The climate's effect on Swartland canola production

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Dryland canola production potential is highly influenced by climatic factors such as temperature, carbon dioxide (CO_2) concentration and rainfall amount and distribution, in addition to soils, agrochemical inputs and management.

In the Western Cape, information on the climate drivers of canola growth and seed production can help to decrease the yield gap by identifying current and future areas of medium to high production potential. Furthermore, knowledge of expected future climate risks to canola production can be used to mitigate the risks and implement adaptations.

Canola in the Swartland region

Canola is an important dryland crop in the winter-rainfall Swartland region of South Africa and is widely employed within crop rotation systems. The potential production of canola in terms of yield and suitable planting areas has not yet been exploited under current climatic conditions, i.e., there is a 'yield gap'.

However, the climate is already changing, and future production potential and suitable areas are very likely to change. This could be both challenging and provide opportunities for production and efficiency increases for this growing commodity.

The range of genetic types available to South African producers, encompassing cultivars that have been bred for specific herbicide tolerances and cultivars with short to long growing seasons, could provide tools for adaptation and sustainable growth of the industry. While some research in Australia and Canada has focussed on canola responses to climatic factors and climate change, no information is available for the South African context.

Recent research conducted for the Western Cape Department of Agriculture (WCDoA) confirms that the Mediterranean-type climate of the Western Cape, where most of the rainfall occurs in the cool months of April to September, is getting hotter (Jack *et al.*, 2022). The trend in rainfall amounts and seasonal distribution is more complex, with indications that autumn (the canola planting season) is getting dryer, especially in the western parts of the province.

When climate modelling was conducted for various climate change scenarios for the mid-century, the results were consistent with modelling for other Mediterranean climate regions where canola is produced. The future climate of the Swartland will be increasingly warmer, with more hot days and dry spells, and likely with longer-term decreases in seasonal rainfall.

Climate change is driven largely by emissions of CO_2 into the earth's atmosphere, which is also an important factor to consider when studying the response of canola plants to current and future climate. This article provides a brief background to a research project currently underway.

A climate study

In a quest to unlock the full potential of canola cultivation, scientists from the WCDoA and Stellenbosch University (SU) are currently conducting a study to explore the potential impact of climate change on canola crops in the Swartland, and to assess the present and future canola production potential for the region.

The study focusses on increases in temperature and atmospheric CO_2 concentration. In addition, they are investigating how climate variations affect the actual yield of various canola cultivar types in field trials. The Protein Research Foundation or PRF financially supports the project. By understanding the interplay between climatic factors and canola cultivar types, strategies that will optimise canola yields can be developed to ensure its successful cultivation, despite changing environmental conditions.

Andries le Roux, a PhD student from the Department of Agronomy at SU, is conducting the research in three parts, supported by the larger research team. Firstly, the effect of current and future climate on canola production in the Swartland region is explored through a series of pot trials inside a climate-controlled phytotron. Two crucial climatic factors – air temperature and atmospheric CO_2 concentration – are simulated for current and future scenarios.

Secondly, the study focusses on canola production under field conditions to build upon and test the results of the phytotron experiments. Over the past 12 years, canola cultivar trials have been conducted by researchers at the WCDoA, particularly at Langgewens Research Farm near Moorreesburg. Precise measurements of canola yield, together with weather and other environmental factors, have been recorded for the various cultivars included in these trials. Further canola trials and detailed data collection at Langgewens are planned for the next three years as part of this project.

The canola cultivars used in the pot and field trials are categorised into distinct classes based on two factors: growing season length (short and medium for pot trials; and short, medium and long for field trials) and cultivar type (conventional, Clearfield tolerant and triazine tolerant). Climate data including day and night temperatures, stress-inducing (high) temperatures during certain critical growth stages, and rainfall patterns during different growth stages will be meticulously analysed concerning crop phenological development and yield.

The third part of the study will entail canola crop modelling employing the agricultural production systems simulator (Apsim) model to establish the current and simulated future canola production potential in the Swartland. Apsim is an integrated model that effectively mimics biophysical processes in agricultural systems, considering ecological outcomes of various management practices for the present climate and climate change. It encompasses plant, soil and management modules, accommodating a diverse range of crops, soil profiles and management practices suited to Australian conditions.

By incorporating South African canola cultivars, Swartland's predominant soil profiles, climate and diverse management practices, the model will be adjusted to simulate the current canola production potential for this locality. Subsequently, different climate change scenarios and a suite of Global Circulation Models will be employed with the model to project the canola production potential and possible changes in suitability across the Swartland region between 2046 and 2065.

Climate's influence on canola

Canola production, like many dryland crops, is influenced by the region's local climate, including day or night temperatures, and rainfall amount and distribution during the production season. The ideal growing temperature for canola is between 20 to 25°C, while rainfall of less than 450mm during the production season can result in yield penalties (Robertson and Kirkegaard, 2005).

Climate plays a significant role in canola production right from planting, where it is advisable to sow canola after a sufficient rainfall event or at least 10mm (with prior rainfall) to 20mm over a week. Early seasonal planting, with warmer soil temperatures, can improve seedling establishment and growth, along with increasing the vegetative growing season length, ultimately enhancing canola production (Shafighi *et al.*, 2021). Conversely, late planting due to delayed rains in cooler soils negatively affects initial growth and results in reduced seed yield, size and oil content.

During the vegetative growth stage, the environment continues to play a key role in canola production, particularly concerning plant biomass production, which directly affects yield. Optimal temperatures during this stage promote canola leaf growth and biomass production, leading to higher seed yields. While canola is more drought tolerant during its vegetative stage compared to certain other crops, prolonged water stress can still affect leaf area, though recovery occurs with adequate rains.

Temperature and drought stress during the reproductive growth stage have a more severe impact on canola production than during the vegetative stage. Heat stress, typically observed at temperatures higher than 30°C during flowering and seed set stages, leads to flower abortion and infertility, reducing the number and mass of siliquae per plant (Dreccer *et al.*, 2018). Moreover, it negatively alters the oil extraction percentage and fatty acid composition of the oil.

Similarly, drought stress during flowering and seed set causes flower abortion, shortens the flowering period and delays siliqua maturity, ultimately affecting pod numbers and seed size, leading to reduced canola production and decreased seed quality, including oil extraction and fatty acid composition (Elferjani and Soolanayakanahally, 2018).

Future climate effects

A review of the scientific literature was conducted to provide a basis for what we can expect in future as the climate changes in the Swartland.

The rise in global greenhouse gas (GHG) emissions, particularly CO_2, has already caused an increase in the global average temperature of 1,1°C since preindustrial times, with projections of further GHG-driven temperature increases of approximately 1 to 2°C and shifting rainfall patterns within the next few decades for the Swartland region. This would lead to more frequent dry spells and droughts, altered seasonal rainfall distribution, and amount and increased occurrences of extremely hot days and heatwaves (Jack *et al.*, 2021). Canola is more sensitive to stressful environmental conditions during the reproductive phase than the vegetative phase.

Elevated atmospheric concentrations of CO_2 have a fertilising effect on C_3 plants such as canola, enhancing plant photosynthesis and increasing leaf area and plant biomass, and ultimately improving canola production. However, studies have shown that higher CO_2 levels can cause canola plants to allocate more energy towards vegetative growth rather than reproductive growth, leading to an extended flowering period (Qaderi *et al.*, 2006).

Research specific to the Swartland region indicates the likelihood of a later planting date, an increased occurrence of very hot days and heatwaves during the flowering period, and more regular dry spells throughout the production season. While elevated atmospheric CO_2 levels may partially offset the negative effects of heat and drought stress on canola yield, the potential extension of the flowering period under elevated CO_2 levels means that temperature and drought will continue to play a critical role in determining canola yield and seed quality in future.

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