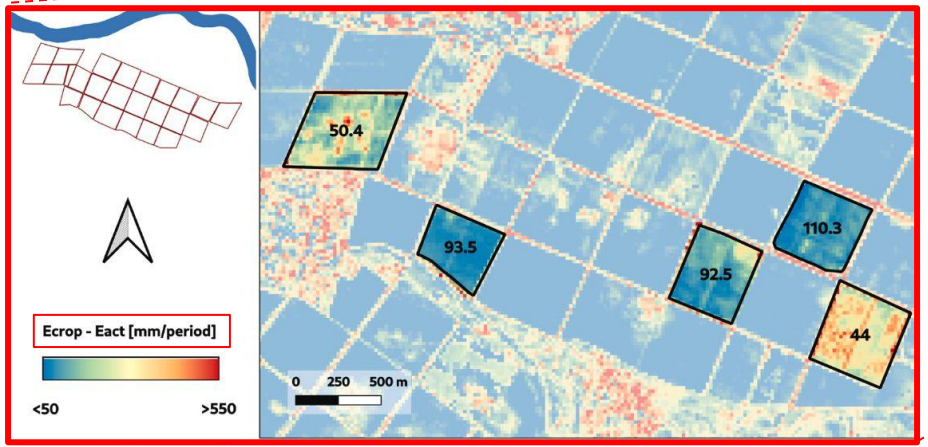
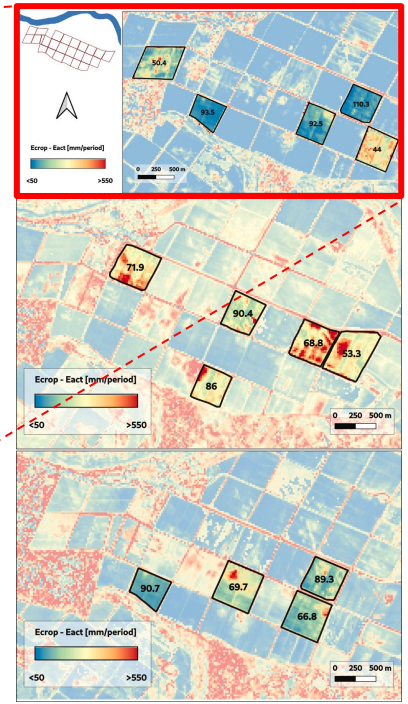
Maximizing sucrose development through optimizing irrigation with a multi-sensor approach

Nadja Den Besten, Susan Steele-Dunne, Richard de Jeu, and Pieter van der Zaag

AGRICULTURE · Taber, Alberta · August 8, 2019

Estimating irrigation with remote sensing

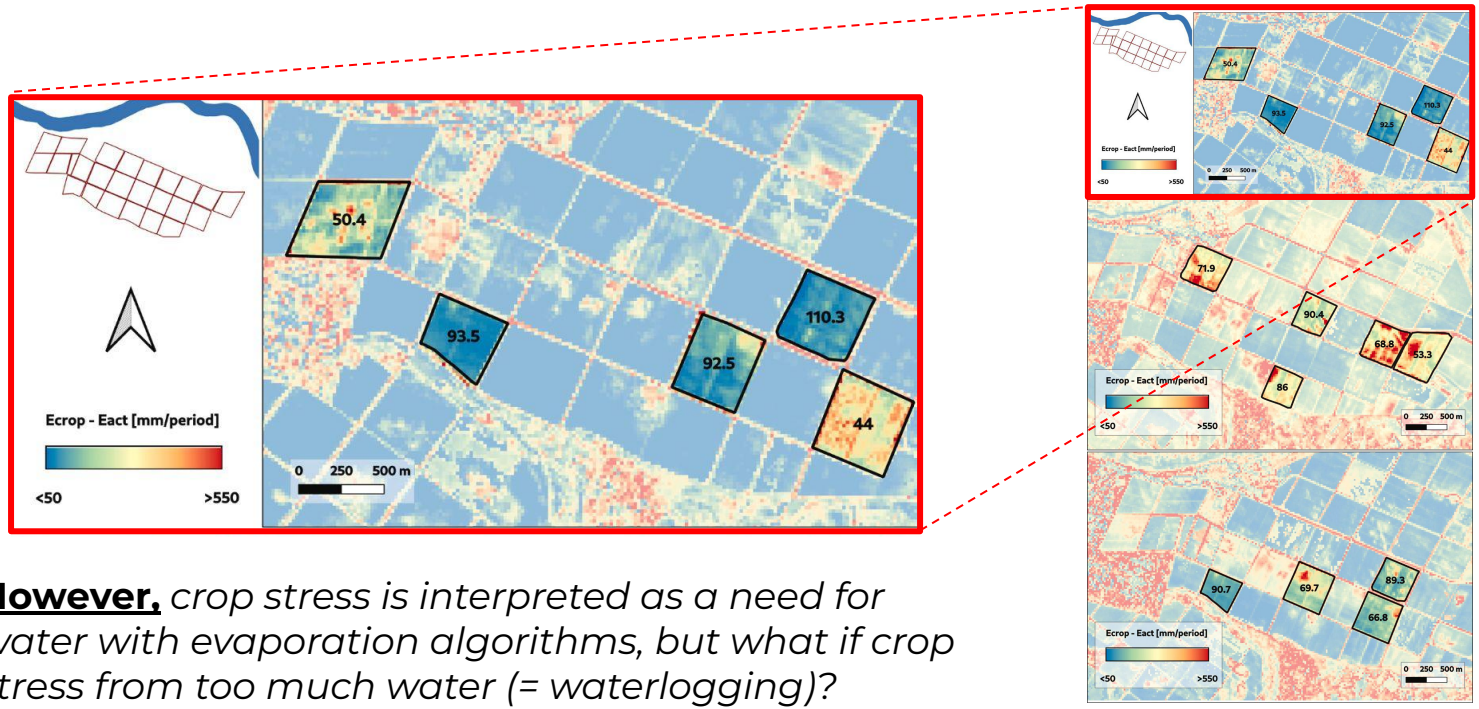




Methodology: *Combination of Sentinel-2, MODIS, and, meteorological data*

*__Figure:__ den Besten, N. I., Kassing, R. C., Muchanga, E., Earnshaw, C., de Jeu, R. A. M., Karimi, P., & van der Zaag, P. (2021). **A novel approach to the use of earth observation to estimate daily evaporation in a sugarcane plantation in Xinavane, Mozambique.** *Physics and Chemistry of the Earth, Parts A/B/C*, *124*, 102940.

Estimating irrigation with remote sensing



However, *crop stress is interpreted as a need for water with evaporation algorithms, but what if crop stress from too much water (= waterlogging)?*

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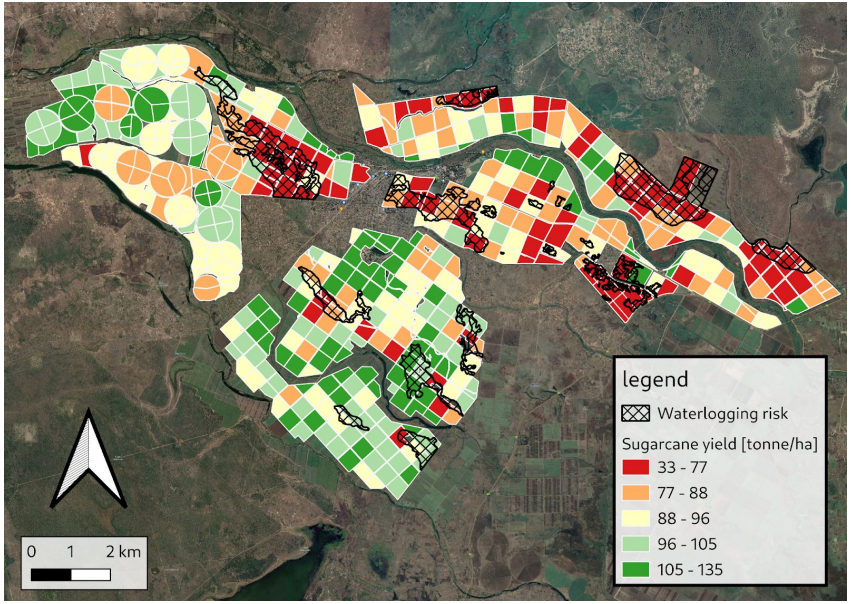
Waterlogging in irrigated agriculture (BIG issue!)



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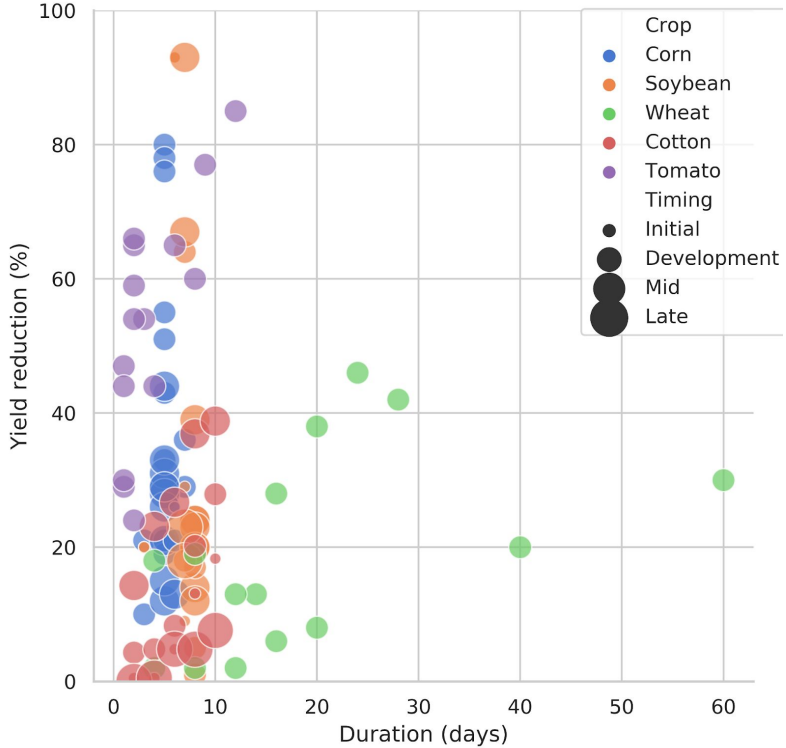
Waterlogging is actually quite overlooked!



In literature: more focus on drought, studies on waterlogging are minimal

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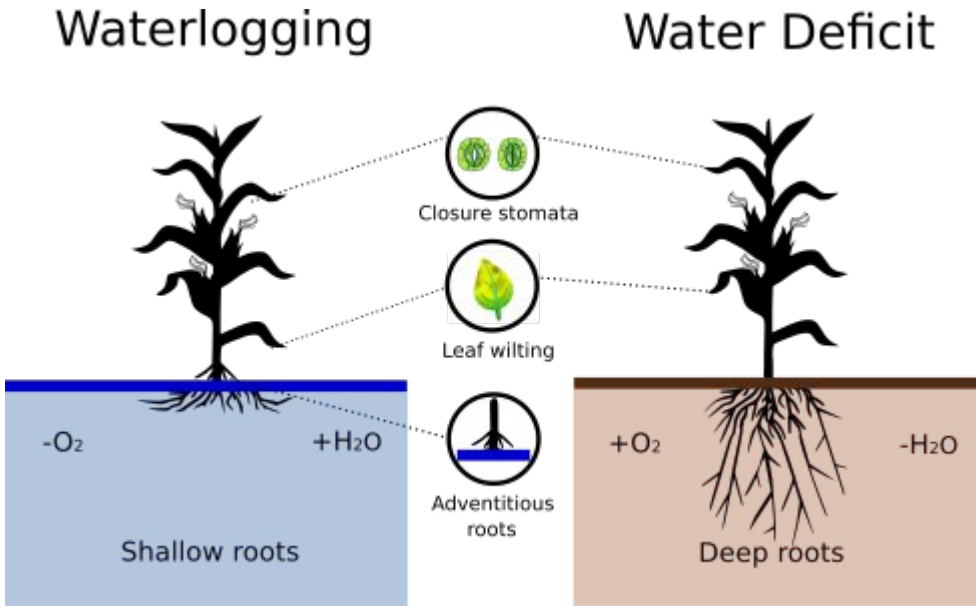
Waterlogging in agriculture - difficult to observe



Not so easily seen from space and may even lead to false irrigation advices...

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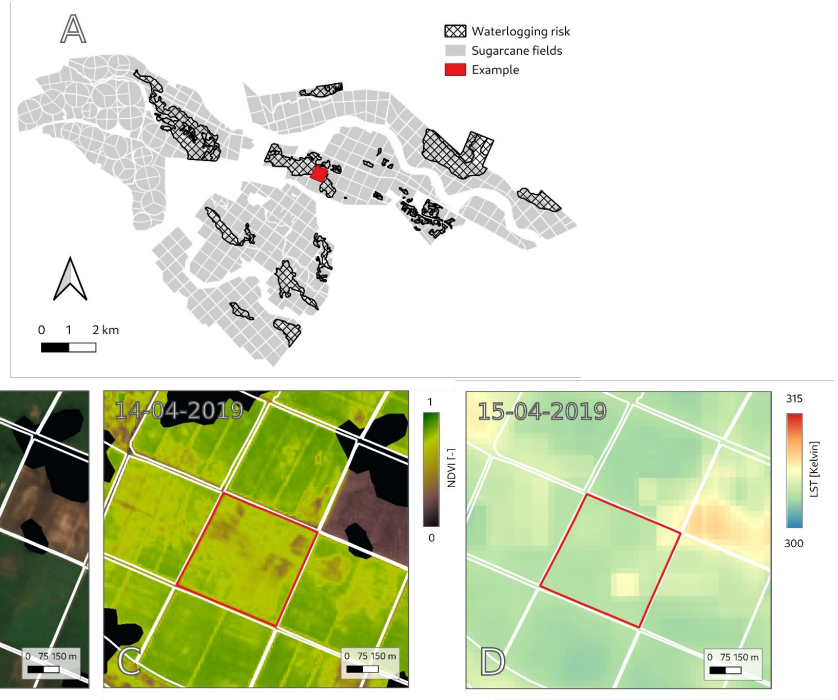
Waterlogging seen from space



- Difficult to see what is happening underneath a canopy
- E.g. NDVI: You may see effects of waterlogging once the damage is done (that's too late)

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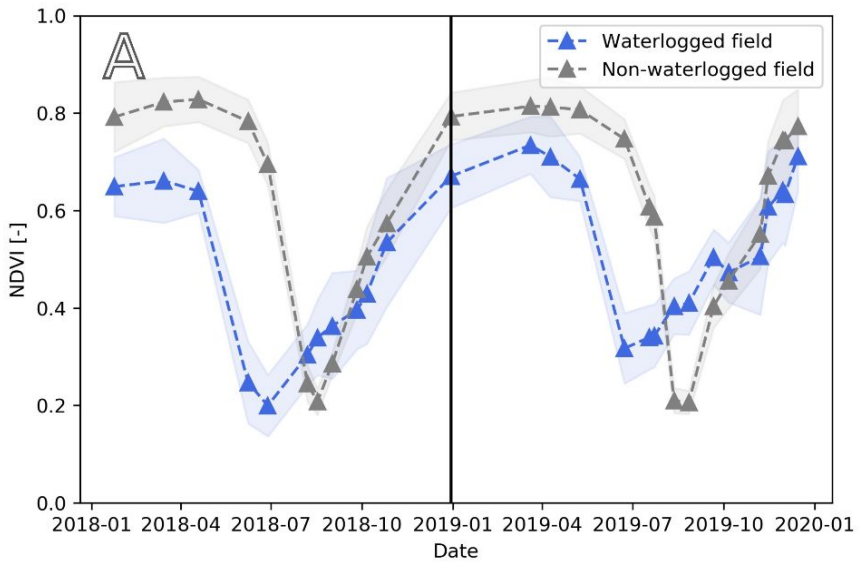
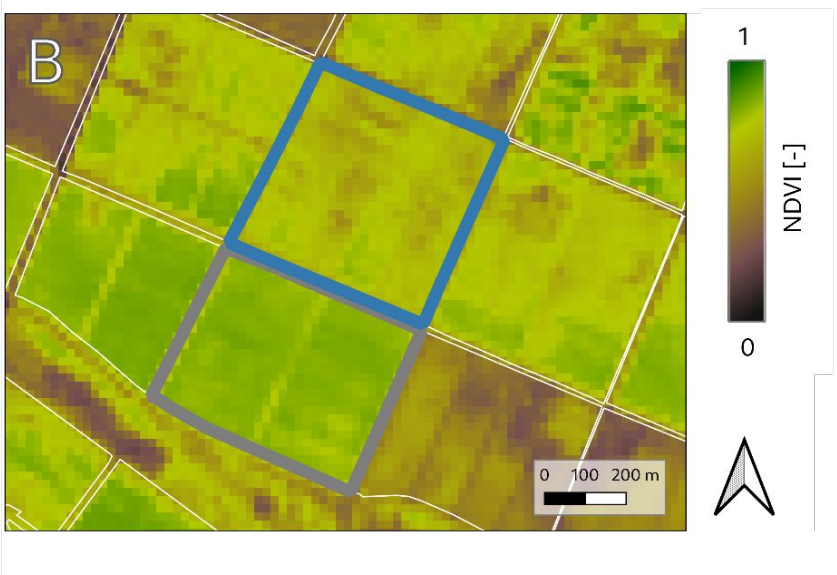
Waterlogging is affecting crop growth





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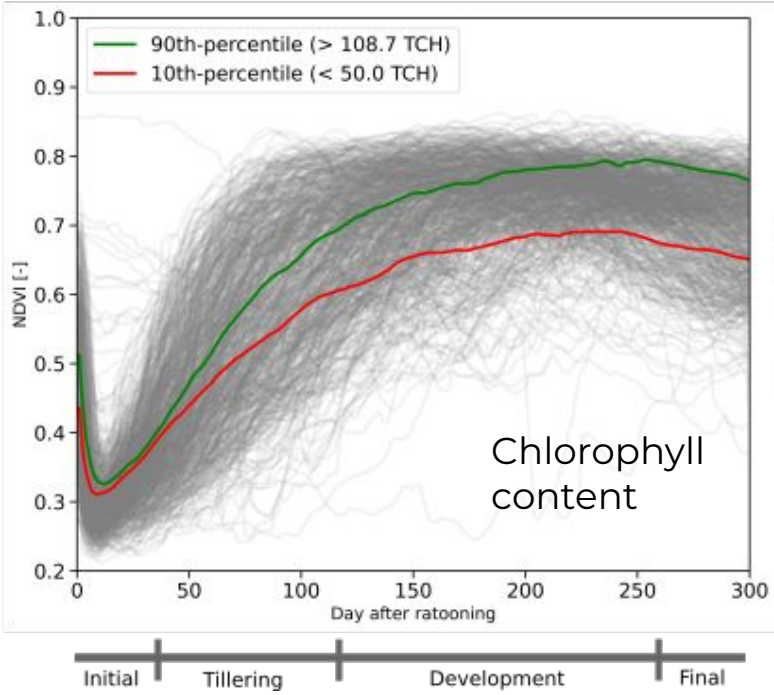
Another interesting thing is happening...

NDVI (Planet Fusion)



Cross Ratio (Sentinel-1)

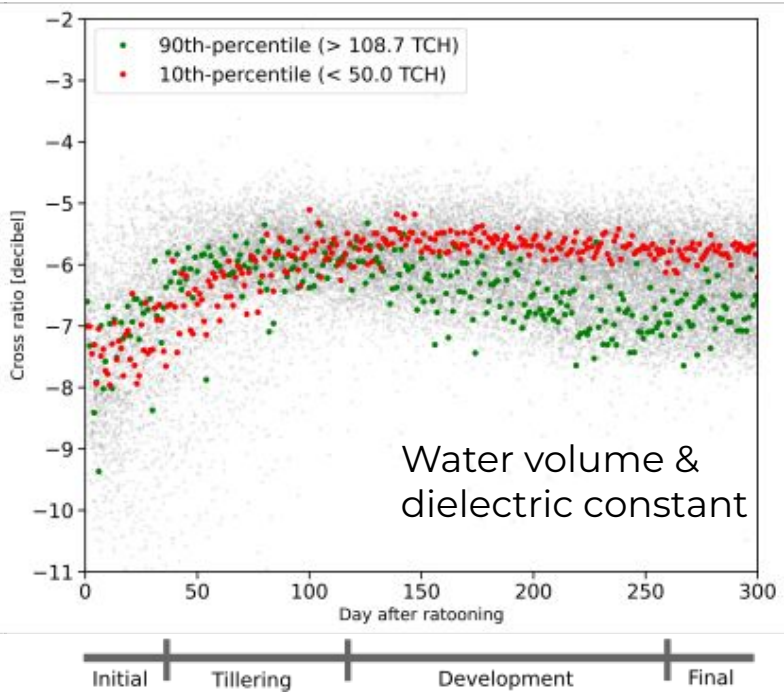
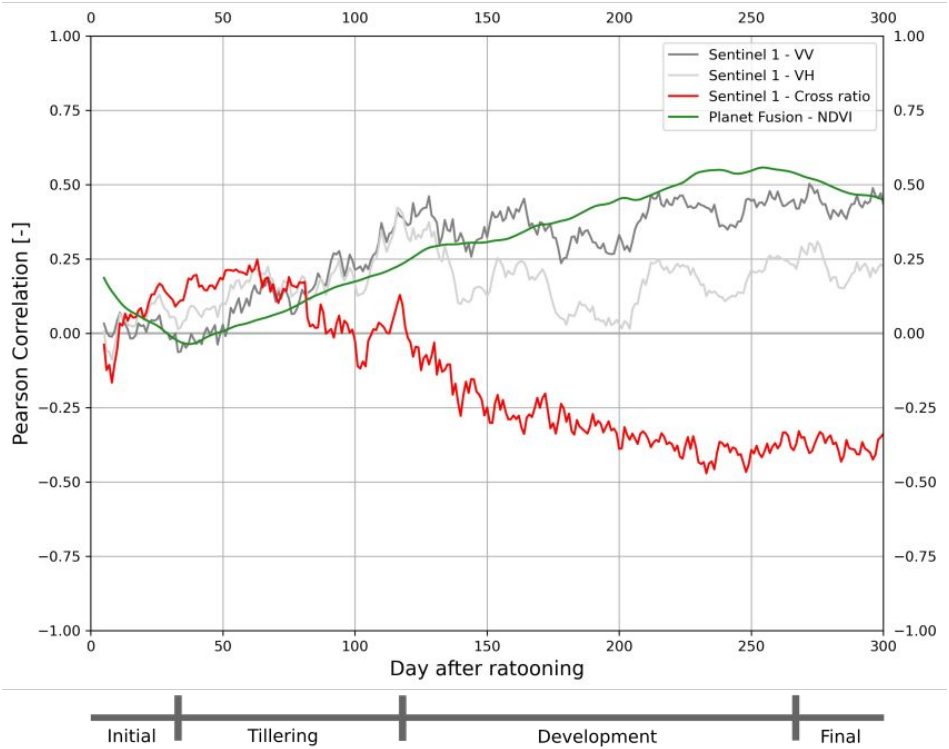


*Figure adapted from: den Besten, N.; Steele-Dunne, S.; Aouizerats, B; Zajdband, A.; de Jeu, R.; van der Zaag, P. **Observing sucrose accumulation with Sentinel-1 backscatter.** *Frontiers in remote sensing.* **2021**

Negative correlation between Crop Yield and Cross Ratio



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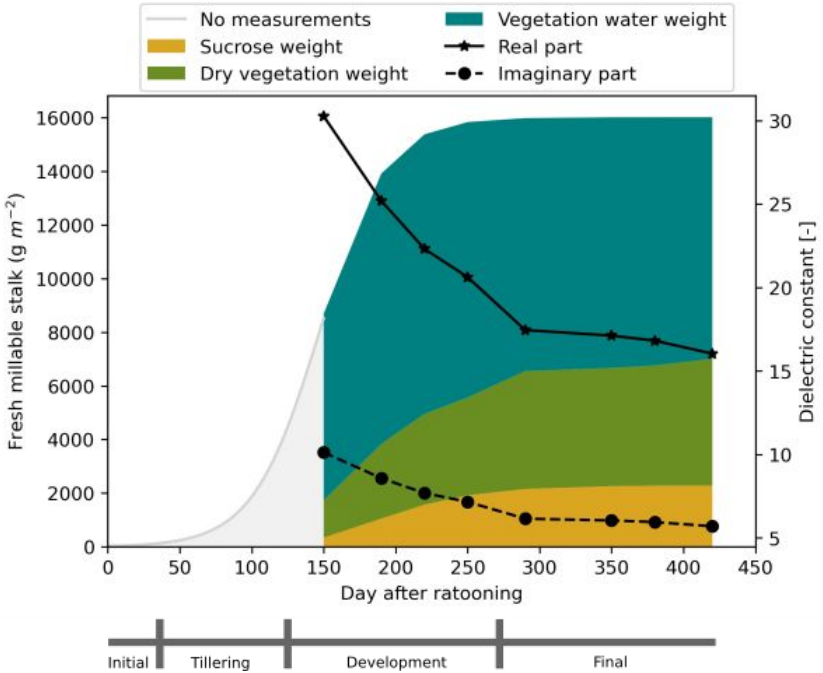
Sucrose accumulation seen from space

Sucrose accumulation begins to play a role

We need to further understand what happens inside the plant...

*Figure adapted from: Molijn, Ramses A. et al. **Sugarcane Productivity Mapping through C-Band and L-Band SAR and Optical Satellite Imagery.** *Remote sensing.* **2019**

Sucrose accumulation seen from space



Sampling day	150	190	220	250	290	350	380	420
v_{fw}	0.29	0.23	0.20	0.18	0.15	0.14	0.14	0.13
v_b	0.52	0.50	0.49	0.48	0.45	0.45	0.45	0.44

- Sucrose accumulation changes chemical composition of plant
- Water fraction decreasing → pulls dielectric constant down
- More research needed on how bound water evolves in sucrose accumulating crops

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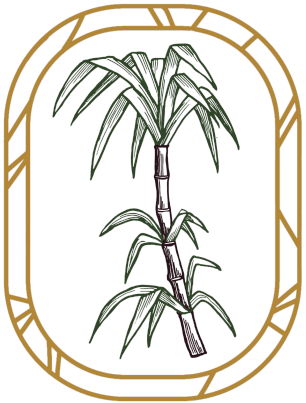
Take-home messages:

- Waterlogging in irrigated agriculture is an issue and overlooked
    - Example Mozambique: waterlogging is prohibiting optimal sucrose yield (even in a drought prone area)
- Waterlogging is overlooked in satellite retrieved evaporation algorithms for irrigation and should be considered to optimize (sucrose) production
- Sucrose accumulation can be observed with Sentinel-1 backscatter
- The dielectric constant of sugarcane decreases over the growing season (opposite to e.g. corn) pulling down S1 backscatter



References

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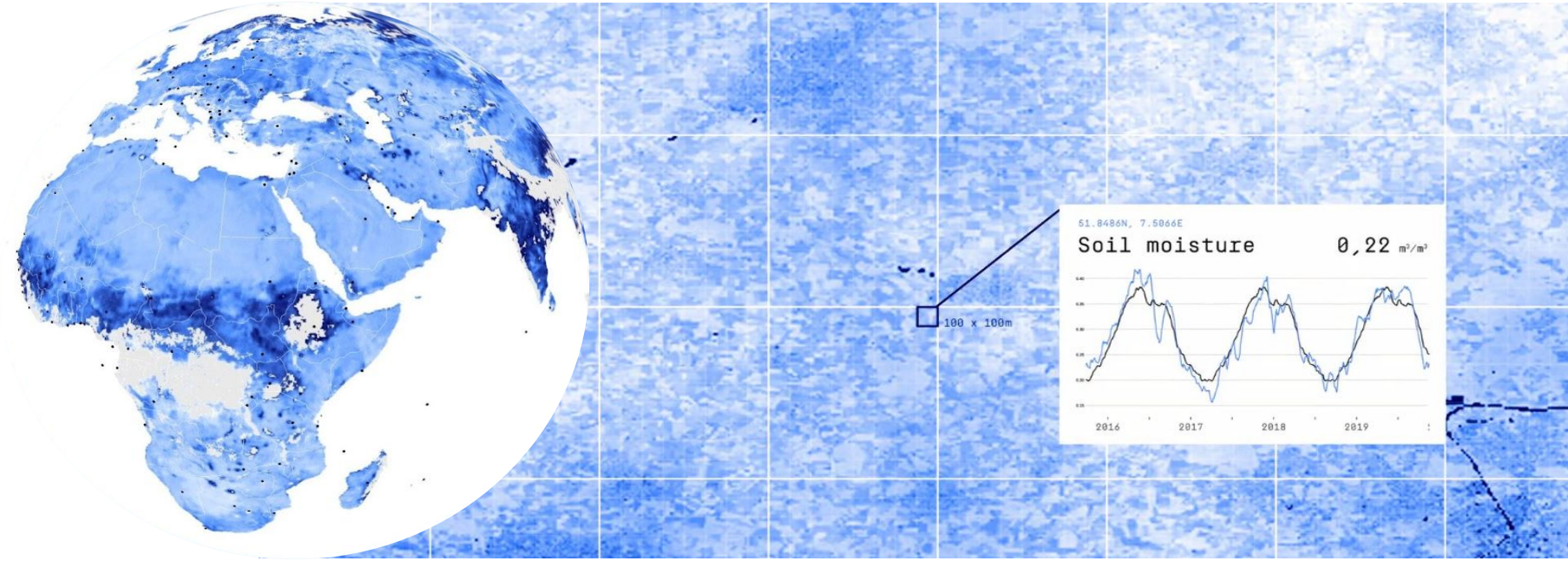
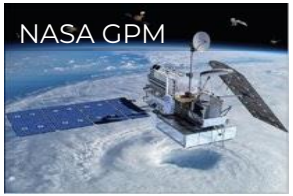
Planet’s planetary variables

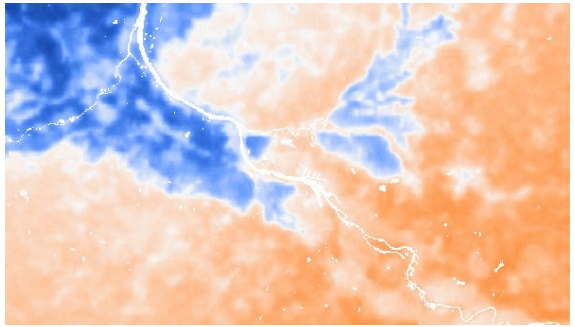


Public Satellite constellation



Planet’s planetary variables

Soil water content [m^3/m^3]



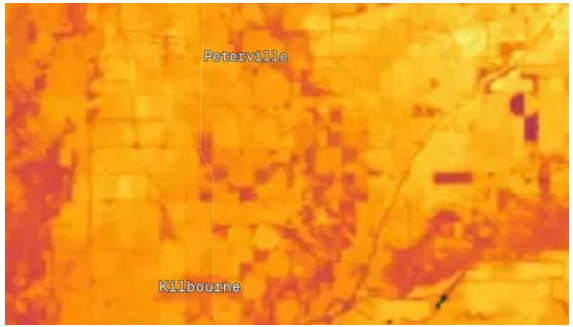
100 x 100 m

Near Real Time

20 years archive

Global

Land surface temperature [K]



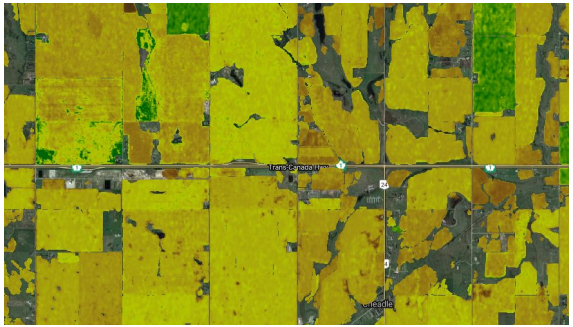
100 x 100 m

Near Real Time

20 years archive

Global

Biomass proxy [-]

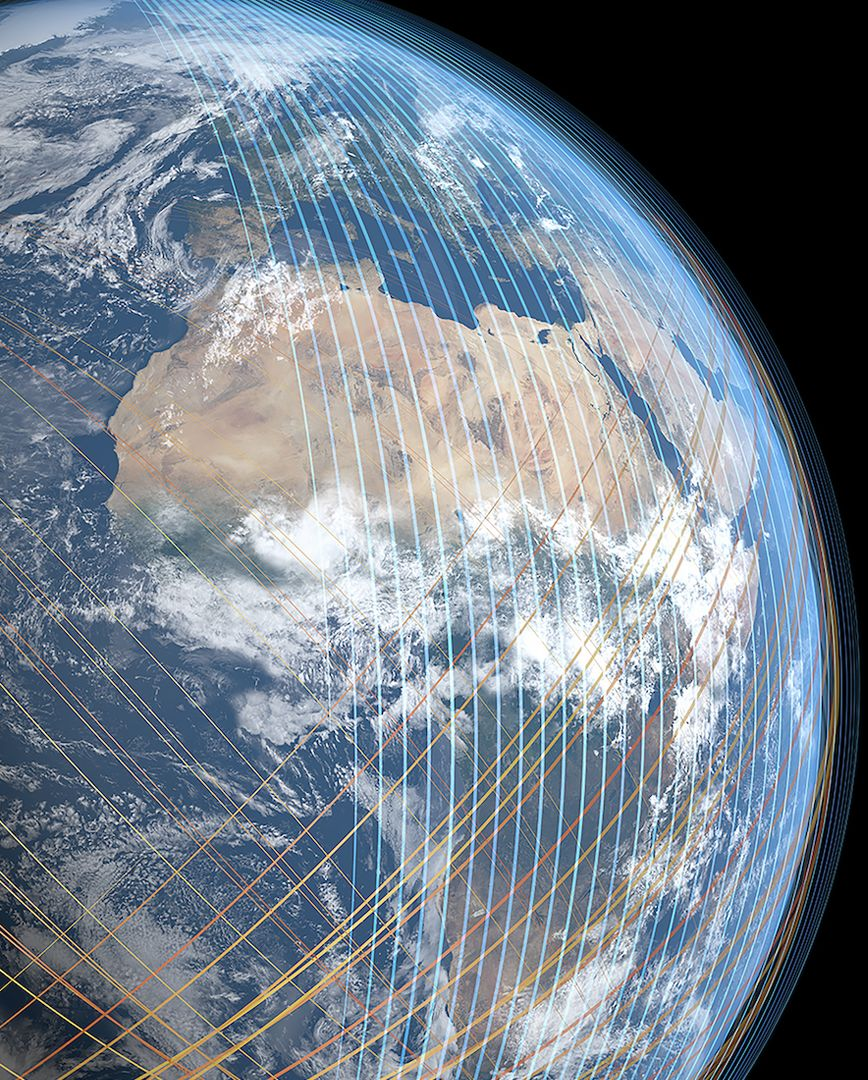


10 x 10 m

Near Real Time

4 years archive

Global



Thank You.

Engage with Planet's Science Programs and apply here for Planet Data via ESA Earthnet
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Nadja Den Besten
Remote sensing scientist
nadja@planet.com

planet.

Maximizing sucrose development through optimizing irrigation with a multi-sensor approach

Nadja Den Besten, Planet

AGRICULTURE -

On irrigation and sugarcane

- The context
- Irrigation and remote sensing: what if there is too much water?
- Stresses crop? Waterlogged or just sucrose accumulating?

Another interesting thing is happening with observing sugarcane

So, we need to consider crop stresses resulting from other stresses

Waterlogging is prohibiting optimal crop yield (even in a drought prone area)

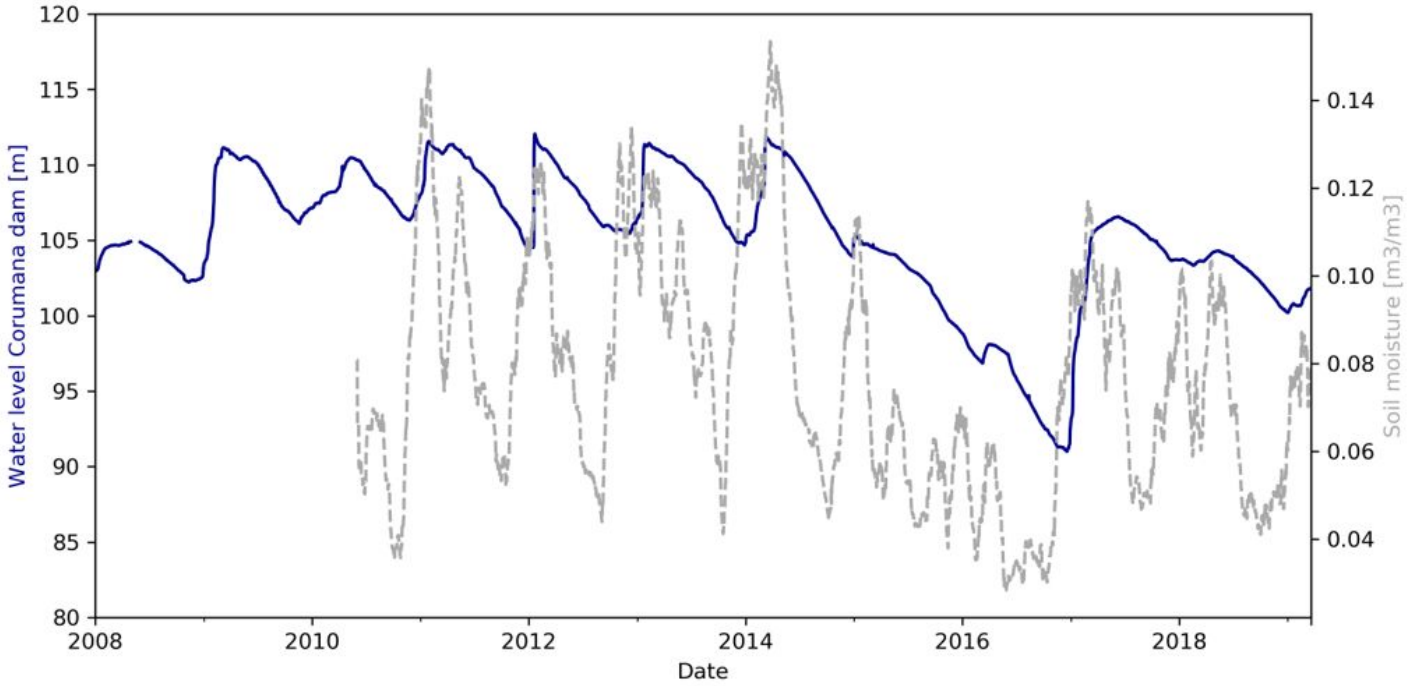
1. Waterlogging is affecting sucrose content

....

*Figure adapted from: den Besten, N.; Steele-Dunne, S.; Aouizerats, B; Zajdband, A.; de Jeu, R.; van der Zaag, P. **Observing sucrose accumulation with Sentinel-1 backscatter.** *Frontiers in remote sensing.* **2021**

Soil moisture (L-band, SMAP) and water availability

On a field-level water shortage was not the issue



Sucrose accumulation seen from space

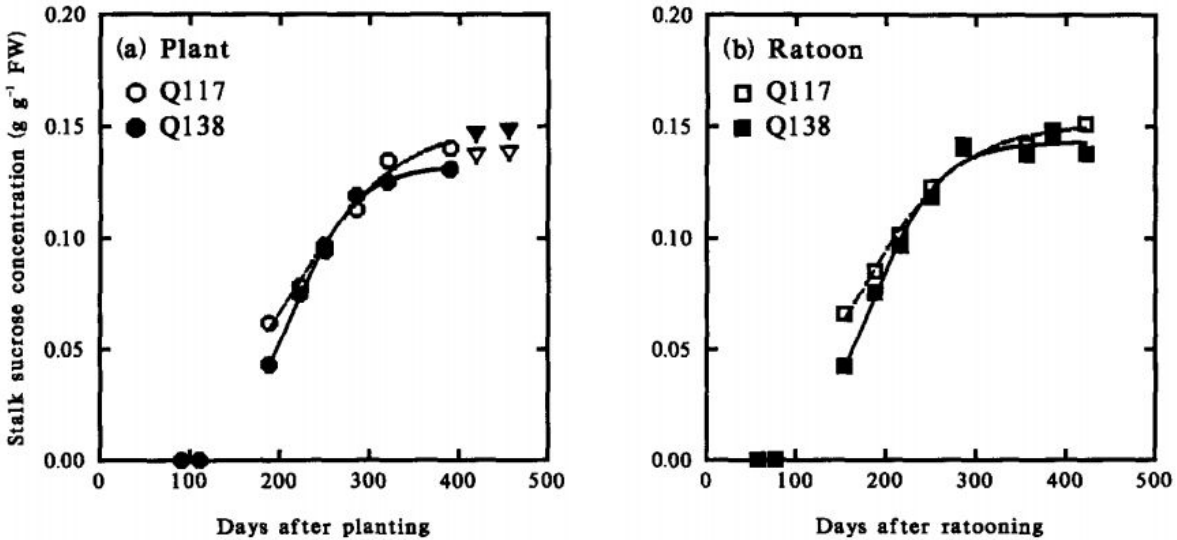


Fig. 5. Stalk sucrose concentration (g g^{-1} FW) with time after (a) planting for the plant crop, and (b) after ratooning for the ratoon crop. The fitted logistic equations were: Plant Q117 $Y = 0.150 \pm 0.009/(1 + \exp(-0.017 \pm 0.004^{*}(X - 213 \pm 9.3)))$, $R^2 = 0.94$. Plant Q138 $Y = 0.132 \pm 0.004/(1 + \exp(-0.028 \pm 0.003^{*}(X - 214 \pm 3.6)))$, $R^2 = 0.98$. Ratoon Q117 $Y = 0.151 \pm 0.003/(1 + \exp(-0.018 \pm 0.002^{*}(X - 172 \pm 3.6)))$, $R^2 = 0.98$. Ratoon Q138 $Y = 0.143 \pm 0.003/(1 + \exp(-0.027 \pm 0.003^{*}(X - 186 \pm 3.7)))$, $R^2 = 0.99$. Points shown as triangles were excluded from the fitted equations.

*Figure adapted from: Muchow, R. C., Robertson, M. J., and Wood, A. W. (1996). Growth of Sugarcane under High Input Conditions in Tropical australia. Ii. Sucrose Accumulation and Commercial Yield. *Field Crops Res.* 48, 27–36. doi:10.1016/0378-4290(96)00042-1

Sucrose accumulation seen from space

Microwave Dielectric Spectrum of Vegetation—Part II: Dual-Dispersion Model

FAWWAZ T. ULABY, FELLOW, IEEE, AND MOHAMED A. EL-RAYES

$$\epsilon_v = \epsilon_r + v_{fw}\epsilon_f + v_b\epsilon_b \qquad (9)$$

with ϵ_f and ϵ_b given by (2) and (8), respectively. At room temperature ($T = 22°C$), ϵ_v is given by

$$\epsilon_v = \epsilon_r + v_{fw}\left[4.9 + \frac{75.0}{1 + jf/18} - j\frac{18\sigma}{f}\right] + v_b\left[2.9 + \frac{55.0}{1 + (jf/0.18)^{0.5}}\right] \qquad (10)$$

To explain the changes in the plant and its effect on dielectric constant of vegetation and thus backscatter...

Sucrose accumulation seen from space

- Ulaby: "*Hence we shall model the dielectric constant of vegetation (Ev) as a simple additive mixture of three components*
  1. *Er a non-dispersive residual component*
  2. *VfEf a free water component, where Vfw is the volume fraction of free water and Ef is its dielectric constant*
  3. *VbEb a bulk vegetation-bound water component, where Vb is the volume fraction of the bulk vegetation-bound water mixture and Eb is its dielectric constant*"

$$\epsilon_v = \epsilon_r + v_{fw}\epsilon_f + v_b\epsilon_b \qquad (9)$$

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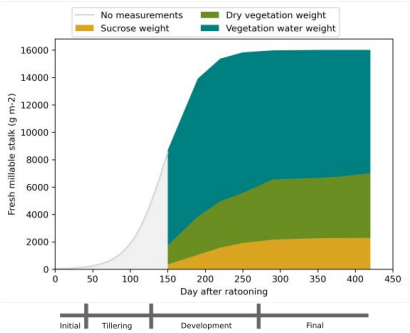
% sucrose increasing over time from ... -->15



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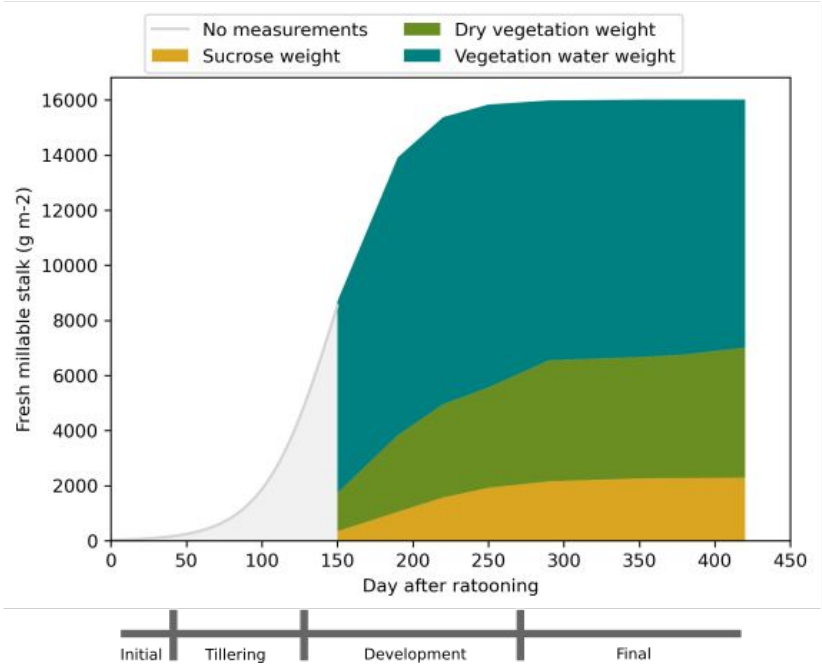

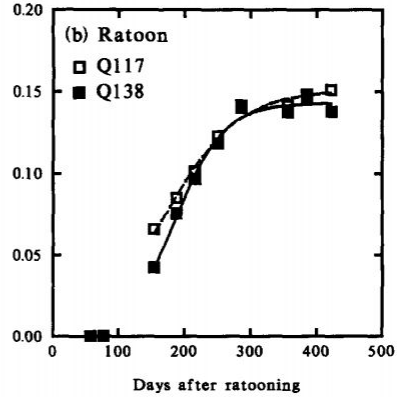

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