Simulations of an impulsive model for the growth of fruit trees

Theme 08 - Introduction to Systems Biology

Reproduce research

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Abstract

Droughts have affected the agriculture in the mediterranean in an increasingly severe matter. The decrease in rainfall and the effects of global warming have taken their toll on many orchards, especially fruit producing ones. Since the water supply of these orchards is always artificial because of the aforementioned factors, dwindling water capacities in reservoirs is a serious issue. This study aims to provide an insight into the effects of different irrigation patterns on the growth of these fruit trees. Because without a sustainable plan for irrigation, whole populations of fruit trees might perish under a critical water deficit.

Summary

List of Abbreviations

ODE Ordinary Differential Equation

Contents

1 Introduction

1.1 Purpose

The effects of climate change are an existential threat to the planet earth. This paper's purpose is to reproduce and expand on the research done by E Duque-Marin to get a further understanding of the dynamics and different scenarios of fruit tree growth, and by extension shed light on a part of this humongous problem that is already cropping up around the world.

1.2 Theory

For use in the simulations, 2 differential equations were obtained from *E Duque-Marín et al 2022 J. Phys.: Conf. Ser. 2153 012018*. Their accompanying parameters are listed below.

Parameter	**Meaning**
q	Accumulated energy constant
r	Fruit trees intrinsic growth rate
N	Fruit carrying capacity
I	Irrigation water amount
β	Evapotranspiration rate
γ	Photosynthetic contribution rate
ω	Mortality rate of fruit trees

$$Equations:$$

$$W'(t) = -\beta q W(t) - rC(t)(1 - \frac{C(t)}{N}W(t)$$

$$C'(t) = rC(t)(1 - \frac{C(t)}{N})W(t) + \frac{\gamma q C(t) W(t)}{(C+1)(W+1)} - \omega C(1) \qquad t \neq nT$$

$$\Delta W(nT) = I$$

$$\Delta C(nT) = 0 \qquad t = nT$$

These equations come forth from a plethora of different papers, all of these are listed in *E Duque-Marín et al 2021 J. Phys.: Conf. Ser. 2046 012017*, the paper which proves these equations.

2 Materials and Methods

Since no datasets were used in the production of the results, the simulation data had to be generated. This data was plotted using R graphics.

2.1 Materials

The simulation data was obtained using the ODE (ordinary differential equation) function of deSolve. This function takes differential equations and parameters and calculates the output of these functions. Aforementioned equations can ben found in the theory section. Other packages like ggplot2, ggpubr, formatR and scales were used in data visualisation.

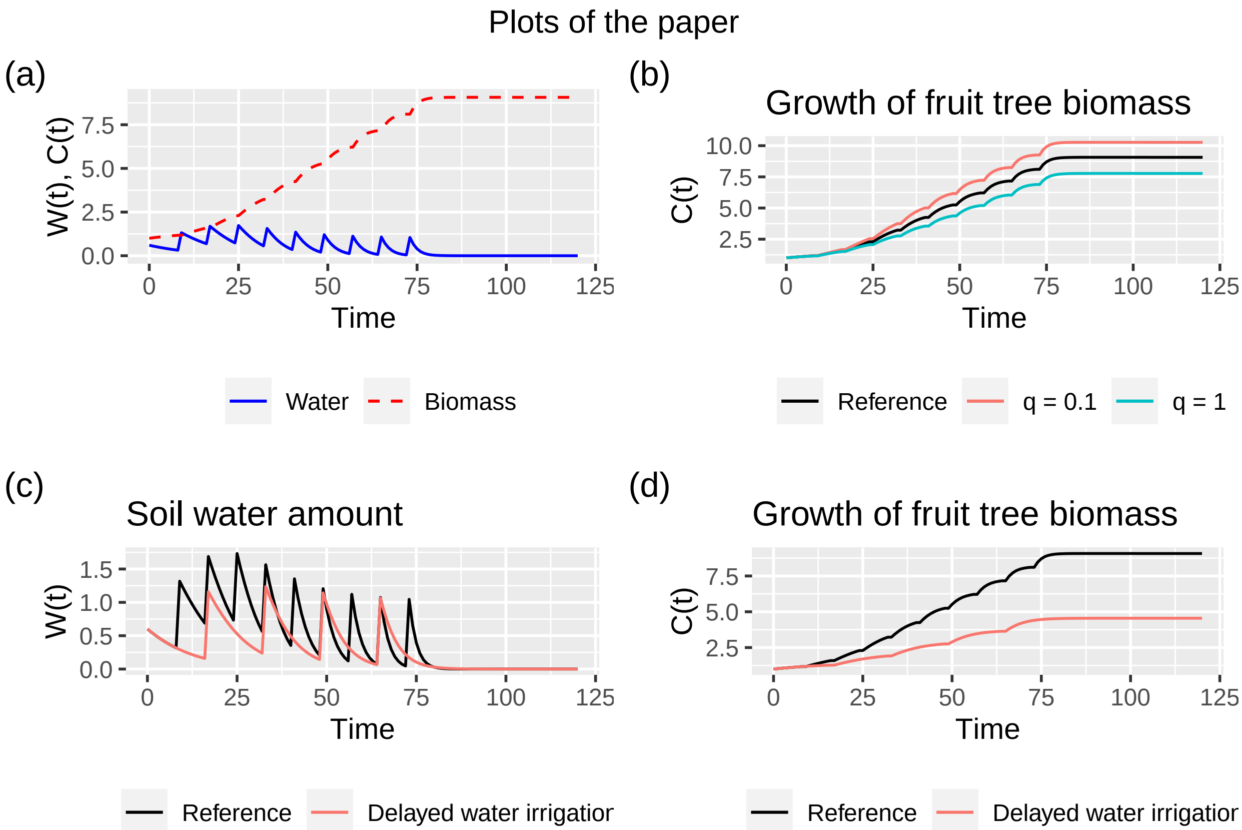
Software	**Package**	**Version**
R		4.0.4
	deSolve	1.32
	formatR	1.11.1
	ggplot2	3.3.5
	ggpubr	0.4.0
	scales	1.1.1

The simulation data consists of an index, the *time*, water level in the soil (W) and biomass (C).

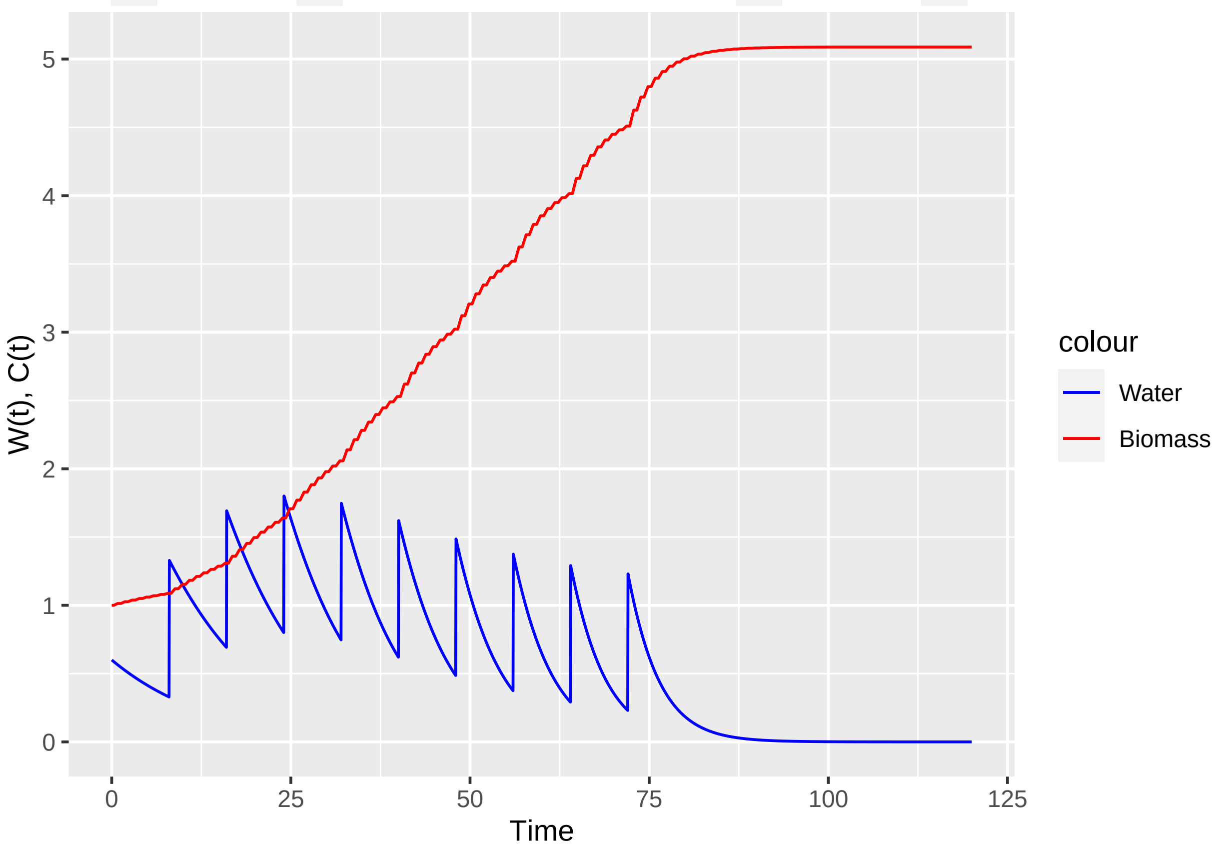
	time	W	C
1	0.00000	0.600000	1.00000
2	1.00000	0.556209	1.02602
3	2.00000	0.514991	1.05076
4	3.00000	0.476281	1.07421
5	4.00000	0.440001	1.09637

2.2 Methods

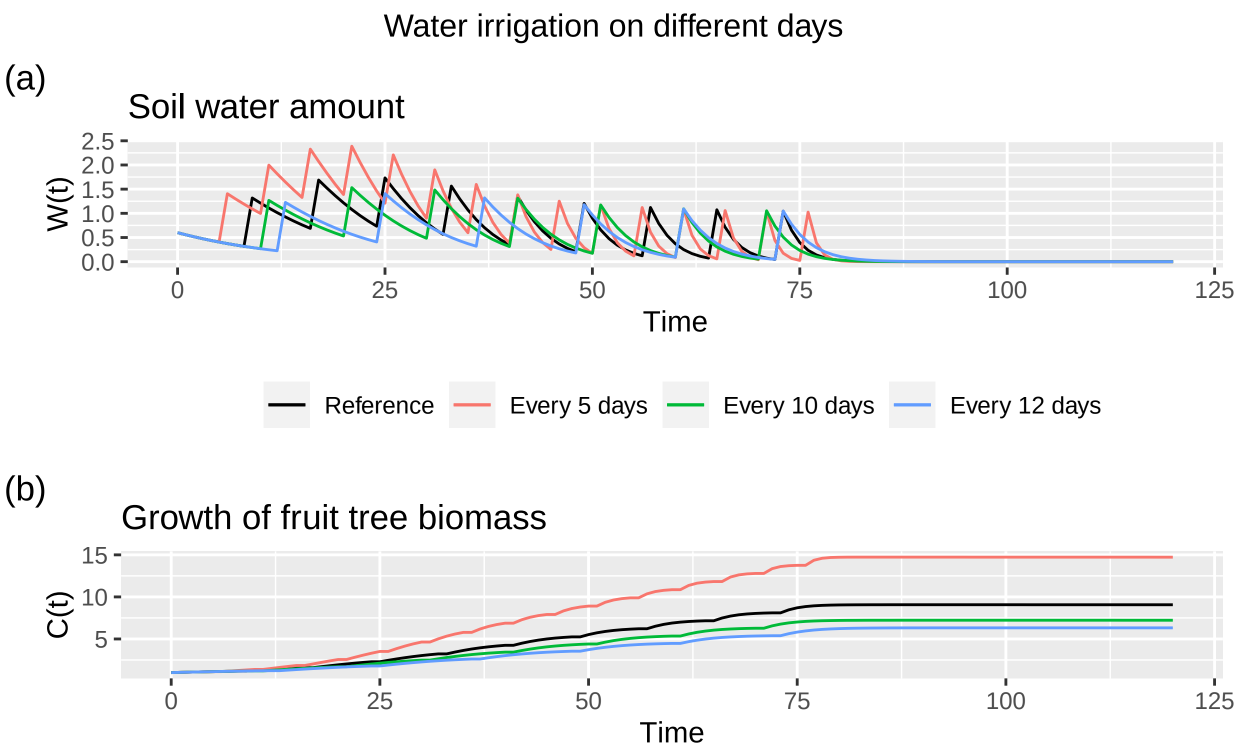
3 Results

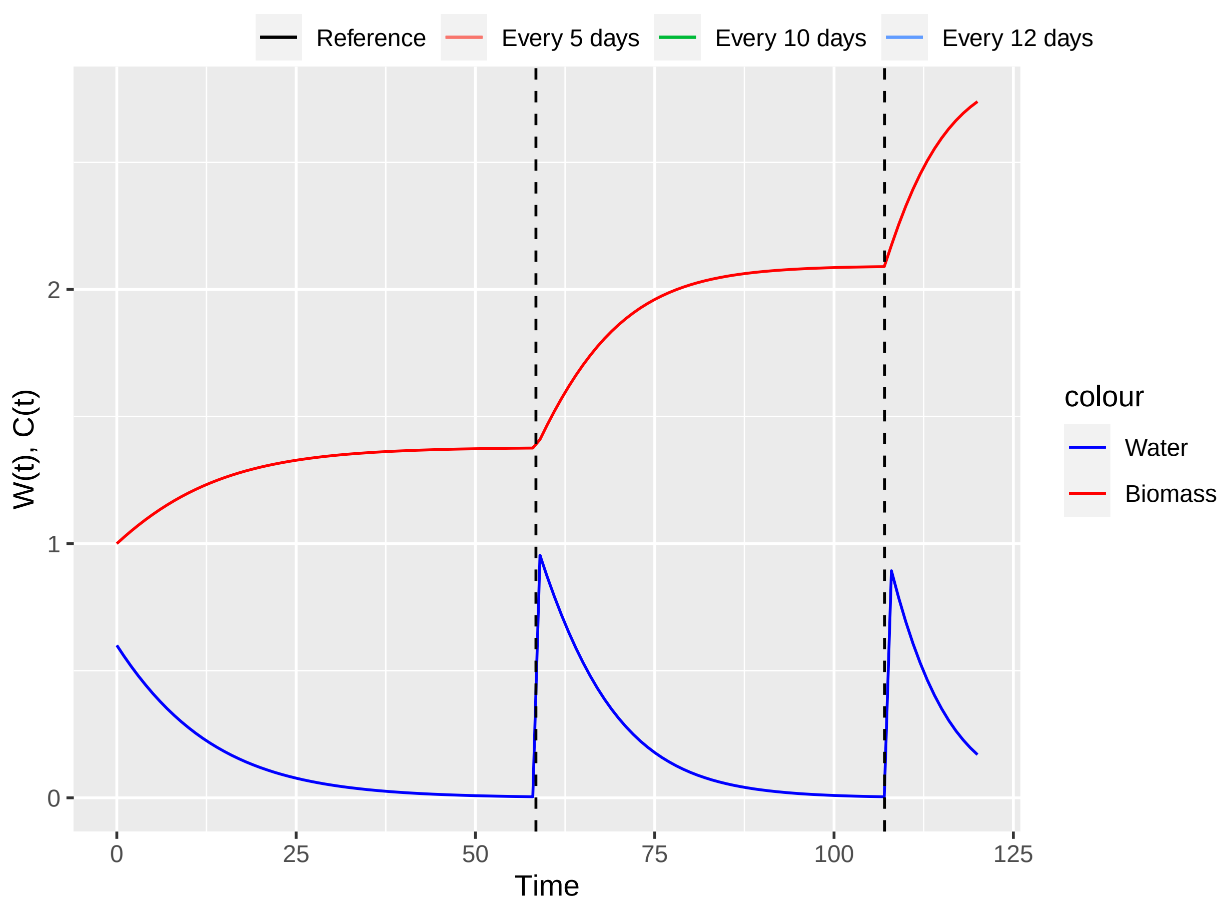


Plots of the paper
(a)
W(t), C(t)
Time
Water
Biomass
(b)
Growth of fruit tree biomass
C(t)
Time
Reference
q = 0.1
q = 1
(c)
Soil water amount
W(t)
Time
Reference
Delayed water irrigatior
(d)
Growth of fruit tree biomass
C(t)
Time
Reference
Delayed water irrigatior



W(t), C(t)
Time
colour
Water
Biomass


Water irrigation on different days
(a)
Soil water amount
W(t)
2.5
2.0
1.5
1.0
0.5
0.0
0
25
50
75
100
125
Time
Reference
Every 5 days
Every 10 days
Every 12 days
(b)
Growth of fruit tree biomass
C(t)
15
10
5
0
25
50
75
100
125
Time
Reference
Every 5 days
Every 10 days
Every 12 days


W(t), C(t)
2
1
0
0
25
50
75
100
125
Time
colour
Water
Biomass

4 Conclusion

5 Discussion

6 References

7 Appendix