Green pea module within Tasmania – summary.

The Water for Profit (WfP) project led by Tasmanian Institute of Agriculture has conducted model simulations using the Agricultural Production Systems SIMulator (APSIM). Part of this work was the parameterisation and simulation of green peas on four local farming properties in Tasmania. The development of a green pea parameterised file in APSIM offers insights to the influence of several management and biophysical options on crop yield. Such options include soil type, soil water capacity at sowing, cultivar and plant density as well as sowing date and nutrient application rates along with a number of other input variables. The parameterised file can also be used to explore potential year-to-year variability in yields as well as rainfall and temperature effects, along with related information including crop biomass, protein levels, flowering times, days to harvest and water use efficiency.

The parameterised green pea file was developed using observed field data from three seasons (2011/2012, 2016/17 and 2017/18) for the cultivar Resal, a commonly used cultivar for green pea production in Tasmania. The WfP team calibrated the model to four sites in Tasmania using observed yields, flowering dates and harvest maturity for irrigated green pea crops (Fig. 1). A fifth site, Longford (2011/12), was also used in the parameterisation of the model with varying sowing dates under irrigation (Fig. 2). In general, the proximity of the simulated data compared with the observed data demonstrated reliable model parameterisation, with simulated green pea yields and phenological data that were close to observed values (Fig. 1) The parameterised green pea file was then validated (by comparing the green pea field observations from season 2017/18 with the modelled value for the same season). Overall, the model adequately simulated green pea yields under irrigated conditions with an acceptable degree of confidence.

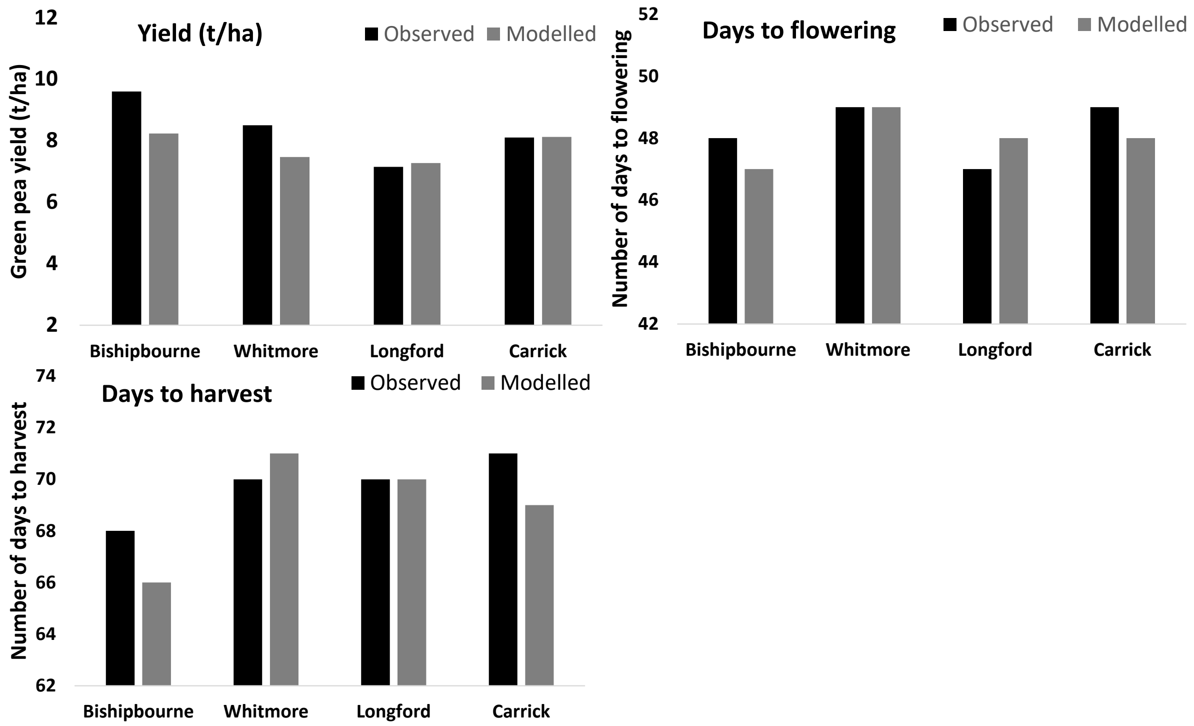

Fig. 1. Simulated and observed green pea yields (t/ha), days to flowering, and number of days to harvest for the Tasmanian farm sites at Bishipbourne, Whitmore, Longford and Carrick during 2016/17.

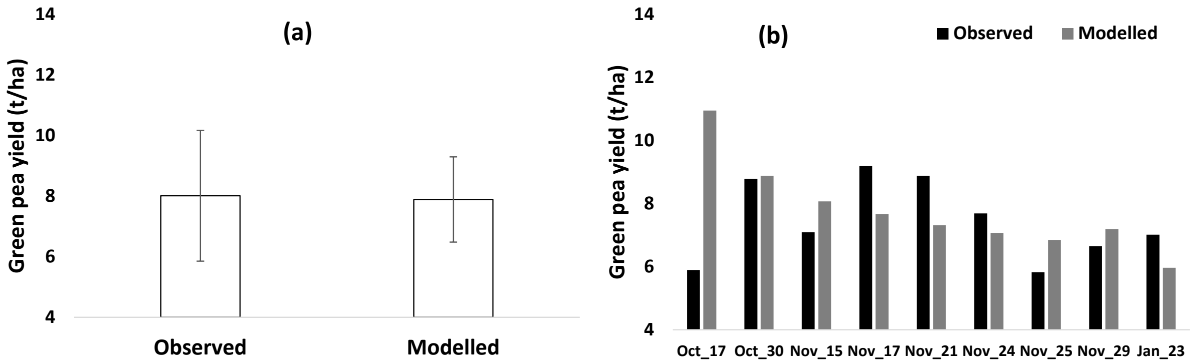

Fig. 2. Simulated and observed green pea yields (t/ha) (a) and simulated and observed yields with various sowing dates (b) during 2011/12 at Longford. These data were also used to calibrate the model.

The parameterised file was then used to simulate other sites across the state in order to examine green pea yields and crop phenology under different climate and soils (Fig. 3 shows such results for 2016/17). Figure 3 indicates that Forthside and Sassafras would have been preferable sites for green pea cropping in 2016/17.

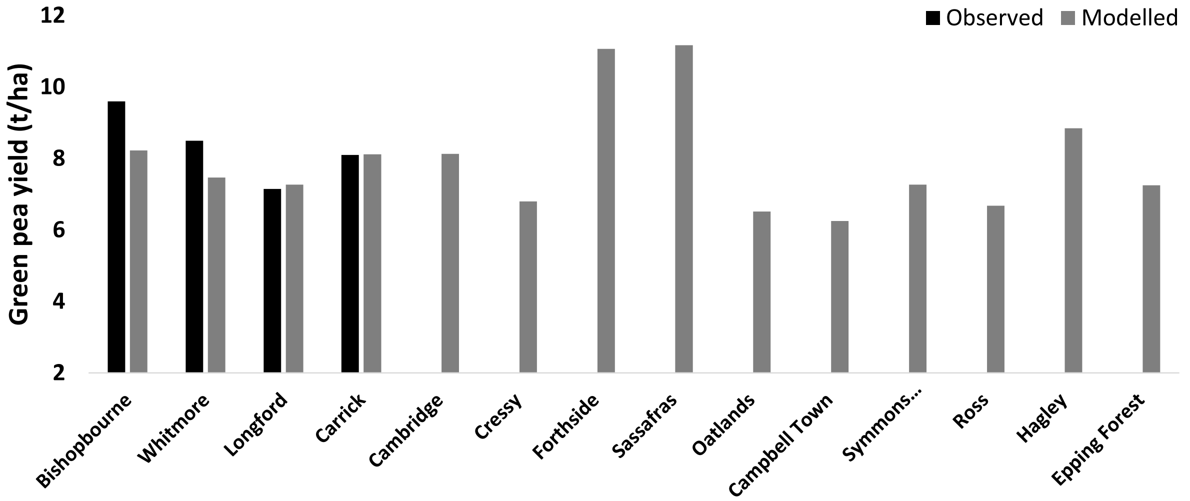

Fig. 3. Simulated and observed green pea yields (t/ha) at the four sites, along with simulated green pea yields at ten additional sites during 2016/17.

Historic climate records at any given site can also be used to assess the year-to-year variability in yields and other factors such as water use efficiency, sowing dates, sowing density, days to flowering and maturity length. As an example, the green pea yields at Oatlands and Cressy are shown in Fig. 4, with historic simulations for the period 1988 to 2018. The mean annual yield at Oatlands was 8.5 t/ha, with a standard deviation of 2.1 t/ha. Similar yields were observed at Cressy with a mean annual yield of 7.7 t/ha and a standard deviation of 2 t/ha over the 30 year period.

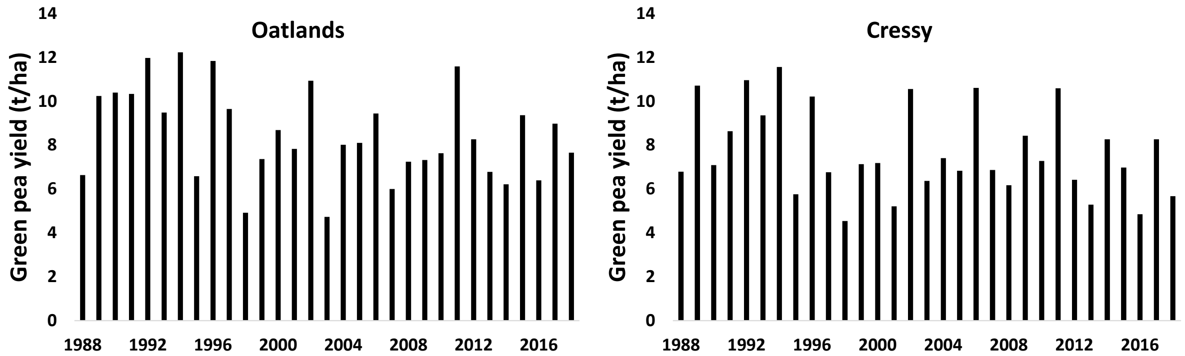

Fig. 4. Simulated green pea yields (t/ha) at Oatlands and Cressy for the period 1988 to 2018.

To demonstrate other outputs available from APSIM, Oatlands was selected in order to demonstrate the effects of daily temperature and water stress on growth and production over an individual growing season. At Oatlands, the green pea yield in 2011 was 11.6 t/ha, while in 2014 the yield was 6.2 t/ha (Fig. 4). Figure 4 shows the corresponding stress for 2011 and 2014. The daily temperature and water stress are on a scale of 0-1, where crop growth becomes increasingly limited as the stress values increase towards 1, conversely if the stress value is at zero then there is no limitation to growth. The daily temperature stress values were similar between the 2011 and 2014 growing seasons (Fig. 5a), however in January 2014, the temperature stress values were considerably higher than 2011. More importantly, the water stress in January was significantly greater in 2014 than in contrast to 2011 (Fig. 5b). Thus the increased daily temperature and water stress in late January 2014 resulted in a significantly lower yield than in comparison to 2011 (Fig. 4).

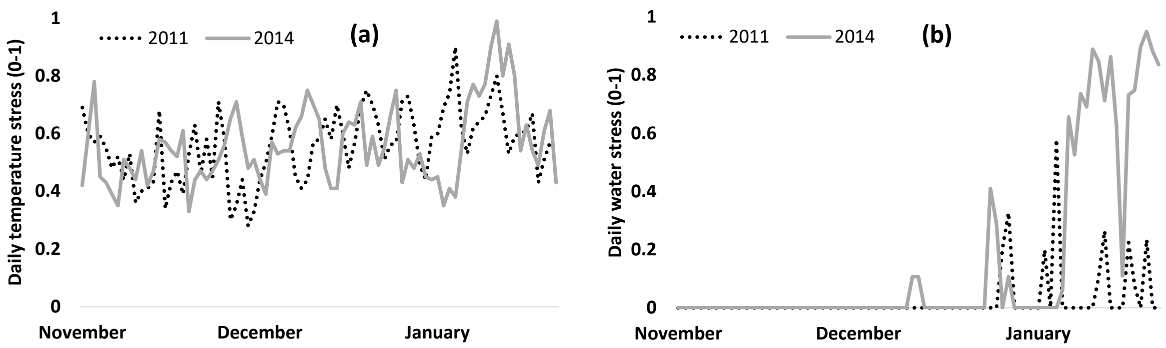

Fig. 5. Simulated daily temperature stress (0-1) (a), and daily water stress (0-1) (b) for 2011 and 2014 at Oatlands.

Historic climate records can also be used to assess the year-to-year variability in water use efficiency as affected by sowing dates, sowing density, days to flowering and maturity length. For example, gross production water use index (GPWUI, total yield divided by the sum of irrigation water and rainfall) and the number of days to flowering at Oatlands are shown in Fig. 6, with historic simulations for the period 1988 to 2018. There was a period between 2004 and 2009 where GPWUI were similar, whereas GPWUI in 2016 was much lower due to a well above average rainfall in January (113 mm, 58% above long term average), thus contributing significantly to a GPWUI that was much lower. Comparing Figs 5a and 5b also demonstrates that there was little correlation between GPWUI and days to flowering.

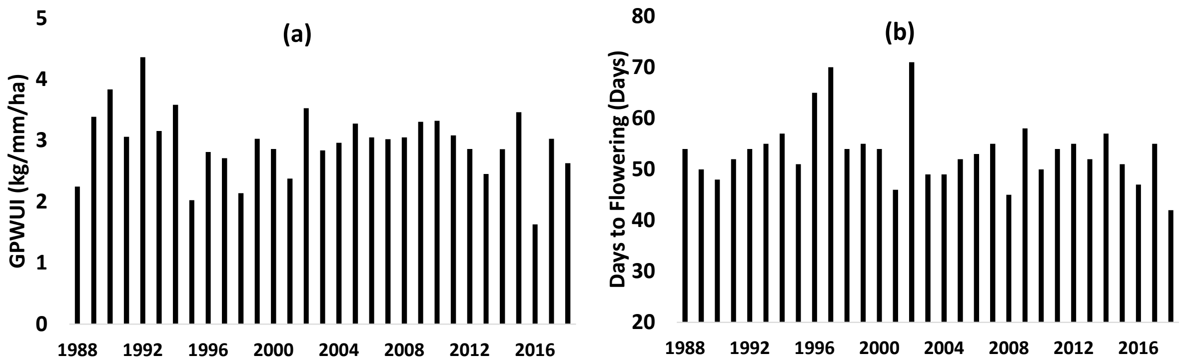

Fig. 6. Simulated gross production water use index (kg/mm/ha) (a) and the number of days to flowering (b) for green peas at Oatlands for the period 1988 to 2018.

Similar to the development of CropARM (e.g. see http://www.armonline.com.au/#/), the effect of different inputs or timing of sowing can be compared side-by-side with multiple simulations within APSIM, where management decisions are reflected in the annual yields or crop phenology. This allows users to contrast relative differences in yield caused by management or genotypic differences in multiple regions as well how different decisions on crop irrigation may influence crop phenology and yields. Fig. 7, presents an example of multiple simulations at Forthside, where different planting dates were simulated and the impact on yields and days to flowering are shown for simulations conducted on a daily basis from 1988 to 2018. Fig. 7 data includes irrigation for the four sowing dates (Oct 10, Nov 5, Nov 25 and Dec 5) and the corresponding total number of days to flowering. The number of days to flowering decreases with later planting dates because the rate of degree-day accumulation is higher during late spring and summer.

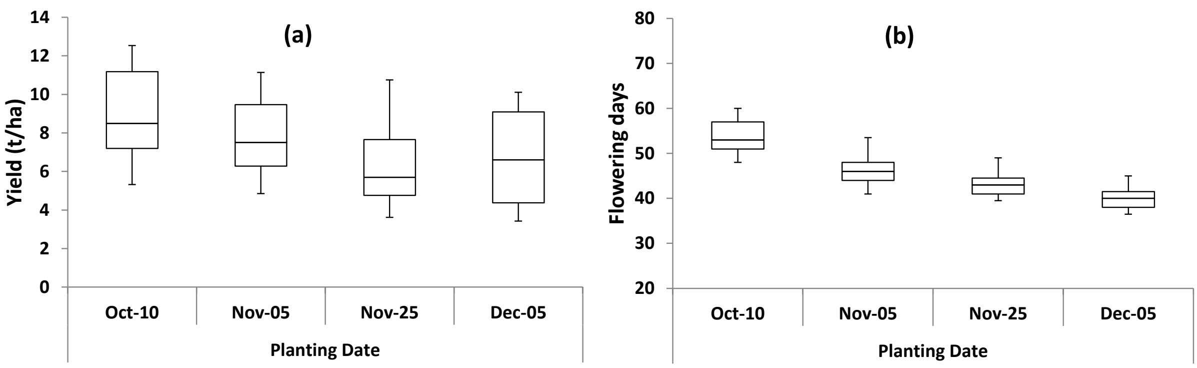

Fig. 7. Simulated green pea yields (t/ha) (a) and the number of days to flowering (days) (b) at Forthside for the period 1988 to 2018.

Conclusion

Here we parameterised an accepted crop model with field data from four Tasmanian farms, then used this parameterised file to conduct an analysis of how management and environment might affect green pea growth and development in other regions of Tasmania. In future the parameterised APSIM file could be incorporated within an online decision-support tool such as CropARM, thereby informing decision-makers about how management options effect green pea crop agronomy and potentially economic returns. Development of an online decision-support tool of this kind would be advantageous for green pea growers in Tasmania, since it would allow users to examine both agronomic and economic outcomes regarding green pea production across the state. The development of the green pea parameterised file within APSIM was achieved in a participatory sense with farmers, where the farmers acted as co-investigators, working with, guiding and providing validation to the Water for Profit researchers along the way. Learnings shared from this exercise were thus two-way, farmers learnt from how changes to model simulations affected green pea production on their farms, whilst researchers learnt about on-farm practices, seasonal crop behaviour, and management effects on yield within the region of the farms modelled.

The farmers initially undertook benchmarking studies to identify what practices would lead to better productivity and sustainable outcomes, while also contributing to and guiding the development of the green pea work shown here. Examples include sowing criteria, fertiliser applied, and crop responsiveness to irrigation water. Participatory studies of this kind thus inform industry of preferable combinations of genotype, environment and management, while simultaneously furthering the RD&E of agricultural science.