and a range of relevant seed sizes on crop emergence, growth, yield and quality at nine western Canadian sites. The four different seed sizes were only made available for a single year.

Materials and methods

Direct-seeded (no-till) experiments were conducted at nine western Canadian sites in Alberta, Saskatchewan and Manitoba in 2013. All plots were established in fields previously sown to wheat, barley or oats. Prior to seeding, an application of glyphosate (900g of acid equivalent per hectare) was applied to the entire plot area to control weeds. Soil samples were collected at each site before seeding and analysed for available soil nutrients. Based on soil analyses, fertiliser additions were made to achieve 100% of the soil test recommendations for each site.

Yield targets varied from 2 800 to 3 900kg per hectare at different sites. Most fertiliser was side-banded 2cm beside and 3 to 4cm below the seed row, with small amounts of nitrogen and phosphorus also placed with crop seeds.

The experimental design was a randomised complete block design with four replications. A factorial arrangement of treatments (5x2) was imposed with four canola seed size treatments (average 1 000 seed weights: 3,96; 4,6; 4,8; 5,7g) and one unsized treatment (4,4g) seeded at 75 or 150 seeds/m. The seed was treated prior to seed size segregation.

One or two in-crop applications of glyphosate at 450g of acid equivalent (ae) per hectare were applied as required to control local weed populations. Fungicides and insecticides were applied as needed, according to local disease and pest insect infestations. Data collection included crop emergence density, crop biomass at the six-leaf stage, days to start and end of flowering, days to maturity, canola yield and productive plant stubble density.

Seeding rate effects

Seeding rate did not interact with seed size for any dependent variable (P ≥ 0,2031) (*Table 1*). Canola seeding rate influenced most dependent variables (*Table 2*). Similar to the results of Kutcher *et al*. (2013), a higher seeding rate did not increase canola yield (P = 0,1360).

Despite significant site x seeding rate interactions for both variables, all individual site data were in complete compliance with the all-site means. Emergence percentage was 55% for both seeding rates. In a previous study, canola seeded at a depth of 1cm had 45% emergence (Harker *et al.*, 2012a).

Canola biomass at the six-leaf stage increased with the higher seeding rate (150 seeds/m) (*Table 2*). Results from seven of nine sites supported the seeding rate effect on biomass. The two remaining sites were not statistically significant. Seeding rates leading to higher crop biomass help to rapidly close the crop canopy and facilitate integrated weed management strategies (Blackshaw *et al.*, 2008) that delay weed resistance to herbicides (O'Donovan *et al.*, 2007).

The higher canola seeding rate (150 seeds/m) also increased 1 000-seed weight and seed oil content. The latter seeding rate effects were not significant at most individual sites, but no sites demonstrated a contrary effect. Seed weight is an important yield component for canola productivity. Greater crop biomass from the higher seeding rate probably reduced compensatory growth (McGregor 1987; Angadi *et al.*, 2003), and the number of smaller, less mature seeds. Similarly, oil content is increased in larger, more mature seeds.

The higher canola seeding rate reduced days to the start of flowering and days to maturity, with a trend (P = 0,0514) to reduce days to the end of flowering (*Table 2*). Greater plant biomass and intraspecific competition from the high seeding rate probably reduced compensatory growth and hastened flowering and maturity. Although the differences in flowering and maturity were small, they could have large impacts on canola yield and quality.

Earlier flowering and maturity increase the probability that canola will avoid relatively high temperatures that reduce canola yield potential. Similarly, earlier maturity can reduce the likelihood of frost damage and subsequent yield and green seed-related quality reductions.

Seed size effects

Yield is usually the most important response variable in agronomic experiments. Even though there were no significant regression contrasts for canola yield versus seed size with sites treated as a random effect (P ≥ 0,2249), it remains useful to observe individual site effects and variability.

Site-to-site yield variability was dramatic. Yields at the highest yielding site were approximately threefold greater than the lowest yielding site. The site-by-seed size interaction for yield was highly significant (P = 0,0010). Excluding only one site, there were no significant

Table 1: The statistical significance of treatment and site sources of variation, including regression contrasts for dependent variables.

Source	Dependent variables										
	Emergence density (nr m^{-2})	Crop biomass (kg per ha^{-1})	Start of flowering (days)	End of flowering (days)	Crop maturity (days)	Yield (kg per ha^{-1})	Stubble density (nr m^{-2})	1 000-seed weight (g)	Green seed (%)	Oil content (%)	Protein content (%)
Seed rate (R)	<0,0001	0,0019	0,0398	0,0514	0,0094	0,1360	<0,0001	0,0405	0,3577	0,0001	0,0006
Seed size (S)	0,4656	0,0005	0,0038	0,0828	0,5727	0,4491	0,1942	0,0561	0,3244	0,9454	0,9527
R x S	0,6462	0,4434	0,5074	0,4350	0,2031	0,8650	0,6456	0,5756	0,4777	0,7417	0,6189
Site	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001
Site x R	0,0230	<0,0001	<0,0001	<0,0001	<0,0001	<0,0001	0,0430	0,0935	<0,0001	0,9449	0,9672
Site x S	0,0006	<0,0001	0,9130	0,0003	0,0957	0,0001	0,7779	0,8475	0,0843	0,9939	0,9872
Site x R x S	0,9408	0,9841	1,000	0,0014	0,1454	0,9895	0,7687	0,9621	0,0085	0,9863	0,9979
Regression contrasts for seed size (S)											
Linear	0,6588	0,0003	0,0003	0,0171	0,2463	0,2249	0,1799	0,0089	0,1775	0,6589	0,7135
Quadratic	0,3567	0,1381	0,7770	0,4303	0,8163	0,6833	0,5295	0,5555	0,7269	0,9086	0,7381
Cubic	0,6479	0,1740	0,9651	0,8062	0,7145	0,4062	0,7029	0,6541	0,5225	0,8370	0,8409

Table 2: Dependent variable means across sites and the site by seeding rate interaction for two canola seeding rates.

Variable[z]	Seeding rate (seeds m^{-2})		Site by seeding interaction	
	75	150	F test *P* value	Compliance[y]
Emergence density (nr m^{-2})	41	**83**	0,0415	9, 0, 0
Crop biomass (kg per ha^{-1})	587	**848**	<0,0001	7, 2, 0
Start of flowering (days)	46,4	**45,8**	<0,0001	5, 4, 0
End of flowering (days)	62,8	61,9	<0,0001	5, 4, 0
Crop maturity (days)	102,7	**100,9**	<0,0001	7, 2, 0
Yield (kg per ha^{-1})	2 880	2 950	0,0094	1, 7, 1
Stubble density (nr m^{-2})	35	**67**	<0,0001	9, 0, 0
1 000-seed weight (g)	3,94	**4,02**	0,0672	3, 6, 0
Green seed (%)	2,0	1,4	<0,0001	1, 8, 0
Oil content (%)	46,0	**46,5**	0,8538	4, 5, 0
Protein content (%)	20,8	**20,3**	0,8361	2, 7, 0

[z]Within each dependent variable, significantly different (P < 0,05) means for the 150 vs 75 seeds m^{-2} rate are in bold. [y]The first value is the number of sites (nine in total) with statistically different means in the same pattern as the across-site mean difference. The second value is the number of sites where seeding rate was not statistically significant (P ≥ 0,05). The third value is the number of sites with statistically different means in a pattern opposite to the across-site mean difference.

regressions for seed size versus yield. Given these data, we reject our hypothesis that canola seed size would influence yield.

Four dependent variables (shoot biomass, days to flowering, days to end of flowering and 1 000-seed weight) had a significant linear association with canola seed size. Early canola biomass increased linearly as canola seed size increased. Only one individual site had a similar significant contrast. A single degree of freedom contrast confirmed significantly greater crop biomass when the largest seed size (5,7g x 1 000 seeds) was compared with the unsized seed (P = 0,0009).

Higher canola biomass early in the growing season is probably the best indication of plant vigour. The vigour index developed by Elliot *et al*. (2005) combined seed weight and germination; that index was strongly correlated with shoot biomass. Early plant vigour is important relative to establishing a plant canopy that can optimise photosynthetic radiation capture and carbon fixation.

In addition, Pavlychenko and Harrington (1934) showed that the final competitive outcome between crops and weeds is disproportionately influenced by competition at early growth stages. Furthermore, greater biomass increases intraspecific competition and thereby reduces compensatory branching, which could hasten flowering and reduce the overall flowering period.

The flowering time difference from the smallest to the largest seed size category was only about one day, but every day that canola growers can avoid high temperatures during the flowering period is important. These effects on flowering are probably associated with greater canola biomass with larger canola seeds. Lamb and Johnson (2004) did not detect canola seed size impacts on canola flowering or maturity timing. In accordance with the current study, Clayton *et al*. (2009) also failed to detect seed size effects on canola maturity.

Harvested canola seed size increased linearly as planted canola seed size increased. A similar significant effect was detected at only one individual site. Here, as well as for the canola biomass data, it is apparent that the additional statistical power gained by treating sites as a random effect prevented a Type II error. A single degree of freedom contrast confirmed significantly greater harvested seed weight when the largest seed size (5,7g) was compared with the unsized seed (P = 0,0064).

It would seem reasonable that plants growing from larger seeds would also produce larger seeds. Elliott *et al*. (2008) also demonstrated that harvested canola seed had higher seed weights after larger seeds were planted. It is also reasonable to assume that if greater crop biomass from larger seeds reduces compensatory growth, it could also reduce the number of smaller, less-mature seeds at harvest. In other studies, planted seed size did not influence harvested seed weights (Lamb and Johnson 2004; Clayton *et al*., 2009).

Large canola seed has both advantages and disadvantages. One advantage is that seedlings from larger seeds are less susceptible to flea beetle (*Phyllotreta cruciferae* [*Goeze*]) damage (Bodnaryk and Lamb 1991; Elliott *et al*., 2008).

One disadvantage of large seeds is that, given the lack of an emergence benefit, increased weight and cost of large seeds are required to achieve the same plant population compared with when smaller seeds are planted. As seed costs increase, growers are pressured to reduce seeding rates; the combined effect of reduced seeding rates and the trend for larger seeds can threaten canola yield potential.

Conclusion

Increasing the canola seeding rate from 75 to 150 seeds/m did not increase canola yield. As expected, higher canola seeding rates increased early crop biomass. Higher seeding rates also increased 1 000-seed weights and seed oil content, and reduced days to start of flowering and days to crop maturity. Neither canola emergence nor yields were influenced by canola seed size.

Increasing seed size had a positive linear association with early canola biomass and 1 000-seed weights. Days to flowering and days to the end of flowering had a negative linear association with seed size. Greater biomass from large seeds increases crop competition with weeds and hastens flowering, shortens the flowering period and reduces the risk that canola will be exposed to high temperatures.

The negative effect of current grower trends to reduce or even maintain the same weight per unit area seeding rates is exacerbated by the fact that canola seed size is generally increasing. Failure to consider seed numbers for a given weight of seed may threaten canola yield potential.

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Breeding strategies for the improvement of sunflower

By Saeed Rauf, University of Sargodha

Sunflower is well known as an important oilseed crop and has been subjected to improvement by plant breeders, resulting in the yellow revolution in many countries. Russian plant breeders improved the oil contents of sunflower converting this crop from a roadside plant to a world-famous oilseed crop.

The cultivated germ plasm retained 50% of genetic diversity present in wild relatives. This may be threatened due to worldwide hybrid cultivation (*Table 1*) which share common parentage and sources of cytoplasmic male sterility. There is thus a need to use the available genetic diversity within cultivated and wild germ plasm, to develop pre-breeding lines and elite breeding material with good combining ability.

Sunflower breeding revolves around the development of breeding lines suitable for hybrid breeding, diseases, abiotic stress and herbicide resistance. These objectives were fulfilled by recurrent selection for population improvement.

Wide crosses were made to transfer cytoplasmic male sterility, diseases, abiotic and orobranchial resistance. Moreover, induced mutations were used to induce new genetic variability for diseases and herbicide resistance, and reduction of plant height. Marker-assisted selection has been validated for rust resistance, downy mildew resistance, oleic acid contents and fertility restorer genes.

Breeding objectives

Hybrid breeding

The hybrid vigour and heterozygous genetic base of hybrids allow them to show better yield even under stress conditions. The superior performance of hybrids in several studies, were due to the manifestation of heterosis.

Heterosis is defined as the superiority of F1 over the mid-parent value or better performance of F1 over the superior parent or best commercial variety. Heterosis is manifested due to genetic divergence of the parents, and superior combining ability of both parents causing the combination of diverse alleles in a single genotype. There was a positive relationship between genetic distance and best parent heterosis (Hladni *et al*., 2018).

In contrast to the open pollinated varieties (OPVs), which only exploited additive gene action for the improvement of plant traits, the performance of a hybrid is dependent on both additive and non-additive gene action. Some of the plant traits such as oil content, days to maturity, biotic or abiotic factors are fixed during the inbred line development through pedigree selection, and may be controlled through additive alleles.

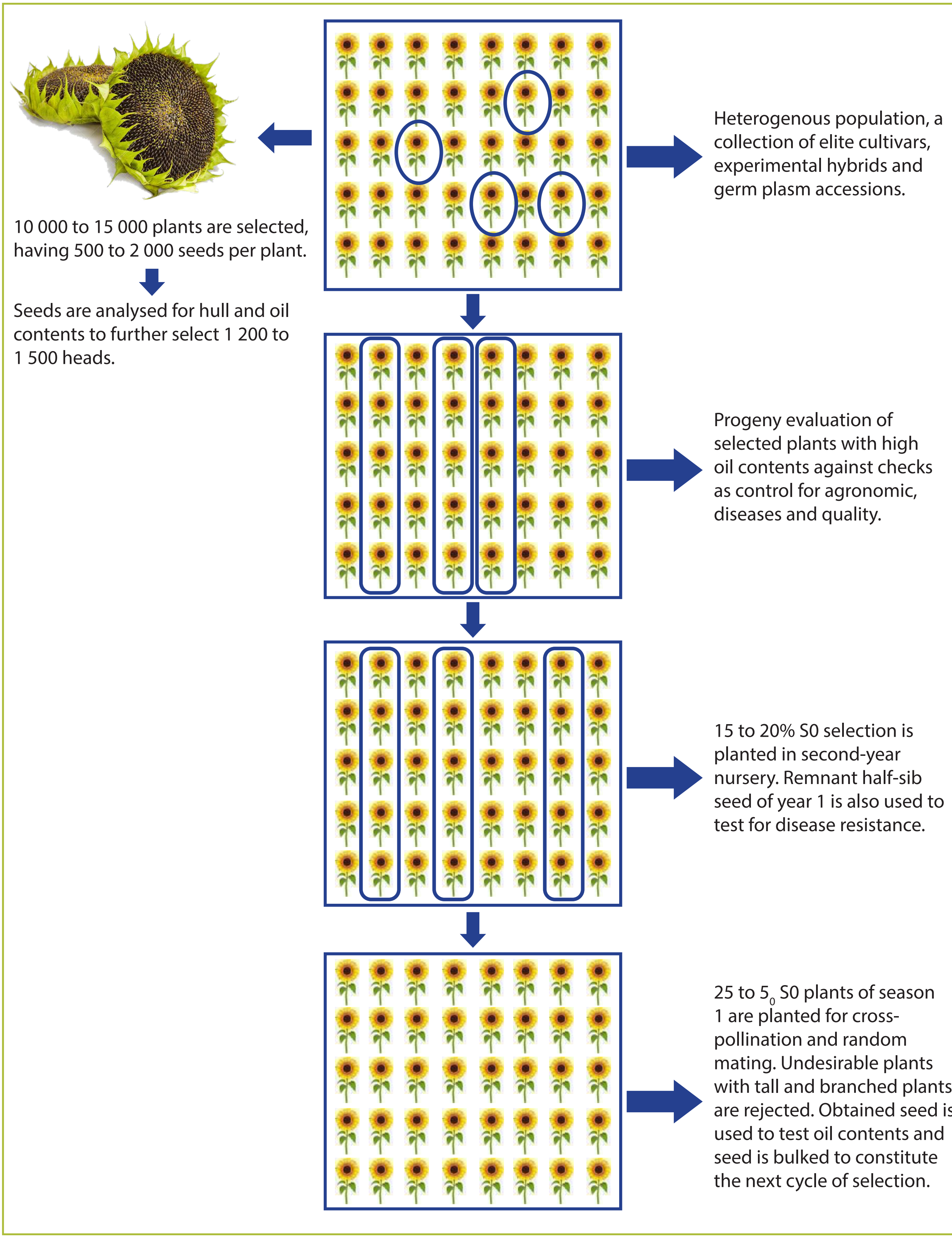
Allelic or non-allelic interaction may be broken to release additive alleles through recurrent selection. However, the grain yield potential of hybrids is based on over-dominance, a genetic phenomenon in which deviation from mid-parents' value greatly exceeds to both parents.

Hybrid seed production in sunflower is done using a cytoplasmic male-sterile female line and fertility restorer male

Table 1: Worldwide examples of sunflower germ plasm resource collections.

Institute	Collection
United States Department of Agriculture	4 087 accessions: 1 886 cultivated, 2 201 wild accessions.
French National Institute for Agricultural Research Occitanie-Toulouse, France	5 576 cultivated accessions, >500 wild ecotypes.
The Indian Institute of Oilseeds Research, India	3 273 accessions: 1 200 exotic lines, 97 genetic stocks, 360 inbred lines, 42 wild species and 154 wild species derivatives (Dudhe and Sujatha, 2016).
The Vavilov Research Institute of Plant Industry, Russia	2 230 cultivated sunflowers and 550 wild accessions (Gavrilova *et al*., 2014).
Chinese Academy of Agricultural Sciences Youliao Institute	2 813 accessions: predominantly cultivated (Gao *et al*., 2001).
The Institute of Field and Vegetable Crops, Novi Sad, Serbia	Several thousand lines (S Terzic, personal communication, 2016), wild sunflower collection of just over 1 000 accessions of 47 wild species, (Atlagić and Terzić, 2015).

Figure 1: Procedure for Pustovoit's famous 'method of reserve' to develop high oil contents progenies.



The diversity in ray and disc floret colour of sunflower. (A) Crimson red ray floret with brown disc floret. (B) Yellow with crimson red pattern ray floret with purple disc floret. (C) Yellow wide ray floret with yellow disc floret. (D) Yellow narrow ray floret with green disc floret. (E) Yellow ray florets with purple disc floret. (F) Crimson red with yellow tip ray floret and purple disc florets. (Photographs: Saeed Rauf)

line at a ratio of 4:2, and pollination is facilitated through honeybee hives (Greenleaf and Kremen, 2006).

Oil content

The improvement of oil content is a major objective of sunflower breeding. Oil content entails quantitative inheritance traits and genetic variation was affected by additive genes. Oil content has ranged from 30 to more than 50% and has shown tremendous improvement due to selection by plant breeders.

Historically, oil content was subjected to improvement during the earlier part of the 19th century through a method of seed reserve proposed by Pustovoit (*Figure 1*), which led to the development of high oil content lines. Seed morphological traits such as embryo size and testa thickness were important traits affecting oil contents. Smaller seed size with larger embryo and thin testa gave higher oil recovery (Rauf *et al*., 2017).

Improvement in oil content occurred due to higher kernel-to-achene ratios (Pereira *et al*., 2000). Oil content accumulation was not constant during the grain-filling period. Oil content accumulation rate was slower after anthesis but increased over time and became constant during the physiological maturity (Rondanini *et al.*, 2003).

Oil concentration was also dependent on the size and concentration of oil bodies. However, high oil content lines had a high concentration of oil bodies rather than larger oil bodies. Oil bodies are the storehouse of triglyceride containing a single layer of phospholipid, which is made intact through oleosins and caleosins proteins (Murphy, 2001). The range of oil body diameter was 0,65 to 2µm in various crop species, including sunflower.

The accumulation rate of oil bodies was negatively affected by the protein contents. However, oil content is significantly affected by the environment, and medium heritability (0,57) of the trait was estimated over multiple environments (Mokrani *et al.*, 2002). Several QTLs (quantitative trait loci) have been identified on various linkage groups for seed oil contents. These QTLs had additive to dominant effects and were closely related to domesticated traits in sunflower (Leon *et al*., 2001; Burke *et al*., 2005).

Rust resistance

Rust caused by Puccinia helianthi Schwein is one of the major factors affecting yield and quality of sunflower seed. It causes a reduction in the green leaf area which reduces the overall assimilation of photosynthates and translocation. It also causes a reduction in the seed weight, size and oil content.

Rust thrives in warm and humid conditions, and fungicides can be used to control the disease, but this method is expensive and challenging. Therefore, incorporating rust resistance in inbred lines is the preferred method to control this disease.

Several rust-resistant genes (R1, R2, R4u, R5, R12, R13a and RHAR6) were identified in various breeding lines, varieties and restorers. A single source of resistance is not sufficient due to the emergence of virulent races which may defeat a single source of resistance in sunflowers. Molecular markers have been developed to stake these genes in single genotypes which increase durability and the spectrum of resistance (Paniego *et al*., 2012).

Two genes were recently identified in HA-R6 and RHA-397 which provide resistance against all virulent races of rust. Pedigree and marker assisted selection was carried out to develop two inbred lines (HA-R12 and HA-R13), which contained multiple rust-resistant genes. HA-R12 contained the rust-resistant (R) genes, R2 from MC29 (AUS) and R13a from HA-R6. HA-R13 contained R5 from HA-R2 and R13a from HA-R6.

Application rust-specific markers confirmed that HA-R12 and HA-R13 contained two rust-resistance genes in the homozygous condition, with both lines showing high levels of resistance to rust races 336 and 777, which are the most virulent races (Ma *et al*., 2016).

Heat stress

Global warming has caused a rapid rise in air temperature. Higher temperatures cause increased leaf senescence, early maturity or premature phenological development due to higher accumulation of heat units in plants (Kalyar *et al*., 2013). It causes higher gametophytic sterility and reduces grain filling. It also accelerates the impact of other stresses such as water and salinity.

Sunflower showed the highest growth at 27°C, and temperatures higher than 30°C were unknown to induce temperature stress. Plant phenological traits such as downward head position and erect leaves reduced pollen sterility and lower canopy temperature. Both traits were selectable in segregating populations and had medium-realised heritability (Kalyar *et al*., 2013).

Breeding methods

Conventional breeding procedures

Sunflower is a cross-pollinated species and all breeding methods of cross-pollinated species such as recurrent selection methods, are applicable for the population improvement programme. However, pure line selection methods are applicable for the development of inbred lines with the additional step of combining ability analysis of inbred lines. The backcross method is used to intogress disease-resistant or monogenic traits.

Inbred line development

Superior inbred lines are obtained by crossing appropriate breeding lines such as crossing disease-resistant or drought-tolerant inbred lines with highly fertile, high oil content and early maturing lines. Disease-resistant or drought-tolerant lines are generally developed from interspecific crosses, which are poor in agronomic characteristics such as high plant height, low oil content and late maturing (Hussain *et al*., 2017; Shehbaz *et al*., 2018).

Resistant genes may be transferred to the elite lines through backcross methods, or segregating populations may be developed for the pedigree selection in subsequent generations (Shehbaz *et al*., 2018). Pedigree selection was generally carried out for traits having high additive genetic variance (Kalyar *et al*., 2013a).

Heritability in the narrow sense or realised heritability are indicators of a selection response. Oil quality traits such as tocopherols and oleic acid contents have been transferred in elite germ plasm through a backcross scheme (Jonic *et al*., 2000).

Traits such as oil content may have been subjected to the pedigree selection for the development of high oil content inbred lines. Generally, five to six rounds of selection (F2 to F6) are sufficient for improvement and fixation of characteristics in inbred lines. Traits related to heat resistance such as downward head orientation at the time of anthesis, have been used as selection marker for the development of heat resistant inbred lines (Kalyar *et al*., 2013a). These selections led to the development of some superior heat resistant hybrids (Khan *et al*., 2017).

Morphological traits such as lower leaf area and cuticular waxes have been used as marker traits for the selection of drought tolerant inbred lines in segregating generations (Hussain *et al*., 2017; Hussian *et al*., 2018).

Combining ability analyses

This is an important step in the evaluation of sunflower breeding lines for their performance in hybrid breeding. Combining ability is the ability of a breeding line to produce the superior progeny upon crossing with testers. A tester may be underperforming if the aim is to uncover deleterious or recessive alleles carried by the female lines (Kalyar *et al*., 2013b). However, superior lines may be crossed to determine the best specific combiners or cross combination, which could be used for the development of high performing hybrids (Khan *et al*., 2018).

In vitro techniques

Sunflower inbred line development requires six cycles of self-pollination and three to four years to achieve homozygosity. It would further take one more year to test the combining ability of the developed homozygous lines. In vitro or in vivo (doubled haploid inducer lines) methods of haploid line development can reduce the time required to achieve homozygosity.

Once the protocol for the development of haploid line is optimised, the required homozygosity can be achieved in a single year. The anthers collected between the dyad and tetrad stages were found to be more responsive for the haploid induction in sunflower. Anthers that were pre-treated with high temperature treatment (35°C) for twelve days were found to be more successful.

Generally, half-strength, medium supplemented with vitamins of Morel and Wetmore with vitamin B12 and a mixture of amino acids, 120g L-1glucose, pH 5,9 plus 0,5g L-1 naphthalene acetic acid, and benzene amino purine, were considered for haploid plant regeneration from anthers culture (Mezzarobba and Jonard, 1986).

A sunflower embryo rescue technique has been used to excise interspecific embryo and to culture over the growth media after excision from the developing embryo. Seven-day old embryos (*Helianthus annuus* × *Helianthus mollis*) were excised from mother plants and were inoculated over the Murashige and Skoog (MS) media (Faure *et al*., 2002).

In vitro multiplication through nodal culture of interspecific hybrid (*H. annuus* × *H. simulans*) was done on MS media supplemented with 0,5mg L-1 benzyladenine (Prabakaran and Sujatha, 2004). Immature embryo cultures were done to shorten the life cycle and subsequent generation advancement of the crosses. Embryos were excised after ten days post-pollination and inoculated over simple MS media (Dagustu *et al*., 2010).

Most of the cultured embryos were regenerated into vigorous seedlings with three to six leaves (Dagustu *et al*., 2010). In vitro screening for drought tolerance was carried out on half-strength MS media supplemented with osmotic 5% polyethylene glycol (PEG-8 000) to reduce the osmotic potential of the media (Khalil *et al*., 2016).

An amphidiploid between cultivated and perennial wild sunflower was regenerated through somatic embryogenesis (Fu *et al*., 2017). Somatic embryogenesis has been optimised using various formulations and concentration of media and growth regulators along with immature embryo size (Sujatha and Prabakaran, 2001).

The highest induction of somatic embryogenesis occurred at Gamborg basal salt media (120 to 210g L–1) sucrose, 0,8 to 1% agar, smaller-sized embryos (0,5 to 2mm) and at incubation temperature of 28 to 32°C.

Growth regulators such as 2,4-D promoted direct embryogenesis, BA+NAA facilitated formation of single/multiple shoots, while there was no response on 2,4-D+kinetin SM (Sujatha and Prabakaran, 2001).

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Increasing yield potential, Resource efficiency and Productivity with INTACTA Round Up Ready 2 Pro

The introduction of INTACTA RR2 PRO® brings a new choice in insect control and convenience to farmers; increasing productivity, efficiency and value - leading to yields of higher quality and quantity.

How can INTACTA RR2 PRO technology benefit your farm?

INTACTA RR2 PRO technology holds three key benefits that make this trait combination stand out in the market:

- PROTECTION against major pests that attack soybeans like African bollworm (Helicoverpa armigera)
- Increased yield potential through repositioned herbicide trait on the soybean DNA to MAXIMISE yield
- IMPROVED tolerance to glyphosate herbicide provided by Round Up Ready 2 (RR2) Technology.

What is African Bollworm and why is it so important to control it?

The African Bollworm, Helicoverpa armigera, is a lepidopteran insect pest capable of causing significant economic losses for growers if left unchecked. It is a polyphagous insect pest meaning that it is able to feed on a whole host of plant species and can cause significant damage in cultivated crops. Besides the obvious yield losses through direct feeding on the pods, secondary infections by opportunistic fungi and bacteria can take place. These secondary infections can significantly reduce the quality of the harvested soybeans and ultimately lead to further economic woes for the farmer. Controlling these insect pests effectively will lead to yields of higher quantity and quality.

PROTECTION against major pests that attack soybeans like African bollworm (*Helicoverpa armigera*)

One of the main benefits of INTACTA RR2 Pro technology is the protection against one of the most devastating insect pests in soybean production, the African Bollworm.

How does INTACTA RR2 PRO technology offer protection?

- Resistance to African Bollworm is conferred through a *Bt* protein produced in INTACTA RR2 Pro Soybeans. The Cry1Ac *Bt* protein is highly efficacious against the African Bollworm
- The larval stage of the African Bollworm feeds on the INTACTA RR2 Pro soybeans, ingesting the *Bt* protein
- The larvae stop feeding and die within 72 hours.

Increased yield potential through repositioned herbicide trait on the soybean DNA to MAXIMISE yield

INTACTA RR2 Pro technology is helping farmers increase their yield potential by allowing farmers to farm more efficiently, sustainably and ultimately more profitably. Through extensive research on a molecular level, the Round up Ready 2 gene was placed precisely in a region of the soybean's DNA, resulting in a positive impact in the yield performance.

A number of key factors contribute to this increase in yield potential:

- This higher yield potential is a direct result of the repositioning of the glyphosate-tolerance trait on the DNA of the soybean
- Protection from devastating yield losses caused by African Bollworm feeding through the introduction of the *Bt* gene
- Increased efficiency through a reduction in the number of applications of insecticides to the soybean crop.

IMPROVED tolerance to glyphosate herbicide provided by Round Up Ready 2 (RR2) Technology

The improved tolerance to glyphosate is a crucial benefit in INTACTA RR2 Soybeans. The insertion of this gene allows farmers to control weeds consistently and effectively right from the very start. Keeping soybean fields weed-free is crucial to prevent competition from weeds which rob the soybeans of important nutrients, water and sunlight.

What is a refuge area and why is it so important?

A refuge area is a vital tool in insect-resistance management and protecting this technology for years to come. A refuge area is a portion of the farm or field which is not planted with *Bt* technology so that a portion of the African Bollworm population is never exposed to this technology and remain susceptible. Refuge should be planted according to the minimum recommendations indicated for soybean which is 20% of the total planted area.

It is important that farmers still carry out constant monitoring and use the additional measures of Integrated Pest Management (MIP) to ensure the efficacy of the trait.

With Bayer's new soybean trait INTACTA Round up Ready 2 PRO®, we are breaking ground and opening a world of possibilities for your farm, providing benefits that will help you improve productivity, resource efficiency and yield potential – helping you farm more sustainably and grow more with less.

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Key decisions and actions in weed management prior to establishing the next crop

By Prof Charlie Reinhardt, North-West University

In order to prevent seed production by weed survivors, the final pest management action performed on crop fields should be weed control. Late-season seed production by weeds is a consequence of plants either having survived earlier control measures or late-germinating seeds which remained dormant in the soil seedbank. *Amaranthus* (pigweed) species and *Ipomoea purpurea* (morning glory) are examples of weeds that display periodic germination throughout the summer growing season.

Weed seed dormancy could mean that recently emerged seedlings sprouted from seeds that remained dormant in soil for several months or even years. Unlike other pests, weeds represent a more stable threat at specific locations due to the longevity of their seeds.

Herbicide tolerance and control

Weeds that survive at the end of the growing season in annual crop systems, could also result from a genetic predisposition that renders certain species tolerant or resistant to specific herbicides. When chemical selection pressure is high due to the use of high dosages at a high frequency of a single herbicide mechanism of action, the few individuals in a weed population that are naturally endowed with herbicide resistance will perform better in the absence of individuals that succumbed to the herbicide.

Consequently, individuals of the herbicide resistant biotype will likely produce more seeds than they would have in the presence of the herbicide susceptible biotype. If this herbicide selection pressure situation remains unchanged for three to five years, the resistant biotype in a weed population will eventually dominate in numbers, resulting in poorer weed control and increasing yield loss.

Weed control strategies to mitigate existing herbicide resistance are well proven; they depend on the use of more than one herbicide mode of action in a season, integration of control methods (chemical, mechanical, biological or cultural), and zero tolerance to weed seed production. Proactive implementation of such a strategy is considered superior practice.

Weed growth during fallow periods

Weeds that only grow during the fallow period, meaning autumn/winter in a summer rainfall region, such as *Senecio consanguineus* (ragwort), might not compete directly with a summer crop. They do, however, withdraw precious water and nutrients from soil, creating a greater need for inputs such as rain, irrigation and fertiliser.

> Obviously, for the CPWC measurement to be reliable for a particular scenario, considerable research efforts are required.

The *Conyza* (fleabane) species, notably *C. bonariensis* (hairy fleabane) and *C. sumatrensis* (tall fleabane), can establish late in summer, as well as through autumn and winter, and persist into the following summer season where they compete with the crop for growth factors. Both fleabane types thrive in zero-tillage systems since optimal seed germination requires that seeds occur in soil at depths less than 5mm.

Weeds and below ground biomass

Weeds that grow for several years rarely attain problem status on fields where mechanical weed control is an option, since perennial weeds typically prefer a stable soil environment (zero- or minimum-tillage systems). Perennial weeds with an extremely well-developed root and underground stem system (rhizome) are particularly tolerant to herbicides in zero-tillage systems, which promote the proliferation of below ground plant parts.

Substantial below ground biomass of weeds dilutes herbicides applied to the foliage, reducing efficacy such as in the case of glyphosate, of which the activity depends on foliar absorption. Another stubborn weed in both zero-tillage and conventional systems is *Commelina benghalensis* (wandering yew), which has an annual life cycle. Other important annual weeds with substantial below ground biomass that hamper effective control are *Cyperus esculentus* (yellow nutsedge) and *C. rotundus* (purple nutsedge).

Figure 1: The period (time T_0 to T_1) during which weeds can be tolerated in the crop before weed interference reduces crop yield.

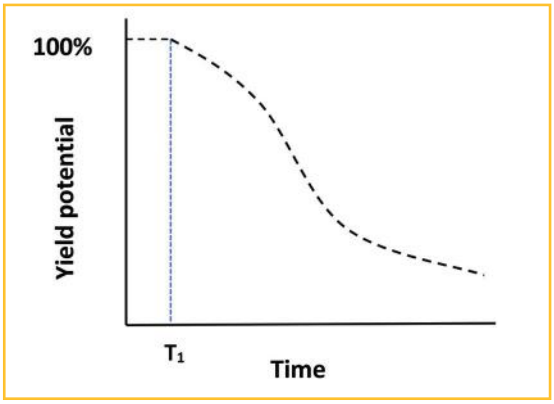


Figure 2: The period (time T_0 to T_2) during which weeds must be controlled to attain maximum crop yield potential.

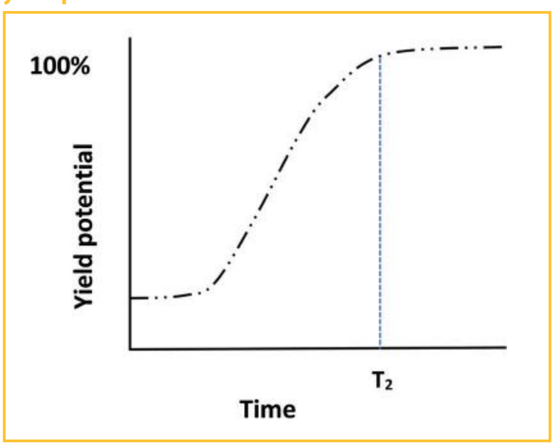
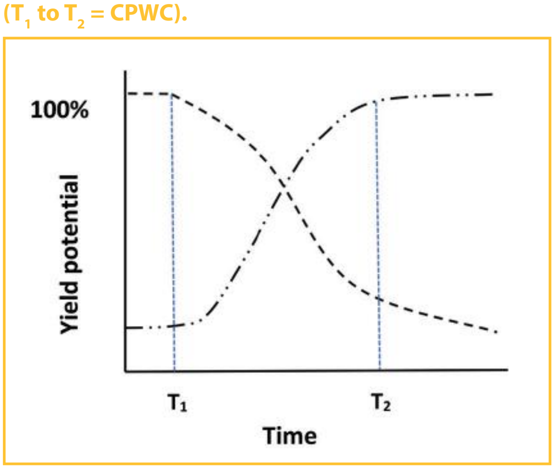


Figure 3: The critical period for weed control (T_1 to T_2 = CPWC).



Perennial weed types and/or weeds with well-developed below ground root and rhizome systems can best be controlled with herbicides before they emerge or when they are seedlings. Generally, far too little attention is given to herbicide label recommendations on ideal weed growth stages for effective control.

Double-knock concept

The 'double-knock' approach to herbicide use was first adopted in Australia. The practice requires the in-tandem use of glyphosate and parakwat – the two cannot be mixed because of chemical antagonism. Glyphosate is always applied first, and survivors are then treated with parakwat.

This is because glyphosate is fully systemic and parakwat is not, meaning parakwat is a 'contact' herbicide with a mainly localised scorch effect, whereas glyphosate is translocated to all plant parts after absorption by foliage. The efficacy of glyphosate will be compromised if it is applied after parakwat because the lesions caused by parakwat will impede the absorption and translocation of glyphosate.

Because both glyphosate and parakwat are non-selective herbicides, meaning all plant species are susceptible, excluding glyphosate-tolerant crops, the 'double-knock' approach can only be used pre-plant or pre-emergence. In soil, both glyphosate and parakwat have negligible to zero herbicidal activity, and zero persistence – parakwat is rapidly inactivated by exceptionally strong adsorption to negatively charged soil colloids, and glyphosate is rapidly degraded by soil microbes.

A 'precision agriculture' tool

To the best of my knowledge, a 'precision agriculture' tool for weed management is not formally applied in South Africa but is popular in America. The concept is based on weed science principles related to weed-crop interactions. Actually, South African farmers intuitively apply the principles of a critical period for weed control (CPWC), based on their local (on-farm) experience that certain weeds can be tolerated to a certain degree in crops grown under certain conditions.

A leading proponent of CPWC in America, Dr Stevan Knezevic, defines CPWC as "a window in the crop life cycle during which weeds must be controlled to prevent unacceptable yield losses". The CPWC represents the interval between two separately measured crop-weed competition components, as seen in *Figures 1* and *2*, respectively.

Figure 1 explains that weeds can be tolerated in a crop for only a short period, typically early in the season when numbers are lowest, and seedlings dominate at a time when there are usually adequate growth factors available to meet the needs of both crop and weeds. *Figure 2* explains that crop yield is positively correlated with the period during which weeds are controlled – the shorter the period, the lower the crop yield, and to obtain optimum crop yield, weeds must be controlled for as long as possible during the crop's life cycle.

The overlaid *Figure 3* enables determination of the CPWC; in other words, the period during which weeds must be controlled in a specific setting of weed community, crop type and cultivar, plus environmental conditions. Obviously, for the CPWC measurement to be reliable for a particular scenario, considerable research efforts are required.

We should strive to improve current over-simplified perceptions. The CPWC is but one concept linked to 'precision agriculture', and we should not shy away from applying such tools despite the considerable commitment in time and money required. Are South African farmers, organised agriculture, and associated industry up to the task?

Prof Charlie Reinhardt is a professor in the agricultural sciences programme at North-West University (Potchefstroom campus) and research leader in the South African Herbicide Resistance Initiative (SAHRI) at the University of Pretoria. He can be reached at 083 442 3427 or dr.charlie.reinhardt@gmail.com.

The effect of fertiliser prices on the grain industry

By Christiaan Vercueil, intern economist, Grain SA

Traditionally, between 30 and 50% of a grain and oilseed producer's existing input costs are spent on fertiliser. Fertiliser makes up such a large part of input costs that any change, especially a price increase, can drastically affect profitability.

South Africa is also a net importer of fertiliser which further aggravates the situation, since all imported fertilisers are not only affected by their actual price but by a whole range of factors such as the exchange rate, transport costs and so on.

Import volume and price changes

Figure 1 shows South Africa's fertiliser imports of MAP, ammonia, urea, potassium chloride and ammonium sulphate, from various countries since 2009. Although not the only fertilisers imported, these are five of the most important products imported.

As of 2009, fertiliser imports for these products have increased by 199% in total. During 2021, South Africa imported a total of 2 295 365 tons of just these five fertiliser products from various countries. Apart from the increase in import volume, the exchange rate of the rand to other major currencies also weakened sharply from 2009 onwards, which further intensified the effect of price increases.

Table 1 shows the average price changes for nitrogen (N), phosphate (P) and potassium (K) during March last year compared to March 2022. It is staggering to see how sharply the prices for these products have increased in a matter of a year.

Fertiliser requirements

If we look at the fertiliser requirements of different parts of the country we see that on average, the western Free State uses 72 units of nitrogen, 16 units of phosphate and 14 units of potassium per hectare. The eastern Free State uses 100 units of

Figure 1: Fertiliser imports to South Africa.

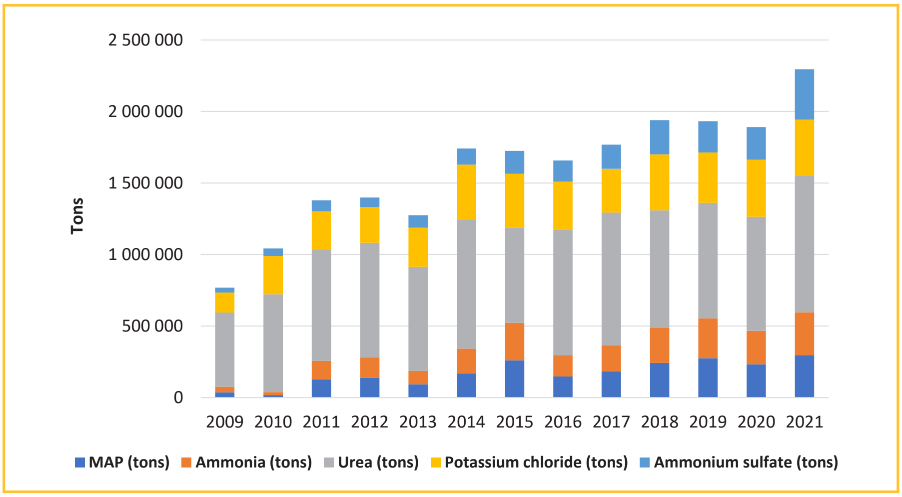


Figure 2: The affordability of fertiliser.

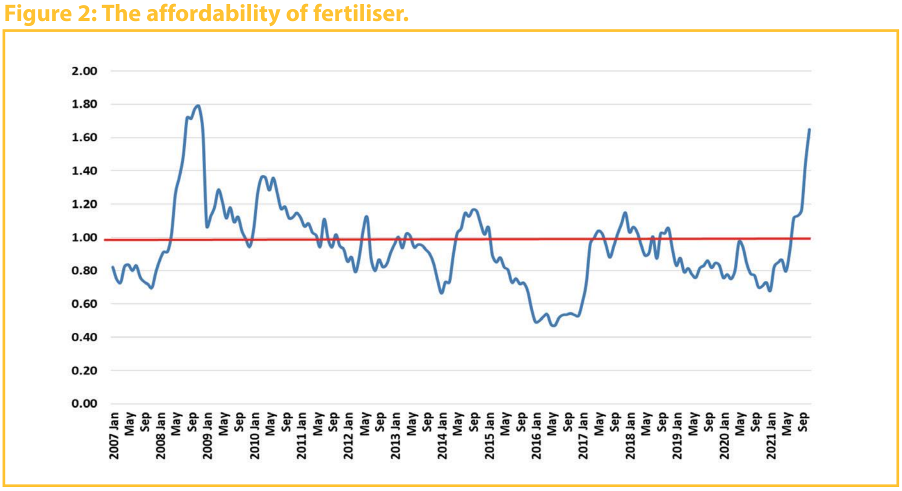


Table 1: Price comparison of nitrogen, phosphate and potassium for March 2021 and March 2022.

	Nitrogen (N)	Phosphate (P)	Potassium (K)
Avg. price: March 2021 (R/kg)	R21	R45	R13
Avg. price: March 2022 (R/kg)	R43	R75	R32
Change (year on year)	105%	67%	135%

nitrogen, 19 units of phosphate and 27 units of potassium per hectare. Irrigated areas use 286 units of nitrogen, 52 units of phosphate and 80 units of potassium per hectare.

Table 2 provides a comparison of the average fertilisation requirements for these three regions for March 2021 and March 2022. On average, the cost of fertiliser increased by 98%. This means that prices have almost doubled.

Fertiliser affordability

Figure 2 provides an indication of the affordability of fertiliser compared to the SAFEX price of maize. Fertilisers, which account for between 30 and 50% of input costs, have become less and less affordable, which means that the producer's margin for trade has weakened excessively. This puts pressure on the producer's profitability and can result in fewer hectares being planted, especially maize.

This information paints a clear picture of the extreme challenges that producers face daily to try and stay afloat. Fertiliser is not the only input cost that has seen sharp price hikes; the cost of energy sources such as fuel and electricity has also risen sharply, and the price of seed and chemicals has also increased. It is becoming progressively more difficult for farming operations to remain profitable and sustainable.

Since there is little room for mistakes, producers must make sure they are not being taken for a ride by fertiliser suppliers. Do the homework, make sure the representative's prices are market related, compare offers to find the best price, and select the most suitable offer for your purposes.

Table 2: Change in fertiliser cost per hectare for March 2021 compared to March 2022.

	Nitrogen (N)	Phosphate (P)	Potassium (K)	Price: March 2021	Price: March 2022	Change
Eastern Free State: Avg. units (kg/ha)	100	19	27	R3 322,20	R6 589	98%
Western Free State: Avg. units (kg/ha)	72	16	14	R2 422,40	R4 744	96%
Irrigation: Avg. units (kg/ha)	285	52	80	R9 434	R18 758	99%

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

Micro-nutrient fertilisation requirements to produce quality canola oil

By Dr Anneli Heyns, project and communications manager, Nutrico SA

Nutrico

Better Growth, Better Yield, Better Value

Canola (*Brassica napus* L.) is one of the three major oil crops in the world, and provides essential edible oils and raw materials for bio-energy production. The physical and chemical properties of canola oils, and consequently their end use, depend on the composition of fatty acids that accumulate in the storage lipids during seed development.

Seed development is greatly affected by abiotic stress that includes nutrient deficiencies, limiting plant growth and development, crop yield and oil quality.

Fatty acids in canola oil

Fatty acids are the building blocks of fats (lipids) and are vital dietary sources for humans as they are a structural component of cells. The fatty acid composition in canola seeds can vary according to the cultivar, and largely depends on the crop development and processing technology used during production.

Canola oil is a source of many fatty acids, the most important being oleic acid (omega-9) and linoleic acid (omega-6) since these depict the shelf life of seeds/oil and the resulting suitability for human health.

Micronutrient requirements

Micro-nutrients such as zinc (Zn), boron (B) and molybdenum (Mo) play an important role in the growth and development of canola crops. These micro-nutrients are essential in improving seed formation, pollen grain germination, protein and amino acid synthesis.

Foliar nutrition is an effective way to supply micro-elements, especially in conditions that are not favourable for the proper supply of nutrients through the root system of plants. Deficiencies mostly occur early in the season because the translocation of elements from the root to the above-ground part may not be sufficient before leaf expansion.

> Foliar fertilisation with rapidly available forms of nutrients improves plant vigour, and thus increases the seed/oil yields and the fatty acid profile of the oil.

Foliar feeding results in faster delivery of deficient micro-nutrients, high efficiency of small amounts of substances compared to soil fertilisation, even distribution of nutrients, as well as the reduction of environmental pollution, and avoidance of chemical and biological sorption. Foliar fertilisation with rapidly available forms of nutrients improves plant vigour, and thus increases the seed/oil yields and the fatty acid profile of the oil.

B, Zn and Mo: A power combo

A recent study investigated the effects of treating canola crops with a combined application of B, Mo and Zn on seed yield and fatty acid profile in comparison with the application of B, Mo or Zn alone. The seed yield of the B plus Mo and Zn treatment delivered a statistically significant increase in the seed yield, compared to any of the treatments containing only the individual micro-nutrients.

A significant increase in the seed oil content and an improvement in the oil quality were also observed for the combination treatment of B, Mo and Zn. These results suggest that optimal micro-nutrient application could provide both yield and quality advantages for canola oil. The increased mono-unsaturated fatty acid (e.g., oleic acid) composition associated with the application of B, Zn and Mo may offer several health benefits.

Canola oil that is high in oleic and linoleic acid is also more chemically stable than conventional canola oil because it is less susceptible to oxidation, offering a longer shelf life during processing.

Nutrico has expertly formulated MolboroX® (Reg no B5122, *Act 36 of 1947*) to combine the benefits of B, Zn, Mo and bio-stimulants into a powerful liquid foliar fertiliser. MolboroX® encompasses patented technology to deliver nutrients to crops in a highly mobile and absorbable format. Each 1ℓ/ha contains 100g B, 40g Mo and 6g Zinc, as well as other proprietary ingredients to boost crop growth, seed yield and quality.

For more information on how to use micro-nutrient fertilisation practices to boost oilseed yields and increase the quality of the oil produced, contact your local Nutrico representative at 011 392 4072 or info@nutrico.co.za.

Expeller soya beans: What's in a name?

By Dr Dave Albin, Insta-Pro International

Soya beans are produced in vast quantities around the world and exported to many countries. Almost always, soya beans, which contain protein, oil and other nutrients, are processed into meal (protein fraction), while the oil is removed and used for other purposes. The commodity version of this process, which uses hexane for complete oil removal, along with toasting to improve the meal and remove most of the residual hexane solvents, results in the production of soya bean meal.

However, mechanical versions of this process exist, and when run properly using the right equipment and processes, superior versions of soya bean meal can be produced. Unfortunately, these mechanical soya meals are often crudely and incorrectly lumped together in one category – expeller meal.

Understanding the difference

It is important to understand that different versions of expeller meals exist and that the underlying process affects the feeding (and economic) value of the final meals. It is often difficult to obtain this information without some digging. Following are some tips to better understand your mechanical soya ingredients – the so-called expeller soya bean meals.

First, it should be quite easy to obtain a proximate analysis on the soya meal. Variations on this group of tests exist, but typically for soya meals, results for at least moisture, oil, protein and fibre should be included. Most laboratories around the world can analyse these, but care should be taken when choosing a lab. The data will be used to make important decisions, so a little probing into their procedures, employee training and quality controls is warranted.

Moisture levels in soya meal

Moisture is a crucial value to understand because it indicates various things about the process. With mechanical processes that can be used to manufacture high-quality soya meal, such as high-shear dry extrusion and mechanical oil pressing, the amount of moisture remaining in the meal should be relatively low.

Commodity soya bean meal, using the hexane process, will often contain 12% moisture since it is easier for these large companies to sell more water (and fewer nutrients). Well-executed expeller soya meal will contain 5% moisture, or even slightly lower, when the moisture content of the raw soya beans is in the 9 to 11% range. Roughly 50% of the moisture will be flashed off when the procedure is run correctly.

This has major implications. When high-shear dry extrusion is run properly – meaning at high enough temperatures, pressure and shearing forces – many aspects of the meals are improved. First, plant cell walls are ruptured, making digestion and access to nutrients easier.

Secondly, the naturally occurring plant defence mechanisms, known as antinutrients, are deactivated. This also improves digestion, giving animals greater access to the nutrients contained in soya. Therefore, having access to moisture level data can provide you with a lot of information about the quality of the meals.

Residual oil levels

It is important to consider other data as well. Residual oil levels are another key indicator. With any mechanical expeller process, removal of all oil is impossible. There are limits to how much oil can be squeezed out of soya beans with these processes. Conversely, using the hexane process will result in soya bean meal with less than 1% oil remaining.

Understanding what it means to have less residual oil with the right process is important. When initial oil levels in raw soya beans are 18 to 20%, any mechanical expeller process should reduce the residual oil levels to 6 to 8% or lower. Again, several inferences can be made about the process and the meal quality from these values.

With high-shear dry extrusion – again, a quality approach to processing soya beans – run properly, the amount of energy in the meal that is available for productive purposes increases. It is counter-intuitive at first because oil is energy-rich, but with the right equipment and processes, as more oil is squeezed out, the amount of useful energy and the economic value of the meal improves.

Protein and fibre content

Lastly, the levels for protein and fibre are also important, but can be misleading. The total amount of protein is important for assigning value to mechanical expeller meals, but it is really the digestibility of the amino acids in protein that affects how a particular soya meal fits into an animal diet formulation. This can only be determined accurately with animal feeding studies, but with reduced moisture and residual oil, amino acid digestibility often improves.

Likewise, crude fibre levels can vary by a few percentage points, depending on whether or not the soya beans were dehulled, but even soya meal with higher crude fibre (5% or greater) can have highly digestible amino acids if the right process, such as high-shear dry extrusion, has been used.

It is clear that the category, expeller meal, for soya is woefully inept. Request data and seek help from experts to properly use and value your soya meals.

For more information, email Mike Martin at mmartin@insta-pro.com or visit *www.insta-pro.com*.

World soya bean outlook: Many opportunities to grow hectares

By Christiaan Vercueil, intern economist, Grain SA

Over the past few years, oilseed production has been booming. The reason is quite simple: oilseed profitability is increasing compared to that of maize. Oilseed supplies have suffered some difficult scenarios in recent months, resulting in the current situation where low international oilseed stocks are supporting oilseed prices.

These difficult scenarios include:

- Drought affecting the Canadian canola crop which lowered production by 35% in the 2021/22 marketing season.
- A 12% or almost 30 million ton reduction in soya bean production in Brazil, Paraguay and Argentina due to intense droughts experienced during the production seasons of these countries.
- The damaging effect the Russian invasion is having on the world's largest sunflower seed producer, Ukraine. Ukraine produces 30% of the world's sunflower seed and is responsible for 50% of the world's sunflower oil exports and 61% of the world's sunflower meal exports.

United States of America

The increasing trend in oilseed production is visible in the fact that the United States (US) has shifted 4% of viable production hectares from maize to soya beans. Soya bean hectarage has slowly but steadily increased over time. If the intentions to plant soya beans in the 2022/23 production season are realised, it will be the biggest hectarage in US history.

US soya bean supply and consumption figures for the 2021/22 marketing season include increased exports and consumption, which resulted in lower ending stocks.

US-origin soya bean exports are showing an upward trend due to the weak crops in South America. Compared to maize, soya bean consumption also increased as soya bean profitability increased; this is illustrated by a 19 and 5% increase in production over the past two seasons, and major increases in export sales during the 2022/23 production season.

South America

South America is the world's largest producer of soya beans, with most of its soya beans destined for export. For the last five years, South America has on average produced more than half of the world's soya bean crop. On 13 March 2022, Argentina closed its borders for exports of soya bean oil and meal due to tight supplies. This news gave rise to a very volatile and uncertain international soya bean market, which resulted in price increases on the global market on the back of the strong Chinese demand.

China

China is the world's largest importer and consumer of soya beans due to their extensive pork production industry. In the last ten years, China has imported an average of 80 million tons of soya beans per year. That accounts, on average, for 64% of the world's total imports. Following the difficult swine flu period, China's demand for soya meal has increased substantially as its pork industry is recovering.

Major drivers in the soya bean market

- **Weather:** Weather is a major factor influencing crop performance and production, especially in major producing countries such as Brazil, China or the US, which can influence global stocks significantly.
- **Protein demand:** The importance of Asia as a market for soya beans has been driven by an increased demand for meat as consumers shift from a predominately rice-based diet to a diet consisting of more pork, poultry and meat.
- **Chinese demand:** This demand driver was discussed earlier.
- **Price of other crops:** Maize and soya beans compete at multiple levels, including the cooking oil industry, animal feed industry and the biofuels industry.

Figure 1: US soya bean export sales in the new marketing year to date. (Source: USDA)

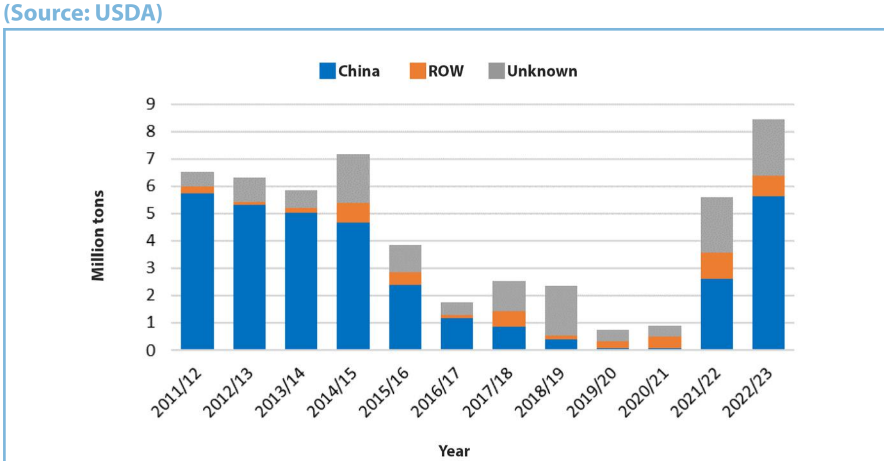


Figure 2: China's imports of soya beans compared to world imports. (Source: USDA)

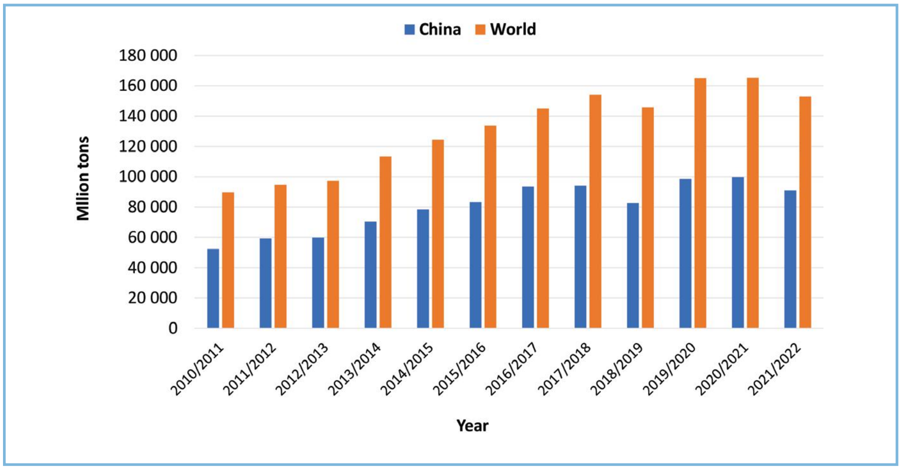


Figure 3: Soya beans crushed monthly for oil and oilcake in South Africa. (Source: Grain SA and SAGIS)

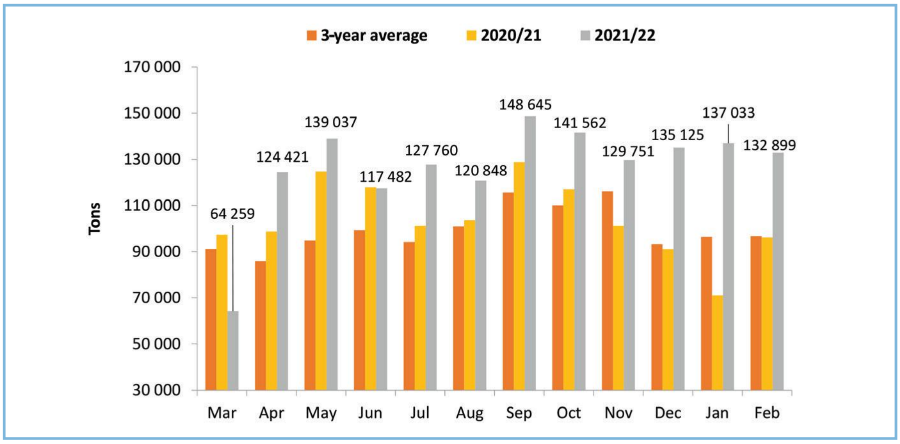
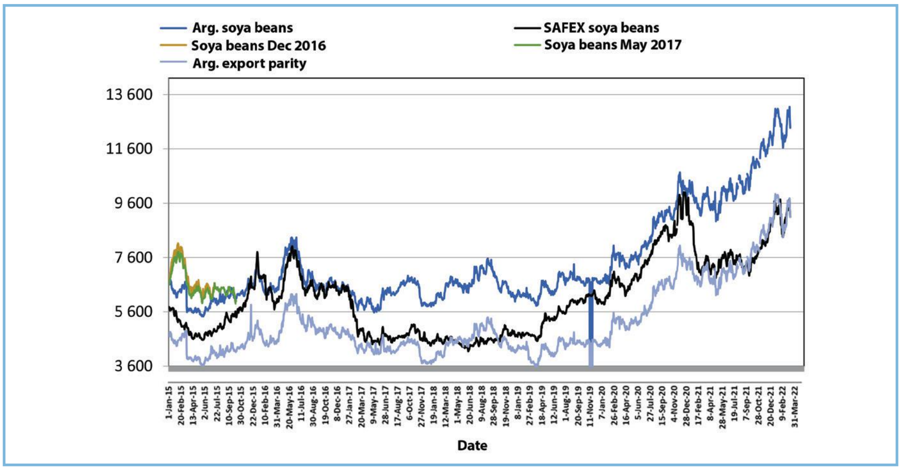


Figure 4: SAFEX and parity prices of soya bean seed delivered in Randfontein. (Source: Grain SA)



An evaluation of the South African supply and demand scenario of soya beans shows that the 2021/22 season resulted in an ending stock of 170 000 tons. This amounts to 36 days of stock. This is a lot less than was expected in the market, and was mainly due to an increase in crushing figures.

The 2021/22 season was one of South Africa's best soya bean crop years with 1,89 million tons of soya beans harvested. If the Crop Estimates Committee's hectare estimates are realised, the 2022/23 crop will be South Africa's largest soya bean area planted to date. It is, however, estimated that production will be slightly lower due to unfavourable weather conditions in the initial stages of planting. At the start of the season, various areas were subject to water damage due to excessive rain and insufficient heating units.

Along with the record harvest of the 2021/22 season, soya bean and soya bean product imports were also at low levels. This created an opportunity for South Africa to increase its local processing of soya beans. If the season's processing figures are compared to that of the three-year average, it is clear that the demand increased and South Africa utilised more local oilcake. This is good news for the local market, given the high production figures and the need to plant more soya beans in future.

However, the higher production figures did have an impact on prices, and since the end of 2020 prices were trading closer to export parity prices on the local market.

Given the Crop Estimates Committee's latest estimate of 1,85 million tons for the 2022/23 marketing season, prices can be expected to continue trading closer to export parity prices. This means that the exchange rate and international market prices will be the greatest determining factor of prices within the local market, and must therefore be closely monitored.

Conclusion

Soya bean prices are currently at strong levels due to continued lower stock and uncertainty caused by the South American crop, and a slower than usual planting progress in America. With harvesting already in process and given the expected crop, the local market will continue to trade closer to export parity prices.

This also provides an opportunity to increase local processing and utilisation of soya beans, even to the coastal areas. There are also some opportunities for export. However, this must be facilitated with competitive prices and an efficient supply chain to ensure the required specifications.

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

The effect of the Russia-Ukraine conflict on world edible oil prices

By Christal-Lize Muller

Oilseed supplies for the production of vegetable oil remain a major focus across the globe, especially given the Russia-Ukraine conflict. The prices of essential edible oil commodities such as sunflower seed, palm, canola and soya beans have increased notably over the past months. This is due to ongoing concerns regarding supply constraints and a rising demand from countries that would have typically imported products from the war-ridden Black Sea region.

Morné Botes, commercial director of Southern Oil (SOILL) which owns the B-Well and African Gold oil brands, says there have been incremental price increases in the oil complex. This can be attributed to weather conditions and crop forecast updates since September/October last year, but the main bullish reaction was the Russia/Ukraine conflict which had a major impact on global sunflower supply.

Sunflower oil shortages

Botes says Russia's invasion of Ukraine contributed to a significant shortage of sunflower when its harbours closed. Ukraine is the largest exporter of sunflower oil, equating to 70% of the world's sunflower exports. Subsequently, the sunflower oil price increased from US$1 505 per metric ton on 31 January this year, to US$2 950 per metric ton on 8 March (a 96% price increase in a month).

This was accompanied by a significant constraint in availability. Trade constraints


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Table 1: South Africa's demand and consumption of total oils and fats. (Source: SOILL)

	Total oils and fats in metric tons (MT)		
	2018/19	2019/20	2020/21
Opening stock	193 200	235 900	237 100
Import	852 400	921 500	923 200
Production	774 292	707 607	787 126
Export	152 200	150 500	166 500
Consumption	1 431 792	1 477 407	1 478 026
Ending stock	235 900	237 100	302 900

Table 2: Statistics of major oil types imported into South Africa in 2020/21. (Source: SOILL)

Major oil type	Import (MT)	Import (%)	Local (MT)	Total (MT)
Soya bean oil	150 600	39,1%	234 800	385 400
Cotton oil	2 800	19,4%	11 600	14 400
Sunflower oil	209 200	39,2%	324 300	533 500
Rapeseed/canola oil	2 900	7,1%	38 046	40 946
Olive oil	7 200	100%	–	7 200
Palm oil	491 100	100%	–	491 100
Palm kernel	34 500	100%	–	34 500
Coconut oil	5 100	100%	–	5 100
Groundnut oil	–	0%	300	300
Corn oil	–	0%	84 400	84 400
Oil demand (2020/21)	903 400	56,6%	693 446	1 596 846

put on Russia (which is also an important contributor to sunflower exports) led to the world market, which was already experiencing a shortage in vegetable oils, suddenly entering panic buying mode.

According to Botes, as with sunflower oil, the same trend was seen in canola oil (36% increase), soya bean oil (41% increase) and palm oil (33% increase) during the same period – over and above the increases in 2021.

Seeking other alternatives

Botes says the market at that stage started to move away from sunflower oil to other alternatives, which increases the pressure on the oil complex. This led to a total sunflower demand destruction in March and April. Some of the Ukrainian sunflower oil supply did start making its way out to the market by road freight to neighbouring countries, placing inflationary pressure on the commodity.

Further pressure was also placed on specifically the palm complex. Indonesia is the largest exporter of palm oil, accounting for 60% of the world supply. The country also took a stance in banning palm exports in totality from the end of April this year, placing additional pressure on world vegetable oil supply.

All-time high for FFPI

Wandile Sihlobo, chief economist at Agbiz, says expectations of lower exports of sunflower seed from the Ukraine and Russia, together accounting for nearly 60% of global sunflower oil exports, and poor soya bean production conditions could keep global vegetable product prices elevated from now to the medium term. He says the damage to Ukraine's infrastructure and disruptions in society and businesses could still hinder the production and export resumption of sunflower oil from this region in the foreseeable future, even if the conflict ends soon.

According to Sihlobo, reports of dry conditions in Brazil and Argentina, accounting for 50% of global soya bean production, and the frequent downward revision of the crop by local analysts raised fears of a potentially lower global soya bean harvest. The 2021/22 global soya bean harvest stood at 350 million tons in April, which is four million tons less than the March harvest.

These pre-existing drought-related challenges in South America, the strong demand and the Russia-Ukraine conflict are upside risks to global vegetable product prices. The Russia-Ukraine conflict, the pre-existing drought in South America and Asia, and strong demand were upside drivers of oilseed prices. He says these supply and export dynamics are reflected in the surge in prices the past few months, with the Food and Agriculture Organization's (FAO) Food Price Index (FFPI) averaging a new all-time high at 159 points in March.

Russia's invasion of Ukraine contributed to a significant shortage of sunflower when its harbours closed.

Sihlobo says these developments are a global occurrence and are reflected in the South African market which is interlinked with the world's food market. The FFPI averaged 158,5 points in April, down 0,8% from March. According to the FAO, the drop in the FFPI in April was led by a significant downturn in the vegetable oil sub-index.

The FFPI is a measure of the monthly change in international prices of a basket of food commodities. It consists of the average of five commodity group price indices weighted by the average export shares of each of the groups from 2014 to 2016.

A downward trend

According to the FAO, its vegetable oil price index averaged 237,5 points in April, decreasing by 14,3 points from the record high in March. The sharp rise of the index in March was driven by higher sunflower, palm, soya bean and rapeseed oil prices. International sunflower seed oil quotations increased substantially in March, fuelled by reduced export supplies amid the ongoing conflict in the Black Sea region.

The vegetable oil price index decline in April was driven by lower world prices of palm, sunflower and soya oils. The moderate drop in international palm oil prices was mainly weighed by subdued global import purchases amid high costs, as well as a weakening demand outlook in China. Uncertainties about export availabilities out of Indonesia held further declines in international prices. World sunflower and soya oil prices also decreased month-on-month, largely tied to demand-rationing following the recent record high prices.

As a net importer of vegetable oils and fats, South Africa imports 62% of its total consumption of all oils and fats. In 2020/21, South Africa imported almos 40% of its soya bean oil comsumption.

Global supply of vegetable oils

Botes says the world balance of the eight major vegetable oils entered the 2021/22 period with 27,16 million tons (MnT), and the expected production for the year is 204,12 MnT, leading to a total availability/supply of 231,28 MnT. There is a demand/consumption of 202,2 MnT, leading to a carry-over/ending stock of 28,48 MnT, which is a stock/usage of 14,1%.

As a net importer of vegetable oils and fats, South Africa imports 62% of its total consumption of all oils and fats (*Table 1*). Botes says 56,6% of the oil South Africa imports is of the major oil types, which is a clear indication of the country's reliance on imports (*Table 2*).

It is important to note that oils move in a complex, with a higher price or decreased supply in one commodity leading to market movement in another, while the supply and demand of the other commodity is affected, thus influencing pricing.

The road ahead

Botes says the inflationary levels of oils have reached a peak and forward pricing is seemingly coming down. This is expected to start coming through towards September and October this year once the European harvest period for sunflower and canola commences. The exact adjustment in prices will, however, be impacted by the yield of the crop, which is reliant on the weather conditions in the coming months, as well as the uncertainty about whether Ukraine will have a sunflower crop and, if they do, the size thereof. How long the conflict will continue and its impact on infrastructure will also need to be taken into account.

He believes prices in local retail are still expected to increase slightly on some lines and channels, as the increases filter through the channel to the shelf. Further increases from producers to retailers are not expected to occur. Consumers can, however, expect to pay anything between R89,99 to R129,99 for a two-litre bottle of cooking oil, depending on the type of oil and the channel through which they buy.

For more information, send an email to Morné Botes at morne@soill.co.za or Wandile Sihlobo at wandile@agbiz.co.za.

EVONIK
Leading Beyond Chemistry

AMINORed®: Accurate and rapid assessment of processed soya bean quality

By Chantelle Fryer, Technical Service Manager, Evonik Nutrition and Care

Soya beans are an important ingredient in animal diets. Unfortunately, raw soya beans contain anti-nutritional factors that can severely depress the performance of these animals.

Common soya products used in animal feed are soya bean meal (a by-product of soya oil extraction) and full-fat soya (the roasting and extraction of the entire dehulled bean). Both processes require the application of adequate heat to destroy the anti-nutritional factors, the most well-known of which are trypsin inhibitors found in raw beans. Trypsin inhibitors block sites where the enzyme trypsin binds with proteins during the digestion process, thereby reducing the ability to liberate amino acids and small peptides. This leads to performance and health issues such as poor growth and diarrhoea.

Although underprocessing of soya beans is always a concern, the opposite is also true. Overprocessing, where too much heat causes damage to the tertiary structure of proteins and reduces enzymatic binding, and thus digestibility of the amino acids of soya beans, is often overlooked.

When formulating animal feed, nutritionists consider the amount of digestible lysine in the soya bean meal or full-fat soya. Overprocessing leads to an overestimation of the amount of digestible lysine, and indeed many other amino acids, in the processed end-product.

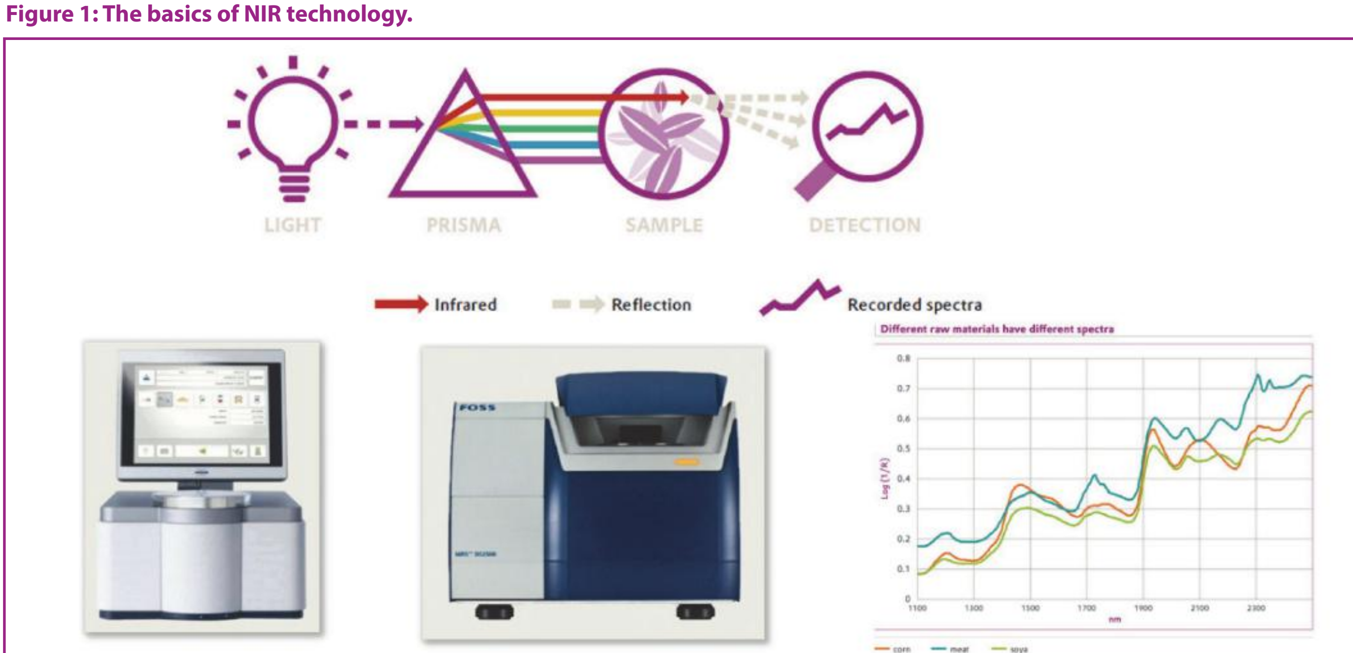
Table 1: Chemical analysis methods for processed soya beans.

	TIA	Urease activity	KOH	PDI	Reactive lysine: Total lysine
Underprocessing	+++	+++	+	++	No
Overprocessing	No	No	++	+	+++
Target values	<4mg/g	<0,3 pH rise <0,4mgN/g*min	73 to 85%	15 to 40%	>90%
Comment	Difficult	Most common		Simple method	Difficult

Methods for processing evaluation

There are multiple chemical analysis methods to evaluate processed soya beans, all with various advantages and disadvantages (*Table 1*). Trypsin inhibitor

Figure 1: The basics of NIR technology.

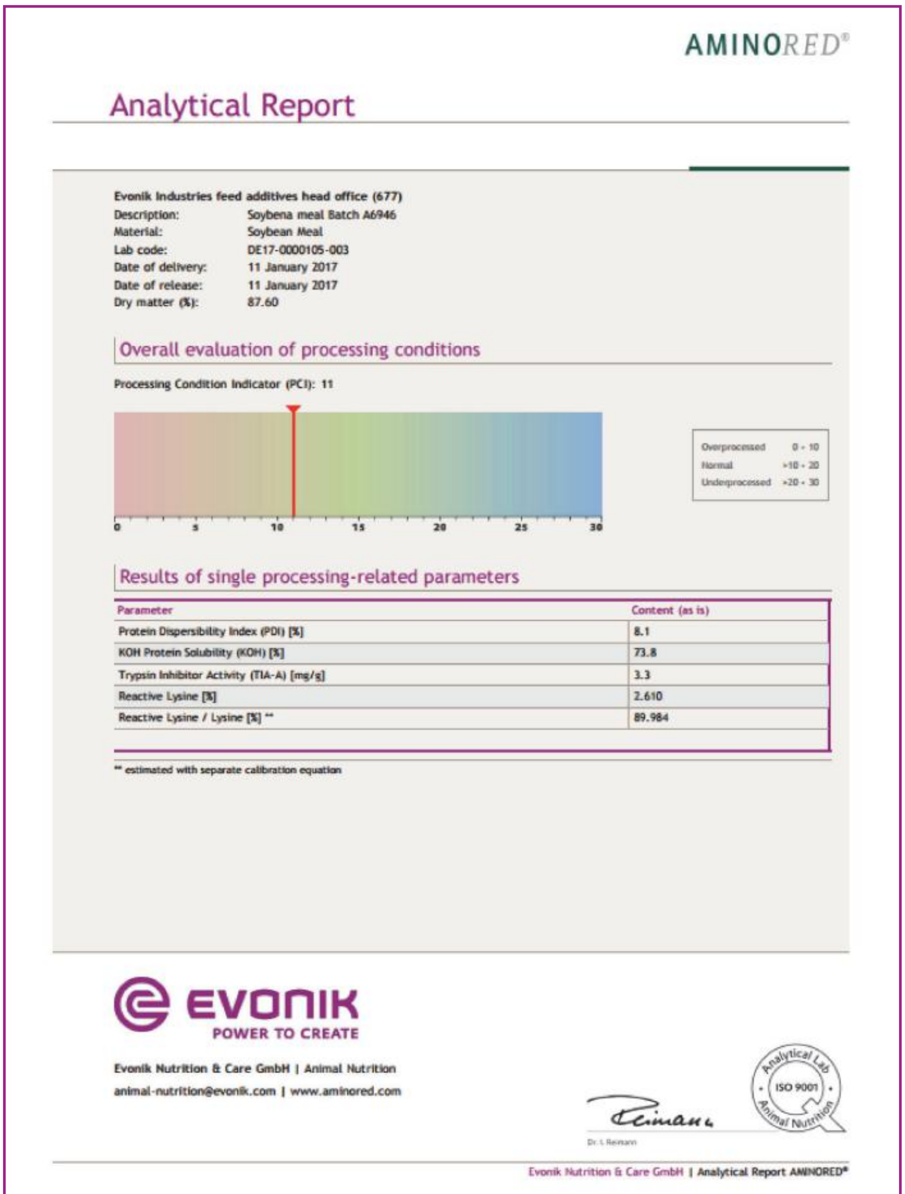


Different grades of processed soya bean meal used for the development of AMINORed® 2.0.

activity (TIA) is the most accurate test for determining underprocessing, but it is very difficult and costly to perform.

A urease test is simple and can be performed by most mills and processing factories, but results can vary depending on various factors, including particle size and even room temperature. TIA and urease cannot give any indication of overprocessing either, whereas methods such as potassium hydroxide (KOH) protein solubility can indicate overprocessing, but not underprocessing.

Figure 2: AMINORED® analytical report depicting the PCI and predictions for parameters such as TIA and KOH.



AMINORED®

Analytical Report

Evonik Industries feed additives head office (677)

Description:	Soybena meal Batch A6946
Material:	Soybean Meal
Lab code:	DE17-0000105-003
Date of delivery:	11 January 2017
Date of release:	11 January 2017
Dry matter (%):	87.60

Overall evaluation of processing conditions

Processing Condition Indicator (PCI): 11

Results of single processing-related parameters

Parameter	Content (as is)
Protein Dispersibility Index (PDI) [%]	8.1
KOH Protein Solubility (KOH) [%]	73.8
Trypsin Inhibitor Activity (TIA-A) [mg/g]	3.3
Reactive Lysine [%]	2.610
Reactive Lysine / Lysine [%] **	89.984

** estimated with separate calibration equation

EVONIK POWER TO CREATE

Evonik Nutrition & Care GmbH | Animal Nutrition

animal-nutrition@evonik.com | www.aminored.com

Dr. L Reimann

Analytical Lab ISO 9001 Animal Nutrition

Evonik Nutrition & Care GmbH | Analytical Report AMINORED®

While lesser known, the reactive lysine assay is one of the most accurate ways to determine the effect of heat treatment on amino acid digestibility and availability.

Near-infrared technology

One of the biggest breakthroughs in ingredient analysis over the past few years has been the development of near-infrared (NIR) technology. NIR spectroscopy enables the rapid analysis of raw materials by the application of infrared light to a sample and measuring the spectra of that light.

NIR is an excellent tool for quality control as it enables the analysis of thousands of samples per year with precision, accuracy and minimal cost per sample. Evonik's expertise in this technology has enabled the development of a new calibration for the rapid assessment of soya bean processing quality – AMINORed®2.0.

This calibration was developed for the quality assessment of soya products and delivers predictions on well-established quality parameters used by the feed industry, such as TIA, KOH, and the Protein Dispersibility Index (PDI).

These parameters were combined with Evonik's leading position in amino acid analytics, especially the reactive lysine assay, to design a new parameter – the Processing Conditions Indicator (PCI). The PCI can classify all soya products according to the degree of processing, from raw beans to heavily overprocessed samples, within minutes (*Figure 2*).

Processed soya bean quality is a vital consideration for animal feed producers and soya bean processors alike. Using the latest technology will deliver benefits to all role-players in the soya bean value chain.

For more information, email Chantelle Fryer at chantelle.fryer@evonik.com or visit *www.evonik.com*.

Perspectives on agriculture's performance in Q4 of 2021

Article supplied by the Bureau for Food and Agricultural Policy

Agriculture, forestry and fisheries was South Africa's fastest-growing sector in 2020 and 2021. It was one of only four sectors that realised any growth over this period. In 2021, strong fourth quarter (Q4) growth of 12,2% contributed to the seasonally adjusted, annual agricultural gross domestic product (GDP) growing by 8,3% – almost double the growth for the national economy.

Agriculture, which expanded by 8,3%, was the second fastest growing sector after mining (11,8%). This expansion was well in line with the Bureau for Food and Agricultural Policy's (BFAP) projection of 7,6% when the annual baseline outlook was released in August 2021. What makes this growth in agriculture more impressive is that it followed a 13,4% expansion in 2020, making agriculture the strongest performing sector since the start of Covid-19. The sector has been remarkably resilient during a challenging period.

Comparing 2021 to 2020

In order to explain the drivers of Q4 performance, we evaluated year-on-year (YoY) changes across various sectors, comparing Q4 of 2021 to Q4 of 2020. This removes the need for seasonal adjustment. *Figure 1* (in green) shows the real GDP growth for agriculture over time, based on this metric.

Since detailed value-added numbers per agricultural sub-sector were not published, we assessed the sector's performance based on each specific industry's performance in terms of the gross production value (GPV = price x quantity produced), as compiled by the Department of Agriculture, Land Reform and Rural Development (*Figure 2*).

The growth in agricultural GDP in Q4 of 2021 was driven mostly by an 11% increase in the GPV from horticulture, followed by a 6% increase in the GPV of animal products.

Field crops

Growth in field crops was the slowest in the last quarter of 2021, with a 2% YoY increase in GPV. In Q4, winter crops made the biggest contribution to field crop revenue. Thus, the GPV from wheat production increased by 11% in Q4 2021 relative to Q4 2020, underpinned by a 19% increase in wheat prices and a 7% increase in deliveries. This reflected a bumper crop in 2021, sold at higher prices due to strong international markets.

The GPV from canola also increased by 19% in Q4 2021 compared to Q4 2020, reflecting a record crop, again sold at high prices. Conversely, barley GPV declined by 37% compared to Q4 2020, reflecting significantly reduced production volumes following intermittent bans on alcohol sales through 2020 and 2021. Consequently, the total barley crop in 2021 declined by 30% compared to 2020.

Animal products

Animal products reflected sustained growth throughout 2021, with the sub-sector expanding by 6% in the last quarter of the year compared to the same period in 2020. High prices continue to support this growth in revenue, except for the pork industry, where prices declined by 8% in the final quarter of 2021. In revenue terms, this decline was more than offset by higher volumes, as higher slaughter numbers supported 10% growth in GPV in Q4 2021.

The GPV from beef grew by 9% due to higher prices, which offset a modest contraction in slaughter volumes. Among the smaller red meat industries, the GPV from sheep and goats grew by 2 and 24%, respectively.

The poultry industry is the biggest contributor to the GPV from animal products. It expanded by 6% in Q4 2021, supported by high chicken prices. The average price for IQF mixed portions was around R27 in Q4 2021, compared to R22 in the same period of 2020. This results from higher global prices, where the combination of animal disease and persistent high feed prices has constrained supply.

While revenue performance from animal products was strong, feed prices in South Africa continue to rise and as the single biggest contributor to production costs in intensive production systems, this raises concerns around profitability.

Horticulture

The horticultural sub-sector was the star in Q4 2021, showing an 11% increase in GPV. Despite logistical challenges throughout the season, high export volumes supported growth. The biggest contribution to the GPV from horticulture in Q4 typically comes from a combination of table grapes, stone fruit and berries, together with the last exports from the pome fruit and citrus industries. In the deciduous fruit category, GPV grew by 11% in Q4 2021, relative to the same time in 2020.

Generally, the logistical and port-related challenges delayed the horticultural season. This is reflected in the citrus industry, where exports peaked in Q2 and Q3, with limited final volumes shipped in Q4. However, due to the delays, Q4 orange exports were one million cartons (15kg) higher in 2021 than the comparable period in 2020.

Russia-Ukraine conflict poses risk

One of the greatest key factors that will inevitably impact agricultural growth for 2022 is the Russia-Ukraine war. Both countries are major exporters of wheat, maize and sunflower products. Considering concerns around export supply from the region, global prices of all these products

Figure 1: Year-on-year change in real (2015) agricultural GDP per quarter. (Source: Stats SA, 2021)

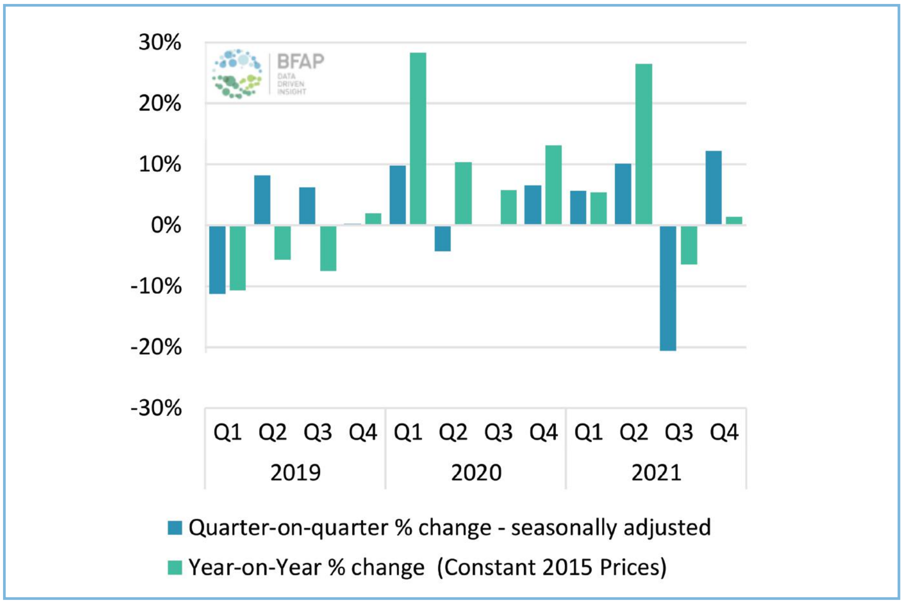
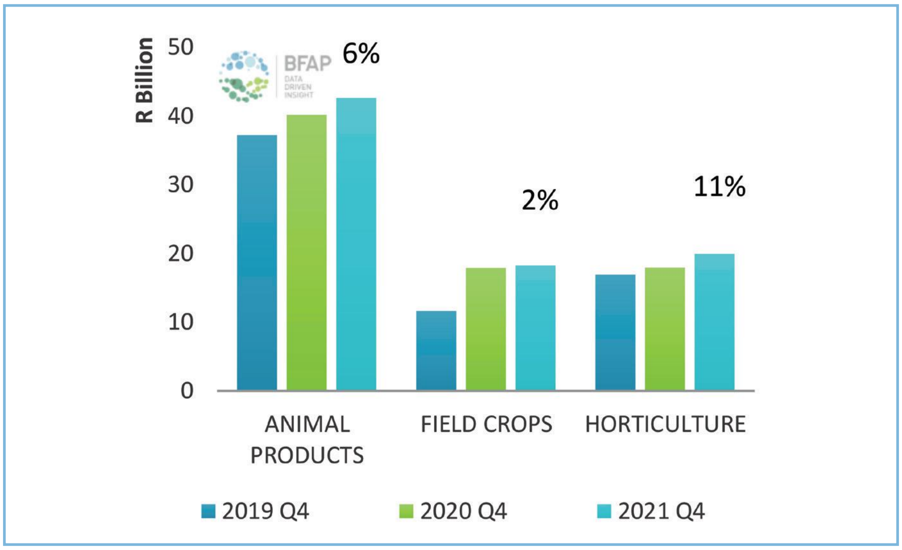


Figure 2: Nominal gross value of production per sub-sector. (Source: DALRRD, 2021)



have increased sharply, but where they peak will depend on the duration and outcome of the situation in Ukraine.

Ukraine's spring wheat should be planted in March and April but given the current situation, this is unlikely to happen. While spring wheat is a small share of the total crop, the winter wheat harvest is also due to commence by mid-year. Ukraine's ability to harvest this crop will be reliant on an end to the current invasion by Russia.

Russia, typically contributing upwards of 15% of global wheat exports, is the major supplier of chemical fertiliser in the global market and is a major exporter of petroleum products. Consequently, ongoing sanctions could restrict the availability of not only wheat, maize and sunflower oil, but also key inputs such as fertiliser. Combined with the sharp increases in crude oil prices that are already evident, this could push input costs substantially higher, particularly for winter crop producers in South Africa, who commenced planting in April.

Expect continued high prices

South Africa produced a bumper wheat crop in 2021 but remains a net importer, therefore prices have already increased sharply and will likely remain high this year. Similarly, as a net importer of vegetable oils, prices tend towards import parity levels and despite estimates of bumper summer oilseed crops, prices have been supported by international levels.

If international prices remain at current levels for most of 2022 and inputs remain readily available, albeit at a higher cost, South Africa's real agricultural GDP could expand for a third consecutive year. Given that stock levels were already low and that weather concerns in South America remain, there is further risk on the upside in the global market space. Likewise, if a peaceful resolution can be reached in the Black Sea region and other Northern Hemisphere producers have favourable conditions, prices could ease later in the year.

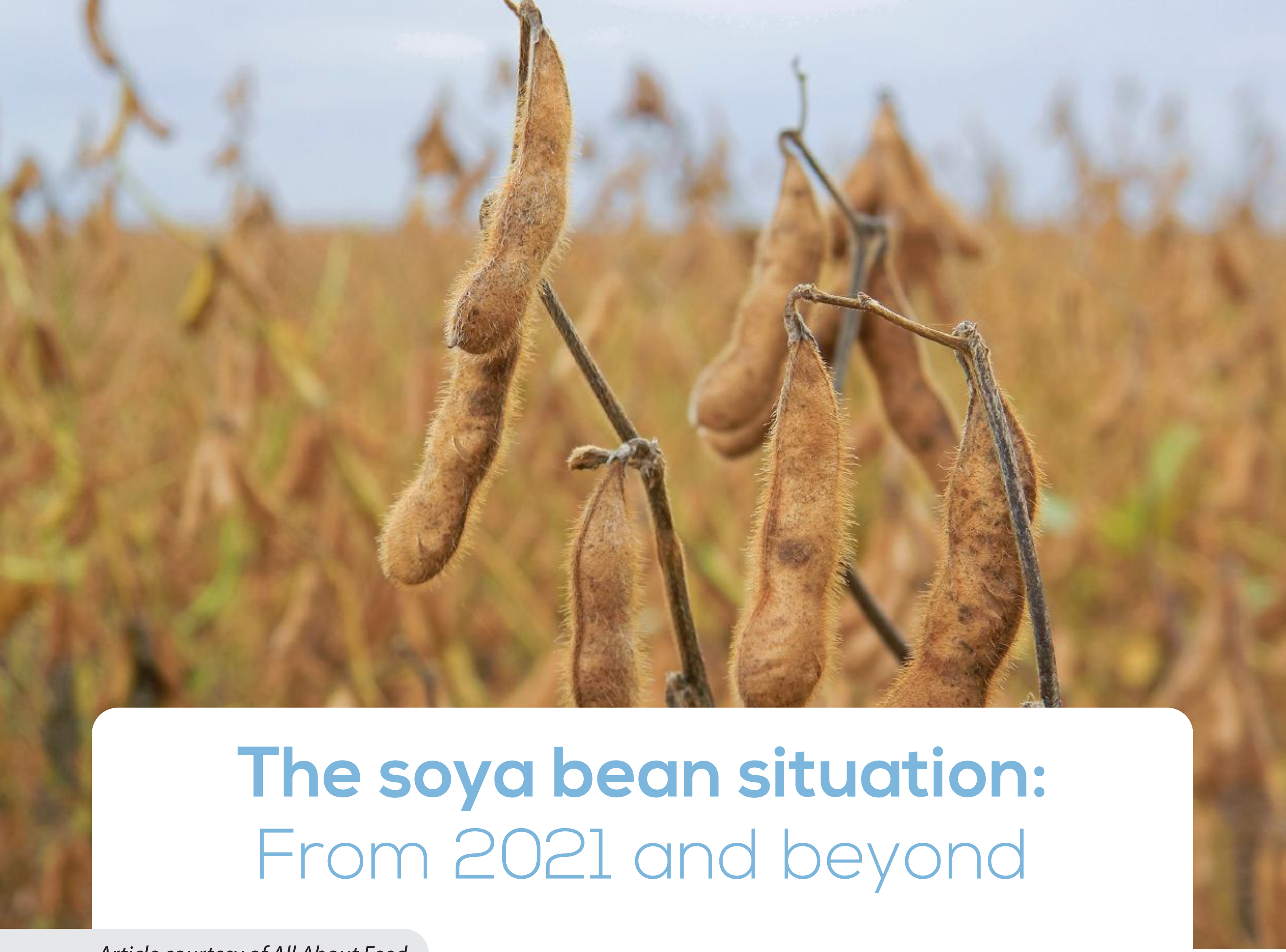
From a consumer perspective, the global market situation, combined with high energy and manufacturing costs, implies that food inflation will unfortunately continue to rise. This despite the fact that South Africa is expected to produce another big summer crop this year. First estimates from the Crop Estimates Committee will likely result in a substantial exportable surplus.

In summary

The horticultural sub-sector has been the star of the agricultural sector in Q4 2021, with an 11% growth in GPV. Despite logistical challenges, high production levels, as well as strong global demand have resulted in high export volumes and value.

High animal protein prices continue to support growth in the animal products sub-sector despite relatively low slaughter numbers, particularly in the red meat industry. Field crops reflected the slowest growth in the last quarter of 2021 with only a 2% increase in the GPV, compared to the same quarter in 2020, but this follows an already very strong performance in 2020 and therefore occurs on a larger base. Given the situation in the Black Sea region and resultant high world prices, South Africa's agricultural sector is likely to expand in real terms for the third consecutive year in 2022.

This article was shortened for use in *Oilseeds Focus*. To read the original article, visit *www.bfap.co.za/wp-content/uploads/2022/03/GDPBrief2021Q4.pdf.* For any other enquiries, contact BFAP at admin@bfap.co.za.



The soya bean situation: From 2021 and beyond

Article courtesy of All About Feed

The soya bean crop is critical for sustaining the current human population, but it is also a crop that brings with it huge sustainability concerns. This article takes an in-depth look at soya bean production for livestock feed in several countries.

Already, large areas of native habitat in South America have been destroyed for activities such as pulp and beef production, as well as soya bean cultivation, mostly for animal feed. Among plant protein ingredients, soya beans have the highest crude protein content – about 40% – depending on their location. They also have a balanced amino acid profile and good digestibility.

It is therefore not surprising that in 2021 (as explained previously in the journal *Nature Sustainability*), soya beans were the largest global source of protein for livestock feed. The authors noted that global production of soya beans has more than doubled since 2000, mostly from new hectares (about 70% of production) but also from yield gains due to advances in soya bean genetics and cropping practices. Soya beans are grown in about 100 countries.

China's hunger for soya

China's soya bean imports from Brazil have surged since the 2000s, most of which are used for animal feed to support increasing meat consumption. At the same time, trade tensions between China and the United States (US) are expected to result in even more soya bean imports into China from South America in future.

"China is the biggest source of soya bean demand," explained Stefan Vogel, global sector strategist of grains and oilseeds at Rabobank RaboResearch Food and Agribusiness. "Whole soya beans are imported by China for animal feed, mostly from Brazil and the US, and some from Argentina and are processed into meal there. The hot market is swine feed, although the use of soya in chicken feed production has recently increased as well."

Continuous growth for Brazil

Brazil also exports sizeable amounts of whole soya beans to Europe and additional volumes to Asia, the Middle East and other parts of the world, said Vogel. Soya bean meal produced in Brazil is exported to many countries, with Europe being the largest destination, followed by countries in eastern and southern Asia.

"We expect the soya bean hectarage in Brazil to continue to increase," he added. "In the past five years, it has grown by 2 to 3% a year. Demand is strong and producers are making good margins, given high global prices and a relatively weak Brazilian currency."

Soya meal in high demand for feed

Apart from China and the European Union (EU), Asim Anand, senior editor at *SP Global*, said Thailand, Turkey and Russia are major importers of South American soya beans, along with Vietnam, Indonesia and Algeria. However, he added that soya bean meal for feed is in huge demand within both Brazil and Argentina amid their soaring meat production for export, making it tough for soya bean exporters to procure the volumes they'd like to ship.

European soya cannot meet demand

Vogel noted that in the EU there is a relatively stable livestock population and, while soya bean production has increased over the last decade, meal made for stock feed from EU soya beans currently only amounts to about 7% of what is needed.

"We need 28 to 29 million tons in the EU, not including the United Kingdom, and only about two million tons of this is from domestic soya beans. The rest is imported, with over half of the EU's needs coming from Brazil and Argentina as soya bean meal. The remaining 35% stems from imported soya beans processed in the EU. The EU will need to continue to import soya bean meal for livestock feed for the foreseeable future if we want to maintain current levels of meat consumption."

Global meat consumption

Globally, the question of whether we have reached 'peak' meat consumption is difficult to answer. Consumption levels in China are similar to those in Europe, where consumption is decreasing. European soya beans should not be underestimated when it comes to meeting livestock feed needs.

"We will continue to use a mixture of both imports and domestic soya beans with a goal of more sustainable global soya bean production everywhere," Vogel said. To help European agriculture become more sustainable, the European Feed Manufacturers' Federation (FEFAC) released its most-recent soya sourcing guideline document in February 2021.

Changing dynamics

The US Department of Agriculture's (USDA) Economic Research Service researchers, which includes senior economist, Fred Gale, explained: "Chinese demand will drive continued growth in soya bean trade over the next ten years, as world soya bean imports climb by 46,9 to 222,7 million tons". Brazil is expected to be the leading country for soya bean exports through 2030.

In addition, the dynamics of world production have changed a great deal in recent decades. In a new book, *Crop Physiology Case Histories for Major Crops*, the authors note that in the early 1990s, the US accounted for half of global soya bean production, while Brazil and Argentina produced about a quarter. "The share of global soya bean production among these three countries has changed drastically over the past three decades," they state, "with Brazil and Argentina together now accounting for half of global production and the US producing a third."

There are a few main factors that may affect world soya bean production for animal feed, chief among them being the success of plant-based food products and world population. The United Nations projects world population to be 9,7 billion by 2050.

Consumers of soya

Currently, there are about 100 countries where soya beans are grown and probably all of them use soya bean meal in livestock diets.

According to an analysis published by the University of Oxford's Food Climate Research Network (using USDA data up to 2018), soya consumption is broken down so that:

- 37% is fed to poultry (the largest consumer of global production).
- 20% is fed to swine.
- 6% goes to aquaculture.
- 2% is fed to cattle.
- The rest is used in human food products and dog food.

Soya bean meal will remain a crucial feed ingredient for many livestock species, but environmental, societal and trade pressures are reducing its use in some areas of the world. More environmentally friendly alternatives to soya beans produced in South America, such as insect meal, lupins, algae and many others, are actively being examined in some countries.

Soya bean meal for feed is in huge demand in both Brazil and Argentina amid their soaring meat production for export.

However, China's government directed the country's swine production sector earlier in 2021 to use alternatives to soya bean meal where possible, to reduce its reliance on imported soya beans, no matter the country of origin. This comes after China imported a record amount of soya beans in 2020.

In addition, in the EU, the need for soya beans in swine and poultry rations may decrease quite significantly in future in that region, now that the ban has been lifted on using some animal by-products in feed.

Rise of synthetic amino acids

Lastly, because synthetic amino acids can now be produced economically in large volumes, they represent another way that the use of soya bean meal in livestock feeds can be reduced. According to the United Nations' Food and Agriculture Organization's 2002 report, *Protein Sources for the Animal Feed Industry*, "it is suggested that … if 550 000 tons of L-lysine hydrochloride is used globally, it could replace 18 million tons of soya bean meal, representing about half of US soya bean meal production."

This article was shortened and adapted for *Oilseeds Focus* from an article originally written by Treena Hein and published on *www.allaboutfeed.net/animal-feed/raw-materials/the-soybean-situation-2021-and-beyond/*.

GROVATION

REGISTRATION NOW OPEN

Become a Participant in the 2022 Ag & Food IT Benchmark

GROVATION

Revolutionise your business strategies *with Grovation's Ag and Food IT Benchmark*

Grovation is presenting the 2022 Ag and Food IT Benchmark for the third consecutive year. This benchmark is the only IT-focussed industry study worldwide that zooms in on agricultural (ag) and food industries in Africa.

The study is designed to assist executive management teams of businesses in the ag and food value chain to benchmark their IT spend, IT strategies, technologies deployed, and much more against trends and industry averages. This will help them develop better IT strategies to execute their business strategies more successfully.

The 2022 report will be released during a prestigious online event on 28 October 2022, where leaders from the ag and food industries who participated in the report will share their knowledge and experience – an all-round highlight on the ag and food calendar!

Mbali Nwoko, CEO of Green Terrace, will act as host and you can look forward to gaining practical insights and data at the event as well as in the published report. The event is free for anyone interested in IT and technology trends in the ag and food industries. You can register via *www.agfooditbenchmark.com*.

Smart farming with the latest IT

The evolving field of disruptive technologies has gained significant interest in various industries, including agriculture (both primary and secondary) and manufacturing (which includes food and beverage manufacturing or processing). The fourth industrial revolution has reshaped the context of agricultural and manufacturing technologies with applications of artificial intelligence, data-driven analytical techniques, additive manufacturing, 3D printing and IoT (Internet of things) solutions.

Motivated by advances in precision farming, digital-to-physical conversion and human-machine interaction technologies, executive teams must now have robust IT strategies to enable smart farms and smart factories more than ever before.

Get the competitive edge you need

This benchmark and industry study was initiated by Sarel Visser, CEO of Grovation, to assist executive teams in developing robust IT strategies, evaluating their spending, and reviewing industry trends that might provide them with the competitive edge they need to execute their business strategy successfully.

For many executive teams and even boards, it is a first to have IT playing such a strategic role in executing their business strategy. And with an overwhelmingly increasing number of options and solutions to choose from, this may be a daunting task and one that should not be left to the sales teams of these ever-increasing number of technologies. Executive teams must take the lead and ensure that their strategies are developed around their business, and not a specific technology solution or vendor.

Participating in this benchmark and industry study will provide your management team with the insights and data to take the lead and challenge proposed strategies and tactics to ensure your IT strategy and team are well positioned to help your business grow and pivot as and when needed, ensuring you stay in the game and even take the lead in your industry.

Grovation is a boutique management technology consulting firm that has helped various businesses grow in the ag and food industries over the past decade, and can share many success stories.

The timelines of the 2022 Ag and Food IT Benchmark study are as follows:

- 1 April to 30 June 2022: Register to participate.
- 1 May to 30 June 2022: Participants to submit their data by completing the selected questionnaires.
- 1 July to 30 September 2022: Processing of the submitted data by the Grovation team.
- 28 October 2022: Launch of the 2022 results at our online event.

If you want to participate in this benchmark and industry study, or you would like to register for the event on 28 October 2022, feel free to register at *www.agfooditbenchmark.com.* Follow us on LinkedIn at *https://za.linkedin.com/company/grovation-we-grow-businesses* for more updates about this IT benchmark.

For additional enquiries, contact Grovation SA at 087 057 2311 or visit *www.grovation.com.*

Investigating the quality of soya as served in the National School Nutrition Programme

By Dr Carmen Muller, Dr Beulah Pretorius and Prof Hettie Schönfeldt

The South African National School Nutrition Programme (NSNP) is a government programme that provides at least one meal a day on school days to pupils in less affluent primary and secondary schools throughout the country. The objective of this programme is to provide nutritious meals to pupils in an attempt to improve their ability to learn.

Adequate nutrition from birth throughout childhood lays the foundation for good health and is necessary for children to learn, as nutritious meals provide food for the brain. Under-achievement in schools is a major problem and is most prevalent in developing countries. Therefore, schools are a priority when it comes to improving nutrition outcomes in a country.

The meals that are provided at schools are therefore intended to provide essential nutrients for mental and physical activities, and to ensure pupils are alert and receptive during lessons.

Helping millions of pupils

The South African NSNP was introduced in 1994 as part of the reconstruction and development programme of the newly founded democratic Republic of South Africa. Upon its inception, the programme only assisted primary schools. During the 2006 survey by the fiscal and finance committee of the Department of Education, it was confirmed that a need exists to extend the programme to secondary schools.

In October 2008, the minister of finance at the time announced a budget for the inclusion of secondary schools in the programme. Currently, the programme assists more than nine million pupils in 19 393 quintiles 1, 2 and 3 primary and secondary schools. The NSNP is critical for furthering pupils' constitutional rights to basic nutrition (Section 28(1)(c) of the *Constitution*) and basic education (Section 29(1)(a) of the *Constitution*).

The programme is funded through a conditional grant that is transferred to provinces on a quarterly basis, according to the *Division of Revenue Act, 2013 (Act 2 of 2013)*, or the *DORA*, and other directives from the Department of Basic Education (DBE) and the National Treasury. The allocation criteria for provinces are based on the poverty distribution table used in the *National Norms and Standards for School Funding* as gazetted by the former minister of basic education on 17 October 2008.

Guided by the relevant legislation and policies, National and Provincial DBEs are accountable for the management and utilisation of the funds as well as the monitoring of implementation, therefore each province's approach differs.

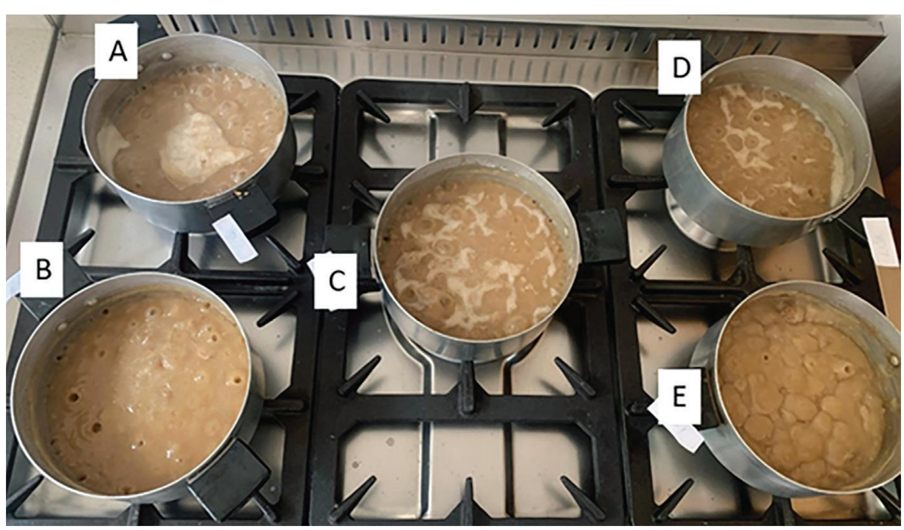
Quality, not quantity

In a previous study that was conducted in 2020 titled 'The role of soya in the National School Nutrition Programme', as well as in the review of the NSNP, it was reported that pupils did not enjoy the soya meals that were served at schools. Negative connotations due to bad experiences with the consumption of soya in the NSNP can lead to unwillingness to purchase the product later in life.

The 2020 study questioned the quality of soya served at schools and the quality of the soya supplied to schools. Schools in the Tshwane district were visited to assess the meals served to pupils and to identify soya suppliers.

Prepacked bags of soya as delivered by suppliers were found to contain large amounts of additives, which were assumed to be maize meal and flavouring. Results from this study showed that up to 60% of a bag of soya, as supplied by registered and accredited vendors to schools, were additives. This brings to question whether the supplied soya mince complies with the specifications as stipulated by the DBE.

The current unprecedented focus on health and nutrition has seen the food system undergo rapid changes, including an increased offering of various products in the same category. The food industry operates in a highly competitive environment and fraudulent practices are often reported in the media. One such



Soya from different blenders being cooked.

Table 1: Labels and analysed nutrient values of different soya suppliers.

Suppliers	Macro-nutrient results per 100g dry product							
		Moisture[+] (g)	Energy (kJ)	Protein (g)	Carbohydrates (g)	Fat (g)	Dietary fibre (g)	Sodium (mg)
Blender A	Label		–	27,4	47,1	–	17,7	2,04[#]
	Results	8,53	**1 279,8**	**23,3**	47	2,29	8,38	**3 220**
	Difference (%)			-15%	0%		-53%	157 743%
Blender B	Label		1 372	26	45,3	3,32	10,2	1 392
	Results	7,71	**1 363,8**	**22,6**	51,9	2,63	7,97	**2 101**
	Difference (%)[*]		-1%	-13%	15%	-21%	-22%	51%
Blender C	Label		1 443	28,3	42,8	5,8	8,3	830
	Results	6,55	**1 297,4**	28,2	36,8	5,2	13,8	**2 622**
	Difference (%)[*]		-10%	0%	-14%	-10%	66%	216%
Blender D	Label		1 559	24	48	7,2	9,1	919
	Results	7,75	1 453,7	**21,2**	47,4	7,77	8,59	**1 798**
	Difference (%)[*]		-7%	-12%	-1%	8%	-6%	96%
Blender E	Label		1 431	28,51	50,9	4,93	12	–
	Results	**9,76**	**1 303,6**	**22,4**	45,1	4,22	8,34	**3 109**
	Difference (%)[*]		-9%	-21%	-11%	-14%	-31%	
Supplier	Label		1 227,2	47	38	2,29	21	43,3
	Results	7,46	**1 231,7**	47,6	19,3	2,43	17,8	19
	Difference (%)[*]		0%	1%	-49%	6%	-15%	-56%
NSNP guidelines		<9	>1 365	>24			4	<1 500

**Percentage difference = [(analysed-label)/label]*100. [#]Assumed typing error on packaging. [+]Moisture is stated in the NSNP guidelines but is not required on package labels. Values in bold do not comply with the NSNP guidelines.*

practice is to bulk products with cheaper alternatives to increase profit. Legislative actions by governments, including regulations relating to the advertising and marketing of food, are continuously being updated to control this volatile market and ensure there is some form of adherence and consumer protection.

Only the real stuff

Soya mince, as served within the NSNP, is supplied to schools via accredited distributors managed by the programme co-ordinator within each school. In South Africa, there is a limited number of distributors that prepare soya as texturised vegetable protein (TVP) for human consumption.

The main supplier of TVP supplies soya chunks to blenders. Blenders further process the 100% soya chunks and add all sorts of additives such as maize meal, flavouring, sugar, salt, citric acid, a vitamin premix, colourants, herbs, spices and monosodium glutamate to create their own unique product that is then supplied to schools.

Since one of the aims of the NSNP is to serve quality nutritious meals, the DBE has published a document titled 'Food Specifications for products marketed to the NSNP'. The rationale behind the document is to ensure standards, improve the quality of meals served to pupils, and to make information available that can guide service providers on the expectations of the NSNP. This document covers both general and specific legislation for foodstuffs included in the programme. It aims to improve the understanding of the current industry to inform food control for future policy and programme development.

This study evaluated compliance to guidelines by the suppliers as set out by the DBE for soya mince (TVP products) served in the NSNP. In order to do this, suppliers in the NSNP were identified and samples were randomly and anonymously drawn from five vendors (n=5). The original soya chunks as provided to processors were also sourced for analysis (n=1).

Probing compliance

To investigate the label compliance of soya served in the NSNP, nutritional analyses (energy [as calculated], protein, carbohydrates, fat, dietary fibre and sodium) were conducted on the soya and compared to each respective product label. To estimate the amount of potentially cheaper, non-nutritive bulking agents added to the soya to increase product weight, a gravimetric ratio was determined by sieving the respective products to separate the TVP from the additives. These ratios of TVP chunks/mince to other products were compared to the guidelines as set out for soya served at schools.

Table 1 shows the label and analysed values for the dry soya mince product as

Table 2: Results depicting the gravimetrical ratio and percentages of soya to additives in a pack.

Supplier	Ratio soya to additives (g:g)	Percentage soya in pack	Percentage ratio additives to soya
Blender A	5 314g:7 239g	42%	58:42
Blender B	2 225g:2 213g	50%	50:50
Blender C	410g:587g	41%	59:41
Blender D	2 656g:2 390g	53%	47:53
Blender E	2 448g:2 545g	49%	51:49
Supplier	No additives	100%	0:100

Table 3: Soya mince cooking methods.

	Soya	Water	Cooking instructions
Blender A	1 part	3 parts	Add 3 parts water to 1 part soya mince and cook for 20 minutes or until tender.
Blender B	1kg	6 litres	Bring to a boil and then simmer for 20 to 30 minutes and serve.
Blender C	1 part	5 parts	Mix well and soak for 15 minutes, bring to a boil and simmer for 20 minutes. Stir regularly until mince is ready to be served.
Blender D	1kg	5 litres	Mix with cold water and bring to a boil, allow to simmer for 5 minutes. Serve as required.
Blender E	1kg	4 litres	Heat while stirring. Allow to simmer before serving.

supplied and sampled. Each nutrient will be discussed separately. The guidelines as set out by the DBE do not state the allowance of variance of values as shown on the labels.

Regarding the composition of soya mince, which is to be served in the NSNP, the DBE stipulates the following contents per 100g dry product:

- Moisture content must not exceed 9g.
- Protein content must be at least 24g from soya protein.
- The energy content should not be less than 1 365kJ.
- The sodium content must not exceed 1 500mg.
- The calcium content must be 150mg.
- The iron content must be 13,3mg.
- Zinc must be 3,7mg.
- Dietary fibre must be 4g.
- The product should not contain more than 10% fat from other sources than specialised protein products (SPPs) or poly-unsaturated vegetable oil.

From *Table 1* it is seen that there are numerous inconsistencies between what is stated on the label and the true analytical value. One of the most concerning findings is the discrepancies in protein values as soya is defined as the protein source in the meal. Four of the five suppliers did not comply with the requirements for protein.

The guidelines of the NSNP state that "the SPP shall remain the main ingredient of the final product". This statement can be argued from various points, since it does not stipulate exactly what the ratio of soya to optional ingredients may be. However, this study finds that only the product of Blender D had a higher soya:additives ratio.

Currently, soya is prepared as stated on the back of the supplier pack. The cooked product then has a slush-like consistency. This is an unappealing meal and is most likely the reason for low consumption of food on days that soya is served in the NSNP. From a previous recipe development study where recipes were developed, a ratio of 70:30 soya to additives was deemed reasonable. However, none of the samples attained this ratio (*Table 2*).

The five soya products all had different cooking guidelines to prepare the soya. These cooking guidelines are summarised in *Table 3* and are visually presented in *Photograph 1*.

The importance of guidelines

These findings provide constructive information to the soya industry to address the concerns of young consumers of soya. Soya, as currently served in the NSNP, is not enjoyed by pupils. Research has shown that this may not be due to soya as a product itself, but rather due to unappealing additives present in the soya as provided by suppliers. Guidelines, as currently stipulated by the DBE, state that soya should be the main ingredient available in the soya packs. These guidelines need to be updated to specify what the maximum acceptable ratio of soya to additives may be.

Regarding the labelling of foodstuffs in South Africa, a level playing field between food operators in order to meet label legislation has not been achieved. Some operators have reformulated their products, due to changes in legislation, as well as in preparation for the establishment of nutrient profiles, while other operators have not, creating unfair competition as claims are not standardised and, in some cases, not regulated. Food business operators may also be sceptical to apply label claims due to associated costs and a lack of knowledge in terms of regulations and compliance.

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For more information, go to *www.education.gov.za/Programmes/NationalSchoolNutritionProgramme.aspx*.

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Transforming sunflower production sustainably

By Aron Kole, managing director, FarmSol Holdings

The Russia-Ukraine war has had a major impact on the local farming industry, with the cost of fertilisers and fuel increasing drastically since the start of the conflict. Disruptions in global food supply chains and the skyrocketing price of sunflower oil further reflect the pressure experienced over the past months.

At farm level, sunflower seed production plays an important role as an ideal crop within the grain farmer crop production and crop rotation system, especially in the warmer and drier areas of the Free State, North West and Limpopo. Sunflower seeds are also an important food source in South Africa – the seeds are pressed and crushed for their oil, which is primarily used as cooking oil in many local households.

The extraction process of oil from seed results in sunflower meal, or sunflower oilcake, which is a valuable by-product in the feed industry. It is a powerful and excellent protein source used in the formulation of livestock feed. Among many others, niche sunflower oil use includes being used as sunflower fat spread or margarine, and it is also an important ingredient in skincare, acting as an emollient agent in cosmetic products.

Dwindling oil supply

Although the country produces 70% of sunflower oil and only imports 30% to meet demand, many South Africans are starting to see the impact of the Russia-Ukraine war on their daily food baskets as the price of cooking oil soars. Ukraine is the largest exporter of sunflower oil in the world and with fears of a decrease in sunflower oil stock levels around the world, some South African retailers have started rationing the sale of cooking oil by limiting the number of cooking oil bottles consumers can buy.

According to the Bureau for Food and Agricultural Policy (BFAP), local sunflower production has shown virtually no growth over the past two decades. Sunflower yields have increased by only 1% compared to 2,5% for maize, while sunflower oil content has been decreasing in the same period.

According to Peter Lovelace, CEO of Central Edible Oils (CEOCO), they realised around 40% oil with the sunflower intake during the 2010/11 seasons. Lately, however, the oil percentages of the sunflowers delivered to the company's oil mill in Boksburg have declined to as little as 35%.

Exploring new opportunities

With sunflower yields almost having reached their ceiling, an opportunity exists to increase the overall oil content of sunflowers, as well as boost the amount of sunflower oil that can be supplied to the local market as part of reducing reliance on imports.

In addition, multi-stakeholder partnerships and collaborations are crucial to complete the entire value chain from farm to shelf and, most importantly, to link emerging farmers to valuable markets to supply their produce, thus contributing to poverty alleviation, better incomes and improved food security.

In this regard, FarmSol Holdings, in partnership with Siqalo Foods, CEOCO, Unigrain and the Oil and Protein Seed Development Trust, started a project in the 2021/22 season aimed at supporting and enabling a group of emerging farmers participating under the FarmSol Emerging Grower Programme, to produce sunflower seed using high oil content cultivars.

Through this initiative, participating emerging farmers are rewarded with a SAFEX price premium for sunflower oil content exceeding 40% on delivery to CEOCO. The sunflower oil, once extracted at the CEOCO crushing plant in Boksburg, is supplied to Siqalo Foods. It is then used as part of the manufacturing of famous household brands such as Rama, Stork and Rondo.

FarmSol aims to continue playing a crucial role in farmer development, alongside industry partners, by building a strong agricultural sector in South Africa. Crucially, the challenges in agricultural transformation do not always relate to producers or the market, but often involve a lack of connecting these two with one another.

For any enquiries, contact FarmSol Holdings at 011 480 8592 or visit *www.farmsol.co.za*.

Enforceability of agreements regarding the relinquishment of labour tenants' rights

By Clarissa Pienaar, Moolman & Pienaar Incorporated

It is increasingly becoming commonplace for the director-general of the Department of Agriculture, Land Reform and Rural Development to refer the claims of labour tenants for the allocation of land, among others, to the Land Claims Court.

This growing tendency to refer the claims of labour tenants to the court can be attributed to the recent ratification by the Constitutional Court, in the case of *Mwelase and Others vs the Director-General of the Department of Agriculture, Rural Development and Land Reform and Another [2019] ZACC 30*, of the Land Claims Court's appointment of a special master for labour tenants to play a supervisory role over the department's processing of labour tenant claims.

A labour tenant is described in the *Land Reform (Labour Tenants) Act, 1996 (Act 3 of 1996)* as a person who resides on a farm or has the right to reside on a farm; has the right to use the land for cultivation or grazing purposes, and provides labour to the landowner in return; or whose parent or grandparent resides or used to reside on the farm, or has or had the right to use the land for cultivation or grazing, and provided labour to the owner in return.

Land application notices

In terms of Section 16 of the *Labour Tenants Act*, labour tenants had to apply for the allocation of land before or on 31 March 2001, and in terms of section 17, the director-general had to notify the landowner immediately upon receipt of such application and publish a notice of the application in the *Gazette*.

Unfortunately, given the thousands of applications, the director-general has failed to do so, and section 17 notices, owing to the pressure applied by the special master, are now being sent to landowners at a brisk pace.

Settlement and waiving of rights

Landowners who are now receiving notices, following the department's lack of action over the years, can either deny the claim and demand that the claim be formally referred to the Land Claims Court and fight the claim, or he/she can try to settle the case. In some instances, the landowner might not want to fight the application, instead opting for a quick settlement of the labour tenant's claim. In other cases, the labour tenant would rather relinquish his/her rights.

In this instance, it is important to remember that a landowner is entitled to fair compensation for the portion allocated to the labour tenant (whether by way of a settlement or court order), as stipulated by the *Constitution of the Republic of South Africa, 1996 (Act 108 of 1996)*, which is payable by the state.

> In some instances, the landowner might not want to fight the application, instead opting for a quick settlement of the labour tenant's claim. In other cases, the labour tenant would rather relinquish his/her rights.

The right of a labour tenant to reside on and/or make use of the farm, lapses when the labour tenant waives his/her rights, if such waiver is in writing and the agreement has been signed by both the landowner and the labour tenant.

However, when the landowner wants to enter into a settlement agreement with the labour tenant, it is vital to keep in mind that the *Labour Tenants Act* explicitly states that the provisions of any agreement under which a labour tenant relinquishes his/her rights, do not come into effect before the director-general has certified that he/she is satisfied that the labour tenant has full knowledge of the nature and extent of his/her rights, as well as the consequences of waiving such rights, or unless such provisions are incorporated into a court order or arbitrator's order.

Invalid settlements

Any relinquishment of rights must be handled with the utmost care. It often happens in practice that landowners, to their own detriment, negotiate directly with the labour tenant and offer a monetary settlement or erect a house for the labour tenant, without involving the department or the director-general.

It may also be the case that, after the landowner and the labour tenant 'settled' the matter, and because the director-general was not involved in the matter, the director-general will withhold his/her certification because he/she is not satisfied that the labour tenant had full knowledge of his/her rights and the consequences of relinquishing such rights.

As the terms of such an agreement consequently did not come into effect, the landowner is suddenly confronted with a formal referral of the labour tenant's claim to the Land Claims Court. The referral will then have to be handled without the landowner being armed with a certified agreement.

Therefore, before a labour tenant's claim is settled by way of settlement negotiations, the department and the director-general need to be involved, in order to prevent the landowner from compensating the labour tenant financially or building a house for him/her, only to later be confronted with a claim regarding the allocation of a portion of the farm.

For more information, contact Clarissa Pienaar on 018 297 8799 or clarissap@mmlaw.co.za.

Trade unions and strikes: What employers should know

By Adv Kees Gouws, manager: Legal Services, LWO Employers Organisation

When trade unions lay claim to organisational rights in the workplace, employers are often uncertain about their own rights and those of the trade union, as well as how these rights are regulated.

Every employee has the right to belong to a trade union, just as every employer has the right to belong to an employers' organisation. Both bodies are regulated by the *Labour Relations Act, 1995 (Act 66 of 1995)*, or the *LRA*.

There is, however, a growing tendency among certain political parties in South Africa to try and appropriate trade union rights for themselves. In the process they intimidate employers into consulting and reaching agreements on terms and conditions of employment.

The rights of trade unions

The *LRA* grants trade unions certain organisational rights, subject to certain requirements. This includes access to the workplace, the deduction of union registration fees, trade union representation in the workplace, leave for trade union activities, and disclosure of information.

No authorisation or permission is given to political parties to exercise rights similar to those of trade unions. Employers must guard against entering into discussions with political parties regarding rights in the workplace.

If a trade union wants to claim organisational rights in the workplace, the trade union must first be registered with the Department of Employment and Labour. The trade union's constitution must also be in line with the employer's business sector. Furthermore, the trade union must have sufficient representation (± 20%) or majority representation (50% + 1) in the workplace in order to be able to claim certain organisational rights.

Legislation further requires trade unions to follow a procedure, which entails that the trade union must notify the employer in writing of the rights the trade union wishes to exercise in the workplace. If the trade union meets the requirements, the employer must then meet with the trade union within 30 days to conclude a recognition agreement, which stipulates the terms and conditions agreed upon.

Strikes

In terms of the *Constitution of the Republic of South Africa, 1996 (Act 108 of 1996)* every employee has the right to strike. The *LRA* defines a strike as the partial or complete concerted refusal to work, or the retardation or obstruction of work by employees for the purpose of remedying a grievance or resolving a dispute in respect of a matter of mutual interest.

Labour legislation distinguishes between protected and unprotected strikes. For a strike to be considered 'protected', the *LRA* stipulates certain provisions and procedures that must be complied with. Dissatisfied employees must first make use of the employer's internal grievance procedure to try and resolve the dispute. If the outcome is not satisfactory, the employee can refer the matter to the Commission for Conciliation, Mediation and Arbitration (CCMA). A CCMA commissioner will then try to resolve the dispute through conciliation.

If the dispute cannot be resolved or the matter is not mediated within 30 days after referral, the commissioner will issue a certificate stating that the employees have the right to strike. However, the employees are still obliged to notify the employer in writing of their intention to strike, and the employer must receive the notice at least 48 hours before the intended strike.

It is acceptable practice for employees to be remunerated for the services they provide. Therefore, the principle of 'no work, no pay' will apply, and employers do not have to compensate employees who take part in the strike.

Unprotected strikes

If a strike does not comply with the required terms and procedures of the *LRA*, the strike will be considered 'unprotected'. Employers can take disciplinary action against employees who participate in an unprotected strike, but employers remain subject to labour legislation and, as such, must follow correct and fair procedures.

It is essential that employers act proactively to strengthen the employer-employee relationship. Clear rules and guidelines in the workplace limit misunderstandings and conflict, and promote productivity and a positive work environment.

The LWO Employers Organisation assists employers to comply with labour law, and to use it to their advantage to protect their business. As a registered employers' organisation with the Department of Employment and Labour, the LWO has the right to represent members at the CCMA. Contact the LWO on 086 110 1828 or send an email to info@lwo.co.za.

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