Irrigation

New guidelines to determine pasture water requirements

A recently completed project funded by the Water Research Commission (WRC) has culminated in the publication of guidelines on irrigating mixed pastures for livestock grazing. Article by Sue Matthews.

It's a tough gig being a farmer nowadays, with profit margins continually eroded by rising input costs, and water availability declining due to competing demands. Some 60% of water use in South Africa is for agricultural irrigation, and farmers are increasingly aware that it is in their own interest to improve the efficiency of their irrigation practices because this has a direct impact on the amount of money they must spend on electricity and fertilizer. Get it wrong, and they've not only paid Eskom more than necessary, but also wasted precious water and expensive fertilizer through runoff and deep percolation, which leaches nutrients out of the crop's root zone.

About 16% of the total area under irrigation is pasture cultivated for livestock production, with ryegrass, kikuyu and lucerne being the most common species. While ryegrass and kikuyu are the primary sources of feed in the pasture-based dairy industry, concentrated in the high-rainfall areas of the KwaZulu-Natal midlands and the Western and Eastern Cape coasts, lucerne is predominantly cultivated in the drier parts of the country for hay. In other words, it is grown specifically to be cut, dried and stored as nutritious fodder to supplement grazing in poor-quality natural veld, particularly during winter. Being a nitrogen-fixating legume, though, lucerne is increasingly also sown with grasses in mixed pastures in the dairy production areas as a way of reducing fertilizer application and providing more palatable, digestible and nutritious grazing than grass alone.

Managing these mixed pastures is considerably more complicated, however. For one thing, the species making up the mix probably have different water requirements, so how do farmers ensure optimal irrigation scheduling?

"Knowing how much water to apply through irrigation and how often is no trivial matter," says Dr Wayne Truter, a pasture

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Using measured in-field research data together with the models SWB and DairyMod, the project team was able to generate irrigation guideline tables for different pastures.

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A mixed pasture made up of tall fescue and white clover.

specialist in the University of Pretoria's Department of Plant and Soil Sciences. Dr Truter headed up a recently completed research project funded by the WRC entitled 'Water use and crop parameters of pastures for livestock grazing management', and is lead co-author of the project report and the accompanying technology transfer document, 'Irrigation guidelines for mixed pastures and lucerne'.

Dr Truter explains that the broad guideline for irrigating most temperate grasses and legumes is 25 mm of water per week, regardless of season or region, but evaporative demand obviously differs between locations, with changing weather conditions, and as crop canopy cover varies. A rigid guideline of 25 mm per week will therefore lead to over- or under-irrigation at different times and places.

A previous WRC-funded project in which he was involved, completed in 2012, focused on irrigation management of ryegrass pastures, with limited research on kikuyu and kikuyu-ryegrass mixtures. It culminated in the publication of irrigation guidelines for ryegrass in the major pasture-growing areas of South Africa.

The more recent project expanded this research to various mixtures of grass species such as ryegrass, kikuyu, tall fescue and cocksfoot with the legume species, lucerne and white clover. The project team, which included research collaborators from the University of KwaZulu-Natal, conducted evaluation trials to improve understanding of pasture water requirements at the University of Pretoria's Hatfield Experimental Farm in Pretoria and the Western Cape Department of Agriculture's Outeniqua Experimental Farm in George, representing the summer and year-round rainfall regions respectively. Monitoring sites were also established on farms situated 120 km north-west of Pretoria and in the Cedara region of KwaZulu-Natal to measure water use and growth rate of commercially planted lucerne and mixed pastures under irrigated conditions.

Most pastures, whether monospecific or mixed cultures, are perennial production systems with a lifespan of at least five years. During this time they are repeatedly defoliated by grazing livestock or mechanical cutting, left to regrow for six to eight weeks, and then defoliated again. One of the main findings of the research was that less water than the current guideline of 25 mm per week is required in the first two weeks after defoliation, because the smaller canopy shading the soil surface means that more water is lost through evaporation.

On the other hand, if the period between grazing or cutting cycles is too long – resulting in a large and dense canopy – water use will be high, but since the plants will likely have reached reproductive maturity, the quality of pasture will start to decrease. Furthermore, the species in a pasture mixture may have different growing seasons, so even if the canopy is fully developed a higher percentage of water may be lost to drainage if one of the species is in a dormant phase.

In fact, different cultivars within the same species have distinct preferences that further complicate pasture grazing management. For example, two varieties of lucerne – WL357 and WL711 – were used in trials conducted at the Outeniqua Using Experimental Farm. The kikuyu-lucerne WL357 mixture was comprised of mostly kikuyu during winter, lucerne during summer, and similar compositions of kikuyu and lucerne in autumn, because lucerne WL357 is a semi winter-dormant cultivar. By contrast, lucerne WL711 is highly winter-active, and made the largest contribution to the kikuyu-lucerne WL711 mixture in winter, even though kikuyu remained the dominant component. As a result, the kikiyu-lucerne WL711 mixture had a higher yield than kikuyu-lucerne WL357 in the cooler seasons and vice versa for the warmer seasons. Clearly, it would not make sense to apply the same amount of water to the two mixtures throughout the year.

Based on their research findings, the project team was able to estimate the water requirements of various pasture species and mixtures in all four seasons. For example, while kikuyu grown on its own at the Hatfield Experimental Station would require as little as 12 mm of water per week in winter, when it is dormant, this would increase to 30 mm per week in summer. When mixed with lucerne, which has higher water usage, slightly more water would need to be applied, rising to 34 mm per week in summer. However, a kikuyu-lucerne mixture at the Outeniqua Experimental Farm would likely only require 28 mm per week in summer.

A table showing the various water requirements is provided in the two project documents as a general guideline to irrigation, although applying these figures to other sites with different climatic conditions and soil characteristics would of course

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seem inherently risky. Truter explains that using the guideline values in conjunction with some basic monitoring data would improve their reliability considerably. Most important is the evapotranspiration (ETo) value – recorded by the simple weather monitoring systems most farmers have on their land, or provided by local weather stations in the vicinity – as this allows one to benchmark more or less the water to be applied according to ambient conditions. However, the management objective would be to achieve a more accurate value according to the specific crop growth parameters. Many farmers also routinely use a pasture disc meter – otherwise known as a Rising Plate Meter (RPM) – to estimate the amount of pasture they have available. The quick and easy RPM method relies on measurements of height and compressibility of the pasture, calibrated to dry matter yield per unit area.

"It's probably the simplest way of determining how much biomass has been produced in the last week," says Truter. "So repeated measurements over time should allow you to deduce the water requirement of the pasture. It is imperative that the RPM be calibrated to the specific pasture as this will give you more accurate readings."

An alternative approach that the project team investigated is to use the Soil Water Balance (SWB) Model, which at its most basic level can generate site-specific irrigation calendars that farmers can print out and refer to for irrigation scheduling. Input on crop, weather, soil and irrigation management is required, but this is relatively uncomplicated because the model has various built-in datasets. For the crop input, farmers need only insert their crop type, the field size and date planted, while the minimum weather input involves simply selecting the nearest major weather station from a dropdown menu, or alternately entering the site's latitude, longitude and elevation.

Other weather parameters such as solar radiation, relative humidity and wind speed can be added, if available, to improve accuracy. The soil input entails a little more effort, as it includes soil depth (determined by digging profile holes at representative sites in the field), soil type (having soil samples analysed at a soil laboratory, or simply choosing between coarse sand, sandy, sandy clay loam or clay soil) and initial soil water content (selecting dry, medium or wet at a minimum, but ideally using soil water probes). Lastly, the irrigation management input includes the type of irrigation system (furrow, sprinkler, pivot, micro and drip), its delivery rate, as well as irrigation timing and refill options.

The final output – the irrigation calendar – recommends irrigation dates and amounts, which must be corrected by subtracting any rainfall that occurs. While the calendar tells the farmer when to irrigate, the optional use of wetting front detectors (WFD) – funnel-shaped tools inserted into the root zone that indicate when water has reached a specific depth – will tell him when to stop.

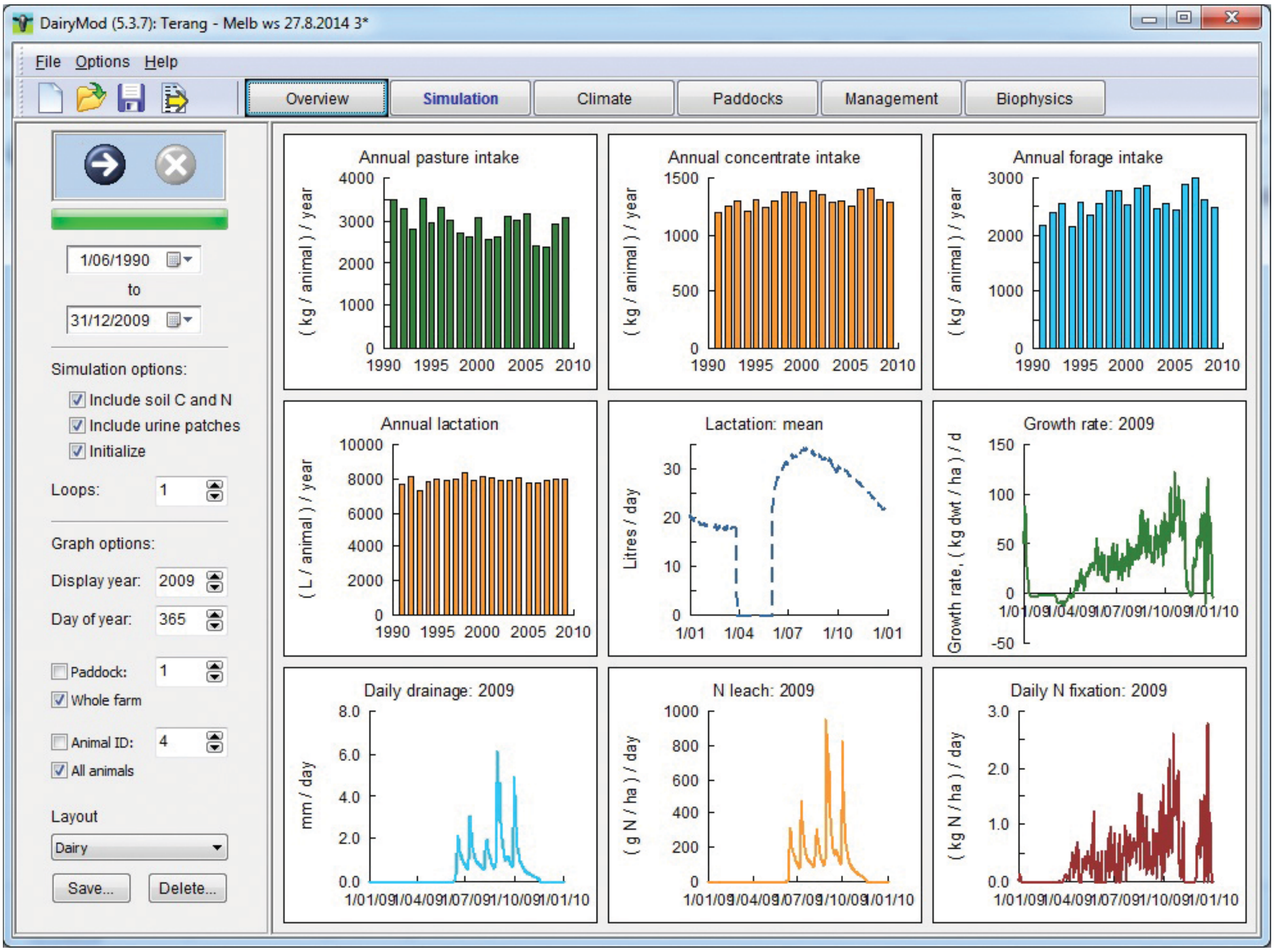
The SWB Model is available in a more advanced 'consultant version' for those who want to use their own inputs, such as different soils in different layers, or to simulate and display crop growth and soil water balance components. There is also a 'researcher version' for complex simulations pertaining to specific research questions.

"The first prize, though, would be to use DairyMod," says Dr Truter. This is a biophysical simulation model for dairy systems that the project team tested and validated during their research. Developed by IMJ Consultants in collaboration with Dairy Australia and the University of Melbourne, the model has the ability to incorporate local weather data and to adjust specific parameters related to the soil, pasture growth and animal management factors.

"The model is available online for free downloading and registration with its developers, but it can only be used effectively if set up for the region in question," notes Dr Truter. "We would have to help the farmer set up the baseline dataset that the model requires as supportive information, and from there he or she could incorporate their own data to get a prediction of how best to irrigate."

"So the idea was that we collaborate more closely with IMJ Consultants to update any model development changes, house and run the model and build a comprehensive database for South African pastures, and then we will advise farmers on what minimum information they need – because, of course, the model is only as good as the information you put in!"

To order the project report, *Water use and crop parameters of pastures for livestock grazing management* (**WRC Report No. 2173/1/16**), and/or the technology transfer document, *Irrigation guidelines for mixed pastures and lucerne* (**WRC Report No. TT 697/16**), contact Publications at tel: (012) 671-9300; email: orders@wrc.org.za or visit: www.wrc.org.za to download a free copy.



A screenshot of DairyMod, a biophysical simulation model for dairy systems that the project team tested and validated during their research.