Climate change: Lessons from Australia

By Prof RM Gous, Protein Research Foundation

South Australia has a Mediterranean climate similar to that of the Western Cape, so it is no surprise that the three most important crops grown there – wheat, barley and canola – are also the most popular in the Western Cape. Climate change in South Australia has caused several important changes that have consequences when growing these crops, and we could learn much from the research that is currently being done there.

Producers in Australia have noticed a considerable decrease in autumn rainfall, when sowing traditionally takes place, and an increase in spring temperatures, both of which have influenced the timing of crop events such as flowering (crop phenology), leading to an increased risk of frost damage.

One of the many interventions introduced to overcome these problems has been to make use of faster-growing varieties that are generally planted later in the season. However, these have been shown to reduce yield potential. Dr John Kirkegaard, farming systems agronomist at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Canberra, has innovative ideas for overcoming the problem in the short and medium term.

Dr Kirkegaard and his colleagues believe that the negative impact climate change has on canola production can be mitigated to a large extent through several management interventions. Three of these – storing summer rainfall more effectively, sowing earlier with slower-maturing varieties, and using variable nitrogen (N) fertilisation management – are discussed here.

Storing summer rainfall

Under increasingly warm and variable climates, the efficient use of soil water carried over from the previous crop, and of rainfall accumulated during fallow periods, is an important element of the farming system.

In 2008, the Australian grains industry established the five-year Water Use Efficiency (WUE) Initiative, which challenged growers and researchers to increase WUE of grain-based production systems by 10%. In the years that followed it was demonstrated experimentally that water productivity could be improved by levels well above the 10% target through better summer weed control (37 to 140%), inclusion of break crops (16 to 83%), earlier sowing of appropriate varieties (21 to 33%) and matching N supply to soil type (91% on deep sands).

Fallow efficiency, the proportion of fallow rain that is stored and hence available for the subsequent crop, is a key concept that is worth studying in more detail. It is influenced by the management of weeds, crop residues, and soil tilth during the fallow period. The capacity of soil to capture, store, and supply water to crops depends on its long-term management. Interventions such as minimising excessive cultivation, avoiding compaction by heavy machinery or livestock, and maintaining adequate inputs of soil organic matter are all principles of conservation agriculture that maintain soil structure, and are well known to Western Cape producers.

Retaining surface residues

Perhaps most important is retaining surface residues to protect the soil from raindrop impact and erosion. Residues slow the flow of water on the soil surface, thereby allowing more time for infiltration, and reduce soil evaporation following rainfall events. However, if conditions remain dry for an extended period, residues will not affect total evaporation.

Weeds are not considered appropriate residues, as they transpire water that could otherwise be used by subsequent crops. Weed control has the biggest impact on grain yield when pre-crop rainfall is high and subsequent in-crop rainfall low.

Integrated pre- and in-crop weed management that will maintain weeds below damaging thresholds include pasture leys, crop sequences, rotating herbicide groups, hay-cutting, chaff collection, and strategic tillage and burning. Strict control of weeds is necessary if summer rainfall is to be stored efficiently.

In most southern Australian dryland farming systems, a fallow period of four to six months follows the harvest in early summer and precedes planting of the subsequent crop in late autumn. This 'short' fallow period occurs when mean monthly rainfall is low (20 to 50mm) and evaporation rates high (250 to 300mm), but a significant portion of rain falls during large, infrequent events.

Rainfall above 20 to 30mm can infiltrate below the evaporative zone at the soil surface and be stored for subsequent crop growth. Fallow rainfall stored in the soil can contribute between 6 and 58% of average crop yield depending on soil type and both pre- and in-crop rainfall patterns.

Sow slower-maturing varieties

In Australia, attempts were made to overcome the effects of water limitations on yield by adapting crop phenology with the use of faster-growing varieties. Crops sown following autumn rains flowered after the period of significant frost risk but matured before the onset of summer heat and drought.

A better understanding of cultivar phenology and improved agronomic management has prompted a re-evaluation of sowing date recommendations in canola,

with sowing windows shifting three weeks earlier than previously recommended. This ensures that crop establishment occurs following autumn rains (April and May), and flowering occurs in an optimal period in spring after frost risk, but before heat stress and terminal drought.

In Australia, canola yield declines by 5 to 12% per week of delay in establishment after mid-April, resulting in decreases of 44 and 85% for crops established in June and July, respectively. Early crop establishment and longer growth duration means that greater efficiency is achieved in converting rainfall into grain. This occurs primarily through deeper root growth and access to water, reduced evaporative losses from the soil, and increased transpiration efficiency. In South Australia, the sowing window closes in the second week of May.

Early sowing of crops

The concept of fallow efficiency is important for storing rainfall prior to sowing a canola crop. Another important concept is that of crop establishment opportunity, which relates to the likelihood that pre- and post-sowing conditions will result in the establishment of 40 or more plants per square metre.

The management of and yield from a canola crop depend heavily on whether the opportunity exists for the crop to become established. This in turn depends on the rainfall predicted for the period after sowing, the soil type, and whether more than 25% of fallow rainfall has been stored. The rule for sowing early in sandy soil is that 10mm of rain must fall over seven days soon after sowing, while loam requires 15mm of rain over seven days. As the chances for genuine crop establishment opportunity diminish, the predicted yield from the crop will decrease and the use of N-fertilisation will change.

Field selection and pre-crop management are critical for the successful implementation of early sowing. Early sowing increases the reliance on in-season weed management as options for knockdown weed control are limited. Therefore, choosing fields with low weed pressure is key to success. This can be achieved through various strategies including crop rotation, which minimises the weed seed bank, and harvest weed seed control in the preceding crop, including the use of chaff carts, windrow burning, crop topping and seed destruction.

Other key factors to consider when choosing which fields to sow early or dry, include topography and soil type. Sowing should start in the higher areas of the farm, followed by sowing in the low-lying fields that are more prone to frost. In water-repellent sandy soils, disturbance of dry soil can adversely affect the germination and emergence of dry sown crops. Therefore, these soils are not recommended for dry sowing. Lighter sandy soils with lower water-holding capacity require less rainfall to germinate dry sown crops and are more suitable for large dry sowing programmes.

N-fertilisation management

N-fertiliser inputs should be adjusted in response to soil type and yield potential as determined by seasonal conditions. The amount supplied should relate to the crop establishment opportunity: If this is low, then the amount of N should be low and vice versa. The response to N is always greater on sandy soils, and the highest response is during a wet season, although there is an advantage in delaying the application of N in such a season. Split application of N allows management decisions to be delayed until seasonal conditions and forecasts provide more knowledge of crop yield prospects.

There is always a yield gain when canola follows a legume crop because of the N remaining in the soil, irrespective of the amount of N added later. In sandy soil, canola responds to additional N application with no interaction with the previous crop or rainfall during the season, whereas in loamy soils and high rainfall there is less advantage in applying additional N if canola has followed a legume crop. Soil-specific management of N leads to increased profit and reduced risk.

Important considerations

For a season of average rainfall, the Australian experience is that if sowing took place on land preceded by a legume crop, according to the crop establishment opportunity and using variable N management, the gain in profit over a base of AU$100 was a further AU$200/ha. With this in mind, Western Cape canola producers who are not currently using these interventions should seriously consider taking advantage of the research that has been conducted in Australia.

However, a couple of important provisos need to be mentioned:

- High-yielding, early-sown crops can leave a legacy of dry, N-depleted subsoil, which may require changes to crop sequence and management to avoid yield penalties. If the subsequent rainfall during the summer fallow period is low and fails to refill the soil profile, it may be necessary to reconsider the crop sequence plan or the intended sowing date of subsequent crops in order to avoid high-risk scenarios.
- The success of agriculture in the southern Australian cropping zone has not come without the emergence of environmental problems such as soil acidification, dryland salinity, compaction, and herbicide resistance in weeds. Addressing these issues, while maintaining crop yields, is crucial for the future.

For more information or references, send an email to the author at gous@ukza.ac.za.