ABSTRACT

Evaluating productivity and yield stability of crops in water-limited environments and under climate change scenarios is difficult in real field conditions. Modelling approaches can be used as alternative and efficient methods to evaluate the above. APSIM is a simulation model used to study the performance of crops under diverse management and environmental conditions. APSIM-oryza, APSIM-maize and APSIM-mungbean modules were parameterized and validated for widely grown Sri Lankan varieties, *i.e.* short (Bg300) and medium (Bg359) duration rice varieties, local variety Ruwan and hybrid variety Pacific for maize, and variety MI-6 for mungbean, across all three major climatic zones of the country. Historical rainfall data were analyzed to study the changes in rainfall onset and amount of rainfall received in those seasons. Moreover, validated models were used to evaluate the crop and water productivities (CP and WP, respectively) under different management and climate change scenarios.

The APSIM-oryza module estimated the grain yield of rice under moisture-limited farmer-field conditions with a strong fit (n = 24, $R^2 > 0.97$, Root Mean Square Error (RMSE) = 484 kg ha^{-1}) under a wide range of conditions tested. APSIM–maize and APSIM–mungbean modules also estimated the grain yield with a strong fit for maize (n = 37, $R^2 > 0.95$, RMSE = 353 kg ha^{-1}) and for mungbean (n = 26, $R^2 > 0.98$, RMSE = 75 kg ha^{-1}). Historical weather data analysis revealed that the amount of rainfall received was higher when an early onset was occurred (63 % to 94 %) than that observed with a late onset. Moreover, an early onset resulted longer seasons than the late onset. Farmers regularly established rice crops 2–4 weeks after the rainfall onset.

The APSIM-simulated results showed that the early and late onset coupled with early and late planting, had 33 % and 34 % higher CP, respectively, than when it was not coupled. When the onset of rainfall was delayed, dependency on supplementary irrigation for rice was predicted to be

increased. Moreover, late planting with a late onset could result in higher variability in WP (4.3 ± 0.34 kg ha^{-1} mm^{-1}) than that with an early planting and early onset (4.4 ± 0.12 kg ha^{-1} mm^{-1}), even though the mean WP would be similar. The WP (24 %) and CP (10 %) of rice were greater in Alternate Wetting and Drying (AWD) condition in model simulation than those in continuous flooding. It is predicted that the WP of rice-based farming systems could be increased by over 65 % when maize or mungbean extent was increased in water-limited conditions. The most efficient crop combinations to maximize net return were estimated as the diversification of land with 50 % rice and 50 % mungbean sole crops, or 25 %, 25 % and 50 % with rice, maize and mungbean sole crops, respectively. The model simulated that the CP negatively affects the yield stability of rice (33 %) in *Yala* season, and maize (30 %) and mungbean (32 %) in both seasons with changing climate at the end of the century in all three climatic zones, with a greater risk in the Dry Zone.

In conclusion, the parametrised and validated APSIM modules for rice, mungbean and maize showed promising results and could be used in future predictions. Timing of rice planting should be adjusted based on the forecasted rainfall onset to harness the maximum potential of available natural resources. Access to supplementary irrigation with AWD irrigation also increased the stability of grain yield, CP and WP irrespective of the onset of rainfall or time of crop establishment. Selecting best crop combinations can increase the CP, WP and income. As the crop growth and grain yield could be adversely affected by climate change, precautions may take to maintain the stability of crop production.