# Simulations of an impulsive model for the growth of fruit trees

Theme 08 - Introduction to Systems Biology

Reproduce research

Lisa J.B. Hu (414264)
Niek R. Scholten (388602)
Bio-Informatics BFV2
Institute of Life Science & Technology
Hanze University of Applied Sciences
Tsjerk Wassenaar
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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

## 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 |
| $\beta$ | Evapotranspiration rate |
| $\gamma$ | Photosynthetic contribution rate |
| $\omega$ | 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)



(b)

### Growth of fruit tree biomass

(c)

### Soil water amount

(d)

### Growth of fruit tree biomass
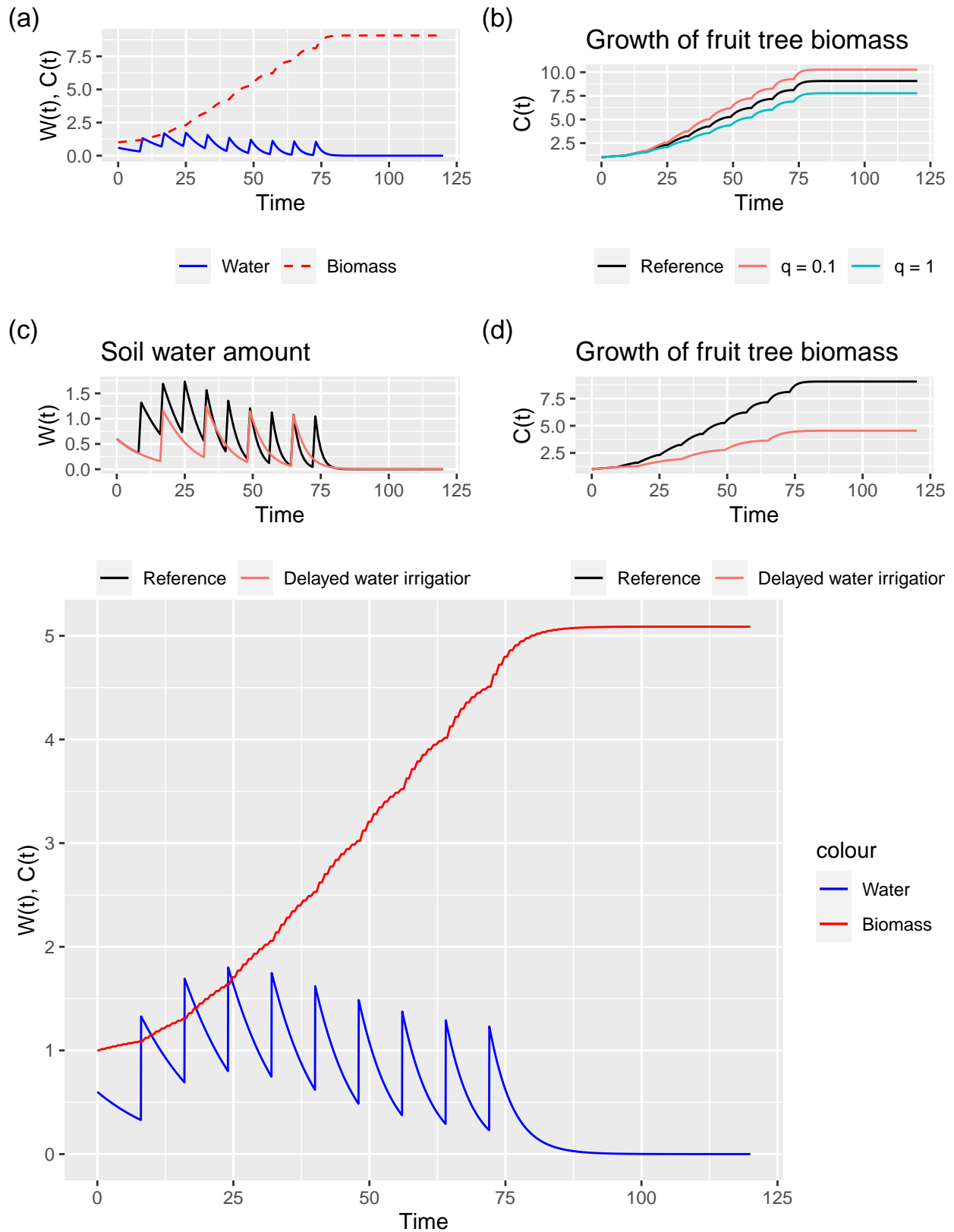
# Water irrigation on different days

(a)

## Soil water amount



- Reference
- Every 5 days
- Every 10 days
- Every 12 days

(b)

## Growth of fruit tree biomass



- Reference
- Every 5 days
- Every 10 days
- Every 12 days



colour
- Water
- Biomass
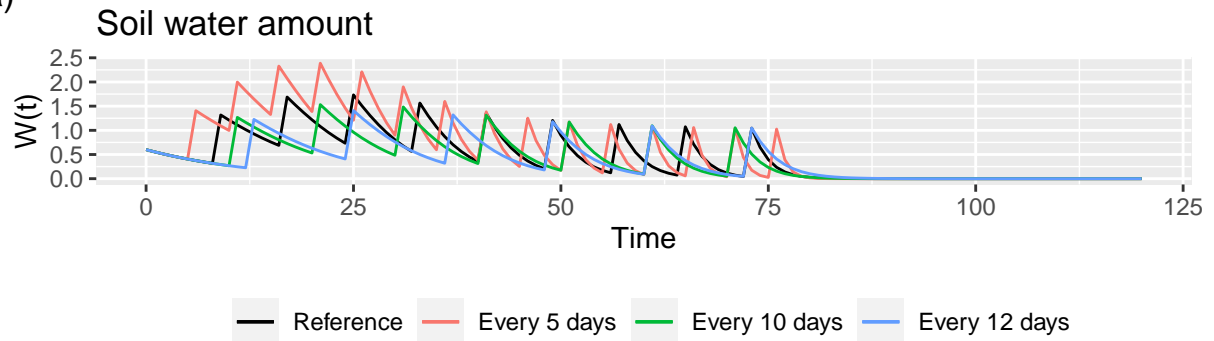
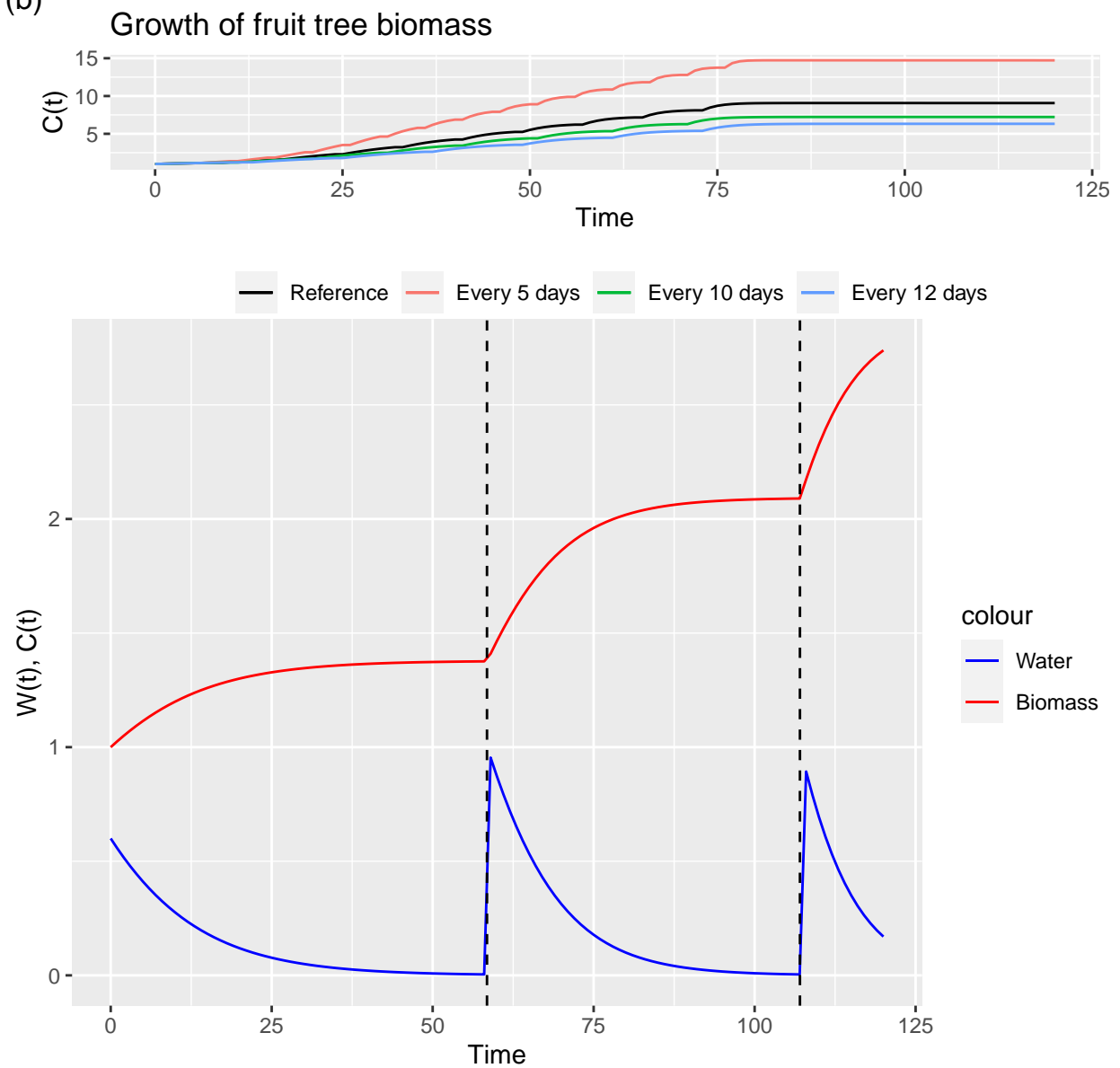# 4    Conclusion

# 5    Discussion

# 6  References

# 7 Appendix