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Role of biophysical canopy traits on evapotranspiration and its impact on soil water dynamics within the vadose zone

Sruthi Surendran[1] (162114001@smail.iitpkd.ac.in) and Deepak Jaiswal[1,2] (dj@iitpkd.ac.in)

[1]Environmental Sciences and Sustainable Engineering Centre, Indian Institute of Technology Palakkad, Palakkad, Kerala, 678557, India

[2]Department of Civil Engineering, Indian Institute of Technology Palakkad, Palakkad, Kerala 678557, India

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INTRODUCTION

Climate change, impact plant and plant processes, which in turn, influences soil processes. Soil provides the necessary physical and chemical conditions for plant growth and development, influencing their physiology and overall health. How are all the changes in climate and plants going to affect the soil water dynamics, will be the main focus of this study. We demonstrate the impact of selected climate variables (CO2 & Relative Humidity) and plant biophysical traits (Jmax – maximum electron transport and RuBP regeneration rate) on CO2 assimilation and the soil water dynamics within vadose zone.

PHOTOSYNTHESIS, TRANSPIRATION AND STOMATAL CONDUCTANCE

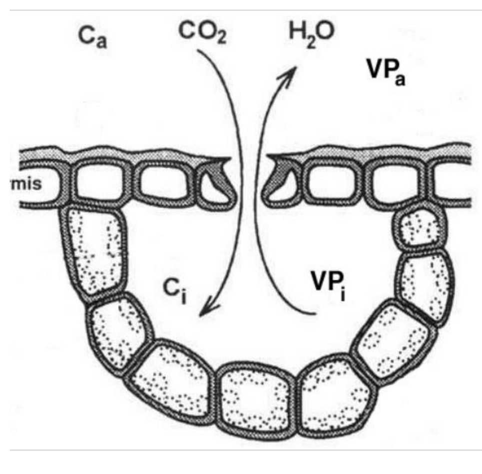


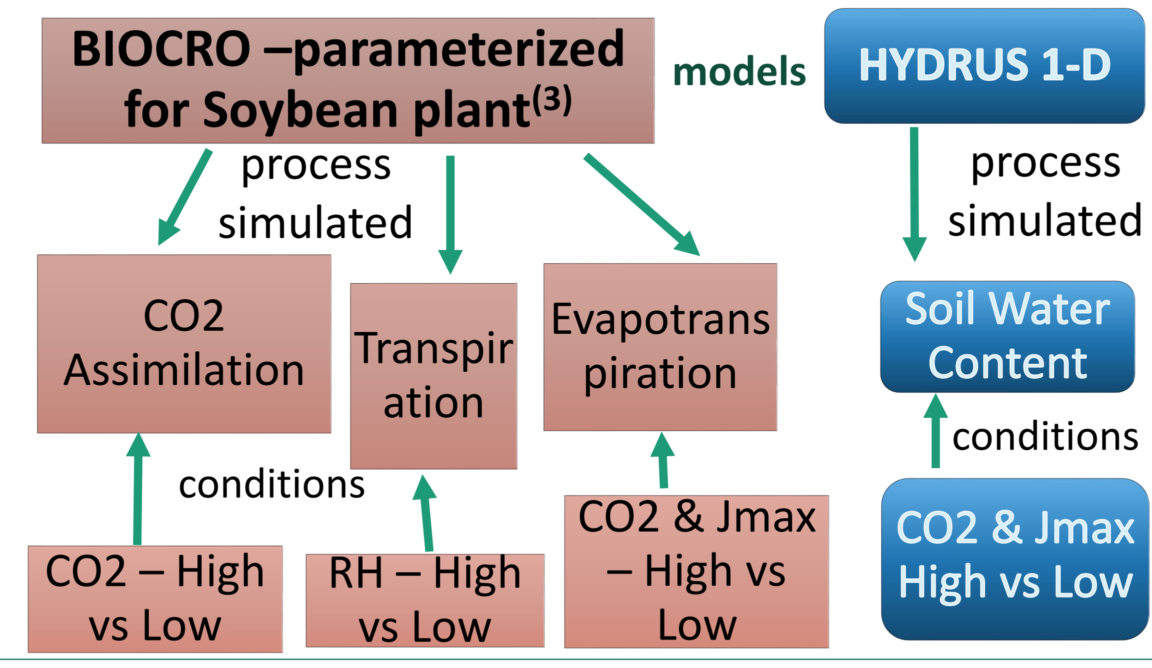
Fig. 1
Source: [1]

Concentration gradient of CO2 **(C_a – C_i)** responsible for the movement of CO2 between leaf and the atmosphere. Vapor Pressure Deficit **(VP_a - VP_i)** is the driving force for transpiration.

Eq. 1 $A = g_{CO2}\,(C_a - C_i)$ $T = 1.6\, g_{CO2}\,(VP_a - VP_i)$

g_{CO2} is the stomatal conductance. CO2 assimilation (A) & transpiration (T) changes with change in conc. of CO2, VPD and stomatal conductance[2]. Variation in leaf temperature also occurs which may impact gas exchange processes.

METHOD



IMPACT OF CLIMATE & BIOPHYSICAL TRAITS ON EVAPOTRANPIRATION RATES

(*Predicted by BioCro*)

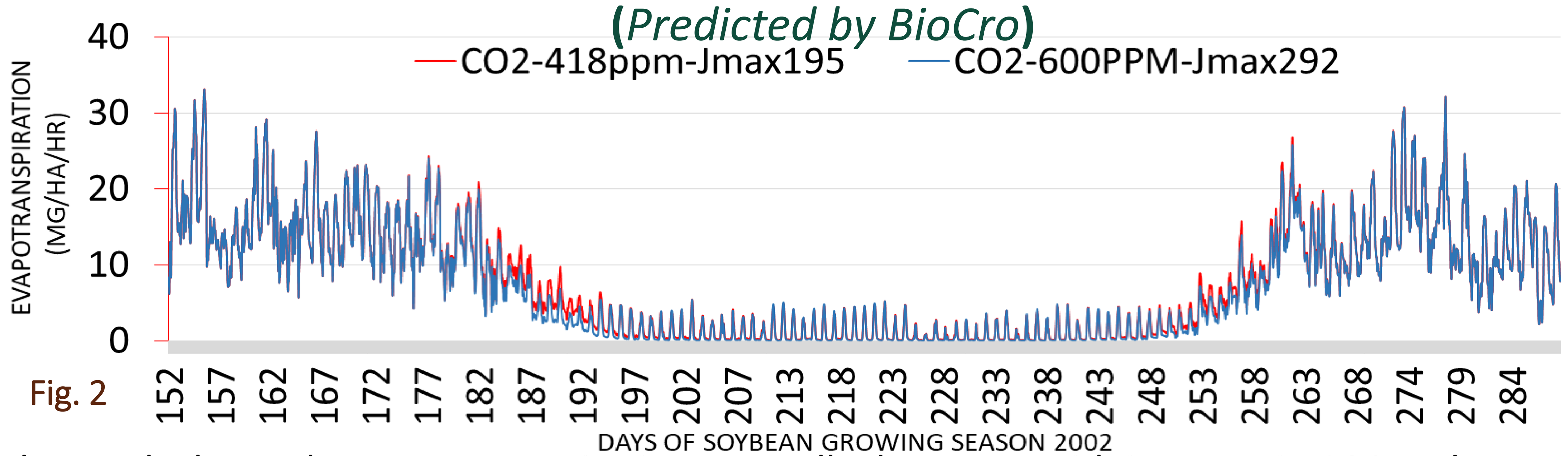
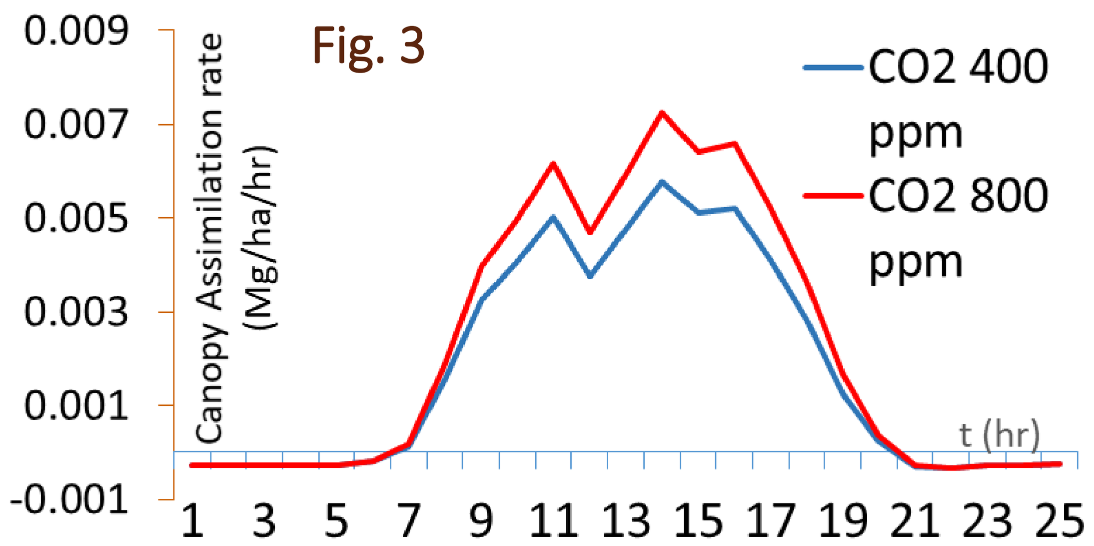


Fig. 2

The result shows that evapotranspiration generally decreases with increase in CO2 and Jmax.

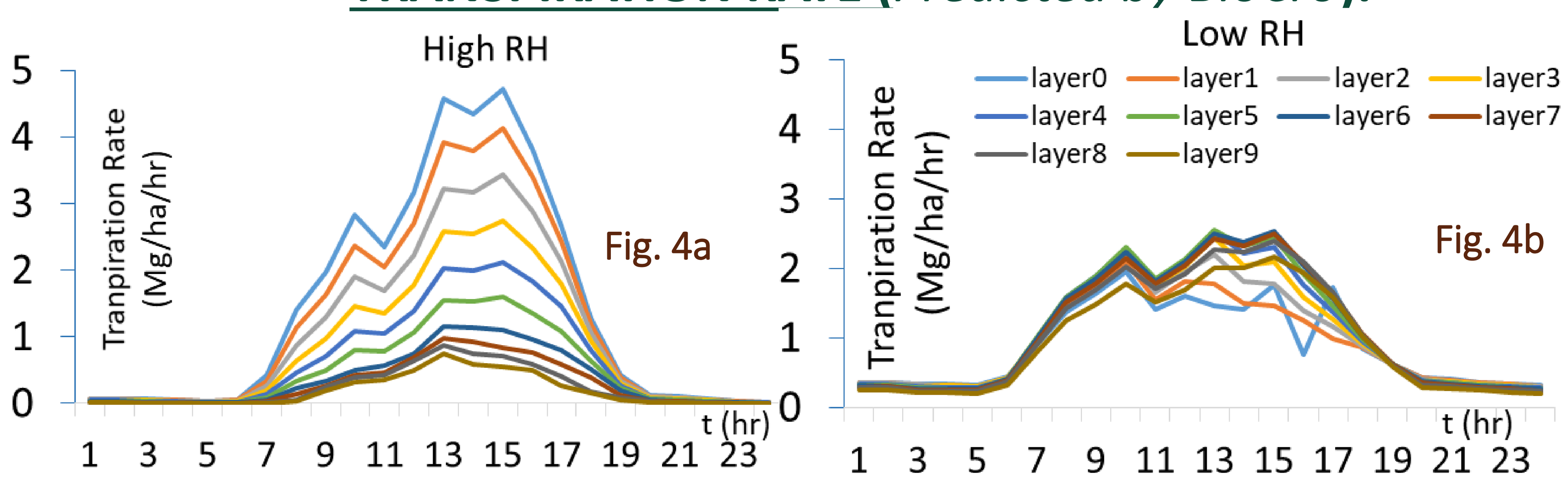
IMPACT OF CHANGING CO2 ON DIURNAL CO2 CANOPY ASSIMILATION RATE

(*Predicted by BioCro*)



CO2 canopy assimilation rate is predicted for elevated CO2 rate for 198th day of growing season in 2002. Elevated CO2 reduces stomatal conductance[4] but increase in concentration gradient results in increased assimilation rate (Eq.1).

IMPACT OF CHANGING RELATIVE HUMIDITY ON DIURNAL CANOPY TRANSPIRATION RATE (*Predicted by BioCro*).



Low atmospheric RH corresponds to low VPD reducing transpiration (Eq. 1).

IMPACT OF CLIMATE AND BIOPHYSICAL TRAITS ON SOIL WATER DYNAMICS

(*Predicted by HYDRUS 1-D using I/O exchange between BioCro & HYDRUS 1-D*)

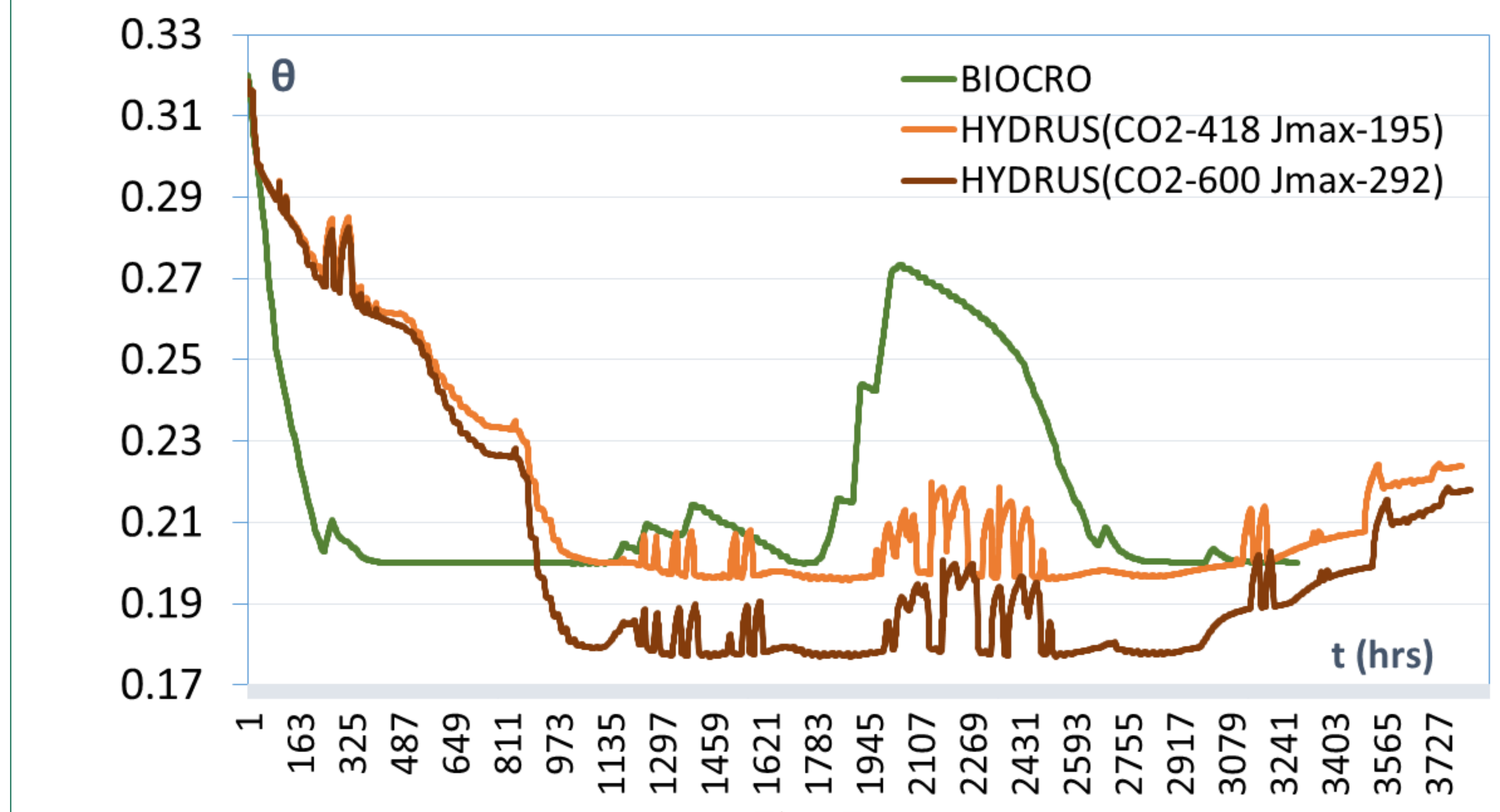


Fig. 5

We have seen the variation in bio-physical plant processes due to climate change. Fig. 5 shows the impact of these variations on soil water content. The result also compares soil water simulations using BioCro and HYDRUS 1-D. BioCro uses a simple tipping bucket approach while HYDRUS 1-D uses the 1-D Richards equation to simulate water transport.

CONCLUSION

This work demonstrated the impact of climate change on biophysical processes like canopy assimilation rate, transpiration and evapotranspiration simulated using BioCro. The impact of changing CO2 and biophysical parameters like Jmax on soil water content was demonstrated using HYDRUS 1-D. The comparison of soil water simulations by BioCro and HYDRUS 1-D is also shown. Impact of climate variables on biophysical plant processes like photosynthesis, transpiration and evapotranspiration will definitely impact the soil water content as seen in Fig 5. Hydrological models which many a times represent plants (in the form of Roots/LAI) often ignore the role of plant physiochemical processes. This can be addressed by two way dynamic coupling of hydrological models and mechanistic plant growth models like BioCro. The two way coupling will also help BioCro strengthen its soil water module.

FUTURE WORKS

Future works would be dynamically coupling HYDRUS 1-D and BioCro so that plant physiochemical processes can be incorporated into the simulations of HYDRUS 1-D and model validation using field data.

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Result Analysis for evapotranspiration (Fig 2)

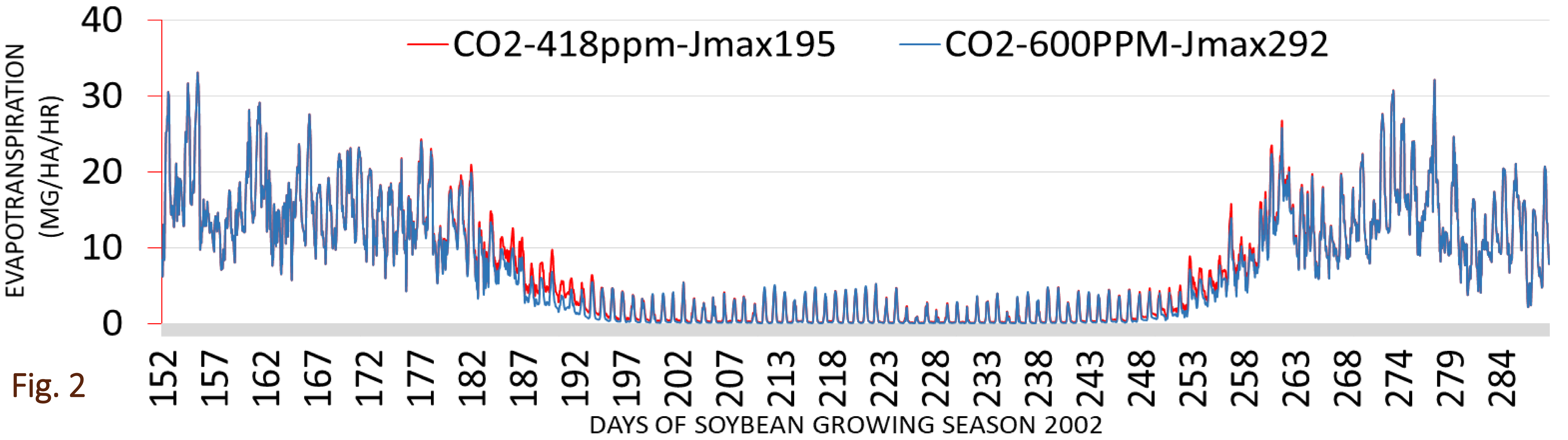
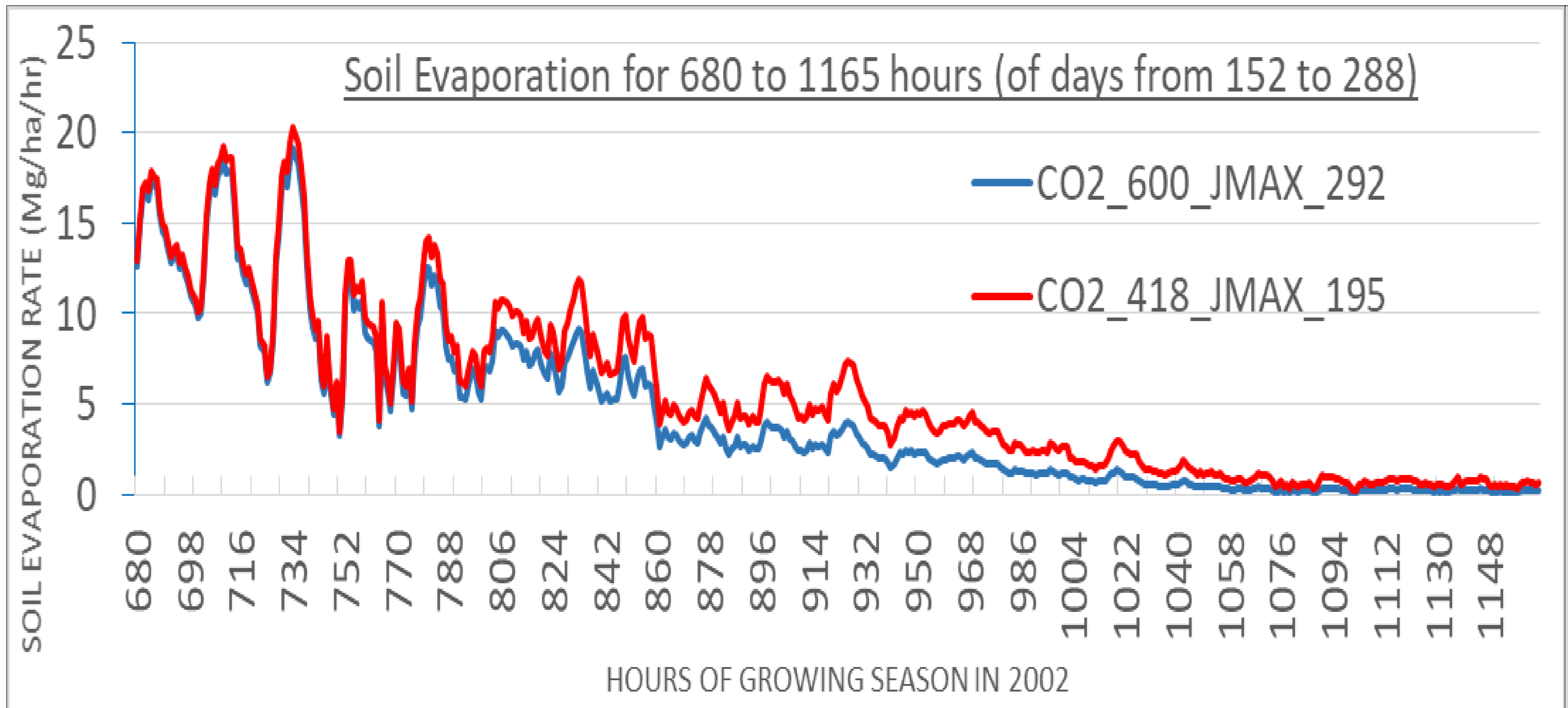
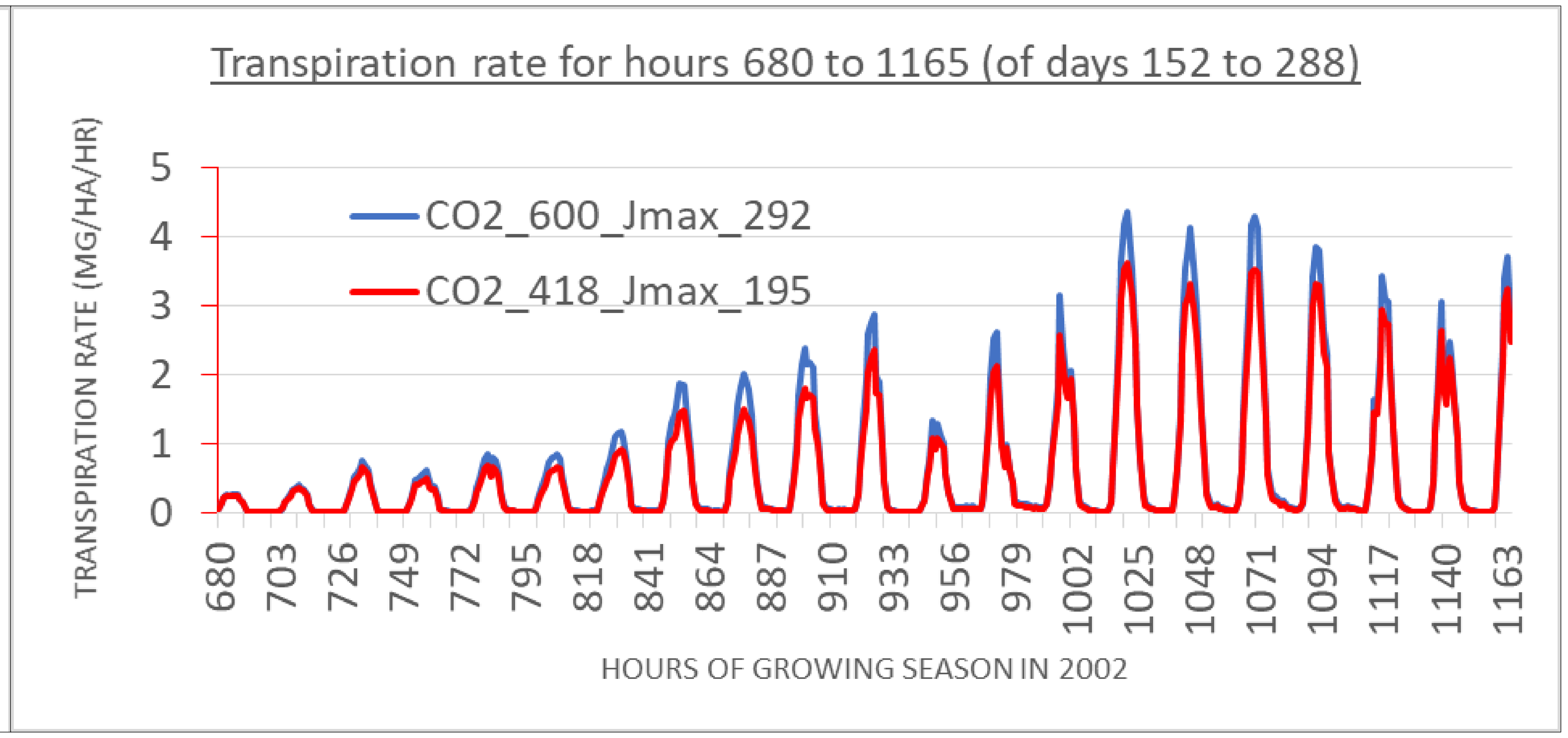


Fig. 2





Soil evaporation and transpiration when plotted separately shows soil evaporation decreases for the elevated conditions of CO2 and transpiration increases for elevated conditions of CO2 and Jmax. The transpiration results are in accordance with the results produced in Fig 3.