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New seed breeding technologies can benefit the oilseeds industry

By Dr Lukeshni Chetty, general manager, South African National Seed Organisation

Agricultural challenges continue to grow in the wake of global climate, social and economic changes. For producers to remain profitable and to address these challenges, they need to have access to a variety of improved seed choices to sustain food and fibre production. It is therefore imperative that innovative breeding technologies are employed in the oilseed industry.

Breeding programmes focus on the development of varieties with improved yield, good agronomic adaptation to growing conditions, disease resistance, and varieties that can respond to lower inputs. But they should also address high-end use qualities required in the value chain. Barriers placed in the path of breeders to employ the latest novel research and breeding techniques, may lead to the stagnation of the development of new varieties and hybrids.

Government's support is vital

A seed technology environment that focusses on the development of new and improved varieties can only be created with the support of government. A mutual appreciation of the value of technology for agriculture and South Africa at large is needed. The future of the agricultural industry lies in breeders having access to several new breeding techniques.

Over the years, the introduction of biotechnology traits has resulted in the growth of the local soya bean industry. Last year, the South African regulatory authority approved a new genetically modified (GM) soya bean trait for the first time in almost 20 years. As a result, new soya bean germ plasm can now be sourced from across the globe. This one action will increase the profitability of producers and the industry.

Intacta Roundup Ready® 2 Pro (Intacta RR2 PRO™) is only the second GM soya bean trait to be approved for cultivation in

South Africa. The first was Roundup Ready® soya bean, which was approved in 2001. Now, soya bean growers can benefit from cultivars with protection to damage caused by *Lepidopteran* soya bean pests, together with the advantages offered by the herbicide-tolerant trait in the past.

On the opposite side of the coin, there are a number of examples where limited access to new breeding techniques, a lack of funding, and limited support for breeding programmes have had a major impact on the development of new and adapted plant varieties.

One such example is that of sunflower. The same breeding technologies and biotechnologies that are available for maize and soya beans are not available in sunflower breeding programmes, and this can be seen as one of the fundamental reasons why yield and specific trait advantages are lacking.

An enabling environment may change the situation. The ability of the sunflower industry to remain competitive will be determined by the availability of new cultivars addressing market requirements, such as high-oil content or mitigating stress in the field by being less susceptible to diseases such as *Sclerotinia*. However, more research is needed. *Sclerotinia* has played a significant role in the decrease in sunflower plantings and recently also reached the far western production regions, where it was previously unknown.

Promoting new breeding technologies

Novel techniques of plant breeding are continuously evolving and creating onerous and costly barriers for new technologies that could be used to create new products. This will be detrimental to the agricultural sector. These barriers may discourage the development and uptake of new technologies and innovation.

There are many upbeat prospects in South Africa's oilseed industry, but it is



Dr Lukeshni Chetty.

important that government understands its role in this. Placing unnecessary barriers in the way of introducing products derived from new breeding technologies (NBTs), can seriously hamper the sector's growth and the country's ability to feed the nation.

We would like to see that South Africa employs science-based regulations for the safe introduction of products derived from NBTs. The South African National Seed Organisation (Sansor) is committed to engaging in this process in good faith and welcomes any joint action with the Department of Agriculture, Land Reform and Rural Development, as well as the executive council of the *Genetically Modified Organisms Act (Act 15 of 1997)* to remove any obstacles, and in so doing, facilitate effective, efficient and evidence-based regulation of products derived from NBTs. 🌱

For more information, contact the author at 012 472 9500, email lukeshni@sansor.co.za or visit www.sansor.org.

Looking to the future with alternative proteins

The Good Food Institute, a non-profit organisation, has received substantial funding from China to promote the product development of alternative proteins and to scale up the alternative protein industry.

The increased investment in alternative proteins has been compared to the surges in funding in China for solar panel technologies and electric vehicles, prior to market booms in these industries. China appears to be positioning itself to dominate the alternative protein sector in anticipation of a significant growth in global demand for these products.

It is postulated that the constant threat of animal diseases as well as value chain disruptions due to Covid-19, could be some of the reasons for the initiative.

Homing in on consumer needs

In South Africa, the Soya Bean for Human Consumption Symposium held by the Oilseeds Advisory Committee (OAC) late last year, was a step in the right direction to promote and investigate the future of increasing domestic soya bean consumption. In addition, numerous studies have been funded by the OAC to better understand the requirements of the South African consumer with regard to soya-based products.

We are optimistic that this market will grow robustly in South Africa, provided the consumer is offered quality, flavourful products.

Another excellent year of growth

The growth in soya bean plantings from 827 100ha in 2021/22 to 910 000ha in 2022/23 is a positive sign for the industry. The Free State has taken the lead with an expansion of 12%. Unfortunately, it is anticipated that due to new entrants in

the market and excessive wet weather in certain areas, lower yields will result in the harvested crop to be below that of 2021/22.

The increased investment in alternative proteins has been compared to the surges in funding in China for solar panel technologies and electric vehicles prior to market booms in these industries.

The increase in sunflower hectares from 477 800ha to a current estimate of 580 000ha is encouraging and could result in an improved crop size, but is still below the required amount for the country. The cost benefits for producers to grow oilseeds over maize, are currently very clear. Soya beans tend to tolerate excess water better and input costs are lower.

Prices for oilseeds are expected to stay firm in 2022/23 due to global strength in these markets as well as the robust demand in South Africa. The soya oilcake/oil crush volume for the calendar year 2021 was 1,3 million tons – the highest in history.

The canola crop of close on 197 000 tons in the Western/Southern Cape for 2021 is encouraging, albeit mainly at the expense of the barley industry which is going through a challenging period. The expansion of the canola industry has been a very positive contribution to oilcake demand in South Africa.

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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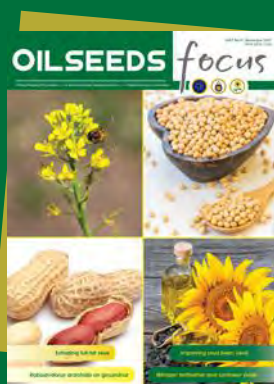
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NEWS

Appeal launched against NBT regulations

Late last year, the national Department of Agriculture, Land Reform and Rural Development (DALRRD) announced that products derived from new breeding technologies (NBTs) would be evaluated under the risk assessment framework that exists for genetically modified organisms (GMOs) under the *Genetically Modified Organisms Act, 1997 (Act 15 of 1997)*.

South Africa's decision to regulate all products derived from NBTs as GMOs will have widespread implications not only in South Africa and on its innovators, but it will also have implications with regard to international trade of commodities that may contain products derived from NBTs. Asymmetric regulation may cause food insecurity and create significant barriers between South Africa and its trading partners.

In an appeal under the umbrella of Agbiz, industry partners suggested that South Africa proactively promotes science-based regulation for products derived from NBTs. The broader agricultural value chain is committed to engaging in this process in good faith. – *Press release, Agbiz, Sansor and CroPLife SA*

Record year for oilseed production

In Germany, the Union for the Promotion of Oil and Protein Plants (UFOP) has reported that according to current United States Department of Agriculture (USDA) estimates, global production of oilseeds in the crop year 2021/22 is set to hit a peak of around 627,6 million tons, which would be up around 4% year-on-year.

Global processing of oilseeds is also set to rise to a record high of 527,2 million tons, according to the most recent USDA outlook. This would be up around 18,3 million tons on the 2020/21 crop year. Global ending stocks will presumably amount to 114,1 million tons, which would exceed the previous year's level by 400 000 tons.

However, ending stocks are seen to be clearly below the 133,9 million ton record high recorded in the 2018/19 season. Also, world trade in oilseeds is expected to increase from 6 million to 196 million tons. – *Biofuel Digest*

Heating homes with leftover canola

After years of meticulous research, Dr Ajay Dalai's exploration of canola meal pellets as an eco-friendly alternative to coal and natural gas for both heat and energy, is poised to move into its next phases – scaled-up pellet production and commercialisation. Dr Dalai is the Canada research chair of bio-energy and environmentally friendly chemical processing at the University of Saskatchewan's College of Engineering.

"Eventually, the world is going to phase out coal because of pollution," said Dr Dalai. His quest is to find ways to turn leftover materials from crop production, such as canola meal, into bio-coal.

In 2019, Canada produced over 18 million tons of canola. The oil extraction process leaves behind canola meal, which is about 60% of the original crop by weight. Some canola meal is exported and about 40% is fed to livestock. The remainder is what Dr Dalai sees as potential bio-coal. – *Press release, Canadian Light Source*

Biotech crops approved in China

Safety certificates for production and application were granted to four genetically modified (GM) maize and three GM soya bean varieties that were pilot tested in China last year.

"The application of traits that resist pests and tolerate herbicides and drought, has improved the competitiveness of genetically modified crops such as maize and soya bean in production cost, price, and quality," according to Qian Qian, director of the Chinese Academy of Agricultural Sciences' Institute of Crop Sciences.

Results of the pilot programme showed that with only one herbicide spray, the GM soya bean varieties can achieve over 95% weed control. – *ISAAA*

Bayer Crop Science awarded top seed ranking

The World Benchmarking Alliance (WBA) awarded Bayer Crop Science a stellar scorecard for the 2021 Access to Seeds Index for the Eastern and Southern African region. WBA represents organisations working at global, regional and local levels to shape the private sector's contributions to achieving its sustainable development goals (SDGs).

The Access to Seeds Index evaluates and compares seed companies according to their efforts to improve access to quality seeds of improved varieties for smallholder farmers. Bayer's first place ranking for its vegetable seed business in East and Central Africa, recognises the effort the company has invested in the region.

Bayer was ranked 15th on the index in 2019, showing the remarkable progress made over the past two years. Bayer also performed well in the ranking for marketing and sales, governance and strategy, and seed production in Eastern and Southern Africa. – *Press release*



Bayer launches Testing4Ag programme

Bayer announced the launch of Testing4Ag, a new programme which allows research scientists from around the world to submit novel chemistries to Bayer for testing, in hopes of identifying potential new modes of action to control fungal diseases, insect pests or weeds.

Testing4Ag, a part of Bayer's Open4Ag partnership development and innovation approach, seeks to develop the newest generation of crop protection products that safely and sustainably address the changing needs of producers.

"Bayer is the leader in agricultural research and development, and we are committed to driving the future of agriculture by delivering innovative and sustainable solutions to the problems facing farmers," said Bob Reiter, head of research and development at Bayer's Crop Science Division.

"Testing4Ag will combine the transformative ideas of pioneering researchers with Bayer's knowledge, experts and resources without taking ownership of the intellectual property that participants contribute." – *Press release, Bayer*

Black Sea sunflower oil market faces challenges

In 2022, the Black Sea sunflower oil market will face problems as, against the background of forecasts of record oil production, producers are holding back seed sales. India, the world's largest buyer of vegetable oils, plans to increase its imports to 14 million tons in the 2021/22 season.

The first forecasts of sunflower oil production in the Ukraine in the current season were not too optimistic, as the heat could reduce the sunflower harvest. However, it is now expected that in 2021/22 the production of sunflower oil in Ukraine will grow by 23% to a record 7.1 million tons, and the area of sunflower sowing will remain at a high level due to high prices, which will be resistant to 'bearish' factors. – *Grain Trade*

High vegetable oil prices risk faster inflation

More bad weather for the world's oilseed growers is pushing rapeseed and canola prices to new records and adding to food inflation worries. Futures have been on a tear for a while after last year's harvests in Canada and Europe were plagued by scorching drought and planting cutbacks, cutting global rapeseed stockpiles to a four-year low.

Worries are mounting regarding supplies of rival vegetable oils, with hot and dry weather hurting South American soya bean prospects and flooding hitting palm oil farms in Malaysia.

As a recent crude oil rally also aids demand for the crops to make biodiesel, Paris rapeseed futures and North American canola notched new all-time highs. Rapeseed prices have nearly doubled in the past year. A United Nations index of food prices averaged 28% higher last year than the prior year, led by a surge in vegetable oils. – *Taipei Times*

Kenyan farmers appeal for GM feed importation

Livestock farmers in Kenya are facing a bleak future following a dire shortage of livestock feed. Farmers are appealing to the government to allow importation of genetically modified (GM) feed. Many dairy, swine and poultry farmers have downscaled their production or even closed. Thirty-six feed millers closed shop in 2021.

In August 2021, feed manufacturers in the country petitioned the government to lift the ban on importation of GM foods and allow them to import GM maize and soya bean. However, the government through a *Gazette* notice issued in December 2021, exempted import duties on the importation of non-GMO raw materials used in feeds.

The duty waiver appears to be an attractive offer, but will not bring down the cost of feed as there is a shortage of conventional soya bean and maize globally. – *ISAAA*

Record soya production forecast for Brazil

Palm oil production is set to recover in 2022 in Malaysia, while soya bean production in Brazil is forecast to reach record levels. In 2021, the oilseeds markets in North America were characterised by a sharp rise in vegetable oil markets.

The greatest impact on global oilseed markets in 2021 has been the drop in palm oil production in Malaysia, driven by a combination of poor conditions leading to lower yield, but also harvest challenges due to lockdown measures reducing available labour.

The combination of strong recovery in global demand and shortfalls in vegetable oil supply pushed Chicago soya bean oil up. Soya bean meal prices have been under pressure in 2021. As the oil proportion gained in value, meal prices came under pressure, capping the gain in soya beans. – *Feed Navigator*

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Swartland's producer of the year

The Protein Research Foundation (PRF) held its canola working group meeting for the Swartland region at the Perdeberg Cellar, Agter-Paarl. At the meeting, the PRF announced its canola producers of the year for the Swartland region in the following three categories:

- **50 to 150ha:** Thys Louw, Diemersdal, Durbanville. Average yield of 2,71 ton/ha on a total planting of 120ha.
- **>150ha:** Hennie Walters, Walters Group, Malmesbury. Average yield of 2,67 ton/ha on a total planting of 172ha.
- **New entrant:** Ewan van Heerden, Bakensig Farming, Moorreesburg. Average yield of 2,23 ton/ha on a total planting of 50ha.

In the photograph from the left is Andries Theron, chairperson of the PRF, Gerrit Visser, who received the award on behalf of Thys Louw of Diemersdal, Hennie and Fred Walters, Walters Group, Ewan van Heerden, Bakensig Farming, Gerhard Keun, CEO of the PRF, and Dr Erhard Briedenhann, vice-chairperson of the PRF. – *Hugo Lochner, Plaas Media*



Industry appeal against GMO regulatory approach

In October last year, the Department of Agriculture, Land Reform and Rural Development (DALRRD) announced that a diverse and evolving group of products derived from new breeding technologies (NBTs) will be evaluated under the risk assessment framework for genetically modified organisms (GMOs) under the *Genetically Modified Organisms Act, 1997 (Act 15 of 1997)*, or the *GMO Act*.

At the end of November, the agricultural industry lodged an appeal under Section 19 of the *GMO Act*, particularly in support of the South African bio-economy and local innovation and is looking forward to furthering communication regarding the next steps in this process.

In the appeal, under the umbrella of Agbiz, industry partners suggested that South Africa pro-actively promote science-based regulation for products derived from NBTs. The South African regulator's interpretation of the GMO definition goes against the widely accepted principle that NBTs should not be regulated differently if they are identical to, or indistinguishable, from products that could have been obtained naturally or through conventional breeding methods.

This decision will risk the ability of South African producers to access the latest innovative technologies that could further enable them to sustainably produce food with minimal environmental impact, as well as denying consumers access to better end products. – *Press release, Agbiz, Sansor and Croplife SA*

Top canola producers in Southern Cape announced

South Africa's canola industry is currently in a growth phase. According to Andries Theron, chairperson of the Protein Research Foundation (PRF), the recent growing interest in the industry can be ascribed to above-average yields and good prices achieved over the past season. Theron was speaking during a recent canola working group meeting held at Rûens College near Klipdale. Speakers included Kellie Becker, managing director of Southern Oil (SOILL), and Tony Esmeraldo, business director at Corteva.

During the event the PRF also announced its canola producer of the year for the Southern Cape region, in three categories:

- **50 to 150ha:** Danie du Toit of Springerskuil Boerdery, Caledon. Average yield of 2,72 ton/ha on a total planting of 72ha.
- **>150ha:** Jan Paul Kempen, Amerika Landgoed, Klipdale. Average yield of 3,03 ton/ha on a total planting of 314ha.
- **New entrant:** Wynand Wessels, Wynarend Boerdery, Napier. Average yield of 2,95 ton/ha on a planting of 27ha.

In the photograph from the left is Andries Theron, PRF chairperson, the winner in the new entrant category, Wynand Wessels, and Gerhard Keun, chief executive officer of the PRF. The other category winners were not present. – *Hugo Lochner, Plaas Media* 🌱



Managing blackleg of canola starts with knowing your enemy

By H Schreuder and D Mostert, Department of Plant Pathology, Faculty of AgriSciences, Stellenbosch University, and G van Coller, Directorate: Plant Sciences, Western Cape Department of Agriculture, Elsenburg

The South African canola industry has grown steadily over the past 25 years. After a record yield of over 2t/ha was achieved in 2020, the year 2021 stood out for both the highest area planted under canola (100 000ha) and the highest canola production (195 000 tons). With this came the need to address some of the challenges facing canola production.

Blackleg is the most damaging disease of canola, but little research has been done in this regard. Planting cultivars that provide resistance to blackleg is one of the most efficient ways to manage the disease. However, to make the best use of cultivar resistance, it is important to have information on the local pathogen population and to understand the life cycle of the blackleg pathogen.

This article will explain how knowledge on the pathogen population and life cycle link to cultivar resistance, and will also provide feedback on progress

made in research, funded by the Oil and Protein Seeds Development Trust (OPDT), which commenced in 2021.

The basics of blackleg resistance

Resistance against blackleg is governed at a genetic level. Two types of resistance exist, namely single-gene (qualitative) and polygenic (quantitative) resistance. Little is known about polygenic resistance against blackleg. It cannot prevent infection but can reduce the severity of the crown and stem cankers that develop later in the season.

In contrast to this, single-gene resistance can prevent infections. Single-gene resistance is controlled by what is called the gene-for-gene concept. This means that for each gene that enables the pathogen to cause infection (known as an avirulence or avr gene), there is a corresponding gene (called a resistance or R-gene) in the host, which provides resistance against the avr gene.

For successful infection, the specific avr gene should be present in the pathogen while the corresponding R-gene should be absent in the host. If the corresponding R-gene is present, the host will be able to recognise the avr gene in the pathogen and stop infection.

In short, the blackleg pathogens (*Leptosphaeria maculans* and *Leptosphaeria biglobosa*) produce spores which encounter a canola plant, germinate

and grow into the plant tissue, thereby causing infection. The first infections occur early in the season during the cotyledon to five-leaf stage. The pathogen grows from the initial infection sites on the cotyledons or young leaves into the developing stem, where it remains to cause the characteristic stem and crown cankers (Photograph 1) later in the season.

Because single-gene resistance can prevent these initial infections, it can prevent the development of damaging stem and crown cankers later in the season and limit yield loss. However, to utilise single-gene resistance against blackleg, it is necessary to know which avr genes are present in the local pathogen population. Cultivars with the corresponding R-genes can then be selected, which will limit early infections and reduce the number of cankers later on.

Genes and races

To date, 15 R-genes against blackleg have been detected in the *Brassica* family. These genes can occur in different combinations within a host and are based on the number of known gene-for-gene interactions. As an example, a study conducted in Canada determined that 170 races of *Leptosphaeria maculans* (*L. maculans*) occur in Manitoba alone.

A race is a group within the pathogen population that can only infect certain canola cultivars. Because of the large number of potential races, single-gene resistance in a cultivar can easily be overcome if cultivars with the same R-genes are successively planted on the same fields. Because R-genes only suppress pathogens with the correspondent avr genes, races without these specific avr genes can still infect the plant and will increase in numbers. This is known as selection pressure.



Crown canker caused by blackleg.



A cultivar trial was held at Uitkyk Farm, Riversdale, to assess the resistance of canola cultivars to blackleg under field conditions.

Over time, these races will become dominant, and since the host does not have the corresponding R-genes, these races will cause disease.

To prevent the pathogen from overcoming host resistance, cultivars from different resistance groups are planted in successive years which decreases selection pressure. However, for this practice to be successful, the pathogen populations must constantly be monitored to detect shifts in the race structure.

Information on the avr genes present in the pathogen population is then used to make recommendations to producers on which cultivars would be safe to plant the following season. To establish a similar practice in South Africa, information is

needed on the avr genes present in the local pathogen populations. Unfortunately, the race structure of the blackleg pathogen populations in the Western Cape is currently unknown. To address this problem, one part of the blackleg research project which started in 2021 focusses on determining the race structure of the local pathogen population.

The first step to acquire this information was to obtain a pathogen isolate

collection representative of all the canola production regions in the Western Cape. Isolate collection commenced in the 2020 season, and to date, 1 850 isolates have been obtained from infected leaf, crown and stem tissue. Isolates were collected in representative regions across the Western Cape, including fields in Eendekuil, Langgewens and Hopefield in the Swartland, and Napier, Swellendam and Riversdale in the Overberg and Southern Cape.

These isolates have all been identified as *L. maculans*, which is the most damaging of the two blackleg pathogens. No *L. biglobosa* has been found so far. Isolate collection will continue throughout

2022. Once a complete collection has been obtained, further testing will be done to aid decisions on cultivar choice.

Western Cape cultivar trials

The canola cultivars planted in South Africa are primarily imported from Australia. These cultivars have a resistance rating based on how they performed in blackleg resistance trials in Australia. The performance of a cultivar in such trials is dependent on the races of the pathogen present, as well as environmental conditions, and although South Africa has a similar climate to Australia, a cultivar which achieved a high resistance rating in the Australian trials will not necessarily perform the same in South Africa.

To assess the resistance of the commonly planted cultivars under local conditions, cultivar trials were conducted at Langgewens Research Farm (Moorreesburg), Tygerhoek Research Farm (Riviersonderend) and Uitkyk Farm (Riversdale) during 2021 (Photograph 2). Twelve cultivars were evaluated (Table 1).

Blackleg severity (percentage visible damage on a stem cross section) was the greatest at Langgewens (39%), followed by Riversdale (33%) and lastly Tygerhoek (19%). Due to heavy rains during the autumn of 2021, the trial at Tygerhoek had to be replanted in early June and, as a result, the plants did not develop optimally and could not be compared to the two other trials.

For the two other sites, some patterns were visible. Excluding 44Y90, all the other Clearfield® cultivars were in the top five. On the other end of the spectrum, Hyola 559TT had the highest blackleg severity in both trials. For the remainder of the cultivars, no clear relationship could be seen between the trials at Riversdale and those at Langgewens.

Cultivar resistance against blackleg cannot be utilised efficiently without knowing the race structure of the pathogen population. Studies like the one in progress can therefore contribute to better blackleg management. Apart from the work on cultivar resistance, fungicide trials are also in the pipeline, which will further provide information for an integrated approach to managing blackleg. 🌱

This project was funded by the Oil and Protein Seeds Development Trust. For more information, contact 011 234 3400 or visit www.opot.co.za.

Table 1: Resistance rating of cultivars evaluated in field trials in the Western Cape in 2021, with R-genes present and blackleg resistance grouping.

Cultivar	Blackleg resistance rating (without seed treatment)	R-genes present	Blackleg resistance group
Quartz	R	<i>Rlm1, Rlm4, LepR1</i>	ABD
43Y92	R-MR	<i>Rlm4</i>	B
Hyola 350TT	R	<i>Rlm1, Rlm4, Rlm6, LepR1</i>	ABDF
45Y93	R	<i>Rlm3, Rlm4</i>	BC
44Y90	R-MR	<i>Rlm4</i>	B
Hyola 559TT	R-MR	<i>Rlm1, Rlm4, LepR1</i>	ABD
45Y95	R-MR	Unknown	Unknown
Diamond	MR	<i>Rlm1, Rlm4, Rlm6</i>	ABF
Alpha TT	MS-MR	Unknown	Unknown
Blazer	R	<i>LepR1 (maybe also Rlm1)</i>	ADF
44Y94	R-MR	<i>Rlm3, Rlm4</i>	BC
Hyola 650TT	R	<i>Rlm1, Rlm4, LepR1</i>	ABD

R = resistant, MR = moderately resistant, MS = moderately susceptible.

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Irrigation of soya beans in the US:

A short overview

Irrigated soya bean systems are the most productive in the US, averaging over 48% more yield than dryland systems. Drought is the most damaging abiotic (non-living) stress to soya bean crops. Overcoming drought is a key factor to sustaining maximum soya bean yields, but only about 8% of US soya bean acres are irrigated. The ability to continue using irrigation will rely on maintaining the quantity and quality of ground and surface water resources.

Soya beans are a relatively drought-tolerant crop but respond well to irrigation. While irrigated soya bean acres can be found in every soya bean producing state, the largest percentage of irrigated acres occurs in the Central and Northern Great Plains, particularly Nebraska, Kansas and the Texas Panhandle.

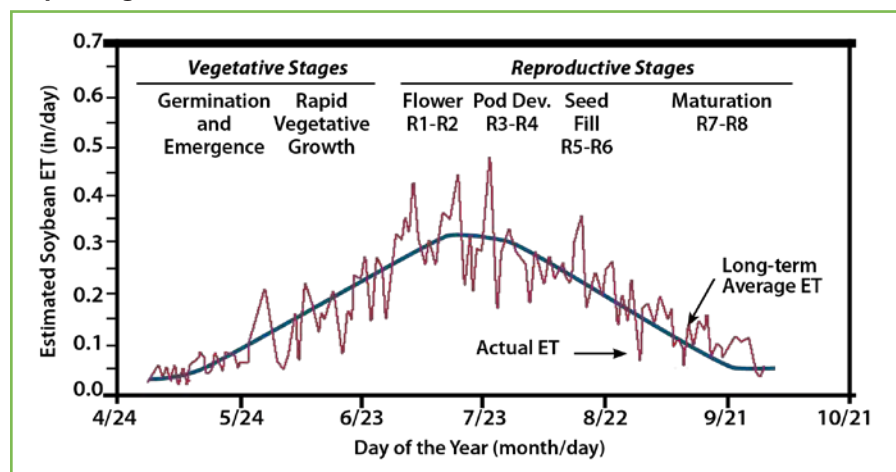
Plant characteristics

Soya beans are a relatively deep-rooted crop. In deep, well-drained soils with no restricting layers, roots can penetrate to 1,8m. As with all crops, most of the roots are concentrated in the upper half of the root zone. Managing a root zone of just below 1m (0,9m), is the general irrigation recommendation. Water use requirements, also known as evapotranspiration or ET, for soya beans range from 43 to 71cm depending on climatic conditions.

Water use rates

Daily water use varies according to the stage of growth and weather conditions. The typical peak water use rate is about 0,89cm per day as typical for all summer-grown

Figure 1: Soya bean water use of daily evapotranspiration (ET) from a well-watered crop. (Nebguide 1367 UNL).



field crops, which normally occurs near the beginning of the podfill stage (Figure 1).

Single-day peak water use rates can approach 1,2cm per day. Water use is low at the germination and seedling stages, peaks at or near the full-bloom stage, and then declines with maturity. The most critical time for adequate soil water availability is during the end of the reproductive period when podfill begins.

Soya beans produce many flowers relative to the final number of pods, so losing a few flowers to light water stress earlier in the reproductive cycle is not as critical to final productivity as the same water stress during podfill. Net irrigation requirements for soya beans in dry years range from around 35cm in western production regions to less than 12,7cm in the east. Requirements in an average rainfall year will be 5 to 10,1cm less.

and development can be satisfied by typical rainfall and stored soil water.

When full irrigation is possible, a managed allowable depletion level of 50% in the managed root zone is the recommended management guideline – the typical managed allowable depletion for most field crops. The peak water-use rate is generally later in the season than maize, which means soya beans may be used as a field acreage split with maize as a way to reduce water stress potential at tasseling for maize crop.

Irrigation scheduling using the soil water depletion method is a best management practice. Irrigation scheduling in this form can be accomplished using either soil water measurement devices (sensors/probes) or climatic-based (also known as evapotranspiration-based) irrigation scheduling. Many states provide an irrigation scheduling program. One example is the K-State Research and Extension KanSched irrigation scheduling program. Other free irrigation decision support software is also available. 🌱

Table 1: Example of soya bean water use (ET) by growth stage.

Growth stage	Water use (cm/day)
Germination and seedling	0,05 – 0,10
Rapid vegetative growth	0,10 – 0,20
Flowering to podfill (full canopy)	0,20 – 0,30
Beginning maturity to harvest	0,05 – 0,20

Source: Tacker, P and Vories, E, *Arkansas Soybean Handbook*, Chapter 8, Irrigation. MP197. www.uaex.edu.

Irrigation timing

Research studies throughout the High Plains confirm that the most beneficial timing for a limited amount of irrigation is during the latter part of the reproductive growth stages rather than earlier. This is generally true because early-season growth

This article was adapted for *Oilseeds Focus* from articles originally published on www.soybeanresearchinfo.com and www.specialtyhybirds.com.

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FOLIAR FEEDING: An important strategy for productive crop management

By Hendri Botha, International Sales and Marketing Manager, Introlab



Foliar feeding is an effective method of providing essential nutrients to plants when soil nutrient availability is limited. It is the method by which a nutrient solution is applied to the leaves of a plant, where the nutrients are absorbed and translocated within the plant to parts where required. When used correctly, foliar feeding is more environmentally friendly, target specific and more effective than soil fertilisation since nutrients can be directly delivered to the plant tissue during critical stages of plant growth.

Soil applied nutrients might become unavailable to plants due to leaching, antagonism between certain nutrients, fixation of nutrients, soil nutrient imbalances, or soil chemical properties like high or low soil pH conditions. The available nutrients provided by foliar feeding are more effectively utilised by plants, because foliar absorption is a physical and chemical process and not a biological process, as is the case with granular fertilisers. The purpose of foliar feeding is not to replace soil fertilisation, but to supplement any shortages and increase its effectiveness.

Bolstering plant growth

Foliar feeding has proven to be the most effective way of supplying plant requirements of secondary nutrients (calcium, magnesium and sulphur) and trace elements (boron, cobalt, copper, iron, manganese, molybdenum and zinc), while supplementing macro-nutrient (nitrogen, phosphorous and potassium) requirements during critical growth stages.

The primary function of foliar feeding is to delay the natural leaf senescence process, and to increase photosynthesis and chlorophyll production in the leaves. Foliar feeding targets the growth stages where the photosynthesis rate is declining, and where root growth and nutrient absorption are levelling off.

It can also be an effective influence in the early growth stages by stimulating vigorous vegetative growth or regrowth, and by maximising the yield potential by compensating for environmental stresses and poor nutrient availability during this growth period.

Key advantages of foliar feeding include:

- A highly effective method to supply essential nutrients at critical growth stages.
- Compensating for soil or environmentally induced nutrient deficiencies.
- Foliar absorbed nutrients are immediately available to the plant.
- More control with less risk.
- Easy adjustment of the crop nutrition programme during the growing season.

The primary objective of foliar feeding is for maximum absorption and translocation of nutrients. Foliar applied formulations should meet certain standards to be effective and minimise possible damages. Factors affecting the bioavailability of nutrients include:

- High solubility.
- High purity.
- Low salt index.
- Small particle size and molecular weight.

Introducing Introlab

Introlab manufactures a wide range of world-class foliar fertilisers that include aminogluconate chelated nutrients, suspension concentrate nutrients, water soluble nutrients and crop stage specific gel nutrients.

Introlab's foliar fertilisers are specifically formulated to effectively supply nutrients to the plant at critical growth stages by utilising different formulation types for specific objectives. Introlab's different formulation types enable the grower to create a complete

and tailor-made nutrition programme for each crop type, ensuring constant nutrient supply and preventing nutrient deficiencies during the growing season.

The **Intro Range** is an aminogluconate chelated foliar feeding range comprising single and multiple nutrient formulations. The **Intro Range** is a deficiency corrector and preventor as the chelated nutrients are quickly absorbed and translocated within the plant. Glycine, one of the smallest amino acids, is used to chelate the nutrients in the **Intro Range** formulations. The chelated nutrients improve absorption tempo and translocation within the plant, increase compatibility with other agrochemicals, and decrease toxicity.

The **Opty Range** consists of highly concentrated and micronised nutrients in a suspension concentrate formulation. The small particle size, <4 micron, allows for effective absorption and continuous longer lasting nutrient supply. It is recommended for use as maintenance foliar fertilisers, ensuring nutrient supply levels are maintained during growing seasons. The **Opty Range** is safe on sensitive crops due to a low salt index.

The **IntroSol Range** is a balanced, all-in-one, water-soluble fertiliser range that can be used to supplement macro-, secondary and micro-nutrients at specific crop growth stages.

The **IntroCel Range** is a new generation water-soluble gel fertiliser range that combines the benefits and advantages of water-soluble crystalline and liquid fertilisers into a single gel formulation. The **IntroCel Range** contains the correct ratios of macro-, secondary and micro-nutrients for each crop growth stage.

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Sunflower genetics:

From ancestors to modern hybrids

By Aleksandra Radanović, Dragana Miladinović, Sandra Cvejić, Milan Jocković
and Siniša Jocić, Institute of Field and Vegetable Crops, Novi Sad, Serbia

Domestication and the first steps of sunflower breeding date back more than 4 000 years. It has undergone significant changes in the past to finally find its place as one of the most significant oil crops today.

Recent advances in molecular techniques with improved experimental designs contributed to the understanding of the genetic and molecular basis underlying the architectural and phenotypic changes that occurred during domestication and improvements in sunflower breeding.

All modern domesticated sunflowers (*Helianthus annuus* L.) can be traced back to a single centre of domestication in the interior mid-latitudes of eastern North America. Today, sunflower is the fourth-most important oil crop in the world.

History and domestication

Archaeological findings show that the Native Americans started the domestication of sunflower in 4225 BC. Since the harvest of each sunflower was a special operation and any variation in the seed size was easy to see, it is logical that the plants with the largest seeds were left for planting in the following season. This was in essence a mass selection for the seed size. The cultivated sunflower as we know it today was most likely created by mass selection from the wild *Helianthus annuus* (*H. annuus*), which has small seeds and a branched stem.

The history of sunflower as an oil crop can be divided into three basic periods. The first period is the use of varieties created by mass selection, while the second is the use of varieties created by the method of individual selection, and the third, which is still present, is the introduction of hybrids in the production of sunflower.

The phenotypic changes that sunflower has undergone during domestication largely follow the domestication syndrome. These adaptations to human cultivation include a dramatic increase in apical dominance, an increase in seed size, the loss of natural seed dispersal and seed dormancy, and the loss of self-incompatibility.

Genetic studies of sunflower domestication revealed that, contrary to findings in other plant species where it was found that the phenotypic differences caused by domestication are due to a smaller number of genes with a strong effect, in sunflower there is a larger number of genes involved in domestication, with the majority of genes showing a small or moderate phenotypic effect.

Another difference between wild and cultivated sunflowers is the copy number of long terminal repeats (LTR) retrotransposons and splicing divergence.

Characteristics and composition

Achene size and shattering

Wild *H. annuus* achene is of wide obovate shape, measuring 0,29 to 3,3mm in width, and 0,41 to 6,7mm in length. Its colour is somewhat brown, with two or three dark stripes that are variable in width. However, cultivated sunflower achene is significantly larger, measuring 7 to 25mm in length and 4 to 13mm in width (*Figure 1d*).

When sunflower was domesticated, its seeds increased in size and weight, while easy seed dispersal was disabled. Direct selection for increased seed oil in early oilseed sunflower breeding programmes indirectly selected for smaller achenes and shifted the phenotype toward the wild type. Burke *et al.* associated seven and five quantitative trait loci (QTL) to achene weight and width, respectively, while only two QTLs were associated with achene length.

Chromosomes 3, 6, 9, and 10 carry QTLs for more than one achene morphology parameter, confirming the polygenic nature of these traits. Burke *et al.* and Baack *et al.* discovered two QTLs that have been associated with the domestication QTLs on chromosomes 6 and 10, however, the position of the QTLs was different in the two studies.

Concerning shattering, Burke *et al.* found QTLs on chromosomes 11 and 17 that explained 6,6 and 5% of the phenotypic variation for this trait. Both QTLs expressed a dominant mode of action (MOA) of the *cmsHA89* allele. In contrast to this study, Wills and Burke mapped two QTLs that were associated with shattering on chromosomes 4 and 10.

Oil content

The populations of wild *H. annuus* usually contain below 30% of oil in seed. The first sunflower varieties with increased oil content that were created at sunflower breeding centres in the former Soviet Union had 40 to 45% oil content. Today, most of the sunflower hybrids have 45 to 50% of oil in seed.

Burke *et al.* mapped QTL controlling differences in seed oil content and composition between cultivated and wild sunflower and used the results to guide a genome-wide analysis of genetic variation for evidence of past selection. They identified a QTL for oil content on LG4 and determined the MOA of the *cmsHA89* allele as partly recessive.

By analysing the sequence homology with *Arabidopsis* genes, these two putative domestication genes showed the highest homology with AT5G49460 and AT5G52840 genes, which encode ATP citrate lyase sub-unit B2, and have a function related to NADH ubiquinone

oxidoreductase, respectively. The third domestication gene showed homology with a gene that codes a sub-unit of pyruvate kinase, which is an enzyme that was involved in the conversion of carbohydrates to seed oil.

Oil composition

Standard sunflower oil is usually composed of polyunsaturated linoleic acid (18:2) and monosaturated oleic acid (18:1) in ratios of 70%:20%. Although the content of these two fatty acids could vary because of the environment, it is typical for sunflower oil that they jointly make about 90% of the total fatty acid content in the oil.

In cultivated sunflower, there are also traces of monosaturated myristoleic and mitoleic acids, as well as unsaturated myristic, arachidic and behenic acids. An analysis of the changes in the fatty acid content between wild and cultivated sunflower in the progeny of cultivated sunflower cmsHA89 and wild *H. annuus* (ANN1238) showed that only palmitic fatty acid content was similar between the examined cultivated and wild sunflower.

Chapman and Burke discovered that seven out of the eleven genes that underlie fatty acid biosynthesis and metabolism in wild and cultivated sunflower underwent selection (FAD2-1, FAD2-3, FAD3, FAD6, FAD7, FAB1, and FATB). The authors selected sequences that showed orthology with *Arabidopsis* for the study and analysed different desaturase and thioesterase enzymes that were involved in the fatty acid conversion pathway.

Plant architecture changes

Stem properties and height

Sunflower hybrids are typically non-branched annual plants, from 150 to 180cm in height, which are distinguished from other cultivated crops by large conspicuous inflorescence containing many large achenes.

Unlike cultivated sunflower, wild *H. annuus* is characterised by a plant height ranging from 63 to 171cm, highly branched growth form with numerous small flowering heads, and relatively small achenes that are released upon maturation (Figure 1a).

Stem diameter QTLs were found on chromosomes 1, 3, 6, 7, 11, and 17 in an F3 cross between cmsHA89 and wild *H. annuus* var. annuus individual that

was collected in the United States, while Baack *et al.* found one stem diameter QTL on chromosome 3, and Dechaine *et al.* mapped a QTL associated with stem diameter on chromosome 13 by analysing the recombinant inbred lines (RILs) derived from the same parental material as in Burke *et al.* and testing it in two different environments.

Out of all the identified QTLs, only the QTL that was mapped by Corbi *et al.* on chromosome 13 fell in the similar region as the one mapped by Dechaine *et al.* The other QTLs were mapped in different positions compared to the already identified QTLs, and were located on chromosomes 1, 3, and 9.

Leaf properties

In sunflower, there is significant variability in all the leaf characteristics (Figure 1b). There is a considerable difference in the leaf number per plant in connection to the vegetation period, as it is described that early genotypes have a lower leaf number per plant, while genotypes with longer vegetation have a higher number of leaves per plant.

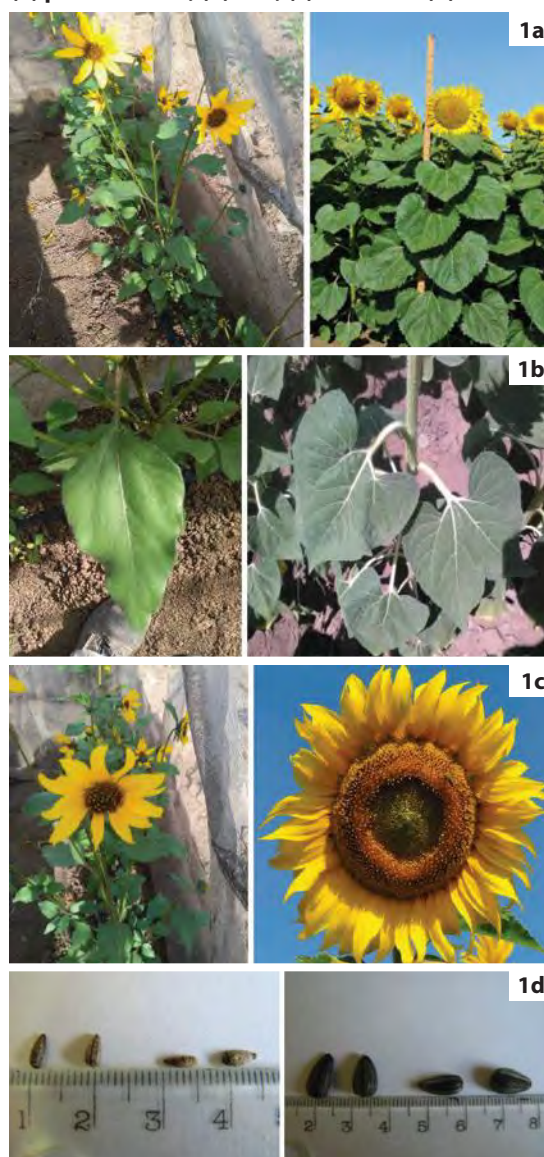
Burke *et al.* reported two QTLs on chromosomes 12 and 13 for leaf shape that expressed dominant and additive MOAs. The leaf size QTLs that were found on chromosomes 3 to 5, and 9 expressed recessive and partially recessive MOAs, while two QTLs expressed over-dominance. Three of the QTLs on chromosomes 1, 9, and 17 for the number of leaves on the main stem expressed a partially dominant MOA of the cultivated allele, while the remaining two on chromosomes 6 and 7 expressed additive and partially recessive MOAs.

Dechaine *et al.* mapped QTLs associated with leaf area while testing RILs in North Dakota and Nebraska in the United States, and found no mutual QTLs for the two locations. Among others, the authors mapped a

QTL on chromosome 5 that was present in two locations, however, it was mapped in different positions on chromosome 5.

Unlike the studies mentioned above and in which a cross between cmsHA89 and wild *H. annuus* was used, Wills and Burke used a domesticated Hopi sunflower landrace to cross with wild *H. annuus* and mapped the QTLs for several main stem leaves on chromosomes 6, 7, 9, and 15, and for leaf size on chromosomes 5, 8, 10, and 14 to 16. The QTL for the number of main stem leaves on chromosome 15 explained 57% of the phenotypic variation and was the nearest to the simple sequence repeats (SSR) marker ORS687.

Figure 1: Differences in phenotypes of wild (left) and cultivated *H. annuus* (right) in terms of the (a) plant habitus, (b) leaf, (c) head and (d) seeds.



Head properties

The domestication of sunflower significantly changed head properties. Besides being monocephalic, cultivated sunflower has a significantly larger head diameter than wild sunflower (Figure 1c). The head diameter in wild sunflower ranges from 2.4 to 8 cm, while the head diameter in cultivated sunflower falls between 20 to 30 cm.

Furthermore, there is great variability in the head shape of cultivated sunflower as determined by breeder preference and head inclination. Depending on the region where cultivated sunflower is grown, there is a significant variability of head inclination which is connected to sun damage, damage caused by birds and head rot diseases.

Baack *et al.* reported several QTLs associated with head diameter on chromosomes 4, 6, 19, and 14, of which only the position of one QTL on chromosome 14 overlapped for the two tested environmental conditions (Nebraska and Indiana), which was mapped near marker HT319.

Changes in reproductive strategy

The domestication of sunflower was marked by a loss of self-incompatibility, favouring the pollination of one sunflower plant with the pollen of another and decreased seed dormancy. These traits have been completely or partly lost during domestication and breeding, thus cultivated sunflower is self-compatible and has a short-lived seed dormancy.

Ghandi *et al.* were the first to examine the QTLs for self-incompatibility and self-pollination in sunflower. The authors used a BC1 family obtained from a cross between an inbred line NMS373 (self-pollinated, non-dormant) and wild sunflower ANN1811 (self-incompatible, dormant). They mapped S locus (self-incompatibility locus) as an incomplete dominant allele on the lower end of chromosome 17.

Burke *et al.* found two major QTLs associated with the number of selfed seeds on the lower half of chromosome 17. These QTLs explained 12.7 and 68% of the phenotypic variation, and both were found to be partially recessive.

Life cycle shift

Flowering time is one of the most important domestication traits as it influences the

success of the crop. Selection favoured consistent flowering time, however, a late flowering date was favoured in the early stages of domestication in primitive sunflower, while modern cultivated sunflower is characterised by relatively early flowering.

Burke *et al.* reported ten QTLs associated with days to flowering, five of which expressed an additive MOA. Three QTLs found on chromosomes 8 and 17 showed a dominant MOA, while the QTLs on chromosomes 4 and 7 expressed under-dominance and partial recessiveness. Lai *et al.* mapped a locus HT160 on chromosome 8. Based on homology, this locus was predicted to be the APETALA2-like protein and was previously reported as a QTL associated with flowering time and achene size.

Later, Chapman *et al.* mapped five candidate genes on chromosome 7 in the interval where the QTLs for flowering time and the number of main stem leaves were mapped previously. Two out of the five candidate genes, c1921 and c2588, that were mapped by Chapman *et al.* showed homology with the genes that code a DNA-binding with one finger (Dof)-like protein and a protein with the INDETERMINATE domain, respectively.

Dechaine *et al.* enriched a previously reported map by adding the domestication and/or improvement loci identified by Chapman *et al.* to the SSR markers that were used by Baack *et al.* and found QTLs associated with flowering time on certain chromosomes.

Blackman *et al.* conducted a comprehensive study of the different genes that have undergone changes during domestication and improvement. The authors used an integrated candidate approach by analysing the homology with genes of known function and the positions of QTLs associated with flowering times that have already been reported in the literature.

Additionally, they determined that the expression of duplicated homologs of the FLOWERING LOCUS T (FT) in sunflower has a role in sunflower domestication. Four FT-like paralogs have been isolated (HaFT1-4) in the sunflower genome. HaFT1 was under selection in domestication, while the other paralogs were selected during improvement. HaFT1-3 was

mapped on chromosome 6 and HaFT1 underlies a major flowering time QTL.

With the availability of new technologies, Mandel *et al.* mapped the QTLs associated with days to flower by use of the Illumina Infinium 10 k SNP array for sunflower and found significant associations for this trait in ten genomic regions located on eight of 17 sunflower chromosomes.

Future prospects and implications

The QTLs reported in this review are associated with major domestication traits. These QTLs can be used as diagnostic markers in tracking introgression from wild into cultivated sunflower and eliminating unwanted sequences surrounding the gene of interest during introgression.

Another application would be to identify the types of crop-like traits that are favoured in the wild if they are subjected to manipulation. Linkage maps obtained from wild and cultivated sunflower crosses can differ from a cultivated sunflower cross due to suppressed recombination, as reported by Wills and Burke, making it difficult to compare QTLs obtained in different crosses.

As QTLs are also highly environmentally dependent, all these QTLs should be further validated in different crosses and by association analysis.

The real breakthrough in sunflower molecular biology was achieved with the publishing of the sunflower genome sequence. Further insight into the domestication process would be achieved by sequencing the wild *H. annuus* genome, preferably through choosing from the population used in most of the QTL analysis of sunflower domestication, such as Ann1238.

This sequence could be further used to define the location of QTLs associated in domestication that have been previously reported to gain more insight into the important metabolic pathways, as was done with the cultivated sunflower, and enable the replacement of SSR markers with more precise SNPs. 🌱

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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 MAXIMIZE 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 MAXIMIZE 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.

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Palmer amaranth:

A threat to soya bean production in South Africa

By Prof Charlie Reinhardt, North-West University, and
Prof Juan Vorster, University of Pretoria

Palmer amaranth is the latest addition to South Africa's growing list of *Amaranthus* species (commonly known as pigweed or marog). Some of these *Amaranthus* species are indigenous to Africa, while others originate from other continents.

Before Palmer amaranth reached our shores, the most important weedy *Amaranthus* species which South African crop producers had to contend with was *Amaranthus hybridus* (commonly known as pigweed or Cape pigweed). *Amaranthus hybridus* (*A. hybridus*) is a serious problem in basically all annual cropping systems in the summer rainfall region. *Photo 1* shows a decidedly harmful common pigweed infestation on a soya bean field in the eastern Highveld region.

Recent research by the South African Herbicide Resistance Initiative (SAHRI)

at the University of Pretoria has for the first time revealed glyphosate-resistant *A. hybridus* populations in the country, specifically in Winterton in KwaZulu-Natal and Cradock in the Eastern Cape.

The prospect of having to contend with glyphosate-resistant common pigweed in glyphosate-tolerant crops is already daunting and now, added to this, there is the frightening spectre of another, even more competitive glyphosate-resistant *Amaranthus* species, Palmer amaranth. The possibility of hybridisation between common pigweed and Palmer amaranth is a real threat – the amaranth plant seen in *Photo 2* shows morphological characteristics of both these weeds.

Palmer amaranth's spread in SA

Early in 2018, Palmer amaranth was conclusively identified in South Africa

for the first time by the SAHRI research team on a farm in the Douglas district in the Northern Cape. Since then, other populations have been confirmed in the Howick and Winterton districts of KwaZulu-Natal, as well as in proximity to the Limpopo River in the Kruger and Mapungubwe national parks (Sukhorukov *et al.*, 2021).

Further afield in Southern Africa, also in 2018, a Palmer amaranth population was confirmed in Kasane, Botswana. Additional populations from other parts of South Africa are currently undergoing herbicide resistance evaluation and DNA analysis through the SAHRI research programme.

Photo 3 shows a Palmer amaranth plant. Palmer amaranth is a dioecious (sexes on separate plants) annual summer forb, originating from the desert washes and riparian areas of the Sonoran Desert, which covers large parts of the southwestern United States and northwestern Mexico. Because of its origins, it is considered pre-adapted to agricultural systems where regular soil disturbances and nutrient fluctuations are the norm. Based on its origins and adaptation to harsh environmental conditions, Palmer amaranth can also flourish in most parts of Southern Africa, particularly in annual summer crops.

In the United States, increased seed pressure attributed to long-distance grain, feed and machinery transport have been linked to the range expansion of Palmer amaranth from the natural habitats which it has occupied for thousands of years.

Climate change, soil disturbances and elimination of competitor species through the use of highly effective herbicides (e.g. glyphosate) are also coupled with the rapid expansion of Palmer amaranth infestations across most states in the ecologically brief time frame of ten to



A crop-debilitating infestation of common pigweed in soya bean in the eastern Highveld region.

15 years (from approximately 2000 to 2015). A similar scenario exists in South Africa.

A near-inexorable weed

Among the alarming characteristics of Palmer amaranth is its high fecundity – one female plant can produce up to 500 000 seeds which can survive in soil for about three years, and seeds show staggered germination over several months. Plants grow at an extremely high rate, which explains the strong competition ability of this species.

A two-year field study by Bensch *et al.* (2003) in the United States found that Palmer amaranth caused up to 78,7% yield loss in soya bean at a density of eight plants per metre of row, whereas common waterhemp (*A. rudis*) and redroot pigweed (*A. retroflexus*) caused 56,2% and 38% yield loss, respectively. In the same study, maximum seed production for Palmer amaranth, common waterhemp and redroot pigweed was 32 300, 51 800, and 9 500 seeds per square metre, respectively.

Palmer amaranth infestations may appear innocuous from the onset when relatively few plants occupy a site, but once critical seed numbers have accumulated in the soil



A suspected hybrid of Palmer amaranth and common pigweed. A SAHRI research team has confirmed glyphosate resistance to this population in KwaZulu-Natal. Research is ongoing.



A Palmer amaranth female plant which could be mistaken for other amaranth species. A guide to identifying Palmer amaranth is available from the authors.

seedbank, there will be a veritable explosion of plant numbers. This critical period lasts two to five years, or over entire summer seasons.

Another two-year study (Klingman and Oliver, 1994) in the United States reported that soya bean canopy cover ranged from 77cm in the weed-free check, to 35cm in plots with ten Palmer amaranth plants per metre of row at twelve weeks after crop emergence. Soya bean yield reduction was 17, 27, 32, 48, 64 and 68%, respectively, for Palmer amaranth densities of 0,33; 0,66; 1; 2; 3,33; and ten plants per metre of row. At the latter density, the Palmer plants competed against one another (intra-species competition), which explains the relatively small increment (64 to 68%) in yield reduction between 3,33 and ten plants per metre of row.

In January 2022, the number of herbicide resistance cases reported worldwide for Palmer amaranth was 70 (Source: www.weedscience.org). This weed has proven resistance to a staggering total of nine extremely important herbicide modes of action (MOA) or sites of action (SOA).

The following Herbicide Resistance Action Committee (HRAC) groups are implicated:

- Group 9 (EPSPS inhibitors, e.g. glyphosate).
- Group 2 (ALS inhibitors, e.g. chlorimuron-ethyl and imazethapyr).

- Group 3 (microtubule assembly inhibitors, e.g. trifluralin).
- Group 5 (Photosystem 2 inhibitors, e.g. atrazine).
- Group 27 (HPPD inhibitors, e.g. mesotrione).
- Group 14 (PPO inhibitors, e.g. fomesafen).
- Group 4 (auxin mimics, e.g. 2,4-D and dicamba).
- Group 15 (long chain fatty acid inhibitors, e.g. metolachlor).
- Group 10 (Glutamine synthetase inhibitors, e.g. glufosinate ammonium).

The worst-case scenario in the United States regarding herbicide resistance of Palmer amaranth, was recorded in 2016 in Arkansas in cotton and soya bean. Multiple resistance to five SOAs was recorded, i.e. HRAC groups 2, 14, 9, 3, and 15. In this case, the herbicides implicated were flumetsulam, fomesafen, glyphosate, imazethapyr, pendimethalin, and s-metolachlor. The most common herbicide resistance of Palmer amaranth in the United States is multiple resistance to the combination glyphosate and ALS-inhibitors.

Only one possible non-resistant SOA

Weed resistance to herbicides registered in soya beans in South Africa was discussed by Prof Charlie Reinhardt in the July 2015 edition of *Oilseeds Focus*

in the article titled, "Weed control in soya beans – make-or-break herbicide choices". Twenty-four different herbicides (actives, not products) belong to the eight HRAC groups registered in South African soya bean.

Superficially viewed, this represents a healthy situation regarding diversity in herbicide MOA/SOA, because the use of herbicide combinations representing multiple MOAs/SOAs is universally regarded as one of the cornerstones of a successful resistance management strategy. However, of the eight SOAs available to soya bean producers, only one – Group 11 (carotenoid inhibitors) – has not yet been linked to Palmer amaranth resistance globally.

Even more disconcerting for South Africa, is the fact that all those herbicides that control mainly broadleaf weeds in soya bean have a record of resistance in one or the other weed species somewhere in the world. Moreover, many of those weeds are damaging to crop production in this country as well.

Research into herbicide resistance

Researchers in the SAHRI, principally the authors of this article, have conducted research into herbicide resistance in Palmer amaranth since it was first confirmed in South Africa in 2018. To date, 14 herbicide actives have been assessed by the SAHRI for their ability to control this weed.

Resistance to two herbicides, glyphosate and chlorimuron-ethyl, was confirmed while varying tolerance levels were recorded for other herbicides; the upshot is that several of the herbicides tested, gave good control. Prof Vorster also determines mechanisms of herbicide resistance in weeds, and conducts DNA analysis for confirmation of plant identity. The information generated will thus assist with the design of an effective weed management strategy for this weed in South Africa.

The authors encourage readers to contact them about sightings of real or apparent Palmer amaranth. Available on request from the authors is a guide for identification. 📄

Prof Charlie Reinhardt is a professor in the agricultural sciences programme at North-West University (Potchefstroom campus), and research leader in the SAHRI at the University of Pretoria. He can be reached at 083 442 3427 or dr.charlie.reinhardt@gmail.com. Prof Juan Vorster is an associate professor in the department plant and soil sciences at the University of Pretoria, and research leader in the SAHRI. He can be reached at 079 110 9596 or juan.vorster@up.ac.za.



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Clearfield® Plus: Your alternative choice for weed control and crop rotation



By Corné van der Westhuizen, agronomist, North West, Pannar Seed (Pty) Ltd

Clearfield® Plus technology offers producers an alternative solution to control weeds while benefiting from economic, time and yield gains. The Clearfield® Production System combines high-yielding sunflower hybrids with broad-spectrum herbicides with a different mode of action (MOA) that delivers efficient weed control.

Clearfield® Plus sunflowers are classified as non-transgenic. The inherent herbicide resistance is a natural mutation. The original Clearfield® trait in sunflowers is based on a natural acetohydroxy acid synthase (AHAS) mutation discovered in 1996 in a wild sunflower growing in a soya bean field in the United States.

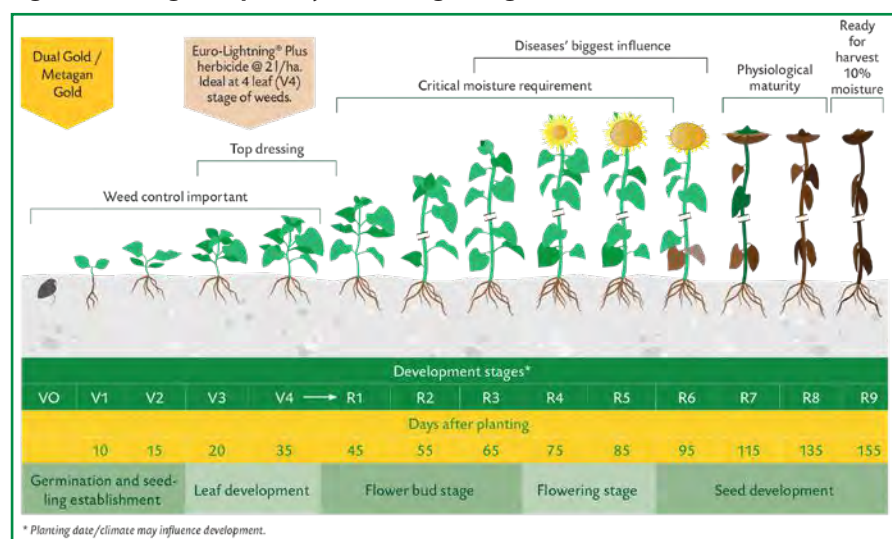
The Clearfield® Plus Production System for sunflower delivers important agronomic benefits, which include:

- Crop rotation.
- Superior breeding efficiency.
- Greater herbicide tolerance.
- Improved weed control.
- Potential for higher grain yield.

Invest in leading genetics

The Pannar® brand sunflower package with the Clearfield® Plus trait provides stable performance with good risk management. The Euro-Lightning® Plus herbicide provides effective post-emergence control of a variety of broadleaf weeds and grasses and delivers consistent post-emergence efficacy against broadleaf weeds, due to better retention and adhesion of active matters (*Figure 1*).

Figure 1: Timing and quantity of Euro-Lightning® Plus herbicide use.



Pannar brand hybrids with the Clearfield® Plus trait are only registered for the use of Euro-Lightning® Plus herbicide (Reg. No. L10316). Pannar does not support the use of any other post-emergent herbicide on our Pannar brand hybrids with the Clearfield® Plus trait that have not been tested or proven in official qualification trials.

The Clearfield® Plus programme

- For successful control, apply at the two to six-leaf stage of weeds. The timing of Euro-Lightning® Plus should be completed by 32 days after planting.
- Prior to the use of Euro-Lightning® Plus, spray tanks, booms and nozzles must be thoroughly cleaned and decontaminated of all previous spray residues.
- Poor water quality: Only use a flowable (50%) high-quality ammonium sulphate

at a 2% dilution to ameliorate the water before adding Euro-Lightning® Plus. Do not use any additional wetters, spreaders or other adjuvants. Do not mix with organophosphate or carbamate insecticides.

- Soil application: 2 l Euro-Lightning® Plus at 150 to 250 l of water per hectare.

Always follow grain marketing, stewardship practices and herbicide label directions. Clearfield® Plus sunflower hybrids are tolerant to Euro-Lightning® Plus herbicide; this is indicated by the letters 'CLP' in the seed product code. Other crops, including conventional sunflower hybrids that do not contain the Clearfield® Plus trait or have confirmed imazapyr tolerance, will be severely damaged if unregistered imazapyr-based herbicides are applied.

Table: Euro-Lightning® Plus herbicide recommended waiting periods at 2 l per hectare.

Subsequent crops	Waiting period
Pannar brand sunflowers with the Clearfield® Plus trait	None
Wheat	Four months
Maize (all maize-producing areas, including irrigation), dry beans and soya beans	Nine months
All other crops	20 months

Valid only if the correct amount of Euro-Lightning® Plus herbicide is applied and a minimum of 350 mm of rain falls.

The unique Clearfield symbol, Clearfield® Plus and Euro-Lightning® Plus are registered trademarks of BASF. For more information, contact Corné van der Westhuizen at 082 570 8240 or corne.vanderwesthuizen@pannar.co.za.

Extrusion-based oilseed processing methods

By Wilmot Wijeratne, Insta-Pro International, Tong Wang,
Iowa State University, and Lawrence Johnson, Iowa State University

Oilseeds occupy an important place in global agriculture by providing vegetable oils and high-protein meals for food, feed and industrial uses. The leading oilseed crops by volume of world production are soya beans, cottonseed, groundnut, sunflower, canola, coconut and palm. Soya beans constitute the largest share of the world oilseed supply, accounting for 57% of global production from 2001 to 2002.

The oil content of oilseeds varies considerably among crop species, cultivars within species, and the agroclimatic conditions under which they are grown. The economic exploitation of oilseeds begins with the primary process of separating oil and protein meal. The technology of oil separation (Table 1) has progressed from primitive manual methods to mechanical methods, and to chemical methods using organic solvents. Today, solvent extraction using hexanes is the method of choice for large-scale oil extraction.

Mechanical and hydraulic devices

In the early phases of development, heat was used to condition oilseeds for extraction. Heat conditioning dries the seed, denatures the protein, and reduces the viscosity of the oil. Oilseeds are crushed using mortar and pestle, followed by steaming in open vessels.

The steamed mass was packed while hot into sock-shaped baskets of intricately woven cane. The basket was held inside the borehole of a large log. The oil was pressed out by driving a wedge between the basket and the side of the borehole.

The next development in oilseed extraction technology was hydraulic pressing devices. High-oil bearing seeds were dry heated in open pans or in steam-jacketed vessels. The material was then pressed in perforated baskets by gradually applying hydraulic pressure.

Screw presses

The next development occurred around 1908 with continuous screw pressing, a practice that is still prevalent outside the United States. The screw press consists of a flighted screw rotating within a slotted barrel. It is also often referred to as an 'expeller'.

The barrel is of fixed diameter and the root diameter of the screw increases from the feed end to the discharge end. This design achieves increasing pressure by compensating for volume reduction due to product compaction, thereby achieving oil removal through the slotted barrel while retaining the partially defatted solid mass within the barrel.

Continuous screw presses have been used in two ways in oilseed extraction for over 80 years. The first is full-press operation, where the oilseed, after heat conditioning, is pressed one or more times through the same press or through several presses installed in series. In these cases, the screw press is the sole means of extraction.

Solvent extraction

With solvent extraction, soya beans are prepared by cleaning, drying, tempering, cracking, dehulling, conditioning and flaking. The flakes are extracted using an organic solvent, usually a petroleum distillate high in n-hexane. The advantage of this process is high extraction efficiency, with the residual oil in the meal potentially reduced to 1 to 2%.

Solvent extraction is well suited for extremely large-scale operations with the associated economies of scale. As the cultivation of soya beans expanded tremendously over the past half-century,

Table 1: Quality characteristics of soya bean meals recovered in commercial practice by different oil extraction processes.

Property	Processing method		
	Extruding-expelling	Solvent extraction	Screw pressing
Moisture (% as is)	6,9	11,7	11
Oil (%) ^a	7,2	1,2	5,6
Protein (%) ^a	42,5	48,8	43,2
Urease (ΔpH)	0,07	0,04	0,03
KOH solubility (%)	88,1	89,1	61,6
PDI (%)	18,1	44,5	10,6
Rumen bypass (%)	37,6	36	48,1
Colour (Hunter L)	65,8	69,1	51,5
Trypsin inhibitor (mg/g)	5,52	5,46	0,03
Trypsin inhibitor (TIU/g)	12 250	5 275	2 000

^aAt 12% moisture basis.

solvent extraction technology was able to handle the ever-increasing crop volume.

Traditional extruders

Extruders are mechanical devices in which a feed material is transported by a screw rotating within a closed barrel under varying conditions of heat, shear and pressure, and then discharged through the openings in the optimal geometry for the desired product. These machines are used in processing food, feed and industrial products. Extruders vary widely in design, function, capabilities and cost.

Expanders for solvent extraction

Two types of extruders have found applications in the oilseed processing industry. The first type is the class of extruders called expanders. The general design of the expander consists of an unsegmented barrel housing a worm screw with interrupted flights. Expanders are provided with needle valves at the flight interruptions to inject water or steam into the product stream (usually flakes).

The expander converts flaked materials into porous collets that are much denser than flaked oilseeds and allow more material in the fixed volume solvent extractor. This transformation increases the throughput capacity and efficiency of subsequent solvent extraction.

Interrupted flight expanders are used ahead of solvent extractors in many soya bean processing plants. The original design for expanders was not capable of forming collets from high-oil bearing seeds. This was due to the accumulation of oil within the closed barrel, causing slippage and unsteady mass flow. A new design called the Hivex Expander, which married an expander to a screw press, was developed by Anderson International to remove part of the oil from the expander barrel.

Dry extruders for feed applications

These are high-shear extruders running at screw speeds of about 600r/pm. They fit the needs of small-scale processing operations in remote places where utilities such as steam sources may not be readily available.

Cooking soya beans in dry extruders results in full-energy soya beans as all the original fat is present. Full-energy soya beans have the advantage of being not only a good source of protein, but also a

generous source of metabolisable energy from the oil. Proper heat processing denatures protein and inactivates natural soya bean protease inhibitors (trypsin inhibitors), thereby maximising the qualities of protein and energy in soya beans.

Accepting new technologies

Oilseed crushers are facing a delicate balance between control of hexane emissions and containment of energy costs. The 1990 *Clean Air Act* caused much concern regarding hexane emissions. n-Hexane, the main component of the distillate fraction known as “hexanes,” is one of 189 hazardous air pollutants listed in the *Clean Air Act*, and hexane is regulated as both a criteria pollutant and a hazardous air pollutant.

The emission limit for hexane as a criteria pollutant is 49,6 tons per year and as a hazardous air pollutant is 4,9 tons per year. Exceeding either limit requires a federal operating permit and an annual fee based on the level of hexane consumption.

The application of extrusion technology in oilseed extraction has received considerable attention during the past 15 years. Much of the development has taken place in the soya bean processing industry. Soya beans have become increasingly important as a food source in meeting acute nutritional needs around the world, especially in developing countries.

In some countries, soya bean production is practiced on small farms over widely scattered areas. The infrastructure for collecting, handling and transporting seed to a central processing facility is unavailable and impractical. Under these circumstances, new technologies for small-scale operations on a decentralised basis has become a necessity.

There has also been a new awakening on the part of consumers with respect to health and organic foods. With the advent of transgenic soya beans (genetically modified organisms, or GMOs) to achieve resistance to certain herbicides, demands for certifiable identity preserved, non-GMO soya beans and their oil and protein products for food and feed, have grown.

Low-linolenic soya beans (<1% linolenic acid) developed at Iowa State University are one example. This oil does not require

partial hydrogenation with attendant production of trans-fatty acids to achieve good oxidative stability. Trans-fatty acids will soon have to be labelled as fat.

Large-scale solvent extraction plants find it, in most cases, technically and economically infeasible to preserve the identity of specialty soya beans during processing. Their scale is usually far too great for the available supply and demand for these products. Typical soya bean solvent extraction facilities have crushing capacities exceeding 3 000MT per day.

The high capital costs to control hexane and meet environmental emission and safety requirements require these plants to have large capacities to be competitive. Therefore, technologies to process soya beans without using solvents and to be consistent with identity preservation have become necessary. Processing without solvents is also an attractive proposition based on environmental considerations because of increasing pressures to reduce emissions of organic compounds.

Mechanical oil extraction

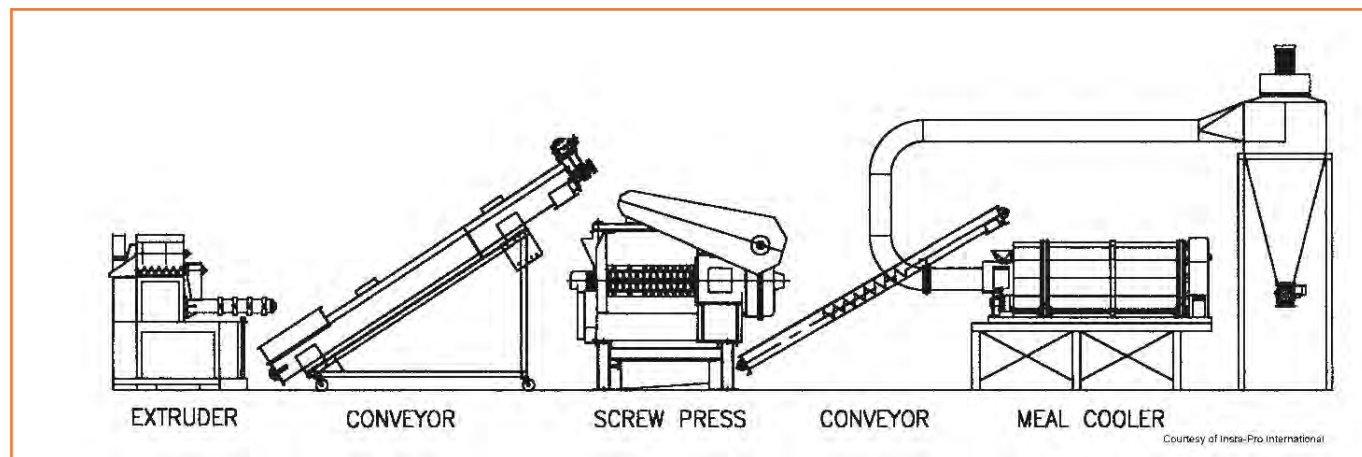
Nelson *et al.* in 1987 reported the use of dry extrusion as an aid to mechanical expelling of soya beans. They reported that when coarsely ground soya beans were processed in a dry extruder, the material discharged was in a semi-fluid state when the extrusion temperature was about 121 to 135°C. They pressed the hot extrudate in a hydraulic press as well as several pilot-plant models of continuous screw presses.

When the extrudate was pressed immediately after exiting the extruder, it was possible to press out the oil easily and efficiently. However, upon cooling, the extrudate turned into a dry meal. Pressing at this stage resulted in drastic reduction of oil yield.

The authors reported 71,8% extraction of oil in a single pass through the extruder and screw press system (*Figure 1*). The residual oil content in resulting press cake was 5,8 to 9,7%. Another significant finding was that the throughput capacity of one of the presses tested was 125 to 135kg/h of extrudate, compared with the manufacturer's rated capacity of 39kg/h for pressing whole soya beans.

Nelson *et al.* postulated that increased throughput capacity was due to the functions of grinding, heating and release

Figure 1: Schematic of an extruder screw press system.



of oil by the extruder before entry into the screw press. In an effort to produce low-fat soya flour suitable for human consumption, they proceeded to extrude and press dehulled soya beans. The trypsin inhibitor activity in raw soya beans was reduced by 91% due to the heat exposure during the extruding and screw-pressing operations.

Scaling up mechanical processing

Nelson and his colleagues collaborated with Insta-Pro International, the manufacturer of dry extruders, to scale up the extruding and screw-pressing process. The process became known in the trade as Express Systems, a registered name of Insta-Pro International. Among academicians, this process is often referred to in the scientific literature as extruding expelling.

Extruding-expelling system

The extruder screw is assembled on a central keyed shaft using several screw segments. The root diameter of the screw is constant. The pitch of the screw segments is variable so that the screw assembly can be configured to exert more or less shear, depending on the material being processed and the shear desired.

Shear locks, also called steam locks, are placed between the screw segments. These are discs that have a straight face on one side and are bevelled on the other side with radial grooves. The shear locks are installed with the bevelled side facing the feed end of the extruder. These locks are made in different diameters and land lengths. They impose restrictions in the path of the material being processed and thus generate mixing and shearing.

The clearance between the land of the shear lock and the internal surface of the barrel can be changed by choosing shear locks with certain diameters. The larger diameter shear locks provide a tight screw configuration resulting in high shearing rates. The screw assembly is held in place by a nose bullet with reverse threads screwed into the end of the shaft. The barrel is assembled in segments over the screw, and these segments are secured with clamps.

Unlike most other extruders, the barrel segments in the dry extruder are not jacketed because all the heat of cooking is generated internally by friction. This reduces manufacturing costs. The internal surface of the barrel is rifled to promote mixing and shearing. The discharge end of the extruder is connected to an end cap, which accepts dies of the desired size and shape. The die, also called the nose cone, is threaded into the end cap. Its inner face is bored in a conical shape to complement the geometry of the nose bullet. The die can be moved toward or away from the nose bullet while the extruder is operating.

The processing temperature profile is controlled by selecting the screw segments, shear locks and dies appropriate to the material being processed. A tight configuration is required to process soya beans because the oil in the beans acts as a lubricant. The die can be moved back and forth to achieve minor adjustments to the process temperature profile while the machine is operating.

Extruding

Whole or dehulled soya beans at normal field moisture content (9 to 13%) are continuously

fed to the extruder. The extruder operates at screw speeds of approximately 600r/pm. During passage through the barrel, the material is sheared, compressed and heated. Heat is generated purely by the dissipation of mechanical energy.

The temperature and pressure increase gradually, reach a peak at the die, and drop drastically upon exiting the die. The average residence time of the material within the extruder barrel is less than 30 seconds. The temperature profile can be varied as desired by making equipment changes. The highest temperature at the die end is adjusted to 160°C when the processed soya bean meal is to be used as an end product.

Shearing forces exerted by the dry extrusion system disrupt the cellular structure. Upon exiting the die, the material is suddenly released to the atmospheric pressure environment. This sudden decompression results in explosive disruption of the cell tissue.

Screw pressing

The extrudate exiting the extruder is in a semi-fluid and frothy state, while the oil is free within the matrix. Upon cooling, the oil is absorbed back into the protein matrix and the material becomes a dry and mealy mass. In order to extract the oil, the extrudate must be pressed immediately after extruding. There is a progressive loss of oil extraction efficiency upon cooling of the extrudate. The soya bean extrudate is conveyed immediately and continuously into a screw press, where the oil is pressed out.

The physical properties of the soya bean extrudate coming out of the

extruder are very different from those of cracked or whole oilseeds. The particle size of extrudate is also much smaller and the bulk density of the material is lower. Therefore, the pressing worm designed to extract whole or cracked oilseed will not perform well with soya bean extrudate.

It must be modified to provide more aggressive transport and the higher compression demanded by extruded material. With the proper combination of extruder and screw press, soya bean and cottonseed extrudates are pressed in one pass through the press.

It must be realised that both the oil and meal coming out of the extruder-expeller system are at elevated temperature depending on the processing parameters. Both the meal and oil must be cooled to near room temperature before they are sent to storage. The protein-rich meal that comes out of the press in the form of press cake is declumped by using a roller mill and is passed through a meal cooler.

A simple meal cooler design consists of a slowly rotating inclined drum through which a stream of ambient air is drawn at a controlled rate. The meal tumbles as it

travels down the inclined drum while air is drawn counter-current to the path of the meal. The air picks up heat from the meal and passes into a cyclone separator, where entrapped fine material is recovered, and the warm air is exhausted.

The oil stream exiting the screw press carries small quantities of protein meal particles known as foots. The coarse particles are removed by passing the oil through continuous screening or settling basins. In large-scale operations, decanter centrifuges may also be used to separate the foots on a continuous basis. The foots can be recycled to the extruder to reclaim oil and meal.

The presence of any foots in the oil imparts a cloudy appearance and forms sediments in storage tanks. The oil stream must be cooled before being placed into storage in order to maintain oil quality. Plate heat exchangers or tubular heat exchangers using water as cooling medium may be used for this purpose.

Future prospects

The future for the extruding-expelling process seems to be bright as a means of

processing identity preserved oilseeds into specialty oils and meals. The low cost of constructing plants and the reduced safety issues are additional advantages. There are now over 150 extruding expelling plants around the world and over 65 plants in the United States and Canada, with most processing soya beans.

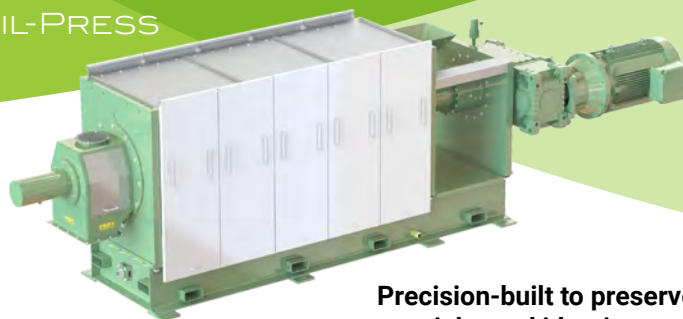
As soya bean producers recognise opportunities for adding value to their crops and as consumers recognise the enhanced properties of soya products and health advantages of increased soya protein consumption, the extruding-expelling process will likely become more widely used. 🌱

This article has been shortened for use in *Oilseeds Focus*.

To read the original article, visit the Iowa State University's Digital Repository at <https://dr.lib.iastate.edu/home> or send an email to one of the authors, Tong Wang, at tongwang@iastate.edu.

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Sunflower scenarios for the new season: International perspective

By Ikageng Maluleke, agricultural economist, Grain SA

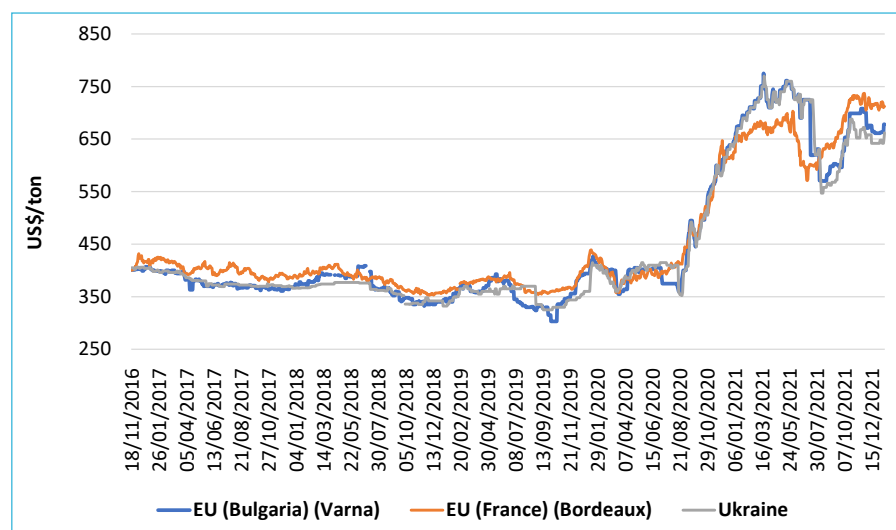
According to the United States Department of Agriculture (USDA), global sunflower production is anticipated to be at a five-year peak of 57,3 million tons. The vegetable oil market is currently facing a situation where there is subdued demand and limited supplies for the early months of 2022.

According to Oil World, exports of sunflower oil and meal have thus far been reduced in the season due to lower than expected crushing in Ukraine and Russia, caused by reserved selling by producers who are now holding back record stocks of sunflower seed. The stocks will likely move into the market in the second half of this season.

A closer look at the bigger picture

Iran banned soya bean oil imports effective from March 2022. This will trigger changes in trade flows, with more imports of sunflower oil expected in the

Figure 1: International sunflower seed export prices. (Source: International Grains Council)



country. It is expected that sunflower oil as a feedstock for biodiesel, will increase in Europe due to demand rationing of other oils and restrictive policies regarding palm oil and used cooking oil.

Exports of sunflower meal were smaller than expected in late in 2021 compared to the year before. This may be attributed to some logistical issues, which resulted in an accumulation of stocks. China remains the key destination for sunflower meal in recent months. Global sunflower seed stocks at the end of the 2021/22 season are forecast to increase by almost 10%, but remain within the five-year average.

The scale and timing of producer sales are major factors in terms of price determination for both sunflower seeds and their derivatives. High prices in international sunflower seeds are expected to continue in 2022 after unprecedented increases in 2021 (Figure 1), supported by bullish fundamentals and the shortage in vegetable oils.

Local perspective

According to the October report of the Crop Estimates Committee (CEC) on intentions to plant, the expectation is that the intended plantings of sunflower could increase to a four-year high by 78 000ha

Figure 2: South African sunflower oil imports. (Source: South African Grain Information Service)

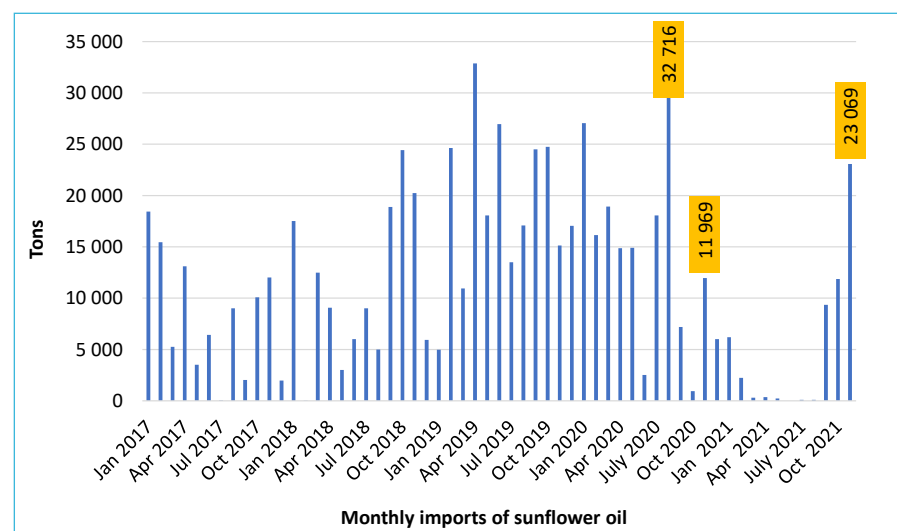
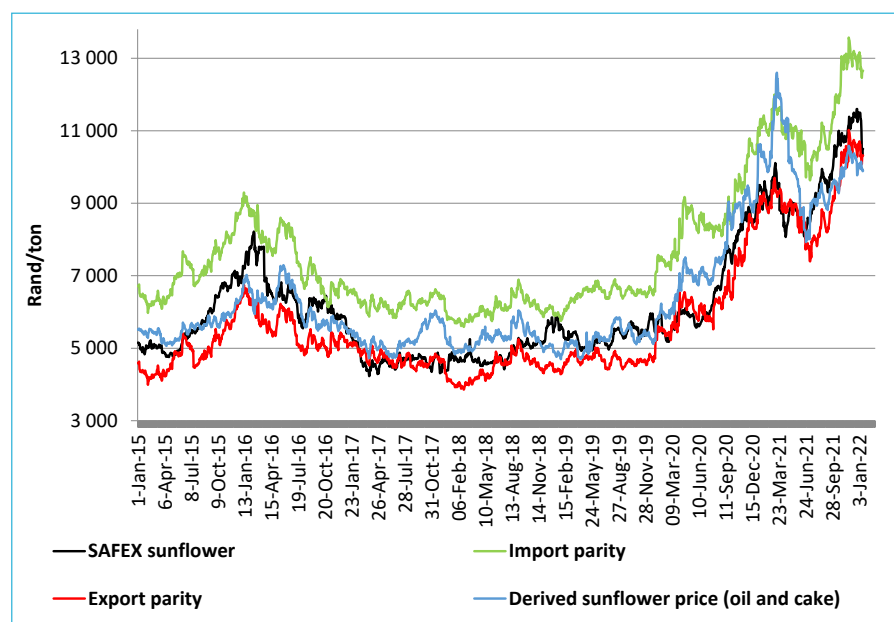


Table 1: The supply and demand for sunflower in South Africa. (Source: Grain SA)

	CEC 9th estimate	Low yield	Avg yield	High yield
2021/11/29	2021/22*	2022/23**	2022/23**	2022/23**
Marketing year		Scenario 1	Scenario 2	Scenario 3
Area planted (x1 000ha)	478	556	556	556
Yield (ton/ha)	1,5	1,3	1,4	1,6
CEC crop estimate ('000 ton)	677	723	778	889
Commercial supply	'000 ton	'000 ton	'000 ton	'000 ton
Opening stocks (1 March)	61,4	27,6	27,6	27,6
Commercial deliveries	677	693	748	859
Imports	0,5	-	-	-
Total commercial supply	739	720	776	887
Commercial demand				
Commercial consumption				
• Food	1,8	1,8	1,8	1,8
• Feed (full-fat soya)	5,65	5,5	5,5	5,5
• Crushed for oil and oilcake	700	680	720	830
Total South African soya bean demand	707	687	727	837
Other consumption	4	6	6	6
Exports	0,2	-	-	-
Total commercial demand	712	693	733	843
Carry-out (28 February)	28	27	43	44
Pipeline requirements	88	86	91	105
Surplus above pipeline	-61	-59	-48	-61
Carry-out as a % of South African consumption	4%	4%	6%	5%
Carry-out as a % of total commercial demand	4%	4%	6%	5%

Figure 3: Prices of sunflower seed from the European Union delivered in Randfontein. (Source: Grain SA)

(16,32%) compared to the previous season, from 477 800 to 555 800ha. This comes as no surprise, given the price incentive for sunflowers as well as the excessive increases in input prices, which usually create a shift from maize to oilseeds. However, it is not advised that producers plant oilseeds without applying fertiliser, especially if long-term effects are considered.

With the CEC report as background, *Table 1* illustrates different scenarios that could occur in the new season based on low, average or high yields. The most likely scenario is that of an average yield (scenario 2). With this in mind, production can be around 778 000 tons, and given total commercial demand of about 733 000 tons, the carryover stocks will be moderately low at 43 000 tons, which would create a deficit in terms of pipeline requirements. This situation could likely keep local prices strong.

Sunflower oil imports increased to a 15-month high in November 2021 (*Figure 2*), all from Europe. Between September and November 2021, sunflower oil imports doubled compared to the same period in 2020. South Africa currently

faces declining sunflower seed stocks and therefore reduced crushing by 39% compared to 2020, which will keep oil import requirements high until harvest time.

Sunflower seed and its derived products have been trading at export parity for the second half of 2021 (*Figure 3*). At the time of writing, the weather both internationally and locally remained unpredictable with drought in certain parts of South America, while other areas were inundated with floods. South Africa is also in a predicament where most areas were receiving an influx of rain, causing flooding in most parts of the country. Given both international and local fundamentals as well as the uncertain weather conditions, indications are that sunflower and its derived products could remain high for 2022. 🌱

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Reviewing technologies and devices for drying grain and oilseeds

By Jalolitdin Pakhritdinovich Mukhitdinov and Elyorbek Xasanovich Safarov, Tashkent State Technical University, Uzbekistan

Sunflowers are one of the most widely grown oilseeds in several countries. Oil-bearing sunflower seeds, after harvesting, are characterised by low flowability, high humidity and low mechanical strength of the husk. Sunflower seed is distinguished by its heterogeneity in size, meaning the difference in mass and moisture.

The moisture content of harvested sunflower seeds can range from 15 to 50%. Timely drying is necessary to preserve seed quality and prevent irreversible physical and chemical changes in the grain.

The distinctive feature of freshly harvested oilseeds, particularly sunflower seeds, is their increased instability during storage. One of the main ways to prepare oilseeds for long-term storage, which is the most important factor affecting the energy consumption and processing quality of oil-bearing seeds, is drying.

Purpose of drying

The purpose of drying is to process the initial raw material into an industrial material with improved biological, physical, chemical and mechanical properties. However, the structure of specifically sunflower seeds during drying, requires distinctive thermo-humidity conditions and modes. Therefore, grain dryers are used.

The uniformity of dried seeds predetermines the duration of storage without self-heating or other undesirable effects. Additional losses during storage of raw materials can be attributed to weak logistics and infrastructure. Therefore, the creation of new – or modernisation or processing of existing grain dryers to supply high-quality, biologically

complete, environmentally friendly, capable of maintaining the organoleptic, nutritional, and sowing qualities of seeds – require urgent attention.

These indicators largely depend on the quality of heat treatment. At the same time, the task should be solved not only to improve the quality of the final product, but also to increase the productivity of the devices, their versatility and to reduce the cost of production.

A large variety of materials which are dried are necessary for the proper selection of a drying plant and drying technology. Currently, there are many different drying technologies and apparatuses for each of them, which makes a comparative analysis very difficult.

Drying processes

Modern drying installations can be classified according to a number of characteristics. The state of the grain layer, which affects the main patterns in the drying process, determines the main characteristic of the drying installation. In the convective drying method, the moisture contained in the material to be dried moves from the core towards the surface of the material, washed by heated air, which transfers its heat to the material to be dried, and creates a temperature gradient.

Under the influence of this gradient, moisture moves in the direction of the heat flow. Regardless of the drying method, the directions of moisture movement can either coincide, or thermal moisture conductivity will resist the evaporation of moisture from the material.

Only under the condition that the surface temperature of the material to be dried is less than the temperature in

the core, is it possible for the direction of moisture movement to coincide.

Mine dryers

A distinctive feature of this type of dryer is the design simplicity, high productivity and ease of use. Installations are of both stationary and mobile types. There is a fairly large number of types of these dryers, subdivided into direct flow and recirculation. The disadvantage is the uneven heating of the material being dried, which can have a significant effect on seed performance.

There are several inventions and patents which deal with increasing the efficiency of installations of this type. Thus, in operation it is proposed to use the lower working chamber of the dryer as an additional drying zone during grain cooling.

The drying quality of loose materials is proposed to be improved by reducing the non-uniformity of drying achieved by dividing the material flow before inversion into two parts, mechanically mixing it and adjusting the speed of gravitational movement. The disadvantage of the apparatus is that the shaft-modular design does not ensure heating uniformity and grain cooling.

There are significant specific energy costs. Pollution due to the release of the drying agent into the environment should be eliminated by perforating the outer walls of grain channels, installing an external housing for recirculation of spent coolant and installing cyclones for cleaning heat carriers, after which the fluxes of spent heat carriers will be returned to the drying and cooling zones, respectively, to form recirculation circuits, thereby reducing energy costs.

Energy saving and more complete

exhaustion of the coolant are achieved by equipping the unit with an internal separating cylinder, a movable regulating cylinder and a movable ring. The analysis of the mine type dryers shows that it is continuously being improved. However, the main disadvantages inherent in this type of installation remain.

Conveyor dryers

Conveyor dryers are the conveyor chambers with conveyors located inside. The dryers are equipped with ventilation equipment where the product is continuously dried at atmospheric pressure. The drying agent is clean-air heated in steam or fire heaters. In this case, the air movement can be organised in the form of a counter- or crossflow to the direction of the material to be dried.

The air temperature depends on the product type and its initial moisture content. A layer of wet material fed to one end of the belt moves along the belt, and the dried layer is removed from the opposite end of the belt.

In operation, the drying chamber is divided into drying, cooling and drying zones. The dryer is equipped with two infrared radiators, a system for automatic control of radiation power depending on the moisture content of the material, humidity and temperature sensors, a hopper dispenser, and a mechanism for adjusting the thickness of the layer of loose material.

To increase drying efficiency, the drying unit is supplemented by a conveyor with heat fans installed along it with permanent magnets installed on different sides of the fan blades. Mathematical models have been created to predict the required temperature regime of drying, depending on the initial humidity and thickness of the dried grain layer and the intelligent control system of the drying plant.

Fluidised bed dryers

This is a progressive type of dryer with intensive mixing of material, accelerated heat and mass transfer, allowing a significant increase in the heat and mass transfer surface between the material particles and the drying agent.

Dryers of this type differ in the number of chambers, process mode, drying chamber configuration and hydrodynamic

mode. The most common is a single-chamber type of fluidised bed dryer, consisting of a receiving hopper with a feeder, and a drying chamber inside which there is a grate for gas distribution, a mixing chamber, and a cyclone. The dried material is discharged through the nozzle.

There are several patent studies with proposals for improving apparatus designs and drying technology, ultimately aimed at reducing drying energy costs. Due to the type of specifics of drying, the entire surface of the particles is the evaporation area.

At the same time, the task should be solved not only to improve the quality of the final product, but also to increase the productivity of the devices, their versatility and to reduce the cost of production.

At the beginning of drying, the interaction between the material particles and the hot air is quite efficient and the process proceeds at a high speed with low energy consumption. However, as the particles of the material dry out, its thermal and mass conductivity decrease, and the amount of energy penetrating deep into the interior decreases.

Pneumatic dryers

Pneumatic dryers are used to dry granular, fine, crystalline and fibrous materials. In these installations, the drying process takes place at a high intensity. The pneumatic dryer consists of a vertically arranged pipe, and a hopper with a feeder for the material to be dried. The dried material moves due to the airflow created by the fan. The drying material is heated in the heater and the dried material is unloaded through the unloading device.

Particles of the material to be dried move in a stream of heated air at a speed exceeding the hovering speed. More than 50% of all moisture is removed on the 1/5th of the pipe, and the driving force of the process also changes dramatically.

Pneumatic dryers are compact, have a simple design and operating

principle, but the rapid deterioration of the dryer material, the need for periodic cleaning of the dryer bottom, high energy consumption and other shortcomings inherent in the convection drying, limit the scope of these dryers.

Heliodryers

Drying agricultural products outdoors requires constant manual mixing. The impossibility of organising drying at a constant temperature leads to uneven and incomplete drying of the product, its spoilage and large losses. All this is an argument for the creation of special types of dryers based on the use of solar energy.

The climatic features of the area, the type of material to be dried and the cost of additional energy determine the choice of the drying method. The heat from the drying agent to the material can be supplied by a convective method, where the material to be dried is exposed to solar-heated air or by radiation where the material is exposed to sunlight. The temperature in heliodryers can reach 60 to 75°C.

Combined heliodryers can be used using both types of heat transfer, but with a predominance of convective heat transfer. Solar dryers are subdivided into dryers with direct and indirect action of the absorbed solar energy on the material to be dried.

The upper and southern side parts of the chamber are covered with translucent insulating material, holes are made for air entry into chamber heat insulation, and the platform for material placement is perforated. The humid air from the solar dryer is removed through the holes made in the upper part of the cold wall.

Thermo-radiation dryers

Due to the supply of significant heat fluxes of infrared radiation to the material in installations of this type of dryer, an increase in the intensity of moisture evaporation from the material to be dried is achieved. Drying takes place in a thick layer of material. In this case, the main factor is the rate of internal diffusion of moisture and high requirements for the quality of the dried material.

At the initial time of drying under the influence of a high temperature gradient, it coincides with the moisture

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Table 1: Comparative technical characteristics of grain dryers.

Name and technical characteristics of devices	Mine dryer ДСП-32	Conveyor dryer ASM-AGRO-34	Dryer with fluidised bed CKC1,5-1000Б	Pneumatic dryer JG1000	Heliodryer	Infrared ray dryer Sahara12	Drum dryer C3C5-8
Performance (kg/h)	32 000	34 000	4 500	1 500	80	500	8 000
Installed capacity (kW)	125	91	40	78	0,2	36	28,2
Evaporation capacity (kg/h)	2 300	2 500	3 000	1 000	30	30	560
Drying agent temperature (°C)	50 ÷ 160	125	190	150 ÷ 600	50 ÷ 60	30 ÷ 50	140 ÷ 160
Weight (t)	32,6	15	10,8	5	0,5	2,4	8,3
Service life (years)	10	20	10	10	10	15	15
Fire safety and fire protection	Depends on the grain type	+	+	-	+	+	Depends on the grain type

Symbol designations in the table: - fire-dangerous, + fire-proof.

movement direction, that is, moisture moves from the periphery deep into the material. After a while, the moisture gradient begins to prevail and the direction of moisture movement changes to the opposite. With the onset of this moment, moisture evaporates from the material. Because of the above, thermo-radiation drying is preferably used for drying thin-layer materials.

Dryers with infrared emitters are equipped with energy sources obtained by electric current, or by burning natural gas. Such devices provide greater uniformity of drying, but the complexity of the constituent elements and the high frequency of failure are the reasons for the limited use of these

dryers. Today, special attention is paid to installations using infrared dryers as an additional source of energy.

Drum dryers

The most widely used dryers for grain drying are drum dryers, constructed of three parts that make up their basis – a drum, a firebox and a cooling chamber.

Dryers of this type can be made in one pipe form or a plurality of pipes inserted into one another. The drum axis, equipped with metal plates, moves the grain upward in a spiral. The spiral is at an angle of up to 6° relative to the horizontal. With the direct flow of the material to be dried, the drying agent moves along the drum at a speed of 2 to 3m/s.

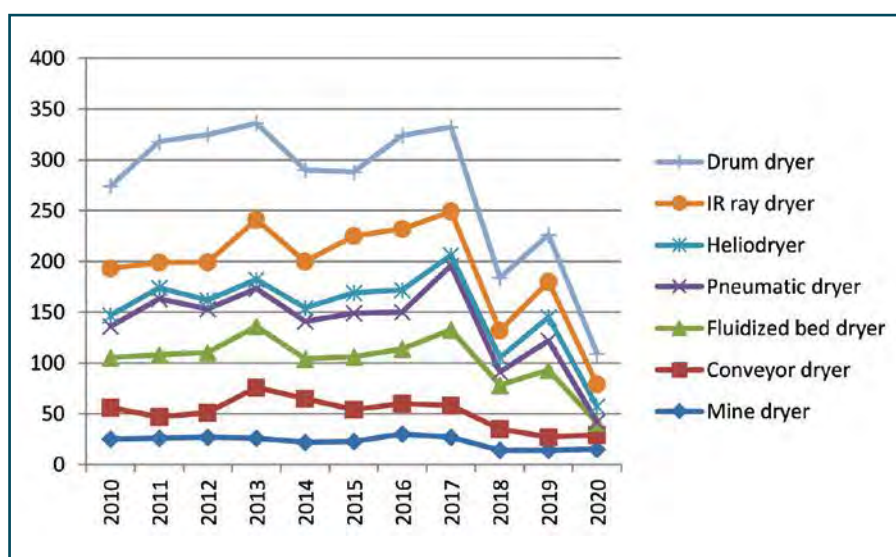
The grain, dried to a certain moisture content, is automatically rolled into the cooling chamber. The rotation speed of the drum (on average from one to eight minutes) is determined by its inclination angle and the residence time (15 to 20 minutes) of the food grain in the machine. At the same time, the drying gas temperature is recommended to be maintained within 180 to 250°C.

Comparative analysis of devices

There are many dryers for drying grain and oilseeds harvested in agriculture, which also differ from one another in their technical characteristics. Comparative technical characteristics of the above grain dryers are given in *Table 1*.

Scientific developments regarding dryers over the past decade are analysed by comparing patents for inventions formed in patent databases of Russia, the United States and Ukraine. The analysis results are shown in *Figure 1*.

The analysis of the devices' indicators for drying grain and oilseeds showed that all of them have both advantages and disadvantages. The dryer that meets most of the requirements is a drum dryer. However, the existing dryers of this type also do not fully meet the modernity requirements. 🌱

Figure 1: A comparison of drying devices based on patent bases of the countries of Russia, the United States and Ukraine.

This article has been shortened for use in *Oilseeds Focus*. To read the full report, visit <https://uzjournals.edu.uz/ijctcm/vol2021/iss3/1/>.

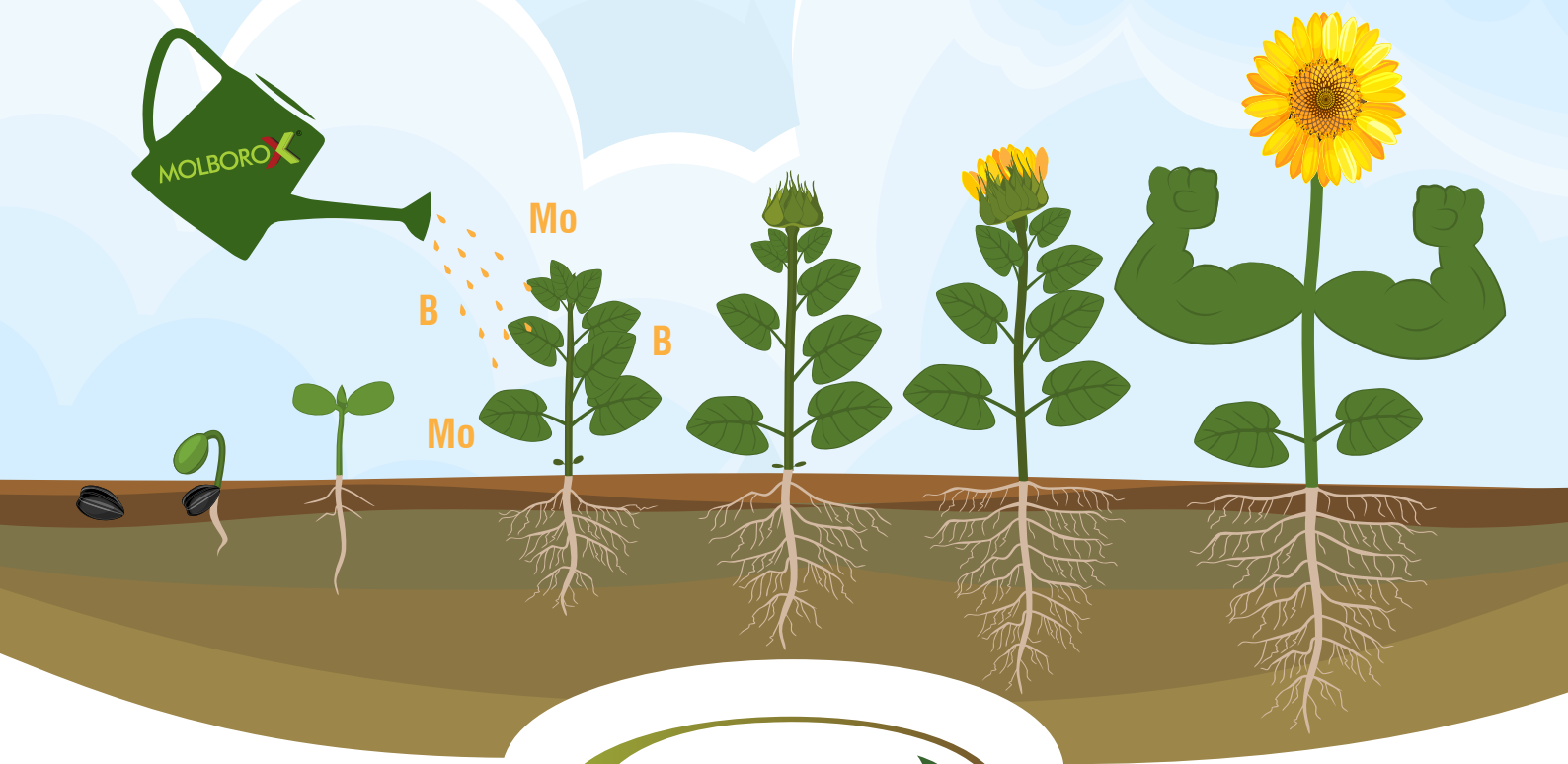
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Rising fuel prices have both a direct and indirect effect on producers. Grain producers' diesel consumption tends to increase during planting. A tractor, for example, can guzzle up to 15ℓ of diesel per hectare.

Fuel price increases: How does it affect producers?

By Christal-Lize Muller

Rising fuel prices are inflicting a heavy blow on the agricultural industry, with the direct impact on their input costs putting producers on the back foot. Rising fuel prices also affect them indirectly in terms of transport costs to and from the farm, while the impact of fuel price decreases as recorded in January this year, is minimal seeing as most plantings have already been concluded.

Agri SA chief economist, Kulani Siweya, says fuel prices in South Africa are mainly determined by the exchange rate and international oil price. A weaker rand coupled with the rising price of crude oil are the main drivers of fuel price increases.

Impact on agriculture

According to Siweya, fuel accounts for around 13% of producers' production costs, especially in the grain and oilseeds industry. Fuel price hikes such as those seen in November 2021, however, are a major source of concern, especially

since it marks the start of the summer crop planting season and an associated increase in fuel consumption.

This results in rising input costs, notably those of fuel and fertiliser, which put pressure on producers' profit margins. "Producers are generally price takers, which means they can rarely pass the costs on to the consumer. This makes mitigating the impact very difficult," he says.

Department of Mineral Resources and Energy (DMRE) statistics show that fuel prices on 3 November 2021 reached a record high since 2 January 2019. The retail price of petrol rose by R1,21/ℓ to R19,54/ℓ in November for 95-octane unleaded petrol inland, and R18,82/ℓ at the coast. Diesel rose by R1,48/ℓ to R17,19/ℓ inland and R16,58/ℓ at the coast in November.

In December, fuel prices hit another record high since 2 January 2019, when 93- and 95-octane petrol increased by 75c/ℓ to R20,29/ℓ inland, and R19,57/ℓ at the coast. Diesel (0,05%) increased by 72,5c/ℓ while 0,005%

diesel increased by 74,50c/ℓ to R17,92/ℓ inland, and to R17,30/ℓ at the coast.

January 2022 was marked by an overall decrease in fuel prices, with the price of 93-octane petrol dropping by 71c/ℓ, while 95-octane petrol decreased by 68c/ℓ to R19,61/ℓ inland and R18,89/ℓ at the coast. Diesel (0,05%) dropped by 67,80c/ℓ and 0,005% diesel by 69,80c/ℓ to R17,24/ℓ inland, and to R16,63/ℓ at the coast.

This decrease was attributed largely to the rand strengthening against the American dollar after a weak performance during December, when travel restrictions due to the spread of the new Omnicron variant created new fears regarding the South African economy.

According to Siweya, the petrol price increased by 30% over the eleven months from January 2021 (R14,68/ℓ) to November (R19,54/ℓ) – a risk-carrying trend, especially during harvesting, as 75% of grain and oilseeds are transported by road.

However, there is a lifeline for producers. "If global commodity prices

remain high, it could be producers' saving grace, especially in terms of field crops and horticulture," says Siweya.

Composition of fuel prices

International fuel price calculations are based on free-on-board (FOB) values and the petroleum product prices quoted daily by export-oriented refining centres in the Mediterranean, Persian Gulf and Singapore.

The basic fuel price (BFP) is the average of those quotes for diesel to which freight, insurance, financing costs, coastal storage and losses are added. "It provides cost insurance and freight costs for fuel delivered to South African ports."

The local BFP also includes levies and taxes such as the fuel and road accident fund levy, customs and excise tax, the illuminating paraffin tracer dye levy, as well as the petroleum products levy. Applicable transport is also included, as well as the slate levy.

The DMRE defines some of these formulas and levies as follows:

- Wholesale profit is a fixed maximum monetary margin that is state-regulated and used to determine the wholesale margin based on refineries' financial efficiency. It is adjusted from time to time.
- The fuel levy is the general tax on fuel as determined by the minister of finance.
- Customs and excise duty is a levy collected in terms of an agreement by the Southern African Customs Union.
- The road accident fund is aimed at compensating third-party victims of motor vehicle accidents.
- The zone differential in Gauteng is the cost of transporting fuel from the port to the relevant zone in Gauteng.
- The petroleum products levy partially reimburses fuel companies for the tariff they pay to Transnet for using its fuel pipeline. The ministers of energy and finance approve the annual budget.

What is the slate levy?

According to the DMRE, the BFP of petrol, diesel and paraffin is calculated on a daily basis. This calculated BFP is either higher or lower than the BFP reflected in the fuel price structures at that time. The official BFP remains constant until next month's adjustment, while the

actual BFP fluctuates every day. These daily fluctuations mean that consumers are paying too little or too much for fuel.

Calculations of this daily under- and over-recovery are performed during the fuel price review period and an average is calculated. The monthly unit (over-/under-recovery) is multiplied by the volumes sold locally in that month, and the cumulative over-/under-recovery is recorded on a cumulative account (slate account).

A slate levy is therefore applicable on fuel to finance the balance in the slate account when the slate is in a negative balance. If fuel prices continue to rise or the rand continues to weaken, the account must pay out more than has been collected. When the slate account is more than R250 million in the red, a slate account levy is introduced.

The slate account had a negative balance of R1,657 billion at the end of September 2021 and the slate account levy was therefore applicable. This levy is applicable to both petrol and diesel, and is paid to the Central Energy Fund (CEF), which eventually reimburses the oil companies. The amount reimbursed will then reduce the balance, until it drops below R250 million and the slate account levy falls away.

High levies and taxes

Wayne Duvenage, CEO of the Organisation Undoing Tax Abuse (Outa), believes the weak value of the rand and government's relentless desire to increase taxes through fuel-related levies, are contributing to high fuel prices.

He says despite the higher basic fuel price component, the 126% increase in the various levies and taxes introduced over the decade are raising concerns. The combined cost of the general fuel, road accident fund and other levies in November 2011 stood at R4,48 for each litre of 95-octane petrol. At the time of writing this article, the situation had changed and this amount stood at R10,10, which is R5,62 (126%) higher than a decade ago.

The situation for diesel is more or less similar, he says. Outa maintains that the state has taken the fuel levy increase too far and that additional tax revenue cuts must take place.

According to Duvenage, the reliance on existing fuel tax revenues – especially the general fuel levy (approximately

R88 billion a year) and road accident fund levy (around R45 billion) – will come under considerable pressure in the coming decade. With the switch to electric vehicles, the state will be under pressure to replace these revenue streams with other mechanisms, and no fuel levy increases should therefore be considered.

Rising agri production costs

Dr Johnny van der Merwe, managing director of Agrimark Trends (AMT), says the drop in the diesel price in January had a negligible impact on grain producers, as most of them had by then already incurred the costs relating to soil preparation and planting. Most maize and soya bean plantings had been concluded at the time, while a few producers might still have been waiting to plant sunflower, although their soil preparations would have already been done at the time.

"The greatest diesel expense for oilseeds and grain producers occurs just before soil cultivation until planting, after which their diesel expenses decrease." Also, the January fuel price decrease was not that big, which means the impact on profitability will be very small.

Van der Merwe says the November 2021 fuel price increases had a significant effect on particularly grain producers' production costs. If only primary cultivation is taken into account, this amounts to a cost increase of as much as R241 per hectare.

"Delivery costs (various inputs) to the farm, as well as delivery costs to silos, will show exactly what impact this additional direct cost has on producers' profit margins," he says. Maize farmers are likely to be worst off, especially if the western parts of the country with their sandy soil and reliance on rail transport are considered.

"Most farmers have hopefully already completed these operations for the coming season and/or purchased fuel in advance, which will significantly reduce the impact on the total cost."

Fuel and the livestock producer

For livestock producers, transport costs will also be driven up, which could have a direct effect on their livestock's marketing costs. "These higher costs will not only affect producers' profitability, but will ultimately mean higher food

prices for the consumer. An upward adjustment to the interest rate also pushes up inflation, which will increasingly come under the magnifying glass."

To illustrate the situation, Dr Van der Merwe uses a mechanical cost table (Table 1). The table is based on primary cultivations only. The price for diesel

in this table is the average price for diesel delivered to the farm, after the rebate. An average yield per hectare for summer crops per region was used.

Table 1: The impact of the November 2021 price increase on fuel consumption in agricultural production.

	Fuel consumption (R/ha)		
	Western Free State	Eastern Free State	North West
R12,24/ℓ (before Nov price increase)			
Maize (5 tons per hectare)	1 072	887	787
Soya bean (2,5 tons per hectare)	744	668	671
Sunflower (2 tons per hectare)	662	689	661
R15/ℓ (after Nov price increase)			
Maize (5 tons per hectare)	1 313	1067	964
Soya bean (2,5 tons per hectare)	912	819	822
Sunflower (2 tons per hectare)	811	844	811
The difference			
Maize (5 tons per hectare)	-241	-180	-177
Soya bean (2,5 tons per hectare)	-168	-151	-151
Sunflower (2 tons per hectare)	-149	-155	-150

Agricultural support

Siweya says Agri SA is constantly engaging with stakeholders in a bid to protect the agricultural industry from the shocks of fuel price increases. There is regular contact with the National Energy Regulator (Nersa) and Eskom to, among others, reduce the impact of electricity costs, seeing that the South African agricultural industry receives little to no direct government support. The industry needs protection to remain viable and ensure food security. 🌱

For more information, contact Kulani Siweya of Agri SA on 012 643 3400 or kulani@agrisa.co.za, Wayne Duvenage on 087 170 0639 or wayne.duvenage@outa.co.za, or Dr Johnny van der Merwe on 073 140 2698 or johnny@amtrends.co.za.

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The impact of climate change on food security

Edited by Ursula Human, Plaas Media

The Intergovernmental Panel on Climate Change (IPCC) recently released a special report on global warming. One of the chapters focusses on the impact of climate change on food security. In this article we feature a shortened version of this chapter's executive summary, which discusses the effects of climate change on cereal crop production.

The current food system (production, transport, processing, packaging, storage, retail, consumption, loss and waste) feeds the great majority of the world's population and supports the livelihoods of over one billion people. Since 1961, food supply per capita has increased by more than 30%, accompanied by greater use of nitrogen fertilisers (an increase of around 800%)

and water resources for irrigation (an increase of more than 100%).

However, an estimated 821 million people are currently undernourished, 151 million children under five years of age are stunted, 613 million women and girls aged 15 to 49 suffer from iron deficiency, and two billion adults are overweight or obese. The food system is under pressure from non-climate stressors (e.g. population and income growth, and demand for animal-sourced products) and from climate change. These climate and non-climate stressors are impacting the four pillars of food security, namely availability, access, utilisation and stability.

More than just climate change

Observed climate change is already affecting food security through increasing

temperatures, changing precipitation patterns, and greater frequency of some extreme events. Studies that separate climate change from other factors affecting crop yields, have shown that yields of some crops (e.g. maize and wheat) in many lower latitude regions have been negatively affected by observed climate changes, while in many higher latitude regions, yields of some crops (e.g. maize, wheat and sugar beets) have been affected positively over recent decades.

Based on indigenous and local knowledge (ILK), climate change is affecting food security in drylands, particularly those in Africa, and high mountain regions of Asia and South America.

Food security will be increasingly affected by projected future climate

change. Global crop and economic models project a 1 to 29% cereal price increase in 2050 due to climate change, which would impact consumers globally through higher food prices; regional effects will vary. Low-income consumers are particularly at risk, with models projecting increases of one to 183 million additional people at risk of hunger across the shared socio-economic pathways compared to a no-climate change scenario.

While increased carbon dioxide (CO₂) is projected to be beneficial for crop productivity at lower temperature increases, it is projected to lower nutritional quality. For example, wheat grown at 546 to 586 parts per million (ppm) CO₂ has 5,9 to 12,7% less protein, 3,7 to 6,5% less zinc, and 5,2 to 7,5% less iron.

The distributions of pests and diseases will change, negatively affecting production in many regions. Given increasing extreme events and interconnectedness, the risk of food system disruptions are growing.

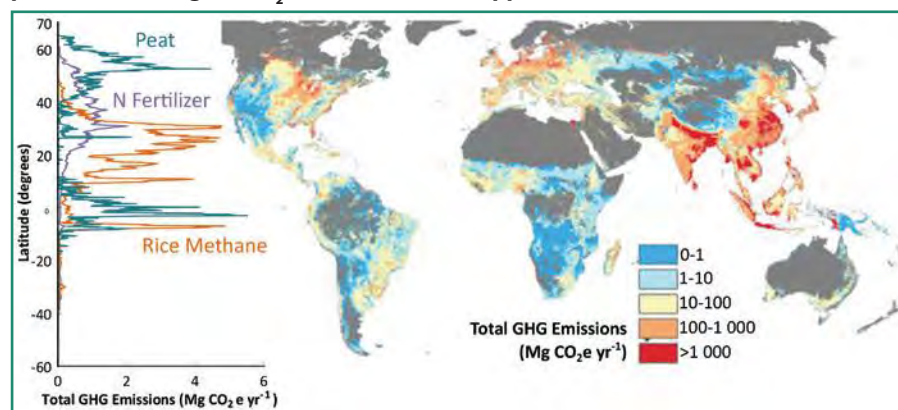
Varying effects among social groups

Food security and climate change have strong gender and equity dimensions. Worldwide, women play a key role in food security, although regional differences exist. Climate change impacts vary among diverse social groups depending on age, ethnicity, gender, wealth and class.

Climate extremes have immediate and long-term impacts on livelihoods of poor and vulnerable communities, contributing to greater risks of food insecurity that can be a stress multiplier for internal and external migration. Both the empowerment of women and rights-based approaches to decision-making, can create synergies among household food security, adaptation and mitigation.

Many practices can be optimised and scaled up to advance adaptation

Figure 1: Cropland GHGs consist of CH₄ from rice cultivation, CO₂, N₂O and CH₄ from peatland draining, and N₂O from N fertiliser application.



**Total emissions from each grid cell are concentrated in Asia and are distinct from patterns of production intensity (Carrison et al., 2017).*

throughout the food system. Supply-side options include increased soil organic matter and erosion control, improved cropland management, and genetic improvements for tolerance to heat and drought. Diversification in the food system (e.g. implementation of integrated production systems, broad-based genetic resources and heterogeneous diets) is a key strategy to reduce risks.

In turn, demand-side adaptation, such as adoption of healthy and sustainable diets in conjunction with a reduction in food loss and waste, can contribute to adaptation through a reduction in additional land area needed for food production and associated food system vulnerabilities. ILK can contribute to enhancing food system resilience.

A look at GHG emissions

Around 21 to 37% of total greenhouse gas (GHG) emissions are attributable to the food system. These are from agriculture and land use, storage, transport, packaging, processing, retail and consumption. This estimate includes emissions of 9 to 14% from crop and livestock activities within the farmgate,

and 5 to 14% from land use and land-use change, including deforestation and peatland degradation; 5 to 10% is from supply chain activities.

This estimate includes GHG emissions from food loss and waste. Within the food system, during the period 2007 to 2016 (Table 1), the major sources of emissions from the supply side were agricultural production, with crop and livestock activities within the farm gate and CO₂ emissions linked to relevant land-use change dynamics such as deforestation and peatland degradation.

Supply-side practices can contribute to climate change mitigation by reducing crop and livestock emissions, sequestering carbon in soils and biomass, and by decreasing emissions intensity within sustainable production systems. Options with large potential for GHG mitigation in cropping systems include soil carbon sequestration (at decreasing rates over time), reductions in nitrous oxide emissions from fertilisers and bridging of yield gaps.

Consumption of healthy and sustainable diets presents major opportunities for reducing GHG emissions from food systems and improving health outcomes. Examples of healthy and sustainable diets include foods that are high in coarse grains, pulses, fruit and vegetables, and nuts and seeds; low in energy-intensive animal-sourced and discretionary foods (such as sugary beverages); and with a carbohydrate threshold.

Meat analogues such as imitation meat (from plant products), cultured meat and insects may help in the

Table 1: GHG emissions (GtCO₂-eq yr⁻¹) from the food system and their contribution (%) to total anthropogenic emissions. Mean of 2007 to 2016 period.

Food system component	Emissions (Gt CO ₂ -eq yr ⁻¹)	Share in mean total emissions (%)
Agriculture	6,2 ± 1,4	10 to 14%
Land use	4,9 ± 2,5	5 to 14%
Beyond farm gate	2,6 ^c to 5,2	5 to 10%
Food system (total)	10,8 to 19,1	21 to 37%

transition to more healthy and sustainable diets, although their carbon footprints and acceptability are uncertain.

Reduction of food loss and waste could lower GHG emissions and improve food security. Combined food loss and waste amount to 25 to 30% of total food produced. From 2010 to 2016, global food loss and waste equalled 8 to 10% of total anthropogenic GHG emissions and cost approximately US\$1 trillion per year.

Proactive measures

Technical options for the reduction of food loss and waste include improved harvesting techniques, on-farm storage, infrastructure and packaging. Causes of food loss (e.g. lack of refrigeration) and waste (e.g. behaviour) differ substantially in developed and developing countries, as well as across regions.

Agriculture and the food system are key to global climate change responses. Combining supply-side actions such as efficient production, transport

and processing with demand-side interventions such as modification of food choices, and reduction of food loss and waste, reduces GHG emissions and enhances food system resilience.

Such combined measures can enable the implementation of large-scale land-based adaptation and mitigation strategies, without threatening food security from increased competition for land for food production and higher food prices. Without combined food system measures in farm management, supply chains and demand, adverse effects would include increased numbers of malnourished people and impacts on smallholder farmers. Just transitions are needed to address these effects.

For adaptation and mitigation throughout the food system, enabling conditions need to be created through policies, markets, institutions and governance. For adaptation, resilience to increasingly extreme events can be accomplished through

risk sharing and transfer mechanisms such as insurance markets and index-based weather insurance.

Public health policies to improve nutrition, such as school procurement, health insurance incentives and awareness-raising campaigns, can potentially change demand, reduce health care costs and contribute to lower GHG emissions. Without inclusion of comprehensive food system responses in broader climate change policies, the mitigation and adaptation potentials assessed in the chapter under discussion will not be realised and food security will be jeopardised. 🌱

This article has been shortened for use in *Oilseeds Focus*. To read the full chapter, scan the following QR code or visit www.ipcc.ch.



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Exploring the wants and needs of the South African soya consumer

By Dr Hester Vermeulen, Bureau for Food and Agricultural Policy

The future of the South African soya industry is dependent upon profitability and sustainability, all within the context of the dynamic nature of consumer behaviour and production environments. Although human consumption of soya comprises only 2% of local soya use, with soya crushing responsible for the largest share of domestic use, there exists significant potential for increasing the use of soya in food products.

The Bureau for Food and Agricultural Policy was contracted by the Oilseeds Advisory Committee (OAC) to investigate South African consumers' knowledge and perceptions regarding selected soya products. In August and September 2021, a sample of 381 low-income, middle-income and affluent consumers were interviewed. This article presents key results from this survey, with a specific focus on typical intake frequencies of soya-based foods, purchase factors, product perception and willingness to pay (WTP).

How often do consumers eat soya?

Overall, the top five most frequently consumed soya-based foods were soya mince, Future Life and ProNutro, followed by cooked soya beans, soya milk and snack bars containing soya (Figure 1).

With rising socio-economic status, the intake frequency of more affordable options such as cooked soya beans and soya mince decreased significantly, while the intake frequency of more expensive soya food options such as soya milk, Future Life or ProNutro, snack bars with soya, and tofu increased significantly.

The most frequently consumed soya-based foods among sub-groups (in order of importance) were:

1. Low-income: soya mince, cooked soya beans and Future Life or ProNutro.
2. Middle-income: Future Life or ProNutro, soya mince, cooked soya beans and soya milk.
3. Affluent: Future Life or ProNutro, snack bars with soya, soya milk and soya mince.

Important purchase factors

In the overall sample, the most important purchase factors pertaining to soya-based foods (in order of importance) were taste, aroma, preparation, health benefits, texture and affordability (Figure 2).

The most important purchase factors pertaining to soya-based foods among sub-groups (in order of importance) were:

1. Low-income: taste, preparation, aroma, health benefits and texture.
2. Middle-income: taste, aroma, preparation, health benefits and texture.
3. Affluent: taste, health benefits, aroma, preparation and texture.

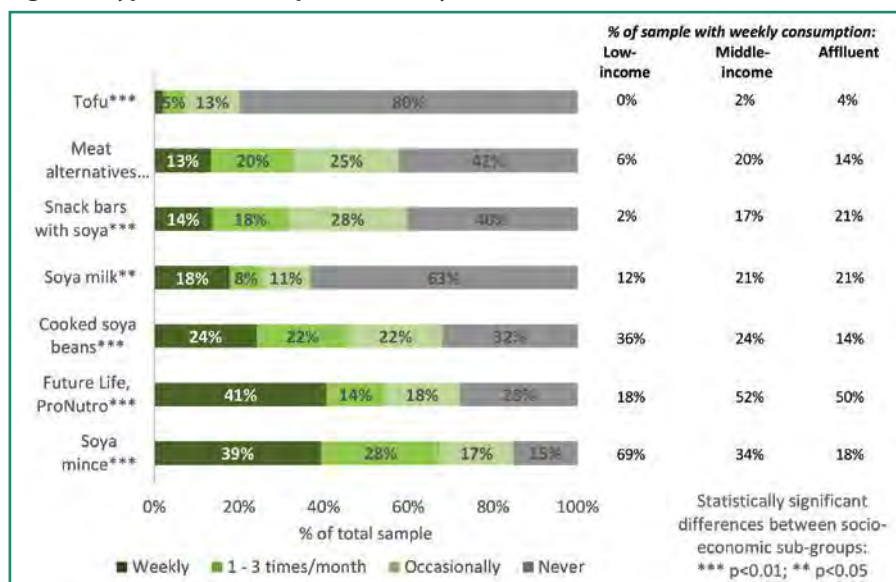


Low-income and middle-income respondents perceived aroma, texture and affordability as significantly more important than affluent respondents. Low-income respondents also perceived preparation, how pure the products were, and colour as significantly more important (at $p < 0,01$) than middle-income and affluent respondents (Figure 2).

South Africans' perception of soya

Respondents were asked to indicate their level of agreement with a series of

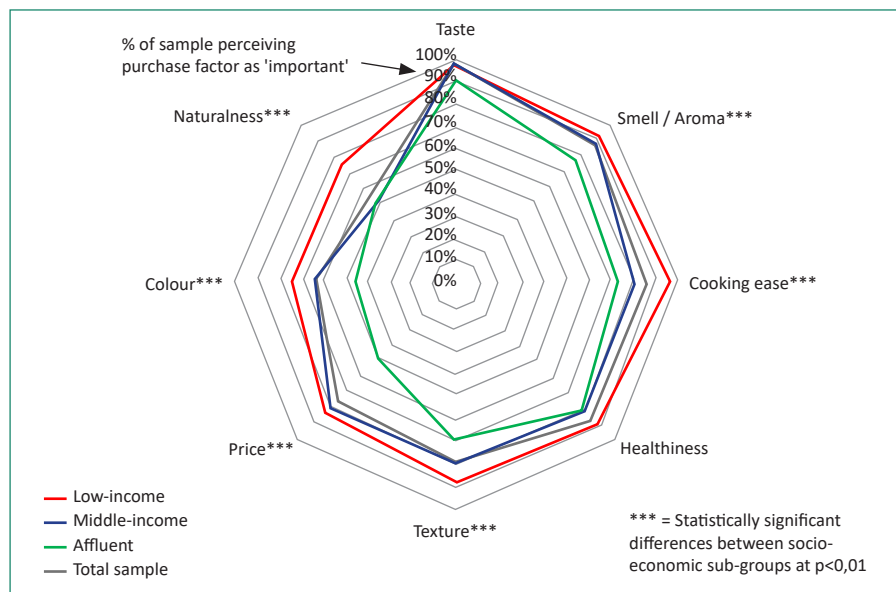
Figure 1: Typical intake frequencies of soya-based foods.



statements involving potential attributes of soya. The dominant positive and negative perceptions are summarised in Table 1.

In the overall sample, respondents were most positive about soya-based foods in terms of:

Figure 2: Perceived importance of purchase factors.



- Product usage: Convenience, preparation, knowledge on preparation.
- Health: Being part of a healthy diet.
- Product origin: Liking South African produced soya.
- Product pricing: Affordability.
- Product image: Not being ashamed to eat soya mince and not being viewed as a 'poor person's food'.
- Sensory appeal: Taste and texture.

Consumers were most negative about soya-based foods in terms of:

- Health: Experiencing flatulence after consuming soya and causing allergies.
- Sustainability: Soya products perceived as not being more environmentally sustainable than animal-protein foods.
- Competing products: Preferring pea protein foods to soya-based foods.

Table 1: Dominant positive and negative perceptions regarding soya.

	Low-income group	Middle-income group	Affluent group
Positive perceptions	Product usage/preparation		
	<ul style="list-style-type: none"> • Easy to prepare (99%). • Know how to prepare (99%). • Like convenience (98%). • Use soya as meat extender (95%). 	<ul style="list-style-type: none"> • Easy to prepare (95%). • Know how to prepare (93%). • Like convenience (96%). • Use soya as meat extender (74%). 	<ul style="list-style-type: none"> • Know how to prepare (66%). • Easy to prepare (66%). • Like convenience (67%).
	Sensory appeal		
	<ul style="list-style-type: none"> • Enjoy taste (99%). • Enjoy texture (99%). • Enjoy aroma (99%). 	<ul style="list-style-type: none"> • Enjoy taste (90%). • Enjoy texture (90%). • Enjoy aroma (85%). 	–
	Product pricing		
	<ul style="list-style-type: none"> • Like affordability (97%). 	<ul style="list-style-type: none"> • Like affordability (85%). 	<ul style="list-style-type: none"> • Like affordability (73%).
	Health/nutrition		
	<ul style="list-style-type: none"> • Part of a healthy diet (88%). • Allergies are rare (74%). 	<ul style="list-style-type: none"> • Part of a healthy diet (87%). 	<ul style="list-style-type: none"> • Part of a healthy diet (81%).
Negative perceptions	Product origin		
	<ul style="list-style-type: none"> • Prefer products produced in South Africa (88%). 	<ul style="list-style-type: none"> • Prefer products produced in South Africa (86%). 	<ul style="list-style-type: none"> • Prefer products produced in South Africa (83%).
	Product perception		
	<ul style="list-style-type: none"> • No shame in eating soya mince (85%). • Not considered a 'poor person's food' (84%). 	<ul style="list-style-type: none"> • No shame in eating soya mince (81%). • Not considered a 'poor person's food' (74%). 	<ul style="list-style-type: none"> • No shame in eating soya mince (84%). • Not considered a 'poor person's food' (76%).
Negative perceptions	Product perception		
	<ul style="list-style-type: none"> • Prefer soya to pea protein (18%). • Do not experience flatulence (55%). • Considered more environmentally sustainable (65%). 	<ul style="list-style-type: none"> • Prefer soya to pea protein (42%). • Do not experience flatulence (28%). • Considered more environmentally sustainable (66%). • Soya allergies are rare (50%). 	<ul style="list-style-type: none"> • Prefer soya to pea protein (28%). • Do not experience flatulence (18%). • Considered more environmentally sustainable (56%). • Soya allergies are rare (47%). • Used as meat extender (43%). • Enjoy aroma (47%). • Enjoy taste (61%). • Enjoy texture (53%).
	Product perception		

Note: % in brackets – share of sub-group in agreement with the particular soya attribute.

Table 2: Consumers' WTP for soya containing foods.

Reference product and price	Alternative product evaluated	Average WTP	Average discount/premium
1kg 100% lean beef mince (R100)	1kg beef mince with soya added	R89	-10%
	250g soya mince (to make 1kg cooked soya mince)	R66	-34%
600g 100% beef burger patties (R100)	600g beef burger patties with soya added	R84	-15%
	600g soya burger patties	R82	-18%
40g healthy snack bar (R10)	40g healthy snack bar with soya 'smart protein'	R11	+11%

Even though most soya beans produced in South Africa are genetically modified, only 7% of the total sample agreed that most soya beans produced in South Africa are from genetically modified plants. The highest levels of uncertainty were observed among middle-income and affluent consumers.

Low-income consumers, followed by middle-income consumers, were significantly more positive about soya in terms of not being ashamed to eat soya mince, not perceiving it as a poor person's food, perceiving soya allergies as rare, having the know-how to prepare soya-based foods, considering it easy to prepare and to be used as meat extender, as well as liking the products in terms of taste, smell, texture, affordability and convenience.

In the overall sample, the soya health attributes recognised by the largest share of respondents were low in carbohydrates (82% of the total weighted sample), high in protein (61%), a good source of fibre (44%), high quality protein (40%) and containing no cholesterol (29%). The average respondent only selected three of the eleven possible soya health benefits that were tested, with recognition increasing towards more affluent respondents with higher education levels. Thus, significant knowledge gaps exist in this regard.

Consumers' willingness to pay

In the overall sample, consumers' stated WTP implied lower prices for soya-added or soya-based products (i.e. beef mince with added soya, soya mince, beef burger patties with soya, soya burger patties), relative to the beef reference products (lean beef mince and beef burger patties). The only product containing soya that consumers were willing to pay more for was a snack bar with soya

'smart' protein (when compared to a regular healthy snack bar) (Table 2).

Learning to love soya

The following factors might motivate consumers to eat more soya-based products:

- Improved affordability.
- Improved taste/flavour.
- More knowledge concerning the health benefits of soya.
- Healthier processing methods.
- Better consumer education.
- Availability/accessibility of products.
- Easier preparation.
- Wider product variety.
- More pleasant aroma.
- Increased awareness about the protein content of soya.
- Improved packaging and/or labelling.
- Improved texture.
- Position as part of weight loss eating plans.
- Increased awareness concerning environmental benefits.
- More appealing appearance.

Recommendations to the industry

The research indicated that consumers are currently most positive about soya in terms of cooking and convenience, preparation knowledge, sensory appeal, affordability, health benefits, its role as a meat extender and not being considered a 'poor person's food'. Continued actions to maintain and enhance these selling points are important to grow its market share.

Consumer education and marketing actions are recommended to inform the target market about the following factors:

- The consumer benefits of soya and soya-based ingredients in food related to improved sensory appeal (e.g. improved palatability when used as a meat extender).

- The science-based health benefits of soya, such as being high in protein, a high quality protein, low in carbohydrates, a good source of fibre, being naturally cholesterol-free, high in vitamin E, high in omega 3 and 6 fatty acids, having anti-cancer properties and low glycaemic index (satiety for longer), and being low in saturated fats.
- The introduction of new and innovative recipes.
- The general awareness regarding sustainable food choices among South African consumers is still low and not as prominent as observed in developed economies such as Europe. Since increased awareness and consideration of aspects related to sustainable food choices do apply to more affluent consumers in South Africa, consumer education regarding the sustainability benefits of soya production versus animal production systems should mainly be aimed at affluent consumers and middle-income consumers, as they could move into more affluent consumer segments due to future class mobility.
- Since most of the soya beans produced in South Africa are genetically modified, educating consumers about the environmental benefits of genetically modified soya beans is recommended, focussing on aspects such as more sustainable production systems using less diesel and fewer chemicals, compared to conventional soya bean production.

Scientific advancements are needed to address soya allergies, and to eliminate flatulence and the beany taste often associated with soya consumption. Product improvement and marketing actions (with a specific focus on soya as

a meat alternative) should reposition soya as a tasty and affordable meal, eaten by modern families with a health-conscious outlook on life.

Eliminating the image of soya as a 'poor person's food' through appropriate marketing seems to be most needed among the middle-income and affluent consumer markets in South Africa. Considering the size and purchasing power of these consumers in South Africa, this could promote the market growth of textured vegetable protein (TVP).

The price discounts/premiums resulting from the WTP section of this survey could assist in the formulation of retail prices which are acceptable to consumers:

- Informing consumers about the benefits of soya as a meat extender (e.g. increased palatability and higher protein content), could increase their acceptance of meat

dishes with soya, as suggested by the 13% increase in the share of respondents who liked the concept of soya being added to meat products following exposure to product benefit information. This could have a positive contribution to growing the market for TVP in the butcher meats market in South Africa.

- Product improvement and innovation could focus on the following soya-based foods in particular: Soya mince, meat with soya, meat alternatives, soup or soup powder, sausages, burger patties, soya milk, soya beans, added dried vegetables to soya mince, health bars, snacks, sweets, porridge, ProNutro, Future Life and polony.
- Soya mince is a common component of school feeding meals in South Africa, with anecdotal evidence pointing to consumer resistance

to the product in this context. As scholars are the consumers of the future, an improved understanding of their perceptions and sensory preferences are critical to guide the development of products with consumer appeal to improve future market success.

- Developing and marketing soya-based foods that present consumers with a value offering that is sensorily appealing, affordable, convenient and healthy, are of utmost importance for the future of the soya food market in South Africa. 🌱

This project was funded by the Oilseeds Advisory Committee. For more information, contact the Bureau for Food and Agricultural Policy at admin@bfap.co.za, or the Oilseeds Advisory Committee at 011 234 3400.

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Developing new and exciting soya recipes for the NSNP

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

Proper nutrition plays an important role in the development of young bodies and minds. A nutritiously balanced diet can promote children's ability to learn, play and develop to become the best version of themselves and supports the strive towards a healthy and happy adult population.

With this in mind, the South African government, through the Department of Basic Education, in 1994 implemented the National School Nutrition Programme (NSNP). This government programme provides one nutritious meal to learners on every school day in less fortunate primary and secondary schools. The NSNP provides nine million learners with a meal each day. For many of these children, this is their only meal of the day.

The NSNP menus consist of one portion of protein, starch, and fruit or vegetable per day. The protein portion includes various options such as beans, soya, pilchards, peas, lentils, sourmilk or chicken, which are served on alternating days throughout the week. Soya plays a key role in the

NSNP as one of the protein options in the meals and is served up to two times a week, accompanied by various starchy staples. Menus in the different provinces are based on availability and preference.

During the review of the NSNP in 2016, it was found that learners ate less on days that soya was served. Therefore, it was necessary to investigate the role of soya within the NSNP and to identify the reason behind this. Based on the outcome of the research, feasible solutions could be tabled to ensure that learners not only enjoy the soya-based meals, but also become lifelong consumers thereof.

A closer look at soya and the NSNP

The project was divided into four components and carried out in four phases. Firstly, a literature review was conducted to familiarise the researchers with school feeding schemes, and more specifically, the NSNP as well as identifying available literature and methodologies with specific emphasis on soya.

In the second phase, three secondary schools which are classified as 'no fee

schools' and are included in the NSNP, were visited. Insight gained from these visits were published in an article in the June 2021 issue of *Oilseeds Focus*, titled 'Exploring soya within the National School Nutrition Programme'. The information gathered in the first and second phase was used to establish recipe development in the third phase, and a consumer taste panel was conducted in the fourth.

Three secondary schools in the Tshwane District in Gauteng were visited and interviews were conducted with the principals, food handlers and teachers in charge of overseeing the NSNP activities. Once researchers had a clear understanding of the issues at hand, a plan was devised on how to improve the soya-based meals.

The recipe developers took the following guidelines into consideration when developing the new recipes:

- Use low-cost, readily available ingredients (as provided by the NSNP).
- Use basic equipment to make the meals.
- Recipes must be easy to read and follow.
- Be successfully tried out following the recipe developed by a minimum of three people.
- Be nutritious and tasty.
- Have a limited number of ingredients.
- Be flexible so the same basic recipe can be used with fresh, frozen or canned food varieties.

The limited resources available to food handlers provided quite a challenge in recipe development, but additional visits to the schools and insight from various role-players within the scheme ensured that the four recipes that were developed ticked all the boxes. The recipes were triple tested and evaluated by three different parties in two different kitchens to ensure they are repeatable and reliable.

Figure 1: Overall liking of the five different recipes by the panellists.

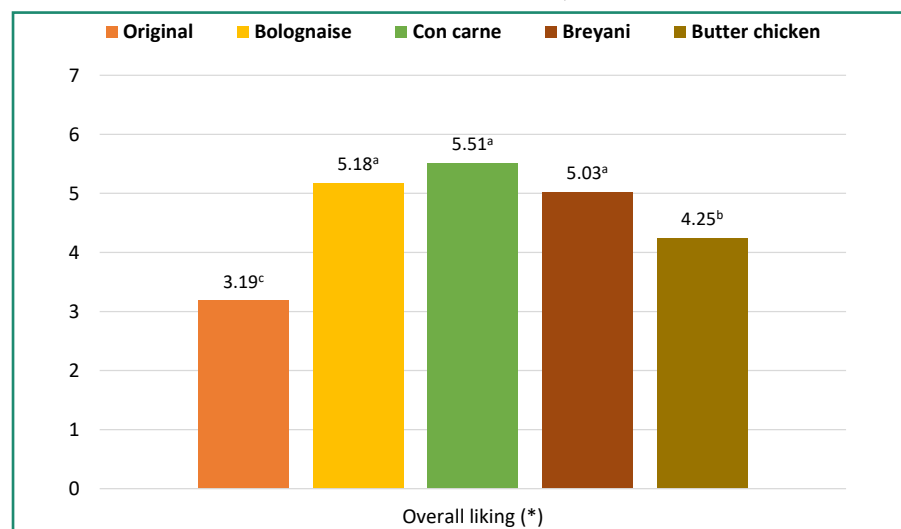


Figure 2: Panellist's willingness to consume the five different recipes.

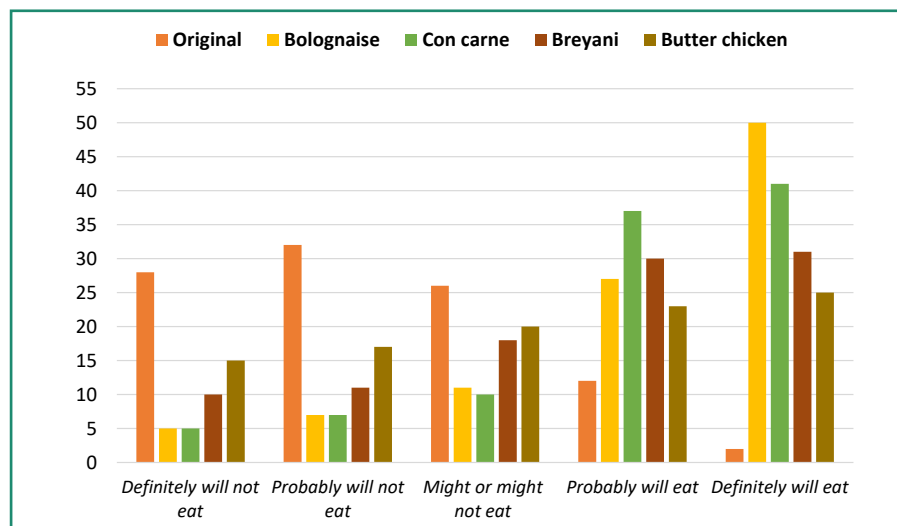
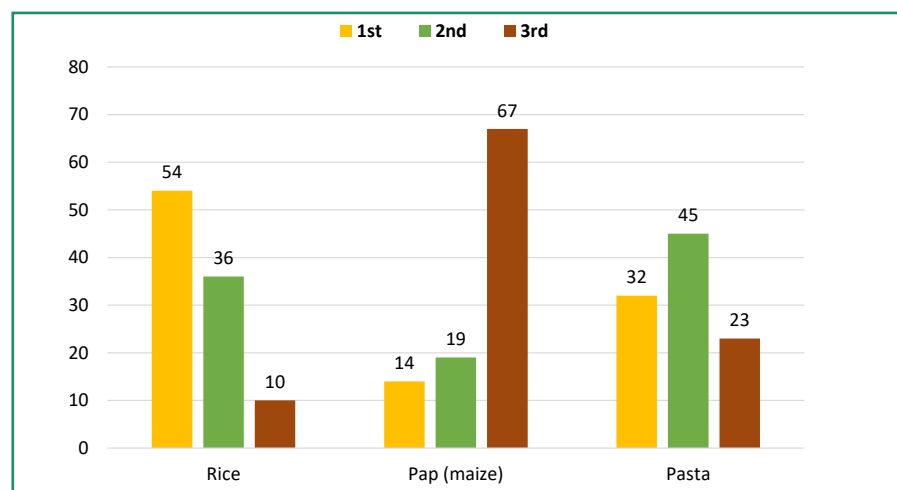


Figure 3: Preferred starches to serve with soya-based meals.



The dishes chosen were beef bolognaise with soya mince, butter chicken, chili con carne with soya mince, and one-pot soya breyani. These recipes showcase the versatility of soya and how it can be appealing to any palate.

New recipes are put to the test

It was essential to test these recipes under the relevant demographic group to ensure they adhered to the NSNP guidelines and were appealing to learners. To achieve this, a consumer sensory panel of 100 learners was conducted at the sensory science laboratory facility at the University of Pretoria. Participants for this study were screened by means of citizenship (only South Africans), home language (Ndebele, Northern Sotho, Sotho, siSwati, Tsonga, Tswana, Venda, Xhosa and Zulu) and age (18 to 21 years old).

To set a baseline, the four newly developed recipes were served along with the soya-based meals that are currently served to learners within the NSNP, to see whether the new recipes were more appealing. With regards to the overall palatability of the meals, the chili con carne with soya mince came out as the favourite, followed by the bolognaise and the one-pot soya breyani as a third option, although not significantly so (Figure 1).

The butter chicken was the least preferred of the new recipes. The original meal as currently served in the NSNP was the least favourite dish (Figure 2). The participants were asked various questions regarding the taste, appearance and liking of the meals served.

Questions regarding the starch options served with the meals were also perused. More than half of the learners selected rice

as their first preference to consume with meals. This is important data as both the beef bolognaise and the chili con carne soya mince meals were served with rice.

Although maize porridge (pap) was reported to be the most often consumed food in South Africa, two-thirds of the children indicated that pap was only their third choice. Pasta was not reported as a favourite but was selected as most learners' second option (Figure 3).

During the school visits, it was found that there is a negative perception regarding soya served in the NSNP. Learners do not like the unappealing appearance, aroma or taste of the current soya-based meals and are therefore unwilling to consume soya on days that it is served.

A worthy investment

During the testing, preparation and finalisation of the four new recipes, every possible variable and occurrence that may occur in the NSNP was considered. Serving an appealing meal with limited resources and supplies requires planning and creative thinking. The newly proposed recipes to include in the programme took both the learners' preferences, as well as the schools' resources into consideration.

As the meals served to these learners may be the only ones they will receive for the day, it is essential to make it a meal that they are willing to eat; one that is both appetising and nutritious.

It was found that there was a general lack of knowledge surrounding what soya is, the various ways in which it can be prepared, as well as the contribution it can make to a person's diet. This study identified possible gaps for consumer education and allowed for the improvement of soya-based meals to entice a future generation of soya consumers. 🌱

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Safe, affordable and nutritious food from soya beans

By LJ Grobler, founding director of CFAM Technologies and professor in mechanical engineering, North-West University

Africa is the second most populated continent in the world; its population is expected to exceed two billion by 2050. According to the World Bank, urbanisation will lead to a 30% growth of cities' population by 2030. With an ever-increasing number of children suffering from malnutrition, it is imperative that we start looking at alternative and more affordable nutritious food to feed the African continent and the world.

More and more consumers are therefore looking at plant-based products that simulate the properties of traditional meat products in order to reduce their meat consumption. Vegetarian and vegan products are a growing trend due to health, animal welfare and sustainability concerns. Moreover, modern meat analogue products can offer roughly the same composition of nutrients as traditional meat products.

The drive towards more plant-based food is not focussed only on healthier food anymore. A meatless plant-based burger patty uses 95% less land and 74% less water, and it emits around 87% less greenhouse gas than making a ground beef burger patty from beef. The plant-based burger has more protein, less total fat, no cholesterol and fewer calories than a similar-sized hamburger patty made with beef. However, it contains more sodium and more saturated fats than an unseasoned beef patty.

These plant-based products are completely free of any animal-sourced content. They mimic the structural functionality of different types of meat such as chicken, beef, fish or pork. The latest processing technologies such as twin-screw extrusion allows

food manufacturers to create world-class meat analogues that satisfy the dietary needs and health concerns of consumers, without compromising taste, look or feel. You literally get meat-like products that look like chicken, taste like chicken but are not chicken.

Nutritional value of soya

The main sources of plant-based proteins used in meat analogues are soya and wheat protein gluten, while other protein sources such as legumes/pulses (pea, lentil, lupine, chickpea and others) and fungi (myco-protein, yeasts and mushrooms) are also used.

Soya is a highly nutritious legume with excellent protein quality that can be used to boost the nutritional value of local food or to substitute costlier protein sources.

We often think of cooking oil and animal feed as the first products associated with soya, but soya beans are a great source of quality protein and energy for humans. Soya beans provide 440kcal per 100g and feature as much as 38% protein and 18% oil content.

The protein in soya beans, unlike other legumes, is a high-quality complete protein, close to that of an egg. Soya is also high in fat and fibre – most of this fat is mono-unsaturated and polyunsaturated fats, including omega-3 fatty acids. Prebiotic fibre in soya beans can support the growth of healthy bacteria in the gut. Plant oils, including soya beans, do not contain cholesterol. Moreover, soya beans are a great source of vitamins E and K, as well as B vitamins such as riboflavin, thiamin, pyridoxine and folic acid.

Global meat analogue market

The marketplace for meat analogue products in Europe and North America

has expanded beyond just vegetarian consumers. It now also includes meat-eating and meat-loving consumers. According to Mordor Intelligence (2019), the market snapshot of the meat analogue marketplace is expected to grow at a 7,9% compound annual growth rate between 2019 and 2024. Overall, the global plant-based meat industry is predicted to reach US\$21,23 billion by 2025. This implies market growth of roughly 50% over the next five years.

Companies such as Beyond Meat and Impossible Foods have been leading the markets in North America in developing modern meat analogues from plant proteins. In total, Impossible Foods, which was started in 2011 by a Stanford biochemistry professor, has raised US\$687,5 million over twelve rounds of funding. The total valuation of Impossible Foods in 2019 jumped to US\$2 billion.

Beyond Meat, which was founded in 2009 by Ethan Brown, has products designed to simulate chicken, beef and pork sausage. As of July 2019, Beyond Meat had a market value of US\$11,7 billion. What's more, Beyond Meat's burger patties are available in selected South African retailer shops, but they are quite expensive.

Product manufacturing technology

The latest advancements in extruders and specific twin-screw extruders have been central in the development of modern meatless meat analogue products. With twin-screw extruders it is now possible to produce meat analogues with the same attributes as real meat. When prepared in a dish it is often impossible to distinguish between the meat analogue and real meat product.

CFAM Technologies is a South African company that was established in 2007



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with the aim to commercialise twin-screw extruders for Africa and the developing world. It is a spin-off company of the North-West University and the only manufacturer of twin-screw extruders in Africa.

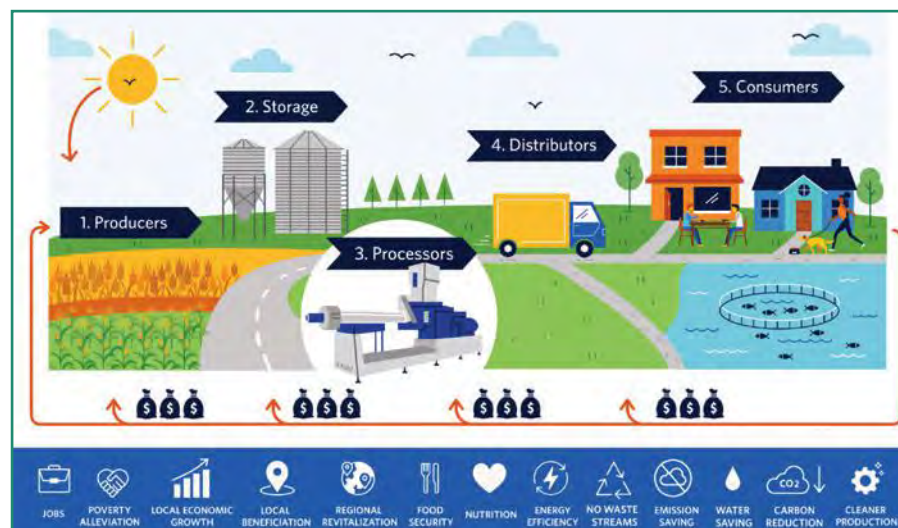
Extrusion is a continuous, high pressure and high temperature cooking process that is used to produce ready-to-eat products such as instant porridges, breakfast cereals, puffed snacks, pet food and aqua feed. The most recent developments focus on meat analogues from plant-based proteins. The extrusion plant forms the backbone of the product value chain between the farm gate and end consumer.

CFAM's extrusion equipment is backed by more than 20 years of research and innovation at the Faculty of Engineering at the North-West University. It focusses its research on developing safe, nutritious and affordable food from locally produced agricultural products.

CFAM is well positioned to assist the South African agricultural sector in developing new products to beneficiate locally produced agricultural products. Extrusion is therefore one of the technologies that do not take away jobs but rather create them, since it creates a market for farmers' produce, jobs for semi-skilled people, empowerment, and assists in local economic revitalisation of remote areas.

CFAM has recently developed its own meatless burger patty. Although it is completely plant based, one of the best attributes of the meatless burger patty is the fact that it turns in colour from meat-like red to meat-like brown when the patty is prepared on a grill. Furthermore,

Figure 1: Extrusion sustainability circle.



it is made from soya beans. Contrary to general belief, soya beans are well suited and positioned to become one of the preferred oilseeds for human food.

Extrusion as processing technology

CFAM's research and development are aimed at providing the average person with safe, affordable and nutritious food. It is their mission to develop new applications of extrusion that are affordable and are made from locally produced and sourced agricultural products. As a country and region, they beneficiate local produce in order to make the country more competitive globally.

In addition, extrusion as processing technology is ideally suited for Africa since it is a clean, energy-efficient processing technology that generates no waste stream, in contrast to other food processing technologies. Extrusion

therefore has the ability to assist Africa in tackling topical issues such as malnutrition, food security, job creation, empowerment and even climate change.

CFAM's extrusion sustainability circle is illustrated in *Figure 1*. Extrusion facilities are central to the establishment of complete value chains between the farm gate and end consumer. Extrusion facilities form the heart of the value chain. These facilities also perform functions that cannot be done by humans. Extrusion is therefore a technology that, contrary to general belief, creates jobs. The establishment of strong value chains also creates a market for local producers, thus strengthening the local economy.

Proper implementation of these value chains assists in creating jobs and alleviating poverty while also supporting local economic growth, local beneficiation of products, regional revitalisation, food security and supply of nutritious food.

Figure 2 shows examples of extruded soya bean products. The texturised meat-like products can be used in dry or wet formats, depending on the needs and applications of the products.

The latest developments in high moisture extrusion also offer opportunities to produce meat-like fish and chicken products from plant-based products. 🌱

Figure 2: Examples of soya bean extruded products.



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Is peanut butter good for you?

By Natalie Olsen, registered dietitian, and Jayne Leonard, psychotherapist

Peanut butter provides a good amount of protein, along with essential vitamins and minerals. Each two-tablespoon serving (Table 1) provides the following nutrients, minerals and vitamins:

- **Protein:** Peanut butter contains 7,02g of protein per two-tablespoon serving. This counts toward the recommended dietary allowances (RDA) for women (46g) and for men (56g).
- **Magnesium:** With 57mg of magnesium, each serving contributes to the RDA of 400 to 420mg in men, and 310 to 320mg in women. Magnesium plays an essential role in over 300 chemical processes in the body.
- **Phosphorous:** Each serving contains 107mg of phosphorus, which is about 15,3% of the RDA of 700mg for adults. Phosphorus helps the body build healthy cells and bones, and helps cells produce energy.
- **Zinc:** One serving of peanut butter provides 0,85mg of zinc. This is 7,7% of the RDA of 11mg for men, and 10,6% of the RDA of 8mg for women. Zinc is necessary for immunity, protein synthesis and DNA formation.
- **Niacin:** Peanut butter contains 4,21mg of niacin per serving, which makes a useful contribution towards the RDA of 14 to 16mg. Niacin benefits digestion and nerve function, and helps produce energy.
- **Vitamin B6:** With 0,17g of vitamin B6 per serving, peanut butter provides almost 14% of an adult's RDA of 1,3mg. It plays a role in over 100 enzyme reactions in the body.

Weight loss

Several studies suggest that eating nuts can help people maintain weight or even assist with weight loss. This may be because peanuts improve satiety thanks to their protein, fat and fibre content.

A 2018 study suggests that eating nuts, including peanuts, reduces a person's risk

of being overweight or obese. This study compared the dietary and lifestyle data for over 373 000 people from ten European countries over five years.

Improved heart health

Peanut butter contains many nutrients that can improve heart health, including mono-unsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), niacin, magnesium and vitamin E. The proportion of PUFAs and MUFAs to saturated fats in the diet plays a particularly important role in heart health.

Bodybuilding

Although calorie amounts will vary based on stature, activity level and metabolic rate, the typical recommended daily intake ranges from around 1 600 to 2 400 calories per day for women, and up to 3 000 calories per day for men. Thanks to its high calorie

Table 1: A detailed nutritional profile of two tablespoons of smooth peanut butter.

Nutrient	Quantity
Calories	188
Protein	1,02g
Saturated fats	3,05g
MUFAs	6,63g
PUFAs	3,63g
Carbohydrates	7,67g
Fibre	1,80g
Sugars	2,08g
Calcium	17mg
Iron	0,69mg
Magnesium	57mg
Phosphorus	107mg
Potassium	189mg
Sodium	152mg
Zinc	0,85mg
Niacin	4,21mg
Vitamin B6	0,18mg
Vitamin E	1,90mg



content, peanut butter is an easy way to increase calorie and unsaturated fat intake.

Managing blood sugar levels

Peanut butter is a relatively low-carbohydrate food that contains good amounts of fats and protein, as well as some fibre. These characteristics mean that peanut butter, with no added sugar, does not have a significant impact on blood glucose levels, which makes it a good option for those with diabetes. Peanut butter is a good source of magnesium, which is an essential nutrient for people with diabetes.

Reduced risk of breast disease

Eating peanut butter, especially from a young age, may reduce the risk of benign breast disease (BBD). A study in the journal *Breast Cancer Research and Treatment* reports that eating peanut butter and nuts at any age may result in a lower risk of developing BBD by age 30. Other types of pulses, such as beans and soya, along with vegetable fats and other nuts, may also offer protection from BBD. 🌱

This article has been shortened for use in *Oilseeds Focus*. To read the original article, visit www.medicalnewstoday.com/articles/323781#nutritional-profile.

Common law in future: Enough to stop land invasions?

By HJ Moolman, Moolman & Pienaar Incorporated

Land invasions in South Africa can be divided into two groups with different motives: homeless people who have nowhere else to go, and people with a political agenda who erect structures and invade land.

The *Constitution of the Republic of South Africa, 1996 (Act 108 of 1996)* protects people who invade and occupy land from being evicted without a legal court order. Evictions are also legally executed by the sheriff of the court from which an eviction order was obtained.

Where landowners are concerned, the *Constitution* stipulates that no person may be unilaterally deprived of property. Both individuals and the state can commit this type of property deprivation, and therefore the *Constitution* also prohibits any legislation that would allow unilateral deprivation of property.

Spoliation or spoiling of possession can occur in different ways, for example physically taking away someone's property or prohibiting access to a premises.

Between these two opposites in the *Constitution* exists a maze of provisions that must be considered in circumstances where a response to land invasion is necessary. It is against this background that the Western Cape High Court recently heard arguments regarding a common law (legal principles from other countries and our history that have become part of our legal system) remedy known as counter spoliation.

Counter spoliation and spoliation

Counter spoliation is a counter measure against what is known in our legal system

as spoliation. Spoliation is closely related to the word 'spoil' and simply means spoiling of possession.

If you are wrongfully deprived of your right of possession by someone who takes the law into their own hands, you will be entitled to approach the court by means of a remedy – *mandament van spolie*, or spoliation remedy – to restore your right of possession through a court order. The spoliation remedy is part of an advanced way of resolving disputes in a civilised country where the rule of law is upheld and citizens are discouraged from taking matters into their own hands.

Spoliation or spoiling of possession can occur in different ways, for example physically taking away someone's property or prohibiting access to a premises. Counter spoliation is a permissible response to spoliation in our legal system. This simply means that a victim of spoliation has a legal recourse, based on counter spoliation, to immediately or spontaneously and physically take back their possession without any legal consequences for the victim of spoliation.

Land invasions can be seen as a form of spoliation. The issue on which the Western Cape High Court must decide, is whether counter spoliation (spontaneous and immediate action to physically prevent land invasions) is permissible within the scope of the aforementioned constitutional provisions, and in particular within the framework of evictions that may not take place without a court order.

Deprivation of land

In essence, this means the court will have one of two choices, namely to uphold the common law with regard to land invasions, but set clear guidelines on the manner in which landowners may use counter spoliation to prevent

land invasions, or to determine that the remedy of counter spoliation can no longer be used to stop land invasions if it is measured based on the *Constitution's* provisions on eviction.

The South African Human Rights Commission and the Economic Freedom Fighters (EFF) are the other party in this matter and it is, of course, the commission and political party's view that counter spoliation may not be used to stop land invasions.

Unfortunately, the rejection of counter spoliation as a legal remedy in the case of land invasions means that landowners or people who legally own land in ways other than property rights, will enjoy less protection of their property rights from a legal point of view. This, together with upholding the rule of law, should be a strong argument in favour of retaining counter spoliation in the case of land invasions.

The state's duty to protect rights

Section 7 of the *Constitution* places a duty on the state to respect, protect and promote the *Bill of Rights of the Constitution*. This duty includes the constitutional provisions set out in the *Constitution* to protect property rights.

The Western Cape High Court case will bring this issue to a close, although it will in all probability not be the final decision in this regard. Hopefully, in the interest of agriculture, this decision will have a positive outcome and will preserve an important legal remedy for the protection of property rights and a counter measure to unlawful deprivation of property. 🌱

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Geared towards the new national minimum wage

By Charlene Steyn, legal advisor, LWO Employers Organisation

In terms of the *National Minimum Wage Act, 2018 (Act 9 of 2018)*, or *NMWA*, the National Minimum Wage Commission annually assesses and reviews the national minimum wage. The commission then submits a recommendation to the minister of employment and labour to adjust the minimum wage for the next period.

The national minimum wage for the 2022/23 period will come into effect on 1 March 2022.

Agricultural sector increases

The agricultural sector's national minimum wage for the 2021/22 period increased by 16,1%, after the sector's exemption to pay only 90% of the national minimum expired, and the minimum wage for farm workers was made equal to the national minimum wage for 2021. Employers in the agricultural sector should take note that domestic workers on a farm are regarded as farm workers and must receive the correct wage.

The commission uses the consumer price index (CPI) plus 1% to determine the proposed increase. The CPI was 5% in September 2021, and the national minimum wage increase is consequently calculated at 6%. This means an increase in the current minimum wage from R21,69 to R22,99 per hour.

The environment in which South African businesses operate can be challenging, with the economy and other external factors leaving business owners with few options when it comes to being

competitive and sustainable. The national minimum wage and associated increases are putting additional pressure on employers, as there is no negotiating the payment of the wage.

Waiver of the minimum wage

However, Section 15 of the *NMWA* stipulates that if employers cannot afford the national minimum wage, they can apply for a waiver online (nmw.labour.gov.za). If a waiver is granted, the employer will still have to pay at least 90% of the national minimum. A waiver is valid for a maximum of twelve months.

As part of the waiver application, the employer must provide a valid reason for the waiver as well as evidence that meaningful consultations took place between employees and representative unions, where applicable.

The regulations further stipulate that such an application will not be granted if the employer fails to meet the affordability elements relating to profitability, liquidity and solvency. Calculations for these tests are included in the schedules to the *NMWA*.

Moreover, a waiver will only be considered if the employer's legal payments are up to date, including the Unemployment Insurance Fund, the Compensation Fund, and any other applicable levies.

As it is an online application, the outcome is available immediately, unless the application is flagged for an audit (which will take place within 30 days from

the application date). The outcome will confirm the commencement date of the waiver, as well as the period for which it is granted, the wages the employer is obligated to pay employees, and any other relevant conditions.

If a waiver is granted, a copy of the waiver certificate needs to be displayed in the workplace and provided to the relevant employees and representative unions, where applicable. In case of an unsuccessful application, the employer will receive a notice stipulating the reasons for refusal.

Non-compliance with the NMWA

A dispute over non-compliance with the *NMWA* can be referred to either the Commission for Conciliation, Mediation and Arbitration (CCMA), or the Department of Employment and Labour. If an employer fails to comply with the *NMWA*, the employer can be fined as follows (whichever amount is the highest): Twice the value of the amount to be paid to the employee as per the prescribed minimum wage, or twice the employee's monthly wage.

Restrictive labour regulations are considered one of the most problematic factors when it comes to doing business in South Africa. Employers need to change their mindset and start to proactively manage the business risk associated with labour legislation compliance. Going forward, employers should be on the right side of legislation in terms of the employment relationship, as well as any possible future disputes relating to minimum wages. 🌱

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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