A FRAMEWORK FOR EXTENDING PRINCIPLES OF CONSERVATION CROPPING

D.M. Freebairn[1], G.H. Wockner[1], D. Lawrence[2], S. Cawley[2] and A.N. Hamilton[2]

[1]APSRU, Queensland Department of Natural Resources;
[2]Queensland Department of Primary Industries.

Abstract

The concept of water use efficiency (WUE) is being tested in the northern cereal belt as part of an action learning approach to investigating principles of fallow and crop management in farmer groups. WUE is a robust concept for the northern cereal region, being useful for yield targeting as well as bench marking paddock and farm performance.

Key words: Extension, conservation tillage, action learning, fallow management, bench marking.

Water supply is commonly a limiting factor in cereal production in Queensland and northern New South Wales. During crop growth unreliable rainfall and high evaporative conditions result in moisture stress with subsequent reductions in yield. Any bonus moist-ure to be gained from better fallow and crop manage-ment is worth seeking as relatively small improvements can make large differences in crop yield. This paper describes an approach being tested to present principles of fallow and crop management within a simple decision framework. The concept of water use efficiency (WUE) is being used successfully as an indicator of system performance as well as a planning tool for crop manage-ment.

Decision context for tactical response to current conditions and futures expectations

This overview describes principles of water supply management (capture and use of rainfall) in a context of adult learning, in particular a series of workshops focusing on soil water. An aim is to provide participants with an understanding of how the soil water system works and how management can impact on water storage. This is followed up by using an estimate of water stored and rainfall to determine an expected crop yield. This paper concentrates on soil water (reflecting the author's interest), but the framework has proven useful in linking other factors important in managing farming systems.

In introducing material to land managers, it is useful to consider a simple tactical decision framework;???? "Current conditions + Future expectations leads to a decision" where:-

? "current conditions" might be the soil water and nutrient status, or current commodity prices.

? "future expectations" might be average rainfalls, a seasonal weather forecast or commodity futures.

? "a decision" might be to carry out an action (*eg*. apply fertiliser, plant a crop or adjust area planted), or it might be to delay the action (plant later with the expectation of better soil or weather conditions).

Management options and tools can reduce uncertaint-ies in part of the above equation (current conditions) or at least provide more realistic estimates of the odds. As information providers we need to check that information is likely to lead to a change in a decision.

WUE, a framework for considering yield expectations and planning inputs

The Water Use Efficiency model (WUE), (3) is used extensively in southern Australia as a means of compar-ing crops, seasons and management options and predicting target or expected yield. We are inexperienced in using this model in the north, but it has already been shown to be an effective vehicle for negotiating common language between farmers and scientists, and appears to provide a balance between complexity and transparency.

(Stored water + In crop rain - Threshold water)? = Water supply

?mm?????????????????? mm????????????????????? mm????? mm

??? Fallow??????????? Seasonal

management???????? forecast

?

Water supply?? X???? WUE = Expected yield

?????? mm?????????????????? kg/mm????????? kg/ha

????????????????????????? Crop management

?? (Italics indicate management areas for improved performance)

Is the WUE model valid for the northern cropping environment?

The simplicity of the WUE model and its demonstrat-ed usefulness as a benchmark tool in southern Australia make WUE an enticing concept. To examine the validity of the model, yield and water supply data have been examined from shire yields and catchment data where soil water and runoff have been measured in detail.

Regressing shire yields against the sum of 20% fallow rain and in-crop rain explains 30-40% of the variation in yield. Similar patterns are found for catchment data.? If starting and final soil water and in crop runoff are also considered, 60% of yield variation is explained by water supply. It appears that the WUE model is robust enough to be useful, at least as a discussion and general explanatory tool in the northern cropping zone. To be general, the WUE model should consider a threshold value to account for unused water, in-crop runoff, evaporation and infrastructure water costs. Our initial examination of data indicates that a first estimate of fallow water storage is to assume a fallow efficiency of 20%, and a threshold water subtraction of 100 mm. (Fig**.** 1a, 1b).

Fallow management options to improve water storage

Why is storage of rain so inefficient?- a new look at rainfall charts

On average, 70% of rainfall during a summer fallow is lost as evaporation, 20% stored as soil water and 10% lost as runoff and drainage. The reason for this high loss is largely the high water holding capacity of many of our clay soils, high evaporative conditions and long durat-ions between rain falls. As much as 35 mm of rainfall can be temporarily 'stored' in the surface 100 mm (plough layer) which is readily available for evaporation until the next rainfall

Soil cover, runoff and erosion

Stubble or crop cover reduces runoff if a water deficit is present, and dramatically reduces erosion in all grain systems. Rainfall can be lost as runoff when either the soil approaches full (no room in the profile) or a crust or surface seal forms on the surface reducing the rate of water entry. This has been shown clearly in tillage and catchment studies (2).

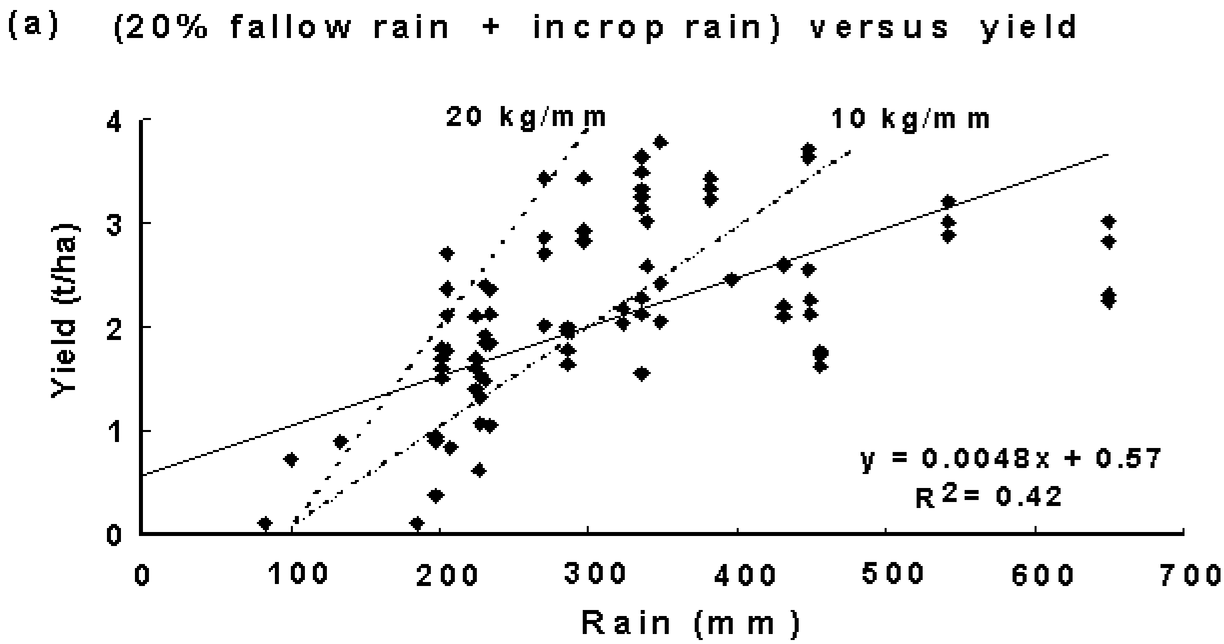

Figure 1

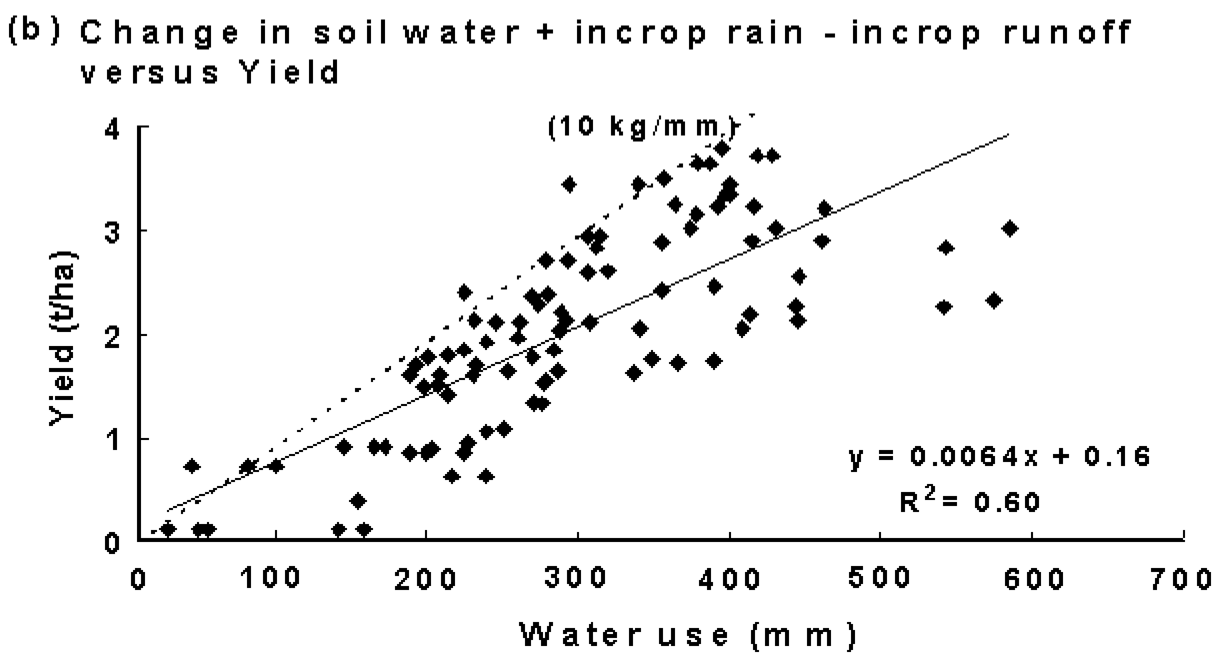

Figure 2

Maintaining a soil moisture deficit

Soil moisture content is the most important factor in determining whether rainfall is lost as runoff, especially in cracking clay soils. While seasonal conditions have a strong and unavoidable influence on soil moisture, the sequence and number of crops grown will have a major effect on the timing of soil water deficits and hence on runoff.

Summer crops better match water supply to water use, and maintain soils at a lower water content during summer. Increasing cropping intensity maintain soil profiles with a moisture deficit.

Mulches can reduce evaporation, but for how long?

Stubble retention combined with zero tillage almost universally results in better water storage, but this appears to be mostly due to reduced runoff (4). By increasing soil reflectance and reducing the velocity of air movement at the soil surface, the rate of water loss can be reduced. The catch is that wet soils dry at a faster rate than drier soils, therefore the benefits of stubble are reduced with time.

Evaporation potential in the summer can be 10 mm/day, therefore getting water away from the surface can potentially reduce evaporative losses very quickly.

Tillage

Tillage is the most important factor influencing stubble cover. Tillage frequency and type control how much stubble remains on the surface. Tillage also exposes moist soil with the colour change behind a plough indicating a potential for accelerated drying.

Deep tillage (20-40 cm depth) has been used to improve water storage and root growth with variable results. In general, deep tillage should only be used if there is a soil layer present which impedes water and root movement.

Soil cracks, a free ride to safety?

Maintenance of soil cracks can capture early fallow rains that otherwise might run off. Cultivating dry and cracked clay soils partially closes cracks, reducing soil cover and aggregate sizes in surface soil. Infiltration via cracks can be an important mechanism for water entry.

Soil structure, tillage and pasture leys

Paddocks with well structured surface soil are better placed to capture and store rainfall. Excessive cultivat-ion is often blamed for reducing the structural stability of soils, leading to poorer infiltration capacity and crusting problems. The main advantage of stubble retaining systems is due to the presence of soil cover rather than improving the soils physical properties. Pasture leys may be an effective method of improving soil structure on crusting soils (1).

Surface configuration

Any practice which retains water on the surface rather than letting it run off may assist infiltration. By cultivat-ing on the contour, each furrow acts as a small detention dam and water has more time to infiltrate. A 12 mm reduction in average runoff was recorded near Roma on a brown clay where infrequent chisel tillage was compared with finer scarifier tillage (4). Equipment which produces pits or small depressions may be useful in low stubble situations.

Yield

Yields are similar in catchment studies for the bare, incorporated and zero tillage treatments while stubble mulch yielded 6% more grain. The extra water stored in zero and minimum tillage fallows is sometimes not converted into extra grain yield, especially during wetter growing seasons. This lack of response is attributed to inadequate supplies of available soil nitrogen (possibly due to leaching and N immobilisation), plant diseases (crown rot, yellow spot), and sometimes poorer crop establishment due to the use of inappropriate machinery on untilled soil. Generally, if more water is stored, yields will increase if attention is given to the above problems (*eg.* rotation).

What can a little bit of extra water be worth?

The following example came from a soil water workshop in southern Queensland held in February 1997. The question asked was; What impact will an improvement in fallow water storage from 20% to 25% of rainfall have on the gross margin (GM)? Participants used their own estimates of water supply and WUE based on average yield and rainfall data for their area.. Using an estimated WUE of 9 kg/ha/mm (fallow rain 440 mm, in-crop rain 240 mm, variable costs $132/ha and wheat price $120/t:

Gross margin = {[(440 * 0.20 + 240) -100] * 9 *$120/1000}-$132 = $114/ha.

With improved fallow management where fallow efficiency increased to 25% (typical for stubble mulch or no-till fallows):

Gross margin = {[(440 * 0.25 + 240) -100]*9 * $120/1000}-$132 = $138/ha

This marginal analysis indicates that improving water storage by 22 mm increased the gross margin by 20% or $24/ha. By improving WUE from 9 to 10 kg/ha/mm (achievable through more timely planting or better nutrition) in conjunction with fallow management, a 47% increase in GM can be achieved. This example demonstrates the value of what appear to be very small improvements in system performance.

On the day of a workshop, the real learning was that producers can work through the analysis using their own numbers. Our role is to throw in some of our "scientific" evidence of possible management scenarios and to encourage discussion.

Conclusion

We have learnt a lot about managing our soils for better water capture and use by drawing on information from catchment studies and replicated tillage trials, and farmer experience. One thing is certain, farmers have taken conservation tillage by the throat and are giving it a good shake. Tillage frequency is decreasing, stubble retention levels are increasing and farmers are monitor-ing their paddocks better. We think that farmers, researchers, advisers and agribusiness can be pleased with progress, but we still have plenty to do.

References

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