Understanding the Determinants of Soil C Stocks and Water-Use Efficiency in the Semi-Arid Tropics of India Using APSIM

Margarethe S. Karpe[1], Andrew Smith[2], Thomas Falk[2], Klaus Dittert[1], GV Anupama[2], Dakshina Murthy[3]

[1] Georg-August University of Göttingen, Dept. of Crop Sciences, Germany
[2] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Innovation Systems for the Drylands, India
[3] ANGR Agricultural University Guntur, Agronomy, India

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Background and objectives

Irrigation

Root biomass

Dry soil

- Soil organic carbon (SOC) is an indicator for soil health and agricultural productivity.
- Higher SOC is linked with higher water-use efficiency (WUE).
- We analysed big data generated by APSIM with a decision tree algorithm to find site-specific improved management for Indian drylands.

Materials and methods

- A panel dataset was generated using APSIM to mimic a 25-year-long field experiment in Maharashtra, India (Fig. 1).
- Model specification: Cropping system, irrigation, N fertiliser, and manure influence SOC change, biomass, income, and income per water used.
- For each dependent variable, 84 conditional inference trees were computed for 28 district-soil combinations under 3 climate scenarios (historic climate, two projected scenarios RCP 8.5).

Large, unbalanced dataset with climatic and agro-ecological gradient and context-specific patterns.

- 5981 unique georeferenced panels
- Soil (n = 10)
- Historic climate & 2 projected scenarios
- Cropping system (n = 13)
- Fertiliser and irrigation
- Period 1985 – 2009 (n = 25)

Data mining: Decision tree algorithm
Conditional inference tree (CTree)

Figure 1: Dataset and statistical method.

Results

- The algorithm split the data into different homologous classes (leaf nodes) by making binary splits based on the independent variables s (system), m (manure), i (irrigation) and f (N fertiliser) (Fig. 2).
- Observations in the leaf nodes are depicted as boxplots with zero on the scale being the mean of the district-soil-climate combination (in Fig. 2: average annual SOC increase of 9 kg/ha).
- In Fig. 2, the best-performing leaf node in terms of SOC is node 7 (bottom right) with an annual SOC increase of 39 kg (30 kg higher than mean).
- Best performance is attained through best management, which in Fig. 2 is growing maize-chickpea*, millet-sorghum, mungbean-sorghum, soybean-maize, sorghum-chickpea or sorghum-wheat plus applying >1575 kg manure/yr.

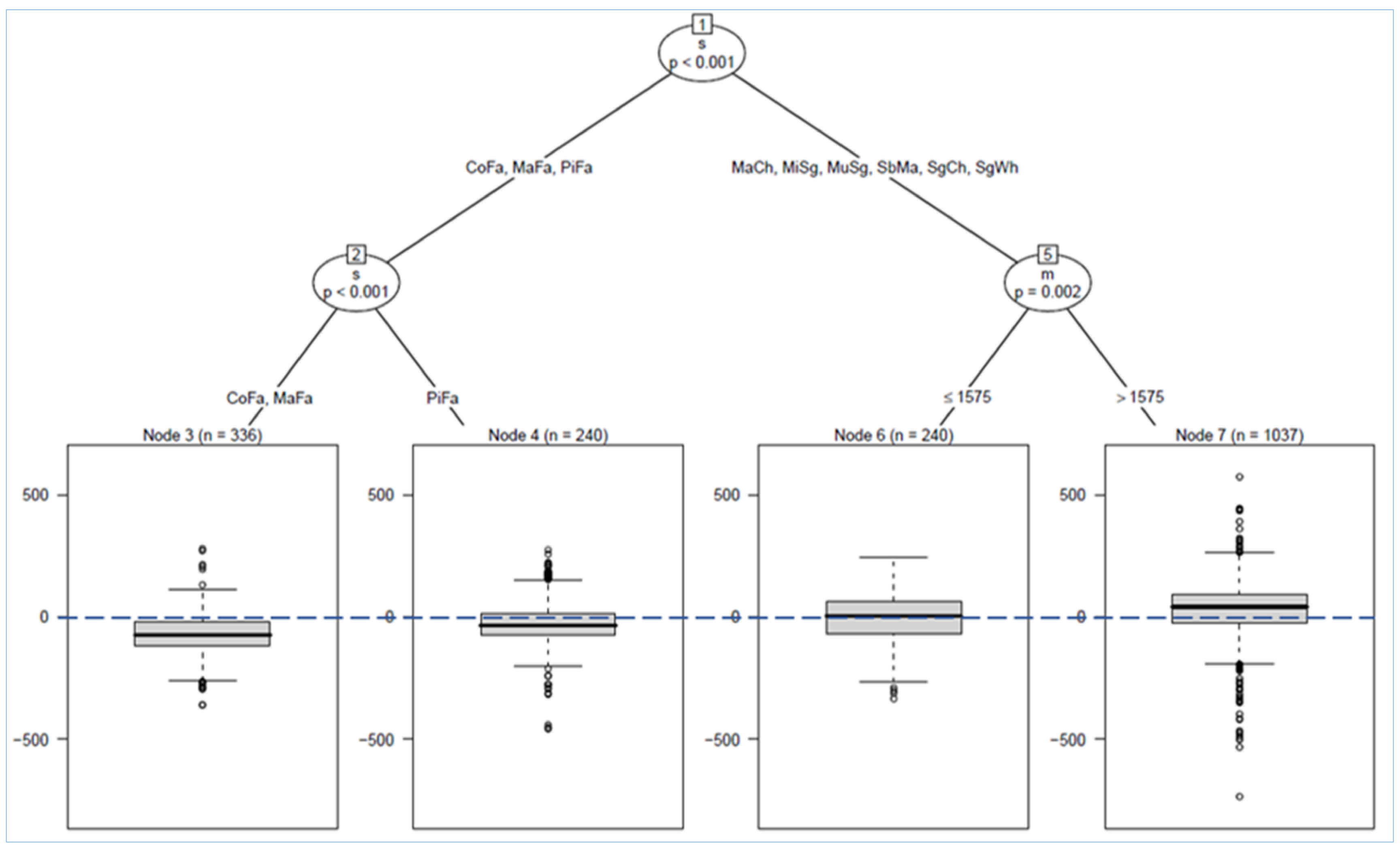

Figure 2: One CTree example for annual SOC changes (kg) in Ahmednagar on deep Entisol under historic climate.

Conclusions

- Cropping system selection is key for maximising SOC, biomass allocation, income generation and WUE.
- To increase SOC stocks, sorghum-chickpea and sorghum-wheat were top-performers on most soils.
- Higher N inputs favoured increases of SOC.
- To increase WUE, high profitability per water used was demonstrated for mungbean-sorghum, sorghum-chickpea, and pigeonpea-fallow.
- Adjusted irrigation holds great potential to improve income per unit of water used on shallow soils and in drier regions.

Contact: Margarethe S. Karpe, margarethekarpe@gmail.com

*abbreviations Fig. 2: Ch – chickpea, Co – cotton, Fa – fallow, Ma – maize, Mi – millet, Mu – mungbean, Pi – pigeonpea, Sb – soybean, Sg – sorghum, Wh – wheat; first crop grown during rainy season, second during post-monsoon season