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Mid North SA agronomist works with farmer groups to combine soil moisture probe data with information from two computer based yield prediction models to assist decision-making in crop and, eventually, pasture management.

Soil moisture and decision-making: Three heads are better than one!

Written for Grain & Graze 2 by
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SA Mid-North Rural Directions agronomist Tony Craddock has been working with farmer groups on a project funded by the GRDC under its Southern Agribusiness Trial Extension Network program. The project focuses on the integration of soil water sensing equipment and computer crop modeling to guide grower decision-making. Co-funding has come through the Grain & Graze 2 project, which has enabled additional soil characterization work to be completed on some of the focus paddocks

Sub surface capacitance probes together with Yield ProphetTM (Hochman et al. 2009) and the CSIRO Your Soils Potential Yield and Nitrogen Calculator (Baldock et al. 2005) were utilised to help guide post-emergent nitrogen fertiliser applications on a durum wheat crop.

Both sensing and modeling approaches proved extremely useful in providing the grower with confidence to apply post emergent nitrogen fertiliser in a challenging season based on indicated yield potential, with the focus crop successfully achieving high yields and high quality. In most instances, the approaches were consistent in indicating the trends in plant available soil moisture, although the absolute amount of predicted PAW differed between methodologies.

Tony explained that the project has evolved from its beginnings with a DAFF Farm Ready grant which enabled him, through a network of five grower groups called the Cropping Boards Network, to set up a cluster of 11 soil moisture probes through the Mid and Lower north plus two in the Upper SE.

The growers and the local NRM boards shared the $5000 cost per probe. In that way the farmers felt strong ownership for the investment in the equipment.

Soil moisture probe installation

Setting up the probes

The sub-surface capacitance (SSC) probes were situated 15-20cm below the soil surface to reduce the chance of damage from knife points or other machinery which could obviously wreak havoc with the expensive equipment. As long as they are not disturbed they should have a life expectancy of ten years or more.

The SSC probes are situated about 15m into the paddock from the fence and are connected via cable to a solar powered telemetry unit that transmits data from the probe every 15 minutes to the hosting organization, AquaLab Scientific.

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Soil moisture probe telemetry unit

Data downloaded from their server is then used to produce real-time graphs of soil moisture levels. The telemetry units are equipped with an automatic rain gauge that also transmits rainfall data at 15-minute intervals.

According to Tony, "that means we can match trends in soil moisture with the rainfall as well. You can say, for example, 'we got 25mm of rain and that penetrated to a depth of 40cm.' That teaches us a lot about what is happening with the moisture in the soil."

That initial two year project was extended for another year by GRDC Southern Agribusiness Extension Network funding which enabled the group to sharpen their skills on "identifying from the graphs produced over successive years the driest points and when the soil is actually full of water. We are learning what the bucket size is and where in the bucket we are sitting at any particular point in the year."

Last year – Yield Prophet with probes

Yield Prophet is a computer model that uses what we know about a soil and its characteristics and the plant available water associated with that soil. It combines that information with historic climatic data and actually models the crop development, the growth stages and the yield potential.

Last year the project scaled up to another level by running Yield Prophet in conjunction with the soil moisture probes. The reason for doing that is because the soil moisture probes report in mm of moisture, but not plant available moisture, and they don't predict yield potential straight from the probe.

"We wanted to see what a model would suggest if run side by side with the probe. We might be able to say, if we are sitting here with this amount of moisture according to the soil moisture probe and Yield Prophet says we are sitting at so many mm of plant available water (PAW), then these are the potential yield outcomes if we get a Decile 1 or a Decile 5 or a Decile 9 finish to the season."

Tony and his group saw this tandem approach as key to helping with decisions about nitrogen (N) management and potentially grain marketing decisions. "If you have a fair idea that you are on track for a crop that will go 4t/ha then there are certain decisions you can make might which might be different to those you would make if the model told you to expect only 2t/ha."

Part of the Yield Prophet process is to measure deep soil N at the start of the growing season. From these measurements and measurements of soil PAW, Yield Prophet calculates crop nitrogen requirements based on the possible range of yield outcomes given the stage of the season, nitrogen and soil water levels. That enables farmers to see how they are traveling as the season progresses in terms of whether they are over or underdone on N supply, based on the seasonal outlook.

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Tweaking the models

One of the important aims of the project was to try to establish whether there was a good and useful relationship between a model like Yield Prophet and what the probes were saying.

Tony says, “that relationship was there but we had to tweak a few things. Yield Prophet relies not only on an accurate soil N test but also on a soil moisture test at the start of the season. We found the soil moisture tests had underestimated the soil moisture present at the start of the year on two of the three focus paddocks due to insufficient sample size.”

As a result, Yield Prophet was predicting around a 4t/ha crop when the yield was actually closer to 6t/ha. “When Yield Prophet was re-run using the starting moisture obtained from the probe data, (indicating that the soil was 75-100% full of water) this changed the predictions to within a range of 2-11% of the actual yield. This was much more accurate.”

“So it tells you firstly, about the importance of accurate measurement of soil moisture to make Yield Prophet meaningful but it also tells you that having the sensing technology of soil moisture probes side by side can actually ground truth it. That extra information can make the whole process a bit more accurate.”

Integrating the probes with Yield Prophet

In a big leap about to happen this year in trials, an attempt will be made to feed probe data directly into the Yield Prophet model so it can be converted into a potential yield outcome for the crop.

Tony explained that, “AquaLab Scientific and the Birchip Cropping Group, who manage Yield Prophet, will together use a couple of our moisture probe network focus paddocks to actually marry the two. That is the ultimate as far as I’m concerned but it is still at the developmental stage.”

Models or Probes or Both?

Modeling gets more accurate with the right data input and the right soil characterization. But which is better, the probes or the computer model?

Tony says, “I’m a bit global in all this. I think different tools actually appeal to different people. Some people like the idea of having a sensor that directly measures soil moisture in real time. Others are happy with a more modeled approach. I think that the important thing is that it gets growers thinking, talking and assessing plant available water at any one time. I’m not going to get into the debate about sensing versus modeling because I use both.”

“You can run more than one probe off the one telemetry unit but cabling is a bit of a problem. In theory you might have it on an adjoining fence running to a wheat crop on one side and, say, a bean crop on the other. To go 500m away, well, that‘s a lot of cable. Maybe wireless transmission is an option further down the track.”

Tony can see the pros and cons of both approaches but what he really values is that both methods get

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farmers in; thinking, talking, discussing and making decisions on soil moisture rather than gut feel.

Grower experience: Adrian McCabe

It's probably useful at this point to look at the experience of Adrian McCabe, one of the first farmers in Tony's groups to jump at the opportunity of putting a probe to use on his Salter Springs property. It was a logical step for him as he had been using remote monitoring of a moisture probe on a property he owns in NSW to assist with decision-making and providing direction to a contractor he uses there.

Last year, the SSC probe Adrian installed on his SA property was one of three pieces of information he used to augment decisions on nitrogen application. He also used Yield Prophet and a CSIRO Potential Yield and Nitrogen Calculator. This was available as a free download from the CSIRO website developed by Jeff Baldock, a CSIRO soil researcher in Adelaide. It's been around a while and Tony Craddock jokingly refers to it as the 'Holden Commodore' of yield profit indicators! It was originally developed for Mallee soils but Jeff and Tony made some adjustments to adapt it for SA's mid north. Tony sees Yield Prophet as the next step for farmers as it is far more sophisticated.

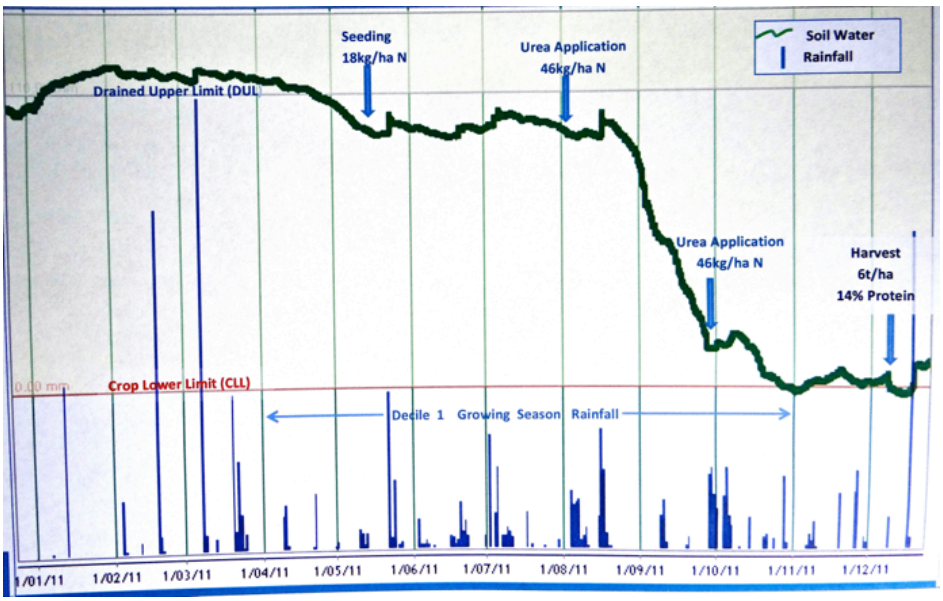

Figure 1: Plant available water estimated by a sub surface capacitance probe at Adrian McCabe's Salter Springs focus paddock in 2011

With these three tools, Adrian started the year with a full soil profile of water but then entered a Decile 1 growing season, the driest 10% of years on record. Effectively, it was a drought except for the full bucket of water in the profile, which made decisions on N top up applications very difficult for the durum crop he was focusing on.

Because it is durum, it is extremely important to the get the nitrogen right. This was complicated further because it was durum following canola. There is generally less stored soil N after canola compared to the traditional rotation of following a pulse crop with durum.

Tony explains, "Adrian went through the year doing one conservative top up of N and then he got to the Yorke Peninsula Field Day week in late September. It was the real turning point. Adrian was asking himself, 'have I got enough N there to achieve the yield but also to get enough protein requirements to achieve my Durum 1 classification at 13%?" SA farmers know that rainfall tends to drop off dramatically after this time of year however, there was rain forecast during that YP Field Day time.

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Weighing up the information, Adrian could see that the probe was indicating a reserve of PAW still in the soil. If the rainfall forecast was accurate, his potential yield was going to be in excess of 5t/ha in spite of a Decile 1 winter but he was going to be underdone on nitrogen if that happened. This was his last chance to add N.

The yield potential came from Yield Prophet and the CSIRO calculators. On that basis he added another 80kg/ha of urea. The end result was that Adrian reaped 6t/ha at over 13% protein and achieved a gross margin of over $1000/ha.

Tony Craddock says, "with three bits of information all telling him to go for it, Adrian made the decision and it paid off in a big way. I couldn't tell you that it was the soil moisture probe or Yield Prophet or the CSIRO calculator that gave him the end result but rather all three combined that gave him the confidence to make the decision."

Working backwards on the N budget Tony calculated that had the extra nitrogen not been applied then the result would have been Durum 3 worth $300-390/ha less than the gross margin he achieved.

The combined outcome was that the information did provide the grower with increased confidence in basing decisions on both the sensing and modeling outputs. This outcome is illustrated by the following quotes made by the Adrian McCabe:

"Without the information behind me I would have not have the confidence to apply the amount of urea in September as I did"

"Yield Prophet was telling me that I still had available soil moisture for at least two weeks. The soil moisture probe was saying the same thing and the The CSIRO Calculator was telling me I was underdone on N inputs if yield was going to be greater than 5 t/ha".

"With a strong rainfall forecast for late September, I thought I had to go for it, with the end result of 6t/ha of DR1 quality grain and a gross income of over $1500 per hectare".

Additional research funding from Grain & Graze 2 for soil characterization

One of the reasons that Grain & Graze 2, as part of the "Where in the Landscape" Program, became a funding partner in Tony's project is that they were interested in getting more soil characterizations done to build the database of characterized soils through the Northern / Yorke cropping districts. "The characterizations added an extra degree of precision to what I was doing with my farming groups."

Soil characterization is an involved and specialist process. It involves taking soil cores down to 1.2m, segmenting those cores and analyzing them for different soil properties, nutrients and also potential chemical barriers. "It showed us for example, that a site at Pinery had a chemical barrier at about 60cm indicated by a high EC."

The next step is to set up a 'pond', which involved a coil of dripper hose in a paddock hooked up to a 3000L tank that dripped water into the soil over a period of a week. Soil moisture is then measured to find what is called the drained upper limit (DUL). That is the moisture content when the soil is absolutely full.

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"Then at the end of the season we set up a little tent over the crop at anthesis. When the crop dries down we sample again for moisture and that tells us the amount of moisture there that is unavailable to plants. That is what we call the crop lower limit (CLL). So you could imagine then, if we had 120mm for the DUL and the CLL was 50mm then the plant available water holding capacity would be 70mm."

Probes and Models for Pastures?

Some really interesting case studies in decision-making are now emerging from an integration of modeling and SSC probe data. The results are more accurate than using probes alone or a model such as Yield Prophet in isolation. With more soil characterizations completed in the district, farmers will have more choices when they want to use models such as Yield Prophet.

Looking down the track, it is likely that we will see the focus shift to see if pasture growth can be modeled in the same way as the crop growth.

Bill Long, project manager for the Where in the Landscape project, says that, "we need these paddocks in grain crops to understand how to set up the pasture models. Similar principles apply. The pastures are rainfall fed and they rely on plant available water to produce dry matter. If we are building our skills on assessing and interpreting PAW in cropping paddocks we can essentially be applying that to pastures as well."