OPPORTUNITY CROPPING ON THE LIVERPOOL PLAINS: A COMPARISON OF RISK ASSESSMENT BY FARMERS AND SIMULATION MODELS

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Summary. Simulation modelling using long-term climate data is used to assess the risks associated with opportunity cropping. The simulated distributions are compared with farmers' subjective distributions. We discuss possible reasons for the different estimates and whether these differences might change decisions.

INTRODUCTION

The Liverpool Plains are at the southern extremity of the north-eastern cropping belt. Unlike the rest of Australia, this region has no single cropping season. The lack of a defined winter cropping season led to the region being judged as *a drought area suitable for sparse grazing* until the 1920's (11). Seventy years later, wheat yield trends for the Quirindi shire ranked fourth in NSW (7). The Liverpool Plains are also the largest production area of sorghum and sunflower in the State. Improved management of fallows has made cropping possible on the Liverpool Plains, but ironically, fallow management may be contributing to dryland salinity that is threatening future production.

Leaving a paddock for a long period of fallow is an effective but possibly wasteful means of coping with climate variability through storage of rain in the soil as a buffer for unreliable rain in the growing season. Following the introduction of strip farming and summer cropping, the most common rotation has been Wheat - 10 month fallow - Sorghum - 15 month fallow - Wheat. This sequence has been simple to implement, provided excellent disease and weed control, and minimised risk by ensuring crops were always sown on close to a full profile of water. However, in 36 months, there are less than 12 months when a crop is actively growing.

Opportunity cropping involves sowing a crop whenever soil water reserves are adequate. Since 1976, studies from Queensland have shown that opportunity cropping increases profit and reduces soil erosion (2, 4). Recent rises in the water table have increased pressure for farmers to adopt a more flexible approach to fallow length. This has come from catchment hydrology studies (3), water balance modelling (1), and economic studies (6). Nevertheless, surveys indicate that many farmers perceive opportunity cropping as too risky to switch from their current fallowing practices (9).

A risky decision such as opportunity cropping can be partitioned into decisions to be made, uncertain events and outcomes of varying value (5). Simulation modelling using long term climate data is potentially a powerful tool to assess the risks of different decisions. Farmers however, have their own risk assessment which can be elicited as a subjective probability distribution. This paper deals with the differences between these two assessments of risks associated with opportunity cropping, and what is more important, do these difference change any decisions?

METHODS

We held a workshop with farmers, consultants, and government extension and research agronomists to discuss opportunity cropping. First we discussed objectives in terms of both profit over 2-3 years and land degradation. The workshop agreed that the primary objective was profitability. Farmers who practised opportunity cropping arguing that not only was it was more profitable, it minimised land degradation. We then identified the key decision as; to sow or continue the fallow. This decision occurs 3 times after the harvest of a crop. For example, after a sorghum crop is harvested in March, the first decision node is to sow a winter crop within 3 months (double crop), if the fallow is continued for 6 months from harvest the second decision is to sow a summer crop (short fallow). If this opportunity is not taken, the fallow is continued for 15 months before a winter crop is sown (long fallow). Similarly, there are 3 decision nodes following a winter crop.

The chance nodes effected by climate were identified by the growers as the crop yields for 30, 60, 90 and 120 cm of wet soil and how often the 6 different fallow periods recharged to these levels of stored water. Probability distributions for these chance nodes were also generated by simulation models. Distributions for fallow recharge were generated by APSIM (8) for a black earth. Yield distributions were calculated for the 4 depths of wet soil assuming 1.8 mm per cm of wet soil. Wheat and chickpea distributions were taken from the decision support system WHEATMAN (13) and sorghum and sunflower distributions were generated by the cropping systems model PERFECT (12).

Eight farmers who were practising opportunity cropping and considered district leaders were used to generate individual subjective distributions. We sought their estimate for wheat, sorghum, chickpea and sunflower yields sown on the 4 levels of starting soil water. For each crop and level of starting soil water (e.g. wheat on 60 cm of wet soil) they were asked the yield in a very dry (driest 1 in 10), dry (3rd driest in 10), median (driest/wettest 1 in 2), wet (3rd wettest in 10) and very wet season (wettest 1 in 10). We also asked them to estimate the amount of water stored for the 6 fallow lengths in each of the 5 season scenarios. This process was carefully explained and took about 90 minutes to generate information for 6 distributions of fallow recharge and 16 crop yield distributions. The use of imperial units for depth of wet soil and bags/acre for yields was encouraged. We also asked the farmers to indicate their rule for the depth of wet soil they required to sow each crop. A spreadsheet model of a 5-year crop sequence was developed to compare decision scenarios mapped out by the workshop. The spreadsheet model randomly sampled the appropriate distributions for yields and stored soil moisture using the @Risk add on to EXCEL.

RESULTS AND DISCUSSION

Simulated fallow recharge over the 15-month period following the harvest of sorghum (Fig. 1) reinforces the need for fallowing on the Liverpool Plains. The amount of stored soil water to trigger sowing is shown as 60 cm of wet soil for winter crops and 90 cm for summer crops. These rules appeared to be non negotiable in the double crop and short fallow situation but largely ignored after a long fallow. Following these rules double cropping is only possible after a wet harvest or in very wet seasons and it is rare that sorghum can be grown in any situation but a long fallow. This analysis also shows that under a flexible cropping regime there are sufficient sowing opportunities for stored water to be efficiently used and to minimise the time that the profile is full and prone to erosion and drainage. In the last 10 years there have been some cases when the fallow has been continued past a sowing window because it was too wet to sow, or the crop failed due to waterlogging. There are however, many farms that have continued long fallows before both winter and summer crops despite there being a number of sowing opportunities.

As evident in Table 1, the growers have lower estimates of the amount of water stored when there is a double crop following wheat but the rest of the time are slightly more optimistic than the model. Overall the results are surprisingly close, especially considering that farmers are measuring depth of wet soil converted into available water, and the model is simulating available water.

Table 1. The ratio of grower to model estimates of water stored over different fallow lengths.

Fallow period:	10%'ile	30%'ile	50%'ile	70%'ile	90%'ile	Mean
Wheat - no fallow- summer crop	0.7	0.3	0.9	1.0	1.1	0.8
Wheat - short fallow - winter crop	1.4	1.0	1.0	1.1	1.0	1.1
Wheat - long fallow - sorghum	1.2	0.9	1.1	1.0	1.0	1.0

Sorghum - no fallow - winter crop	1.2	1.1	1.2	1.2	1.3	1.2
Sorghum - short fallow - summer crop	1.2	1.1	1.2	1.3	1.0	1.1
Sorghum - long fallow - winter crop	1.1	1.3	1.4	1.2	1.0	1.2
Average	1.1	1.0	1.2	1.2	1.0	1.1

As shown in Figure 2 there is good agreement between the average of the farmers' estimates and the model. The farmers estimated a greater frequency in the tails, particularly for low yields but in some cases also had a slightly higher estimate of high yields. The pattern was similar for the other crops.

There is ample evidence from psychology that human judgement can be biased by recent or more available events (5). The climate on the Liverpool Plains is quite variable and farmers have seen *boom and bust* seasons over the last 5 years. Farmers, like the rest of us, are not good intuitive statisticians and so the frequency of extreme years is probably increased in their memories.

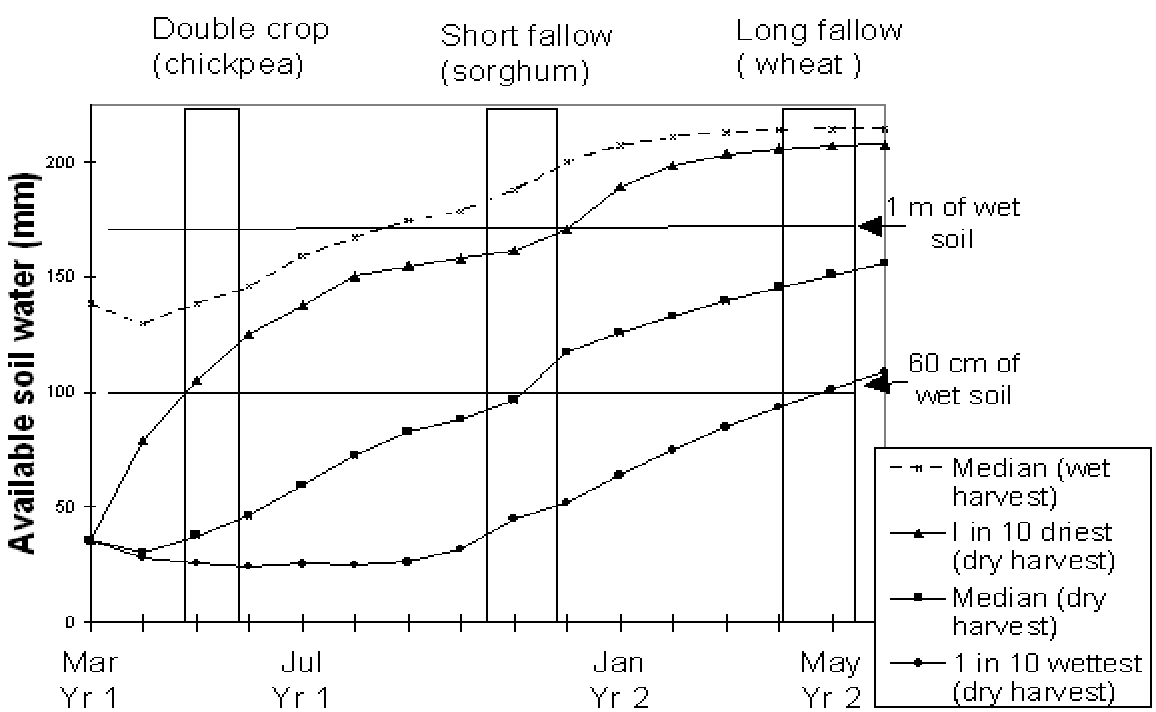

Figure 1. Four soil water recharge scenarios following sorghum harvest. In the case of a wet harvest the profile was already half full at the start of the fallow.

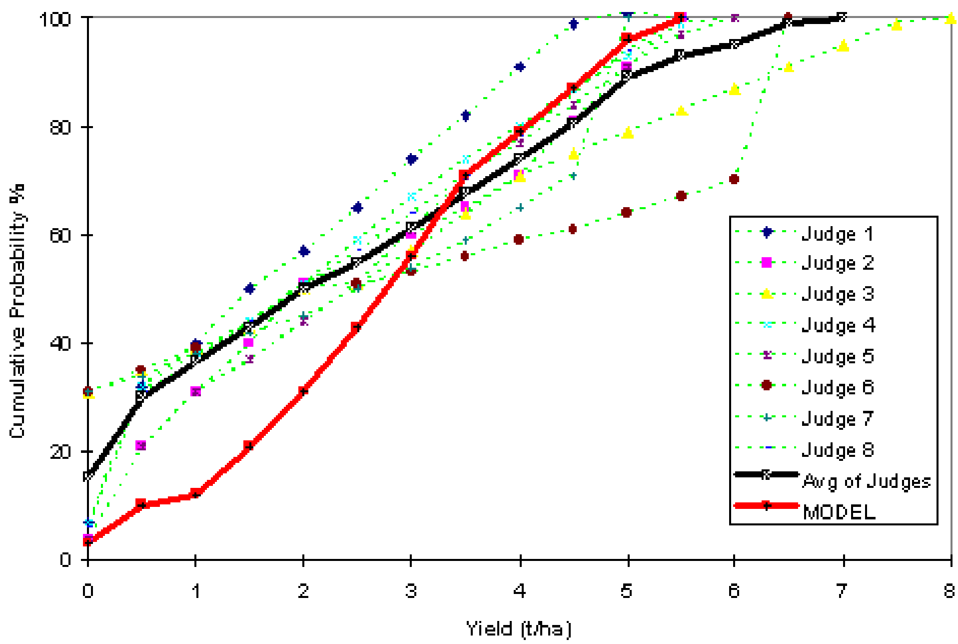

Figure 2. Cumulative density function of yield distribution of wheat sown on 60 cm of wet soil (100 mm available soil water) as estimated by the 8 farmers and simulation model.

There may also be a form of proximity bias in the crop models which are driven primarily by water and nitrogen but take less account of other factors such as weeds and disease. While the higher frequency in the bottom tail was to be expected, the higher frequency in the top tail was surprising. This may be simply due to a higher rainfall on farmers' properties compared to the site modelled.

The distributions from the models and farmers are different but neither is a *golden standard* against which the other can be judged. While there is ambiguity on both sides, the comparison between the two can lead to fruitful discussion and is probably valuable decision support in its own right. Given that differences occur, do they change decisions? In this simple analysis of 5 year gross margins the conclusion from using either source of distributions was the same; that opportunity cropping shows stochastic dominance over long fallow farming. A similar conclusion was made when the distributions from this study were used in RISKFARM, a whole farm model for the Liverpool Plains (13).

Individual iterations of the 5 year gross margin spreadsheet model showed that despite a different *assessment* of risk provided by simulation, the risk *management* options dictated by the growers' planting rules had such an overriding effect that the decision rarely changed. An argument could be mounted to encourage the growers to use less conservative planting rules. However, the yield distributions for planting on marginal moisture are where the growers and models have the greatest differences. When this difference is discussed, the growers are very suspicious of the model output. Simulation models have been useful for research and dialogue with growers on the dynamics of opportunity cropping on the Liverpool Plains. When models are used as tactical tools there may be a mismatch between the finer resolution in risk assessment offered by the models and the limited decisions options that are available to manage the risk. In short, a case of measuring with a micrometer, marking with a piece of chalk, and cutting with an axe.

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