

## **Stems of Steel: Using engineering to understand lodging**

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Lodging, when a stem loses its vertical position, occurs during hard rainfalls/high winds and if severe can result in yield loss. The likelihood of lodging has been compounded by breeding for increased panicle size and test weight to increase yield potential. Often, crops do not have the structural capacity to remain vertical under these forces. Breeding for these agronomic traits does not take into consideration of the structural physics of increased grain weight without increased stem strength which results in lodging. An interest in nature-inspired architecture has lead engineers to apply core-engineering principles to plants to take a fresh look at building structural designs. Our study in contrast, utilizes engineering principles, material properties and material allocation within stems, from the cellular to field level, to determine possible failure points that result in lodging. This process is similar to that used by forensic engineers to determine why a building collapsed. Our present findings indicate that various cereal crops differ in the location of failure points that cause lodging. These sites are related to many traits such as cell wall structure, density, plant maturity, and prior exposure to wind. Therefore, in order to mitigate lodging, breeders need to take into account the traits that address structural engineering principles when determining breeding targets.