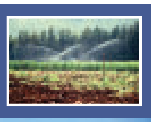


Pivot Irrigation-
The Never-Ending Quest for Improvement

Wilken Boerdery is located within sight of Teebus and Koffiebus near the outlet of the Orange-Fish tunnel.

"On any farm one is constantly looking for better yields, savings on mechanisation costs etc. Farming is a constant cycle of investigations into the effectiveness of the practices you are applying, how you do things." This is the view expressed by Mr Louis Wilken, chairman of the Orange-Vaal Water Users' Association, when we visited him to discuss the role that the irrigation-planning program SAPWAT is playing in his farming operation, Wilken Boerdery, in the Karoo.

Louis Wilken

"Scheduling and the effectiveness of irrigation systems in use are one of the first phases you consider," says Wilken. "You carry on until you feel you have the situation under control and then you move on to the next phase. You start looking at cultivars and planting densities and this leads you to planters and their suitability for the various soil conditions that apply on the farm. Inevitably this raises the issues of soil cultivation methods and implement suitability and the impact on soil compaction and root development. Fertilisers are an important factor, how much, what sort, when and how should they be applied? As improvements are implemented they have an impact on irrigation management and this means revisiting scheduling and the suitability of irrigation equipment and management. This cycle of investigations followed by improvements may extend over a year or two but all the time you are striving for progress, always returning to the factors that make a difference."

Wilken's involvement with the Orange-Vaal Water User's Association goes back to 1984 when he became the manager of what was then the Irrigation Board. He initi-

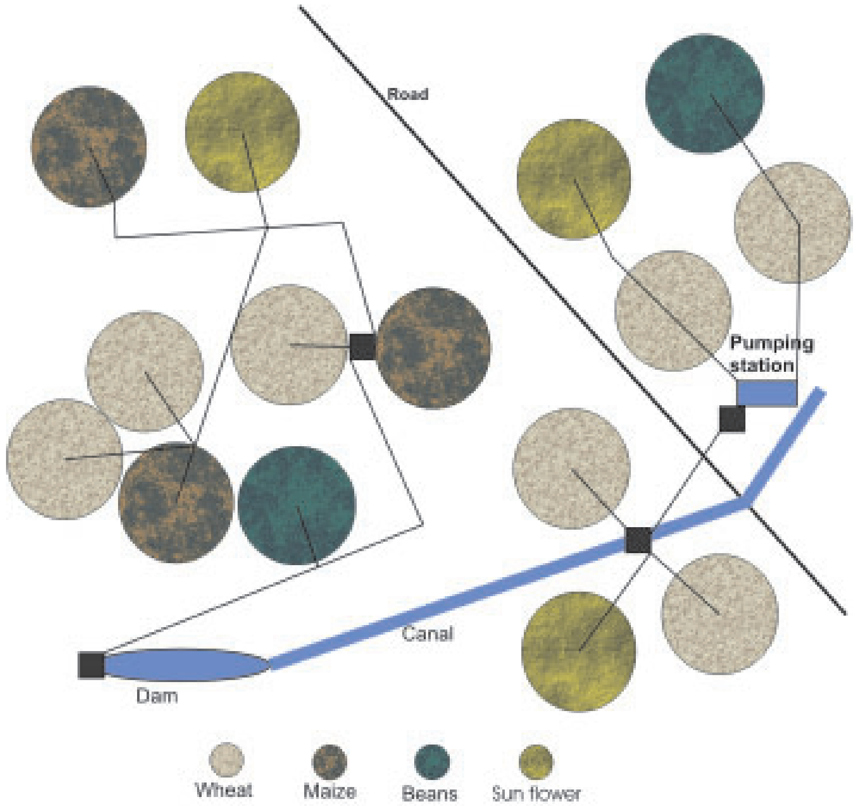
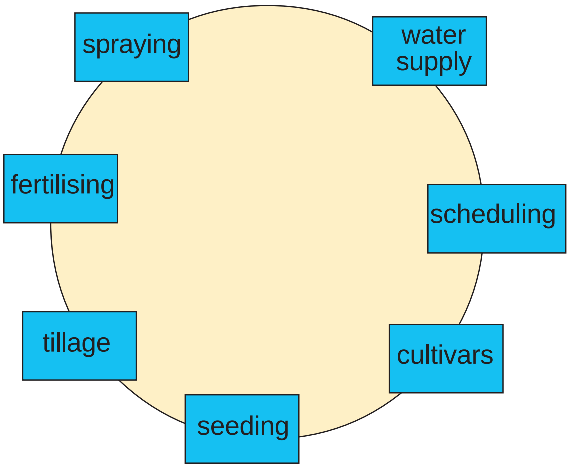


Diagram to illustrate the complexities of the irrigation planning and management task. The layout and the crop selection do not represent any specific farm.

ated the innovative approach of water management based on scientifically estimated crop irrigation requirements that is still successfully applied and has also been adopted by the Orange-Riet Water User Association.

Wilken has recently extended his farming activities to an irrigation farm at Schoombee in the Karroo that is served by a canal that originates at the outlet of the Orange-Fish tunnel. The irrigation system comprises ten centre pivots, several pumping stations and storage/balancing dams.



Louis Wilken's irrigation improvements cycle.

It will be appreciated that on a farm of the size and diversity of Wilken Boerdery this cycle is implemented for each land, crop rotation and pivot and integrated when developing the water management procedures for the farm as a whole. At the end of the day each change or improvement will influence irrigation requirements in terms of both volumes and timing. SAPWAT has a significant role to play in this process. It is a tool for evaluating and re-evaluating, on a continuing basis, the impact of changes in practices on irrigation management as well as the management of water resources and supply.

DEVELOPING CROP IRRIGATION REQUIREMENTS ESTIMATES

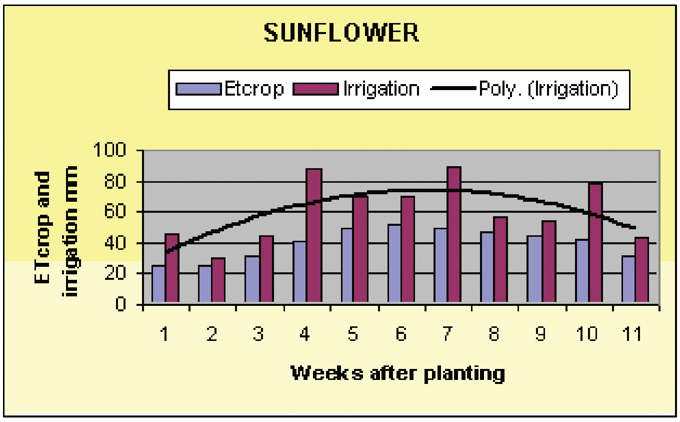
In the case of a farm such as Wilken Boerdery with 10 pivots served by several pumping stations and operating on varying soil types crop production planning can be complex. The impact on water supply and irrigation scheduling is facilitated if various alternative options can be weighed up interactively on a computer screen.

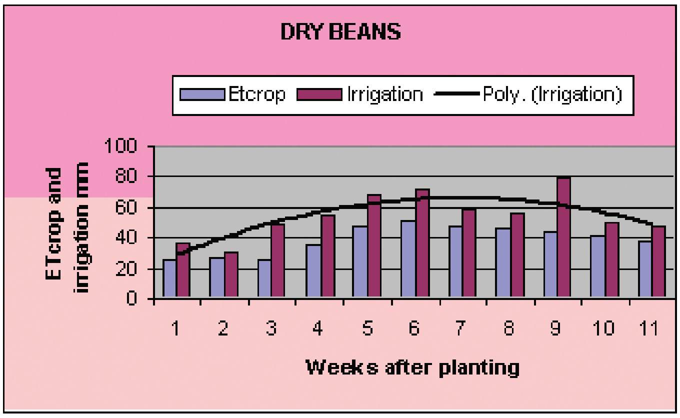
SAPWAT reflects directly the impact of the various crop production factors such as cultivar selection and planting date on weekly evapotranspiration (ETcrop), the blue columns in the graphs. This is the amount of water required by the crop for stress free production. This is to a large extent determined by climatic factors out of the control of the farmer.

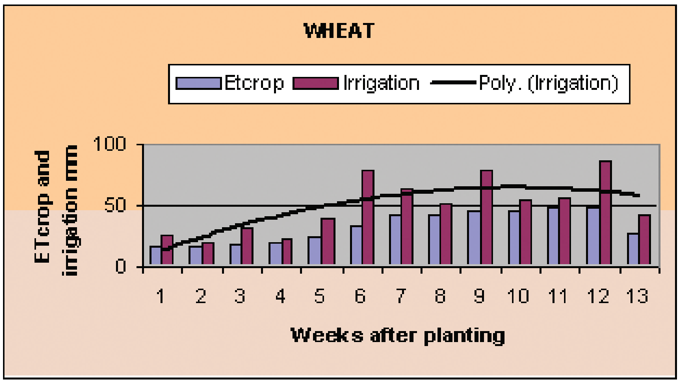
The dark red columns reflect weekly irrigation requirements and are influenced by the amount and frequency of irrigation applications and particularly by the water holding capacity of the soil profile.

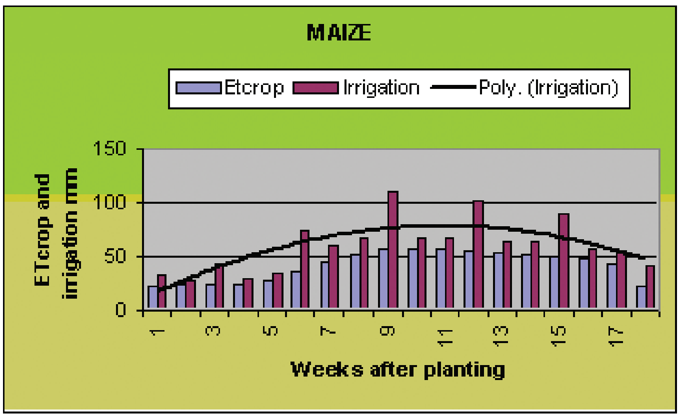
The graphs are based on the soil profile being refilled every three days to field capacity. The unexpected jumps in predicted weekly irrigations are largely caused by the three-day irrigation cycle not being in phase with a seven-day week! Estimates should be based on the black trend line that smooths these differences.

The simulations are conservative and do not take rain into account in this very dry area and the irrigation quantities are the amount of water pumped to the pivots, not "water on the ground".









THE AFFORDABILITY OF CENTRE PIVOTS

(Table and discussion based on data from *Cost Guide for crops produced under irrigation in the GWK area, June 2004.* Produsentedienste-GWK beperk.)

Crop	"Water factor" R/mm	Yield tons/ha	Gross margin R/50 ha	Irrigation Costs %	Irrigation Applied - mm
Wheat	4.31	6.50	142 050	13.8	660
Groundnuts	5.68	3.50	198 800	8.1	700
Cotton	5.97	5.00	253 550	10.3	850
Soya beans	7.00	3.50	193 250	17.8	550
Maize	7.96	12.0	299 250	14.2	750
Dry beans	8.04	3.00	181 000	8.1	450
Lucerne	9.13	22.0	593 600	25.4	1300
Sunflower	16.53	0.80	454 600	18.4	550
Potatoes	32.32	32.5	969 550	1.4	600
Onions	58.70	55.0	2 494 700	2.5	850
Cabbage	129.82	80.0	3 894 550	3.5	600

Crop gross margin is one indicator of the "affordability" of a pivot and is presented for a 50 ha pivot costing complete with pumps, piping mains and electricity supply some R700 000. The "irrigation costs" include only the cost of water and electricity. Affordability is very dependent on the crops grown.

This is a fascinating table. There is a world of difference between irrigating lucerne and onions although both can be produced profitably under pivot irrigation. Onions demand high-cost inputs and dedicated management to ensure quality, high yields and the safety of the crop and here the smaller automated pivots have advantages. They are proportionately more expensive than the large pivots but this will not be a consideration. Two 25 ha pivots would cost about 40% more then one 50 ha pivot.

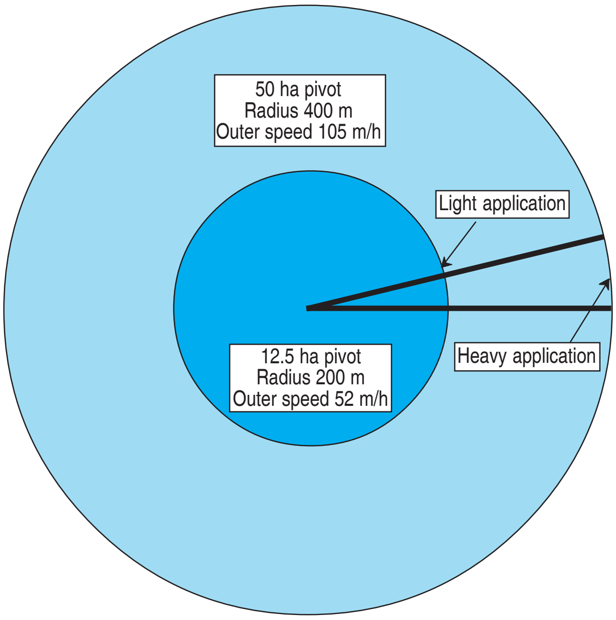
PIVOT IRRIGATION AND THE SOIL

When flood and hand-move sprinkler irrigation systems were the norm irrigation scheduling relationships were relatively straightforward. The objective was to replenish the water extracted by plant roots when the soil profile water content had reached the point where plants were starting to experience stress. The frequency of irrigation depended on how long it took the crop to extract the water from the profile and how much water could be stored. Typically this might be 60 mm so that if the evapotranspiration rate were 5 mm per day the irrigation cycle would be 12 days.

The introduction of the short cycle irrigation systems has greatly simplified management and made irrigation less dependent on soil depth and water holding capacity. It is even possible to work on a one-day cycle although this is not desirable. Each day the crop is given its daily water and, at times, fertiliser.

At Wilken Boerdery they are only too well aware of the need to improve the infiltration rate of the 50 ha pivots. Ploughing in a green manure crop helped but the next step is to fit spreaders and a double row of drop hoses and sprayers on the outer spans to improve infiltration by increasing the spray width. Once a higher rate of application has been confirmed SAPWAT will be applied to assess alternative strategies.

A centre pivot in common with all irrigation systems is required to apply water evenly over the full area of the field. The outer span of the pivot describes a circle while at the pivot centre there is no movement. The sprayer package is computer designed to compensate for this and the further out from the centre the higher the application rate. In many soils this limits the overall application to about 12 mm at each pass so that pivots are then designed to apply up to 12 mm per day. During peak periods this means that water must be applied at a rate of 12 mm per day, every day. This limits management options. Smaller pivots have the advantage of higher application rates.



REDUCING IRRIGATION PEAKS

One of the major problems occurring when the application rate is limited to 12 millimetres per day because of soil and pivot size constraints, is coping with peak demand situations. An important strategy is to utilise the storage capacity of the profile to help cope with peaks. This technique has the additional advantage that management can be simplified by applying a constant volume of irrigation water every week throughout the major part of the growing season. If such a strategy is adopted it is important to physically check that the process is on track by having the water status of the profile checked weekly.

This method can only be effective if the profile is fairly deep and there is nothing to restrict root penetration. Usually the profile will be reasonably dry at the start of the season so that if more water is applied than would normally be required by the small plants it percolates down into the profile and is stored for later use by the maturing plant. At mid season the weekly irrigation application will be augmented from these deeper layers.

This strategy requires reasonably good water holding capacity in the soil profile but because water is being added continuously to the roots in the feeding zone the deeper water sources only come into the picture if the applications are inadequate. This reserve is not only of value if a breakdown should occur but because the peak demand has been reduced, greater use can be made of the Ruraflex off-peak electricity tariffs.

Electricity is charged at prices that vary during the week for peak (20 h), standard (74 h) and low demand (Ruraflex) (74 h) periods. If the irrigation system follows normal practice in the area it will have the capacity to apply 12 mm in 24 h or 0.5 mm/h. This means that the system could provide 74x0.5 = 37mm/week at the low tariff (Ruraflex) rate. It is probable that during the peak period 60 mm/week would be required and the shortfall of 60-37 = 23 mm would have to be augmented by some 23/0.5 = 46 h of operation at standard tariffs. Should it be possible to even out the peak requirement by utilising the storage potential of the profile it might be feasible to reduce the need to pump during standard hours to negligible volumes? The Ruraflex rates apply during the late hours of the night and over the weekend so that some degree of automated control would be desirable! The exploitation of Ruraflex rates appeals when water and electricity are a significant percentage of operational costs (lucerne) but are less significant in the case of the high value/high input crops.

WHAT OF THE FUTURE?

Louis Wilken has been an important role player in the development of the Orange Vaal WUA both as manager and subsequently as farmer and chairman. He has been responsible for innovative developments in water management and he knows irrigation farming in the area intimately.

He has now taken on the challenge of developing irrigated cash crop production in an area that has tended to use irrigation more for fodder production. The climate of Douglas and Schoombee has much in common as far as rain and evaporative demand is concerned but Schoombee is significantly colder and this influences crop selection, planting dates and season lengths. The soils tend to be moderately heavy and some areas are stoney.

One can see that he is following the approach of applying the improvement cycle he outlined earlier. He has given particular attention this past season to tillage (particularly seedbed preparation) and the acquisition of suitable implements for the area. Green manuring has been successful and pivots are being modified to promote better infiltration. Next in line for attention is scheduling based on the GWK Douglas model and it can be expected that there will be innovative developments in the near future. The future role of SAPWAT will be to quantify and facilitate the assessment of these developments on irrigation.

Louis Wilken is a SAPWAT practitioner and is familiar with its applications at Douglas. We are looking forward to further cooperation in the future and know this will contribute to the further development of SAPWAT.

CALL FOR PAPERS:
DEADLINE FOR SUBMISSION EXTENDED TO 31DECEMBER 2004

Special Issue of *Water SA* on: Irrigated and Rain-fed Agriculture for Poverty Reduction in Sub-Saharan and North Africa:
Past Performance and Future Challenges
Water SA is a multidisciplinary journal funded and published by the Water Research Commission (WRC) of South Africa. The journal publishes refereed, original work in all branches of water science, technology and engineering. *Water SA* is introducing a series of special editions on various interdisciplinary themes on water resource management in Africa. The first of these editions is planned in collaboration with the Centre for Environmental Economics and Policy Analysis in Africa (CEEPA), to publish original research work on the contribution of irrigated and rain-fed agriculture to poverty reduction in sub-Saharan and North Africa. Contributions are invited for this special issue from all branches of scientific water research and policy on approaches to measurement and evaluation of experiences in technological, institutional and policy innovations for *managing water resources* in support of irrigation and rain-fed agricultural production systems for poverty reduction. Please note that the particular emphasis of this special issue is on the *role of various aspects of water resource management*, and not the contributions of *other forces of agricultural change* to poverty reduction such as breeding and improved crop management innovations in isolation of associated water management problems and challenges. The special issue will be peer-reviewed by a panel of renowned international experts in the relevant disciplines from Africa and the rest of the world. The final date for submission of manuscripts for this special issue, which will be printed in 2005, is December 31, 2004.

Submission of work solely authored by or co-authored with Africans is especially encouraged.

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