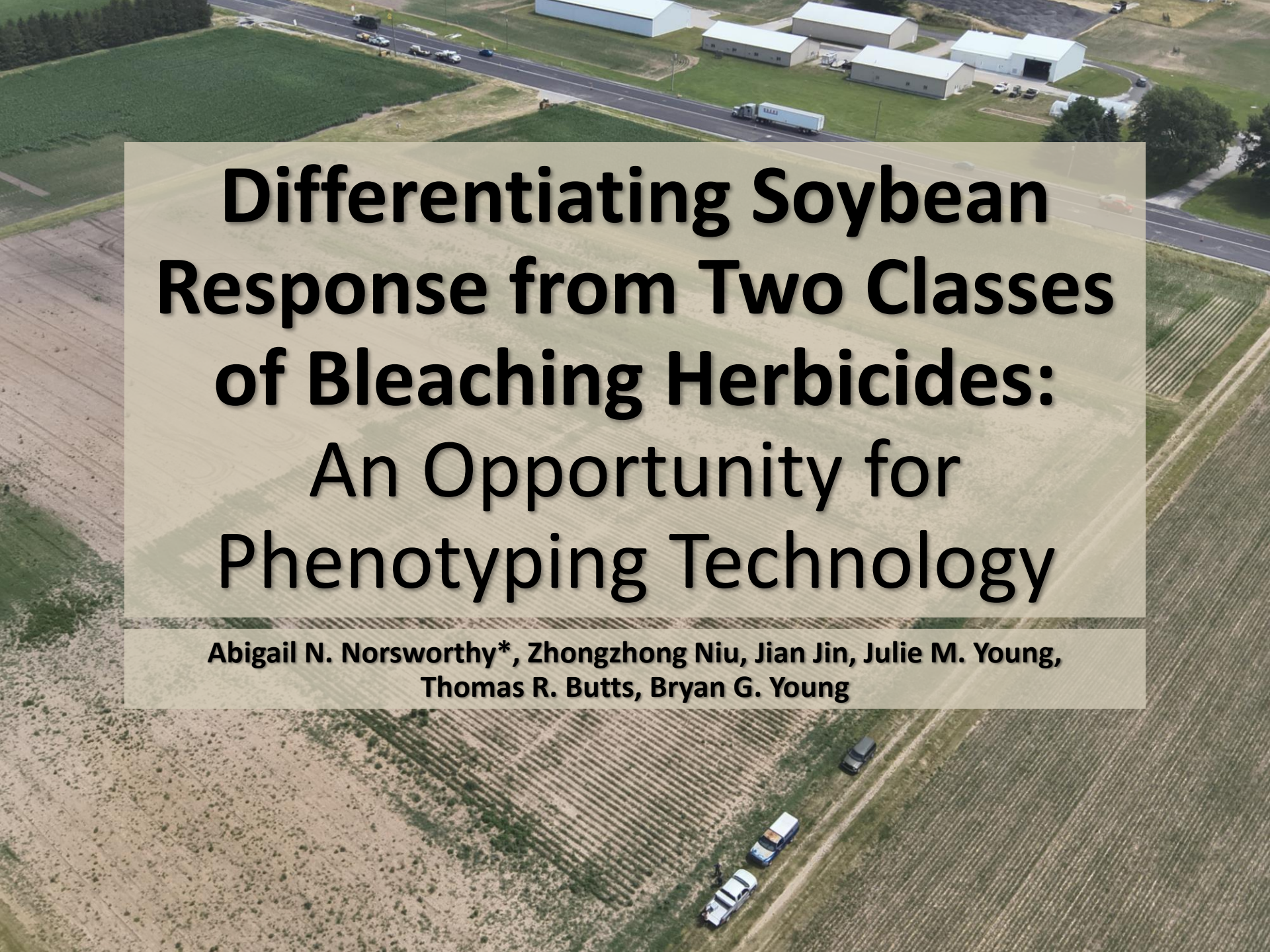

Differentiating Soybean Response from Two Classes of Bleaching Herbicides: An Opportunity for Phenotyping Technology

Abigail N. Norsworthy*, Zhongzhong Niu, Jian Jin, Julie M. Young, Thomas R. Butts, Bryan G. Young

Diflufenican (DFF)

- First HRAC Group 12 herbicide to be available in the US for soybean production
  - Inhibits phytoene desaturase
  - Targets *Amaranthus* species
- Injury to soybean ranged from 3% to 42% when heavy rainfall occurred within 3 days after emergence[1]

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[1] Laplante 2022

Mesotrione Carryover

- Late season applications of mesotrione in corn may occasionally result in carryover to soybean[1]
  - Stunted growth
  - Bleaching, necrosis
  - Reduced grain yield

- Characteristics that increase persistence in the soil[2,3]
  - High organic matter
  - Drought conditions
  - Cool temperature
  - Low soil pH levels

Image adapted from Hartzler 2020[1]

[1] Hartzler 2020
[2] Clay 1993
[3] Helling 2005

Research Justification

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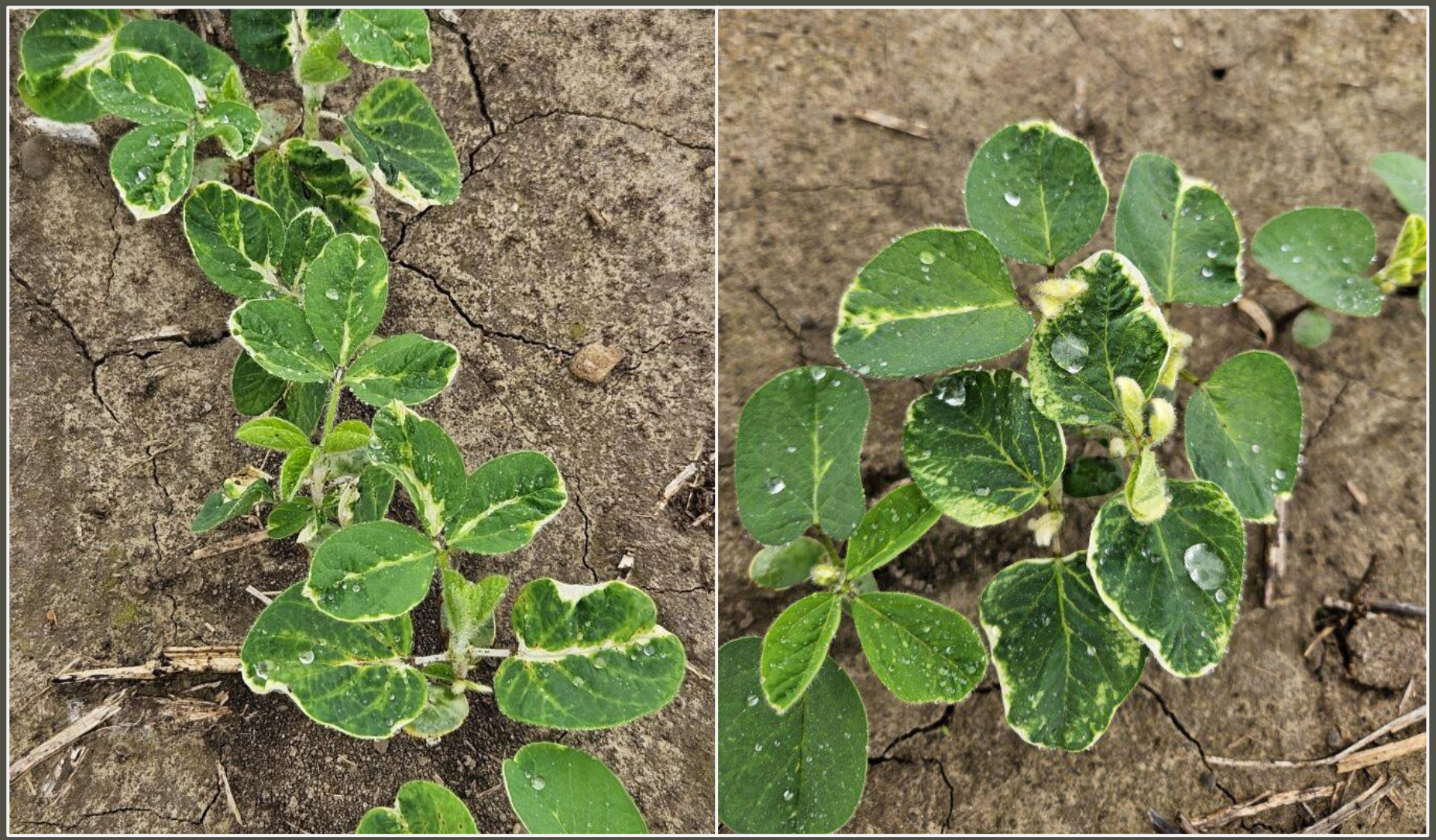
Research Justification



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Imaging in Herbicide Research

- Hyperspectral imaging can predict the ability of corn to recover from varying levels of glyphosate injury with high accuracy[1]
- High throughput imaging using a UAV sensor is more precise in evaluating the severity of crop injury from herbicide stress than visual evaluation[2]
- UAV hyperspectral imaging faces challenges including[3]
  - Spatial resolution irregularities
  - Rough leaf surfaces
  - Shadows
  - Dead pixels

[1] Zhang 2021
[2] Duddu 2019
[3] Yin 2024

LeafSpec Imager

- Handheld, high resolution hyperspectral imager
- LeafSpec can accurately distinguish between damage caused by off-target 2,4-D and dicamba injury on soybean[1]

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[1] Niu et al 2023

Hypothesis & Objectives

Null Hypothesis

The LeafSpec imager will not be able to distinguish soybean injury from herbicides causing similar bleaching symptomology.

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1. Characterize soybean response to simulated mesotrione carryover, diflufenican preemergence applications, and their interaction

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1. Characterize soybean response to simulated mesotrione carryover, diflufenican preemergence applications, and their interaction
2. Evaluate the capability of hyperspectral technology to identify and differentiate herbicide injury from preemergence applications of diflufenican and carryover rates of mesotrione

Materials & Methods

- Field trials conducted near Lafayette, IN
- Planted May 15th and repeated June 24th
- Two-factor RCBD design, 4 replicates
- Rates
  - Diflufenican: 0, 150, 300 g ai ha^{-1}
  - Mesotrione: 0, 26 g ai ha^{-1}
- Soybean
  - AG29XF4
  - 345,000 seeds ha^{-1}
  - 76 cm rows

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Data Collection

Visible injury rating (0-100%)

- 14, 21, 28, and 35 days after application (DAA)
- Overall injury
- Chlorosis
- Stunting

LeafSpec Images

- 26 DAA
- 15 scans/treatment
- All scans collected from the first trifoliate
- 1.5 cm^2 leaflet

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Analysis

Visual Injury

- ANOVA was conducted using RStudio®
- Means separation α=0.05 (Tukey's HSD test)
- Colby's Method:[1] E = (X*Y)/100

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[1] Colby 1967

Analysis

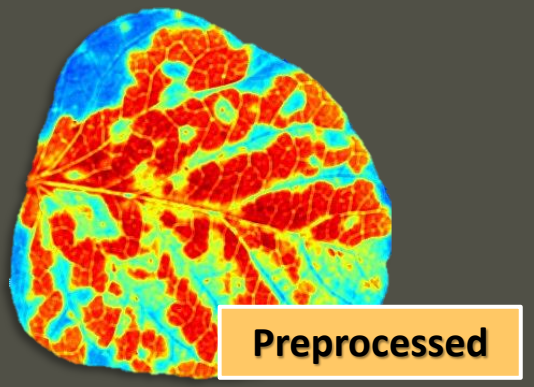
All data processing was performed using MATLAB®

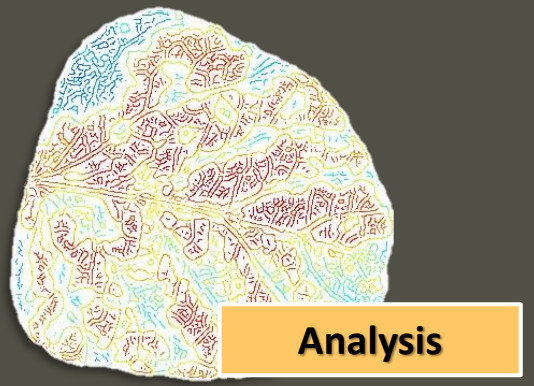
Preprocessing

- White reference calibration
- Image segmentation

Spectroscopic Data Prediction

- Partial least squared discriminant analysis





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Results

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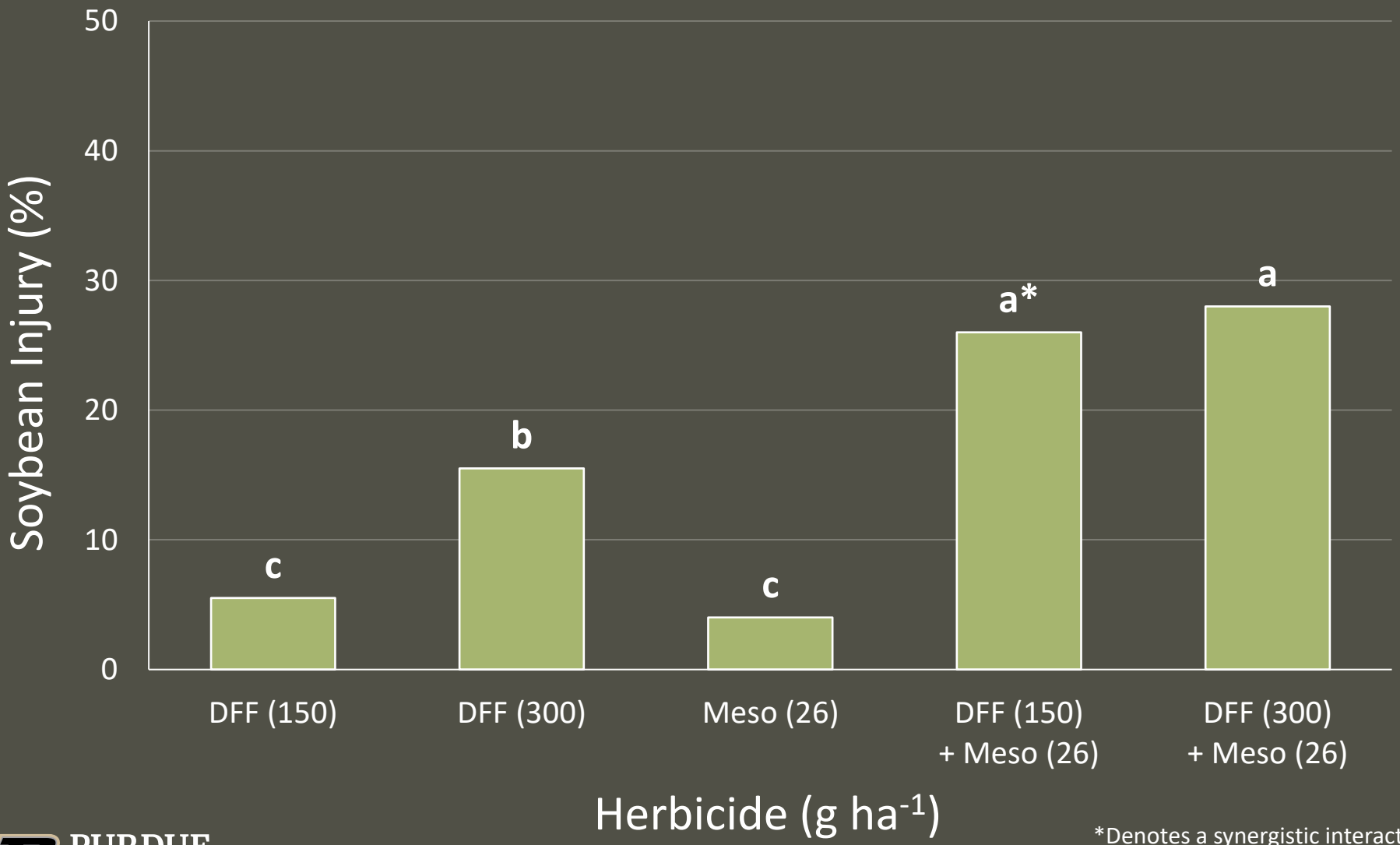
Soybean Injury 21 DAA



*Denotes a synergistic interaction
Data pooled over runs

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Soybean Injury 21 DAA

Nontreated

150 g ha^{-1} DFF

300 g ha^{-1} DFF

26 g ha^{-1} Meso

150 g ha^{-1} DFF
+ 26 g ha^{-1} Meso

300 g ha^{-1} DFF
+ 26 g ha^{-1} Meso

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Soybean Injury 21 DAA

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150 g ha^{-1} DFF

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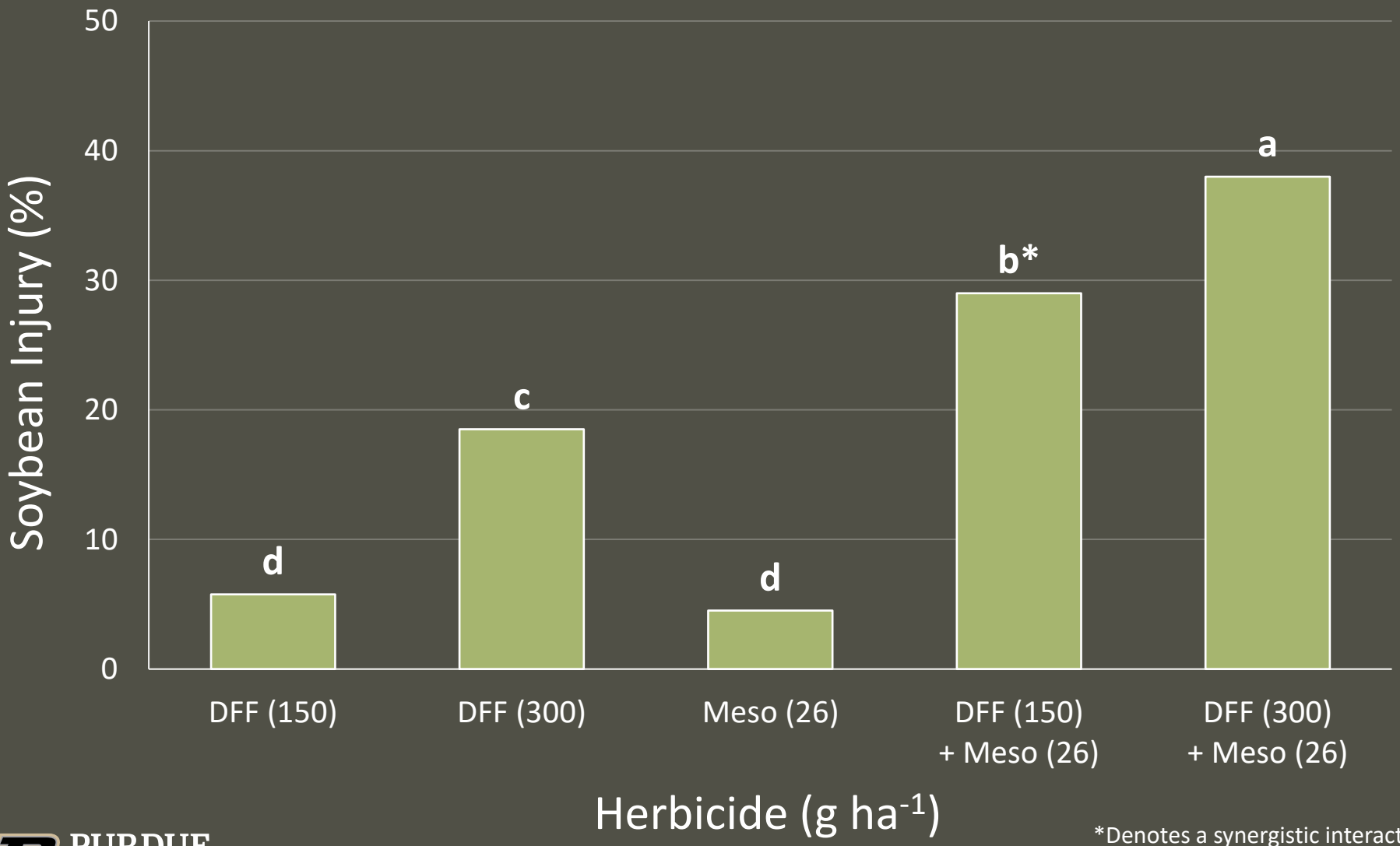
Soybean Injury 28 DAA



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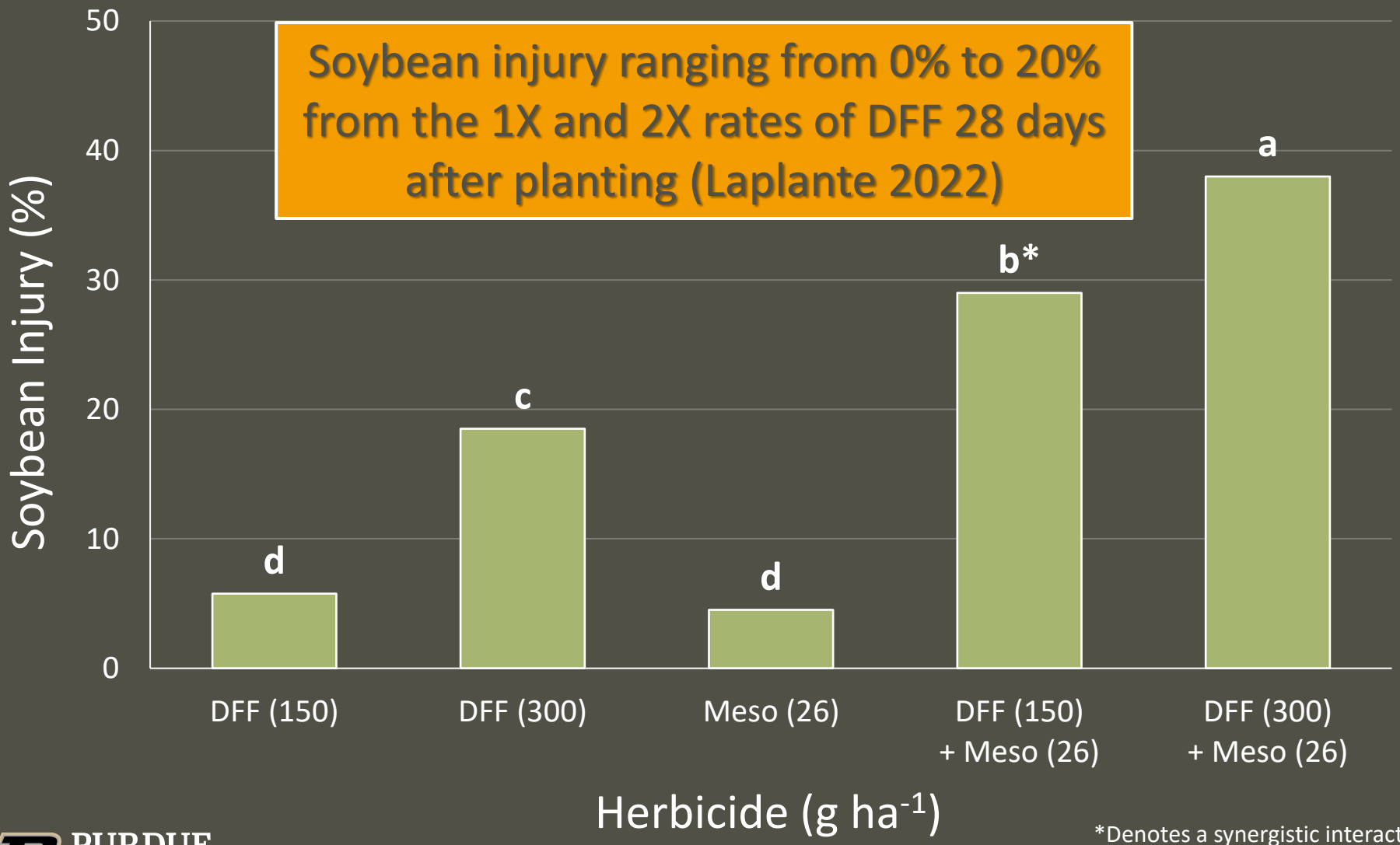
Soybean Injury 28 DAA



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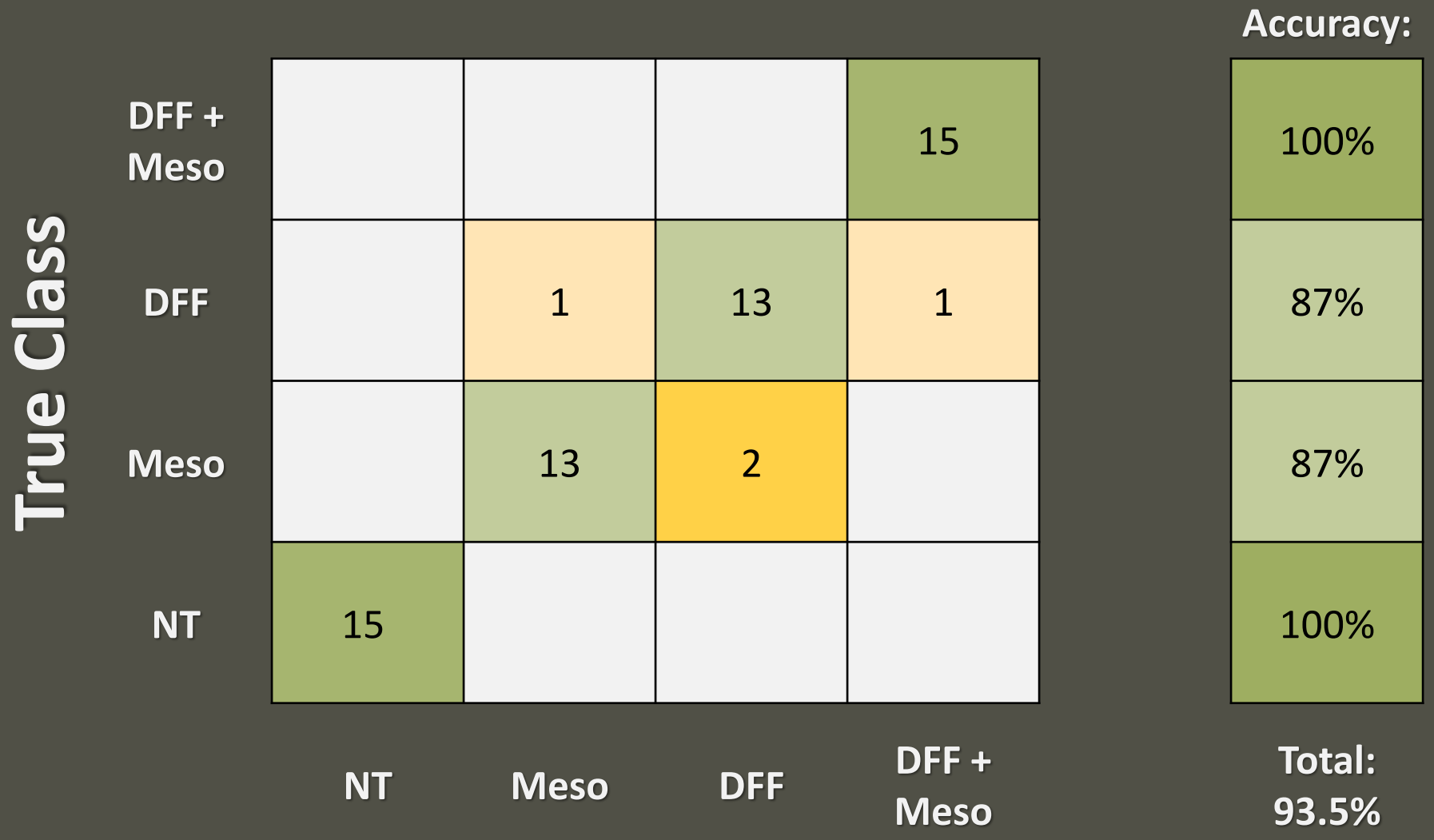
Injury Confusion Matrix



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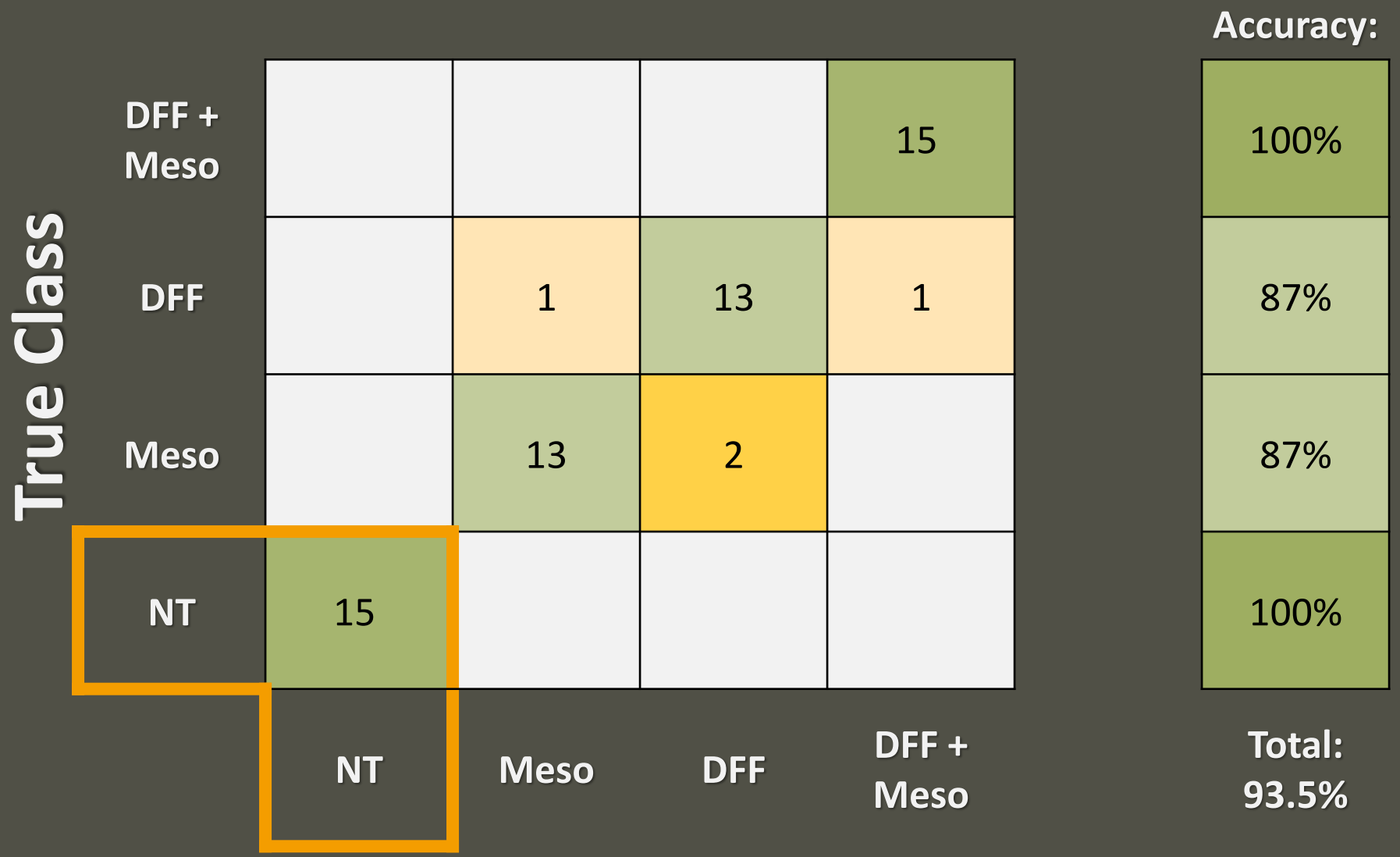

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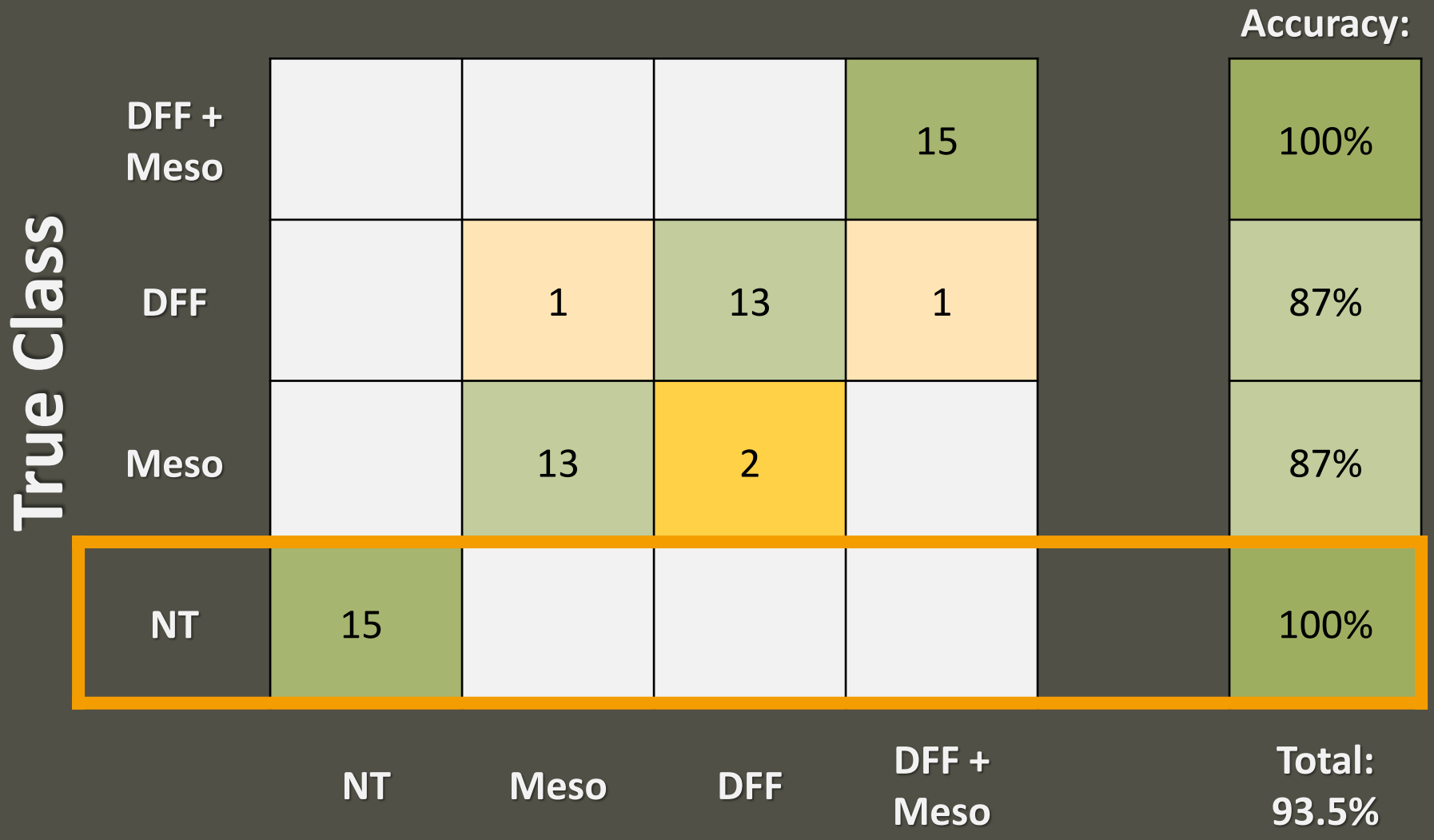

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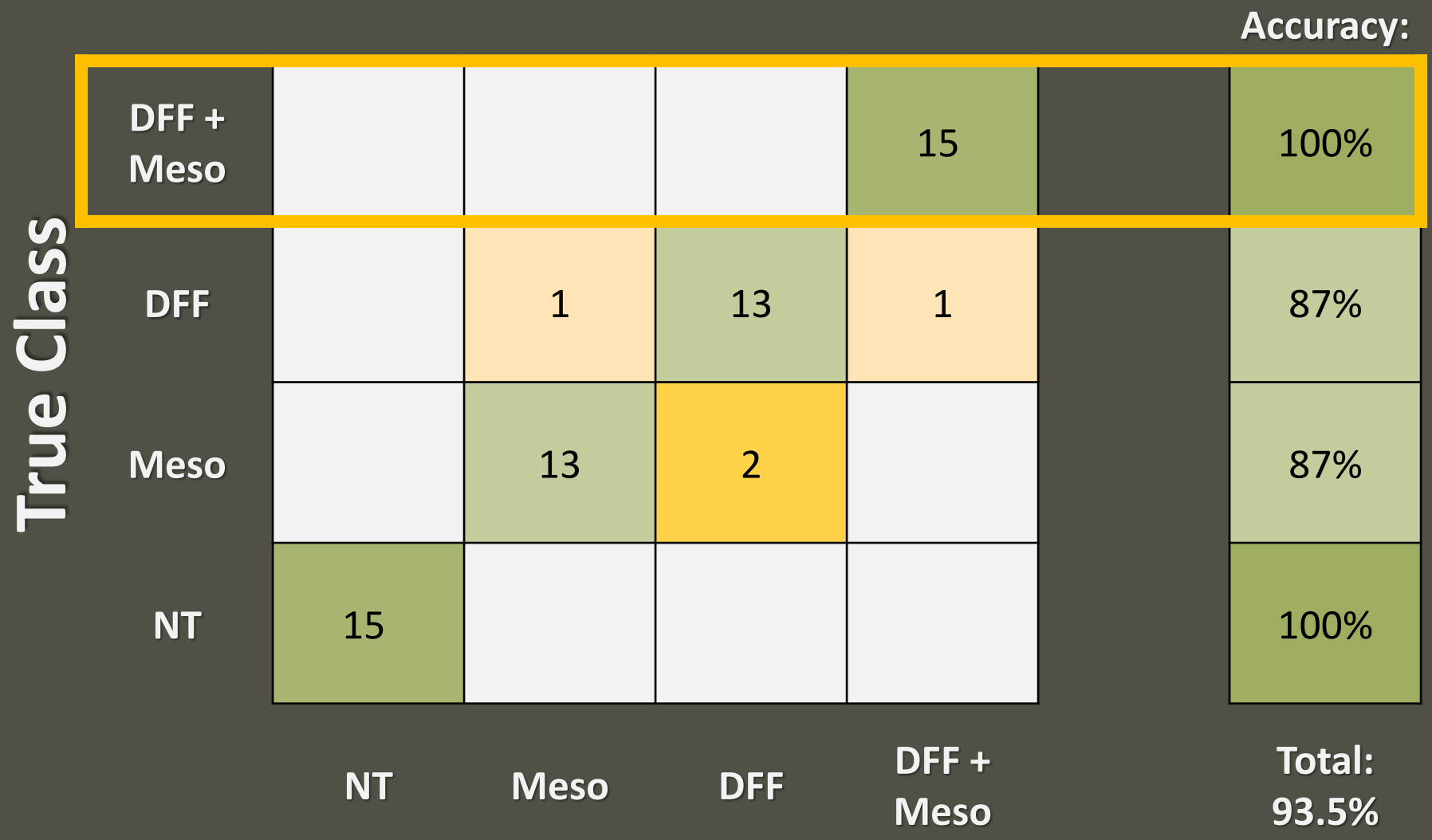
Injury Confusion Matrix



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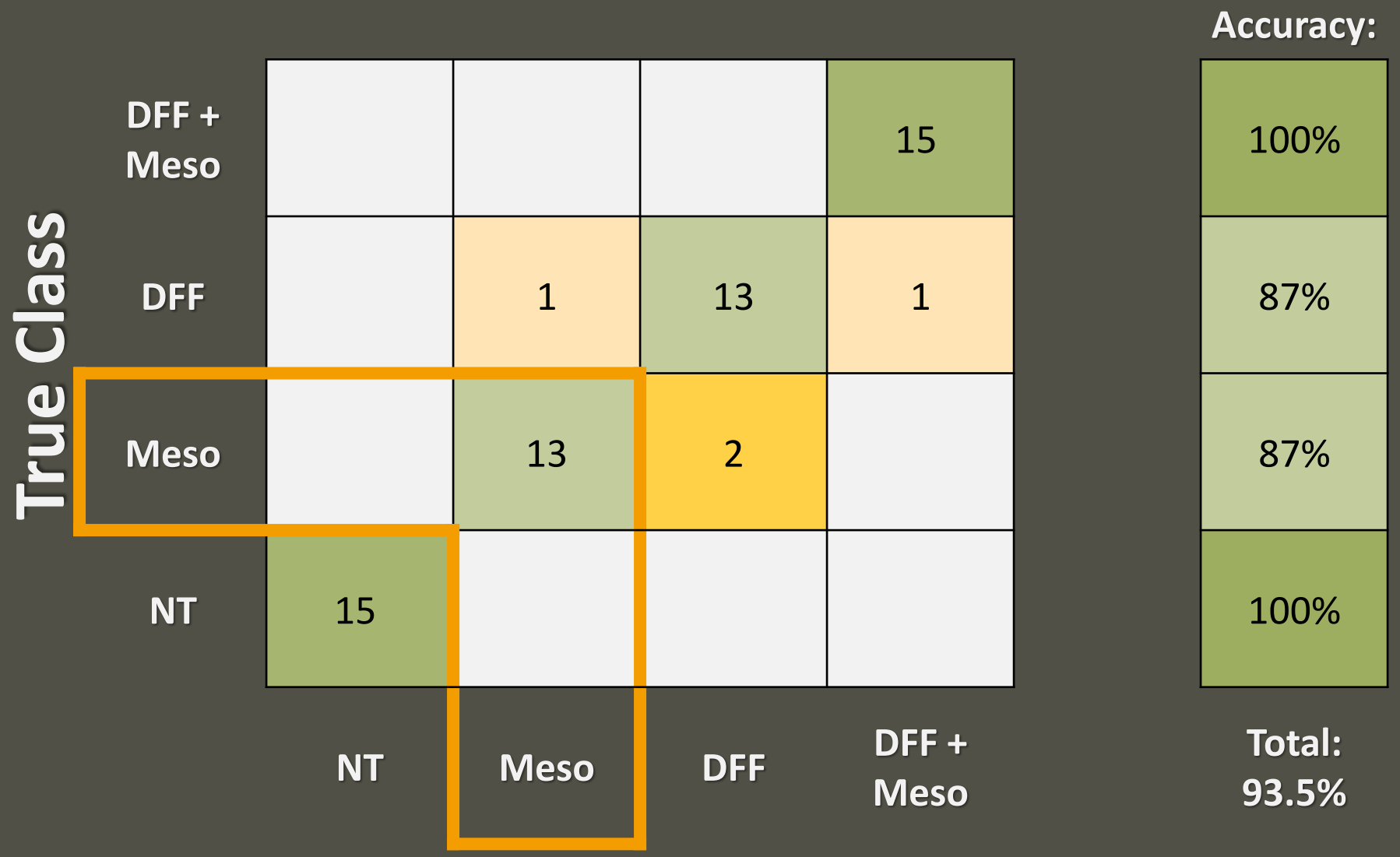

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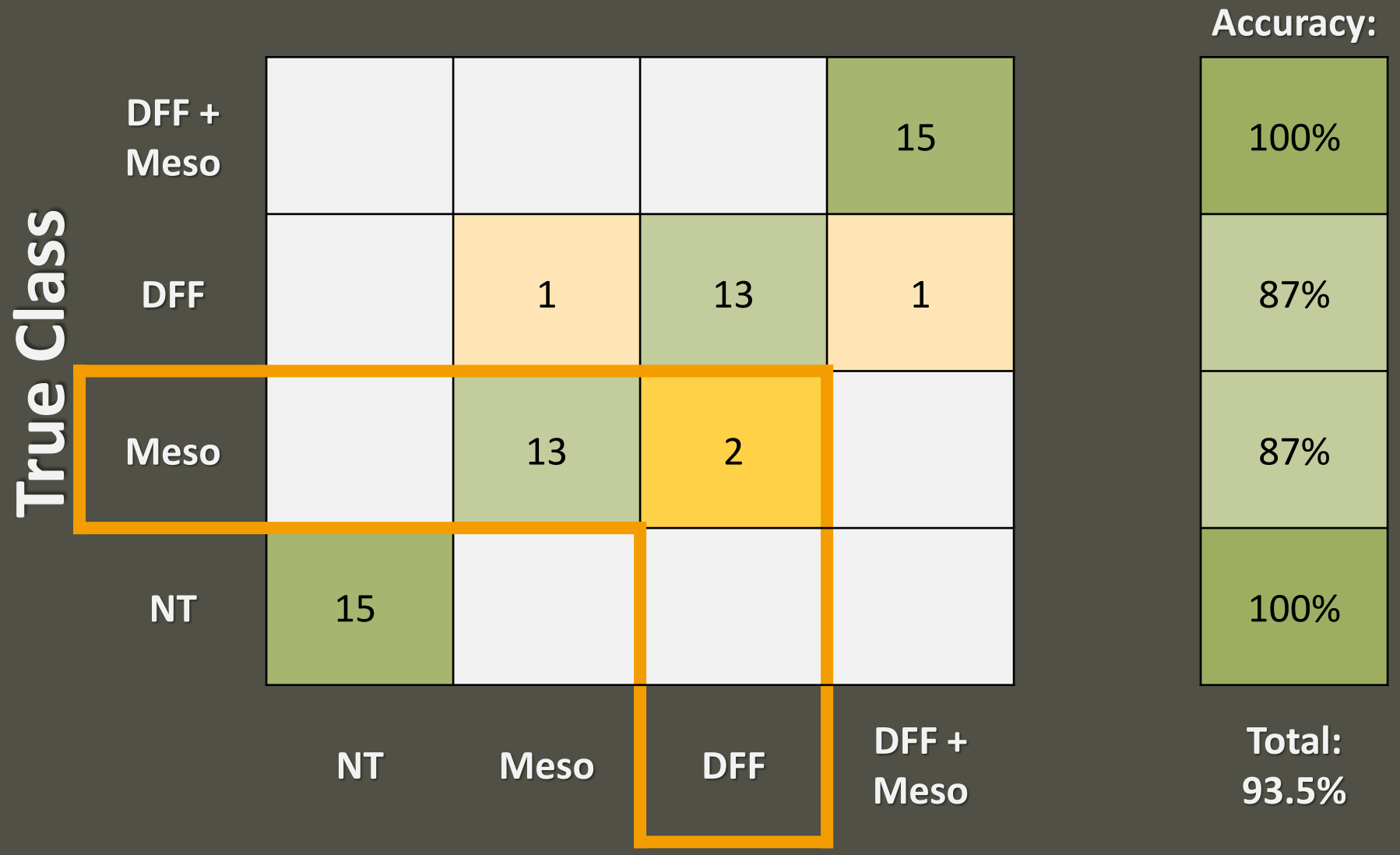

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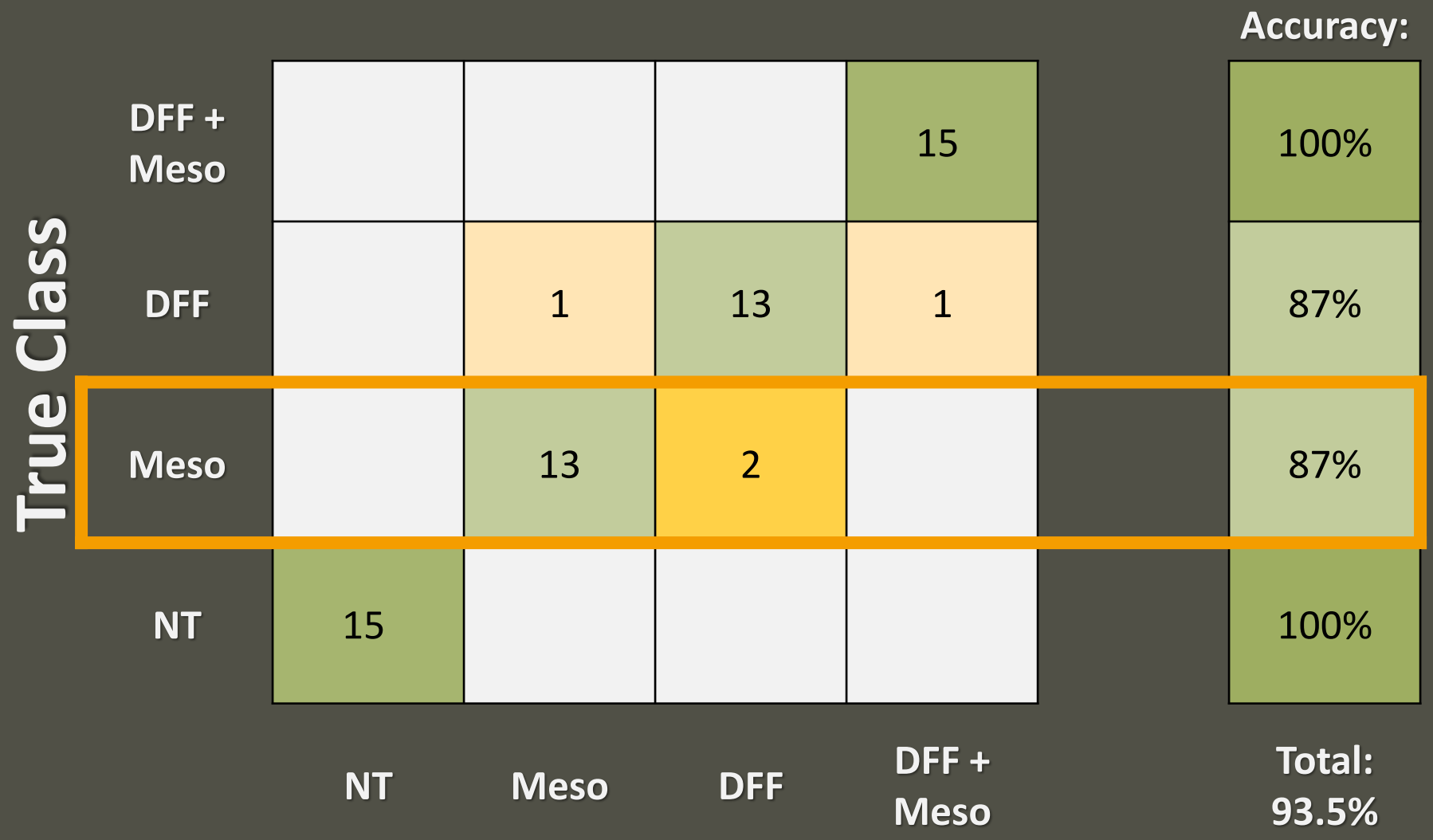

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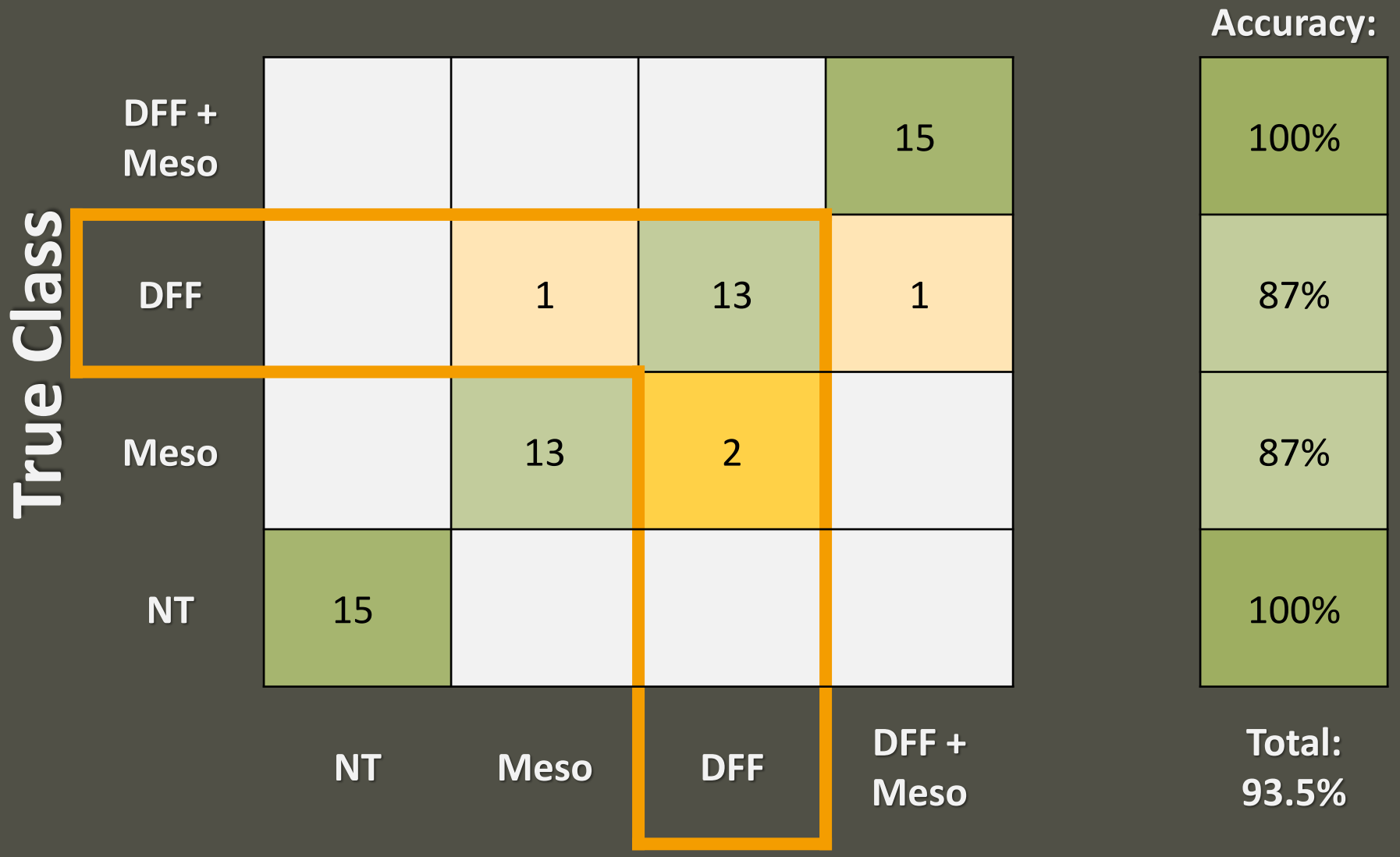

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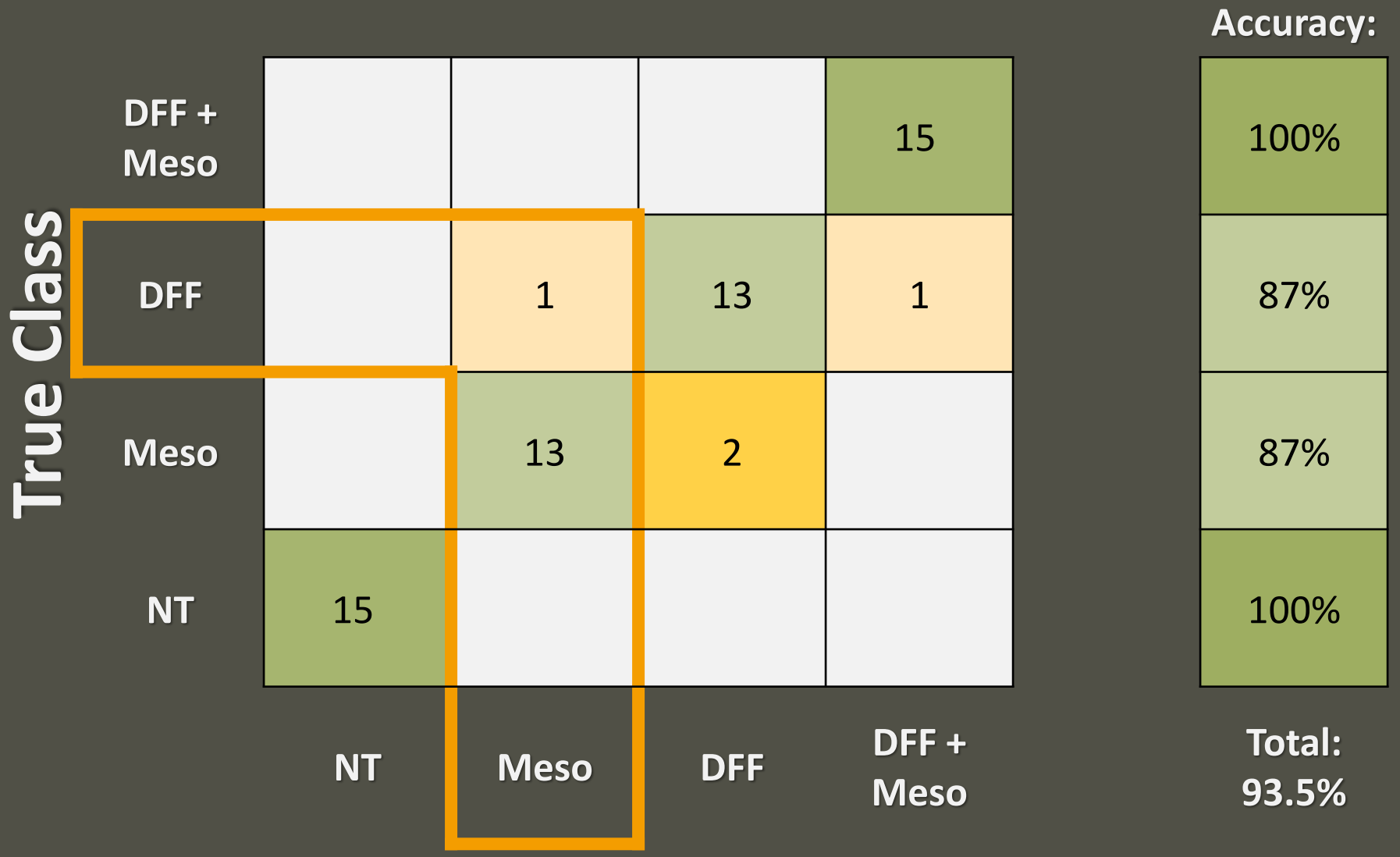

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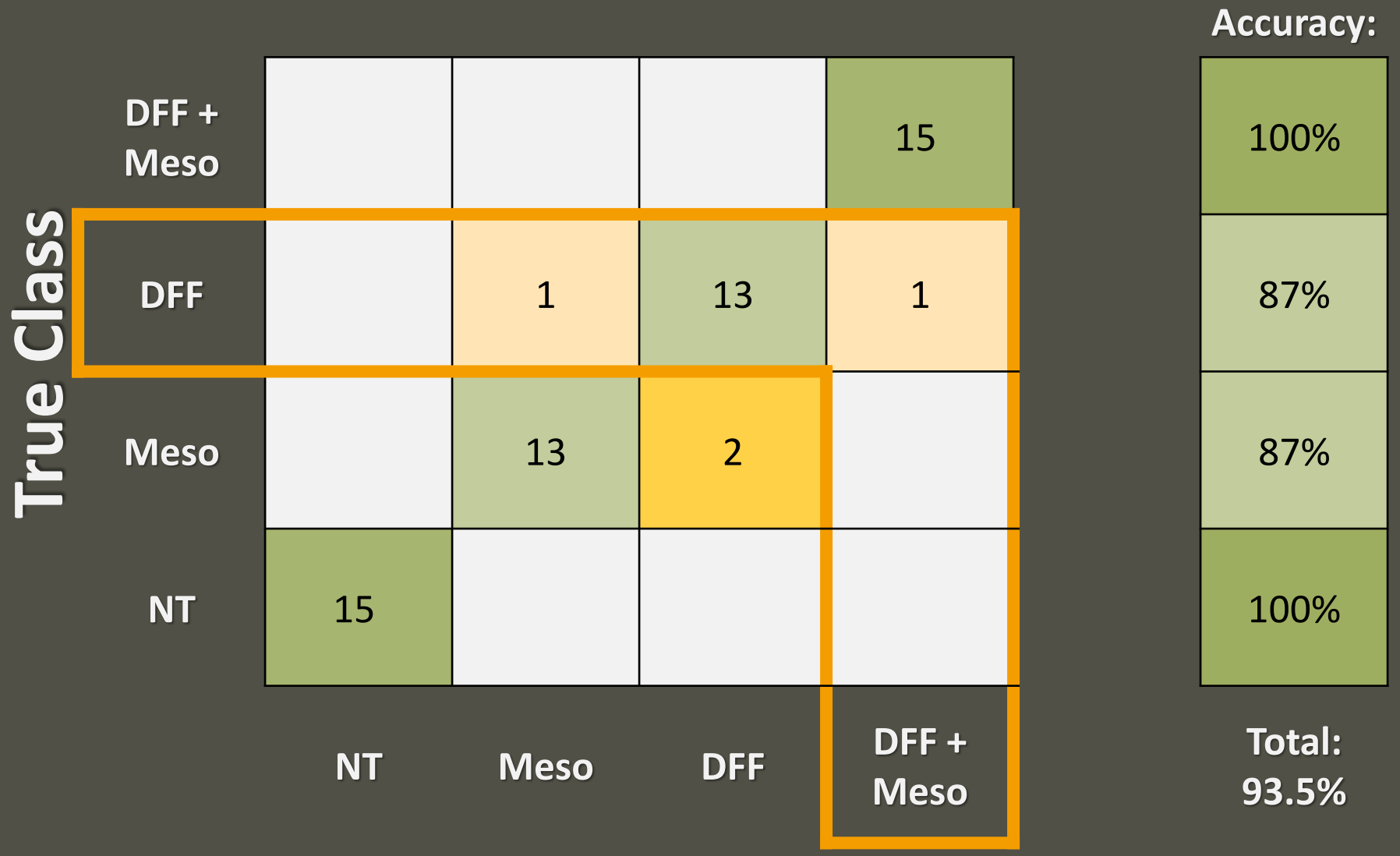

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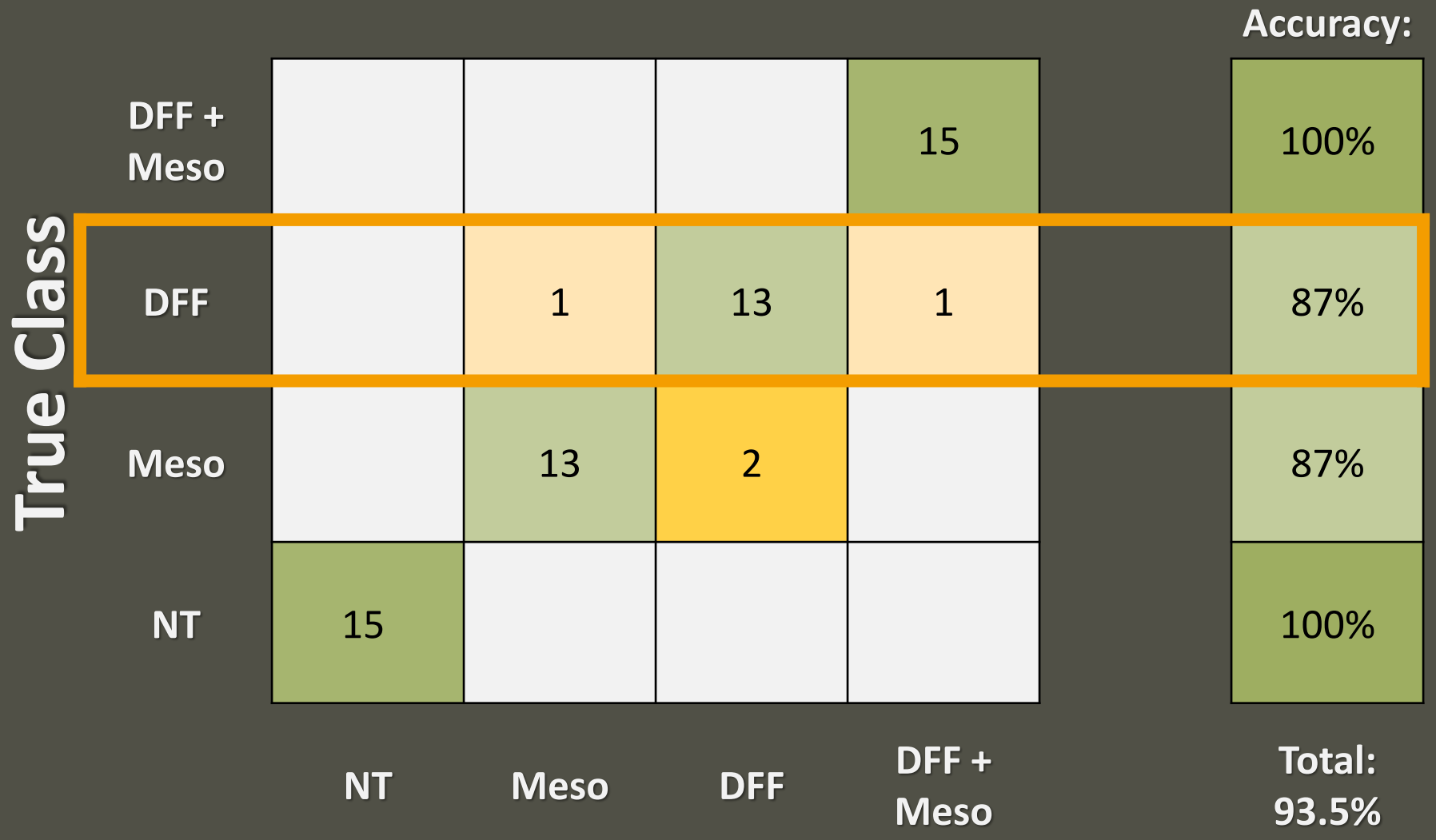

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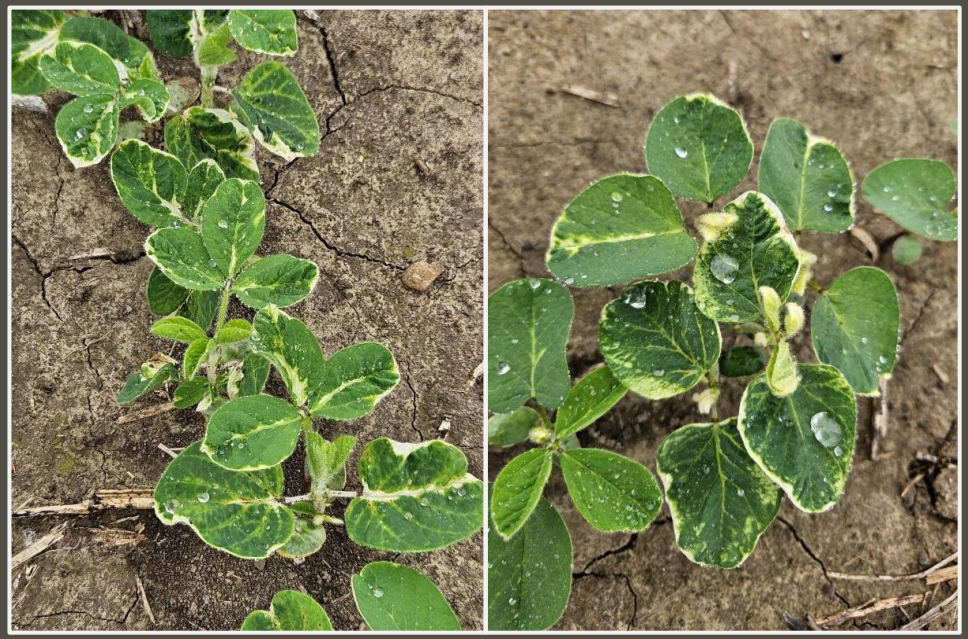
Discussion

Herbicide Injury

- A synergistic interaction at 14, 21, and 28 DAA between mesotrione and 150 g ha^{-1} of diflufenican

LeafSpec Imaging

- Greater than 93% accuracy was achieved in classifying herbicides
- Previous research achieved 75% accuracy when classifying post-emergence herbicides[1]



Diflufenican (150 g ha^{-1}) Mesotrione (26 g ha^{-1})

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[1] Niu et al 2023

Conclusions

Objective 1

- The interaction between diflufenican and simulated mesotrione carryover resulted in a synergistic crop injury response

Conclusions

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- The interaction between diflufenican and simulated mesotrione carryover resulted in a synergistic crop injury response

Objective 2

- Distinguishing herbicides with similar bleaching symptomology is possible with the LeafSpec
  - Reject the null hypothesis

Implication & Future Research

Practical Implication

- LeafSpec technology has the utility to identify herbicide injury and can help inform crop management decisions

Future Research

- Controlled environment experiments will be conducted
  - Greater focus on dose response
  - Evaluate the utility of spectral analysis for evaluating herbicide interactions

Acknowledgements

Thank you Purdue Weed Science staff and Dr. Jin's Lab

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Questions?