Cropping systems modelling – a tool for designing cropping practices to maximise productivity to support food security in Pakistan

Cropping systems models (such as APSIM) allow scientists to investigate and understand crop production impediments in different environments, to assess farmer management options to overcome those impediments, and to evaluate their effectiveness in both current and future climates. When linked with catchment scale water resource models, they also allow assessment of national and regional food production implications associated with future water management and development options.

BACKGROUND

APSIM, the Agricultural Production Systems Simulator (Holzworth et al., 2014) is a modelling platform for simulation of biophysical processes in cropping systems. The model uses daily inputs of daily climate variables (temperature, radiation, rainfall) together with specified information on soil, crop and farmer management practices to estimate the resulting grain and straw production. Environmental outcomes such as drainage, runoff, nutrient leaching, and greenhouse gas emissions are also simulated. The model is particularly valuable in understanding crop yield gaps (Figure 1) and investigating changed practices to overcome them

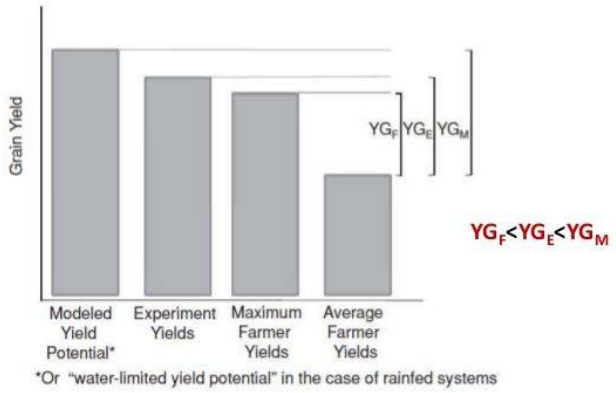

Figure 1. Understanding crop yield gaps (from Lobell et al., 2009)

A particular focus is the simulation of sequences of crops, rotations, and fallow periods, rather than just single crops in their response to daily soil and climate variables. For example, detailed investigations into cropping sequences, yield gaps, and water productivity has been conducted in the Indian Punjab using APSIM (Balwinder-Singh et al., 2015a; 2015b).

APPLICATION

The teams from CSIRO and the University of Agriculture Faisalabad (UAF) are applying similar analyses to the rice-wheat zone in Pakistan Punjab as part of the DFAT-CSIRO Indus Pakistan Project. Within this zone, they are using the APSIM model to understand the key differences in land and water productivity between high and low performing districts. The model is then being used to explore farm management options (agronomic, surface and groundwater irrigation and salinity management) to enhance cropping system performance, considering basin scale water resource sharing constraints. Using this zone as a proof-of-concept, the team will then extend the analyses to each of the twelve (12) agro-ecological zones in Pakistan (Figure 2), encompassing a wide range of crops and cropping patterns

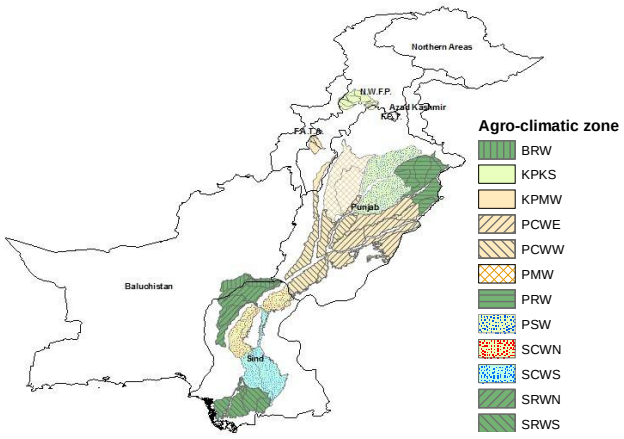

Figure 2 Twelve agro-ecological zones of Pakistan

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CAPACITY BUILDING

As part of these detailed modelling analyses, agricultural experts from all provinces of Pakistan have been exposed to the APSIM model through interactive hands-on workshops. Workshops have been conducted at UAF and Sindh Agricultural University during 2015-16.

Figure 3 Capacity-building of agricultural science experts in APSIM model application

As the analyses widen to include each of the 12 agro-ecological zones, relevant experts from the regions will then engage more deeply in detailed APSIM analyses.

FUTURE APPLICATIONS FOR APSIM IN PAKISTAN

Developing skills in using models like APSIM offer numerous benefits to the Pakistani agricultural research community, and will facilitate a range of additional future opportunities for relevant and targeted research. Other applications for cropping systems modelling include:

- Extending lessons from 1-2 year experiments to longer timeframes to better understand long-term risk
- Climate change studies
- Asking "what if?" questions. For example, what if I increase my N fertiliser application - when do I cease to see yield benefits? (Figure 4). How does this vary across different environments, irrigation practices, and sowing dates?
- Development of decision support tools for farmers (issues could include crop choice, when to sow, optimum fertiliser, irrigation triggers etc)
- Minimizing time to adoption for new technologies by design of targeted field trials
- Upscaling experiments and field trials to regional and national yield forecasting

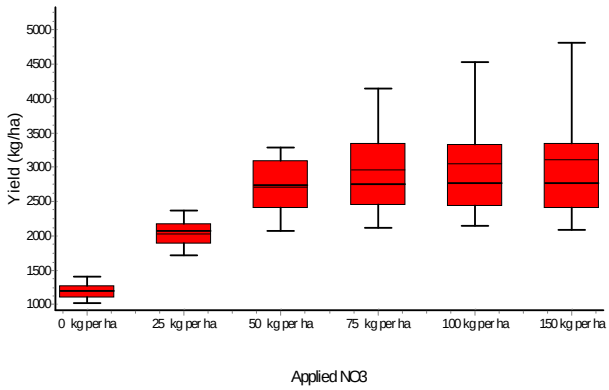

Figure 2. APSIM analysis on increasing fertiliser amounts and wheat grain yield (indicating minimal benefits above 75 kg/ha in this example)

CONCLUSIONS

The APSIM cropping systems model shows promise as a tool to understand crop production impediments in each of the Pakistani agro-ecological zones. As part of using the model in-country we are increasing the capacity of Pakistani agricultural scientists to perform these types of analyses. Ultimately, the model will be used to investigate improved farm management practices in each of these zones and to assess how these will perform as the climate changes. The APSIM model will then become a strong platform to evaluate regional and national grain yield impacts associated with any future water diversion scenarios.

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FOR FURTHER INFORMATION

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