

Background

Pennycress (*Thlaspi arvense*)

- Pennycress is a winter annual oilseed cash cover crop being domesticated for Midwest agricultural systems

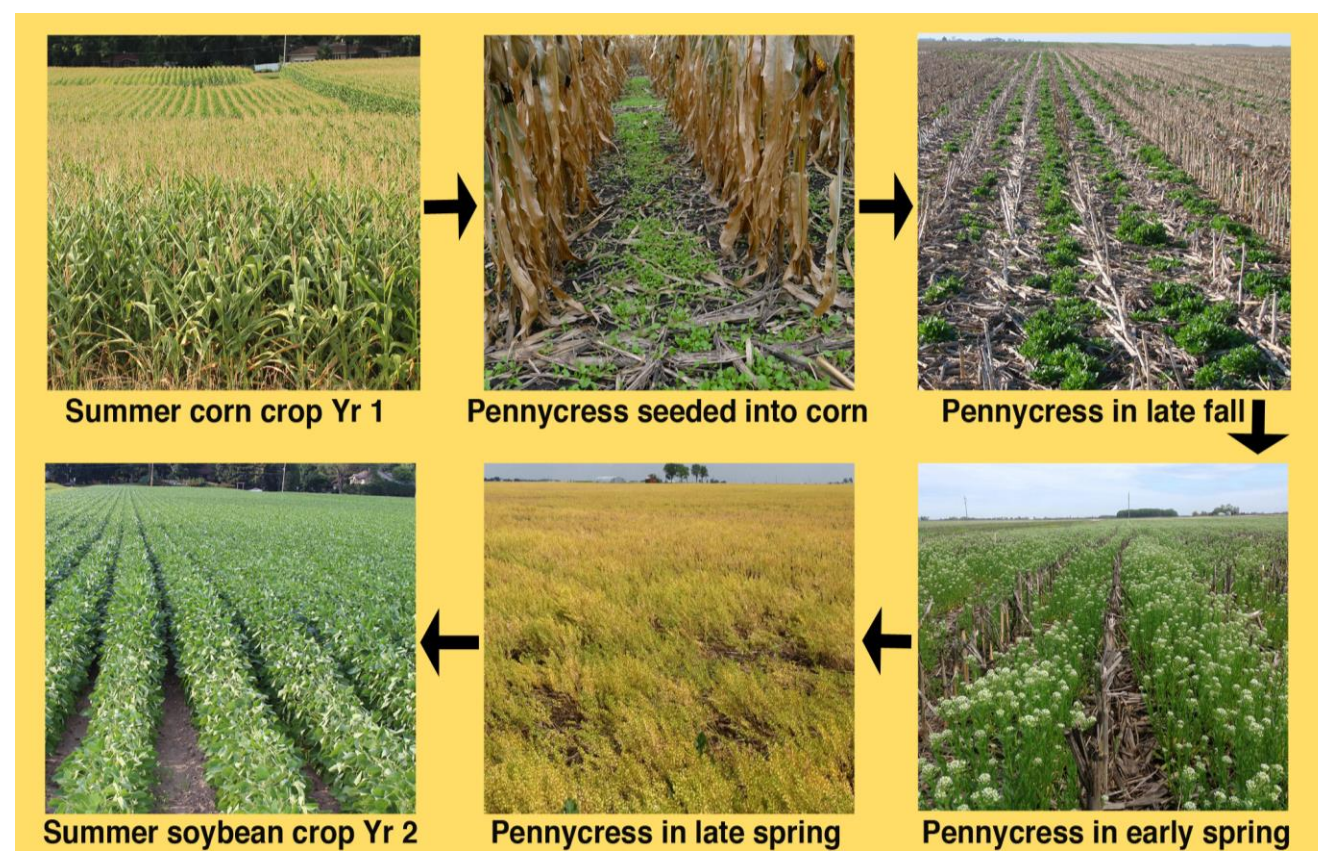


Figure 1. Pennycress can fit into the common corn-soybean rotation of the Midwest, effectively growing three crops during the time that normally two would be grown. This is a form of sustainable intensification.

Domestication

- Pennycress has spent most of its evolutionary history as a weed
- Several traits need to be improved when domesticating a plant in order to be a useful crop in managed systems



Figure 3. Breeding for pods that don't shatter until harvest is an example of a domestication trait.

- Domestication traits include: non-shattering pods, larger seeds, plants less prone to lodging, early-maturing plants, and plants with reduced undesirable compounds
- Genetic information from the model plant *Arabidopsis thaliana* has aided in the domestication effort, and already several domestication traits have been attained

Seed Size

- All of our modern-day crops have undergone an increase in seed size as compared to their wild progenitor
- Larger seed size is important for increasing yields as well as for ease of planting and harvesting with mechanical equipment
- Research efforts haven't largely focused on seed size in pennycress

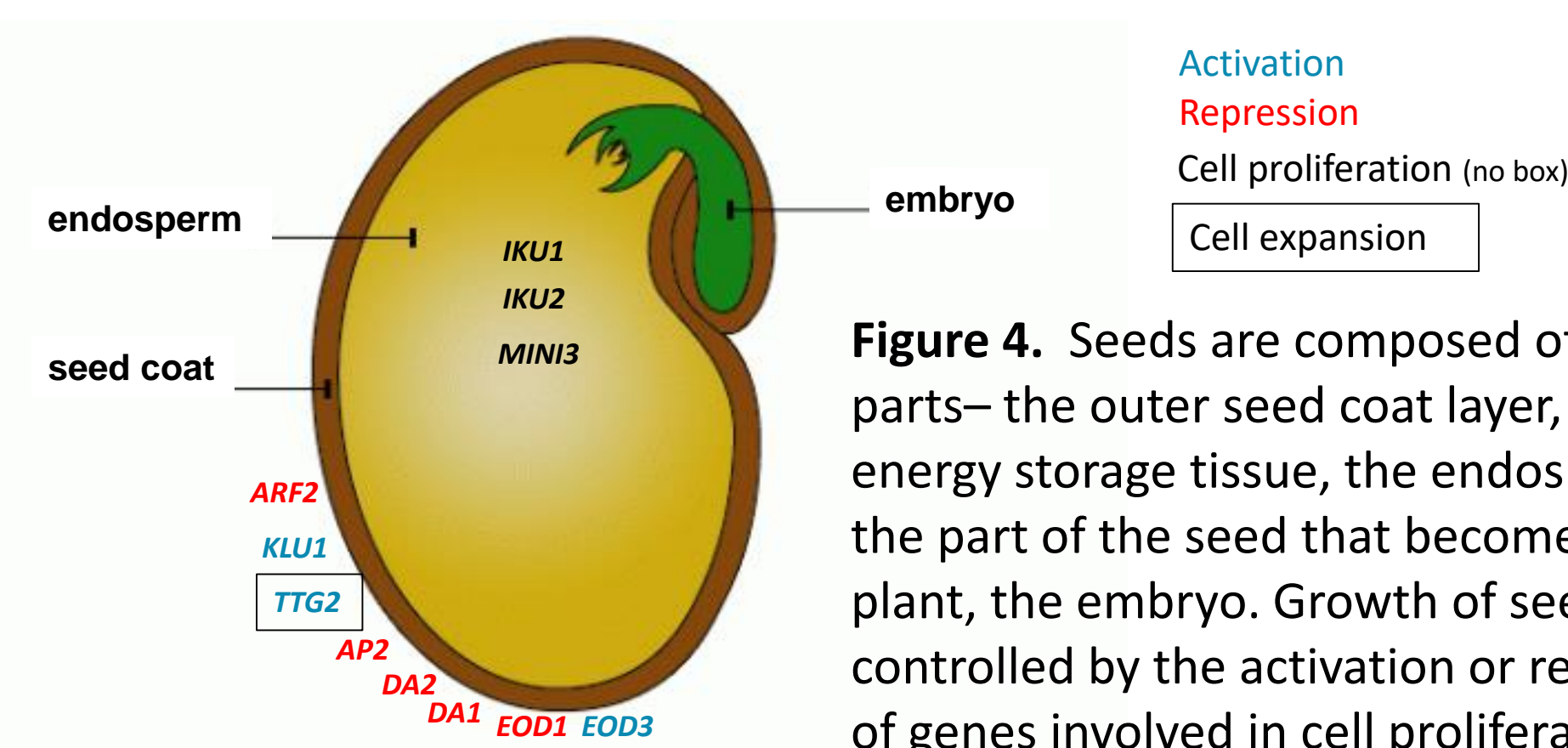
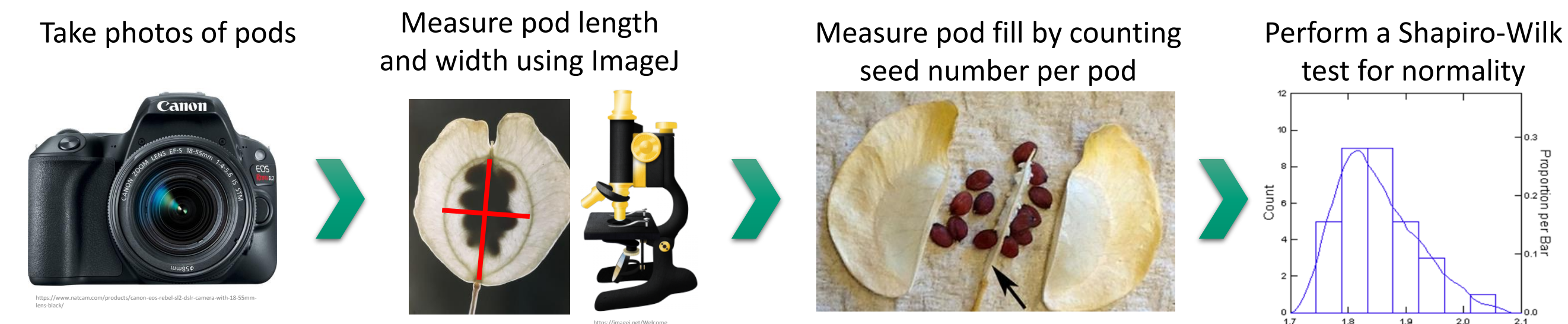


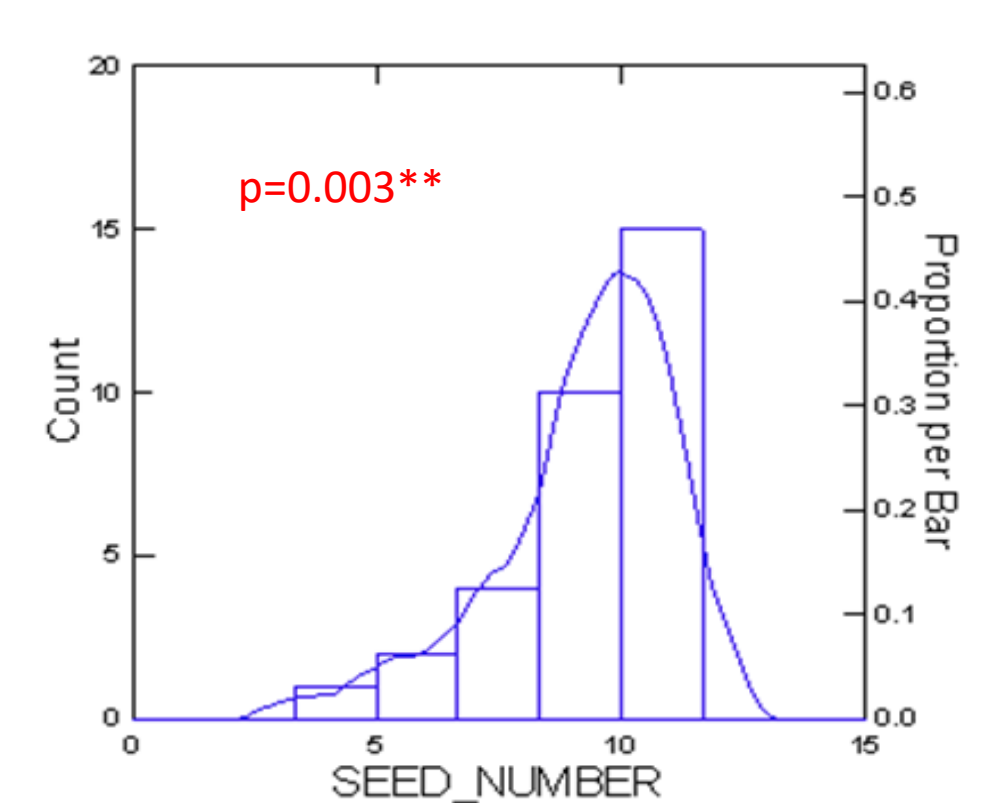
Figure 4. Seeds are composed of three parts—the outer seed coat layer, the energy storage tissue, the endosperm, and the part of the seed that becomes the plant, the embryo. Growth of seeds is controlled by the activation or repression of genes involved in cell proliferation and expansion.

Method 1- Evaluating Pod Size Related Traits



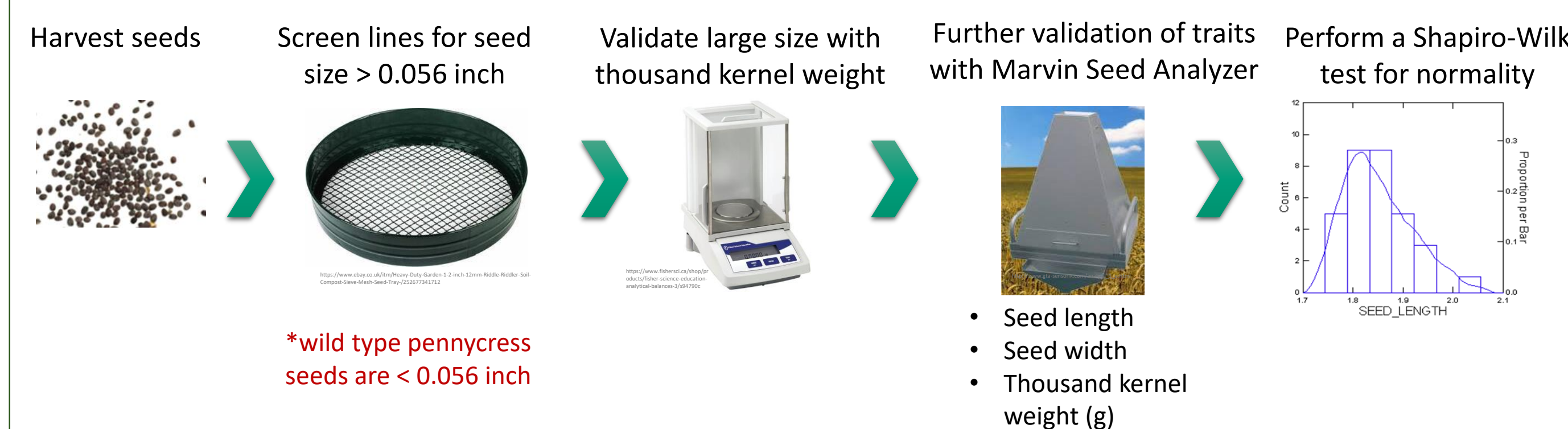
Results

1845 Pod fill (seed number)

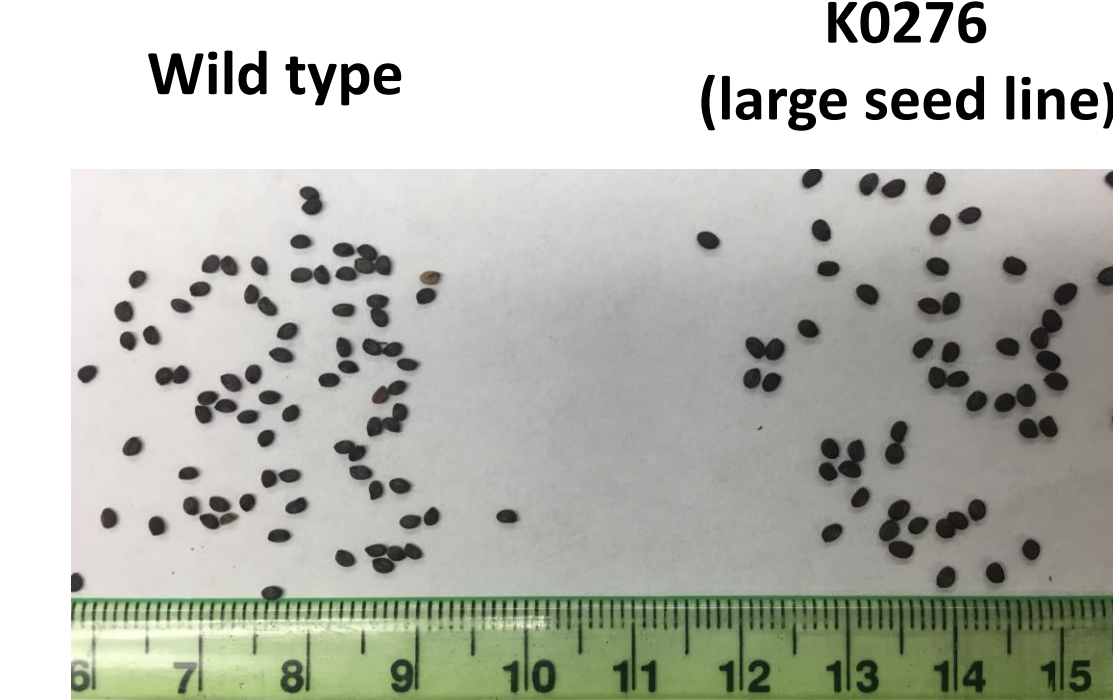
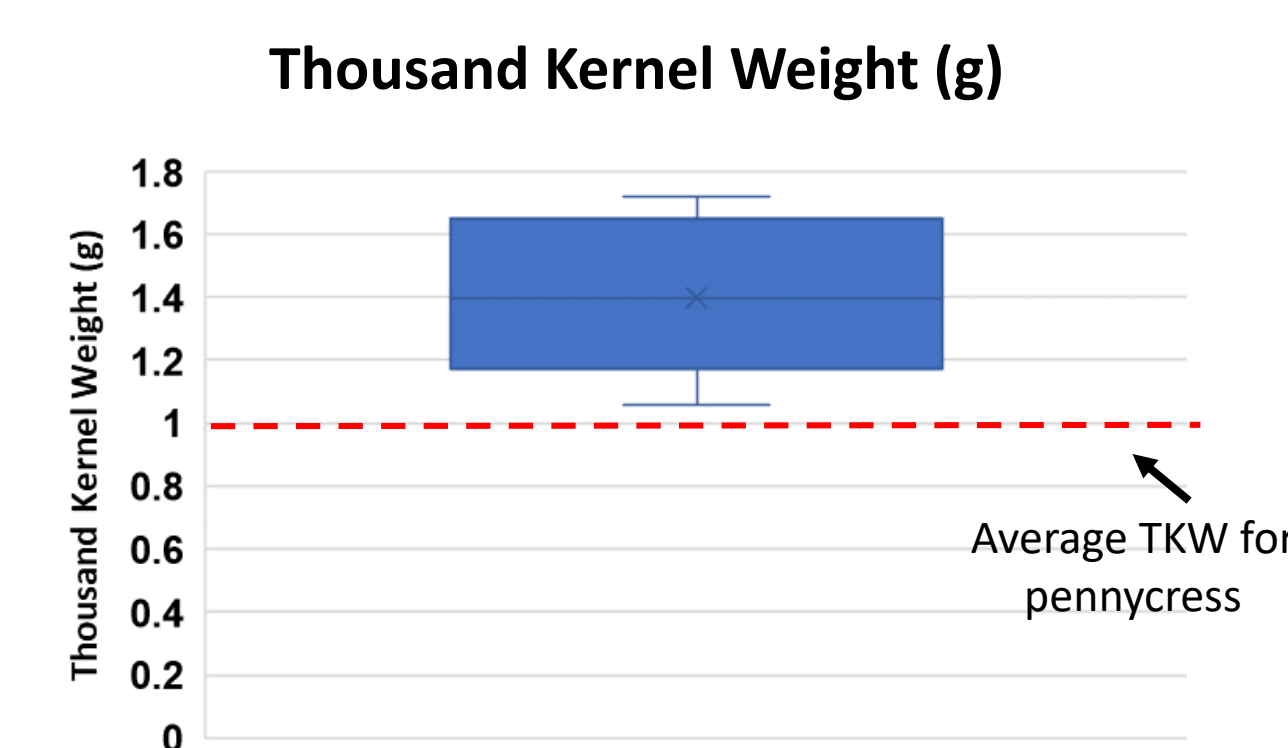


- Shapiro-Wilk test for normality was significant for pod fill in one of the four populations evaluated
- Skewed distribution indicates variation for pod fill compared to the normal distribution seen in wild type pennycress

Method 2- Evaluating Seed Size Related Traits

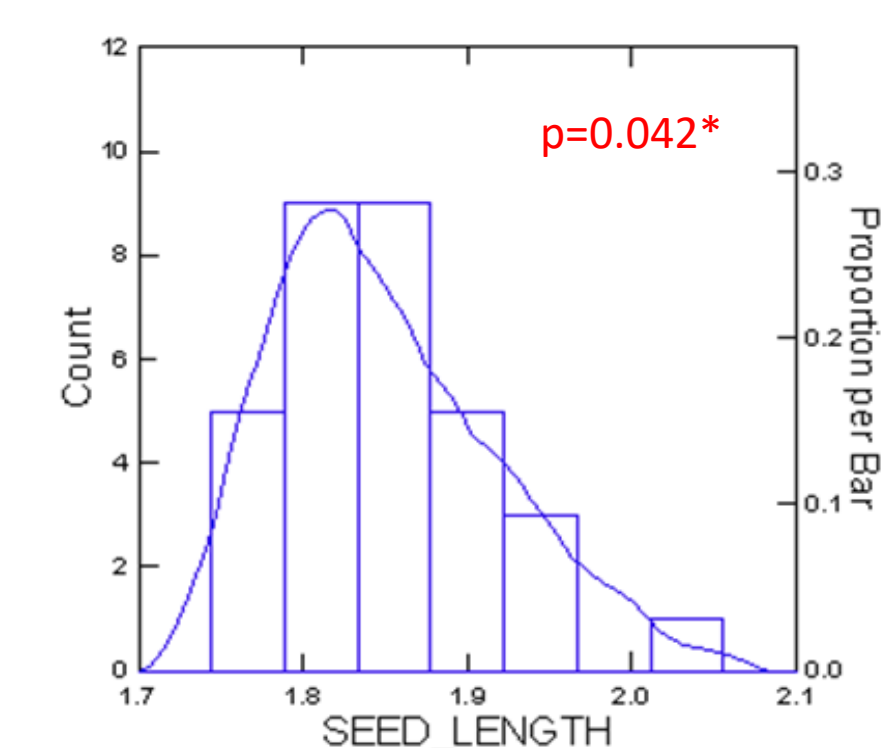


Results



- Mutant screen of 1,000 lines resulted in the identification of more than 20 lines with 30% increase in thousand kernel weight.
- Significant variation was observed for seed length in the segregating population

1845 Seed length (mm)



Summary

- Successfully deployed a methodology to evaluate seed and pod size related traits
- Found significant variation in several seed and pod size traits
- Heritability of identified seed size variants will be verified in summer 2019
- This method will be used to characterize further populations
- The existing diversity for seed size present in the germplasm will be utilized for future breeding efforts

Future Directions

Exploring the effect of seed size mutations on seed coat variants

- Wild type pennycress traditionally has a reddish-brown seed coat color
- A yellow seed variant resulting from seed coat removal has been identified
- Removal of the seed coat increases the oil content of the seed while making oil pressing process easier
- However, removing the seed coat also results in a smaller seed than wild type pennycress
- Combining mutations known to increase seed size in *Arabidopsis* with the seed coat variant has shown encouraging preliminary results in pennycress

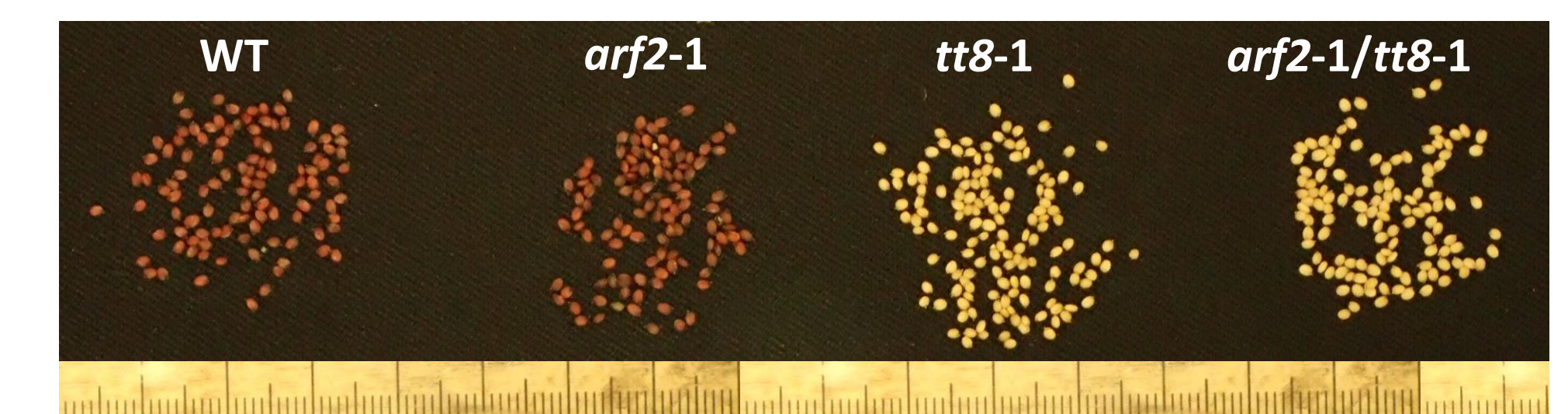
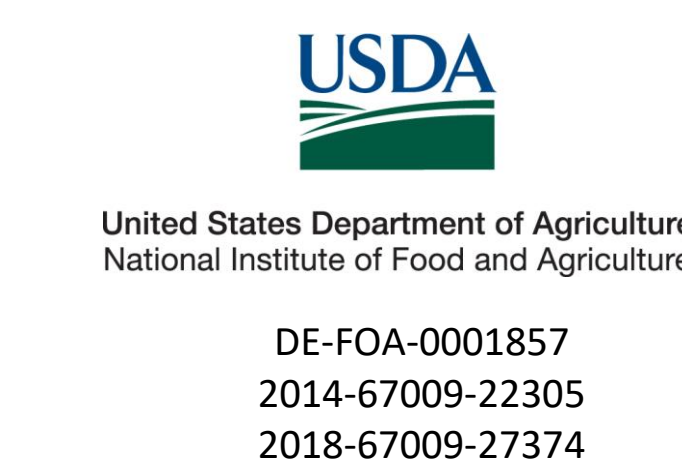


Figure 5. Wild type pennycress has a dark reddish-brown seed coat color (left). A mutation in the *arf2* gene can cause larger seed size (left-center). Yellow-colored pennycress is the result of a mutation in the *tt8* gene that removes the seed coat (right-center). This generally results in a smaller seed size, but the loss of a seed coat is useful for the oil pressing process. Combining both the *arf2* and *tt8* mutations may restore some of the lost seed size from the removal of the seed coat while increasing ease of oil pressing (right).

Acknowledgements



References

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- Chopra, R., Johnson, E. B., Emenecker, R., Cahoon, E., Lyons, J., Kliebenstein, D. J., ... Marks, M. D. (2019). Progress toward the identification and stacking of crucial domestication traits in pennycress. *BioRxiv*, 609990. <https://doi.org/10.1101/609990>