How Should We Set Priorities in Kernza Breeding Programs?

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Heritable Variation?

Possible Selectable Traits in IWG

- Lodge resistance
- Seed size
- Seed shape
- Mixing quality/ baking quality
- Protein content (and many other nutrients)
- Resistance to rancidity
- Flavor
- Early maturity
- Water use efficiency
- Forage yield
- Disease resistance (can consider a wide array of specific diseases)
- Tolerance to various deficiencies, soil types, pH, etc.
- Root biomass, depth, soil carbon building, etc.
- Erosion prevention
- Uptake of deep soil water/nitrate
- Floret site utilization (percent seed set)
- Sustained yield

- Shatter resistance
- Free threshing
- Low toxins (vomitoxin from FHB, or ergot alkaloids)
- Resistance to pre-harvest sprouting
- Hard versus soft grains
- Mycorrhizal association and nutrient uptake
- Maintaining genetic diversity
- Seedling establishment
- Weed competitiveness
- Longevity (summer and winter survival)
- Waxy leaves
- Pubescent leaves
- High or low rhizome production
- Head compactness
- Lax or erect heads
- Percent fertile tillers
- Number of tillers
- Harvest index
- Compatibility with intercrops (legumes, annual grains, other perennial grains)

- Stem diameter
- Hollow versus solid stem
- Lignin content (biofuels)
- Malting quality
- Head morphology (number of florets per spikelet, etc.)
- Leaf length
- Leaf width
- Synchronous flowering
- Rapid dry-down of heads and seed
- Yield (per head, per area, first year, later years)
- Short stature
- Forage quality
- Waterlogging tolerance

Johnny's Decision

Law of the Minimum

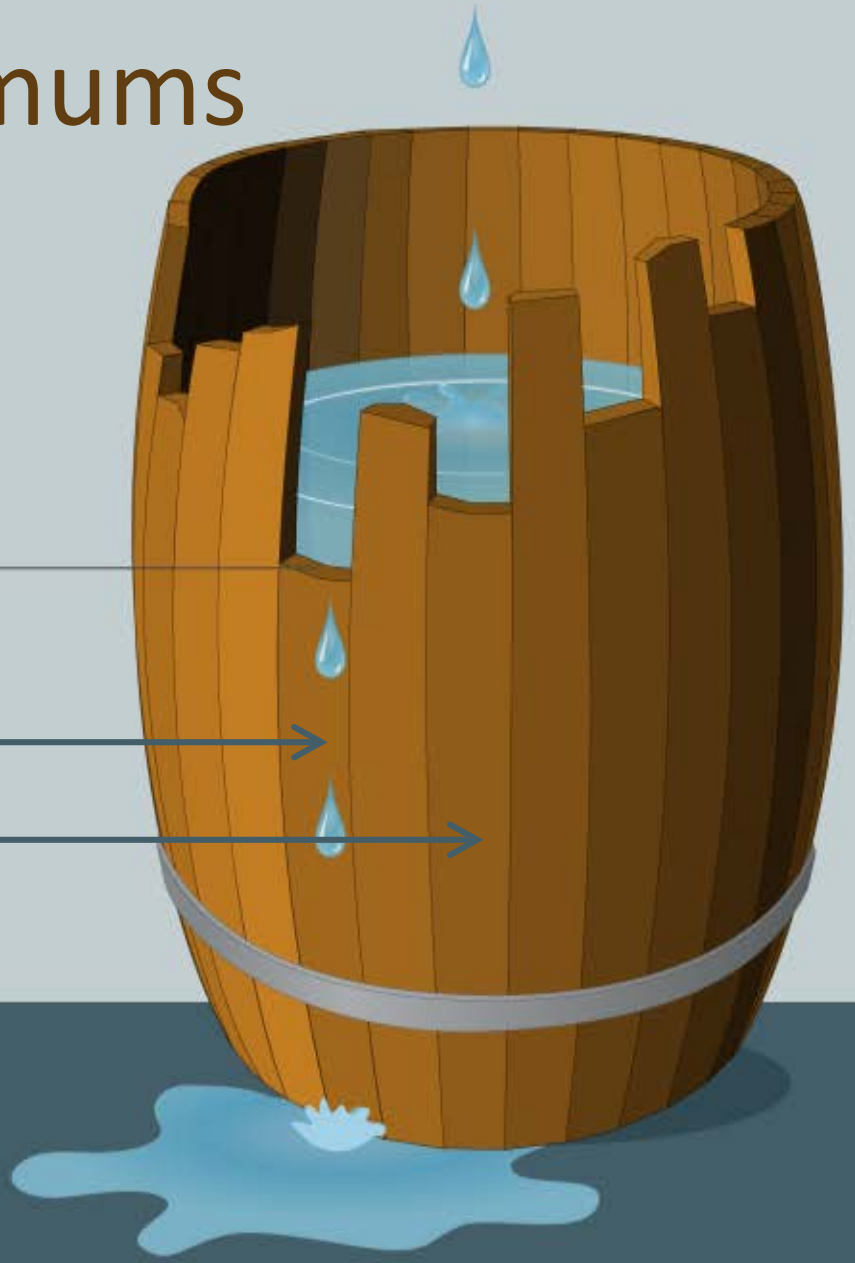
Profitability

Harvested Yield
of Clean Seed

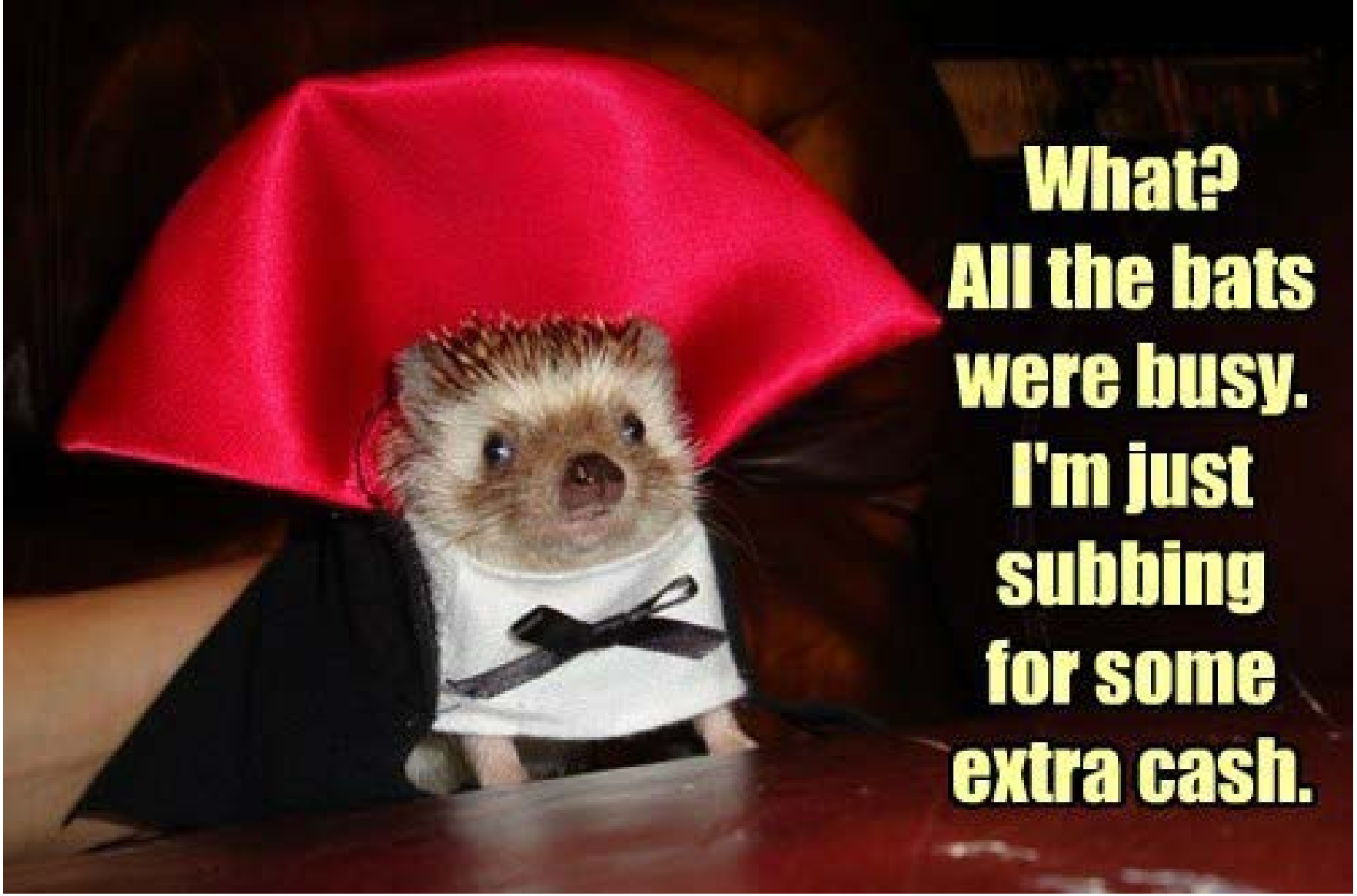
Nested Minimums

- Acres Planted
  - Profitability
    - Harvested yield of clean seed
      - Shatter resistance
      - Seed mass
      - Free threshing ability
      - Number of heads
      - Seed set
      - Synchronous flowering
      - Lodging resistance
      - Seedling vigor
        - Root length
        - Leaf length
        - Leaf area
        - Leaf mass
        - Number of leaves

Sequential Minimums

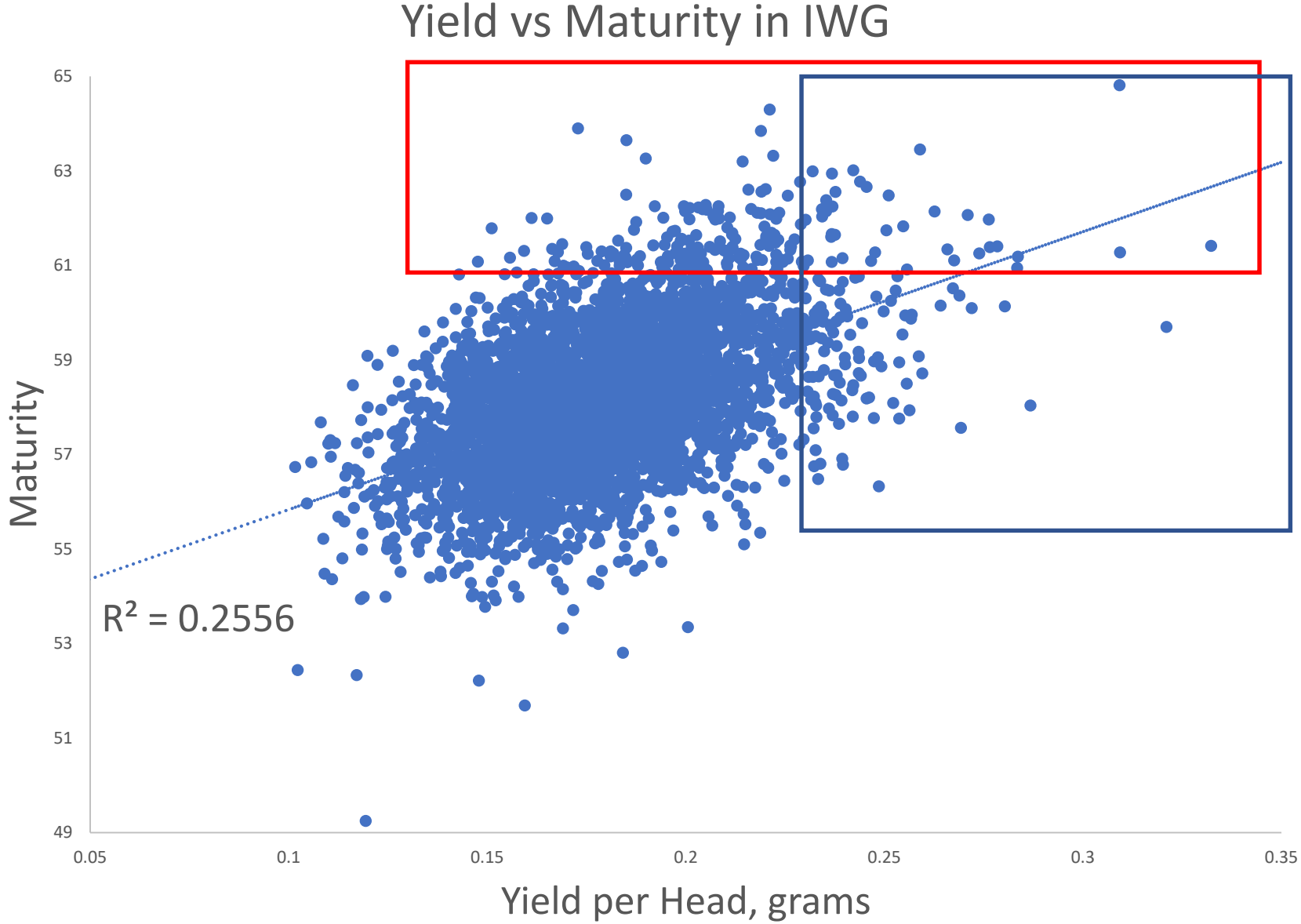


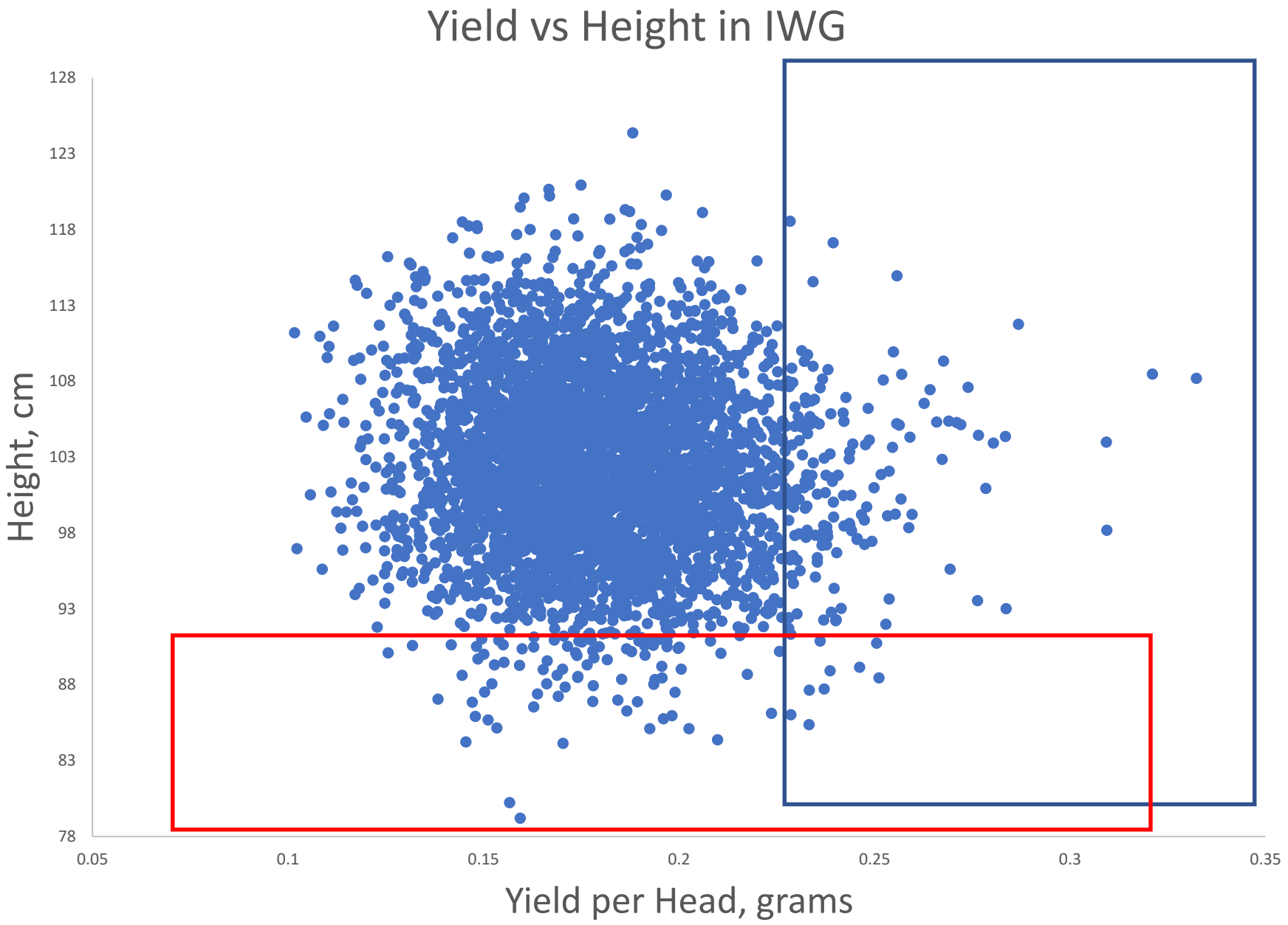
The Limiting Factor Varies by Location and Farming System

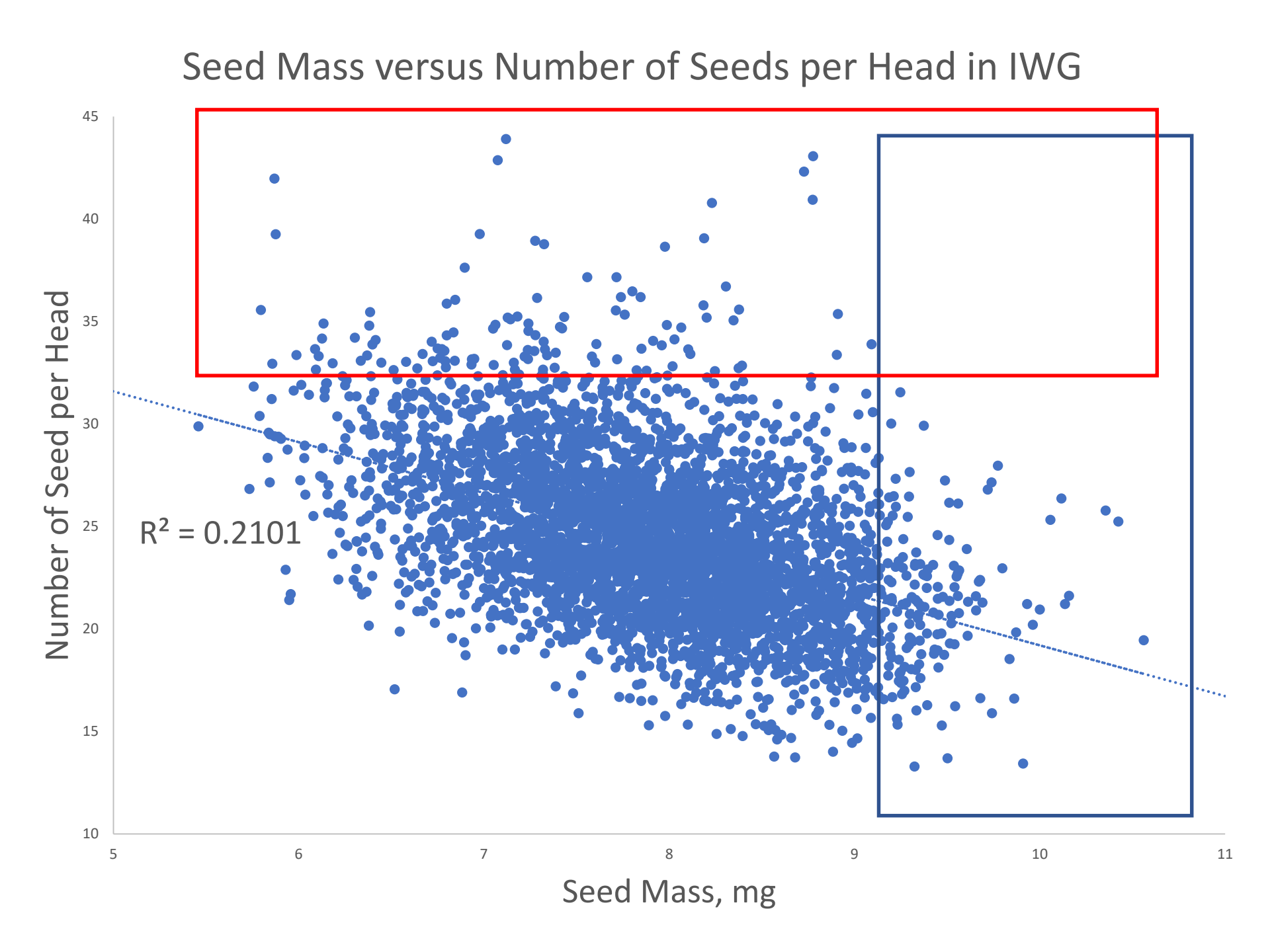


Can we substitute free threshing ability for big seed?

Can we substitute waxy leaves for big seed?


Yield vs Maturity in IWG
Maturity
65
63
61
59
57
55
53
51
49
R² = 0.2556
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Yield per Head, grams


Yield vs Height in IWG
Height, cm
128
123
118
113
108
103
98
93
88
83
78
0.05
0.1
0.15
0.2
0.25
0.3
0.35
Yield per Head, grams


Seed Mass versus Number of Seeds per Head in IWG
Number of Seed per Head
Seed Mass, mg
R² = 0.2101
45
40
35
30
25
20
15
10
5
6
7
8
9
10
11

- Every trait we add to the package will slow progress overall or vastly increase cost
- Therefore in the short term we must use management, engineering, processing, blending, marketing, etc. to address as many limiting factors as possible
- Breeders should target a few key obstacles that must be solved by genetic improvement

Priorities in TLI Kernza Breeding

1. Yield per head, aiming at sustained yield/area
2. Free threshing ability
3. Mass per seed
4. Shatter resistance
5. Floret site utilization (seed set %)
6. Reduced height, now lodging resistance
7. Stem strength
8. Disease resistance
9. Early Maturity
10. Mixing and baking quality
11. Water use efficiency