How changing crop characteristics can enhance the commercial viability of perennial wheat

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BACKGROUND

- Orientation of agricultural technologies has changed over time from *sustainability of farmer incomes* to *environmental conservation* (Batie 1985, Nelson 1997).
- Farmer motivations for adoption have not necessarily changed: ***profitability and risk play a major role.***
- The economic performance of agricultural technologies must compare well with that of existing technologies to be considered commercially viable.
- Example: ***Perennial wheat (PW).*** A novel variety of wheat that can contribute to decreased erosion of farmland, PW is handicapped by low yields and grain quality and high rates of mortality after the first year. ***These characteristics negatively affect commercial viability of PW through increased risk and decreased profit.***

RESEARCH QUESTIONS AND GOALS

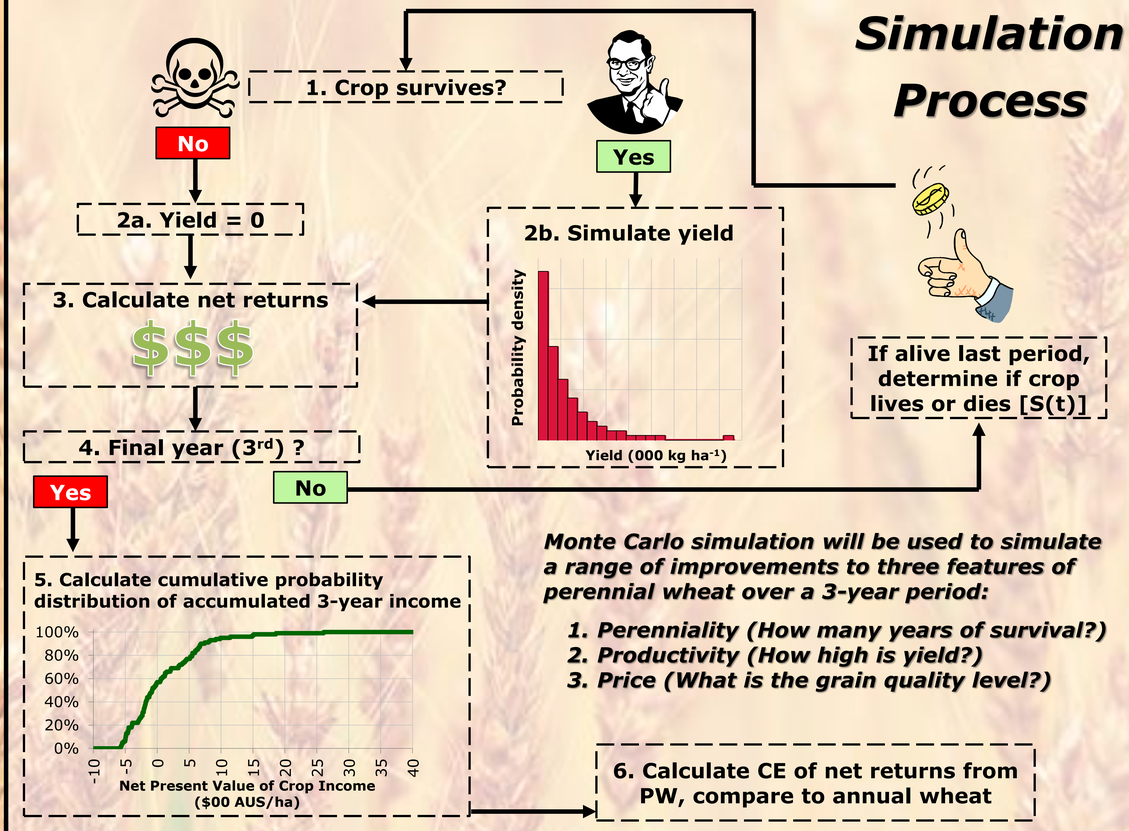
QUESTIONS:

1. What features of PW have the greatest effect on economic performance?
2. Can these features be enhanced to improve commercial viability of PW relative to traditional wheat?

GOALS:

1. Assess effects on farmer profitability and risk from increasing ***price, perenniality, and productivity*** of PW varieties.
2. Identify characteristics of PW that contribute most to commercial viability, then ***use this information to prioritize further research and refinements to PW varieties***.

Simulation Process



Monte Carlo simulation will be used to simulate a range of improvements to three features of perennial wheat over a 3-year period:

1. ***Perenniality (How many years of survival?)***
2. ***Productivity (How high is yield?)***
3. ***Price (What is the grain quality level?)***

METHODOLOGY

- PW and annual wheat (AW) yields will be modeled using ***stochastic simulation***
  - Yields will be modeled as random variables using data on experimental PW yields (see Data section).
  - ***A survival function will be estimated***:

$$S(t) = Pr(\{T > t\}) = 1 - F(t)$$

where *F(t)* is the probability that the crop will not live beyond year *t*. ***From the survival function, we can estimate the probability that our modeled PW crop will die in a given year t.***

  - The stochastic yields and survival function will be incorporated into the simulation process pictured in the figure at left.
- Net present values of net returns to planting PW and AW will be calculated for each iteration; certainty equivalents of planting PW will be compared against the those from AW.
- This process will be repeated for three scenarios by parametrically varying key characteristics of modeled yields:
  1. ***Increasing price from increasing grain quality of PW***
  2. ***Increasing perenniality of PW***
  3. ***Increasing productivity of PW***

ANTICIPATED RESULTS

- ***Results from parametric simulation can be used to:***
  1. ***Identify most productive means of improving commercial viability of PW relative to AW.***
  2. ***Identify standards of improvement in price, perenniality, and productivity of PW that must be achieved in order to be competitive with AW.***

CONCEPTUAL MODEL

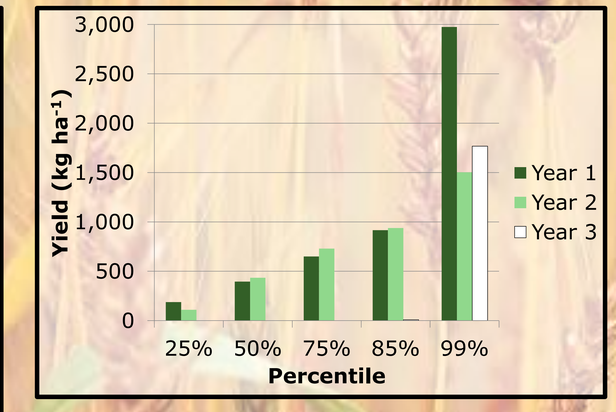
- Breakeven and comparative-breakeven analysis to gauge mean economic performance are important first steps. But farmers care about risk too, so ***methods are needed that account for the risk to farmer profits of adopting PW.***
- Risk-adjusted economic performance can be compared by analyzing the ***certainty equivalents (CEs) of net income*** of adopting farmers (Just 2003):

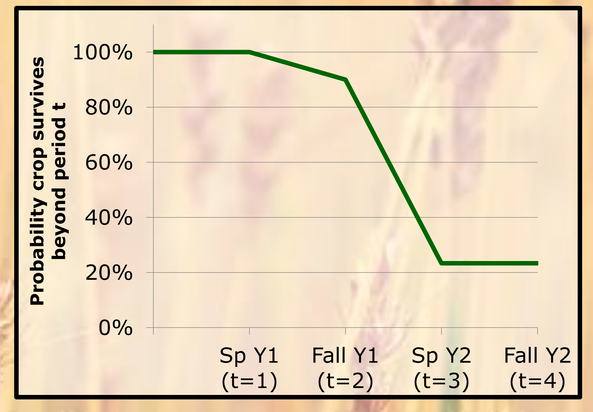
CE = (Expected Profits) – (Risk Premium)

where the risk premium takes into account the variance of net returns and typical levels of risk aversion. ***Increasing variance, risk aversion ⇔ increasing risk premium ⇒ decreasing farmer utility from farming.***

- Pre- and post-adoption CEs can be compared to gauge the economic performance – and thus the commercial viability – of PW.

DATA – PERENNIAL WHEAT YIELDS





The yield data to be simulated come from Australian experiment station trials of 30+ varieties of perennial wheat. The mortality characteristics of the varieties over their three-year trials. ***Note the high rates of mortality and low levels of productivity after year 2.***

SELECTED REFERENCES

1. Batie, S.S., 1985. Soil conservation in the 1980s: a historical perspective. Agricultural History 59, 107-123.
2. Just, R.E., 2003. Risk research in agricultural economics: opportunities and challenges for the next twenty-five years. Agricultural Systems 75, 123-159.
3. Nelson, P.J., 1997. To hold the land: soil erosion, agricultural scientists, and the development of conservation tillage techniques. Agricultural History 71, 71-90.

KBS LTER Kellogg Biological Station Long-term Ecological Research

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