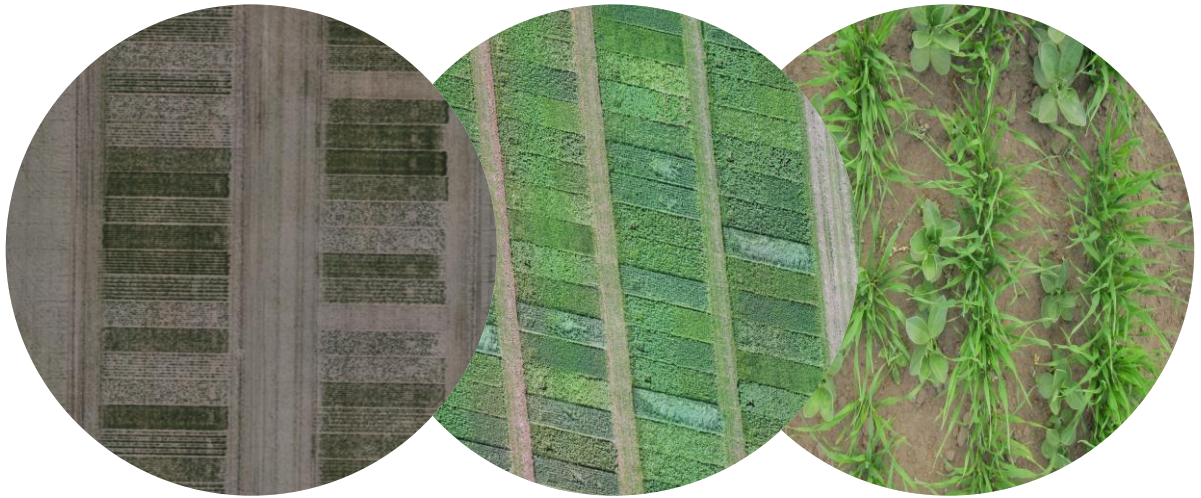
# Quantifying the mechanisms of weed suppression in cereal-legume intercrops

CROPDIVA – Ghent, 06-12-2023

David Kottelenberg, Jochem Evers, Niels Anten, Lammert Bastiaans

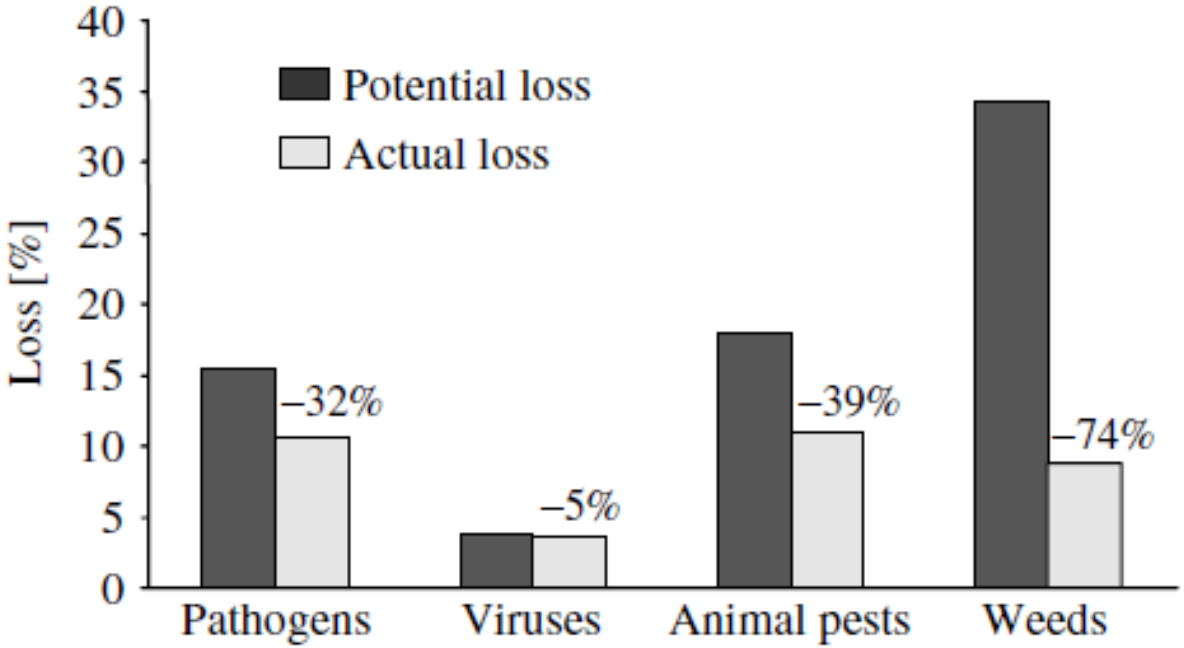




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# The problem of weeds



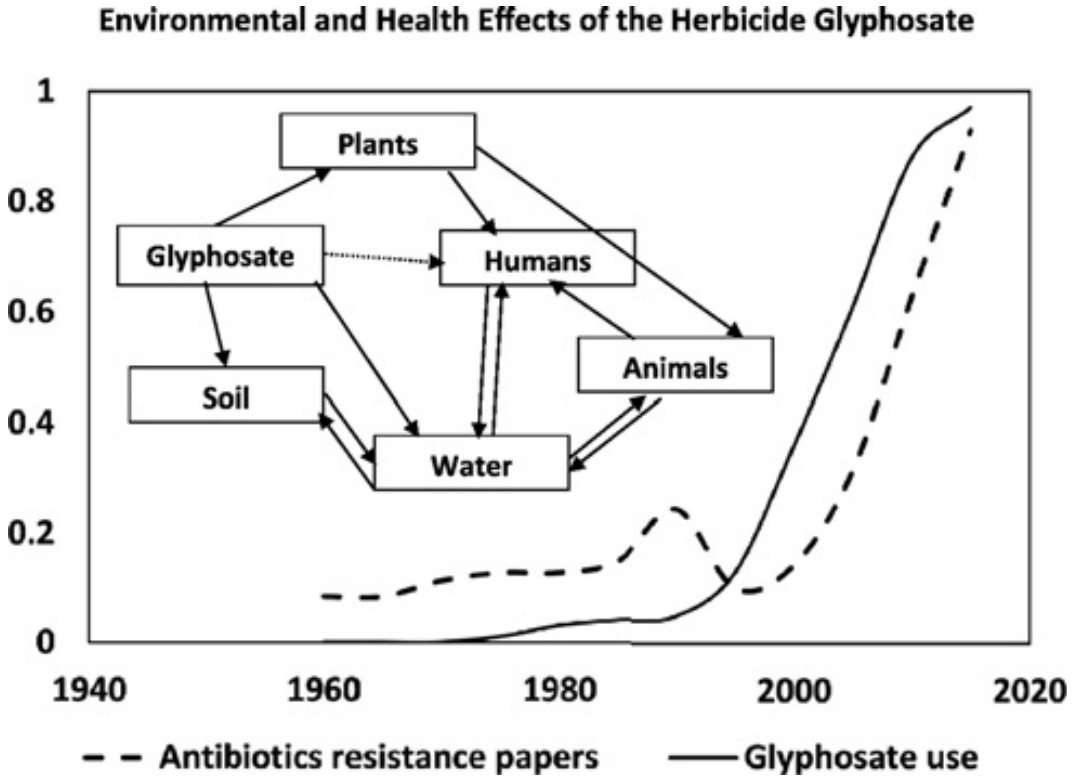



Oerke, 2006

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# The problem of weeds






Van Bruggen et al., 2018





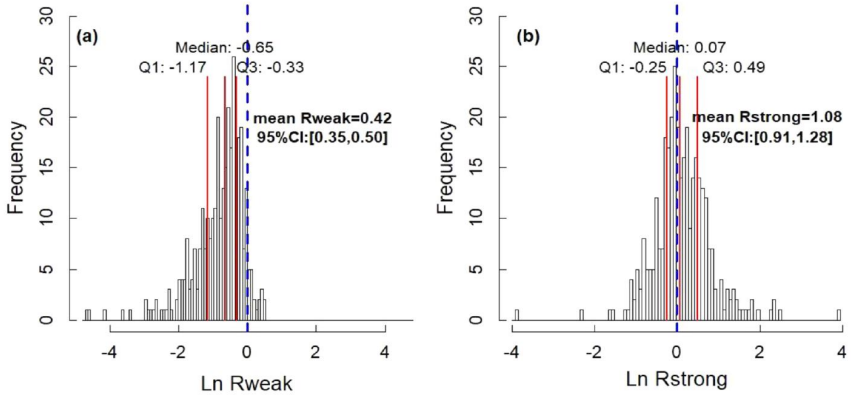






# Crop diversity to combat weeds: Intercropping

- Two or more crops grown simultaneously on the same plot
- Potential benefits over sole cropping
  - Overyielding
  - Increased biodiversity
  - Reduced pests
  - **Reduced weeds**

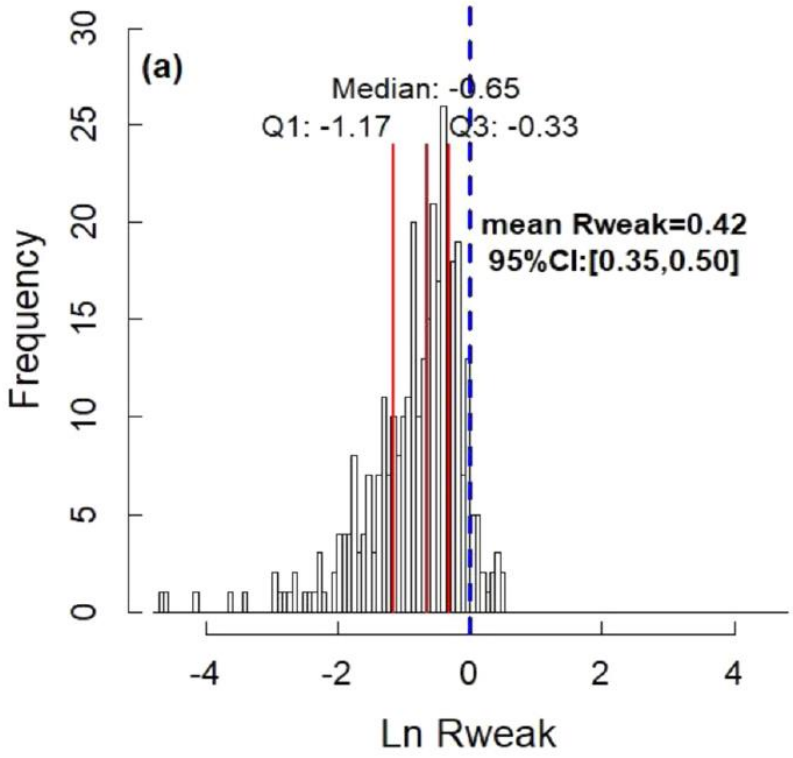


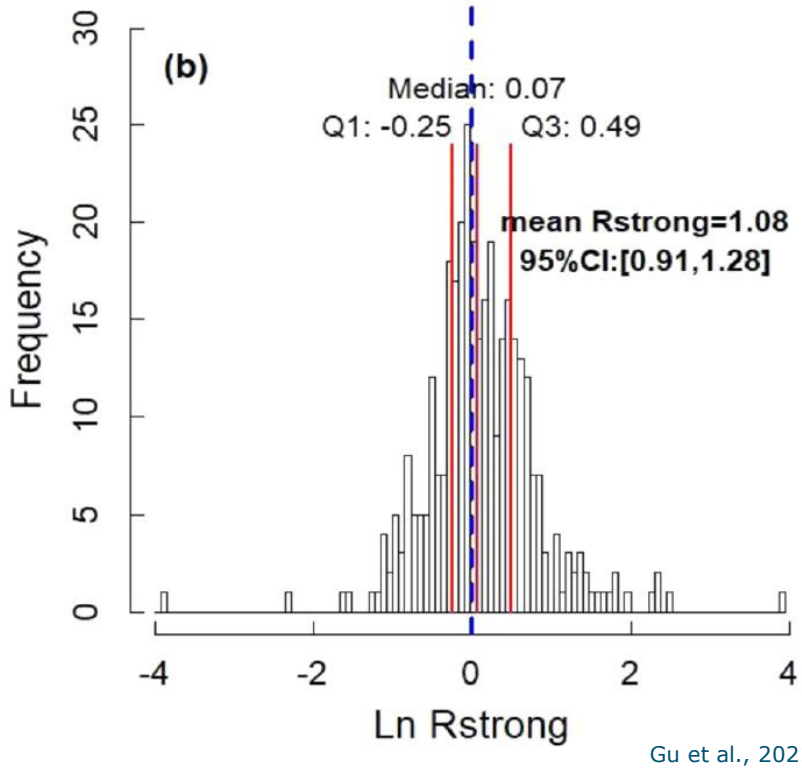

Gu et al., 2021

# Crop diversity to combat weeds: Intercropping

$$R_{weak} = \frac{Y_{w,ic}}{Y_{w,weak}}$$

$$R_{strong} = \frac{Y_{w,ic}}{Y_{w,strong}}$$



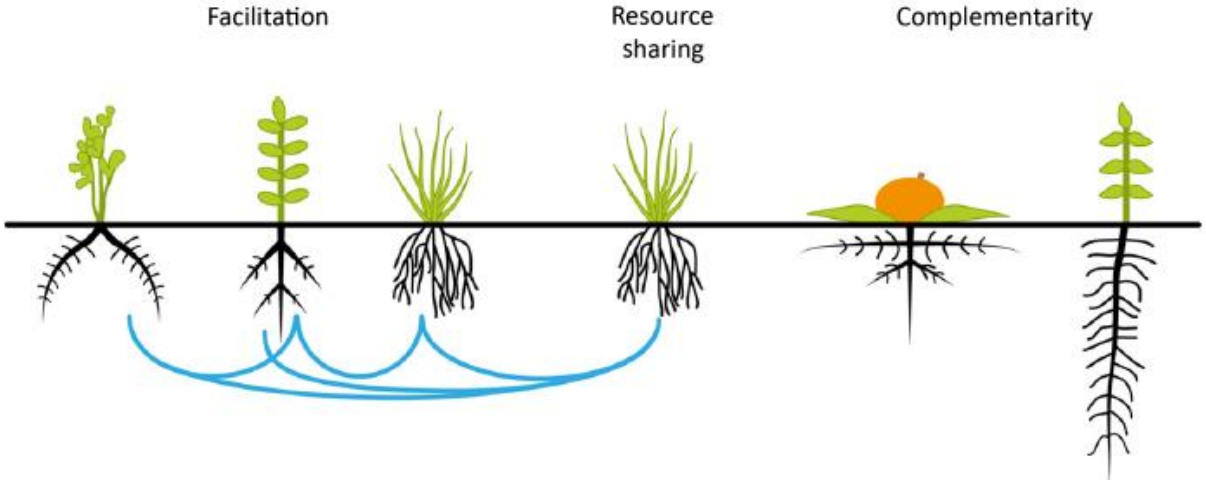






Gu et al., 2021

# Proposed weed suppression mechanisms

- Complementarity: more resources together than apart
- Facilitation: crops supporting each other
- Selection: the more dominant species takes more than its fair share in the intercrop

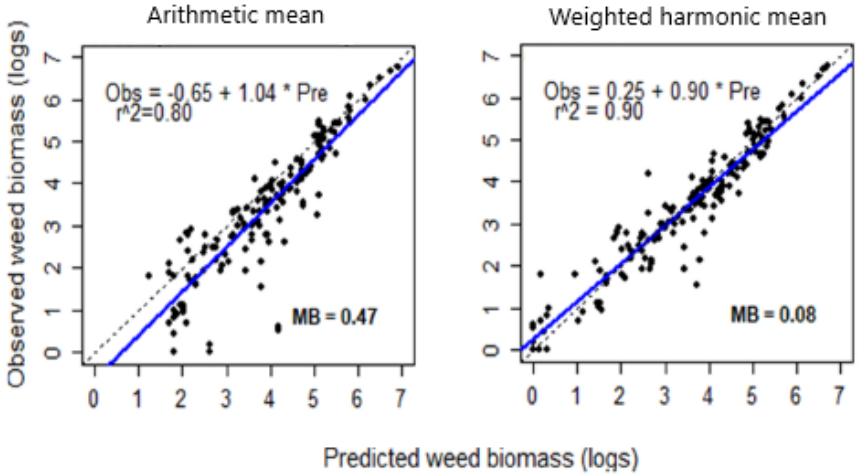



Adapted from Brooker et al., 2015

# Weed suppression in intercrops

- Mainly selection effect
- No systematic overestimation -> No complementarity or facilitation
- **Arithmetic mean**: average weed biomass ($Y_w$) of sole stands ($c_1$, $c_2$)
- **Harmonic mean**: accounts for disproportional contribution of component species (i.e. selection)

$$Y_{w,ic} = \frac{\rho_1 Y_{w,c_1} + \rho_2 Y_{w,c_2}}{\rho_1 + \rho_2} \qquad Y_{w,ic} = \frac{1}{\rho_1 \left(\frac{1}{Y_{w,c_1}}\right) + \rho_2 \left(\frac{1}{Y_{w,c_2}}\right)}$$

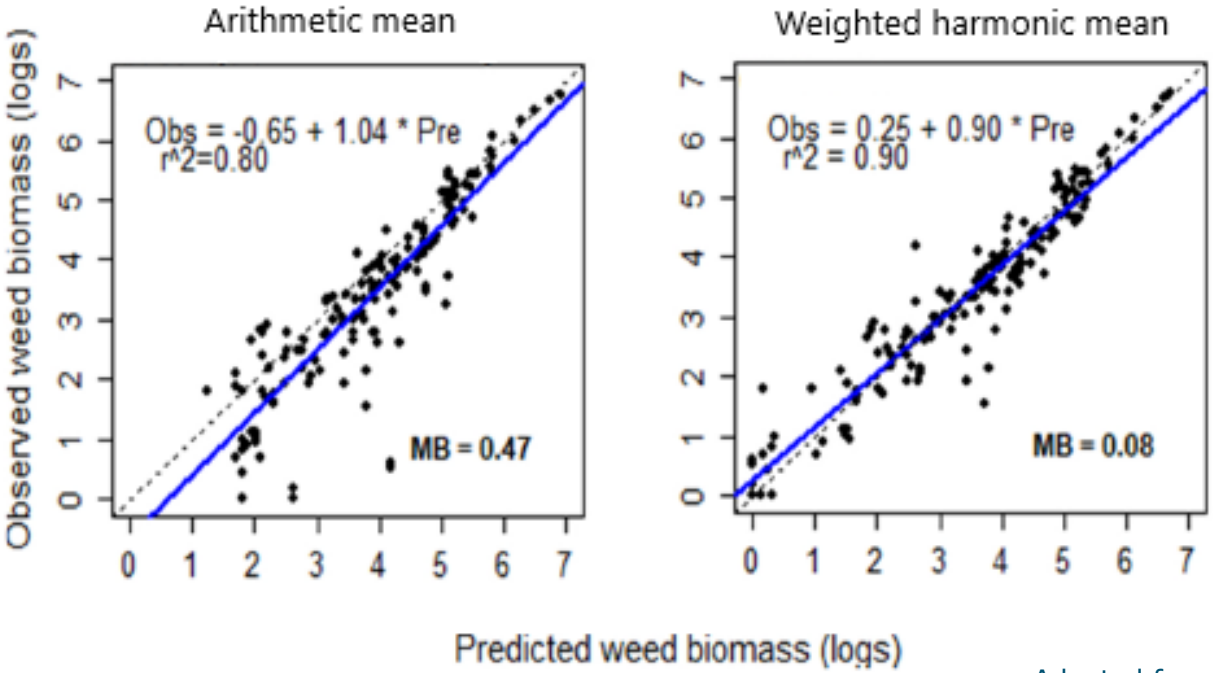



Adapted from Gu et al., 2022

# Weed suppression in intercrops

$$Y_{w,ic} = \frac{\rho_1 Y_{w,c_1} + \rho_2 Y_{w,c_2}}{\rho_1 + \rho_2}$$

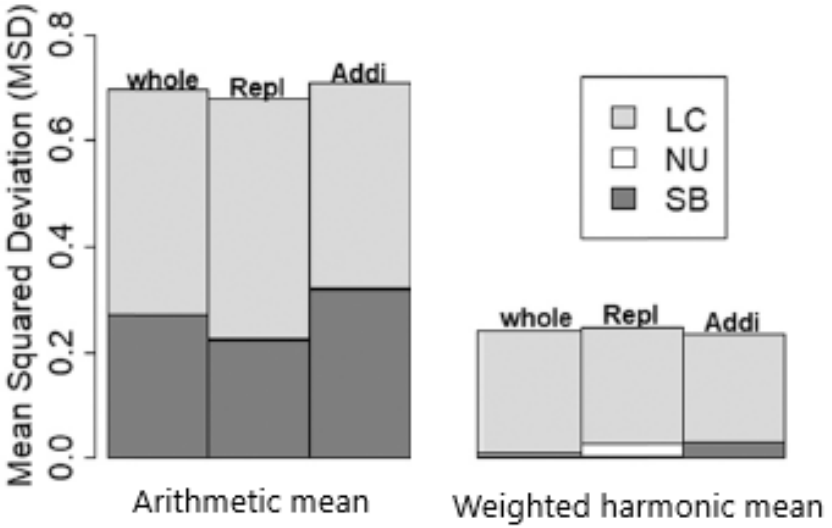
$$Y_{w,ic} = \frac{1}{\rho_1 \left(\frac{1}{Y_{w,c_1}}\right) + \rho_2 \left(\frac{1}{Y_{w,c_2}}\right)}$$




Adapted from Gu et al., 2022

# Weed suppression in intercrops

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Adapted from Gu et al., 2022

# Understanding and optimising weed suppression

- *What are the mechanisms of weed suppression in cereal-legume intercrops?*
    - Investigating species composition and spatial design
- *How are these mechanisms expressed at the crop level?*
    - Canopy cover
    - Light interception









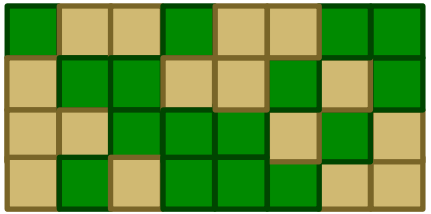
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# Experimental design

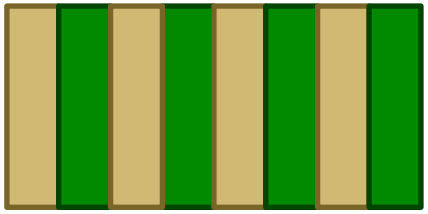
- 2022: Barley, Rye, Triticale, & Wheat with Pea, Lupine, & Faba
- 2023 A: Triticale & Faba, different density and mix designs
- 2023 B: Triticale & Faba, different row distances



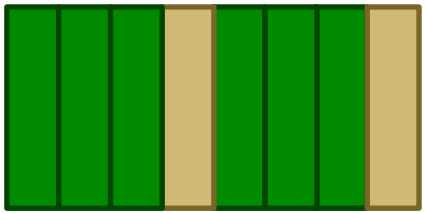
Full mix



1:1 Rows

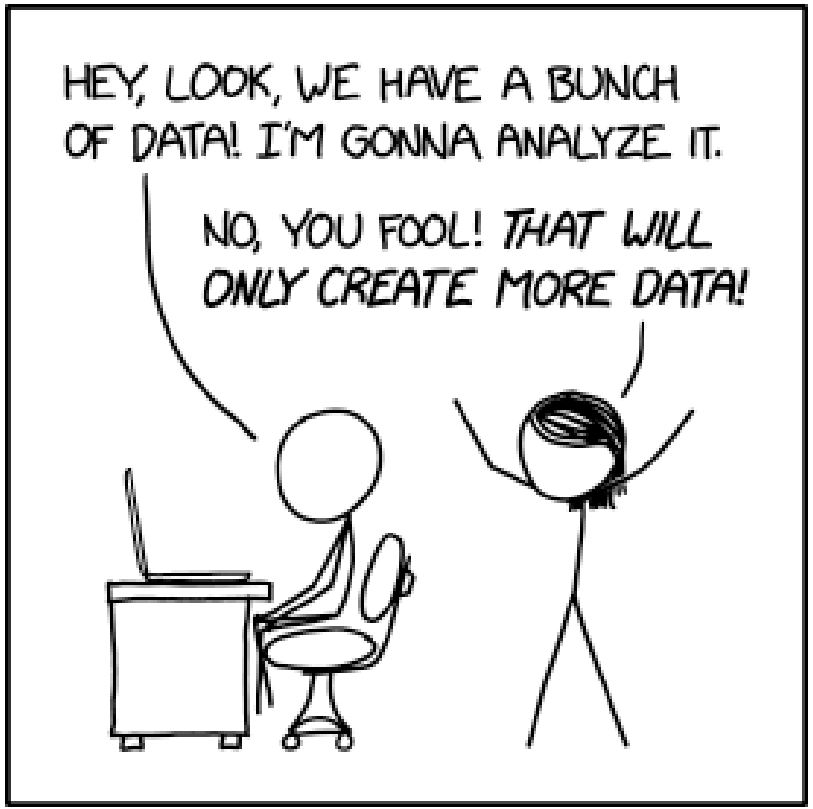


3:1 Strips

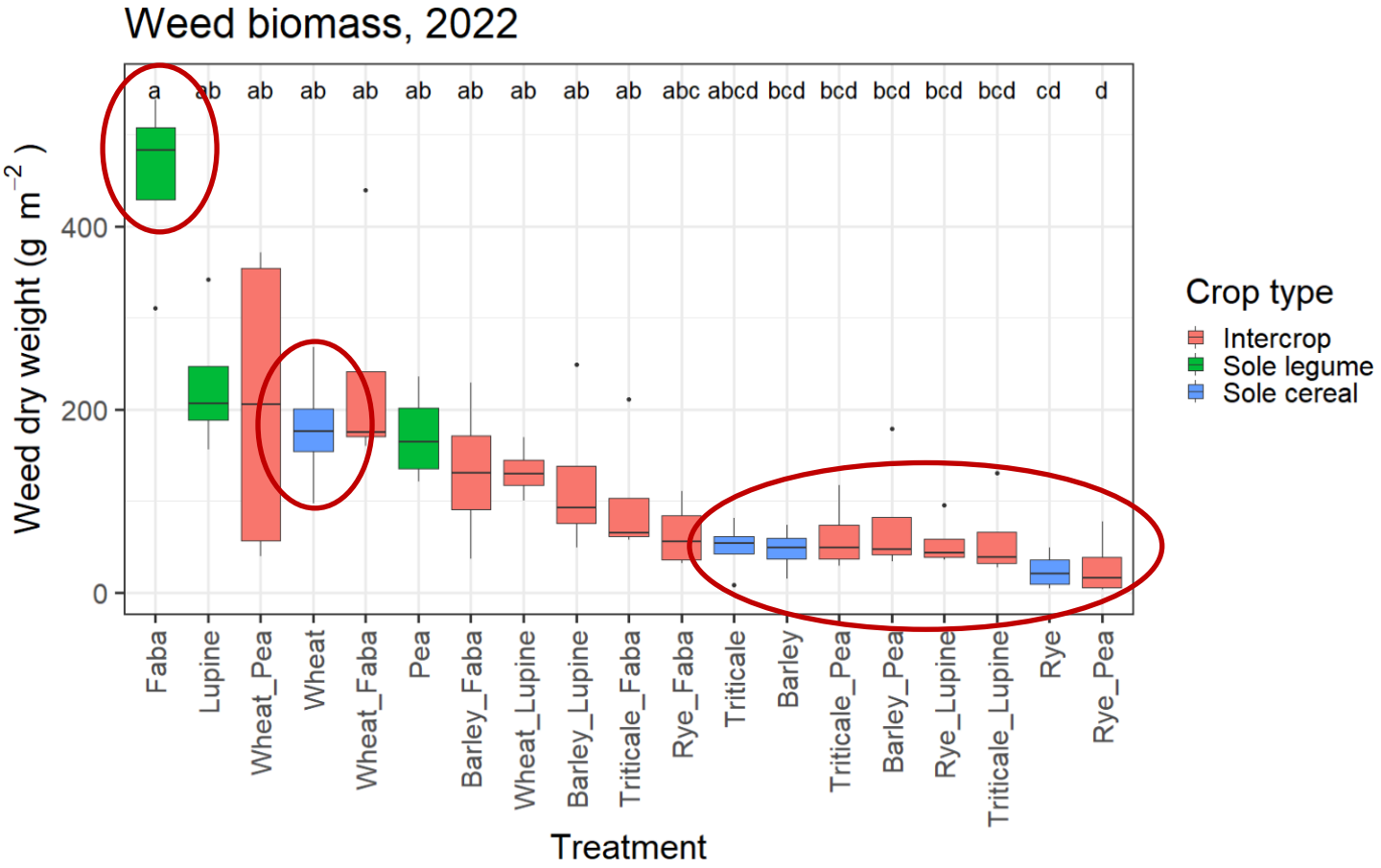


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# Results

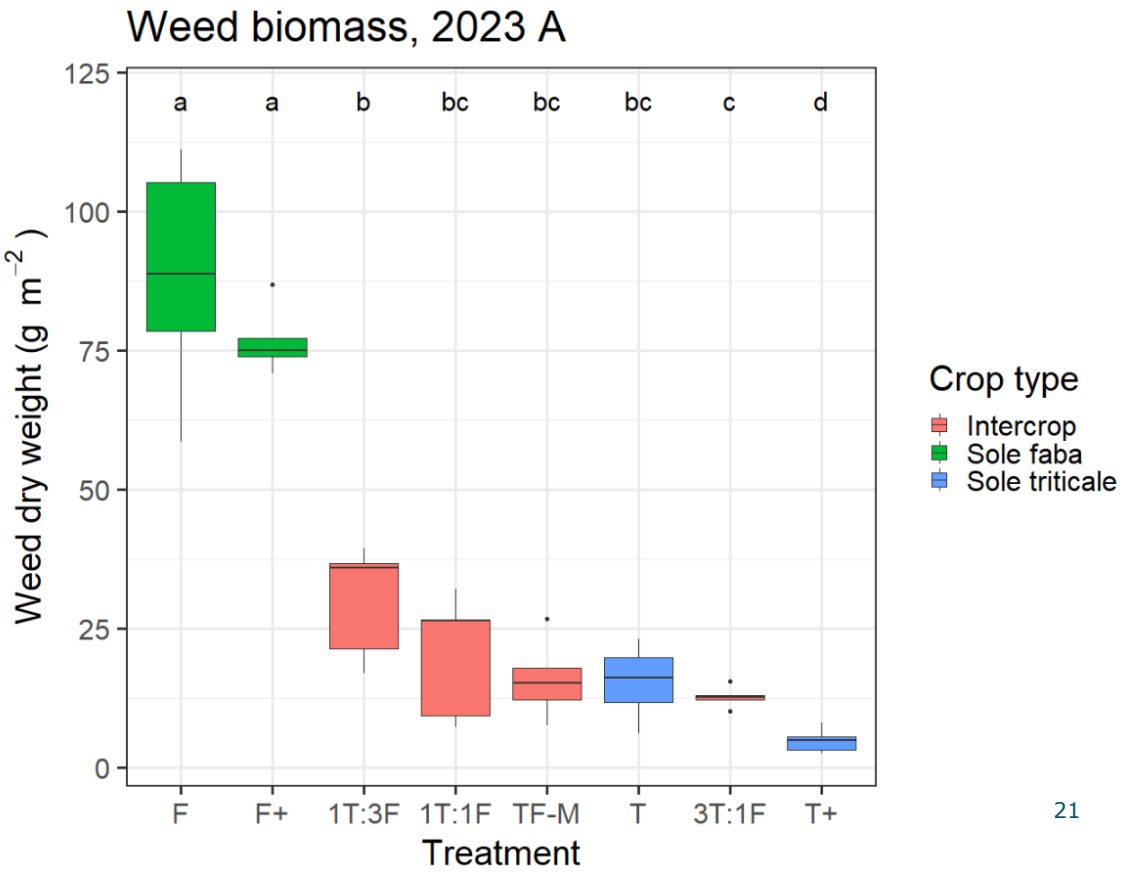

HEY, LOOK, WE HAVE A BUNCH OF DATA! I'M GONNA ANALYZE IT.
NO, YOU FOOL! THAT WILL ONLY CREATE MORE DATA!

# Results weed biomass



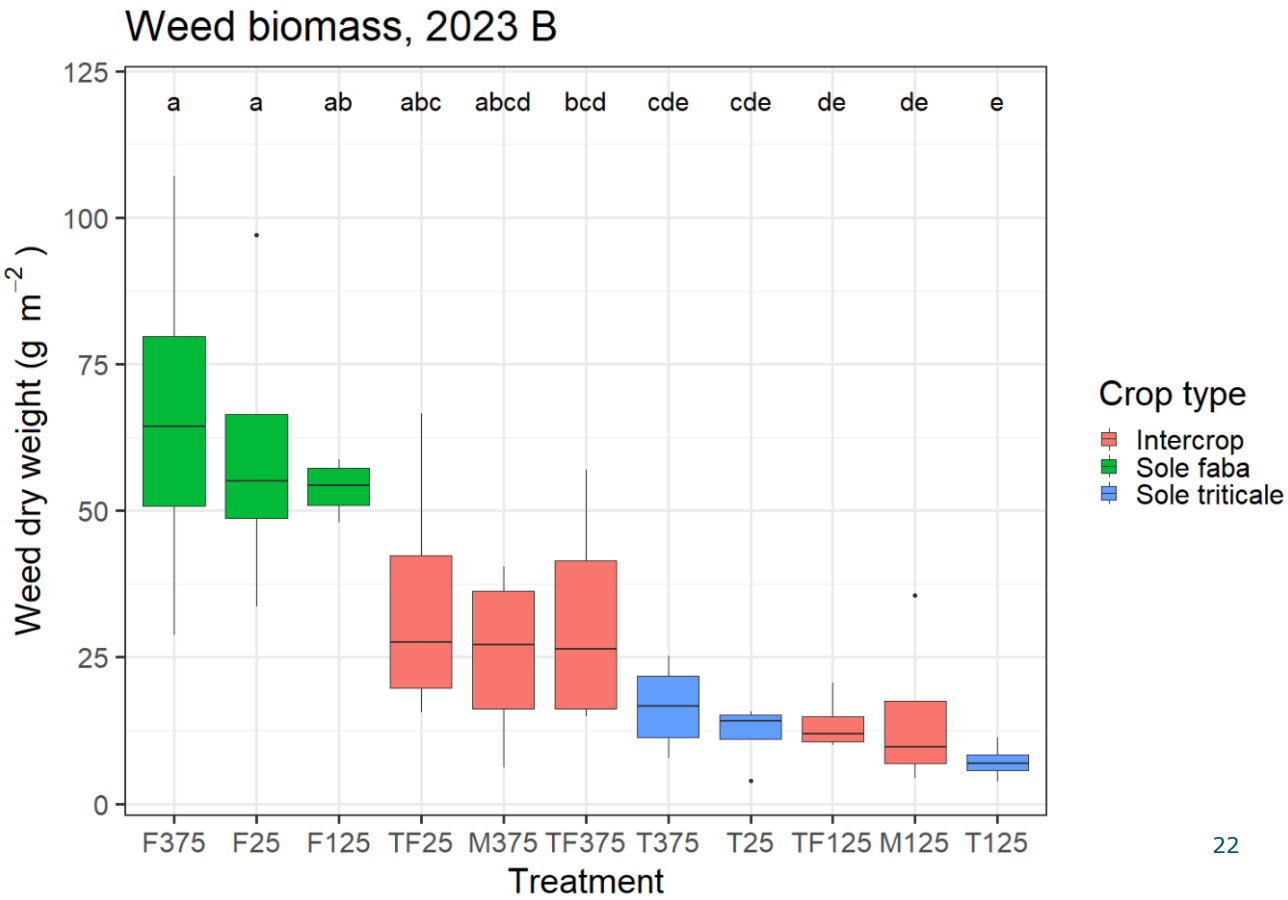
# Results weed biomass

- F: Faba bean
- T: Triticale
- 1T:1F: 1 row T - 1 row F intercrop
- TF-M: mixed intercrop
- +: increased density

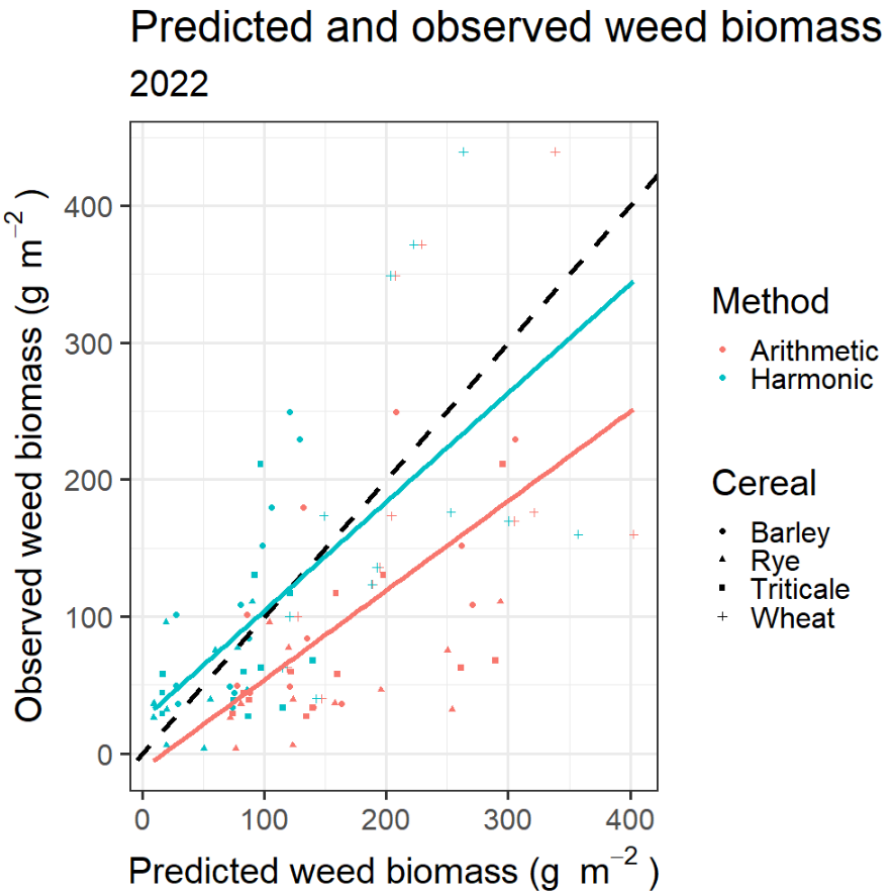


# Results weed biomass

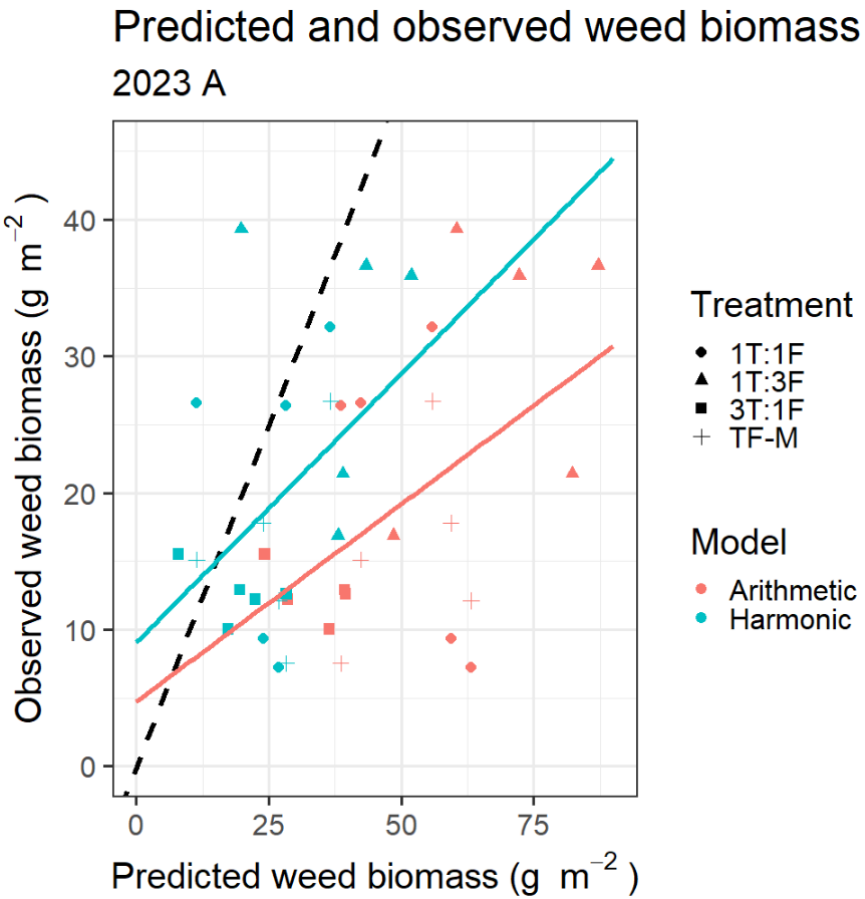
- F: Faba bean
- T: Triticale
- 125: 12.5 cm row distance
- 25: 25 cm row distance
- 375: 37.5 cm row distance



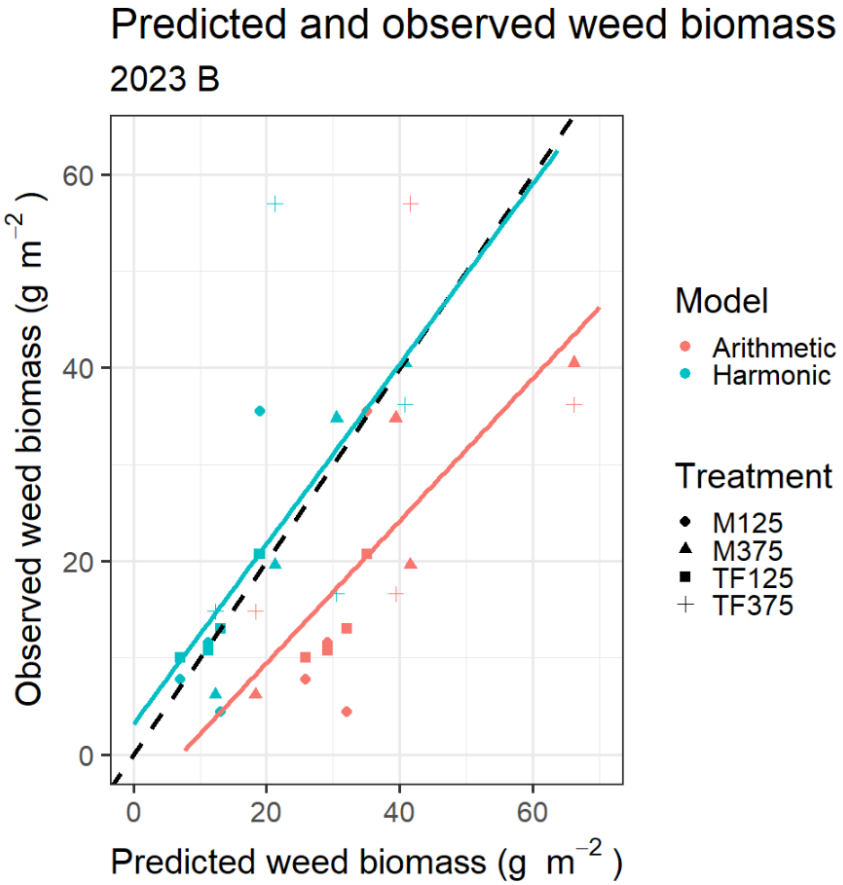
# Results harmonic means



# Results harmonic means

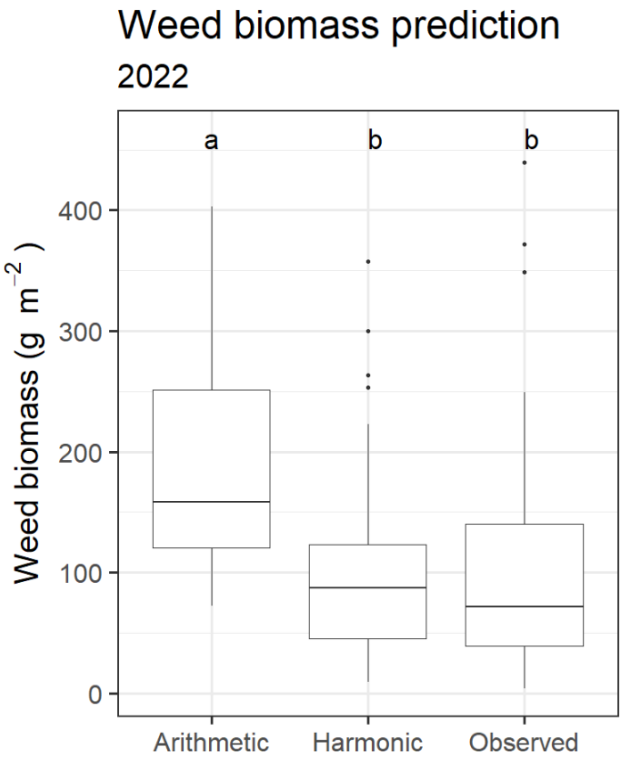


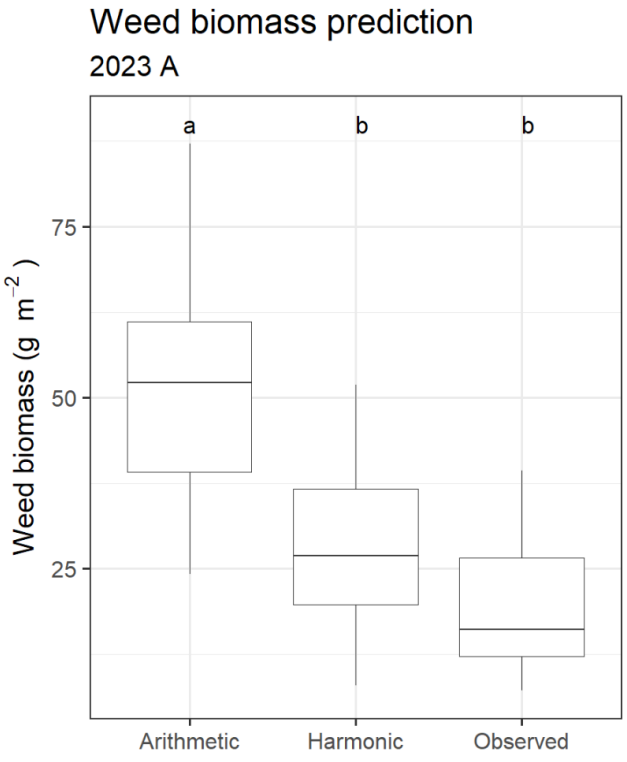
# Results harmonic means

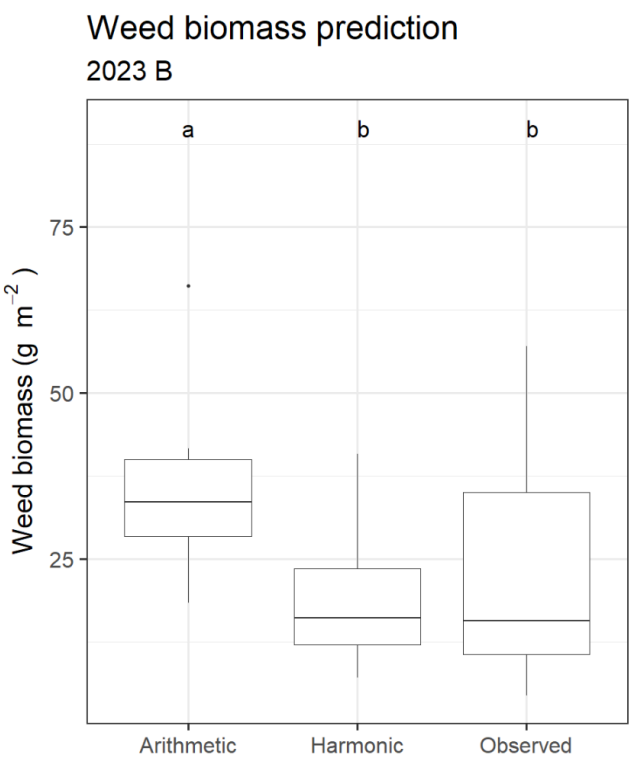



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# Results harmonic means

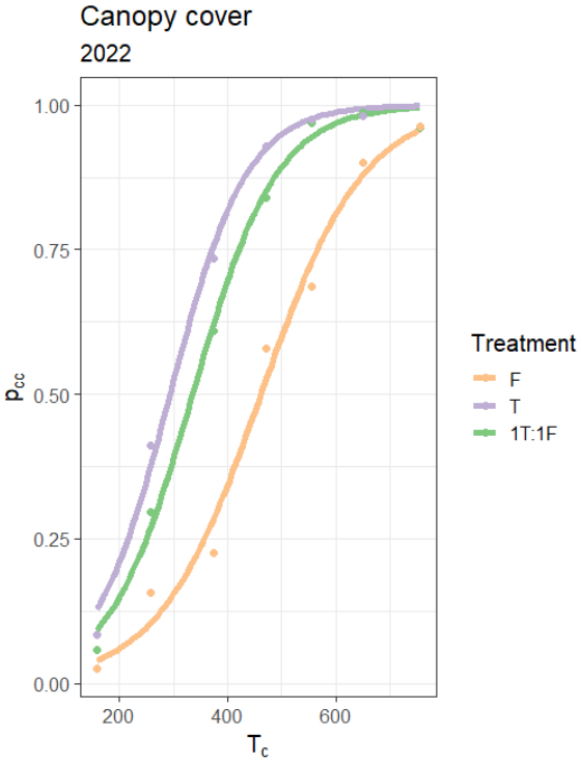


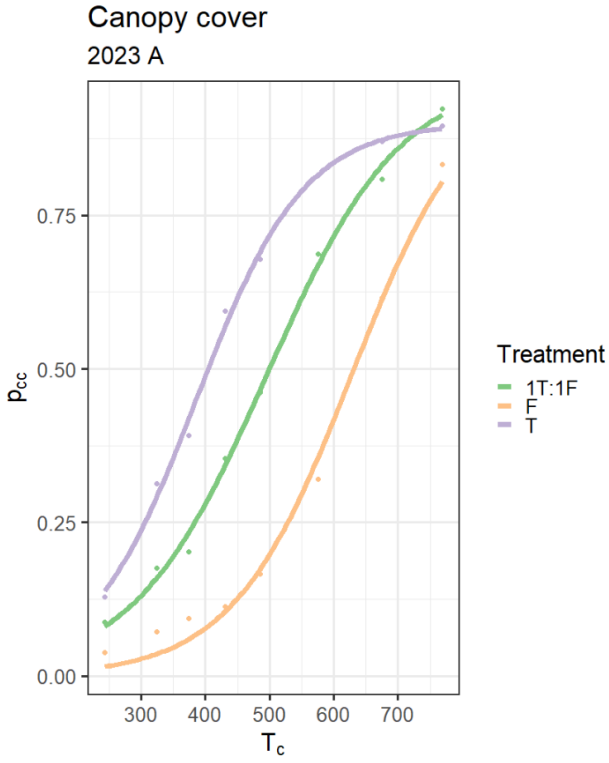



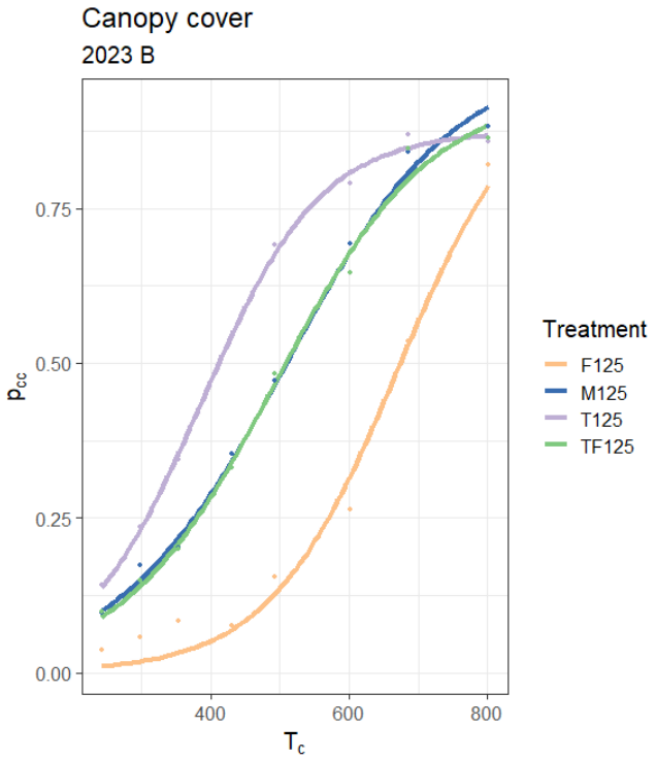




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# Results canopy cover

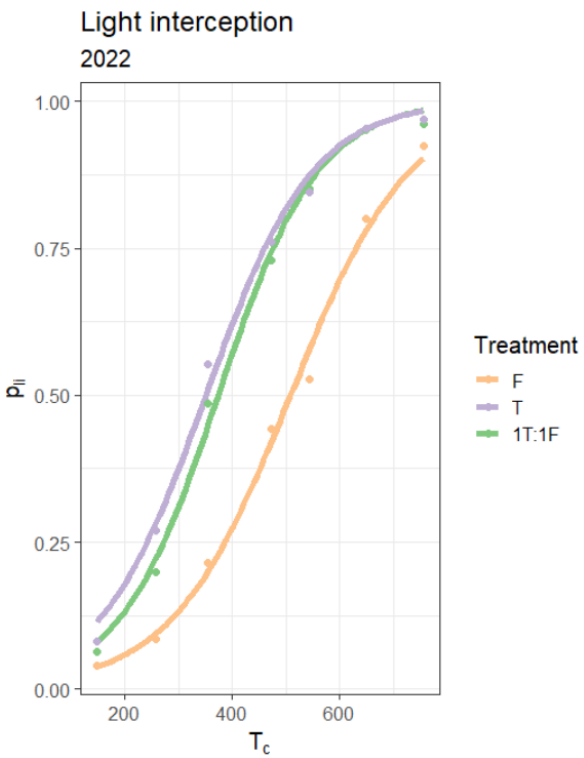


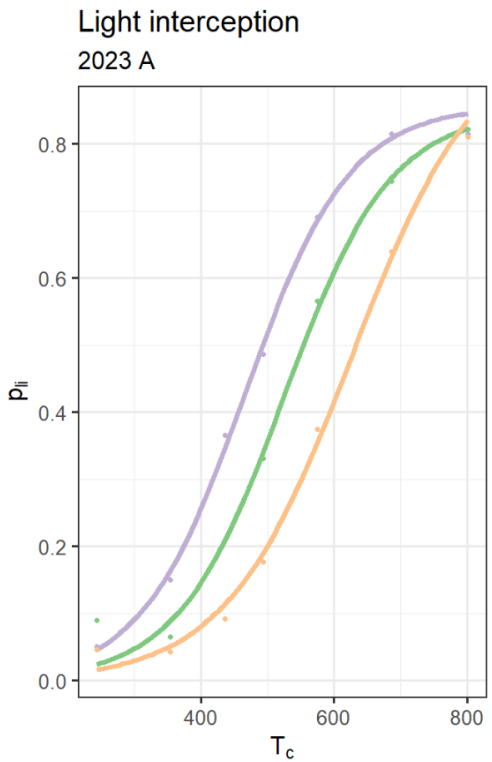



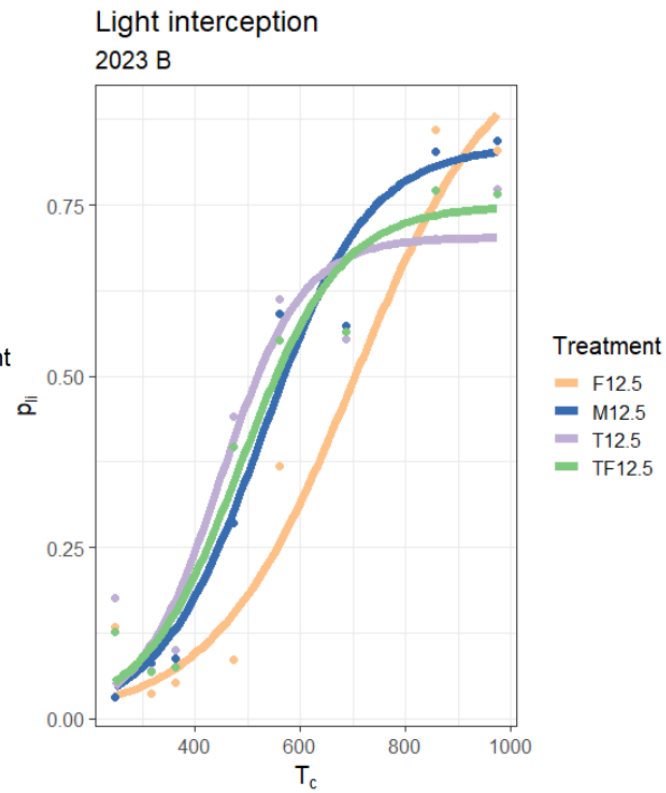




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# Results light interception

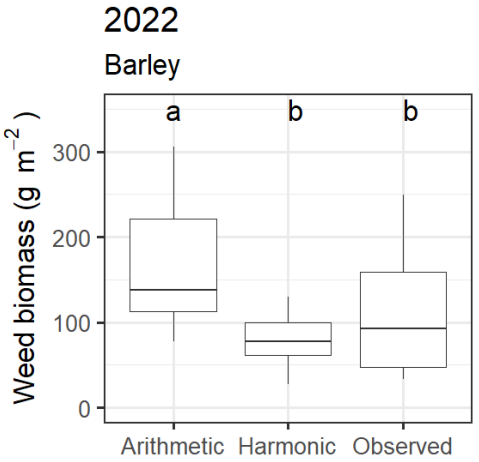


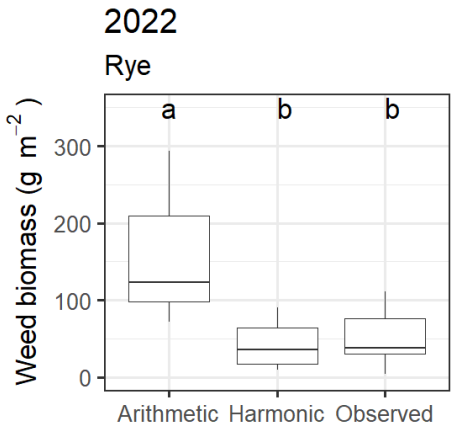



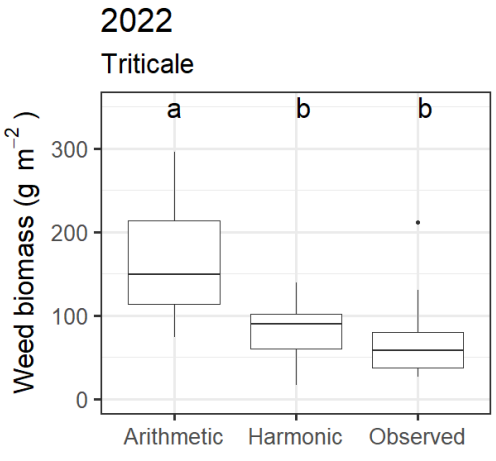



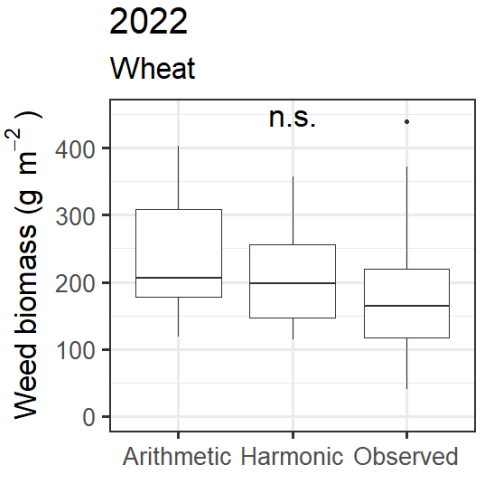

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# Results selection effect



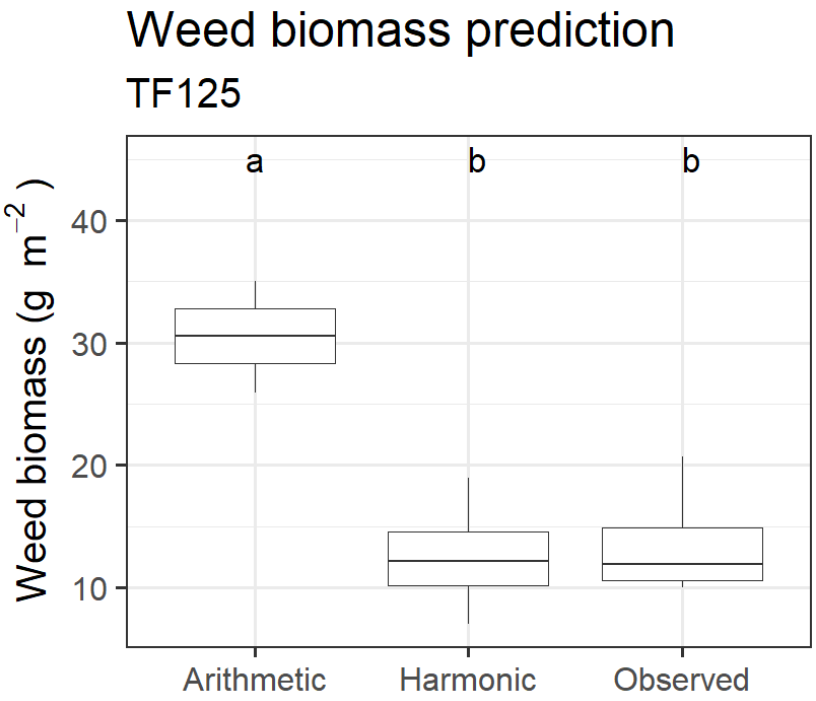



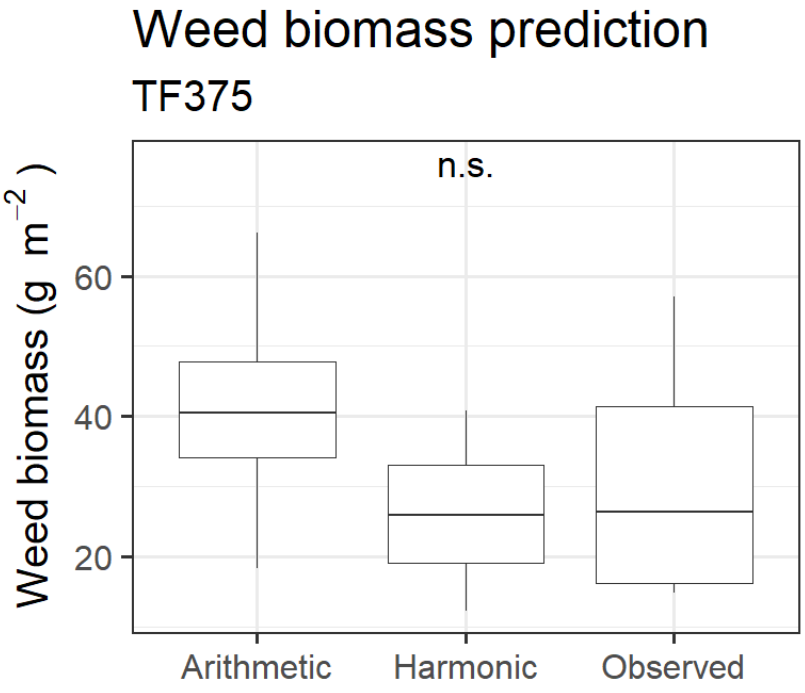




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# Results selection effect



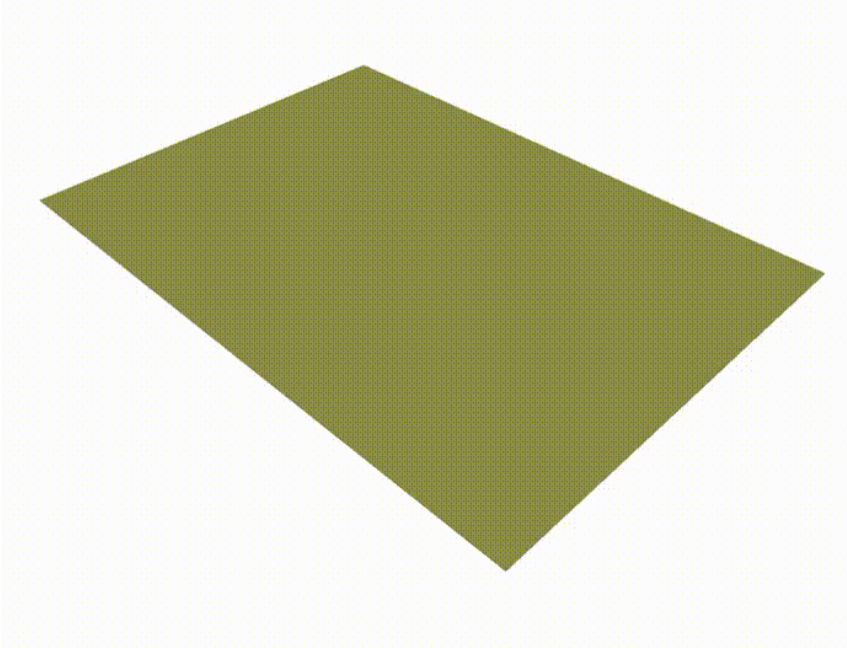
# Conclusions

- Cereal-legume intercrop systems have the potential of enhanced weed suppression
- The selection-effect is the main mechanism of enhanced weed suppression
- The selection-effect is expressed in canopy cover and light-interception
- The selection effect disappears with large row distance and equal competitiveness



# Future perspectives

- Plant trait analyses
- Crop modelling
- Identifying and quantifying plant trait plasticity
    - Breeding target selection
- Below-ground plasticity
- Long-term weed population dynamics
    - Weed-seed bank models



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# Questions, comments, discussion points?

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david.kottelenberg@wur.nl

